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COST ESTIMATING

GUIDE

U.S. DEPARTMENT OF ENERGY

Associate Deputy Secretary for Field Management

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ACRONYMS AND ABBREVIATIONS

A/Es	architect/engineer
ABC	Activity Based Costing
ACM	Asbestos Containing Material
ADP	Automatic Data Processing
ADS	Activity Data Sheet
AES	Automated Estimating System
BA	Budget Appropriation
BM	Bill of Material
BO	Budgetary Outlay
CACES	Corps of Engineers' Computer-Aided Cost Engineering System
CAD	Computer-aided Drafting
CC	Construction Contractors
CCMD	Committee for Cost Methods Development
CDR	Conceptual Design Report
CER	Cost Estimating Relationship
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFO	Chief Financial Officer
CM	Construction Management
CM	Construction Management
CMD	Cost Methods Development
CMI	Corrective Measures Implementation
CMP	Configuration Management Plan
COA	Code of Accounts
CPDS	Construction Project Data Sheet
CSI	Construction Specification Institute Code
CWBS	Contract Work Breakdown Structure
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOS	Disk Operating System
DPT	Design Planning Tabulation
EA	Environmental Assessment
ECER	Enhanced Cost Estimating Relationship
ED&I	Engineering, Design, and Inspection
EIS	Environmental Impact Statement
EM	Environmental Management
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ERMC	Environmental Restoration Management Contractor
ESAAB	Energy System Acquisition Advisory Board
ESAARs	Energy System Acquisition Advisory Reviews
F/O	Functional/Operational
FA	Facility Assessment

ACRONYMS AND ABBREVIATIONS (continued)

FI/CMS	Facilities Investigation/Corrective Measures Study
FI	Facility Investigation
FM	Field Management
FM-50	Office of Infrastructure Acquisition, Office of the Associate Deputy Secretary for Field Management
FONSI	Finding of No Significant Impact
FS	Feasibility Study
FSR	Feasibility Study Report
FTE	Full Time Equivalent
GFE	Government Furnished Equipment
H&N	Holmes & Narver (H&N)
HRS	Hazard Ranking System
ICE	Independent Cost Estimate
ICECAN	Independent Cost Estimating Contingency Analyzer
JMN	Justification of Mission Need
KD	Key Decision
LANL	Los Alamos National Laboratory
LCC	Life-cycle costs
M&O	Management and Operating
NCR	Non-Conformance Report
NEPA	National Environmental Policy Act
OMB	Office of Management and Budget
OPC	Other Project Cost
ORNL	Oak Ridge National Laboratory
ORR	Operational Readiness Review
PA/SI	Preliminary Assessment/Site Inspection
PA	Preliminary Assessment
PACE	Plant and Capital Equipment
PC	Personal Computer
PDS	Project Data Sheet
PD&E	Planning Design and Engineering
PERT	Programmed Evaluation and Review Technique
PL	Public Law
PM	Project Management
PM	Project Manager
PMP	Project Management Plan
POPR	Potential for an Occurring or past Release
PSAR	Preliminary Safety Analysis Report
PSD	Prevention of Significant Deterioration
PSO	Project Support Officer (Chapter 13)
PSO	Project Secretarial Officer (chapter 5)
PSWBS	Project Summary Work Breakdown Structure

QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SAR	Safety Analysis Report
SARA	Superfund Amendments and Reauthorization Act of 1986
SER	Safety Evaluation Report
SI	Site Inspection
SWMU	Solid Waste Management Unit
TEC	Total Estimated Cost
TPC	Total Project Cost
UCR	Uniform Capital Recovery
UMTRA	Uranium Mill Tailings Remedial Action
UMTRAP	Uranium Mill Tailing Remedial Action Project
UMTRCA	Uranium Mill Tailings Radiation Control Act of 1978
WBS	Work Breakdown Structure

CHAPTER 1

INTRODUCTION

1. PURPOSE

This Guide serves as a companion to the Department of Energy (DOE) Order 5700.2, COST ESTIMATING, ANALYSIS, AND STANDARDIZATION. The objective of this Guide is to improve the quality of cost estimates and further strengthen the DOE program/project management system. This Guide strives to achieve this goal by providing uniform cost estimating methods as well as consistent estimate terminology. DOE federal and contractor personnel can use the information contained in this Guide as a check to ensure that estimate items that are required by DOE are included in their project estimates. This Guide also serves as a resource tool for DOE cost estimators who may be asked to develop a project estimate that is unusual or unfamiliar to them. In this case, the Guide serves as a Guide for gathering preliminary information on how to prepare such an estimate. This Guide, however, is not meant to be an inclusive, detailed Guide. It is intended that information specific to activities at particular sites be developed by the cognizant DOE Field Offices.

This volume is divided into two parts. Part I discusses the different types of DOE cost estimates, the elements of a cost estimate, and the preparation of the estimate. Part I also covers the increased role of environmental restoration and hazardous waste management projects in DOE activities and the impact of stringent environmental regulations on DOE programs/projects.

Part II of this Guide contains additional information on cost estimating techniques and their uses. Part II includes topics such as cost estimating relationships, the effect of the learning curve, cost and schedule integration, operating costs, and how cost estimates support baseline management of the projects. There is also a chapter on specialty costs for estimators who may be asked to prepare estimates for innovative or advanced technology projects.

2. BACKGROUND

Originally this volume was prepared as a textbook for DOE personnel involved in estimating construction project costs. Out of necessity, this volume has been expanded to address environmental project costs and other important elements of cost estimating, such as specialty costs, learning cures, and operating costs. Since the original edition, new sections have been added, and many sections have been rewritten based on user comments and the need for additional cost estimating tools in support of DOE's changing mission objectives. Any comments or suggestions for further improving this volume should be directed to the Director, Office of Infrastructure Acquisition (FM-50).

3. COST ESTIMATING AND THE PROGRAM/PROJECT MANAGEMENT SYSTEM

There are several different types of cost estimates, each prepared for different reasons and at different times during the life of a program/project. However, there is one thing that all DOE cost estimates have in common. Each is prepared as a tool that supports the overall management of the program or project. For this reason, a basic understanding of how cost estimates support the DOE Program/Project Management System is imperative for those involved in the cost estimating process.

For many years the Department managed its program/projects with a very “hands-off” approach due to a predominantly contractor, production-oriented focus on nuclear weapons and the highly secretive evolution of the advanced scientific technology associated with this effort. Historically, DOE program/project managers used cost and schedule as the major indicators in program/project accomplishment. In an attempt to improve the overall program/project management system, the Department has shifted emphasis to concentrate on the accomplishment of the project’s technical and schedule baseline objectives and closely control changes to the original baselines throughout the life of the program/project. With this method, costs naturally follow the accomplishment of the objectives of the program/project.

As illustrated in Figure 1-1, cost estimates are tools that support the entire DOE major system acquisition process. Current cost estimates are critical to supporting baselines and providing information for the Key Decision (KD) making process throughout the life of the project. At KD-0, the Acquisition Executive gives approval to begin the conceptual design review process. The conceptual design report (CDR) will produce technical, schedule, and cost baselines that will be approved at KD-1 and updated by the change control process through to the start of operations. An independent cost estimate (ICE) will be conducted prior to KD-1 and updated prior to KD-2 and KD-3.

Accurate and timely cost estimates are integral to the effective and efficient management of DOE projects and programs. However, good cost estimates alone will not guarantee a fully successful project/program management process. Early management involvement in the decision making process at KD-0 and continued management attention to the important issues of technical and schedule baselining, change control, ICE updates, etc., will further strengthen the process. The increased management attention will help to ensure prudent use of scarce fiscal resources and improve DOE’s credibility with oversight groups.

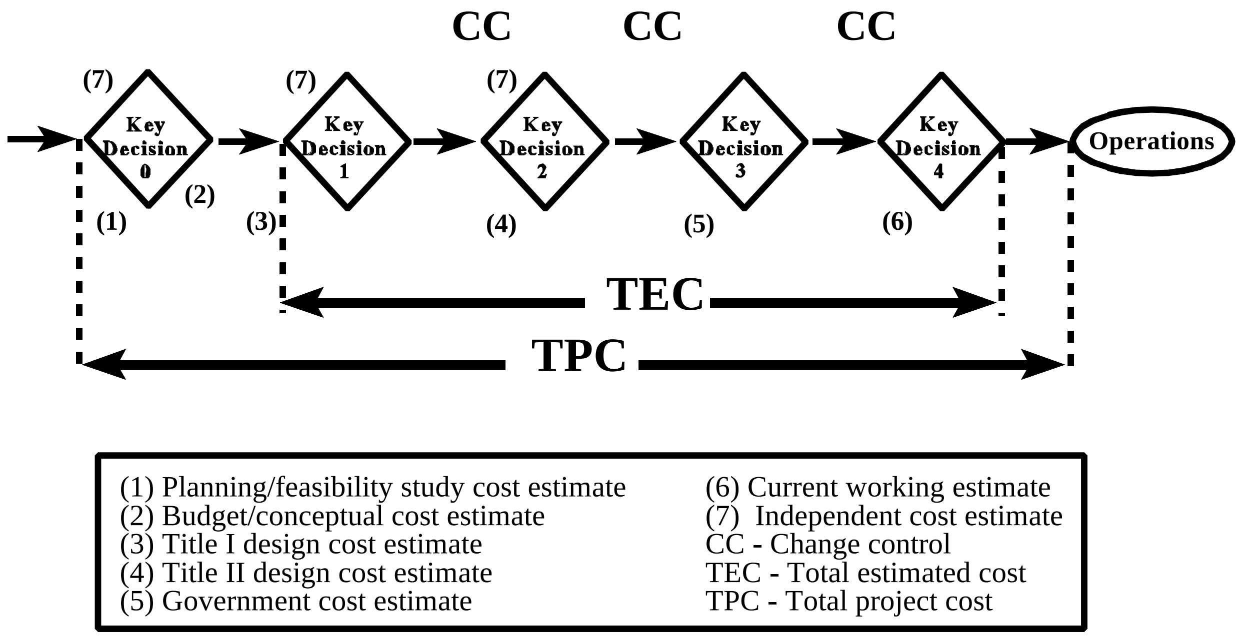

Figure 1-1. Major System Acquisition Process --When Costs Occur.

CHAPTER 2

COST ESTIMATION PACKAGE

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1. INTRODUCTION

When estimating the cost of a project or program, the estimator needs to know more than a quantity and a price for that quantity to develop an all inclusive (or a good) estimate. When developing an estimate, the estimator is producing a cost estimation package. This package consists of the estimate, the technical scope, and the schedule, all of which should be cross-referenced to ensure that they are consistent. This package establishes a baseline document for the project or program at its onset. This chapter focuses on the components (or elements) of the cost estimation package and their documentation. More detail about the components can be found in later chapters of this cost guide.

2. BEGINNING THE PACKAGE

When given the task to develop a cost estimation package, the estimator must first establish the following:

- a description of the purpose of the package (i.e. what type of estimate is required: planning, feasibility, Title I, Title II, etc.);
- a description of the technical scope; and
- a schedule or timeframe for the project.

Once these are established or developed by the estimator as an assumption, the preparation of the cost estimation package may begin.

If developing a revision to an existing package, the estimator must also obtain the complete cost estimation package from the previous estimate.

3. TECHNICAL SCOPE

The technical scope should include all requirements for the project or program. It should include the following information:

- detailed description of work to be performed;
- work not included in the scope;
- description of regulatory drivers;
- deliverables;
- any constraints or special conditions;
- sequence of events and any interdependencies;
- milestones;
- work breakdown structure (WBS); and
- code of accounts (COA).

The above items should be provided to the estimator by the program/project manager or the estimator may assist in their development.

4. COST ESTIMATE

Once the technical scope information is available, the estimator can start developing the estimate. As the estimate is developed, the estimator should keep well-organized worksheets and documentation. These would include the following.

- Definition of what is included in the total project cost (TPC) or the total cost of the program.

- Methodology of how the estimate was developed. This would include information such as any cost databases used, actual quotes, any cost estimating relationships (CERs) used, etc.

- Description of direct and indirect costs. Field distributable overhead should be in enough detail to describe what is included (e.g., site security, on-site trailers, health and safety, etc.).

- Explanation of site overhead rates.

- Definition of when start-up begins and ends and its associated costs.

- Operating costs if the estimate is a program estimate and includes operations as well as construction activities.

- Escalation since most estimated projects are estimated in the current year even though they are not built for several years.

- A written analysis of how contingency was developed.

- Any estimate history if this is a revision to an existing estimate or a change order estimate.

- The name, signature, and/or initials of the preparer and reviewer of the estimate.

5. SCHEDULE

The schedule can play an important role in the cost estimate package since it can help identify the basis for budget cycle timing, any premiums on long-lead items to ensure their timely delivery, and the basis for escalation. The schedule used or developed with the cost estimate should be documented and will become part of the cost estimation package.

6. DOCUMENTING THE COST ESTIMATION PACKAGE

A well-documented cost estimate package withstands scrutiny. If rigorous documentation and estimation procedures are followed, the credibility of the estimate increases. It is important to document all steps of the estimate process. The following items should be well documented and incorporated into the cost estimation package.

- The type and/or purpose of estimate being performed (i.e., Pre-Title I, etc.).

- A detailed description of the technical scope of work. It should define the performance specification and the work activities required, but it should also identify work not included, any constraints or special conditions, ground rules, assumptions, and regulatory drivers.

- All estimating backup, which includes quantity takeoffs, calculations, databases used, historical data, CERs, and actual quotes.

- Detail of indirect costs (field distributables) or a description of what is included and how they were estimated.

- Explanation of site overhead rates.

- If start-up is a part of the estimate, it should be defined and the methodology of its estimation should be included as well as any supporting documents.

- Basis of any operating costs with associated backup.

- Basis of escalation.

- Basis of contingency and how it was calculated.

- A schedule, which can be in the form of a list, a bar chart, or a network diagram.
- A resource loading report, if appropriate.
- A funding profile, or a spreadsheet showing the funding requirements by year in both constant year and escalated dollars.
- Details of how the WBS was developed and a correlating activity dictionary.
- Description of the COA.
- The reviewed estimate.

CHAPTER 3

STAGES OF PROJECT DEVELOPMENT

1. INTRODUCTION

Estimates are produced throughout the life of a project at various stages. It is important to understand the stages of project development in order to understand how they relate to the various estimates. Chapter 4 describes the various estimates and their relationship to each other as well as to the key decisions. All projects, whether they are conventional construction or Environmental Management (EM), evolve through a series of stages. Both types of projects originate with preliminary study and then follow a series of design stages. Finally, the design is implemented in the form of a finished product.

Regardless of the finished product, all projects will require management and support activities throughout the life of the project. Major differences between these two types of projects are observed in the study and design phases. EM projects tend to have more intricate study and design phases than those of conventional construction projects. Also, EM projects are unique in that each complete project is divided into two parts: assessment and cleanup. Each part of an EM project is comprised of a complete cycle of study, design, and implementation; hence, the cycle is completed twice for the completion of a single project, whereas the cycle is only completed once for construction projects. A comparison of activities involved in conventional construction and EM projects is provided in Table 3-1. Also included is Table 3-2, Comparison of EM Project Phases to conventional construction phases.

2. RELATIONSHIP OF STAGES OF DEVELOPMENT TO TYPES OF ESTIMATES

The development of a project occurs in three major stages: study, design, and implementation. As a project develops, more information and specifications are required,

TABLE 3-1

EM AND CONVENTIONAL CONSTRUCTION TERMINOLOGY CROSSWALK

	DOE ASSESSMENT AND CLEANUP PHASE TERMINOLOGY	4700.1 TERMINOLOGY CONVENTIONAL CONSTRUCTION
STUDY	Preliminary Assessment Inspection	Development Phase Conceptual Design Report
DESIGN	Characterization Evaluation of Cleanup Alternatives	Title I Title II
IMPLEMENT	Cleanup Action Compliance	Construction/Title III Operations

resulting in more estimates than were included in the previous stage. These estimates become a more accurate representation of the actual project cost. In the following, a description of conventional construction terminology will be discussed in relation to the project stages of development and their estimates.

A. Study Stage

The study stage consists of a development phase and a conceptual design report (CDR). Investigations and studies are conducted to compile the information that is essential for the design stage. Through these investigating processes, planning feasibility study estimates are derived for preliminary budget estimates of total project cost on the basis of any known research and development requirements. This preliminary phase establishes the scope, feasibility, need, and activities included in the CDRs, which results in a budget/conceptual design estimate, which is used to request congressional authorization for funding.

B. Design Stage

The design stage consists of the Title I and the Title II phases. The Title I (preliminary) design phase defines the project criteria in greater detail, permitting the design process to proceed with the development of alternate concepts and a Title I design summary. The approved Title I concept and the supporting documentation prepared for Title I form the basis of all activity in the definitive phase, Title II of project design. Title II incorporates all the restudy and redesign work, the final specifications and drawings for bids from contractors, and the construction cost estimator along with analyses of health and safety factors. Moreover, the coordination of all design elements and local and government agencies is also included.

The Title I and Title II phases are used to prepare the most accurate estimate possible prior to competitive bidding and construction. Title I estimates shall include all items referred in the CDR estimate basis. The Title II estimate uses the Title II design for its basis. The Title II estimate may be used for the government's estimate.

C. Implementation Stage

The implementation stage consists of construction, Title III, and operational phases. This is the time during which actual work and operations are performed. Current working estimates are required throughout the life of the project for cost control. These estimates reflect the most recent cost and data design available, the estimated cost to complete, the allowance for contingency, detailed contingency analysis, and the uncertainties remaining in the project.

D. EM and Conventional Construction Stages

The terminology of EM and conventional construction stages may differ, but the same basic structure of project development is evident as depicted in Table 3-1, which compares the stages of a project using DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM, terminology with one using EM terminology.

3. NATIONAL ENVIRONMENTAL POLICY ACT ACTIVITIES

The stages of project development will include a number of engineering and scientific studies that address design, technical, and regulatory issues. Environmental assessments (EAs) are conducted to meet the requirements of the National Environmental Policy Act (NEPA). The objective of an EA is to determine if a proposed action or project will have a significant impact on the environment, to assess that impact, and to identify alternatives.

In conventional construction, this step occurs in the Pre-Title I phase of project development. For EM projects, this step occurs in the latter part of the assessment phase.

A. Environmental Assessments

The objective of an EA is to determine if a proposed action will have a significant impact on the environment and to assess that impact. If an EA results in a finding of no significant impact (FONSI), a notice is published in the Federal Register to that effect. If there is a significant impact or if there are objections to the FONSI, an environmental impact statement (EIS) may be required. An EA can include the following elements of work.

1. Planning and coordination of the EA process, in which potential sources of data are identified and the scope of the proposed action is reviewed.

2. Inventory of natural, human, and cultural resources based on existing sources of information. Typical elements of the resource inventory include geology, hydrology, vegetation, wildlife, threatened and endangered species, air quality, land use (existing and planned), visual characteristics, socioeconomic character, and acoustic conditions. Cultural resources include archaeological sites, historical sites, sites with religious or social significance, and other structures or areas with cultural significance.

3. Impact assessment and mitigation planning, in which the proposed action is evaluated to determine the impact on the resources identified in the inventory. Appropriate mitigation measures are identified where it is possible to make adjustments in the proposed action that reduce or eliminate impacts.

4. Participating in agency reviews of the EA and responding to questions and comments.

5. Preparing an EA, including decision documents.

When the NEPA process is successfully concluded with an EA, other environmental permitting actions may follow, such as preparation of a prevention of significant deterioration (PSD) permit under the Clean Air Act. If a FONSI cannot be obtained, an EIS is required.

B. Environmental Impact Statements

EISs are prepared to meet the requirements of the NEPA whenever an EA does not result in a FONSI. The objective of an EIS is to evaluate any major federal action that is proposed that has the potential for significant environmental impact and to provide a forum for a public decision making process regarding the action. An EIS can include the following elements of work.

- EIS scoping in which the general technical approach is agreed upon and the public involvement program is initiated. Potential sources of data are identified and the scope of the proposed action, as well as any known alternatives, is reviewed.

- Inventorying natural, human, and cultural resources based on existing sources of information. Typical elements of the resource inventory include geology, hydrology, vegetation, wildlife, threatened and endangered species, air quality, land use (existing and planned), visual characteristics, socioeconomic character, and acoustic conditions. Cultural resources include archaeological sites, historical sites, sites with religious or social significance, and other sites with cultural significance.

- Impact assessment and mitigation planning, in which the proposed action is evaluated to determine the impact on the resources identified in the inventory. Appropriate mitigation measures are identified where it is possible to make adjustments in the proposed action that reduce or eliminate impacts. Alternatives to the proposed action, including "no action," are considered to evaluate the impact on the environment. The impact of the proposed action is compared to the impact of the other alternatives.

- Preparing a draft EIS and distributing that report to all interested parties including elected officials, citizen groups, and the public.

- Participating in agency reviews and public hearings regarding the draft EIS and responding to questions and comments.

- Preparing a final EIS including all comments and the responses to those comments.

- Preparing decision documents required for a record of decision (ROD).

When the NEPA process is successfully concluded with an EIS, other environmental actions may follow, such as permit preparation.

4. STUDY PHASE ACTIVITIES

Preliminary phase activities consist of studies and investigations. These studies and investigations must be conducted to gather the information that is necessary for the design phase.

A. Pre-Title I Activities

Pre-Title I activities are defined in a variety of DOE references as all activities taking place prior to the start of the preliminary design. This includes siting and related engineering studies conducted to establish project scope, feasibility, need, etc., as well as all activities that produce formal deliverables, such as CDRs. Pre-Title I activities shall be funded from the operating expense budget.

B. Assessment - Environmental Management

Assessment is the technical activity of an engineering, scientific, or regulatory nature that is required to establish scope, meet regulatory requirements, or evaluate alternatives for a task. This will include preliminary assessment/site inspection (PA/SI), facilities investigation/corrective measures study (FI/CMS), remedial investigation/feasibility study (RI/FS), and any other pre-cleanup design activities performed in support of a particular activity.

The environmental restoration program scope will include a large number of engineering and scientific studies, as well as activity and program management that address design, technical, and regulatory issues not encountered on conventional construction projects. These have been grouped into legal categories that establish the general requirements for each.

1. Comprehensive Environmental Response Compensation and Liability Act (CERCLA): Preliminary Assessment/Site Inspection

PA/SI is the first phase of work for sites being remediated under CERCLA and is comparable to the development phase of construction. The objective of this effort is to identify potential release sites for future study and to rank the hazard according to a U.S. Environmental Protection Agency (EPA) methodology called the Hazard Ranking System (HRS) from existing data and cursory inspection. PA/SI includes the following elements of work:

- review of existing data concerning past operating practices including waste disposal, operations involving potentially hazardous materials, and spills or similar incidents;
- review of existing data concerning the natural setting, such as geology, hydrogeology, surface water, flora, and fauna;
- analysis of existing data to assess completeness and determine if there is a need for sampling;
- site visit to confirm site location and relationships with major features;
- limited sampling and analysis where warranted;

- evaluation of the hazard posed using the HRS; and

- preparation of a PA/SI report.

2. Resource Conservation and Recovery Act (RCRA): Facility Assessment

A RCRA facility assessment (RFA) is the first step undertaken at a suspected hazardous waste site that is regulated under RCRA and is comparable to the development phase of construction. The objective is to review operations and identify potential sources of release for further investigation. An RFA can include the following elements of work:

- develop an facility assessment (FA) workplan, submit the plan to regulatory agencies for comments, and incorporate comments;

- review historical data concerning present and past operations including any known spills or other unusual events;

- identify all solid waste management units (SWMUs) on the site;

- conduct technical investigations necessary for the identification of a potential for an occurring or past release (POPR);

- prepare a POPR report; and

- identify the need for interim corrective measures to contain or eliminate sources of continuing releases.

5. DESIGN ACTIVITIES

Following the preliminary phase activities are the design activities. The basic stages of design activities are discussed below.

A. Conventional Construction

Design activities for conventional construction projects are divided into two categories: Title I design and Title II design.

1. Title I (Preliminary) Design

Title I is the preliminary stage of project design. In this phase, the design criteria are defined in greater detail to permit the design process to proceed with the development of alternate concepts and a Title I design summary, if required.

As detailed in DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM, Title I includes the following elements of work:

- design studies, including alternate design approaches, energy conservation evaluations, and analysis or review of health, safety, and environmental aspects of the project;

- review of the project design criteria to develop greater detail and to incorporate any design modifications that may result from engineering studies conducted in Title I;

- preliminary design drawings showing the proposed design and any alternates in sufficient detail to establish the design features of each approach and to permit a preliminary estimate to be made of the construction cost;

- outline specifications for construction and specifications for equipment procurement; identification of long lead time items for advance procurement;

- preliminary safety analysis report (PSAR) if not included in the CDR;

- preliminary cost estimate based on the approved design and other such estimates as required to support the evaluation of alternate designs prepared during preliminary design (Title I);

- preliminary project schedule based upon information available during preliminary design (Title I).

Title I activities are funded from the Plant and Capital Equipment (PACE) Fund (engineering, design, and inspection (ED&I)).

2. Title II (Detailed) Design

Title II is the definitive stage of project design. The approved Title I concept and the supporting documentation prepared for Title I form the basis of all activity in Title II. As detailed in DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM, Title II design includes the following elements of work:

- restudy and redesign work required to incorporate changes from the design prepared in Title I;

- final drawings, specifications, and test plans, suitable for soliciting bids from contractors;

- construction cost estimates;

- analyses of health, safety, environmental, and other project factors that may impact the project, as directed by the contracting officer;

- coordination of all design elements with other project features, such as utilities, government-furnished equipment, and portions of the project or related projects being designed by others; and

- attendance at all meetings scheduled for design review or coordination with the DOE, the management and operating (M&O) contractor, and local agencies, such as public utilities.

Title II activities are funded from the PACE Fund (ED&I).

B. Environmental Management

1. CERCLA: Remedial Investigation/Feasibility Study

RI/FS is the investigation phase of assessment under CERCLA and is comparable to the CDR phase of construction. During remedial investigation (RI), quantitative methods of cleanup are developed and compared, and a preferred method is selected for implementation. RI/FS ends when a ROD is reached.

Remedial investigation can include the following elements of work:

- review of information collected in the PA/SI and applicable regulations;

- development of an RI/FS work plan, including a sampling and analysis plan, a quality assurance project plan, and a health and safety work plan;

- field sampling and laboratory analysis;

- evaluation of data from field sampling and data analysis;

- preparation of risk assessment reports including identification of source terms, identification and analysis of pathways and exposure scenarios, identification of receptors, and toxicological assessment.

The feasibility study (FS) can include the following elements of work:

- screening of cleanup technologies for suitability;

- screening of process options for cleanup considering waste character, site conditions, regulatory considerations, and other factors;

- conducting an endangerment assessment;

- developing and evaluating alternatives for cleanup, including preparation of conceptual designs, schedules, and feasibility estimates;

- conducting treatability studies to establish the effectiveness of selected treatment alternatives;

- preparing a feasibility study report (FSR) presenting the results of the FS, including the results of cleanup technology screening, process options evaluation, alternative evaluation, regulatory review, and treatability studies;

- responding to comments from regulatory agencies and the public;

- preparing a ROD.

2. RCRA Facility Investigation/Corrective Measures Study

A facility investigation under RCRA is comparable to a remedial investigation under CERCLA and the CDR phase of construction. The objective of this effort is to characterize the natural environment, the nature of any hazardous materials that may be present, and identify technologies that will be needed to implement corrective measures. A RCRA facility investigation (FI) can include the following elements.

- Development of an FI workplan, submittal of the plan to regulatory agencies for comments, and incorporation of subsequent comments. The work plan typically includes such elements as data management, health and safety, and project management.

- Field investigation, analysis, and research needed to develop a complete description of the regional setting including climatic conditions.

- Field investigation, sampling, modeling, and analysis required to characterize the extent of any release of hazardous material that may have occurred.

- Field investigation, sampling, modeling, and analysis required to describe the site hydrogeology, geology, soil conditions, and surface water hydrology.

- Performance of a health risk analysis, including quantification of source terms, identification and evaluation of pathways, identification of receptors, and toxicological evaluation of dose response relationships for the affected populations.

- Development of a community relations program and implementation of elements of that plan consistent with plan requirements for the FI.

- Identification of potential technologies to be employed in corrective measures.

A CMS develops and evaluates alternatives for corrective measure implementation. A CMS can include the following elements of work:

- develop a CMS workplan, including submittal of that workplan to regulatory agencies for review, comment, and incorporation of subsequent comments;

- screen cleanup technologies for suitability;

- screen process options for cleanup considering waste characteristics, site conditions, regulatory requirements, and other factors;

- develop and evaluate alternatives for cleanup, including preparation of conceptual designs, schedules, and feasibility estimates;

- conduct treatability studies to establish the effectiveness of selected treatment alternatives;

- prepare a CMS report presenting the results of the cleanup technology screening, process options evaluation, alternative evaluation, regulatory review, and treatability studies;

- respond to comments from regulatory agencies and public comments; and

- prepare a consent order or permit modification.

C. Cleanup

Engineering design for the cleanup will be performed on the basis of the method identified in the ROD (CERCLA) or permit (RCRA). The activities that encompass cleanup design are preliminary design, detailed design, and engineering during construction. The initial phase of cleanup design is referred to as preliminary design because engineering alternatives are being developed and evaluated. In some cases, this phase may be shortened or eliminated entirely if no alternatives can be identified within the scope of the ROD or permit. The second phase of cleanup design is definitive design, in which a single alternative is carried to completion.

6. IMPLEMENTATION OF DESIGN

Once design activities are complete, the next stage is implementation of design.

A. Conventional Construction

Implementation of design for conventional construction projects is simply the building of the facility. Construction activities are funded from the PACE Fund (construction).

B. Environmental Management

The implementation of assessments follows the completion of the first cycle of stages of an EM project and the beginning of the next cycle of stages (i.e., the cleanup part of the EM project). At this point in the project's life, the cycle begins again for cleanup.

C. Cleanup

Engineering design for the cleanup will be performed on the basis of the method identified in the ROD (CERCLA) or permit (RCRA). The activities that encompass cleanup design are preliminary design, detailed design, and engineering during construction. The initial phase of cleanup design is referred to as preliminary design because engineering alternatives are being developed and evaluated. In some cases, this phase may be shortened or eliminated entirely if no alternatives can be identified within the scope of the ROD or permit. The second phase of cleanup design is definitive design, in which a single alternative is carried to completion.

All equipment, labor, and materials required to install a remedy are considered part of cleanup construction. Construction can consist of the following activities:

- site modifications (e.g., installation of containment systems, excavation of contaminated and uncontaminated materials, site preparation for installation of equipment);

- demolition of existing structures;

- installation of equipment (e.g., construction of pumping systems; construction required for installation of treatment systems; installation of testing and monitoring equipment); and

- surface controls (e.g., erosion control, site restoration).

7. PROJECT SUPPORT ACTIVITIES

Throughout the life of a project, various support activities are required to ensure successful completion of the project. These activities are discussed below.

A. Project Management

Project management covers those services provided to the DOE on a specific project, beginning at the start of design and continuing through the completion of construction, for planning, organizing, directing, controlling, and reporting on the status of the project. They are as follows:

- technical management and liaison with the designers, architect/engineers (A/Es) management, and M&O contractors during Title I, II, and III design;
- coordination, including interface control during design and construction;
- maintenance and operation of scheduling, estimating, and project control systems during design and construction;
- technical management and coordination of the construction manager and his support staff;
- overall management and coordination of the activities of non-dedicated project support personnel;
- technical management of review and approval activities conducted by dedicated management personnel;
- coordination of all aspects of the project; and
- preparation, revision, and related activities in support of the final safety analysis report.

Project management activities are funded from the PACE Fund (ED&I).

TABLE 3-2

COMPARISON OF EM PROJECT PHASES

DOE ASSESSMENT AND CLEANUP PHASE TERMINOLOGY	RCRA TERMINOLOGY ACTIVE FACILITIES	CERCLA TERMINOLOGY SUPERFUND/ INACTIVE FACILITIES	DECOMMISSIONING & DECONTAMINATION TERMINOLOGY RADIOACTIVE/ INACTIVE FACILITIES
Preliminary Assessment	RCRA Facility Assessment	Preliminary Assessment	Included in Characterization
Inspection	Included as a part of RCRA Facility Assessment	Site Inspection	Included in Characterization
Characterization	RCRA Facility Investigation	Remedial Investigation	Characterization
Evaluation of Cleanup Alternatives	RCRA Corrective Measures Study	Feasibility Study ROD	NEPA Environmental Review ROD or FONSI
	NEPA Environmental Review	NEPA Environmental Review	
Cleanup Action	RCRA Corrective Measures Implementation (CMI)	Remedial Design Remedial Action	Engineering and Operation
Compliance	Postclosure Monitoring	Operation and Maintenance	Postdecommissioning

B. Construction Management

Construction management (CM) covers those services provided by the organization responsible for management of the construction effort during Title I and Title II design and continuing through the completion of construction. CM services are further defined in DOE Order 4700.1. Typically, CM includes—

- reviewing and approving construction packages;
- reviewing and acceptance of construction test procedures;
- control of field design change requests; and
- supporting the construction contractor by furnishing general condition items not provided in the bid package, such as security, temporary facilities, debris removal, and other similar project requirements not included in the bid package.

All costs associated with CM shall be charged against PACE Fund (Construction).

C. Construction Management for Environmental Management Projects

CM includes those activity management services required to manage construction or cleanup activities, including review and approval, cleanup bid package review and acceptance of construction test procedures, control of field design change requests, and review and approval of contractor pay requests. The construction manager provides items and services not included in the construction contractor's bid package, such as debris removal, temporary facilities, site security, and storage.

All of the above functions (program management, program support, activity management, and CM) will be charged directly to the Environmental Restoration Program to the extent allowed by DOE policy. When M&O contractors are providing program or activity management services, only those services will be charged to EM that are incremental and not covered under the operating contract, as required by DOE Order 2200.6, FINANCIAL ACCOUNTING.

Activity support services, which consist of activities performed by the M&O contractor for internal management and technical support of activities or programs but are within the scope of the operating contract, are not chargeable to the program. Examples of activity support services include establishment and maintenance of site programs for health, safety, quality assurance, legal affairs, training, and security.

Cost methods development (CMD) identifies several common elements applicable to EM that form the basis of allowance costs for project and program management.

- Construction management cost is rolled up into project management cost.

- Project management functions should be provided by full-time personnel to the greatest extent possible. This does not preclude the use of a matrix organization; however, DOE policy clearly prefers the use of full-time personnel assigned to the project wherever possible.

D. Project Support

Support covers those activities performed by the M&O contractor for internal management and technical support of the project manager (PM), including—

- document control;

- auditing of compliance with quality assurance, health physics, safety, and environmental requirements; and

- design review by non-dedicated M&O contractor personnel on an as-needed basis including: independent technical analysis, constructability review, life cycle cost comparisons, life safety review, health physics review, and code checks.

Project support is funded from the M&O contractor's expense budget.

E. Startup

Startup covers one-time costs incurred by the M&O contractor during the transition period between the completion of construction and operation of the facility. This includes the following activities:

- operations planning, operator training, and operational readiness review;

- startup coordination, post-acceptance testing, startup chemicals, and related supplies; and

- salaries of startup personnel.

Startup activities are funded from the Operating Expense Fund.

F. Construction Engineering

This phase of the activity begins when bid packages are assembled following detailed design and consists of engineering services during construction, including both office support and field services. The following elements of work are included under office support:

- review of all vendor drawings and submittals for conformance with the approved design drawings and specifications;

- review and evaluation of all proposed deviations for the original Detailed Design for conformance with regulatory requirements, codes, and standards;

- incorporation of all approved as-built record drawings for delivery to the activity manager; collection and maintenance of all construction related records;

- preparation of cost estimates to establish reasonable amounts of increase or decrease in contract price or schedule caused by design or procedure changes; evaluate proposals submitted by the cleanup contractor for reasonableness from the perspective of cost and schedule, and make recommendations to the activity manager;

- expedition of the procurement of material and equipment from suppliers, vendors, or fabricators;

- audits of vendors, suppliers, and subcontractors as required by the quality assurance program plan; and

- additional technical service, such as evaluation of site monitoring data, update of risk analyses, review of regulatory correspondence, participation at public meetings, and other similar activities.

The following elements of work are included under field services:

- furnishing and maintaining governing lines and benchmarks to prime horizontal and vertical controls to which construction may be referred;

- inspecting the construction contractor’s workmanship, materials, and equipment and reporting on their conformance or nonconformance with the approved drawings and specifications;

- making or procuring such field or laboratory tests as are necessary to ensure that construction materials and practices are in accordance with the approved drawings and specifications;

- marking up field copies of the design drawings and specifications to show the as-built condition for submittal to the designer for incorporation into the as-built record drawings;

- providing input to construction progress reports as required; and

- verifying that planned quality control measures are implemented and evaluating the results of those measures to ensure that the work is being completed in accordance with the approved plans and specifications.

G. Program Management

Program management includes those services provided to the DOE on a specific program for planning, organizing, directing, controlling, budgeting, and reporting on the program. Program management will be provided as multiple levels within the EM program, including the Headquarters, operations office, and installation. Program management includes program support.

H. Program Support

Program support covers those activities performed for internal management and technical support of the program by part-time or full-time personnel. The following activities are illustrative of services included in this category:

- program document control;
- development of program plans and auditing of activity level functions for compliance with programmatic quality assurance, health physics, safety, environmental, and related requirements;
- design review or technical oversight of activity level functions by including independent technical analysis, constructability review, life cycle cost comparisons, life safety review, health physics review, and code checks;
- program level reporting, budgeting, and planning; and
- purchasing, contracting, and other functions required to obtain the services of outside contractors.

I. Activity Management

Activity management services are those provided to the EM Program on a specific activity beginning at the start of assessment and continuing through the completion of the cleanup. Activity management includes those services required to plan, organize, direct, control, and report on the activity. The cost of construction management is rolled up into activity management. The following functions are illustrative of services included in activity management:

- technical management and liaison with the designers during cleanup design;
- coordination, including interface control, during design and construction;

- maintenance and operation of scheduling, estimating, and activity control systems during design and cleanup;
- technical management and coordination of the construction management staff;
- overall management and coordination of the activities of non-dedicated activity support personnel;
- technical management of review and approval activities conducted by dedicated management personnel;
- coordination of all aspects of the activity; and
- preparation of activity plans, activity management plans, and quality assurance project plans.

J. Environmental Restoration Management Contractor

An environmental restoration management contractor (ERMC) is a contractor that manages and executes the Environmental Restoration Program at a particular site. The ERMC includes the prime contractor and any named member(s) of the ERMC team of subcontractors considered essential to the accomplishment of the work.

CHAPTER 4

TYPES OF COST ESTIMATES

1. INTRODUCTION

All projects, both construction and environmental restoration, require cost estimates to plan and budget the project efficiently. Numerous estimates are often prepared sequentially for a given project as the project matures, and the level of information and detail available to the estimator increases.

This chapter will describe the estimates required on government-managed projects for both general construction and environmental management. The various estimates required for each type of project will be described, including what comprises these estimates and the time frame in the project's life at which they are required. Guidelines for these designs and estimates will be in accordance with the DOE Order 5700.2, COST ESTIMATING, ANALYSIS AND STANDARDIZATION, and DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM. Table 4-1 summarizes these estimates and indicates the Degree of Accuracy associated with each.

2. CONSTRUCTION ESTIMATES

For construction project development and control, there are four basic types of cost estimates that are developed and used by DOE and its contractors. These estimates are planning/feasibility study estimates, budget or conceptual design estimates, Title I design estimates, and Title II design estimates. Each type of estimate has a separate purpose, basis, and design scheme. These traits are described in this section. The level of accuracy and confidence in the estimate are based on the type and detail of the estimate.

The American Association of Cost Engineers defines accuracy as "the degree of conformity of a measured or calculated value to some recognized standard or specified value." Accuracy depends on the amount of quality information available as well as the judgment and experience of the estimator. Consequently, as the amount of information and specific details increase, so does the degree of accuracy.

A. Planning/Feasibility Study Estimate

1. Purpose

Planning/feasibility study estimates are normally prepared by the operating contractor for a proposed project prior to completing conceptual design. Planning estimates are used for scoping studies and for preliminary budget estimates of TPCs and shall be reflected on short form project data sheets for identified projects. The short form project data sheet includes an estimate of funds required and a schedule for the performance of conceptual design on each project. These short form project data sheets are submitted to the appropriate DOE Headquarters program office for review and advisement on which projects will be supported in the budget requests. Planning/feasibility study estimates should support Key Decision 0.

2. Basis

The basis for the planning estimate must describe the purpose of the project, general design criteria, significant features and components, proposed methods of accomplishment, proposed construction schedule, and any known research and development requirements. Any assumptions made by the estimator in this phase shall be documented for review and concurrence. Planning estimates are based on past cost experience with similar type facilities, where available, and order of magnitude estimates in the absence of previous cost experience. Engineering costs in this type of estimate generally are based on a percentage of estimated construction costs, and consideration will be given to the complexity of the project in establishing the percentage to be used. Similarly, an allowance for contingency will be included in the total project estimate using a percentage of total engineering and construction costs established on the basis of complexity and uncertainties of the component parts of the project.

3. Design Scheme

a. Requirements: Sufficient criteria must be provided to enable the estimator to prepare a planning estimate. This criteria can range from a description of the functional/operational requirements of the project to a brief description of the completed project's intended objective. The description may be supplemented with a sketch, a tour of the proposed project site, or references to similar projects that are already existing.

b. Guidelines: A planning estimate is an order of magnitude estimate; it can be estimated on a per square foot, linear foot, cubic yard, kilowatt, etc., basis. The estimator shall get all available information about the project from the requestor. On many projects, the available data will be minimal and only an allowance can be made for various segments of the estimate. It is imperative that the estimator fully describe the basis of the estimate, how the estimate was prepared, and any items specifically excluded from the estimate.

c. Degree of Accuracy: Because this estimate is an order of magnitude estimate, the degree of accuracy is generally plus or minus 40 percent. This range could be wider if the design criteria are not well defined.

B. Budget or Conceptual Design Estimates

1. Purpose

A budget/conceptual design estimate is required to request congressional authorization for funding. This request is required for each line item construction project and each contingency-type project. The fundamental purposes of a budget or conceptual design estimate are:

- to ensure project feasibility and attainable performance levels;
- to develop a reliable project cost estimate consistent with realistic schedules;
- to use it to establish baseline project definitions, schedules, and costs; and
- to support Key Decision 1.

The completed conceptual design estimate normally serves as the basis for preparation of a construction project data sheet. This form is submitted to DOE Headquarters for review and, if approved, the project is included in the budget submitted to the Office of Management and Budget (OMB). If the project is approved at this level, it is included in the President's budget submittal to the Congress. When the project is approved by the Congress and funds are appropriated, OMB apportions the funds to DOE Headquarters which, in turn, issues a financial plan to the DOE Field Office providing funds for the project. Work on the project is initiated at this time.

2. Basis

The basis for a budget or conceptual design estimate shall include as many of the detailed requirements in the CDR as possible. This CDR shall include all general criteria and design parameters, applicable codes and standards, quality assurance requirements, space allocations for required functions, types of construction, significant features and components, building and facility utility services, energy conservation goals, site work, process equipment requirements, project cost estimates, schedules, methods of performance, environmental protection requirements, waste minimization requirements, decontamination and decommissioning requirements, health and safety requirements, related research and development or test programs, comprehensive project planning, and any other special requirements for the project.

3. Design Scheme

a. Requirements: The conceptual design sketches and specifications, as well as the functional/operational requirements, shall be available to the estimator prior to developing the budget/conceptual design estimate. Where possible, this information shall be supplemented with a tour of the proposed site. Site drawings can be used as a reference for details of construction and for quantity take-off. These reference drawings are very helpful when estimating demolition costs.

b. Guidelines: The request for funding is based on the budget/conceptual design estimate. The estimate shall incorporate all details available as well as a detailed breakdown of any allowances used. The estimator must fully document the basis of the estimate, including sources of quotations, assumptions, and any items specifically omitted.

c. Degree of Accuracy: The degree of accuracy is plus or minus 30 percent for budget/conceptual design estimates.

C. Title I Design Estimate

1. Purpose

The Title I design estimate is an intermediate estimate used to verify that the Title I design details still remain within the project funding. The Title I design details are written in the Title I design phase; this is the initial work accomplished under an approved project. Estimates of this type are completed in conjunction with the Title I preliminary design phase. These Title I design estimates should support Key Decision 2.

2. Basis

The basis for the Title I estimates shall include all items mentioned in the CDR estimate basis, plus all the refinements developed during the course of producing the Title I engineering package. This includes all drawings, outline specifications, data sheets, bills of material, schedule refinements, definitions of scope, methods of performance, and changes in codes, standards, and specifications.

3. Design Scheme

a. Requirements: Title I estimates are based on the Title I drawings and specifications. In addition to the Title I drawings and specifications, the estimator shall have access to the budget/conceptual design estimate and the project's final functional/operational requirements. A tour of the site and reference drawings of the construction site shall be used in preparing the estimate. Criteria to be followed in the performance of Title I design are based upon the conceptual design for the project. In Title I, the design criteria are defined in greater detail, and, if necessary, the conceptual design drawings are expanded with more detailed information including additional drawings. Also, further refined descriptive information and more detailed specifications are developed, as required, to serve as a firm basis to proceed with Title II definitive design.

b. Guidelines: The Title I estimate is an estimate of construction cost. At this point in a project, the engineering design, inspection, and project administration costs have been allocated and only need to be verified. A Title I estimate will have more detail available than a conceptual estimate and this additional detail shall be shown.

c. Degree of Accuracy: Due to the increased accuracy of the detailed drawings and information developed during the course of Title I design, the Title I estimate and the schedules developed from the estimate are more accurate than those previously developed. The degree of accuracy range is plus or minus 20 percent.

D. Title II Design Estimates

1. Purpose

The purpose of the Title II estimate is to estimate construction costs as accurately as possible, prior to the commencement of competitive bidding and construction activities. As Title II design specifications and drawings are developed, the Title II estimate is completed. The completed Title II estimate is in support of Key Decision 3.

2. Basis

The basis for the Title II cost estimate must include all the approved engineering data, methods of performance, final project definition and parameters, project schedule, and final exact detailed requirements. This will include a complete list of all engineering data used (i.e., drawing data sheets, specifications, bills of material, job instructions, proposed schedules, etc.) Since the Title II definitive design results in working drawings and specifications for construction work, including procurement and shop fabrication, the Title II estimates are prepared in accordance with the approved Title II drawings and specifications.

3. Design Scheme

a. Requirements: The Title II estimate is based on the Title II drawings and specifications. This estimate shall approximate the construction bids that will be received for this project and may be used as the independent government estimate. The estimator shall have the Title II drawings and specifications for the Title II estimate, the functional/operational requirements, and the tentative construction schedule before generating the Title II estimate. A project site tour shall be made if the estimator is not completely familiar with the construction area.

b. Guidelines: The Title II Estimate is a refinement of the Title I estimate. Allowances shall only be used on minor items whose total is an insignificant portion of the total cost. Engineering design, inspection, and project administration costs only need verification at this point.

c. Degree of Accuracy: The degree of accuracy is plus 15 percent to minus 5 percent.

3. ENVIRONMENTAL RESTORATION ESTIMATES

Unlike construction capital projects that have well established points at which cost estimates are generated, there is little agreement in the environmental community on the types and time frame of environmental restoration estimates. In this document, the environmental restoration project will be discussed using the terminology and phase divisions found in CERCLA, Superfund Amendments and Reauthorization Act of 1986 (SARA), and RCRA programs.

Environmental restoration projects can be divided into two distinct phases, the assessment phase and the cleanup phase. Estimates for both phases have different purposes, bases, code of accounts, and degrees of accuracy.

A. Assessment Phase

In the assessment phase of an environmental restoration project, information is gathered on the types and amount of contamination involved at a project site. All sampling is completed and a list of environmental restoration options is developed. The assessment phase concludes with a final decision on the remediation alternative to be implemented on site. In the assessment phase there are three types of estimates: the planning estimate, the preliminary estimate, and the detailed estimate.

1. Planning Estimate

a. Purpose: The planning estimate assists in the preliminary planning and budgeting of the project. This estimate is normally requested for use in Environmental Restoration and Waste Management 5-Year Plans.

b. Basis: The basis for the planning estimate is very limited because there is a large amount of unknown and/or highly uncertain information. Only the location of the work, likely contamination, and prior use of the land may be known. Due to the limited information available, analogies, simple cost estimating relationships, and more sophisticated parametric tools are utilized for the estimate.

c. Degree of Accuracy: The degree of accuracy for the planning estimate is minus 50 percent to plus 100 percent.

2. Preliminary Estimate

a. Purpose: A more detailed estimate can be completed after some basic information is available from a preliminary assessment or site inspection. preliminary estimates are used as a budgetary tool and are included in the Environmental Restoration and Waste Management's 5-Year Plan.

b. Basis: This estimate is developed after the preliminary assessment is completed. The estimate is more detailed. Unit cost is applied at this point to some project categories in the assessment phase, such as laboratory analysis and monitor well drilling.

c. Degree of Accuracy: The degree of accuracy for the preliminary estimate is minus 30 percent to plus 70 percent.

3. Detailed Estimate

a. Purpose: Detailed estimates are used to decide between the alternatives for remediating a site. There are numerous detailed estimates, one for each remediation alternative. The detailed estimates are the final estimates of the assessment phase.

b. Basis: The basis of the detailed estimate includes all information gathered during the assessment phase.

c. Degree of Accuracy: The degree of accuracy for the detailed estimate is plus or minus 25 percent.

B. Cleanup Phase

After the remediation alternative is selected, estimates are required during the cleanup phase of the project. There are four basic cleanup estimates: planning estimates, feasibility estimates, preliminary estimates, and detailed estimates.

1. Planning Estimate

a. Purpose: The planning estimate is required for budgetary purposes or for inclusion in planning documents. This estimate is included in the Environmental Restoration and Waste Management 5-Year Plan, and is the basis for the funds represented in the activity data sheets (ADSs).

b. Basis: Minimal design information is available; therefore, use of historical cost data is helpful. All information gathered during the assessment phase is used in the computation of this estimate.

c. Degree of Accuracy: The degree of accuracy for the planning estimate is minus 50 percent to plus 100 percent.

2. Feasibility Estimate

a. Purpose: Feasibility estimates are used to evaluate the numerous technical solutions developed to remediate a site. These estimates perform two functions: one, they present a total estimated cost on each alternative on the basis of the best information available, and two, they provide a logical, traceable framework for comparing alternatives with each other.

b. Basis: Use lowest level of detail possible and takeoffs from available drawings. When sufficient detail is not available, historical data may be used.

c. Degree of Accuracy: The degree of accuracy for the feasibility estimate is minus 30 percent to plus 80 percent.

3. Preliminary Estimate

a. Purpose: After a remediation alternative is selected, a more detailed cost estimate is developed. This estimate shall be in sufficient detail so it can be used as one of the project control tools.

b. Basis: This estimate shall show all costs incurred to date. All future estimated costs, such as equipment costs, vendor pricing, or materials pricing, shall be as accurate as possible.

c. Degree of Accuracy: The degree of accuracy for preliminary estimates is minus 30 percent to plus 60 percent.

4. Detailed Estimates

a. Purpose: This estimate is used to verify the contractor's figures in both lump sum and negotiated fee projects.

b. Basis: The basis of the final detailed estimate for an environmental restoration project includes the final approved drawings, specifications, calculations, schedule, and anticipated method of accomplishment of the project goals. This estimate shall be performed as an independent contractor would perform the estimate for bidding purposes. All cost figures shall be escalated to the midpoint of each activity. All major equipment required for the project shall be outlined and priced, and escalation rates shall be established to arrive at a total dollar figure.

c. Degree of Accuracy: The degree of accuracy for detailed estimates is minus 10 percent to plus 25 percent.

4. OTHER ESTIMATES

Once actual work commences on either construction or EM projects, revised estimates may be required when changes in the work are discovered or unknowns are identified. A revised estimate may also be generated when schedule changes affect escalation calculation.

A. Government Estimate

1. Government estimates, sometimes called engineer's estimates, are used to determine the reasonableness of competitive bids received in connection with construction contracts and serve as a control in evaluating cost estimates prepared by a prime construction contractor. In construction, the Title II design estimate is prepared by the designer. After the Title II estimate is reviewed and approved by the government, it is the basis for the government estimate. The detailed cleanup estimate is used in EM projects.

2. The services of an M&O contractor, construction contractor (with respect to subcontracts), or construction manager may be used as appropriate to prepare, review, or revise the government estimate prior to government approval. 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 contracts as delineated below.

a. Architect-Engineer and Construction Contracts

Government estimates shall be prepared for all construction and architect-engineer contracts, except for contracts less than $25,000. Such estimates may be revised when inaccuracies or inconsistencies are revealed during negotiations.

b. Fixed-Price Construction Contracts

1. Government estimates for fixed-price construction contracts and modifications thereto shall be based on approved Title II working drawings and specifications. These estimates shall be prepared in accordance with the practices of the construction industry and in the same careful manner as if the government were bidding in competition with private contractors.

2. Government estimates shall be summarized to conform with bid items but shall include the following items as backup listed separately:

   - separate estimates for alternates set forth in the bidding documents;

   - a breakdown indicating quantities and unit costs for labor, materials, and equipment entering into the work;

   - estimates for mobilization, demobilization, etc.; and

   - allowance for contractor's overhead and profit, including the cost of such items as sales tax, insurance, and bonds.

3. Government estimates shall be prepared independently in advance of any bid or solicited proposal submitted by a prospective contractor or subcontractor.

4. Prior to opening of bids, access to or disclosure of information concerning government estimates shall be limited to personnel requiring such information in performance of their duties.

5. Government estimates for formally advertised or competitive proposal fixed-price construction contracts shall not be changed after the opening of bids or proposals except where careful reexamination indicates a definite typing or arithmetic error. In the event an estimate is changed under such circumstances, detailed reasons for the revision shall be documented.

B. Estimates for Minor Projects

The preparation of government estimates in connection with work estimated to cost less than $10,000 is optional with the field organization manager. Where the field organization manager elects to use a contractor's estimate, bid, or proposal instead of a government estimate under this limitation, the contractor's estimate shall be carefully evaluated to verify that it is fair and reasonable. The basis used to make adjustments or refinements shall be listed and made a part of the project file. Estimates shall be performed in the same manner as Title II estimates.

C. Current Working Estimates

Current working estimates are required for cost control on construction projects and are conducted periodically throughout the life of the project from the completion of conceptual design until final completion of construction. It is necessary that working estimates be kept under constant review to ensure that they reflect the latest cost and design data available, the estimated cost to complete, the allowance for contingency, detailed contingency analysis, and the uncertainties remaining under the project.

D. Independent Cost Estimate

An independent cost estimate (ICE) is 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 ICE is performed by the Office of Infrastructure Acquisition (FM-50), Office of the Associate Deputy Secretary for Field Management, in support of key decisions by the Under Secretary. Other check estimates may be initiated by an Assistant Secretary, program manager, project manager, or some other program advocate as an "independent" assessment of the project estimate, but they shall be labeled as a program office check estimate.

The basis for an ICE shall be the identical parameters used to formulate the estimate it will be compared with.

The basis for these cost estimates must carefully define the purpose and scope of the estimate, along with a complete list of all the considerations used to develop the estimate for costs experienced to date and data used to complete the projections.

E. Bilateral (Two-Party) Estimate

This estimate is prepared concurrently by two parties who have mutual responsibility or interest in the total cost. For example, when a site changes operations from production to decontamination and decommissioning (D&D), a budget estimate for the shutdown and D&D must be completed. When this transfer of operations involves two programs or agencies, both interested parties will work together to develop the estimate. An FM-50 ICE could also be performed on this type of estimate.

F. Performance versus Forecast

Performance versus forecast estimates are usually produced for long-term projects (i.e., a project life of 5 or more years). These estimates can be completed for the whole project or a portion of a project. The performance versus forecast estimate looks at the project costs in two divisions: what the costs are to date, and what the forecast costs are to complete the project. The costs to date can be compared against what was expected (performance). The estimated forecast costs may need to be adjusted based on the performance of the project. For example, if actual excavation costs are higher than the original estimate, the soil may have been rockier than originally expected. This slows productivity. This new productivity factor should be used in the forecast amount. The actual and forecast values will give you the total project costs.

TABLE 4-1

DEGREES OF ACCURACY

TYPE	PURPOSES	ACCURACY RANGE
Conventional Construction		
Planning/Feasibility or Order of Magnitude Estimate (Proposal)	1. Scoping Studies. 2. Preliminary budget estimates of Total Project Cost. 3. Support Key Decision 0.	± 40%
Budget/Conceptual Design Estimate (Equipment Factored)	1. Ensure project feasibility. 2. Develop reliable project cost estimate. 3. Establish baseline project definitions, schedules, and costs. 4. Support Key Decision 1. (Design 10% to 15% Complete)	± 30%
Title I Estimate	1. Verify that Title I design details still remain within the project funding. 2. Support Key Decision 2. (Design 25% to 35% complete)	± 20%
Title II or Definitive Estimate (Detailed)	1. Estimate construction costs as accurately as possible, prior to the commencement of competitive bidding and construction activities. 2. Support Key Decision 3. (Design 60% to 100% Complete)	- 5% to + 15%
Construction Estimate	1. Estimate is based on bid information. (Design 100% complete)	- 5% to + 10%

TABLE 4-1

DEGREES OF ACCURACY

TYPE	PURPOSES	ACCURACY RANGE
Environmental Restoration - Assessment Phase		
Planning Estimate	Assist in the preliminary planning and budgeting of a project. (usually requested for use in EM 5-Year Plans)	- 50% to + 100%
Preliminary Estimate	Used as a budgetary tool and is included in the EM 5-Year Plan.	- 30% to + 70%
Detailed Estimate	Used to decide between the alternatives for remediating a site.	- 25% to + 55%
Environmental Restoration - Cleanup Phase		
Planning Estimate	1. Assist in preliminary planning and budgeting of the cleanup. 2. Required for budgetary purposes for inclusion in planning documents. 3. Included in the EM 5-Year Plan. 4. Basis for funds represented in the ADSs.	- 50% to + 100%
Feasibility Estimate	Used to evaluate the numerous technical solutions developed to remediate a site.	- 30% to + 80%
Preliminary Estimates	A more detailed cost estimate that is developed after a remediation alternative is selected.	- 30% to + 60%
Detailed Estimate	Used to verify the contractor's figures in both lump sum and negotiated fee projects.	- 10% to + 25%

CHAPTER 5

COST CODES AND THE WORK BREAKDOWN STRUCTURE

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1. INTRODUCTION

This chapter will discuss the purpose of the work breakdown structure (WBS) and code of account (COA) cost code system, show the purpose and fundamental structure of both the WBS and the cost code system, and explain the interface between the two systems. For further information, see DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM.

2. DEFINITIONS

A. Work Breakdown Structure

A WBS is the result of project/program planning that establishes the physical work packages or elements and the activities within those packages that completely define a project. It organizes the physical work packages into levels that can be developed into a summary. Figure 5-1 shows a typical WBS.

B. Code of Accounts

A COA is a logical breakdown of a project into controllable elements for the purpose of cost control and reporting. The breakdown is a numbered structure, organized in a logical manner. Chapters 16 and 17 contain example COAs for construction and Environmental Restoration and Waste Management projects.

3. PURPOSE OF SYSTEMS

The WBS and COA systems provide a consistent organization throughout the life of the project. The Department does not require a specific WBS or COA for use in cost estimating. It is envisioned that each Field Office or Program Officer will specifically delineate a WBS and COA for each office or program. These would be used in developing cost estimates throughout the project's life.

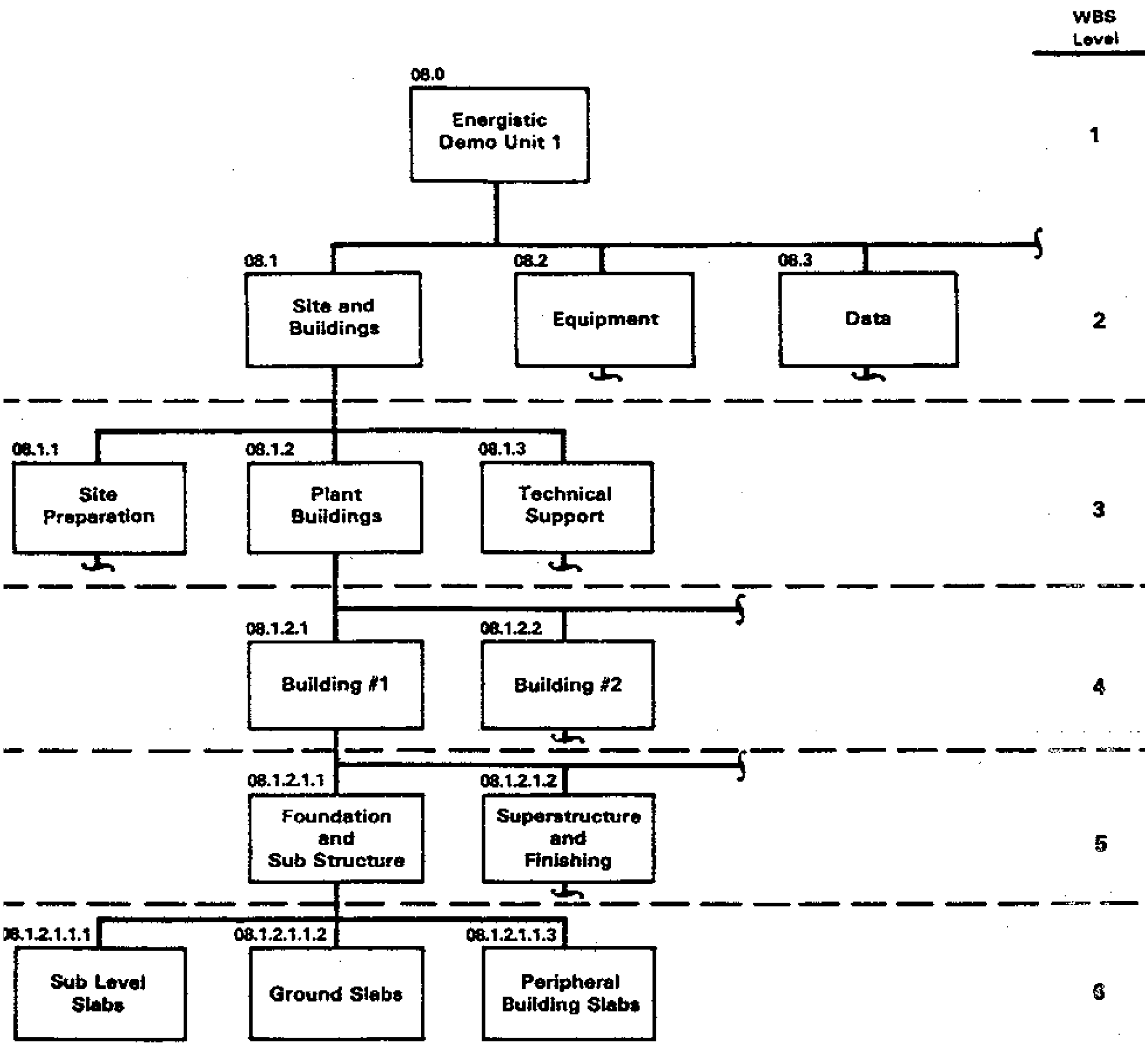


Figure 5-1. Typical Work Breakdown Structure

A. Work Breakdown Structure

A WBS shows the relationship of all elements of a project. This provides a sound basis for cost and schedule control.

During that period of a project's life from its inception to a completed project, a number of diverse financial activities must take place. These activities include cost estimating, budgeting, accounting, reporting, controlling and auditing. A WBS establishes a common frame of reference for relating job tasks to each other and relating project costs at the summary level of detail.

Since the WBS divides the package into work packages, it can also be used to interrelate the schedule and costs. The work packages or their activities can be used as the schedule's activities. This enables resource loading of a schedule, resource budgeting against time, and the development of a variety of cost budgets plotted against time.

B. Code of Accounts

A cost code system or COA is established early in a project and is used for its duration. An organized, numbered structure for a project is developed. This standardization is used in the development, collection, organization, and reporting of project data.

The COA organizes data at a detail level that is developed into higher summary levels. As the detail of a project increases, more detail levels can be developed.

The COA is used during the estimate stage to organize the costs. As a project progresses, the same COA is used, but the elements of data are updated. By comparing the changes in the elements of the COA, variances and trends can be identified. Using the same COA once construction work begins will provide consistency between the estimate and actual cost data for cost control purposes.

A project cost code manual must be provided for each line item construction project. If the cost code system has not been developed prior to the CDR, it must be issued as a part of the CDR. All subsequent estimates must then be made in accordance with the cost code system.

4. INTERFACE OF SYSTEMS

Even though the numeric systems established for the WBS and COA differ, they are both based on a structure that increases in detail as the levels increase. A correlation exists between the WBS and COA levels. This relationship is inherent since there are costs associated with the execution of each work package or element of the WBS. This correlation is shown in Figure 5-2.

Incorporating the cost codes into the WBS will provide:

- a framework for basic uniformity in estimating and accounting for the costs of construction work;
- a means for detecting omission and duplication of items in budget estimates;
- a basis for comparing the cost of similar work in different projects or at different locations;
- a record of actual costs incurred on completed projects in a form that will be useful in the preparation of estimates for other projects; and
- a means of establishing the cost of property record units for continuing property accounting records.

5. THE WORK BREAKDOWN STRUCTURE

A. Fundamental Structure of a Work Breakdown Structure

A WBS is a numerical, graphic representation that completely defines a project by relating elements of work in that project to each other and to the end product. The WBS is comprised of discrete work packages, called elements, that describe a specific item of either hardware, service, or data. Descending levels of the WBS provide elements of greater and greater detail. The number of levels of a WBS depends on the size and complexity of the project. The DOE WBS Guide presents a structure that may be used as a guideline when developing the project/program WBS.

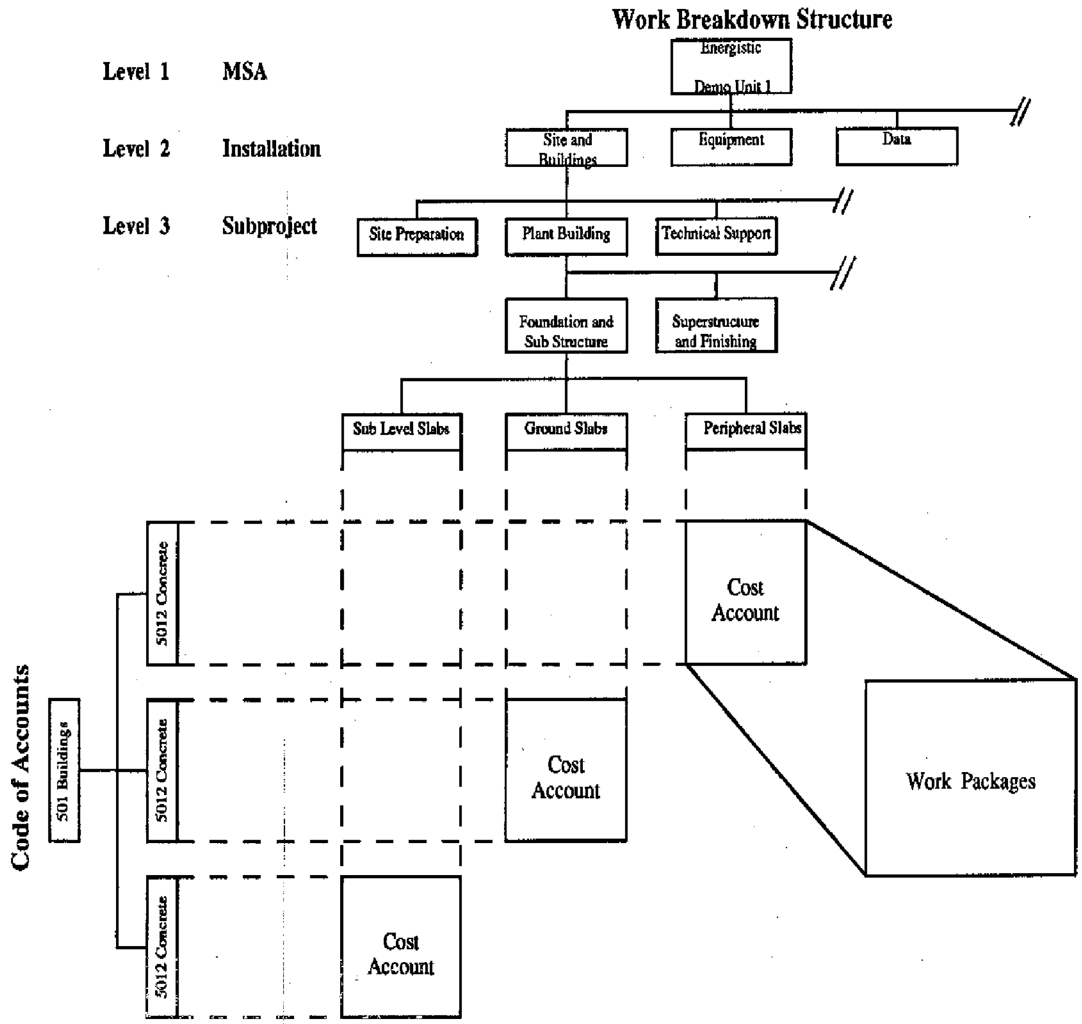
Examples of the first three levels of a WBS are as follows.

1. Level 1 contains only the project end objective. The product at this level shall be identifiable directly to elements of the DOE Budget and Reporting Classification Structure.

2. Level 2 contains the major product segments or subsections of the end objective. Major segments are often defined by location or by the purpose served.

3. Level 3 contains definable components, subsystems or subsets, of the Level 2 major segments.

Figure 5-2 Work Breakdown Structure Extended to Cost Account and Work Package Levels Indicating Cross Walk to Code of Accounts



B. Preparing a Work Breakdown Structure

The initial WBS prepared for a project is the project summary work breakdown structure (PSWBS). Normally, the PSWBS contains the top three levels only. Lower-level elements may be included when necessary to clearly communicate all project requirements.

1. Understanding of the Scope

The first prerequisite to the preparation of the PSWBS is the clear understanding and statement of the project objective by the Project Secretarial Officer (PSO). This can include the delivery of a specific major end item, the erection of a building, or the remediation of a section of land. Once this overall project objective is established, it assists in determination of the supporting project subobjectives. This process of identification and definition of subobjectives assists the PSO in structuring WBS levels and the contributing elements during WBS preparation.

2. Defining the Levels and Elements

Early in project planning, DOE project management should select the summary WBS(s) that will best describe the work of the project in the way it will be executed. WBS elements can be organized by physical area, process, or function. All elements of the WBS should be defined in an accompanying WBS dictionary.

The summary WBS elements should be used as guides as the levels of the WBS are added or changed to reflect the changes and refinements of the scope as the design and project execution are being developed. As levels are added to the WBS, they should be checked across the project to ensure that they remain at the same level of detail. When developing a numbering system, the use of the computerized system should be considered since they may limit the number of digits in the WBS numeric identifier.

3. Use of the Work Breakdown Structure

The PSWBS should be used to identify work for proposed supporting contractors.

Subsequently, the PSWBS elements assigned to contractors are extended by the contractors to derive each contract work breakdown structure (CWBS). Together, the PSWBS and each CWBS constitute the project WBS, which then provides the framework for cost, schedule, and technical planning, and control through the life of the project.

4. Updating the Work Breakdown Structure

The PSO must maintain the WBS. Changes may occur when the work effort can be more accurately defined or if a revised approach (e.g., technically different or more cost effective) is implemented to satisfy or meet the project objective. Also, contractors, while developing their CWBS, may propose to DOE alternative approaches to better accomplish the contract objectives. If the alternatives are accepted by DOE project management, the preliminary PSWBS will be revised accordingly. Thus, when establishing the numeric series for the WBS, it is advisable to leave some blocks of numbers for changes and additions to the scope. This makes the WBS revision process easier.

6. THE COST CODE SYSTEM

Fundamental Structure of a Cost Code System

A direct cost system generally includes three levels of codes. The “first-level” codes, sometimes called “primary levels,” represent the major cost categories. The major components or categories of work for each of the primary levels are listed and assigned a “second-level” or sub-summary code. These “second-level” codes are then broken down by work elements or bills of material and each work element or bill of material (BM) is assigned a “third-level” or fine-detail-level.

The cost estimate will list the labor and material required at the “third-level” code, then all “third-level” codes will be summarized by their respective “second-level” codes. Likewise all “second-level” codes will be summarized by their respective “primary levels.” The “primary levels” will be summarized by each “subproject” or “project” total to obtain the “project” overall cost estimate.

Subproject Designation. Subproject is a term used to divide a project into separately manageable portions of the project. A subproject is generally used to identify each separately capitalizable identity, such as a building. A subproject can also be used to identify a specific geographical area or separate physical features of a project. A matrix should be drawn for each project listing the subprojects designated and indicating all the second-level cost codes for the construction work required by each.

7. INTERFACE BETWEEN ASSET TYPES AND CODE OF ACCOUNTS

When a construction project has been completed, an asset has been created and must be reflected on DOE’s property book. The *Accounting Practices and Procedures Handbook* contains a listing of the asset types used by DOE. In an effort to bridge the gap between a construction account and an asset type, the committee to update the code of accounts decided to use a primary level of accounts coincided with the asset types used by the Finance and Accounting Offices and thereby reduce the likelihood of introducing errors that could result from translating “as built” costs to asset type categories. Thus, the numbers differ from those used in the older Energy Research and Development Administration (ERDA) manuals and, of course, differ from the Construction Specification Institute Code (CSI). It should be noted that although the numbering is different, the elements of the emerging code of accounts permit both the older ERDA classification system and CSI system to be applied at sublevels of the cost code.

CHAPTER 6

PROJECT FUNCTIONS AND ACTIVITIES DEFINITIONS FOR TOTAL PROJECT COST

1. INTRODUCTION

Because of an obvious disparity of opinions and practices with regard to what exactly is included in total estimated cost (TEC) and total project cost (TPC), guidelines were developed and are included in this chapter. The development of guidelines is important because it provides consistency in estimating and reporting of project costs and it provides uniformity of information used for cost data bases. It should be noted that TEC does not apply to most of the EM projects; only TPC applies.

2. DEFINITIONS

Total project cost is defined as all costs specific to a project incurred through startup of a facility, but prior to the operation of the facility. Thus, TPC includes TEC and other project costs (OPC), or

$$TEC + OPC = TPC.$$

A. Total Estimated Cost

TEC is defined as all engineering design costs (after conceptual design), facility construction costs, and other costs specifically related to those construction efforts. These are typically capitalized. TEC will include, but not be limited to: project and construction management during Titles I, II, and III; design and construction management and reporting during design construction; contingency and economic escalation for TEC-applied elements; ED&I during Titles I, II, and III; contractor support directly related to design and construction; and equipment and refurbishing equipment.

B. Other Project Costs

OPCs are defined as all other costs related to a project that are not included in the TEC, such as supporting research and development, pre-authorization costs prior to start of Title I design, plant support costs during construction, activation, and startup. OPCs will include, but not be limited to: research and development; NEPA documentation; project data sheets (PDSs); CDR; short form project data sheets; surveying for siting; conceptual design plan; and evaluation of RCRA/EPA/State permit requirements.

C. Total Project Cost

TPC is defined as all costs specific to a project incurred through the startup of a facility but prior to the operation of a facility. It is comprised of TEC and OPC. TPC will include, but not be limited to, activities such as: design and construction; contingency; economic escalation; Pre-Title I activities; feasibility study reports (FSRs); maintenance procedures (to support facility startup); one-time start-up costs, initial operator training, and commissioning costs; and operating procedures (to support facility start-up).

3. DISCUSSION OF CHARTS

Table 6-1 is a matrix that summarizes the different individual project activities and indicates their designation with respect to TPC and TEC. The project activities identified are divided into different phases of project development. The activities are charged to the different functions that comprise TEC and OPC and are shown in the sequence they would most likely occur.

A. Different Phases of Project Development

The different individual project activities identified are divided into different stages of project development. The first section of the matrix identifies activities encountered during pre-authorization or Pre-Title I design. The second section of the matrix identifies activities encountered during Titles I and II of design. The matrix progresses in that manner to include Title III design and start-up.

B. Different Functions of Total Estimated Cost and Other Project Cost

The different project activities are allocated to different project functions with respect to TEC and OPC. The activities are designated as based on the project phase under which the activity occurs.

1. Total Estimated Cost

TEC is divided into costs associated with ED&I, project management (PM), construction management (CM), and construction contractors (CC).

a. ED&I: ED&I activities include the engineering and design activities in Titles I & II, the inspection activities associated with Title III, and activities defined in the Brooks Bill (e.g., the 6 percent allowed for design, drawings, and specifications).

b. PM: Project management covers those services provided to the DOE on a specific project, beginning at the start of design and continuing through the completion of construction, for planning, organizing, directing, controlling, and reporting on the status of the project.

c. CM: Construction management covers those services provided by the organization responsible for management of the construction effort during Title I and Title II design, and continuing through the completion of construction. CM services are further defined in DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM.

d. CC: Construction contractors cover salaries, travel, and other expenses of engineers, engineering assistants, and their secretarial support responsible for engineering and design performed by the construction contractor. When work normally performed by an architect/engineer (A/E) is performed by a CC, the associated costs are charged to the applicable ED&I accounts.

2. Other Project Cost

Any activities that are not representative of TEC functions are allocated to OPC. They are typically Pre-Title I activities, startup costs, and some support functions.

4. COST ALLOCATIONS

The definitive document within DOE for allocations of cost is DOE Order 2200.6, FINANCIAL ACCOUNTING, but a general discussion of cost allocations follows.

A. Plant and Capital Equipment (PACE) Fund

The Plant and Capital Equipment (PACE) Fund provides funding for the plant and its basic equipment/furnishings. This fund is for conventional construction projects only.

B. Operating Expense Fund

The Operating Expense Fund provides funding for ongoing activities, such as laundry, cleaning, etc. These items are typically captured in site overhead accounts and then allocated to projects as site overhead. Operating expense funded items more directly related to projects are items such as Pre-Title I and start-up activities, etc.

C. Usage

Once standard definitions are developed and the different project activities are identified, it is then possible to uniformly allocate costs to the different project development activities. Table 6-2 is a matrix that summarizes recommended cost allocations for operating expense and PACE (ED&I and construction). It is important to note that the estimator should refer to these tables throughout the entire life of a project.

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
1. PRE-KEY DECISION - 0 (Prior to Determination of Mission Need)					
A. Engineering Study	X				
B. Alternatives Assessment/Site Selection Studies	X				
C. Surveying for Siting	X				
D. Capital Review Board	X				
E. Candidate Projects (support sheet and presentation to DOE)	X				
F. Conceptual Design Plan	X				
G. Work Orders - CDR Preparation, etc.	X				
H. Integrated Programmatic/Project Schedule (R&D, Safety, Environmental, Operations, etc.)	X				
I. Requirements for Safety Analysis Determination	X				
J. Functional Design Criteria	X				
K. Evaluation of RCRA/EPA/State Permit Requirements	X				
L. Cultural Resources Review	X				
2. Key Decision - 0 and Key Decision - 1 (Determination of Mission Need and Approval of New Start)					
A. Conceptual Design Report	X				
B. Design Reviews	X				
C. NEPA Documentation	X				
D. Conceptual Project Schedule	X				
E. Plant Forces Work Review	X				
F. Energy Conservation Report	X				

TABLE 6-1

**TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC**

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
G. Economic/Life Cycle Cost Analysis	X				
H. Alternative Engineering (before Title I)	X				
I. Physically Handicapped Review	X				
J. Energy System Acquisition Advisory Board and Acquisition Executive Review Board Support	X				
K. Preliminary Safety Analysis Report (PSAR)	X				
L. Facility/Project Security Review and Plan	X				
M. Facility Security Vulnerability Assessments	X				
N. Master Safeguards & Secure Analysis	X				
O. Construction Project Data Sheet (CPDS)	X				
P. ES&H Requirements Assessment	X				
Q. Strategic Facility Assessment	X				
R. Budget/Conceptual Estimates, as required (Parametric Assessments)	X				
S. Project/Validations Support	X				
T. Monthly Conceptual Status Report	X				
U. Architect/Engineer (A/E) Selection and Statement of Work Development	X				
V. Identification of Project Record Requirements	X				
W. Project Management Plan (PMP)	X				
X. Project Quality Assurance (QA) Plan	X				
Y. Configuration Management Plan (CMP)	X				

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
Z. Pilot Plants	X				
AA. Research and Development (Project Specific)	X				
AB. Facility As-Built/Existing Condition Drawings (Prior to Design Start)	X				
AC. Obtain Permits Required Prior to Start of Construction (before Title I)	X				
3. Key Decision - 1 and Key Decision - 2 (Approval of New Start and Start of Detailed Design: Title I and II Activities)					
A. PMP Revisions			X		
B. CPDS Revisions			X		
C. Integrated Detailed Project Schedules/Critical Path Analysis			X		
D. Project Revalidations			X		
E. Project Authorization Modification Support			X		
F. A/E Internal Design Coordination		X			
G. Identification of Long Lead Procurements		X			
H. Design Studies		X			
I. Design Calculations & Analysis		X			
J. CADD and other Computer Services		X			
K. Cost Estimates			X		
L. Procurement & Construction Specification Development		X			
M. Design Reviews by Project Team		X	X		
N. Design Review Support	X	X			

TABLE 6-1

**TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC**

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
O. Drawings		X			
P. Project Schedules			X	X	
Q. Acceptance Test Procedures & Plans		X		X	
R. Certified Engineering Reports		X			
S. Research & Development (required to complete project as defined by KD-0)	X				
T. Performance Evaluations of A/E			X		
U. Inspection Planning			X	X	
V. Surveys - Support Design			X		
W. Design Cost & Scheduling Analysis & Control		X			
X. Decision Progress Reporting		X	X	X	
Y. Design QA Plan and Overview		X	X		
Z. Constructibility Reviews			X	X	
AA. Safety Reviews by A/E		X			
AB. Regulatory Overview by A/E		X			
AC. Reproduction - for Design		X			
AD. Travel - Support Design		X			
AE. Obtain Permits Required Prior to Start of Construction (after Title I)	X				
AF. Change Control - for Design		X	X		
AG. Value Engineering (after Title I)			X		

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
4. Key Decision - 3 Approval to Start Construction or Full Scale Development to Key Decision - 4: Approval to Commence Operations or Pre-Production (Title III Activities)					
A. Bid Package Preparation			X	X	
B. Bid Evaluations, Opening and Award			X	X	
C. Construction Coordination and Planning			X	X	
D. Contract Administration			X	X	
E. Engineering Support (A/E)			X		
F. Design Changes/Control		X	X	X	
G. Non-Conformance Reports (NCRs)			X	X	
H. Control Systems for Construction Activities			X	X	
I. Project Assessment & Reporting		X	X	X	
J. Construction Status Reports and Meetings			X	X	
K. Davis-Bacon Administration			X	X	
L. Vendor Submittals		X	X	X	X
M. Field Support of Construction			X	X	
N. Field or Lab Tests				X	
O. Radiation Control Timekeepers					X
P. Radiation Protection by Contractor			X		
Q. Safety and Safeguard/Security Operations				X	X
R. M&O Contractor/M&O Project Support During Construction	X				
S. Project Estimates (Purpose Dependent)		X	X	X	

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
T. Quality Control (QC) Inspection			X	X	X
U. Inspection and Acceptance		X		X	
V. Negotiations of Fixed Price Contract Changes			X	X	
W. Trips to Vendor/Fabricators		X	X	X	X
X. Procurement Coordination			X	X	X
Y. Equipment/Hardware Cost				X	X
Z. Material Procurement Rate				X	X
AA. Initial Office Furniture and Fixtures					X
AB. Spare Parts Inventory	X				
AC. Installation/Alterations					X
AD. Disposal of Mixed Waste					X
AE. Cost Plus Award Fee/Fixed Price Construction		X			X
AF. Plant Forces Work					X
AG. Initial Spares					X
AH. Safety Plan & Overview				X	X
AI. Decontamination (exceeds normal operating levels)	X				
AJ. Decontamination (as removal cost)					X
AK. Surveying to Support Construction			X	X	X
AL. Interest Penalties		X	X	X	X

TABLE 6-1

TPC AND TEC GUIDANCE AND CLARIFICATION
INCLUSION OF DETAILED ACTIVITIES IN TPC AND/OR TEC

ACTIVITY	TPC				
	OPC	TEC			
		ED&I	PM	CM	CC
5. Key Decision - 4: Planning and Preparation for Acceptance/Operational Startup and Pre-production for Commencement of Operations					
A. Perform Acceptance Testing			X		X
B. Perform Operation Acceptance Testing	X				
C. Final Safety Analysis Report (FSAR)			X		
D. Operational Readiness Review (ORR)	X				
E. Start-up Costs	X				
F. Training of Operators	X				
G. As-Builts		X	X		X
H. Project Closeout			X		
I. A/E & Construction Performance Appraisals			X		
J. User Move-In	X				
K. Develop Operating Procedures, Manuals, and Documentation	X				
L. Operations Planning	X				
M. Safety and System Integration	X				
N. Safety Evaluation Report (SER)	X				
O. Post-Acceptance Testing	X				
P. Start Up Coordination, Materials, and Supplies	X				
Q. Correction of Design/Construction Deficiencies					X
R. Transition Planning			X	X	X

TABLE 6-2

RECOMMENDED GENERAL COST ALLOCATION MATRIX

PROJECT DEVELOPMENT ACTIVITY	PROJECTS[1]		
	OPERATING EXPENSE	P&CE	
		ED&I	CONSTR.
Pre Title I	X		
Title I		X	
Title II		X	
Title III		X	
Construction	X[2]		X
Construction Management			X
Project Management		X[3]	X[3]
Project Support	X		
Startup	X		

[1] Applies to Line Item Projects, Major Projects, and Major Systems Acquisitions.

[2] Capital funding for betterments, conversions, and replacements. Alterations are generally funded by operating expense.

[3] Project management during the design phase of Line Item Projects, Major Projects, or Major Systems Acquisitions authorized for design only is funded by P&CE-ED&I.

Reference: DOE Order 2200.6, FINANCIAL ACCOUNTING.

CHAPTER 7

DIRECT/INDIRECT COSTS

1. INTRODUCTION

Estimates can be broken down into direct, indirect, contingency, and escalation costs. Standard definitions of direct and indirect costs provide consistency in estimating and reporting of project costs. This benefits program/project management, project validation, independent estimating and helps to provide uniformity in the departmental cost database. This chapter provides recommended categories for direct and indirect elements developed by the Committee for Cost Methods Development (CCMD) and describes various estimating techniques for direct and indirect costs.

2. DEFINITIONS

A. U. S. Department of Energy

DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM, states that direct costs include “...any costs that can be specifically identified with a particular project or activity, including salaries, travel, equipment and supplies directly benefitting the project or activity.” Emphasis is placed on the term “activity,” which is interpreted as being the same as a cost account.

DOE Order 4700.1 states that indirect costs are “...costs incurred by an organization for common or joint objectives, and which cannot be identified specifically with a particular activity or project.”

B. American Association of Cost Engineers

The AACE defines direct costs as “...costs of installed equipment, material, and labor directly involved in the physical construction of the permanent facility.”

The AACE defines indirect costs as “...all costs which do not become a final part of the installation, but which are required for its orderly completion. It includes (but is not limited to): field administration, direct supervision, capital tools, some start-up costs, contractor's fees, insurance, taxes, etc.”

C. Table of Indirect/Direct Costs

For the majority of the activities, there is agreement as to whether it is an indirect or direct cost. Table 7-1 provides guidance for the treatment of some categories and indicates whether they are indirect or direct costs. The definitions of the categories or activities can be found in Appendix A.

D. Type of Contract Cost Considerations

The items considered a direct cost vary with the type of contract as follows.

Type of Contract	Direct Costs
Fixed Price or Lump Sum	Material and labor costs including payroll burden
Cost Plus Fixed Percentage	Material and labor costs including payroll burden, field and home office expenses, accounting, secretarial, and equipment, or all costs except the fee.

TABLE 7-1

RECOMMENDED CATEGORIES FOR DIRECT/INDIRECT COST ELEMENTS

CONSTRUCTION COST ACCOUNT	DOE-CCMD COMMITTEE
ACCOUNTING	I
ADMINISTRATION	I
AIRCRAFT OPERATION	I
BONDS	I
CAMP OPERATIONS	I
COMPRESSED AIR	I
CONST. CONTRACTOR'S ENG.	I
CONSTRUCTION	D
CONST. EQUIPMENT	I[1]
CONST. EQPT. MAINT.	I
CONST. FACILITIES	I
CONSUMABLES	I
CONTAMINATION RESTRICTIONS	D
CONTRACT FEE	I
CONTRIB. TO WELFARE PLANS	I
DEMOLITION	D
DRINKING WATER & SANITATION	I
ESCORTS	D
FIRE PROTECTION	I
FREIGHT	D
GENERAL CLEANUP	I[1]
HEAT	I
HOLIDAY & VACATION PAY	I
INSURANCE	I
LAUNDRY	I

TABLE 7-1

RECOMMENDED CATEGORIES FOR DIRECT/INDIRECT COST ELEMENTS

CONSTRUCTION COST ACCOUNT	DOE-CCMD COMMITTEE
LEGAL	I
LIGHT & POWER	I
MAINT. OF GEN. CONST. PLANT	I
MATERIAL HANDLING	I
MEDICAL & FIRST AID	I
MOTOR POOL OPERATIONS	I
OFFICE SUPPLIES & EXPENSES	I
PAYROLL INSURANCE	I
PAYROLL TAXES	I
PERMITS, LICENSES	I
PERSONNEL	I
PREMIUM PAY	D
PROCUREMENT	I
PRODUCTIVITY	D
PROTECTIVE CLOTHING	D
REPORTING TIME	I
RETROACTIVE PAY	I/D[2]
SAFETY	I
SALES TAX	I
SCAFFOLDING	I[1]
SECURITY	I
SECURITY RESTRICTIONS	D
SIGNUP & TERMINATION PAY	I
SITEWORK	I/D[3]
SMALL TOOLS	I

TABLE 7-1

RECOMMENDED CATEGORIES FOR DIRECT/INDIRECT COST ELEMENTS

CONSTRUCTION COST ACCOUNT	DOE-CCMD COMMITTEE
STANDARD EQUIPMENT	D
SUPERINTENDENCE	I[1]
SURVEYS, GEOL. STUDIES & TESTS	I
TAXES OTHER THAN PAYROLL	I
TRANSFER AND RELOC.	I
TRANSPORTATION OF WORKERS	I
WAREHOUSING	I
WATER	I
WELDING TESTS	I

[1] INDIRECT ONLY IF NOT ASSOCIATED WITH A PARTICULAR WORK OPERATION.

[2] HOLDING ACCOUNT; ONLY UNALLOCATABLE COSTS SHOULD REMAIN IN THIS ACCOUNT.

[3] DIRECT IF PERMANENT, OTHERWISE INDIRECT.

CHAPTER 8

STARTUP COSTS

1. INTRODUCTION

Many projects will have startup costs associated with the project. Startup is usually a gray area between the time project construction ends and a facility is commissioned and begins its operation. This chapter discusses startup costs for construction and environmental projects, and estimating guidance for startup costs.

2. DEFINITION OF STARTUP

Obviously, different projects will have unique startup costs. This section defines startup costs for conventional and environmental projects.

A. Conventional Projects

Construction projects are usually considered conventional projects. During startup, a facility is tested to ensure that it meets the project's technical performance specifications; however, actual operations at the facility may not have commenced. In fact, construction activities, such as punch lists and corrections, may still be occurring during startup, so it is difficult to separate construction modifications from initial facility operations. A distinction is made between startup and operations because startup costs are usually considered capital costs, while operating costs are charged to the facility's operating budget.

B. Environmental Projects

Startup activities at environmental restoration facilities may commence prior to the completion of the construction phase of the environmental project. For example, contaminated soil may be excavated and stockpiled while startup of an on-site incinerator is occurring. Startup costs will be a function of the types of activities at the site and the remediation/restoration technology used at the site.

3. STARTUP COMPONENTS

Startup activities may include the activities discussed in the following sections.

A. Startup Transition Plan

The development of a startup transition plan for the conventional facility may be essential for smooth startup implementation. Typically, these plans will include test plan procedures, scheduling, security planning, and the associated documentation. A plan provides an excellent opportunity to think ahead to situations that may be encountered at the facility during startup.

B. Startup Organization

Development of a startup organization, including management, administrative, operations, maintenance, and technical support personnel, will be required prior to the actual startup. Employees may have to be relocated to staff the facility while it is being tested, so employee moving costs or employee living costs may also be included in the cost estimate for facility startup.

C. Operating and Maintenance Procedures

Site-specific operating and maintenance procedures will have to be developed for a new facility with special attention paid to equipment startup or initiation procedures. In some cases, as with a nuclear facility, startup operations and their sequence will be strictly regulated.

D. Spare Parts Inventory and Training

The startup cost estimate must include provisions for materials to be used during startup and spare parts for any maintenance that occurs during startup. Training for operations and maintenance personnel will also be required.

E. Testing

Some facilities will require a safety/readiness review before they can be declared operational. Some scheduling may also be involved. For example, a facility may have to demonstrate successful operation at a certain capacity for a specified period of time before it is commissioned. The startup cost estimate must account for the testing schedule.

4. ESTIMATING GUIDANCE FOR STARTUP COSTS

Although startup activities in the field may not begin until construction is almost complete, the planning for startup should occur early in the project. Planning for startup should be an integrated effort with construction personnel and operators to avoid holes or duplication of effort in the startup process. The input from the construction personnel and plant operators should be used when developing the startup cost estimate.

Construction startup costs can range from 0.5 to 10 percent of the installed cost for the conventional construction facility.

The startup cost estimate should be prepared under the guidance of the Program Manager and not an architect/engineer. The work breakdown structure and schedule for startup activities should be developed early. The startup costs are considered other total project cost.

CHAPTER 9

OPERATING COSTS

1. INTRODUCTION

The content of this cost estimating guide is primarily focused on capital costs for conventional construction and environmental restoration and waste management projects. For some projects, particularly environmental remediation projects, the operating costs over the life of the project can be several orders of magnitude larger than the initial capital costs. Therefore, it is important to examine operating cost estimates and verify that all elements of the project have been considered and properly estimated.

2. OPERATING COSTS FOR CONVENTIONAL CONSTRUCTION PROJECTS

This section discusses operating costs which begin after start-up associated with conventional construction projects. All projects are not the same; therefore, some of the costs outlined in this section may not be applicable to a given project. This should not detract from the usefulness of this section to cost estimators and reviewers. In addition, taxes and insurance, which are normally included in operating cost estimates, are not applicable for DOE conventional construction projects because the federal government is not subject to state or local property taxes and is self-insured.

A. Capital Recovery

The operating cost estimate should contain some mechanism for capital recovery. Depreciation is the method commonly used for conventional construction projects. Capital recovery will be a function of the interest rate and the facility's expected life.

B. Utility Costs

Utility costs are primarily comprised of conventional facility heating and cooling costs. Costs for utilities will be based on the utilities available to the facility (i.e., natural gas, fuel oil, electricity) and the climate at the facility's location. Steam, process water, and compressed air may also be required by the facility.

C. Labor Costs

Facilities constructed as conventional projects do not operate without labor. These facilities may employ various types of labor, including operations, technical, administrative, and clerical labor. The level of estimate detail will dictate the level of labor cost breakout in the estimate. For a detailed estimate, the reviewer should verify that all facility functions have been identified and properly estimated.

Operating costs should include provisions for salaries and labor burden, including medical benefits, vacation and holidays, and other employee compensation items. Labor overhead will consist of administrative costs for scheduling, payroll, etc., as well as costs for employee workspace maintenance. Labor overhead will be present regardless of the facility operating schedule, but labor costs may be a function of the facility's operating schedule, especially if shift work is involved.

D. Maintenance

Maintenance and upkeep of all facility components must be considered in the operating cost estimate. Maintenance and repairs should also include costs for labor, materials, and supervision. Facility equipment will have maintenance requirements, and vehicles used at the facility will require service and fluids (gasoline/diesel, oil). Spare parts for equipment and vehicles may also be maintained at the facility, and an allowance for spare parts should be provided in the operating cost estimate.

Buildings and their infrastructures at the facility, including phone lines and power generators, will require maintenance to remain in good condition. Regular housekeeping service is usually necessary. Service roads at the facility must be maintained. Facility grounds may also require maintenance, usually for aesthetic purposes.

Additional information on maintenance activities can be found in DOE Order 4330.2, CAPITAL ASSET MANAGEMENT PROGRAM.

E. Support Services

Support services include those miscellaneous services that may be needed at the facility. Drinking water, sanitation, waste disposal, site security, fire protection, cafeteria, and medical clinic/services are considered support services. Office supplies and expenses and small tools are also classified as support services. These items, if applicable, should be identified in the operating cost estimate. Temporary facilities during expansion or renovation may also require inclusion in an operating cost estimate.

F. Environmental Compliance/Permit Costs

In today's regulated environment, most conventional DOE facilities will require operating permits. Air permits and wastewater discharge permits are two examples of operating permits. These permits may contain annual compliance provisions, including monitoring or testing of effluent or air emissions. Costs for testing and analytical analysis must be included in the operating cost estimate. Operating costs for equipment mandated by permit provisions should also be considered.

G. Downtime Allowance

Facilities will not operate 100 percent of the time. Weather-related shutdowns, equipment repair and maintenance, emergencies, and employee work schedules will affect the number of hours operated per year. Some facilities may be prevented from operating pending acceptance of the facility work plan or other permit. Proper allowance for downtime is important if the operating costs were estimated on a percentage of hours operated basis. For conventional construction facilities, this is not a significant factor unless the facility's operating budget is dependent upon the number of hours operated. Maintenance and repair costs may also be a function of the number of hours of facility operation.

3. OPERATING COSTS FOR ENVIRONMENTAL REMEDIATION AND RESTORATION PROJECTS

This section discusses operating costs for environmental remediation and restoration projects. Each environmental project is unique; therefore, no two projects will have the same operating costs. It is the responsibility of the estimator and reviewer to verify that the operating cost estimate is consistent with activities which will be performed at the remediation/restoration site. Taxes and insurance, which are normally included in operating cost estimates, are not applicable for DOE environmental restoration and waste management projects because the federal government is not subject to state or local property taxes and is self-insured.

A. Capital Recovery

Capital recovery will be a function of the interest rate and the environmental remediation/restoration project's expected life. The operating cost estimate should contain depreciation expenses for capital recovery cost.

B. Utilities

Utility costs will consist of facility heating/cooling plus the energy required to run any waste treatment equipment at the facility. For example, operating costs for a project involving an on-site incinerator would include workspace heating/cooling costs and the fuel requirements of the incinerator. Utility costs for environmental facilities will be a function of the utilities available to the facility, the climate at the facility's location, and the amount of material processed/handled at the facility. Steam, process water, and compressed air may also be required.

C. Labor Costs

Estimates of labor costs for environmental projects will be different than estimates for conventional projects because of job functions required by the project. For example, work at the facility may dictate the number of health and safety professionals working on the project, and additional technical support may be required for projects that involve new or experimental remediation technology. Labor salaries are usually higher because of additional certification and training requirements for personnel who work in the environmental remediation field.

Operating cost estimates should include provisions for salaries and labor burden, including medical benefits, vacation and holidays, and other employee compensation items. Labor overhead will consist of administrative costs for scheduling, payroll, etc., as well as costs for employee workspace maintenance. Training costs may increase labor overhead for environmental projects. Labor overhead will be present regardless of the project operating schedule, but labor costs may be a function of the facility's operating schedule, especially if shift work is involved. Labor scheduling should also contain an allowance for personnel decontamination time.

D. Maintenance

Maintenance and upkeep of all facility components must be considered in the operating cost budget for an environmental project. Maintenance and repairs should also include costs for labor, materials, and supervision. Facility equipment will have maintenance requirements, and vehicles used at the facility will require service and fluids (gasoline/diesel, oil). Specialized vehicles, such as earth movers and dump trucks, and specialized equipment, such as an incinerator, may also be used at the site on a routine basis. Spare parts for equipment and vehicles may be maintained at the facility, and an allowance for spare parts should be provided in the operating cost estimate.

Buildings and their infrastructures at the facility, including phone lines and power generators, will require maintenance to remain in good condition. Regular housekeeping service is usually necessary. Service roads at the facility must be maintained.

E. Support Services

Support services include those miscellaneous services that may be needed at the facility. Drinking water, sanitation, waste disposal, site security, fire protection, cafeteria, and medical clinic/services are considered support services. Office supplies and expenses and small tools are also classified as support services. These items, if applicable, should be identified in the operating cost estimate.

F. Downtime Allowance

Facilities will not operate 100 percent of the time. Weather-related shutdowns, equipment repair and maintenance, emergencies, and employee work schedules will affect the number of hours operated per year. Some facilities may be prevented from operating pending acceptance of the facility work plan or other permit. Proper allowance for downtime is important if the operating costs were estimated on a percentage of hours operated basis. Maintenance and repair costs may also be a function of the number of hours of facility operation.

G. Special Environmental Remediation/Restoration Project Costs

Special project costs for environmental projects include costs for transportation, protective equipment, monitoring, pollution control, permits, and analytical services. All environmental projects will have operating expenses in these areas.

The majority of environmental remediation/restoration projects will require that personnel wear protective equipment. This equipment must be decontaminated on a regular basis and kept in good working order. Site areas may also require personnel and/or ambient monitoring to protect human health and the environment.

Pollution control equipment is usually a permit requirement for waste treatment facilities, and the operation of this equipment must be considered in the operating cost estimate for environmental facilities. Environmental facilities are usually strictly regulated, and the facility permit conditions must be addressed in the operating cost estimate.

Analytical services can be a substantial portion of operating costs because environmental projects are usually characterized by a significant number of soil, water, air, or personnel monitoring samples. An on-site laboratory may be required for project analytical analyses. Provisions for all testing, analytic work, and an on-site laboratory must be made in the operating cost estimate.

CHAPTER 10

ESCALATION

1. INTRODUCTION

Escalation is the provision in a cost estimate for increases in the cost of equipment, material, labor, etc., due to continuing price changes over time. Escalation is used to estimate the future cost of a project or to bring historical costs to the present. Most cost estimating is done in “current” dollars and then escalated to the time when the project will be accomplished. This chapter discusses how escalation is calculated and how escalation indices are applied. Additional information can be found in DOE Order 5700.2, COST ESTIMATING, ANALYSIS AND STANDARDIZATION.

2. EXAMPLE OF USE OF ESCALATION

Since the duration of larger projects extends over several years, it is necessary to have a method of forecasting or predicting the funds that must be made available in the future to pay for the work. This is where predictive or forecast escalation indices are used. The current year cost estimate is, if necessary, divided into components grouped to match the available predictive escalation indices. Then each group of components is multiplied by the appropriate predictive escalation index to produce an estimate of the future cost of the project. The future costs of these components are then summed to give the total cost of the project. Escalation accuracy for the total project increases with the number of schedule activities used in summation.

To properly apply escalation indices for a particular project, the following data is required:

- escalation index (including issue date & index) used to prepare the estimate;
- current performance schedule, with start and completion dates of scheduled activities; and
- reference date the estimate was prepared.

Following is an example of a 5-year project that requires escalation calculations to determine the total project costs in the base year's dollars.

TABLE 10-1

EXAMPLE OF 5-YEAR PROJECT
REQUIRING ESCALATION CALCULATIONS
ESTIMATE REFERENCE DATE: JULY 1, 1992

Step 1 Determine midpoint of scheduled activity.

			Duration		
Scheduled Activity	**WBS**	**Start**	**Complete**	**(Months)**	**Midpoint**
1. ED&I Title I	A1A	02/01/94	10/01/94	8	06/01/94
2. ED&I Title II	A1B	11/01/94	04/01/95	6	01/15/95
3. ED&I Title III	A1C	04/01/95	01/01/99	45	02/15/97
4. Equipment Procurement (General Services)	B2A	10/01/94	10/01/97	36	04/01/96
5. Equipment Procurement (Long-Lead, GFE)	B2B	04/01/95	12/01/95	8	08/01/95
6. Facility Construction	B2C	07/01/95	08/01/98	37	01/15/97
7. Demolition Work	D1A	01/01/98	09/01/98	8	05/01/98
8. Project Management	E1A	02/01/94	01/01/99	59	07/15/96

Step 2 Select appropriate escalation rates (assume escalation rates are for 1992 base year).

FY-1992 = 1.0	FY-1995 = 3.5
FY-1993 = 2.4	FY-1996 = 3.7
FY-1994 = 3.1	FY-1997 = 3.8

TABLE 10-1 (continued)

EXAMPLE OF 5-YEAR PROJECT
REQUIRING ESCALATION CALCULATIONS
ESTIMATE REFERENCE DATE: JULY 1, 1992

Step 3 **Calculate appropriate escalation rates for each scheduled activity using estimate preparation date as starting point and apply escalation rates selected in Step 2 to midpoint dates determined in Step 1.**

For Example: ED&I - Title III (midpoint = 02/15/97)

FY-Period	Years	x Escalation Index	= Escalation Factor
07/01/92 to 01/01/93	6/12	.010	.005
01/01/93 to 01/01/94	1.0	.024	.024
01/01/94 to 01/01/95	1.0	.031	.031
01/01/95 to 01/01/96	1.0	.035	.035
01/01/96 to 01/01/97	1.0	.037	.037
01/01/97 to 02/15/97	1.5/12	.038	.005

Compound Escalation

Factor = 1.005 x 1.024 x 1.031 x 1.035 x 1.037 x 1.005 = 1.144 OR 14.4%

Step 4 **The compound escalation factors derived in Step 3 are then applied to the total costs (direct cost + mark ups) for each scheduled activity. Total project escalation is the summation of escalation for all project activities**

Assume costs for Title III design are $100,000 for the base year. The escalated value would be:

$100,000 x 1.144 = $114,400.

Thus, the cost used for Title III designs in the total project cost is $114,400.

Note: Repetition of calculations is obvious; thus, application to a computerized escalation rate analysis forecast program would prove beneficial. Escalation rates applied to scheduled activities are practically tied to the project WBS. Unless a better determination can be made and supported, the midpoint of cash flow for a particular category is set equal to the midpoint of the scheduled activity for that category.

3. ESCALATION RELATIONSHIPS

To compare the costs of projects with differing durations, inflation/escalation costs must be considered. Escalation in cost estimating has two main uses: to convert historical costs to current costs (historical escalation index) and to escalate current costs into the future (predictive escalation index) for planning and budgeting. Historical costs are frequently used to estimate the cost of future projects. The historical escalation index is used to bring the historical cost to the present and then a predictive escalation index is used to move the cost to the future.

Associated with escalation are concepts of present and future worth. These represent methods of evaluating investment strategies like life cycle cost analyses. For example, a typical life cycle cost evaluation would be determining whether to use a higher R factor building insulation at a higher initial cost compared to higher heating and cooling costs over the life of the building resulting from a lower R factor insulation. Present and future worth are discussed in Chapter 23.

A. Historical Escalation

Historical escalation is generally easily evaluated. For example, the cost of concrete differed in 1981 versus 1992. The ratio of the two costs expressed as a percentage is the escalation and expressed as a decimal number is the index. Generally, escalation indices are grouped. For example, all types of chemical process piping may be grouped together and a historical escalation index determined for the group.

B. Predictive Escalation

Predictive escalation indices are obtained from commercial forecasting services, such as DRI/McGraw Hill, which supplies its most current predictions using an econometric model of the United States economy. They are the ratio of the future value to the current value expressed as a decimal. Predictive escalation indices are typically prepared for various groups and may be different for different groups. For example, the escalation index for concrete may be different than the one for environmental restoration.

C. Escalation Application

Economic escalation shall be applied to all estimates to account for the impact of broad economic forces on prices of labor, material, and equipment in accordance with the following requirements.

- Escalation shall be applied for the period from the date the estimate was prepared to the midpoint of the performance schedule.

- Since economic escalation rates are revised at least annually, all estimates shall include the issue date of the escalation rates used to prepare the estimate.

- Costs used for design concept shall be fully escalated and referenced as required.

4. ESCALATION INDICES

Costs continuously change due to three factors: changing technology, changing availability of materials and labor, and changing value of the monetary unit (i.e., inflation). Cost or escalation indices have been developed to keep up with these changing costs. The use of escalation indices is recommended by DOE to forecast future project costs. The use of an established index is a quick way to calculate these costs. To ensure proper usage of an index, one must understand how it is developed and its basis.

A. Developing Escalation Indices

An escalation index can be developed for a particular group of projects. The projects are divided into their elements, which can be related to current industry indices. The elements are then weighted and a composite index is developed. Complete details on developing escalation indices can be found in the DOE Cost Guide, Volume 5, on How to Construct and Use Economic Escalation Indices.

B. Escalation Indices Published by DOE

DOE has developed construction escalation indices for various types of projects. These are published every February and August. A copy of the latest indices can be requested from Office of Infrastructure Acquisition (FM-50).

5. USE OF DOE ESCALATION INDICES

A. How to Select an Index

An index for a project or program is selected based on the type of project (i.e., the scope of work). DOE publishes several indices to cover the range of projects for DOE. If a project or program does not appear to fall into any of the categories, adjustments can be made and must be submitted to FM-50 prior to their use.

More specifically, they must be selected based on the type of cost being escalated since escalation indices represent groups of items. For example, a predictive escalation index for chemical process piping would be inappropriate for use with a cost estimate for a building construction project.

B. How to Apply an Index

The indices are developed with a base year whose index number is 1.0. Generally, the base year is the current year. Once the index is selected, it can be used to either project a current cost based on historical costs, or it can be used to project future costs based on today's dollars.

C. Limitations

Cost indices have limitations since they are based on average data. Thus, judgement is required to decide if an index applies to a specific cost being updated. If using an index for a long-term project, it must be remembered that the long-term accuracy for indices are limited. However, their usefulness to DOE is that the different groups within DOE can use a common index to produce comparable costs.

CHAPTER 11

CONTINGENCY

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1. INTRODUCTION

The application of contingency for various types of cost estimates covers the entire life cycle of a project from feasibility studies through execution to closeout. The purpose of the contingency guidelines presented in this chapter is to provide for a standard approach to determining project contingency and improve the understanding of contingency in the project management process. These guidelines have been adopted by the DOE estimating community and should be incorporated into the operating procedures of DOE and operating contractor project team members.

2. CONTINGENCY DEFINITIONS

A. General Contingency

Contingency is an integral part of the total estimated costs of a project. It has been defined as—

> [a] 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 which will increase costs are likely to occur.

This definition has been adopted by the American Association of Cost Engineers. DOE has elected to narrow the scope of this definition and defines contingency as follows.

> Covers costs that may result from incomplete design, unforeseen and unpredictable conditions, or uncertainties within the defined project scope. The amount of the 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.

It is not DOE practice to set aside contingency for major schedule changes or unknown design factors, unanticipated regulatory standards or changes, incomplete or additions to project scope definition, force majeure situations, or congressional budget cuts. Project and operations estimates will always contain contingency. Estimators should be aware that contingency is an integral part of the estimate.

B. Buried Contingencies

Some estimators have sought to hide contingency estimates in order to protect the project so that the final project does not go over budget because the contingency has been removed by outside sources. This is affectionately known as buried contingency. All internal and external estimators should refrain from burying extra contingency allowances within the estimate. A culture of honesty should be promoted so that it is not necessary to bury contingency. In addition, estimators should be aware that estimate reviews will identify buried contingency. The estimate reviewer is obligated to remove buried contingency.

3. SPECIFICATIONS FOR CONTINGENCY ANALYSIS

Considerable latitude has been reserved for estimators and managers in the following contingency analysis specifications. These guidelines are to be followed by both the operating contractor and the DOE field office cost estimators to ensure a consistent and standard approach by the project team. Each contractor and field office should incorporate these guidelines into their operating procedures.

A written contingency analysis and estimate will be performed on all cost estimates and maintained in the estimate documentation file. This analysis is mandatory.

Estimators may use the ranges provided in this chapter of the cost guide for estimating 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.

Justification must be documented in writing when guide ranges for contingency are not followed. If extraordinary conditions exist that call for higher contingencies, the rationale and basis will be documented in the estimate. Computer programs, such as Independent Cost Estimating Contingency Analyzer (ICECAN), a Monte Carlo analysis program, are available to estimators and should be used to develop contingency factors. Risk analysis may also be necessary.

A. Construction Projects

Table 11-1 presents the contingency allowances by type of construction estimate for the seven standard DOE estimate types, and Table 11-2 presents the guidelines for the major components of a construction project.

Estimate types “a” through “e” in Table 11-1 are primarily an indication of the degree of completeness of the design. Type “f,” current working estimates, found in Table 11-2, depends upon the completeness of design, procurement, and construction. Contingency is calculated on the basis of remaining costs not incurred. Type “g,” the Independent Estimate, may occur at any time, and the corresponding contingency would be used (i.e., “a,” “b,” etc.).

Table 11-1. Contingency Allowance Guide By Type of Estimate

Type of Estimate	Overall Contingency Allowances % of Remaining Costs Not Incurred
PLANNING (Prior to CDR) Standard Experimental/Special Conditions	20% to 30% Up to 50%
BUDGET (Based upon CDR) Standard Experimental/Special Conditions	15% to 25% Up to 40%
TITLE I	10% to 20%
TITLE II DESIGN	5% to 15%
GOVERNMENT (BID CHECK)	5% to 15% adjusted to suit market conditions
CURRENT WORKING ESTIMATES	See Table 11-2
INDEPENDENT ESTIMATE	To suit status of project and estimator's judgment

The following factors need to be considered to select the contingency for specific items in the estimate while staying within the guideline ranges for each type of estimate.

1. Project Complexity

Unforeseen, uncertain, and unpredictable conditions will exist. Therefore, using the DOE cost code of accounts for construction, the following percents are provided for planning and budget estimates. They are listed in order of increasing complexity:

- Land and Land Rights 5% to 10%
- Improvements to Land/Standard Equipment 10% to 15%

•	New Buildings and Additions, Utilities, Other Structures	15% to 20%
•	Engineering	15% to 25%
•	Building Modifications	15% to 25%
•	Special Facilities (Standard)	20% to 30%
•	Experimental/Special Conditions	Up to 50%

Considerations that affect the selection in the ranges are: 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.

2. Design Completeness or Status

Regardless of the complexity factors listed above, the degree of detailed design to support the estimate is the more important factor. This factor is the major reason that the ranges in Table 11-1 vary from the high of 20 to 30 percent in the planning estimate to 5 to 15 percent at the completion of Title II design. Again, parts of the estimate may have different degrees of design completion, and the appropriate contingency percent must be used. As can be seen from Figure 11-1, as a project progresses, the contingency range and amount of contingency decreases.

3. Market Conditions

Market condition considerations are an addition or a subtraction from the project cost that can be accounted for in contingency. Obviously, the certainty of the estimate prices will have a major impact. The closer to a firm quoted price for equipment or a position of construction work, the less the contingency can be 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 contingency for cost-plus contracts that have been awarded.

4. Special Conditions

When the technology has not been selected for a project, an optimistic-pessimistic analysis can be completed. For each competing technology, an estimate is made. The difference in these estimates of the optimistic and pessimistic alternative can be used as the contingency.

Table 11-2. 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	15% to 25%
Title I	10% to 20%
Title II	5% to 15%
After Award:	
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%
Title I	10% to 20%
Title II	5% to 15%
After Award:	
CPAF Contract	15% to 17-1/2%
Fixed-Price Contract	3% to 8%
d. TOTAL CONTINGENCY (CALCULATED)	Total of above item contingencies

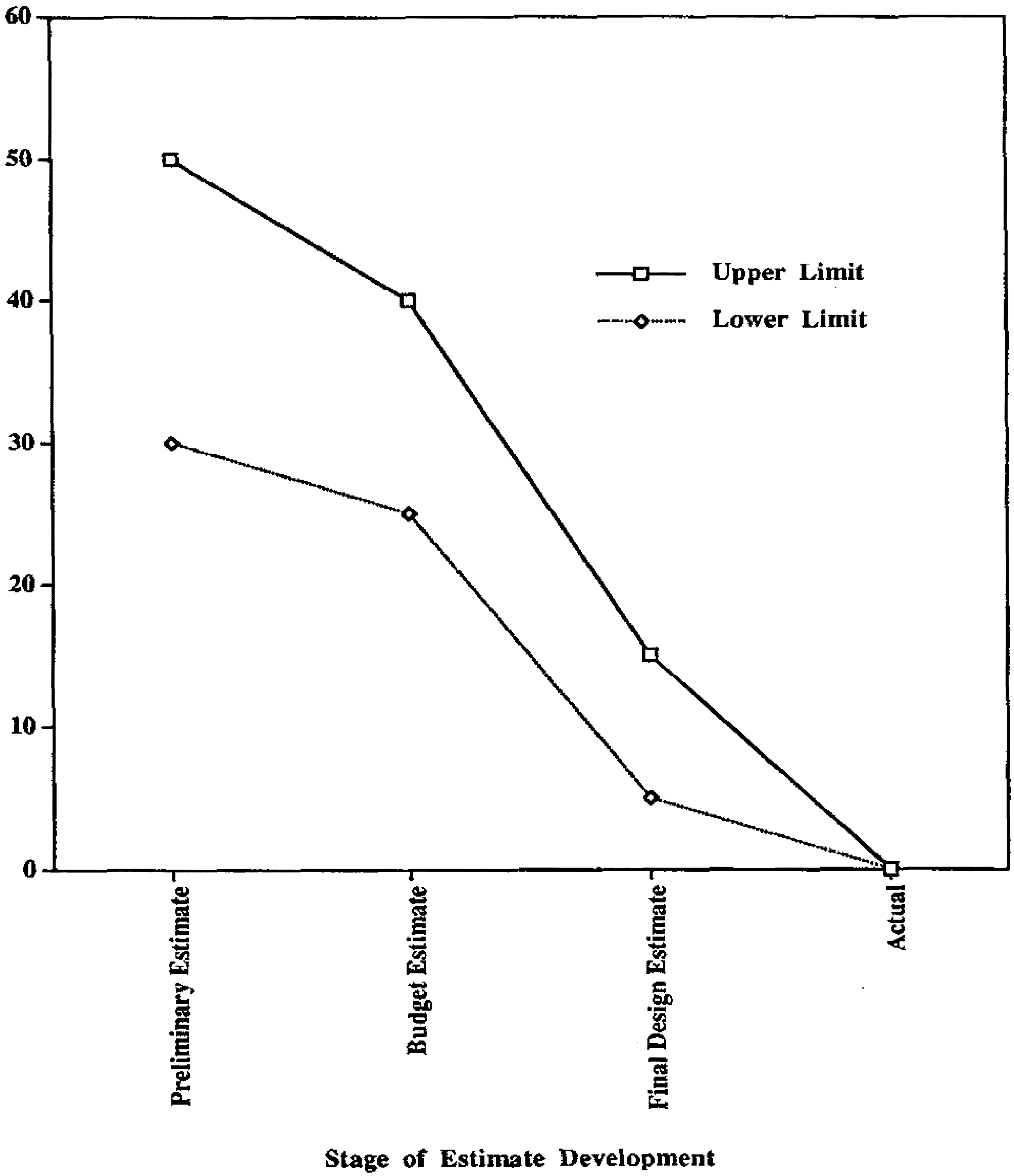

Figure 11-1. Contingency As a Function of Project Life

B. 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 will be discussed below. Table 11-3 lists contingency guidelines for assessment and remediation/cleanup project phases.

1. Assessment Phase

Unlike the remediation phase, the assessment phase does not include the physical construction of a remedy. An assessment determines and evaluates the threat presented by the release 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.

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. 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 more than one assessment may be required.

Other considerations that affect the section of contingency ranges are—

- number of alternatives screened and evaluated;
- level and extent of sampling analysis and data evaluation;
- technical and physical characteristics of a site; and
- level of planning required.

Table 11-3 shows the estimate types for the assessment phase of an environmental restoration project and their corresponding expected contingency ranges. No contingency ranges for planning estimates have been provided. The contingencies become smaller as the project progresses and becomes better defined. However, it should be noted that 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.

Table 11-3. 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%

2. Remediation/Cleanup Phase

For the remediation/cleanup phase, contingency factors are applied to the remaining design work. Remaining design work will use the same contingency factor as established in the ROD, permit, or current baseline for the project. This contingency percentage will depend upon the degree of uncertainty associated with the project, particularly the degree of uncertainty in the scheduled completion dates.

Table 11-3 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.

Other considerations that affect the section of contingency ranges are:

- innovative technology;
- required reliability;
- equipment complexity;
- construction restraints due to continuity of operation security and contamination;
- environmental conditions (weather, terrain, location, etc.);
- scheduling; and
- other unique items to the project such as waste management permits and reviews.

Prior to the completion of a remedial/corrective measure design estimate, the contingency applied to remaining cleanup work will be no more than that established in the ROD, permit, or current baseline for that project. The percent contingency will depend upon the complexity of the work and the degree of uncertainties involved.

When the construction work is defined by definitive design but the cleanup contract has not yet been awarded, a 15 to 20 percent contingency will be provided on the estimated cost. Usually, the cost estimate is based on detailed drawings and bills of material. When the cleanup work is to be performed by a Cost Plus Award Fee contractor, and the contractor has prepared a detailed estimate of the cleanup cost, and it has been reviewed and approved, a contingency of 15 to 18 percent is applied to only that portion of the cost and commitments remaining to be accrued. On fixed-price cleanup contracts where no significant change orders, modifications, or potential claims are outstanding, a contingency of 3 to 8 percent of the uncompleted portion of the work is provided depending upon the type of work involved and the general status of the contract.

C. Contingency Tools - Monte Carlo Analyses Methodology

Many tools are available to assist estimators with contingency. There is no required tool or program, but Monte Carlo analyses may be performed for all major system acquisitions. Monte Carlo or risk analysis is used when establishing a baseline or baseline change during budget formulation. The contingency developed from the Monte Carlo analyses should fall within the contingency allowance ranges in Table 11-1.

Monte Carlo analyses and other risk assessment techniques use similar methodology to obtain contingency estimates; however, for illustrative purposes, the ICECAN program developed for DOE will be discussed in this section.

The estimator must subdivide the estimate into separate phases or tasks and assess the accuracy of the cost estimate data in each phase. After the project data have been input and checked, the computer program will calculate various contingencies for the overall project based on the probability project underrun. The random number generator accounts for the known estimate accuracy. Once the program has completed its iterations (usually 1000), it produces an overall contingency for the project with a certain accuracy.

The following information is an example project estimate that was input into the ICECAN program.

Base Cost	$1,000,000	Fixed Price
Land Rights	40% $100,000 to $250,000 40% $250,000 to $500,000 20% $500,000 to $600,000	Step-Rectangular Distribution
Labor	50% Less than $100,000 20% $100,000 to $200,000 30% $200,000 to $220,000	Discrete Distribution
Profit	Mean = $235,000 Standard Deviation = $25,000	Normal Distribution

The distribution of the ranges is based on the estimator's judgment. For example, the base cost is a fixed price of $1,000,000 with no anticipated change orders. For landrights, 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.

The ICECAN program uses the mean cost calculated by the iterations as the base estimate. With the base estimate, there is a 50 percent probability that the project will be underrun. The results in Figure 11-2 show the contingency that should be used to achieve various probabilities overrun. For example, a contingency of 11.1 percent should be used to achieve an 85 percent probability of project underrun. Therefore, the total cost estimate would be $1,901,842. If the worst case cost of each variable had been used, the total estimate would be $2,080,000 or 21.5 percent contingency.

ICECAN

STIMATE FILE: EXAMPLE   Contingency Report

Cost Estimate: ***$1,711,863

Probability of Underrun	Contingency Required	Contingency + Estimate
0.50	***********$0 (0.0%)	***$1,711,863
0.55	*********$228 (0.0%)	***$1,712,091
0.60	******$33,137 (1.9%)	***$1,745,000
0.65	******$76,269 (4.5%)	***$1,788,132
0.70	*****$111,558 (6.5%)	***$1,823,421
0.75	*****$140,282 (8.2%)	***$1,852,145
0.80	*****$163,372 (9.5%)	***$1,875,235
0.85	*****$189,979 (11.1%)	***$1,901,842
0.90	*****$224,928 (13.1%)	***$1,936,791
0.91	*****$235,725 (13.8%)	***$1,947,588
0.92	*****$248,795 (14.5%)	***$1,960,658
0.93	*****$257,706 (15.1%)	***$1,969,569
0.94	*****$266,618 (15.6%)	***$1,978,481
0.95	*****$278,856 (16.3%)	***$1,990,719
0.96	*****$292,907 (17.1%)	***$2,004,770
0.97	*****$308,836 (18.0%)	***$2,020,699
0.98	*****$321,089 (18.8%)	***$2,032,952
0.99	*****$343,554 (20.1%)	***$2,055,417
1.00	*****$366,427 (21.4%)	***$2,078,290

Figure 11-2. Contingency Data Results

CHAPTER 12

THE SCHEDULE

1. INTRODUCTION

The schedule is one of the building blocks for project development. A schedule helps determine the duration of the project, the critical activities, and when funds are required. This chapter will briefly discuss some scheduling basics.

2. SCHEDULE ELEMENTS/BASIC REQUIREMENTS

The basic elements comprising the schedule consist of the activities in the project, the duration of each activity, and the sequence in which those activities occur.

A. Activities

The activities from a work breakdown structure become the building blocks for a schedule. An activity is any specific element of work.

It is important that activities not be confused with schedule events. Events are indicators of the beginning or completion of an activity. An event milestone is usually one specific point in time, whereas an activity occurs over a period of time.

B. Durations

The activity duration is simply the time required to complete the work involved in a specific activity.

C. Sequence

The sequence of activities refers to the order in which the activities are scheduled to be performed.

D. Critical Path

The longest series or path of interdependent activities of a project is connected end to end. The critical path of a project may change from time to time as activities are completed ahead or behind schedule.

3. SCHEDULE PORTRAYAL

Portrayal of the schedule can occur in a variety of forms. Examples of schedules are bar charts, networks, and lists.

A. Bar Chart

A bar chart represents graphically the different work activities involved in a project. Each activity is usually represented by a time-related bar. See Figure 12-1 for an example of a bar chart.

B. List

Scheduling by means of a list simply involves creating a list of the different activities involved. A list, although easy to prepare and maintain, actually conveys very little information about the job since it does not show the interdependency of activities or constraints.

C. Network

Like the bar chart, a network represents graphically the different work activities. The difference is that the more sophisticated network depicts the activities and their independence and interdependence. Typically, a logic network contains the activities, their durations, their interdependence, and a calculated critical path. Today networks are generated by computer and may also be time scaled.

D. Programmed Evaluation and Review Technique

The Programmed Evaluation and Review Technique (PERT) was developed in the early 1950s for the United States Navy. It was originally developed as a method for expediting completion and has since been modified to include cost. PERT simply employs arrow diagrams to portray a network.

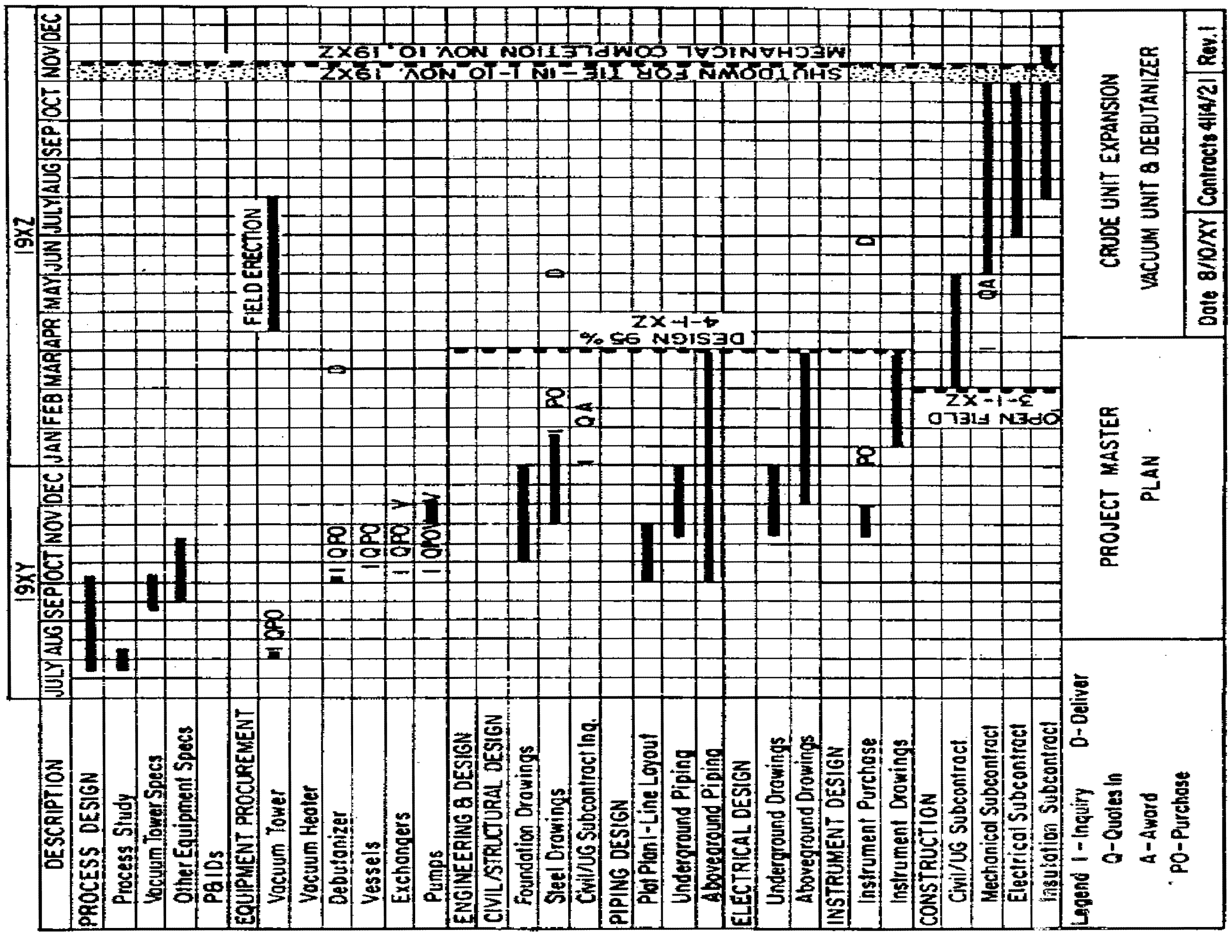

Figure 12-1. Bar Chart Example

4. KEY DECISIONS

Project milestones are called key decisions at DOE. They are as follows.

A. Key Decision 0 (KD-0) - Approval of Mission Need

1. Prerequisite for requesting conceptual design funding in the internal review budget cycle.

2. Approval must occur prior to the planning stages of the annual internal review budget cycle and submission of initial funding requests to OMB and Congress.

3. Documentation Requirement: justification of mission need (JMN).

4. Prerequisite for release of appropriated funding by the Chief Financial Officer (CFO).

B. Key Decision 1 (KD-1) - Approval of New Start

1. Prerequisite for requesting project line item funding in the internal review budget cycle.

2. Approve project plan, including initial project baselines. Initial technical cost and schedule baselines for the project will be based on the CDR and its support documentation.

3. Implement a change control system delineating specific responsibilities, authority, and accountability at the appropriate management levels for changes affecting the project baselines.

4. Other input to the decision process includes completion of the budget validation, the independent cost estimate, and the project data sheet.

5. Prerequisite for release of appropriated funding by the CFO.

It should be noted that for Environmental Management (EM) projects, subsequent key decisions (KD-2, KD-3, and KD-4) have been eliminated in order to streamline the process. After KD-0 and KD-1, the project reports its status with annual Energy System Acquisition Advisory Reviews (ESAARs). The project ESAAR must address the prior year's accomplishments against the year's work plan and present the upcoming fiscal year's work plan, scope, schedule, and cost. In addition, proposed remediation alternatives to support the records of decision scheduled during the fiscal year should also be addressed.

C. Key Decision 2 (KD-2) - Approval to Commence Title II, or Final/Detailed Design

1. Scheduled prior to start of Title II or final/detailed design as identified in data sheet.

2. Input to decision process includes update to the project baselines reflecting completion of preliminary design (Title I) and an independent cost estimate (ICE).

3. Current project plan reflecting approved baseline changes, as appropriate.

4. Approval to begin long-lead procurement, if applicable.

5. Prerequisite for release of appropriated funding by the CFO.

D. Key Decision 3 (KD-3) - Approval to Commence Construction or Enter Full-Scale Development

1. Scheduled prior to date in approved project plan schedule for starting construction or entering full-scale development.

2. Input to decision process is evidence of readiness to proceed, appropriateness of timing, and firm baseline and includes the update of project baselines reflecting the completion of final/detailed design (Title II) and an ICE.

3. Current project plan reflects the approved baseline changes, as appropriate.

4. Prerequisite for release of appropriated funding by the CFO.

E. Key Decision 4 (KD-4) - Approval to Commence Operation/Production

1. Scheduled prior to date in approved project plan schedule for transition from acquisition to operation/production; transition is not formally made until demonstrated capability to meet technical performance goals approved in baseline.

2. Input to decision process is evidence of operational readiness.

3. Prerequisite for release of appropriated funding by the CFO.

5. FUNDING PROFILE

A funding profile indicates costs over time for a project.

A. Definition

A funding profile shows the incremental funds over time required to complete a project. The sum of these incremental amounts equals the total project cost. If a project’s life is several years, all the money required for that project would not be committed when it was initially approved. Based on the initial estimated costs, an amount of money would be set aside to start the project. As the project progresses, money would be allocated to the project. Thus, the schedule and estimate must have a common basis. This common basis is usually the activities that make up the project. Each activity has a duration and a cost associated with it. When the two are linked together, they produce a profile that indicates the cost over time. This can be used to obtain the funding prior to when it is needed. An example of a funding profile is shown as Figure 12-2.

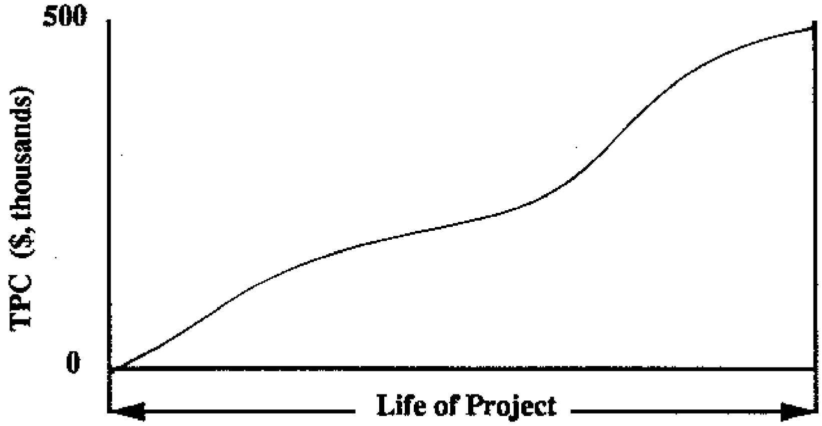

Figure 12-2. Example of a Funding Profile

B. Developing Costs for the Activities

A funding profile is not developed using the greatest level of detail. Therefore, costs must be included in the summary activity. Costs must also be escalated to reflect the dollars that will be needed a few years from today and not what is needed in today's dollars (i.e., unless the entire project is being funded today). Thus, the future activity costs must be escalated.

In summary, each activity will have an escalated cost associated with it. When the costs for each activity are summed in the schedule sequence, a funding profile will be developed.

6. BUDGETARY CONSIDERATIONS

For DOE projects, it is important to forecast not only the expenditures, but also when funds will have to be appropriated by the Congress to support the project schedule. Budget appropriations (BA) is the amount of money that was appropriated by the Congress for the project. Budgetary outlay (BO) is anticipated costs (expenditures). These can be factors to consider when updating the project funding profile. The BO funding profile will always lag the BA profile.

CHAPTER 13

CHECK ESTIMATES
AND INDEPENDENT COST ESTIMATES

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1. INTRODUCTION

Check estimates and independent cost estimates (ICEs) are tools that can be used to validate a cost estimate. Estimate validation entails an objective review of the estimate to ensure that estimate criteria and requirements have been met and a well documented, defensible estimate has been developed. The validation procedure occurs late winter to early spring in the pre-budgetary cycle. Validation is not a direct estimating function; however, estimators need to be aware of the validation cycle to ensure that those projects that require validation are ready for the validation process. This chapter describes check estimates and their procedures and various types of ICEs. DOE Order 5700.2, Cost Estimating, Analysis, and Standardization, also discusses these estimates and can be used as a reference.

2. CHECK ESTIMATES

A. General Definitions

Check estimates are one way that a field office can infuse quality assurance/quality control practices into a cost estimate. These estimates should be developed and performed by a third party who did not participate in the original cost estimate. An "outsider" provides the opportunity for the estimate to be reviewed by a fresh observer. Check estimators should be able to identify any weaknesses in estimate documentation or methodology before these weaknesses have a negative effect on the estimate. For example, if personnel performing the check estimate cannot follow the existing documentation, chances are that the documentation is not sufficient to support the estimate in the approval process.

B. Check Estimate Procedures

General procedures for performing a check estimate are outlined in the following sections. A sample estimate review checklist is provided at the end of this chapter.

1. Review Background Data and Conditions

Before the estimate can be checked, the estimate parameters and requirements must be understood by all personnel performing the check estimate. These conditions provide the framework for the estimate and are what the estimate is compared against. At this time, the check estimator may also want to modify the estimate review checklist based on the estimate criteria.

2. Review Check Estimate Coverage and Scope

During this phase of the check estimate, the original estimate is reviewed and compared against the information gathered in Part A. Check estimators must assess if the estimate satisfies the criteria and conditions.

3. Evaluate the Estimate Methodology

Personnel performing the check estimate must be able to follow and check the estimate methodology. Steps include verifying estimating techniques and sources of estimate data. Check estimators should be able to clearly understand the origin of all numerical data in the estimate.

4. Identify Uncertainties

During this phase of the check estimate, the check estimator should confirm all uncertainties documented in the estimate. Check estimating personnel may also identify other uncertainties in the estimate that were missed or glossed over. It is better to note these uncertainties at this time so that a true, accurate estimate is developed and used.

5. Complete Estimate Review Checklist

Once the estimate has been checked, the results of the check estimate must be documented. Personnel may use an estimate review checklist or prepare a concise written report that documents any findings in the check estimate. A sample estimate review checklist has been included at the end of this chapter.

3. INDEPENDENT COST ESTIMATES

A. General Definition

ICEs are defined as estimates developed by FM-50 for the express purpose of serving as an analytical tool to validate, cross-check, or analyze estimates developed in the proponency channels. ICEs follow a specific procedure and may involve site visits. ICEs are usually performed by a group of cost engineers, the estimator, schedulers, and experts in other disciplines, as required, hereinafter referred to as the ICE team. Estimates not performed by FM-50, but performed for the purpose of validating the official project estimate, are referred to as check estimates or review estimates, not ICEs.

B. Independent Cost Estimate Types

The following techniques will be utilized by the ICE team depending on the stage of the project, the level of documentation available, and the time available.

1. Documentation Review (Type I)

This type of review is not normally accomplished as an ICE, nor does it fulfill the requirements necessary to support an Energy System Acquisition Advisory Board (ESAAB) decision, since it only consists of an assessment of the documentation available to support the estimate. It is merely an inventory of existing documents, not a review, and determines that the required support documentation exists and identifies missing data.

2. Reasonableness Review (Type II)

For this review, the ICE team reviews all available project documentation, receives briefings from the project team, holds discussions with the project team, completes sufficient analysis to assess the reasonableness of the project assumptions supporting the cost and schedule estimates, ascertains the validity of those assumptions, assesses the rationale for the methodology used, and checks the completeness of the estimate. The result is a report that details findings and recommendations.

3. Parametric Estimating Technique (Type III)

This technique, in addition to incorporating all the activities needed for a reasonableness review, uses parametric techniques, factors, etc., to analyze project costs and schedules and is usually accomplished at a summary (WBS) level.

The parametric techniques (including CERs and factors) should be based on accepted historical cost/schedule analyses. At a minimum, these tools should be based on historical estimates from which models have been derived, and, where possible, from actual completed projects. An estimate with a minimum of 75 percent of the total project cost (TPC) based on parametric techniques is classified as a parametric estimate.

4. Sampling Technique (Type IV)

This review also begins with the activities needed for a reasonableness review, but in addition, it requires the ICE team to identify the key cost drivers. A "cost driver" is a major estimate element whose sensitivity significantly impacts the TPC. Detailed independent estimates must be developed, which should include vendor quotes for major equipment and detailed estimates of other materials, labor, and subcontracts. For the balance of the project costs, the project estimate may be used (if deemed to be reasonable through the reasonableness review), or, if appropriate, parametric techniques may be used for certain portions of the project costs. An estimate that provides a detailed cost for all cost drivers is classified as a sampling estimate.

5. Bottoms-up Estimating Technique (Type V)

This is the most detailed and extensive ICE effort, and begins with the activities needed for a reasonableness review. In addition, it requires a detailed bottoms-up independent estimate for both cost and schedule. This involves quantity take-offs, vendor quotations, productivity analysis, use of historical information, and any other means available to do a thorough and complete estimate of at least 75 percent of the project's cost. It may not be possible to do a completely independent estimate on some portions of the PSO estimate, and for those portions—which should not exceed 25 percent of the total estimate—the project estimate may be used if it has passed the test of reasonableness. In all cases, a total cost (both total estimated cost (TEC) and TPC should be developed.

It must be recognized that all estimates will involve a combination of the techniques described in this section, because varying levels of information will be available. The accuracy of the estimate will be subjectively determined based on the weighted totality of the information available.

6. Independent Cost Estimate Content

The ICE is a term that includes all those elements that impact a project's TPC. Therefore, depending on the specific project involved, the ICE will address the reasonableness of the project scope and such activities as:

- direct project costs (equipment, material, labor subcontract),
- indirect costs (overhead),
- NEPA,
- design/site,
- project/construction management (manpower),
- program management,
- research and development,
- startup,

- offsite costs,
- transportation,
- operations,
- remedial investigation/feasibility studies,
- decommissioning and demolition,
- contingency,
- escalation,
- interagency agreements,
- schedule,
- funding profile (including procurement plan),
- progress to date (including estimate to complete), and
- other costs outside DOE.

4. DOUBLE CHECKING THE ESTIMATE

After the estimate has been prepared, a check for completeness and correctness should be made. This check includes but is not limited to the following.

- Check mathematical extensions and additions for correctness;

- Check takeoff for omissions or oversights. For example, a project that is primarily mechanical in nature may have some electrical, structural, civil work, or demolition required with it.

- Compare the construction or cleanup labor hours with the schedule to determine a labor force density. Evaluate whether the labor force density can adequately function on the construction or cleanup site, whether shift work might be required, or whether the total labor hours are adequate to complete the required work. These are judgment considerations, but they are very helpful in finding inadequacies in the estimate.

- Check the calculations of the indirect costs. Verify that the vendor quotations used as direct costs do not include indirect costs.

- Compare the construction or cleanup cost with any similar project for an order of magnitude check.

- Compare the current estimate with the previous estimate and explain any discrepancies.

ESTIMATE REVIEW CHECKLIST

WBS Number:	Review Date:	Review Location:
Program Name:		
Reviewers' Names and Organizations:		
Program Location:	Program Manager:	

	Yes	No	NA	Comments
A. Background Data and Conditions				
• Has a complete technical scope documentation, including the following elements, been prepared for the estimate. ____ Description of the work to be performed; ____ End condition or end product of work; ____ Performance criteria and requirements; ____ Discrete tasks and deliverables; ____ Resource requirements; ____ Sequence of events and discrete milestones; ____ Performance methodology and task plans; and ____ Work not included in the scope.				
• Are the major assumptions used in developing the technical scope for the program clearly identified and justified in the technical scope documentation?				
• Are technical logic diagrams and/or process flow diagrams, where appropriate, included in the technical scope documentation?				
• Have milestone log and milestone description sheets been developed that contain descriptions of each milestone associated with the program?				
• Is the rationale used to develop task descriptions and logic diagrams, milestones, and resource requirements explained in the technical scope documentation?				

	Yes	No	NA	Comments
• Does the technical scope documentation for the estimate include specific activities associated with the work to be performed and activity-based resource descriptions?				
A. Background Data and Conditions (continued)				
• Has an activity dictionary been developed for the program, including detailed descriptions of activities associated with the work to be performed?				
• Does the technical scope documentation for the estimate include descriptions of support activities (e.g., occupational health and safety, quality assurance, security, etc.) associated with the work to be performed?				
• Is back-up documentation (such as production or waste management plans, process technical and engineering data, process output or throughput projections, and historical operating data) available for review, used in scope development, and referenced in the technical scope documentation?				
• Is the technical scope for the estimate consistent with the site mission, regulatory drivers and constraints, and internal and external drivers and constraints (e.g., consent orders, permit conditions, regulations, orders, etc.) identified during the planning process?				
B. Cost Estimate				
• Are historical cost data included in the cost estimate for the activities for which costs have been estimated?				
• Do the historical data used to prepare the cost estimate show each activity costed and show the cost of conducting that activity, broken down into the quantity associated with each activity and the labor cost, material cost, and other costs incurred per unit quantity?				
• Are indirect, overhead, or other costs that are distributed among activities included in the cost estimate clearly and individually identified?				
• Are direct costs that are associated with individual activities included in the cost estimate clearly and individually identified?				
• Are the indirect labor costs used throughout the cost estimate approved and audited, and appropriately and correctly identified?				
• Are unit labor costs broken down into direct costs and indirect costs?				

	Yes	No	NA	Comments
B. Cost Estimate (continued)				
• Has the cost estimate been updated in a timely manner in response to relevant changes in its basis, background data, or assumptions?				
• Are an appropriate change control document and an estimate development history attached to the cost estimate?				
• Does the estimate development history include an itemized and chronological list of the changes made to the cost estimate since initiation of its preparation, and the rationale for each change?				
• Is an estimate purpose statement included in the cost estimate? Does the estimate purpose statement clearly describe the purpose of the estimate?				
• Is the scope of work for the program for which the cost estimate was prepared adequately described and consistent with the planning and technical scope documentation developed through the planning and scoping process?				
• Has an estimate-specific work breakdown structure been developed for the program?				
• Does the estimate-specific WBS organize the work to be performed in a logical and consistent manner?				
• Is the cost estimate activity-based?				
• Are activities, quantities, and unit costs associated with the work to be performed clearly identified and defined in the cost estimate?				
• Has an estimate-specific activity dictionary been developed for the program?				
• Does the estimate-specific activity dictionary describe all activities associated with the work to be performed in a logical and consistent manner?				
• Does the estimate-specific activity dictionary describe all activities associated with the work to be performed in a logical and consistent manner?				
• Are the assumptions and exclusions upon which the cost estimate is based clearly identified and defined in the cost estimate?				

	Yes	No	NA	Comments
B. Cost Estimate (continued)				
• Are time and cost assumptions and cost elements associated with each activity clearly identified, defined, and documented in the cost estimate? Cost elements for program activities include: - quantity; - unit of measure; - labor hours per unit; - total labor hours; - material usage rate per unit; - total material cost; - equipment usage rate per unit; - total equipment cost; - overhead rate; and - total overhead allocated cost.				
• Are significant findings of the cost estimate preparer identified during preparation of the cost estimate included in the cost estimate?				
• Have estimate factors been used to adjust the cost estimate? If so, have they been adequately documented and appropriately applied?				
• Have escalation factors been used to escalate the cost estimate?				
• If escalation factors provided by DOE Headquarters have been used, have they been adequately documented and appropriately applied?				
• If escalation rates other than the provided by DOE Headquarters have been used, have they been audited and approved by DOE Headquarters?				
• Are indirect rates used in the cost estimate adequately documented and appropriately applied?				
• Are estimate summary and detailed reports included in the cost estimate?				
• Do the estimate summary and detailed reports provide cost totals for each activity in the activity dictionary and for each cost element in the cost estimate?				
• Is a schedule included with the cost estimate?				
• Are activities included in the schedule consistent with those included in the technical scope documentation, activity dictionary, and cost estimate?				

	Yes	No	NA	Comments
B. Cost Estimate (continued)				
• Are milestones and deliverables included in the schedule consistent with those included in the technical scope documentation and cost estimate?				
• Is an estimate criteria document included in the cost estimate?				
• Does the estimate criteria document clearly describe the methodology by which the cost estimate was developed?				
• Does the estimate criteria document clearly describe the basis for the cost estimate and the assumptions made in developing the cost estimate?				
• Has the entire cost estimate package (including technical scope and schedule) for the program been subject to peer review by individuals who were not involved in preparation of the cost estimate, but who are qualified to have prepared the cost estimate themselves?				
• Has the peer review considered the elements listed below? - the basis for the assumptions made in developing the cost estimate; - consistency of assumptions made in the cost estimate, technical scope, and schedule; - consistency of definitions of activities in the cost estimate, technical scope, and schedule; - consistency of durations of activities in the cost estimate, technical scope, and schedule; - documentation of productivity and unit cost data for program activities; and - appropriate use of indirect rates, escalation factors, and other factors used by the cost estimate preparer?				
• Have the findings and recommendations of the peer review been documented in a peer review document?				
• Is the peer review document included with the cost estimate documentation?				

	Yes	No	NA	Comments
B. Cost Estimate (continued)				
• Have the findings and recommendations of the peer review been addressed in revisions to the cost estimate?				
• Are activities included in the schedule consistent with those included in the technical scope documentation, activity dictionary, and cost estimate?				

CHAPTER 14

PROJECT CONTROLS

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1. INTRODUCTION

Project controls are systems used to plan, schedule, budget, and measure the performance of a project/program. The cost estimation package is one of the documents that is used to establish the baseline for project controls. This chapter gives a brief description of project controls and the role the cost estimation package plays. Additional information can be found in the Project Control System Guide.

2. COST ESTIMATION PACKAGE USAGE BY PROJECT CONTROLS

The cost estimation package is developed primarily for establishing the project budget and for providing the appropriate documentation and justification for a funding request. Once the project is funded, this package is not filed away. It becomes the baseline or target against which the performance of the project/program can be controlled and compared. By comparing the baseline with the actual performance, deviations from the baseline can be identified and corrected before they cause an impact on the project/program.

A. Technical Scope

As a project develops, some portion of the technical scope may be revised. If there is a deviation from the original technical scope, a change order is initiated and a revision to the original estimated cost usually occurs. Project control can use the detailed technical scope as well as the assumptions made by the estimator when assessing the cost impact of a change in scope. The detailed scope is used as a baseline, and all changes to it are documented by project controls.

B. Schedule

The schedule in the cost estimation package represents the same timeframe as the estimate. Therefore, any change in this schedule could affect the cost of the project/program. Thus, management can compare the baseline schedule to the actual schedule to identify scheduling problems or changes and any associated cost updates.

C. Work Breakdown Structure

The WBS and the organization of the budget cost estimate included in the cost estimation package set the precedence for all estimates throughout the life of the project. The same organization will be used by project controls so any cost changes may be easily tracked against the baseline WBS element.

CHAPTER 15

ESTIMATING METHODS

1. INTRODUCTION

Several techniques are available to help the estimator estimate the cost of a project. Guidance on techniques may be found in the DOE Order 5700.2, COST ESTIMATING, ANALYSIS, AND STANDARDIZATIONS. Based on the project's scope, the purpose of the estimate, and the availability of estimating resources, the estimator can choose one or a combination of techniques when estimating an activity or a project. Estimating methods, estimating indirect and direct costs, and other estimating considerations are discussed in this chapter.

2. ESTIMATING METHODS

The following briefly describes techniques used to estimate.

A. Bottoms-Up Technique

Generally, a work statement and set of drawings or specifications are used to "take off" material quantities required to perform each discrete task performed in accomplishing a given operation or producing an equipment component. From these quantities, direct labor, equipment, and overhead costs are derived and added. This technique is used as the level of detail increases as the project develops.

B. Specific Analogy Technique

Specific analogies depend upon the known cost of an item used in prior systems as the basis for the cost of a similar item in a new system. Adjustments are made to known costs to account for differences in relative complexities of performance, design, and operational characteristics.

C. Parametric Technique

Parametric estimating requires historical data bases on similar systems or subsystems. Data is derived from the historical information or is developed from building a model scenario. Statistical analysis is performed on the data to find correlations between cost drivers and other system parameters, such as design or performance parameters. The analysis produces cost equations or cost estimating relationships that can be used individually or grouped into more complex models. This technique is useful when the information available is not very detailed.

D. Cost Review and Update Technique

An estimate is constructed by examining previous estimates of the same project for internal logic, completeness of scope, assumptions, and estimating methodology and updating them with any changes.

E. Trend Analysis Technique

A contractor efficiency index is derived by comparing originally projected contract costs against actual costs on work performed to date. The index is used to adjust the cost estimate of work not yet completed.

F. Expert Opinion Technique

When other techniques or data are not available, this method may be used. Several specialists can be consulted repeatedly until a consensus cost estimate is established.

3. DATA COLLECTION AND NORMALIZATION

When estimating, cost data is collected. Data may be collected from similar projects, data bases, and published reports. The basis of the cost data should be documented as part of the detailed backup for the estimate. The amount of data collected will depend on the time available to perform the estimate and the type of estimate, as well as the budget allocation for the estimate's preparation.

When using the collected cost data, the estimator must be aware of the source of the data and make adjustments where necessary. Data from one project may not be consistent or comparable with data from a different project. For example, if historical costs data is used, the costs may not be applicable due to escalation, regulatory changes, or geographical differences. The data should be reviewed and adjustments (normalization) should be made before it is used in the estimate. Chapter 19 of this Guide provides more specific information on data normalization techniques.

4. HOW TO ESTIMATE DIRECT COSTS

In the initial stages of project development, estimates must be derived by using various relationships. As the project develops and more detail is available, the estimate also will be in more detail. Following are some general steps that may be used for developing the direct costs of a detailed estimate.

A. Material Takeoff

A material, labor, and equipment takeoff is developed from the drawing and specification review. The amount of detailed takeoff will vary with the amount of design detail. A planning estimate has minimal detail, while a Title II estimate has a great deal of detail. The takeoffs are divided into categories or accounts, and each account has subaccounts. Each project or program should have an established code of accounts. An example of accounts is shown in cost codes for construction projects in Chapter 16. By listing the accounts, a checklist of potential items, and activities that should be included in an estimate is formed. Each account should be considered, even when developing planning estimates, to help eliminate any omissions or oversights.

B. Pricing the Material and Equipment

On fixed price or lump sum contracts, the material cost should be the cost a contractor will pay for the material and does not include any markup for handling by the contractor. Freight at the job site is included in the material cost. Material and equipment that is specified as government furnished equipment (GFE) should be identified and kept separate from contractor furnished material.

Once the quantity takeoff is complete, the next step is to price the individual items. Several acceptable ways of pricing material are by verbal or written vendor quotations, up-to-date catalog price sheets, estimating manuals, and historical data. The current material price should be used whenever possible. If old prices are used, escalation must be added to make the prices current as of the estimate date. Escalation beyond the date of the estimate is included as a separate item.

C. Construction Equipment

Equipment and tools are required to install the materials. Databases can be used to obtain an equipment usage relationship with the materials. Large equipment may be estimated on an activity basis or may be estimated for the duration of the project. Pricing can be obtained from verbal or written vendor quotes, estimating manuals, and from historical data. Current prices should be used whenever possible, or prices should be adjusted to reflect prices at the time of the estimate date.

Some fixed price or lump sum contract projects require special tools or equipment for completion of the work. An example of this is a heating, ventilation, and air conditioning project that might require a large crane for setting an air handling unit on the roof of a building. The cost of the crane would be considered a direct cost. Examples of construction equipment are small tools and pickup trucks. These costs would be included as an indirect cost.

On cost-plus-fixed-percentage contracts, all costs for construction equipment and small tools are considered as direct costs.

D. Labor

Several good publications provide an estimate of the labor hours required for a task that the estimator should use unless adequate experience has given the estimator a more accurate base for determining labor hours required. One important item that must be remembered when using general estimating publications is that these publications are based on a national average construction project for private industry. The situation at various DOE sites may not be the same as an average construction site. Some examples of possible differences are: (1) security areas, (2) remote locations, (3) nuclear radiation areas, (4) degrees of inspection, (5) documentation, etc. For reasons like these, local productivity studies should be conducted to monitor the productivity at the specific site versus the labor hours given in the general estimating publications. If an estimate is derived using the publications, the site productivity factor must be incorporated into the estimated labor-hours. This should be done prior to multiplication of the labor-hours by the labor rate.

When estimating labor costs, the worker’s base rate plus all payroll indirect costs, such as Federal Insurance Contributions Act and payroll insurance, are multiplied by the estimated labor hours to generate the labor cost. Typically, this sum is handled as a direct labor cost. For ease of estimating, an average crew rate can be used and rounded to the nearest even dollar hourly rate.

E. Special Conditions

Consideration must be given to all factors that affect construction. Some of these factors are:

- availability of skilled and experienced manpower and their productivity;
- the need for overtime work;
- the anticipated weather conditions during the construction period;
- work in congested areas or in radiation areas;
- security requirements imposed on the work area; and
- use of respirators and special clothing.

Special conditions may be estimated by applying a factor; for example, 10 percent was applied to the labor hours for loss of productivity due to work in a congested area. Other items may be calculated by performing a detailed takeoff. An example of this would be an activity that could only be performed over a 2-day period. Overtime would be required to complete the activity and the number of hours and rates could be calculated.

F. Government Furnished Material

Labor and equipment costs for installation of Government-furnished materials must be included for each item. They may be estimated as previously discussed. These costs should be kept separate from the labor and equipment costs for the materials the contractor is supplying.

G. Sampling and Analysis Costs

In some remediation projects, sampling and analysis costs are a part of the operations. They may be estimated by using the technical scope requirements to determine the type of sampling and analysis that will be performed and the project schedule to calculate the quantity of samples that will be collected. Costs can be obtained from current vendor quotes or from historical data.

H. Transportation and Waste Disposal

If waste disposal is required as part of a project, the waste classification must be identified. Based on the waste classification, disposal options can be identified. If waste is landfilled, the nearest appropriate landfill can be identified so transportation and disposal costs can be calculated.

I. Environmental Management Considerations

The same principles used for the determination of direct costs associated with construction estimates can be applied to environmental restoration and waste management estimates. In addition to the factors to consider for construction projects, the following factors should also be considered for an EM project.

- EM activities are often required to adhere to multiple regulations; most, if not all, of DOE's EM activities will be required to adhere to guidelines established by different regulatory regimes.

- EM activities usually require considerable sampling and analysis throughout the course of the project.

- EM usually includes waste transportation and disposal, which can be quite costly. The classification of the waste should always be identified as the basis of the estimate.

- The estimates developed are usually more parametric in nature than conventional construction estimates.

- Some projects may have on-site capabilities such as laboratories. This can affect the project cost if it is to be set up for this project or if it is an existing facility. Special facilities such as decontamination units are required. These are a direct cost to the project.

5. HOW TO ESTIMATE INDIRECT COSTS

A. Each Indirect Cost Account

The indirect costs may be included as part of the code of accounts for a project. One method to estimate the indirect costs is to assign a cost to each cost account. This must be based on the size and type of contract and could be a lengthy list. This method requires a great deal of experience and a working knowledge of the construction firm's experience.

B. Percentage

A multiplier from a local data base or from published cost manuals can be developed. Figure 15-1 is a chart that was developed over a set time frame for the average indirect costs of various fixed-price contractors working at the Idaho National Energy Laboratory. To use the chart, the ratio of direct cost material to labor must be determined. This ratio is plotted at the bottom of the graph. A vertical line is drawn from this point to intersect with the curve. The multiplier is read on the left-hand side of the graph and this multiplier is applied to the direct cost to determine the estimated indirect cost. All field offices and laboratories are encouraged to develop these local charts.

C. Government Furnished Equipment

If a project has "government furnished equipment and materials" that the contractor must install, an additional amount of 5 to 10 percent of the value of the GFE must be added to cover the contractor's risk, insurance, and paperwork.

D. Special Considerations

Landlord costs for conventional construction projects include field support activities and are funded by Headquarters. If more than one tenant is located on a site, some of the infrastructure (i.e., indirect costs) may be shared. These costs should be kept separate where they can be easily identified in order to avoid "double-dipping" these indirect costs.

For EM projects, landlord costs can include provisions for compliance oversight and long-term surveillance and monitoring. As an example, assume that groundwater contamination had occurred at a site. Groundwater remediation will be required long after a site's surface has been remediated. The project estimate should include costs for long-term sampling associated with of the groundwater remediation.

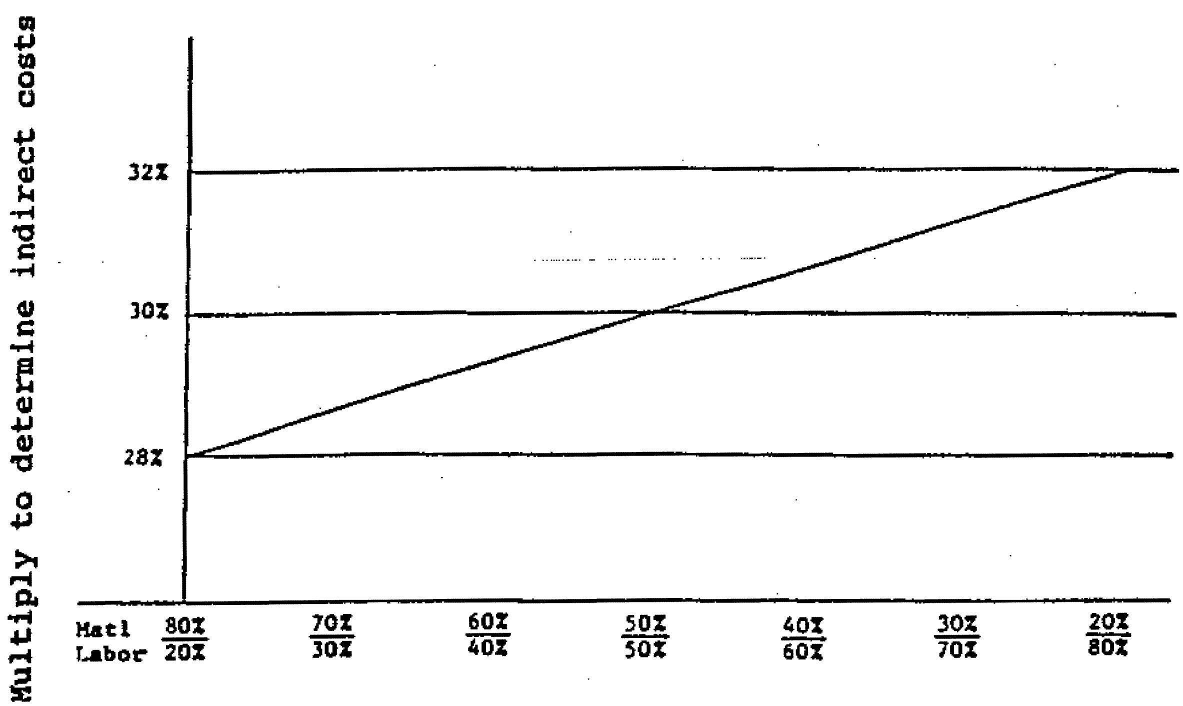

Figure 15-1. Idaho National Energy Laboratories Indirect Costs (1988)

6. GUIDELINES FOR MANAGEMENT COSTS

The estimate for management costs is largely a function of the duration of the project from the start of Title I through completion of construction.

A. Construction Management

A construction manager (CM) is responsible for construction activities. This responsibility includes subcontracting, purchasing, scheduling, and a limited amount of actual construction. Chapter 3 is intended as a guideline for determining whether cost elements should be included as project management, construction management, or project support, and should be followed by all DOE Field Offices and contractors.

Generally, CM costs are approximately 5 to 15 percent of the sum of the direct costs, indirect costs, and GFE whose installation is under the direction of the CM.

B. Project Management

The estimate for project management must consider the time element from start of Title I design through completion of the construction for the project. Other factors to consider are the complexity of the project, the design group, the organization for which the project is to be performed, and the extent of procured items. Projects involving travel must also include those costs. Typically, project management costs range from 2 percent to 5 percent of the total project cost.

C. Construction Coordination

Construction coordination includes a field engineer. The field engineer should be involved in the review of the Title I and II documents, as well as coordinate field construction. This function is generally estimated to be about .5 to 1 percent of the construction costs.

D. Quality Engineering

For the quality engineering estimate, the tasks for the project must be defined, and the man-hour effort with the quality organizations should be negotiated. The estimate will depend upon the quality level of the project, the amount of procurement effort, and level of involvement of the quality inspection organization. Where the latter is involved, quality engineering is responsible for the preparation of the quality plan. Travel must also be considered. The portion of quality engineering that is an audit function is not funded by construction and need not be included in the estimate.

E. Health and Safety

This function is involved with the review and approval of the design package as well as the safety audits and health physics surveillance throughout the course of the construction period. Factors affecting this element are the type of project, operational area where the construction takes place, the amount of work requiring radiation surveillance, and any other special health and safety requirements. The portion of health safety that is an audit function is not funded by construction and need not be included in the estimate. This is typically estimated by taking from .5 to 1 percent of the total construction costs for conventional projects and would be more than that for a remediation job.

F. Environmental Restoration Management Contractor

Construction management costs for environmental restoration projects are those activity management services required to manage construction or cleanup activities, including review and approval of cleanup bid packages, review and acceptance of construction test procedures, control of field design change requests, and review and approval of contractor pay requests. The Environmental Restoration Management Contractor manages and executes the Environmental Restoration Program for a site.

G. Program Management

Activity management associated with environmental restoration parallels construction project management. However, when estimating activity management, consideration must also be given to program management.

Program management consists of those services provided to the DOE on a specific program for planning, organizing, directing, controlling, budgeting, and reporting on the program. Program management will be provided as multiple levels within the EM program including the Headquarters, Operations Office, and installation. Program management includes program support. Program support covers those activities performed for internal management and technical support of the program by part-time or full-time personnel.

CHAPTER 16

EXAMPLE COST CODES FOR CONSTRUCTION PROJECTS

1. INTRODUCTION

This chapter provides an example outline of cost items and their corresponding cost codes that may be used for construction projects. These cost items are divided into 11 general groups (A-K) known as Level 1 cost items with their respective Level 1 cost codes. Each cost item is broken into specific items known as Level 2 cost items and has a Level 2 cost code associated with it. Following each outline of cost items, Level 1 and 2, is their description.

2. OUTLINE OF THE LEVEL 1 COST CODES FOR CONSTRUCTION PROJECTS

An outline and brief explanation of the Level 1 cost codes in the common cost code of accounts are as follows:

Level 1 Cost Item	Level 1 Cost Code
Land and Land Rights	400
Improvements to Land	460
Buildings	501
Other Structures	550
Utilities	600
Special Equipment/Process Systems	700
Improvements for Others	800
Demolition	810
Tunneling	820
Drilling	830
Standard Equipment	860

A. Land and Land Rights (400)

This cost code includes the purchase price, other acquisition costs, and removal costs less salvage realized in disposing of any facilities acquired with the land. Some specific items are as follows.

- the costs of rights, interests, and privileges relating to land, such as leaseholds, easements, rights-of-way, water and waterpower rights, diversion rights, and submersion rights;

- the cost and appraised value of timber and pulpwood; cost of reforestation program for the purpose of dust and soil erosion control, retention of water tables, etc.; cost of development and improvement of timber stand; and other forestry management costs; and

- the cost of mineral rights and land containing mineral deposits owned by the Government.

B. Improvements to Land (460)

This cost code includes the cost of general site clearing, grading, drainage, and facilities common to the project as a whole (such as roads, walks, paved areas, fences, guard towers, railroads, port facilities, etc.), but excludes individual buildings, other structures, utilities, special equipment/process systems, and demolition, tunneling and drilling when they are a significant intermediate or end product of the project.

C. Buildings (501)

This cost code includes the installed cost of buildings and permanently attached appurtenances, such as fire protection, lighting, plumbing, heating, ventilation, and built-in air conditioning systems (excluding window or console air conditioning units that require no ductwork or cooling towers), and the cost of piping, conduit, and cable permanently attached to and made a part of the building. The division between building costs and the costs of utility systems is generally made at a point nominally 5 feet outside the building wall.

D. Other Structures (550)

This cost code includes the installed cost of such structures as dams, retention basins, reservoirs, swimming pools, pits, platforms, underground oil storage reservoirs, and stacks (when not a part of a building), and installed cost of structures and frames used to support such items as heat exchangers, vessels, etc., or special structures, such as towers, utility doors, etc., whether inside or outside a building.

E. Utilities (600)

This cost code includes the installed cost of systems that service the project as a whole and generally extend between individual buildings or process units. Examples include communications systems, electric transmission and distribution systems, alarm systems, gas transmission and distribution systems, irrigation systems, sewerage systems, steam generation and distribution systems, water supply, pumping, treatment and distribution systems, and oil piping and distribution systems.

F. Special Equipment/Process Systems (700)

This cost code includes the installed cost of large items of special equipment and process systems, such as vessels (e.g., towers, reactors, storage tanks), heat transfer systems (e.g., heat exchangers, stacks, cooling towers, desuperheaters, etc.), package units (e.g., waste treatment packages, clarifier packages, sulfurization, demineralization, etc.), and process piping systems.

G. Improvements for Others (800)

This cost code includes the cost of improvements made by DOE to land, buildings, structures, building services, and utility systems not owned by DOE. Plants, laboratories, and similar facilities constructed by DOE on land owned by others are not to be classified in this category.

H. Demolition (810)

This cost code includes the cost of wrecking, dismantling, cutting, drilling, and removing existing structures, equipment, and materials, as well as any excavation required to facilitate demolition and the cleaning, stacking, loading, hauling, and unloading of material for salvage and/or disposal when such activity represents a major activity in accomplishment of the project. Minor, routine demolition will be listed under improvements to land.

I. Tunneling (820)

This cost code includes the complete costs of constructing a tunnel consisting of excavation, drilling, blasting, mucking, shoring, timbering, bolting, mechanical utilities (air, water, and vent lines), surface construction installation (shaft collars, portal facings, retaining walls, rock, volts, fences, gates, hatches, doors, muck dumping facilities, anchors, guys, deadmen, buildings, foundations, docks, etc.), and associated mobilization and demobilization.

J. Drilling (830)

This cost code includes the complete cost of drilling consisting of purchase or lease of the drilling rig and associated material mandrels, jet subs, drill collars, drill pipe, kellys, goosenecks, casing, detergent, mud additives and other chemicals, tool repair, installing casing (double jointing, lugging, cutting lifting eyes, belling, and installing guidelines), installing the drilling rig, correcting problems (plugback to correct well bore deviations), cleaning out and conditioning the hole, coring, sidewall, sampling, dewatering, fishing, laboratory support, building support structures, and safety fences.

K. Standard Equipment (860)

This level includes items of equipment in which only a minimum of design work is required, such as "off-the-shelf" items. Examples of standard equipment include office furniture, laboratory equipment, heavy mobile equipment, etc. Items of standard equipment that are incorporated into Second Level code systems will be included with that system and not under standard equipment.

3. OUTLINE OF LEVEL 1 AND LEVEL 2 COST CODES

Below is an outline of the Cost Codes of a general construction project:

Level 1	Level 2	Cost Items
400		Land and Land Rights
	4010	Land
	4020	Land Rights
	4030	Minerals
	4040	Timber
460		Improvements to Land
	4601	Site Preparation
	4602	Drainage
	4603	Landscaping
	4605	Railroads
	4606	Port Facilities
	4700	Roads, Walks and Paved Areas
	4800	Fences and Guard Towers
	4900	Other Improvements to Land
501		Buildings
	5011	Excavation and Backfill
	5012	Concrete
	5013	Masonry
	5014	Metals
	5015	Wood and Plastic
	5016	Finishes
	5017	Special Construction
	5018	Mechanical

	5019	Electrical
550		Other Structures
	5501	Excavation and Backfill
	5502	Concrete
	5503	Masonry
	5504	Metals
	5505	Wood and Plastic
	5506	Thermal and Moisture Protection
	5507	Special Construction
	5508	Mechanical
	5509	Electrical
600		Utilities
	6100	Communications Systems
	6150	Electric Transmission and Distribution Systems
	6210	Alarm Systems
	6250	Gas Transmission and Distribution Systems
	6300	Irrigation Systems
	6400	Sewerage Systems
	6450	Steam Generation and Distribution Systems
	6500	Water Supply, Pumping, Treatment and Distribution Systems
	6600	Oil Piping and Distribution Systems
	6900	Other Utilities
700		Special Equipment/Process Systems
	7010	Vessels
	7020	Heat Transfer
	7030	Mechanical Equipment
	7040	Package Units
	7050	Process Piping
	7060	Electrical
	7065	Instrumentation
	7070	Protective Cover
	7080	Reactor Components

800		Improvements for Others
810		Demolition
820		Tunneling
830		Drilling
860		Standard Equipment
	8610	Heavy Mobile Equipment
	8615	Hospital and Medical Equipment
	8620	Laboratory Equipment
	8625	Motor Vehicles and Aircraft
	8630	Office Furniture and Equipment
	8635	Process Equipment (for Mfgr.)
	8640	Railroad Rolling Stock
	8645	Reactors and Accelerators
	8650	Portable Security and Protection Equipment
	8655	Shop Equipment
	8660	Reserve Construction Equipment Pool
	8670	ADP Equipment
	8699	Miscellaneous Equipment

4. DESCRIPTION OF LEVEL 2 COST CODES

A. 400 Land and Land Rights

1. 4010 Land

This includes the purchase price, other acquisition costs, and removal costs less salvage realized in disposing of any facilities acquired with the land. Some specific items are as follows.

a. Cost of Land: This includes costs incurred in acquiring land, such as purchase price, amounts paid other Federal agencies, and other acquisition costs.

b. Removal of Existing Structures: This includes the cost of labor and materials for demolition and removal of buildings and other structures, acquired with the purchase or acquisition of the site, that are not usable.

c. Cost Recoveries: This includes the amounts received from cash sale of net transfer values of buildings and other structures, acquired with the purchase or acquisition of the site, on which disposal is made.

d. Relocating Highways and Highway Bridges: This includes all costs required in relocation of highways made necessary by construction of the project.

e. Relocation of Railroads and Railroad Bridges: This includes relocation of railroads made necessary by construction of the project.

f. Relocation of Public Utilities: This includes relocation and protection of public utility properties, such as electrical, communications, water, etc.

g. Cemeteries: This includes disinterment, transportation, and reinterment of remains.

h. Families: This includes relocation of displaced families.

i. Municipal Facilities: This includes relocation and protection of sewage systems, water systems, streets, and other municipal facilities.

j. Industrial: This includes relocation and protection of industrial facilities.

k. Other Structures and Improvements: This includes relocation and protection of buildings and improvements not elsewhere provided for in the cost codes.

2. 4020 Land Rights

This includes the costs of rights, interests, and privileges relating to land, such as leaseholds, easements, rights-of-way, water and waterpower rights, diversion rights, and submersion rights.

3. 4030 Minerals

This includes the cost of mineral rights and land containing mineral deposits owned by the Government.

4. 4040 Timber

This includes the cost and appraised value of timber and pulpwood, cost of reforestation program for the purpose of dust and soil erosion control, retention of water tables, etc., cost of development and improvement of timber stand, and other forestry management costs.

B. 460 Improvements to Land

1. 4601 Site Preparation

a. This includes labor and material required for surveying and mapping, subsurface investigating, clearing, excavating, and backfilling to bring area to a general grade. This cost code includes digging test trenches required during construction, demolition, disposing of surplus materials, maintaining spoil areas, and related work.

b. This excludes specific grading and base materials for roads, walks, drives, and parking areas; grading for culverts and culvert headwalls; final grading (see Landscaping); grading for railroads; and marginal and drainage ditches that are included in other accounts.

c. Some specific examples of items included in this account are as follows.

1. Clearing, Grading, and Backfill: This includes the cost for clearing, digging test trenches, and grubbing required during construction; machine and hand excavation; backfilling and compacting of earth and stone either by hand or by mechanical and pneumatic equipment; disposing of surplus materials; maintaining spoil areas; and related work. This cost code does not include specific grading or base materials for roads, drainage ditches, etc. (See second level cost code description.)

2. Pumping and Dewatering: This includes the cost for handling, installation, operation, and removal of pumps and appurtenances required for dewatering of areas.

3. Subsurface Investigation: This includes labor and material costs associated with subsurface investigations to include borings, core drilling, standard penetration tests, seismic explorations, testing, analysis, laboratory reports, etc.

4. Surveys and Mapping: This includes all costs incurred in connection with locating, marking, or otherwise identifying areas within or about the construction site.

5. Demolition: This includes the cost for demolition of existing on-site facilities to facilitate clearing of the site.

6. Bore Holes: This includes labor and material required to physically locate, identify, backfill, plug, compact, fine grade, landscape, and test any existing bore holes.

2. 4602 Drainage

a. This includes labor and material required for the installation of all storm sewers and drains for the area between points 5 feet outside the building lines. This cost code includes all work for storm sewer manholes, headwalls, precast concrete, concrete slabs, cast-in-place concrete, street storm water receivers and outfall drainage ditches, and all drainage in the switchyard.

b. This excludes culverts and marginal ditches along roads, paved areas, railroads, and cooling ponds or sewage lagoons.

c. Specific elements of this account are the following.

1. Installed Equipment: This includes the cost of labor, material, and installed equipment that is applicable to the work described in the second number account. Cost of equipment includes invoice price and transportation when charged directly. Costs for each size and type of equipment included in this cost code should be readily identifiable in the cost code or supporting records.

2. Excavation and Backfill: This includes the cost required for excavation shoring, backfilling, and removal of surplus material for subsurface piping, manholes, ditches, and catch basins, from a point 5 feet outside the building line. It excludes culverts and marginal ditches along roads, paved areas, and railroads (see second level cost code description). It includes all rip-rap work for storm ditches.

3. Catch Basins and Manholes: This includes the cost required for forming, hauling, reinforcing, placing, curing, protecting, and finishing concrete for manholes, catch basins, headwalls, and drainage ditch slabs. It includes all rip-rap work for storm ditches.

4. Piping: This includes the cost required for installation of cast iron pipe, corrugated metal pipe, and concrete pipe for the storm sewer system, from a point 5 feet outside the building line.

3. 4603 Landscaping

This includes labor and material for final grading and landscaping the area. This cost code includes applying or planting such items as topsoil, fertilizer, seeds, seedlings, sod, and shrubs.

a. Final Grading: This includes the cost for bringing the area surface to its final elevation.

b. Landscaping: This includes the cost for applying or planting topsoil, fertilizer, seeds, seedlings, sod, shrubs, and other similar items,

4. 4605 Railroads

a. This includes labor and material required for installing railroad trackage outside of building limits. This cost code includes excavation, backfill, compacting, fine grading, setting of ties and rails, hauling and spreading of ballasts, construction-related culverts, bridges, and headwalls, and installing warning systems and guard gates.

b. It excludes railroad cars, engines, and other railroad equipment that will operate on the track.

c. Some specific examples of items included in this account are as follows.

1. Installed Equipment: This includes the cost of labor and materials and installed equipment that is applicable to the work described in this cost code. Cost of equipment includes invoice price and transportation when charged direct. Costs for each size and type of equipment included in this cost code should be readily identifiable in the cost code or supporting records.

2. Excavation: This includes the cost for preparing roadbed for trackage. It includes excavating, backfilling, compacting, fine grading, and marginal ditches.

3. Track Laying and Surfacing: This includes the cost for hauling and placing ties, rails, ballasts, and other track materials, such as angle bars, frogs, guardrails, track bolts and nuts, rail joints, switches, spikes, and related work.

4. Special Drainage Structures: This includes the cost for excavating, hauling, and placing drain pipe. It includes forming, reinforcing steel and concrete required for culverts, bridges, and headwalls.

5. Warning Systems and Gates: This includes the cost for the complete installation of railroad warning systems and gates.

5. 4606 Port Facilities

a. This includes labor and material required for constructing a port facility. This cost code includes excavation, backfill, compacting, and construction involved in building docks, piers, levies, jetties, anchorages, and other parts of a port facility.

b. Some specific examples of items included in this account are as follows.

1. Installed Equipment. This includes the cost of labor, materials, and installed equipment that is applicable to the work described in this cost code. Cost of equipment includes invoice price and transportation charge when direct.

2. Erosion Control: This includes the cost of preparing retaining walls, levies, jetties, etc. This includes excavating, backfilling, compacting, and construction materials (including forms and rockfill).

3. Piers: This includes the installed cost of concrete or timber piers, including any track or road surface that runs along its length.

4. Buoys and Warning Systems: This includes the installed cost of channel buoys, warning buoys, warning lights, horns, whistles, and other safety devices or systems.

6. 4700 Roads, Walks, and Paved Areas

a. This includes labor and material required for the stripping, grading, backfilling, compacting, and application of base and surface materials for permanent roads, walks, and paved areas. It includes bridges, culverts, and culvert headwalls over drainage areas, grading of road and marginal ditches, construction and painting of curbs and fabricating or installing guardrails, traffic barriers, and incidental appurtenances and stripping.

b. This excludes any work for railroad track and grade crossings (see Railroads).

c. Elements to be included are the following.

1. Excavation, Grading, and Backfill: This includes the cost for machine and hand excavation, stripping, grading, backfill, and disposal of surplus materials.

2. Surfacing: This includes the cost for hauling, placing, treating, compacting macadam, asphalt, concrete, and other wearing surfaces, and stripping.

3. Drainage Structures and Bridges: This includes the cost for installing drains, culverts, and bridges over drainage areas and grade crossings. It includes all concrete and related items.

4. Guard Rails, Posts, and Traffic Barriers: This includes the cost for all work to fabricate and install protective barriers and necessary stripping.

5. Curbs: This includes the cost of installing curbs and painting.

7. 4800 Fences and Guard Towers

a. This includes labor and material required for security fences and gates for the area and all work for erecting guard towers and gatehouses, complete with interior electrical work.

b. This excludes floodlights and exterior electrical work (see Utilities).

c. Elements to be included are the following.

1. Security Fences: This includes the cost for handling, hauling, excavating, erecting, aligning, and other work to install fence posts, fabric, and all necessary gates, including grounding and electric gate operators.

2. Gatehouses and Guard Towers: This includes the cost for complete installation of foundations and superstructures. It excludes exterior electrical work and floodlights (see Utilities).

8. 4900 Other Improvements to Land

This includes the installed cost of any improvement to land not included in codes 4601 through 4800, except demolition, tunneling, and drilling, which are listed under accounts 810, 820, and 830, respectively. Improvement to land belonging to others will be included under account 800.

C. 501 Buildings

1. 5011 Excavation and Backfill

a. This includes labor and material required for building foundations, including excavation, disposal, and backfill for footings, grade beams, pads, pits, manholes, and other subsurface structures. It also includes pumping, dewatering, compacting, fine grading, and selected materials for fills.

b. Specific elements of this account are the following.

1. Excavation: This includes the cost for machine and hand excavation and disposal of surplus material.

2. Backfill: This includes the cost for backfill and compacting of earth, stone, or other selected materials, either by hand or by mechanical and pneumatic equipment.

3. Pumping and Dewatering: This includes the cost for handling, installation, operations, and removal of pumps and appurtenances required for dewatering excavated areas.

4. Fine Grading: This includes the cost for fine grade work preparatory to ground floor slab construction, including borrow and backfill of fine grade selected materials.

5. Rock Removal: This includes the cost of removing rock during excavation, including drilling, blasting, breaking, loading, hauling, and disposing of surplus materials.

2. 5012 Concrete

a. This includes all building concrete, including concrete on or below grade, major concrete slabs, floors above grade, equipment foundations, and miscellaneous concrete (such as thresholds, stairs, lintels, curbs, walks, etc.). Specifically, it covers labor and material required for forming, placing, and waterproofing of concrete for building foundations, piers, grade beams, walls, columns, and slabs. It includes all work in connection with related reinforcing steel, concrete encasement of structural steel columns, and any precast concrete. It includes labor and materials required for forming, placing of major concrete slabs or floors above grade, including integral beam construction and all work in connection with related reinforcing steel mesh. It covers labor and material required for forming and placing of foundations for building equipment, including all work in connection with related reinforcing steel, and covers labor and material required for forming and placing of concrete for items not otherwise covered above, including all work in connection with related reinforcing steel, as well as thresholds, stairways, landings, penthouse floor slabs, lintels, curbs, walks, and minor floor slabs.

b. This cost code excludes all work in connection with the construction of instrument tunnels, foundations for process equipment, and piping (except the embedded structure support).

c. Specific elements of this account are the following.

1. Forms and Screeds: This includes the cost for hauling, fabricating, erecting, stripping, cleaning, and disposing of form work and screeds.

2. Concrete: This includes the cost for hauling, placing, curing, finishing, protecting, and repairing of concrete.

3. Form Ties, Keyways, Inserts, and Joints: This includes the cost for hauling, fabricating, and inserting of form ties, keyways, inserts, and premoulded expansion material.

4. Precast Concrete: This includes the cost for hauling, handling, and placing all precast concrete items.

5. Waterproofing: This includes the cost in connection with waterproofing required for concrete ground floor slab.

6. Reinforcing Steel and Mesh: This includes the cost of labor for handling, hauling, bending, fabricating, placing, tying, and cleaning of reinforcing steel and mesh.

7. Floor Hardener: This includes the cost of labor for cleaning of concrete slabs, preparing, and applying floor hardener.

8. Foundation Drains: This includes the cost of labor for installing building foundation drain piping.

9. Anchor Bolts and Sleeves: This includes the cost for handling, fabricating, aligning, and setting of anchor bolts for building superstructure and sleeves. This cost code excludes grouting and setting of base plates and miscellaneous structural steel and iron (see second level cost code description).

3. 5013 Masonry

a. This includes labor and material used in masonry building construction. Account includes the hauling, rehauling, handling, erecting, and setting of brick, adobe, structural glazed tile, masonry, concrete unit masonry, high-lift grouted masonry, tile, terra cotta veneer, glass unit masonry, stone, simulated masonry, and refractories (such as flue liners, combustion chambers, firebrick, and castable refractory materials). This includes the cost of mortar, aggregate anchor irons, angle iron, filler, fireproofing, furring, lintel, and the costs of hauling sand, aggregate and mortar, mixing, and carrying it to the work site, scaffolding, and other devices required for masonry construction. Chemicals added to the mortar, including coloring and antifreeze, will also be included, as well as cleanup and conditioning of the job site.

b. Specific examples are the following.

1. Masonry: This includes the cost for hauling, handling, placing, and construction of masonry and concrete block unit walls and partitions, and related scaffolding, bracing, repairing, waterproofing, and finishing. This cost code excludes painting.

2. Face Tile: This includes the cost for hauling, handling, and installation of face tile, and related scaffolding, bracing, and cleaning and washing of face tile after installation.

4. 5014 Metals

a. This includes labor and material required for building superstructure steel, including crane rail and all members framed directly into the superstructure and purchased with the structural steel. The account includes fabrication, handling, hauling, erecting, and setting of base plates required to completely install the structural steel. This cost code will be used for procurement and erection of prefabricated, pre-engineered structures. It includes labor and material required for process pipe structural steel supports and hangers, related base plates, stair and platform stringers, gratings, handrails, valve operating platforms, ladders, structural steel door subbucks, filter and louver structural steel frames, trapeze hangers serving more than one item, railroad track in truck alley to the 5-foot line of building, interior and exterior metal door frames, toeplates, hatch frames, wire partitions, thresholds, door and window lintels, metal sleeves in the building structure, miscellaneous iron embedded in concrete, equipment support structure at the time of placing, and other miscellaneous structural steel and iron.

b. This cost code excludes anchor bolts for building superstructures and base plates included with process equipment.

c. Some specific elements are the following.

1. Base Plates: This includes the cost for handling, hauling, setting, and grouting of base plates required to completely install the structural steel. This account excludes base plates for process gas piping and those included with process equipment (see second level cost code description).

2. Steel Handling and Erection: This includes the cost for handling, hauling, reloading, rehauling, shaking out, erecting, plumbing, and riveting or welding of structural steel for building superstructure.

3. Hangers and Supports: This includes the cost for fabricating, handling, hauling, and installing trapeze-type hangers and supports.

4. Railroad Track in Truck Alley: This includes the cost for installing rail and related items, such as metal ties, tie plates, and bumper blocks.

5. Structural Steel: This includes the cost for handling, hauling, erecting, plumbing and bolting, and riveting or welding of miscellaneous structural steel.

6. Embedded Steel and Iron: This includes the cost for fabricating, handling, hauling, setting, and grouting of anchor bolts and base plates required for miscellaneous structural steel and iron, including related caulking.

7. Equipment Support Structure: This includes the cost of labor for fabricating, handling, hauling, and installing the equipment support structures.

8. Pre-Engineered Structures: This includes all costs necessary for procurement of the pre-engineered, prefabricated structures.

5. 5015 Wood and Plastic

a. This includes labor and material required for building structural frames made of wood or plastic construction. The account includes framing and sheathing, wood decking, fiber underlayerment, timber trusses, pole construction, trestles, wood treatment, and associated hardware items, such as nails, screws, bolts, glue, and other fasteners. It includes wood stairs and railings and any wood used to secure, protect, or in any way provide safety at the building site, including safety rails, safety fences, temporary ladders, temporary overhangs, or ceilings. It includes all plastic used to wrap or protect the materials exposed to the elements at the building site.

b. This excludes wood or plastic used for earthwork and concrete forms.

c. Some specific examples are the following.

1. Framing and Erection: This includes the cost for handling, hauling, reloading, erecting, and fastening of structural wood for the building superstructure.

2. Decking: This includes the cost of fabricating, handling, hauling, and installing decking.

3. Temporary Safety Structures: This includes the cost of fabricating, handling, hauling, and installing temporary structures made of wood that are used to protect the work site, including the digging, emplacement, and fastening of posts and poles.

6. 5016 Finishes

a. This includes accounts that generally fall under the broad categories of thermal and moisture protection, doors and windows, finishes and specialties. This account covers labor and material required for construction and revision of built-up roofing, including flashing, caulking, scuppers, gutters, sheet metal conductors, hatch covers, and insulation and repair of damaged roofs and roofing items. It also includes metal, precast or poured roof decks, other-than-reinforced concrete slabs, and special expansion joints and cap flashings.

b. This excludes roofing items included with pre-engineered structures.

c. Specifically included are the following.

1. Roof Construction: This includes the cost for hauling, handling, and installation of roofing, including revisions, and roof insulation.

2. Roof Repairs: This includes the cost for repairing completed or partially completed roofs that have been damaged by construction operations, high winds, or weather damage.

3. Roof Decks: This includes the cost for installing metal, precast or poured decks, other-than-reinforced concrete slabs, and installation of hatch covers.

4. Expansion Joints, Flashings, and Conductors: This includes the cost for hauling, fabrication, erection, and installation of special expansion joints and cap flashings for building roofs, scuppers, gutters, gravel stops, sheet metal conductors, and similar items.

5. Roof Accessories: This includes the cost for hauling, fabrication, erection, and installation of skylights, roof hatches, and gravity ventilators.

d. This includes labor and material required for the installation of building siding, insulation, flashing, caulking, special expansion joints, and minor repairs. This cost code excludes siding items for pre-engineered structures.

1. Siding: This includes the cost for hauling, handling, and installation of building siding, insulation, and minor repairs.

2. Expansion Joints and Flashing: This includes the cost for hauling, fabrication, erection, and installation of special expansion joints for flashing of building siding, including caulking.

3. Insulation: This includes the cost for purchasing, hauling, and installation of building insulation and fireproofing.

e. This includes labor and material required for construction of interior masonry walls and partitions, toilet partitions, interior plaster walls, metal-stud tile-faced partitions, and acoustical hard plaster or metal ceilings. Specifically included are the following.

1. Interior Walls and Partitions: This includes the cost for hauling, handling, placing, and constructing interior walls and partitions, including related scaffolding, bracing, repairing, waterproofing, fireproofing, and finishing.

2. Ceilings: This includes the cost for hauling, handling, and installation of plaster walls and plaster, metal, or other ceilings. It also includes erection of bar joists, channels, metal lathe, application of hard plaster, acoustical plaster, and metal or fibre acoustical ceiling units, installation of insulation, special moulding, and related scaffolding, patching, and repairing.

3. Special Flooring: This includes the cost for flooring other than concrete, such as asphalt, rubber, koroseal, quarry tile or wood, including hauling, handling, placing, and finishing of flooring and related cove base and shoe moulds.

4. Millwork and Trim: This includes the cost for hauling, handling, fabricating, and installing all millwork and wood trim. This includes studs and plates for all wood partitions.

5. Metal Doors: This includes the cost for hauling, handling, erecting, and other work to install metal and metal clad doors, complete with frames, hardware, and operating devices.

6. Wood Doors: This includes the cost for hauling, handling, erecting, and other work to install wood doors, complete with hardware.

7. Windows: This includes the cost for complete installation of steel or aluminum window frames and sash, complete with hardware and mechanical operating devices.

8. Caulking: This includes the cost for all caulking required for door and window installation.

9. Partitions: This includes the cost required for complete installation of partitions and all miscellaneous items, such as towel racks, mirrors, soap dispensers, urinal screens, hand dryers, etc.

10. Metal: This includes the cost for hauling, handling, and installation of stud for tile-faced partitions.

f. This includes labor and materials required for all field painting, such as structural steel, miscellaneous iron, doors, walls, ceilings, equipment and piping, special codes and identification, hauling and handling of materials, cleaning prior to painting, application of primer and paint, necessary scaffolding and cleanup after painting, and the furnishing of all glass, glazing, and incidental work. Specifically included are the following.

1. Structural Steel and Iron: This includes the cost for all painting and related work, or structural steel for building superstructure and miscellaneous structural steel and iron, such as walkways, stairs, windows, doors, handrails, thresholds, and similar items.

2. Equipment, Piping, and Supports: This includes the cost for all painting and related work, of equipment that is not furnished with a factory finish, pipe hangers and supports, piping, and code coloring of piping.

3. Code and Identification: This includes the cost for all painting, and related work of lettering and code identification, and permanent sign painting.

4. Other Painting: This includes the cost for all other painting, and related work, such as masonry walls, millwork, plaster walls, plaster and metal ceilings, and concrete equipment foundations.

7. 5017 Special Construction

a. This includes labor and material costs that are not addressed by other subaccounts under the 501 account, such as the labor and material required for installation of bridge and gantry cranes, monorails, conveyors, and pipe handling trolley assemblies, including related electrical feed rails, crane rails, internal wiring, erection, and rigging. Also included are the labor and material required for installation of miscellaneous building equipment attached to and part of the building, such as elevators, dumbwaiters, lunchroom equipment, and metal lockers, etc.

b. This cost code excludes process equipment and equipment includable in building systems, such as monorails, bridge cranes, gantry cranes, pipe handling trolley assemblies, shop equipment, and installation of temporary construction overhead cranes.

c. Specific elements to be included are the following.

1. Installed Equipment: This includes the cost of labor, material, and installed equipment applicable to the above described work. Cost of equipment includes invoice price and transportation when charged directly. Costs for each size and type of equipment included in this cost code should be readily identifiable in the cost code or supporting records.

2. Conduit: This includes the cost for hauling, handling, fabricating, and installing all conduit for the equipment, with related hangers, supports, junction boxes, and receptacles.

3. Wire: This includes the cost for installing wiring for the equipment.

8. 5018 Mechanical

a. This includes the installed cost of building mechanical systems, such as refrigeration systems, heating systems, ventilation systems, fire protection systems, plumbing systems and all associated piping, valves, controls, and instruments. Specifically, it covers labor and materials required for the installation of any heating, ventilation, and air conditioning system. Included components are grills, louvers, ductwork, duct insulation, roof ventilators, dampers, unit heaters, related hangers, and supports and self-contained and central distribution units. This cost code also covers labor and material required for the installation of any filter system in connection with an environmental control system. This includes cyclone dust collectors, bag-type filters, electrostatic precipitators, roughing filters, and finishing filters. Labor and material required for the complete installation of piping and equipment, for a piping system, including piping, tubing, valves, fittings, hangers, mechanical equipment, and insulation, are also included in this account. Piping and equipment used in utility or process systems should be costed with the appropriate system.

b. Examples of specific elements to be included in this account are as follows.

1. Installed Equipment: This includes the cost of labor, material, and installed equipment that is applicable to the described work. The cost of equipment includes invoice price and transportation when

charged directly. The costs for each size and type of equipment included in this cost code should be readily identifiable in the cost code or supporting records.

2. Ductwork: This includes the cost for hauling, handling, fabricating, erecting, and installing duct materials, manually operated dampers, and duct specialties. It also includes ductwork for air conditioning systems.

3. Louvers, Grills, Diffusers, and Registers: This includes the cost for the complete installation of louvers, grills, diffusers, and registers.

4. Roof Ventilators: This includes the cost for hauling, handling, and installing roof ventilators.

5. Dampers - Mechanically Operated: This includes the cost for hauling, handling, and installing mechanically operated dampers. This also includes fire dampers.

6. Testing and Balancing: This includes the cost for testing, balancing, incidental repairs, and modifications required for the proper operation of the heating and ventilation system.

7. Insulation: This includes the cost for labor and material to install insulation on environmental control equipment and distribution systems.

8. Controls: This includes the cost for labor and materials to install all components of the control system, whether pneumatic or electric. This cost code includes all control devices, such as thermostats, relays, valves, valve operator dampers, damper operators, local and remote indicators, and recorders. It also includes any other devices used to monitor, record, control, or enunciate conditions and nodes of the equipment or the supply, return, or exhaust systems.

9. Roughing Filters: This includes the cost for shipping, hauling, handling, and installing roughing or prefilters complete with frames, filter media, retaining clips, bolts, nuts, etc., required to complete the installation.

10. Finishing Filters: This includes the cost for shipping, hauling, handling, installing, finishing, or polishing filters complete with frames, filter media, retaining devices, and supports.

11. Piping: This includes the cost for hauling, handling, cutting, fabricating, placing, and erecting piping for the system together with related valves, fittings, hangers, expansion joints, and other piping specialties.

12. Insulation: This includes the cost for handling, hauling, cutting, and installing insulation for piping.

13. Testing: This includes the cost for preliminary testing of the system, such as pneumatic or hydraulic pressure testing.

14. Identification: This includes labor and material to label, color code, tag, or otherwise properly identify the piping system according to specifications. Painting of pipe and equipment is excluded from this cost code (see Painting and Glazing).

15. Cleaning: This includes all costs required to clean, condition, and sterilize the piping system.

16. Underground Protective Coatings: This includes all costs required to apply protective coatings as specified.

17. Excavation and Backfill: This includes all costs of labor and materials to excavate, shore, pump, or dewater ditches; form, reinforce, and pour concrete thrust blocks; backfill with any specified material; compaction of backfill; and repairs to damaged concrete or asphalt surfaces as required for the installation of a mechanical system.

9. 5019 Electrical

a. This account includes the installed cost of building electrical systems, such as electrical lighting systems, electric power systems, emergency light and power systems, building instrumentation systems, building communication systems, and building alarm systems. Each of these systems can be further defined as follows. Building electrical lighting system covers labor and material required for the installation of the electric lighting system for the building or other structure from the low-voltage side of the unit substation or at the service entrance to the building or other structure. It includes lighting transformers, panels, circuits, fixtures, conduit, wire, and the complete installation of the emergency lighting system. An electric power system covers labor and material required for the installation of the electric power system from the building wall through the primary building substation. It also includes switchgear, transformers, potheads, etc. All distribution circuitry and panels required for building items are included in this account. Emergency power and lighting system includes all labor and materials required to procure, fabricate, and install the complete functional emergency power and lighting system. Building instrumentation covers labor and material required for installation of instruments and instrument lines in the building from the point of connection to the equipment within the building up to and including the building control room or equivalent. It includes tubing, conduit, wiring, and control panels. This cost code excludes instrument lines from the building control room or equivalent to the central control building (provided in 600 Utilities). A building communication system is defined as all labor and material for the installation of communication systems. This cost code includes conduit, pull wire, outlet boxes, speaker enclosures, mounting panel, and other related equipment. Building alarm systems include the installed cost of fire, smoke, seismic intrusion, and radiological alarm systems to include conduit, instruments, control panels, and detectors.

b. Specific elements to be included in the costs of electrical are as follows.

1. Installed Equipment: This includes the cost of labor, material, and installed equipment that is applicable to the work described in the second level cost code. The cost of equipment includes invoice price and transportation when charged directly. Costs for each size and type of equipment included in this cost code should be readily identifiable in the cost code or supporting records.

2. Excavation and Backfill: This includes the costs required for excavation, shoring, backfill, and removal of surplus materials for outside, underground communication duct lines and manholes.

3. Concrete: This includes the cost required for hauling, placing, finishing, and waterproofing concrete in underground communication duct lines and manholes.

4. Reinforcing and Miscellaneous Steel and Iron: This includes the cost required for hauling, handling, bending, fabricating, placing, tying, and cleaning of reinforcing steel used in underground communication duct lines and manholes.

5. Conduit: This includes the cost for hauling, handling, fabricating, and installing all conduit for the communication systems with related hangers, supports, junction boxes, and receptacles.

6. Poles and Fixtures: This includes the cost for hauling, handling, and complete installation of poles and fixtures. It includes all work required for the erection of poles, complete with hardware, used exclusively for the system.

7. Miscellaneous Iron: This includes the cost for installing miscellaneous iron and anchor bolts for electrical power systems that may be required in addition to those covered under Metal.

8. Substations: This includes the cost for installing unit substations in the electric power system for process equipment.

9. Auxiliary Structures: This includes all costs of labor and material required to assemble, erect, and install a building to house the emergency power and lighting system equipment or motor generator sets.

10. Instruments and Panels: This includes the cost for installing all instruments and panels and the instrumentation connections, together with related preliminary testing.

11. Switch Panel: This includes the cost for complete installation of disconnect and switching panels, complete with overload protection devices, interconnecting busses, etc.

12. Controls: This includes all costs of labor and materials for the complete installation of all required controls, transfer switches, protective devices, and similar items.

13. Emergency Lights: This includes the costs for procuring, fabricating, assembling, testing, handling, and installing, in strategic locations, battery-operated lights. (Use second level cost code 3205 when motor generators, etc., are required.)

14. Wire: This includes the cost for installing wire for electric lighting systems. It also includes wiring for the emergency system to the lighting panel.

15. Fixtures: This includes the cost for hauling, handling, and complete installation of all lighting fixtures and related wall switches and receptacles.

16. Instrument Vacuum Pumps: This includes the cost for installing instrument vacuum pumps and the instrumentation connections.

17. Insulation: This includes the cost for installing instrumentation insulation.

18. Tubing: This includes the cost for installing and testing all tubing for instrumentation.

19. Grounding: This includes the cost for all ground wire, connectors, grids, etc.

20. Smoke Detectors: This includes the cost for installation of smoke detection systems, with related wiring, panels, instruments, and similar items.

21. Alarms: This includes the cost for installation of fire, intrusion, and radiological alarm systems, with related wiring, panels, instruments, and similar items.

22. Monitoring: This includes the costs for installation of seismic monitoring systems, with related strain gages, wiring panels, instruments, and similar items.

D. 550 Other Structures

1. 5501 Excavation and Backfill

This code is identical to account 5011 except that it applies to structures other than buildings.

2. 5502 Concrete

This code is identical to account 5012 except that it applies to structures other than buildings.

3. 5503 Masonry

This code is identical to account 5013 except that it applies to structures other than buildings.

4. 5504 Metals

This code is identical to account 5014 except that it applies to structures other than buildings.

5. 5505 Wood and Plastic

This code is identical to account 5015 except that it applies to structures other than buildings.

6. 5506 Thermal and Moisture Protection

a. This includes the labor and material required for waterproofing, dampproofing, insulating, fireproofing, joint sealing, and traffic topping structures other than buildings. Waterproofing is defined as impervious membranes or coatings applied to walls, slabs, decks, or other surfaces subject to continuous or intermittent hydrostatic head or water immersion It includes membranes that are bituminous, cementitious, elastomeric (liquid-applied or sheet material), sheet metal, bentonite and similar materials, and metal oxide coatings. It includes boards or coatings required for protection of waterproofing. Dampproofing includes materials installed to provide resistance to moisture penetration through surfaces subject to high humidity, dampness, or direct water contact, but not subject to hydrostatic pressures. It includes bituminous, cementitious, or similar coatings applied to exterior walls below grade, or applied as a protective damp course. It includes silicone, acrylic, or other water repellent coatings applied to exposed surfaces of concrete, masonry, stone, cement, metal, plaster, or similar material. It also includes bituminous, laminated, or plastic vapor barriers. Insulation is defined as thermal insulation for resistance of heat transfer at exterior of structure and at enclosures of high temperature or low temperature spaces. It includes organic or inorganic insulation in the form of granules, pellets, rigid boards, fibrous batts, blankets or rolls, and spray or foam applied to walls, roofs, decks, and similar surfaces. It includes insulation applied to the perimeter of foundations and under concrete slabs on grade. Vapor barriers integral with insulation are also included. Fireproofing includes special coatings, mineral fiber, and cementitious coverings to provide fire resistance. Joint sealants include elastomeric and nonelastomeric sealants, nonshrinking mastic sealants, bituminous sealants, oil-based caulking compounds, compression gaskets, joint fillers, and related products. It includes primers, backer rods, and bond breaker tape applied to exterior and interior moving and nonmoving joints to prevent penetration of moisture, air, and sound. Traffic topping is defined as surface-applied, waterproof, elastomeric, or composition-type membrane exposed to weather and suitable for normal or light duty traffic (foot or automobile), but not intended for heavy industrial use.

b. Some specific examples are as follows.

1. Materials: This includes the cost for materials used for thermal and moisture protection.

2. Structural Steel and Iron: This includes the cost for all painting, insulating, and related work for superstructure and miscellaneous structural steel and iron items.

3. Code Identification: This includes the cost for all painting and related work of lettering and code identification and permanent sign painting.

4. Insulation: This includes the cost of hauling, handling, fabricating, applying, and cleanup associated with the application of insulation.

5. Scaffolding: This includes the cost of hauling, handling, constructing, dismantling, and cleanup of scaffolding required in thermal and moisture protection.

6. Protective Covering: This includes the cost of procuring, hauling, handling, fabricating, erecting, and dismantling protective coverings used during the application of thermal and moisture protection materials.

7. 5507 Special Construction

a. This includes labor and material costs that are not addressed by other subaccounts under the 550 account, such as labor and materials required for installation of bridge and gantry cranes, monorails, conveyors, pipe handling trolley assemblies, including related electrical feed rails, crane rails, internal wiring, erection, and rigging. Also included are the labor and materials required for installation of miscellaneous equipment that is attached to the structure.

b. This excludes process equipment, equipment includable in building systems, and standard equipment in the 700 series.

c. Specific elements to be included are the following.

1. Installed Equipment: This includes the cost of labor, material, and equipment applicable to this account. Equipment cost includes invoice price and transportation when charged directly.

2. Conduit and Wire: This includes costs for hauling, handling, fabricating, and installing all conduit for the equipment, with related hangers, supports, junction boxes, and receptacles.

8. 5508 Mechanical

This code is identical to account 5018 except that it applies to structures other than buildings.

9. 5509 Electrical

This code is identical to account 5019 except that it applies to structures other than buildings.

E. 600 Utilities

1. 6100 Communications Systems

This includes the installed cost of telephone, intercommunication and teletype equipment, telephone instruments and protective devices, lines, poles, cables, and conduits, and stationary and associated portable radio transmitting and receiving equipment.

2. 6150 Electric Transmission and Distribution Systems

This includes the installed cost of all transmission and distribution lines, poles, towers, grounding systems, substations, transformers, controls, cables, conduits, services, meters and protective devices, and lighting fixtures, wire, poles, standards, and related accessories supplying electric service.

3. 6210 Alarm Systems

This includes the installed cost of equipment necessary for receiving and transmitting alarms, including control wiring (both cable and open), and other associated overhead and underground equipment that provides fire, security, radiological or environmental protection or warning.

4. 6250 Gas Transmission and Distribution Systems

This includes the installed cost of equipment involved in the storage, transmission, and distribution of natural and artificial gas, including pipelines, services, and associated regulating and metering equipment of buildings served.

5. 6300 Irrigation Systems

This includes the installed cost of canals, ditches, waterways, flumes, pipelines, and equipment used for irrigation purposes.

6. 6400 Sewerage Systems

This includes the installed cost of sewerage treatment and disposal facilities, including manholes, mains and lateral lines to the point of tie-in with buildings served, and any septic tanks.

7. 6450 Steam Generation and Distribution Systems

This includes the installed cost of all equipment used for the generation and distribution of steam to the point of tie-in to buildings where such steam is utilized primarily for heating and for furnishing power to equipment.

8. 6500 Water Supply, Pumping, Treatment, and Distribution Systems

This includes the installed cost of wells, pumping, water treatments, and distribution facilities to the point of tie-in with buildings served.

9. 6600 Oil Piping and Distribution System

This includes the installed cost of pipelines, pipe racks, raceways, valves, pumps, metering devices, and bulk storage tanks between the oil transporting vehicle (truck, barge, tanker, or pipeline) and bulk storage tanks of other piping systems.

10. 6900 Other Utilities

This includes the installed cost of utility systems not specifically included under the 600 account, such as a compressed air system or an anhydrous hydrogen fluoride gas system.

F. 700 Special Equipment/Process Systems

1. 7010 Vessels

This includes the installed cost of towers, reactors, drums, trays, storage tanks (not associated with site utilities), cyclones, etc., less the cost of supports or supporting structures (see 5600).

2. 7020 Heat Transfer

This includes the installed cost of heat exchangers, heaters, stacks, steam boilers, furnace cooling towers, ejectors, brazed core exchangers, desuperheaters and coolers, and refrigeration equipment.

3. 7030 Mechanical Equipment

This includes the installed cost of pumps, drivers, compressors, blowers, actuators, electrical generators, filters, valves, separators, solids handling equipment, scrubbers, mixers, meters, agitators, silencers, and other items of mechanical equipment.

4. 7040 Package Units

This includes the installed cost of off-the-shelf units that are used in a process (e.g., gas waste treatment package, clarifier package, desulfurization package, demineralization, deaerator, incinerator, flare, and odorization package).

5. 7050 Process Piping

This includes the installed cost of process piping to include pipe, pipe racks, raceways, etc.

6. 7060 Electrical

This includes the installed cost of all process electrical transmission and distribution equipment not considered a utility system. Costs include wire, cable, poles, insulators, towers, grounding systems, substations, transformers, controls, meters, lighting, conduit, piping, distribution fumes, and control panels.

7. 7065 Instrumentation

This includes the installed cost of all process instrumentation whether electrical or nonelectrical, such as pneumatic and pressure instruments. The cost includes all associated wire, cable, tubes, pipes, grounding equipment, poles, raceways, meters, and control panels.

8. 7070 Protective Cover

This includes the installed cost of process insulation, painting, fireproofing, refractory lining, waterproofing, and dampproofing.

9. 7080 Reactor Components

This includes the installed cost of reactor support, reactor structure, reactor internals, reactor control devices, instrumentation and control devices, monitoring system, leak detection equipment, cooling equipment, makeup water system, inert gas system, fuel handling tools and equipment, service platforms, etc.

G. 800 Improvements for Others

This includes the cost of improvements made by DOE to land, buildings, structures, building services, and utility systems not owned by DOE. Plants, laboratories, and similar facilities constructed by DOE on land owned by others are not to be classified in this category.

H. 810 Demolition

This includes the cost of wrecking, dismantling, cutting, drilling, and removing existing structures, equipment, and materials, as well as any excavation required to facilitate demolition and the cleaning, stacking, loading, hauling, and unloading of material for salvage and/or disposal when such activity represents a major activity in accomplishment of the project. Minor, routine demolition will be listed under improvements to land.

I. 820 Tunneling

This includes the complete cost of constructing a tunnel, including excavation, drilling, blasting, mucking, shoring, timbering, bolting, mechanical utilities (air, water, and vent lines), surface construction, installation (shaft collars, portal facings, retaining walls, rock, volts, fences, gates, hatches, doors, muck dumping facilities, anchors, guys, deadmen, buildings, foundations, docks, etc.), and associated mobilization and demobilization.

J. 830 Drilling

This includes the complete cost of drilling, including purchase or lease of the drilling rig-associated material mandrels, jet subs, drill collars, drill pipe, kellys, goosenecks, casing, detergent, mud additives and other chemicals, tool repair, installing casing (double jointing, lugging, cutting lifting eyes, belling, and installing guidelines), installing the drilling rig, correcting problems (plugback to correct well bore deviations), cleaning out and conditioning the hole, coring, side-wall, sampling, dewatering, fishing, laboratory support, building support structures, and safety fences.

K. 860 Standard Equipment

1. 8610 Heavy, Mobile Equipment

This includes the cost of heavy, mobile equipment (other than motor vehicles), such as concrete mixers, power shovels, cranes, compressors, rollers, road graders, tractors, farm implements, boats, and barges. The cost of trucks is included in Code 725.

2. 8615 Hospital and Medical Equipment

This includes the cost of hospital, clinical, and dental equipment, such as hospital beds, dentist chairs, instruments, sterilizers, and other scientific equipment used by dentists and doctors.

3. 8620 Laboratory Equipment

This includes the installed cost of laboratory equipment, such as microscopes, analytical balances, electroanalyzers, oscillographs, refractometers, light sources, vibrometers, and other scientific equipment usually associated with laboratories. The costs of furniture, fixtures, and shop equipment are included in Codes 730 and 755.

4. 8625 Motor Vehicles and Aircraft

This includes the cost of passenger cars, trucks, buses, jeeps, trailers, airplanes, and fire trucks.

5. 8630 Office Furniture and Equipment

This includes the installed cost of office furniture and equipment, such as machines, desks, drafting sets, safes, photographic equipment, copy-making equipment, printing equipment, and other office equipment regardless of where located. The cost of automatic data processing equipment is included in Code 770.

6. 8635 Process Equipment (for Mfgr.)

This includes the installed cost of equipment used specifically in product manufacturing and processing, including associated measurement and control instruments.

7. 8640 Railroad Rolling Stock

This includes the installed cost of railroad rolling stock, such as locomotives and cars.

8. 8645 Reactors and Accelerators

This includes the installed cost of reactors, proton synchrotrons, electron synchrotrons, cyclotrons, linear accelerators, Van De Graff generators, and accessory equipment, including associated measurement and control instruments.

9. 8650 Portable Security and Protection Equipment

This includes the installed cost of man and vehicular portable equipment used for police, security, and fire protection purposes. The cost of vehicles is in Code 725, and the cost of installed alarm systems is in Code 621.

10. 8655 Shop Equipment

This includes the installed cost of shop equipment, such as lathes, drilling machines, rolling mills, hoists, grinders, forges, pipecutting machines, presses, saws, shapers, and other equipment usually associated with shops, garages, and service stations. Similar equipment used in laboratories and other areas for research purposes should also be identified by this code.

11. 8660 Reserve Construction Equipment Pool

This includes the installed costs of construction and automotive equipment held for the purpose of maintaining a reserve pool for use in emergencies as part of the DOE Mobilization Program, or for secondary use in future construction programs.

12. 8670 Automatic Data Processing (ADP) Equipment

This includes the installed cost of all equipment used in ADP, such as:

a. tape equipment, whether used alone or in conjunction with electronic computers;

b. electronic computers and all peripheral or auxiliary equipment;

c. data transmission systems employing devices communicating or transmitting data from place to place for processing in an ADP system;

d. all other equipment that is used in conjunction with ADP or electronic computers; and

e. the initial package of software that is required to make the system operational.

Equipment such as flexowriters, typewriters, equipment reading the results of experiments, etc., shall be classified as ADP equipment when used primarily in conjunction with an ADP system. It excludes the cost of equipment such as analog computers, tape file cabinets, and air conditioning for the processing room. Also, it excludes the cost of automatic data recording or electronic control systems used to furnish operating guidance for control of machine tools, equipment used in process operations, reactors, accelerators, etc.

13. 8699 Miscellaneous Equipment

This includes the installed cost of furniture and fixtures for hotels, dormitories, and apartments; laundry equipment; restaurant, cafeteria, and canteen equipment; and other miscellaneous equipment not includable in other codes.

5. INDIRECT CONSTRUCTION COSTS

A. Engineering, Design, and Inspection

1. Surveys, Geological Studies, and Tests

This includes the cost of topographical and other field surveys, soil tests, load tests, geological studies, test borings, or other subsurface investigations.

2. Preliminary Work

This includes the cost of preliminary studies, sketches, cost estimates, layout plans, and reports.

3. Design

This includes the cost of design services consisting of the preparation of working drawings, specifications, cost estimates based on working drawings, evaluation of bids, and the checking of shop drawings.

4. Consulting Services

This includes the cost of expert technical or professional assistance to the extent authorized by the contract.

5. Design of Specialized Equipment

This includes the cost of design of specialized equipment by the A/E contractor or subcontractor as approved by the contracting officer.

6. Expediting or Procurement

This includes the cost of expediting or procurement of materials and equipment for the construction project.

7. Inspection

This includes the cost of inspection of construction work to secure compliance with plans and specifications, field or laboratory tests of workmanship and materials, providing lines and levels to which construction may be referred, preparation of progress reports or estimates of construction performed for payments or other purposes, and the preparation of record drawings.

8. Miscellaneous

This includes the cost of items allowable under the contract or amendments thereto that are not susceptible to classification in any one of the above accounts. Such items include bonds and insurance, materials, and supplies for the Architect/Engineer (A/E) contractors' use; patents; purchase designs and royalty payments; structures and facilities of a temporary nature used by the A/E contractor; taxes, fees, and charges levied by public agencies on personnel; the transportation of personal household goods and effects; losses not compensated for by insurance; litigation; A/E contractor's fees; and other costs specifically certified in writing by the contracting officer according to the terms of the contract.

B. General and Administrative

1. Administration

This includes salaries, travel, and other expenses for the overall administration of the project.

2. Superintendence

This includes salaries, travel, and other expenses of those supervising construction, including construction superintendents, assistants, and their secretaries and stenographers. Only general superintendents are included here. Superintendents assigned to specific portions of the project are charged directly to the cost accounts of the specific portions.

3. Construction Contractor's Engineering

This includes salaries, travel, and other expenses of engineering personnel, including engineers, assistants, and their secretaries and stenographers responsible for plan files; plan detailing; plan distribution; line and grades estimating; material take-offs; and design of contemporary construction facilities. When regular A/E work is performed by a construction contractor, such costs are chargeable to the applicable subdivisions of engineering, design, and inspection (ED&I).

4. Accounting

This includes salaries, travel, and other expenses for accounting staff, including accountants, timekeepers, clerks, and their secretaries and stenographers.

5. Procurement

This includes salaries, travel, and other expenses of personnel responsible for purchasing and expediting materials, supplies, and equipment except if chargeable to ED&I.

6. Personnel

This includes salaries, travel, and other expenses of personnel for recruitment, employment, and employee relations activities.

7. Legal

This includes salaries, travel, other expenses, and legal fees.

8. Security

This includes salaries, travel, and other expenses of personnel for security protection.

9. Office Supplies and Expenses

This includes the cost of miscellaneous expenses of administrative offices, including stationery, forms, blueprints, maps, plans, documents reproduced by blueprinting and other processes, work photographs, telephone and telegraph (including operators), janitor expense, heating, lighting, water, depreciation of office buildings and equipment, repairs and maintenance of office buildings and equipment, messengers, clerks, and other office employees not chargeable to other accounts.

C. Other Indirect

1. Payroll Insurance

This includes the cost of workmen's compensation insurance not charged elsewhere.

2. Insurance

This includes the cost of insurance, other than payroll, carried by the contractor in connection with the construction work and not charged elsewhere.

3. Damages not Covered by Insurance

This includes the cost of damage settlements not covered by insurance and not chargeable elsewhere.

4. Payroll Taxes

This includes the cost of contractors' contributions for social security not charged elsewhere.

5. Taxes Other Than Payroll

This includes the cost of business and property taxes incurred during the construction period.

6. Holiday and Vacation Pay

This includes the cost of holiday and vacation pay not charged elsewhere.

7. Signup and Termination Pay

This includes the cost of signup and termination pay not charged elsewhere.

8. Retroactive Pay

This includes the cost of retroactive pay adjustments. This account is to be used only when actual distribution of retroactive pay adjustments would be burdensome or the specific projects affected are closed.

9. Reporting Time

This includes the cost of time given employees who report for work when no work is available because of weather or other conditions.

10. Welding Tests

This includes the cost of conducting welding tests at the job site or elsewhere.

11. Contribution to Welfare Plans

This includes the cost of contributions to labor union welfare plans not charged elsewhere.

12. Transportation of Workers

This includes the cost of transporting employees engaged in the construction work to and from site locations not charged elsewhere.

13. Motor Pool Operations

This includes the cost of operating a pool of motor vehicles for general, administrative services. Costs of operating automobiles specifically assigned to other services are not to be included.

14. Aircraft Operation

This includes the cost of aircraft operation chargeable to construction projects, generally distributed to this account from equipment clearing accounts.

15. Medical and First Aid

This includes the cost of medical, first aid, and hospital services.

16. Safety

This includes the cost of all safety programs carried on during the course of the construction contract. Costs of glasses for welding operations, gloves for linemen, scaffold railing for bricklayers, etc., are trade safety measures and, as such, are charged to the appropriate cost accounts rather than to this account.

17. Fire Protection

This includes the cost of providing fire protection.

18. Maintenance of General Construction Plant

This includes the cost of maintaining and operating general construction plant facilities not chargeable to other accounts. It includes depreciation on general Site Improvement, Temporary Land Improvements, General Plant, and Miscellaneous Equipment.

19. Small Tools

This includes the cost of small hand tools and of operating the toolroom. Included are costs of tool boxes, tool shanties, wages of toolroom employees, and costs of rehandling and sharpening tools. Costs of boots, raincoats, and other protective clothing issued to workers are included. It does not include hand tools used in shops. The costs of pneumatic and electric tools larger than handtools are chargeable to Miscellaneous Equipment.

20. Drinking Water and Sanitation

This includes the cost of supplying drinking water and toilet facilities.

21. Light and Power
This includes the cost of light and power that is not chargeable to other accounts.

22. Heat
This includes the cost of heat that is not chargeable to other accounts.

23. Compressed Air
This includes the cost of operating the compressed air system that is not chargeable to other accounts.

24. Water
This includes the cost of water that is not chargeable to other accounts.

25. General Cleanup
This includes the cost of general cleanup or yard janitor service that is not chargeable to other accounts.

26. Camp Operation
This includes the cost of and revenues from the operation of construction camp facilities.

27. Camp Operation Costs
This includes the cost of operation and maintenance, including depreciation on construction camp plant. This account should be subdivided to the extent necessary to account for and control these costs.

28. Camp Revenues
This includes the cost of revenues derived from operating construction camp facilities. This account should be subdivided to the extent necessary to account for and control these revenues.

29. Recovery of Indirect Costs
This includes all credits for indirect costs included in billings to others.

30. Contract Fee
This includes all charges for the fee earned by the contractor in accordance with the terms of the contract.

CHAPTER 17

EXAMPLE OF ENVIRONMENTAL RESTORATION CODE OF ACCOUNTS

1. INTRODUCTION

This chapter will describe the fundamental structure of an example remediation cost code system, list and describe the Level 1 cost codes, and list the Level 2 and Level 3 cost codes.

2. FUNDAMENTAL STRUCTURE OF THE REMEDIATION COST CODE SYSTEM

In establishing the cost accounting system for remediation projects, the six project category breakdowns defined in the CERCLA were used. This system of project characterization gives more division to the scope of a project, thus offering more control. The six divisions in the CERCLA remediation process are:

- preliminary assessment,
- site inspection,
- remedial investigation,
- feasibility study,
- remedial design,
- remedial action.

Although CERCLA was used as the basis for the divisions, the four RCRA categories also correspond to this system. The RCRA facility assessment corresponds to both the preliminary assessment (PA) and the site inspection (SI). The RCRA facility investigation correlates with the remedial investigation. The RCRA corrective measures study relates to the feasibility study. The RCRA corrective measures implementation encompasses both the remedial design and the remedial action steps.

3. LEVEL 1 COST CODES FOR REMEDIATION, LIST AND DESCRIPTION

The Level 1 cost codes in the cost codes for remediation are divided along the six main CERCLA divisions mentioned above. The numerical classification of these divisions is as follows:

CERCLA Division	Level 1 Code Number
Preliminary Assessment	100
Site Inspection	200
Remedial Investigation	300
Feasibility Study	400
Remedial Design	500
Remedial Action	600

A brief description of the categories is provided below.

A. Preliminary Assessment (100)

The PA is the first phase of work for a remediation project. This initial review of the project can include the inspection of past and present uses of the site to assess potential hazardous substances. The start of the permitting and budgeting process should begin in this phase, and a basic work plan should be submitted to regulatory agencies for comments.

B. Site Inspection (200)

The initial SI is used to confirm the site location and its relationship with other major features. The site can be divided into solid waste management units to aid in the site assessment and estimating. An interim corrective measures action may be required to stop additional contamination at the site or to stop contamination from leaving the site. Limited sampling may take place in this initial site inspection.

C. Remedial Investigation (300)

The remedial investigation should start with the review of all information collected in the PA and SI stages. A remedial investigation work plan, sampling plan, quality assurance plan, and health and safety plan are developed. All field sampling and laboratory analysis are completed.

D. Feasibility Study (400)

The main task in the feasibility study is to develop and evaluate alternatives for cleanup. This includes the preparation of a conceptual design, schedules, and feasibility estimates.

E. Remedial Design (500)

In the remedial design phase, the final design specifications and drawings are developed. All engineering required to perform the remediation is completed. The project could be competitively bid at this time, or a contractor could be chosen through interviews and negotiations.

F. Remedial Action (600)

The remediation of the site is completed in the remedial action phase. All contamination is removed from the site.

4. LIST OF LEVELS 1 AND 2 REMEDIATION COST CODES

The following is a list of Levels 1 and 2 cost codes for use on the direct remediation costs. Any reasonable breakdown of these cost codes is permissible as long as they can be summarized to the cost codes shown and the definitions given.

A listing of primary and secondary cost codes is as follows:

Level 1	Level 2	
100	Preliminary Assessment	
	110	Health & Safety Plan
	120	Sampling Plan
	130	Surface Soil Sampling
	140	Subsurface Soil Sampling
	150	Surface Water/Sludge Sampling
	160	Air Sampling/Monitoring
	170	Laboratory Services
	180	Safety Equipment
200	Site Inspection	
	210	Sampling Plan
	220	Health & Safety Plan
	230	Surface Soil Sampling

	240	Subsurface Soil Sampling
	250	Surface Water/Sludge Sampling
	260	Air Sampling/Monitoring
	270	Laboratory Services
	280	Safety Equipment
300	Remedial Investigation	
	310	Health & Safety Plan
	320	Sampling Plan
	330	Surface Soil Sampling
	340	Subsurface Soil Sampling
	350	Surface Water/Sludge Sampling
	360	Air Sampling/Monitoring
	370	Laboratory Services
	380	Safety Equipment
400	Feasibility Study	
	410	Sampling Plan
	420	Health & Safety Plan
	430	Surface Soil Sampling
	440	Subsurface Soil Sampling
	450	Surface Water/Sludge
	460	Air Sampling/Monitoring
	470	Laboratory Services
	480	Safety Equipment
500	Remedial Design	
	510	Sampling Plan
	520	Health & Safety Plan
	530	Surface Soil Sampling
	540	Subsurface Soil Sampling
	550	Surface Water/Sludge Sampling
	560	Air Sampling/Monitoring
	570	Laboratory Services
	580	Safety Equipment

600	Remedial Action	
	610	Sampling Plan
	620	Health & Safety Plan
	630	Surface Soil Sampling
	640	Subsurface Soil Sampling
	650	Surface Water/Sludge Sampling
	660	Air Sampling/Monitoring
	670	Laboratory Services
	680	Safety Equipment

5. LIST OF LEVEL 3 REMEDIATION COST CODES

Level 3 cost codes are flexible to permit users the option of using detailed accounts that are site specific. The Level 3 cost codes listed below should be viewed as a base to start a Level 3 cost code system.

Level 2		Level 3	
340	Subsurface Soil Sampling		
		3401	Site Preparation
		3402	Sampling w/Drill Rig
		3403	Sampling w/Powered Hand Auger
		3405	Sampling w/Hand Auger
		3406	Decontamination
		3407	Down Time

CHAPTER 18

USE OF COST ESTIMATING RELATIONSHIPS

1. INTRODUCTION

Cost Estimating Relationships (CERs) are an important tool in an estimator's kit, and in many cases, they are the only tool. Thus, it is important to understand their limitations and characteristics. This chapter discusses considerations of which the estimator must be aware so the CERs can be properly used.

2. LIMITATIONS

The widespread use of CERs in the form of simple cost factors, equations, curves, nomograms, and rules of thumb attest to their value and to the variety of situations in which they can be helpful. Thus, it is essential that their limitations be understood to preclude their improper use.

A. Historical Data

A statistical CER can be derived from information on past occurrences, but the past is not always a reliable guide to the future. An estimate based on past performance is very likely to be wrong. Admittedly, there may be other factors at work, but the problem remains the same as that encountered in any attempt to predict the course of future events; that is, how much confidence can be put in the prediction?

B. Bounds of the Sample

Uncertainty is inherent in any application of statistics. This pertains primarily to articles estimated as being well within the bounds of the sample on which the relationship is based. Although extrapolation beyond the sample is universally deplored by statisticians, it is universally practiced by cost analysts in dealing with advanced hardware because, in most instances, it is precisely those systems outside the range of the sample that are of interest. The question is whether or not the equation is relevant if it must be extrapolated. Good statistical practice would question the validity of such an approach.

C. Different Characteristics

The article being estimated may have characteristics somewhat different from those of the sample CER.

3. CHARACTERISTICS OF THE ESTIMATING RELATIONSHIP

The degree of emphasis placed on statistical treatment of data can cause two fundamental points to be overlooked: first, that an estimating relationship must be reasonable, and second, that it must have predictive value.

Reasonableness

Although it is not possible to resolve all uncertainties with the information available, an estimator can feel reasonably confident that the estimating relationship does not contain a systematic bias, that it should be applicable to normal programs, and that it provides reasonable estimates throughout the breadth of the sample.

Reasonableness can be tested in various ways—by inspection, by simple plots, and by complicated techniques that involve an examination of each variable over a range of possible values.

1. Inspection will often suffice to indicate that an estimating relationship is not structurally sound.

   For example, assume that historical information on hazardous waste disposal costs had been input into a computer with statistical software.

   The statistical package generated the following equation:

   $$C = 200 + 275D - 0.19M$$

   where

   C = cost to dispose of drummed hazardous waste
   D = number of drums
   M = number of miles between waste location and hazardous waste disposal facility.

   The equation is checked and the statistical parameters are within acceptable tolerances. The equation also fits the data very well.

   An examination of the equation for reasonableness shows that it predicted that transportation costs reduced the overall disposal cost. This is contrary to experience.

What is not known about the data is that some of it came from a project where the procurement and contract administration departments were able to negotiate a reduced transportation fee from the disposal company. Therefore, the historical data, out of context, does not provide an accurate forecast of future events. A reexamination of the sample data and equation is in order.

2. Cost estimating relationships may also have a limited range of validity. When an estimating relationship is developed to make a particular estimate, it may have little predictive value outside its narrow range. Use of the estimate outside of the estimate's range may lead to erroneous estimates.

A common method of examining the implications of an estimating relationship for values outside the range of the sample is to plot a scaling curve. The theory on which a scaling curve is based is as follows: As an item increases in one variable, the incremental cost of each addition will decrease or increase in a predictable way. Scaling curves may be plotted on either arithmetic or logarithmic graph paper as Figure 18-1 illustrates.

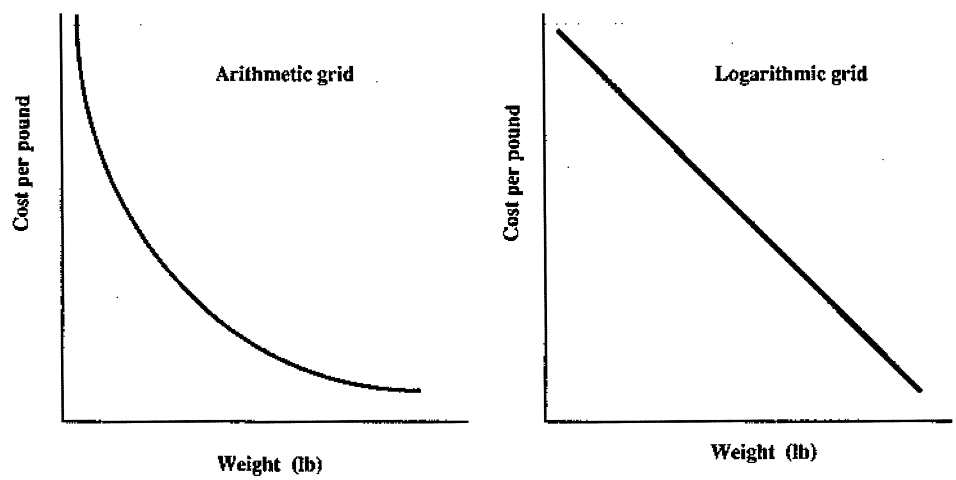

Figure 18-1. Scaling Curve Cost

The slope of the curve in Figure 18-1 is fairly steep. If the curve were extended to the right, it might be expected to flatten. Eventually, the curve might become completely flat at the point at which no more economies of scale can be realized, but it is unlikely that the slope would ever become positive.

Now examine Figure 18-2, in which total cost is plotted against a project variable based on values obtained from an estimating relationship.

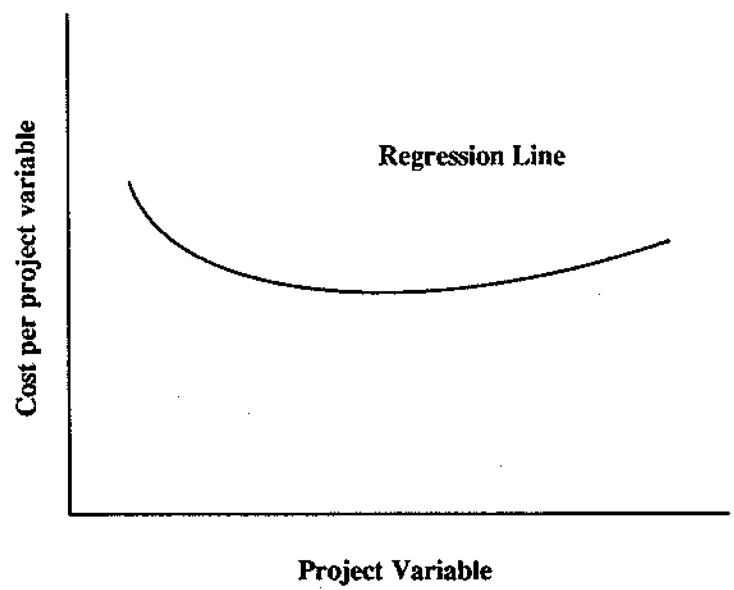

Figure 18-2. Cost Versus Project Variable

Two differences are immediately seen. First, the left-hand portion of the curve is unusually steep. Second, the slope becomes positive in another part of the curve. In some instances, fabrication problems increase with the size of the object being fabricated and a positive slope may result. No such problems are encountered in the manufacture of some items, however, and continued economies of scale are to be expected. Therefore, use of Figure 18-2 for cost estimating the latter case may inflate the estimate.

This figure also illustrates another point: A more useful estimating relationship could have been obtained by drawing a trend line rather than by fitting a curve. With a small sample, it is often possible to write an equation that fits the data perfectly, but the equation is useless outside the range of the sample. Statistical manipulation of a sample this size rarely produces satisfactory results.

3. A final example of the kind of error that overdue reliance on statistical measures of fit may bring about is based on the previous drummed waste example.

   Initially, the equation for estimating disposal costs was based on a variety of drummed wastes. It was then determined that grouping the wastes by type should give a better correlation of disposal costs. Assume that when liquid waste, flammable waste, heavy metal waste, and radioactive waste were considered separately, the average deviation between estimates and actual values was markedly reduced. However, the estimating equation for radioactive waste was as follows:

   $\text{Cost} = 2500\ (\text{drum weight})^{1.08}\ (\text{transportation})^{4}$

   This equation predicts that increased weight will increase the overall cost. New technology focuses on the <u>type</u> of radioactive waste. It cannot be assumed that all future radioactive waste will conform to this trend, especially if new technologies for radioactive waste disposal become available.

4. The cost derived from the use of a CER must be reasonable in a comparison with the past cost of similar hardware. A typical test for reasonableness is to study a scattergram, such as Figure 18-3, of costs of analogous equipment at some standard production quantity.

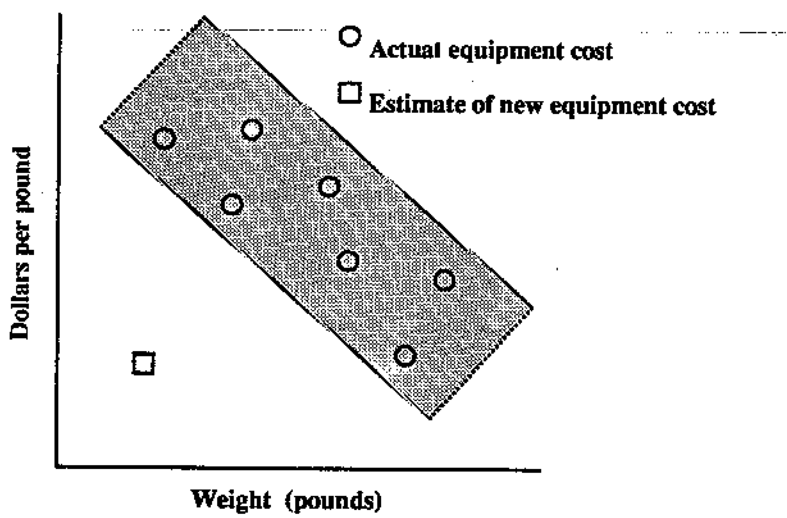

Figure 18-3. Cost Comparison of Analogous Equipment

The estimate of the article may be outside the trend lines of the scattergram and still be correct, but an initial presumption exists that a discrepancy has been discovered and that this discrepancy must be investigated. An analyst who emerges from deliberations with an estimate implying that new, higher performance equipment can be procured for less than the cost of existing hardware knows that the task is not finished. If, after research, the analyst is convinced that the estimate is correct, he/she should then be prepared to explain the new development that is responsible for the decrease in cost. Costs should not be raised arbitrarily by a percentage to make the figure appear more acceptable or because it is felt that the estimate is too low. Such adjustments are the province of management and are generally occasioned by reasons somewhat removed from those discussed here.

4. HARDWARE CONSIDERATIONS

The estimator must decide whether the cost estimating relationship is relevant or how it can be modified to be useful. An estimating relationship can be used properly only by a person familiar with the type of equipment or hardware whose cost is to be estimated. To say that an analyst who estimates the cost of a pump should be familiar with the characteristics of pumps is a truism; however, an estimator is sometimes far removed from the actual hardware. Further, estimators may be expected to provide costs for a construction project one week and for a new waste site remediation facility the next. The tendency in such a situation may be to use the equation that appears most appropriate without taking the required measures to determine whether the equation is applicable.

Further measures could be taken in the form of another independent estimate that uses a different estimating relationship. An estimator does not have this option for most kinds of hardware because estimating relationships are not plentiful. However, in some cases, a number of equations have been developed over the years; it is good practice to use one to confirm an estimate made with another.

5. JUDGMENT IN COST ESTIMATING

The need for judgment is often mentioned in connection with the use of estimating relationships. Although this need may be self-evident, one of the problems in the past has been too much reliance on judgment and too little on estimating relationships. The problem of introducing personal bias with judgment has been studied in other contexts, but the conclusions are relevant to this discussion.

In brief, a person's occupation or position seems to influence his or her forecasts. Thus, a consistent tendency toward low estimates appears among those persons whose interests are served by low estimates; for example, proponents of a remediation technology or an energy alternative whether in industry or in Government. Similarly, there are people in industry and in Government whose interests are served by caution. As a consequence, their estimates are likely to run higher than would be the case if they were free from all external pressures.

The primary use of judgment should be to decide first, whether an estimating relationship can be used for an advanced system, and second, if so, what adjustments will be necessary to take into account the effect of a technology that is not present in the sample. Judgment is also required to decide whether the results obtained from an estimating relationship are reasonable.

Judgments must be based on well-defined evidence. The only injunction to be observed is that any change in an estimate be fully documented to ensure that the estimate can be thoroughly understood and to provide any information that may be needed to reexamine the equations or relationships in light of the new data.

CHAPTER 19

DATA COLLECTION AND NORMALIZATION FOR THE DEVELOPMENT OF COST ESTIMATING RELATIONSHIPS

1. INTRODUCTION

Cost estimating relationships or parametric equations are mathematical statements that indicate that the cost is proportional to a physical commodity. Parametric estimating requires that statistical analysis be performed on data points to correlate the cost drivers and other system parameters. The basis of the data points is collected from databases or is developed by building a model of a project or scenario. The data collection effort is the first step in the development of CERs. Once the data is collected, it must be adjusted so that comparable relationships can be developed. This chapter discusses considerations for data collection and normalizations.

2. DATA COLLECTION

A minimum data requirement exists for any given job, but before data collection begins, the analyst must consider the scope of the problem, define in general terms what is to be accomplished, and decide how to approach the problem. In both construction and remediation projects, many different technologies and methods exist. To obtain data necessary to develop CERs, it is important to identify common or similar procedures among projects. It is also important to remember that both the cost and duration for each project are affected by site specific conditions.

A. Examining the Historical Data for Selection

The data required to estimate long-range maintenance costs at a DOE facility can be substantially different from the data required to develop short-term cleanup costs at the same facility. In the former, equipment upgrade and replacement costs must be considered, but in the latter, these items may not be a big factor. For major items, this means that a functional breakout (e.g., direct labor, materials, engineering, and installation) must be done. One can postulate problems requiring even a greater amount of detail. Suppose, for example, that two similar cleanup projects that are being evaluated have substantially different costs. Only by examining the cost detail can this difference be explained.

In performing this initial appraisal of the job, the analyst will be aided by a thorough knowledge of the kind of project being evaluated, its characteristics, the state of its technology, and the available information. With this knowledge the analyst can determine the kinds of data that are required compared to what are available, where the data are located, and the kinds of adjustments that are required to make the collected data base consistent and comparable.

Only after the problem has been given this general consideration should the task of data collection begin. All too often large amounts of data are collected with little thought about use. The result is that some portion may be unnecessary, unusable, or not completely understood, and other data that was necessary was not collected. Data collection is generally the most troublesome and time-consuming part of developing a CER. Consequently, careful planning in this phase of the overall effort is well worthwhile.

B. Sources for Historical Data

When developing a CER from historical data, it is important to consider the different sources available. Some examples of sources include published reports; adopted and draft regulations; local, commercial, and DOE databases; past and current estimates; and bid documents. The information extracted from these sources will provide the estimator an understanding of the steps that are necessary to perform the work for a project so the cost drivers can be identified.

For example, when considering the Uranium Mill Tailings Remedial Action (UMTRA) Project, data collection might include the following:

- searching a DOE energy database;
- reviewing the DOE Uranium Mill Tailing Remedial Action Project (UMTRAP) Status Report, Project Plan, Project Management Plan, Project Schedule and Cost Estimate Report;
- reviewing the remedial action plans (RAPs), site conceptual design and information for bidders for various UMTRAP sites;
- reviewing the Final Rule for Radon 222 Emissions from Licensed Uranium Mill Tailings, U. S. Environmental Protection Agency (EPA) document 52011-86-009, August 1986; and
- reviewing the report titled *Cost Components of Low Level Waste Remedial Action*, PEI Associates, Inc. Contract No. PE-AC01-85MA00205, PN 3685-9.

The information obtained in this historical data search identified the following information.

PURPOSE: Title I of the Uranium Mill Tailings Radiation Control Act (UMTRCA) of 1978, Public Law (PL) 95-604, authorized the DOE, in cooperation with affected State government and Indian tribes, to develop and provide a program to stabilize and control the tailings and other residual radioactive materials located at inactive uranium processing sites.

DATA COLLECTED: A map of the 24 designated processing sites (22 locations) was developed.

- The stabilization method for each location was defined. The processing sites, their priority, and the estimated amount of materials to be handled were identical.
- The current status and estimated cost and completion dates for the work elements at each site were found.

RESULTS: From this data CERs were developed, and an estimate could be developed for UMTRA with the cubic yards or acres of tailings being the only information available. The estimates could be a total cost or an individual component, such as Planning and Design Development.

C. Developing Data from Model Estimates

Sometimes an analyst will be required to develop estimates and CERs pertaining to projects for which there is no historical data. In this situation, the analyst can develop a conceptual design of the project (a model) and can estimate the cost of the model. This estimate is a more comprehensive effort than ordinary estimates. The project must be designed and then estimated for three to five cases or sizes differing from one another with respect to be parameter expected to drive the CER.

Costs for many of the required activities can be obtained from standard cost references and published reports. For example, remediation scenario costs would use references such as—

- R.S. Means Company Building Construction Cost Data Manuals;
- “Cost of Remedial Action,” Version 3.0, a computer cost program prepared by CH_2M Hill under Contract No. 68-01-7090, for the United States Environmental Protection Agency, Office of Solid Waste and Emergency Response;

- *Cost Components of Low Level Waste Remedial Action*, prepared by PEI Associates, Inc., under Contract No. DE-AC01-85MA00205 for the United States Department of Energy;

- *Guide for Decontaminating Buildings, Structures, and Equipment at Superfund Sites*, prepared by PEI Associates, Inc., and Battelle Columbus Laboratories under Contract No. 68-03-3190, for the United States Environmental Protection Agency, Office of Research and Development, Hazardous Waste Engineering Research Laboratory.

D. Historical Data Versus Model-Developed Cost Estimating Relationships

The advantage of a model-developed CER is that the user knows exactly what went into the CER. The assumptions and design that the estimator used to develop the CER are available to the user. The elements of a CER based on historical data are usually less well-defined. The advantage of the CER based on historical data is that the costs were produced by actual projects. Factors the estimator did not think to include in the model CER would be included in the CER based on historical data.

3. DATA NORMALIZATION

The historical data collection and a thorough understanding of the elements of a project are both important in developing CERs. Knowing the different elements that go into building the total project helps the estimator to normalize the data. Two projects may look similar on the surface, but if they are analyzed in more detail, it frequently becomes apparent that unique problems were encountered in each of the projects.

To be useful to the cost analyst, data must be consistent and comparable, and in most cases the data as collected are neither. Hence, before estimating procedures can be started, adjustments must be made for definitional differences, scope differences, etc. The more common adjustments are examined in this section. It is by no means an exhaustive treatment of the subject. The list of possible adjustments is long and frequently they are project-specific. Also, evidence on certain types of adjustments (for contractor efficiency, for contract type, for program stretch-out) can consist largely of opinion rather than hard data. While the cost analyst may allude to such adjustments, the research necessary to treat them in some definitive way has not yet been done.

A. Accounting Differences

Different contractor accounting practices require adjustment of the basic cost. Companies record their costs in different ways. Often they are required to report costs to the Government by categories that differ from those used internally. Also, Government categories change periodically. Because of these definitional differences, one of the first steps in cost analysis is to state the definitions that are being used and to adjust all data to these definitions.

B. Physical and Performance Considerations

A problem that resembles the one discussed above is the need for consistency in definitions of physical and performance characteristics. For example, remediation requirements may be referenced in many ways: remediation required by the regulations, remediation required by a specific contract, or remediation necessary for facility operations. All of these defining terms differ in exact meaning and value. The remediation required by a specific contract may be more than the remediation required by the regulations. The remediation required to place a facility into operation may not be exactly the same as the remediation required in the regulations. Differences such as these can lead an analyst unfamiliar with remediation to use inconsistent or varying values inadvertently. When data are being collected from a variety of sources, an understanding of the terms used to describe physical and performance characteristics is necessary to understand the content of the various cost elements.

C. Nonrecurring and Recurring Costs

Another problem that involves questions of definition concerns nonrecurring and recurring costs. Recurring costs are a function of the number of items produced; nonrecurring costs are not. Thus, for estimating purposes it is useful to distinguish between the two. Unfortunately, historical cost data frequently show such cost elements as nonrecurring and recurring engineering hours as an accumulated item in the initial contract. Various analytical techniques have been developed for dividing the total into its two components synthetically, but it is not yet known whether the nonrecurring costs that are obtained by these methods will be accurate.

A more subtle problem arises when nonrecurring costs on one product are combined with recurring costs on another (i.e., when the contract is allowed to fund development work on new products by charging it off as an operating expense against current production). Separation of the nonrecurring and recurring costs means an adjustment of the production costs shown in contract or audit documents to exclude any amortization of development. The nonrecurring expense that has been amortized can then be attributed to the item for which it was incurred. Such an adjustment can only be accomplished in cooperation with the accounting department of the companies that are involved.

D. Price-Level Changes

Changes in the average hourly earnings of workers must be considered. Wage rates fluctuate from year to year. Also, the location of the workers must be considered. Wage rates differ in different areas of the country.

E. Cost-Quantity Adjustments

The cost-quantity relationships must be considered. Costs are usually a function of quantity. Typically, as the total quantity of items produced increases, the cost per item decreases. If this principle is applied to remediation projects, it becomes apparent that as the amount of replacement material increases, the cost of replacement per unit decreases. Thus, in speaking of cost, it is essential that a given quantity be associated with that cost. A replacement cost might be $3.00 per square foot or $3.50 per square foot for the same material, depending on the total number of square feet replaced.

F. Escalation

Data will be collected from several projects. Typically, they do not all occur at the same time. Thus, the cost data must be normalized to the same base year prior to developing the CER. The data should be adjusted by using the escalation indices guidelines produced by the Office of Infrastructure Acquisition (FM-50).

G. Regional Differences

The same type of project may have been built all over the United States. The cost data may be for the same activities, but it is from several different regions. There are regional cost differences, and they must be considered when using the data.

H. Other Possible Cost Normalizations

The lack of a way to adjust cost data for productivity changes over time is illustrative of the current situation in which more kinds of cost adjustments have been theorized than have been quantified. For example, it has been suggested that adjustment may be required because of differences in contract type (fixed-price, fixed-price-incentive, cost-plus-fixed-fee contracts) or differences in the type of procurement (competitive bidding or sole source). The hypothesis is that the type of contract or procurement procedure will bias costs up or down, but this hypothesis is difficult to substantiate.

Another question concerns changes in techniques and available equipment. A related question concerns the efficiency of the contractor. It may be surmised that Contractor A has been a lower cost producer than Contractor B on similar items, but this is extremely difficult to prove. A low-cost producer may be one who, because of geographical location, pays lower labor rates.

The cost of delays can also skew the data. For example, when comparing two similar projects, the estimator may learn that one project was delayed for several months because of regulatory problems while the other project proceeded smoothly.

In order to normalize these two projects so they can be compared, the cost of the delay should be deleted from the project that experienced these problems.

Prior to using historical data in a CER, it should be checked to ensure it will not be used out of context. This is particularly important when the data come from a project with special considerations, such as a discount that will not apply to a project being estimated.

4. DEVELOPING COST ESTIMATING RELATIONSHIPS

Once the data have been collected and normalized, a set of data points is developed. These data points are used to build the CER.

A. Simple Averages

Many estimating relationships are simple statements that indicate that the cost of a commodity is directly proportional to the weight, area, volume, or other physical characteristics of that commodity. These estimating relationships are simple averages. They are useful in a variety of situations and, because of their simplicity, they require little explanation.

B. Detail of Cost Estimating Relationships

The estimator will sometimes want to build CERs for each step of a project. These CERs can then be summed to produce a CER for the total project if the steps are independent. This additional detail makes it easier to apply the CER to a new project. If the CER predicts a total cost that is significantly different from the existing estimated cost, the ability to use CERs to estimate the cost of different parts of the project allows the estimator to analyze those parts and identify where in the project the cost variances occur.

C. Enhanced Cost Estimating Relationship Program

The derivation of more complex relationships (i.e, equations that are able to reflect the influence of more than one cost variable) must be developed by using statistical analysis. A computerized software package, called the Enhanced Cost Estimating Relationship (ECER) Program, was designed for DOE for the development of estimating relationships and is available from FM-50.

CHAPTER 20

ESTIMATING SPECIALTY COSTS

1. INTRODUCTION

Specialty costs are those nonstandard, unusual costs that are not typically estimated. Costs for research and development (R&D) projects involving new technologies, costs associated with future regulations, and specialty equipment costs are examples of specialty costs. This chapter discusses those factors that are significant contributors to project specialty costs and methods of estimating costs for specialty projects.

2. RESEARCH AND DEVELOPMENT COSTS

Traditionally, cost estimating has involved the compilation of historical data for use in correlating and validating existing estimating methodologies. These methodologies and the corresponding cost data are then used to prepare cost estimates. Historical data lends a cost estimate some accuracy and credibility. In today's environment, a problem arises when the cost estimate is required for new, innovative, "state-of-the-art," first-of-a-kind projects. According to one author,[1]

> "For many new ventures economic feasibility is dependent on process innovations as yet untried and unproven, and the technical alternatives are numerous and complex. In these cases, technical feasibility must be established and, depending on the size of the project, detailed systems design and planning may be needed to ensure accurate cost estimates."

Knowledge of the processes involved will help the cost estimator in preparing an accurate cost estimate. In the absence of accurate cost information, process knowledge can focus the estimator towards those parts of the project that are significant contributors to overall project cost.

A. Personnel Costs

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[1] Clifton, D.S. and Fyffey, D.E. 1977: "Project Feasibility Analysis—A Guide to Profitable New Ventures."

Personnel costs are usually the largest R&D expenses. R&D personnel are well educated and a have a higher pay scale than employees for conventional projects.

B. Equipment Costs

Equipment costs for R&D projects can be divided into hardware and software costs. Hardware includes machinery, computers, and other technical equipment. Equipment costs increase with increasing project complexity. For example, if the research involves extensive modeling or computer calculations, a supercomputer may be required. Specialized software may have to be developed for the project, so software costs can also be significant contributors to the overall project cost.

C. Prototypes and Pilot Plants

In some instances it will be cost effective to develop a prototype or a pilot plant for an R&D project. A cost estimate for a prototype or a pilot plant will have to account for the following:

- construction of the equipment or plant;
- operation of the equipment;
- development of test criteria for plant studies;
- analysis of test results; and
- computer simulation of plant processes.

The estimate will also have to provide for project management and personnel during the pilot plant study or prototype testing.

D. Scaled Models

Plastic, scaled models of industrial facilities are used to improve visualization of the facility in three dimensions. Building the model can identify problems that may occur during actual construction of the facility. Models can also be used as a management tool if the model is constructed as the facility is constructed. The model then shows the status of the project.

Models have many advantages, but the main disadvantage is cost. The models are expensive to construct; however, in most cases the benefits obtained from the model exceed the model’s cost.

E. Computerized Models

Computerized modeling may need to be performed for some projects. For example, if the project goal is to construct a new incinerator for mixed hazardous and radioactive waste, site-specific air dispersion modeling may be required to demonstrate that emissions from the incinerator will not have an adverse impact on public health or the environment. Groundwater modeling may be required for some remediation sites. Assume the groundwater contamination had been found at a site, and several technologies are being proposed for the site. Modeling can be used to select the best technology or to determine the optimum locations for pumping or injections wells. Computer models have also been used to develop risk assessments for contaminated sites. Finally, for conventional projects, finite element analysis may be used to determine potential weaknesses in a design.

Some models can be quite complex and require specialized technical expertise on the part of the modeler to avoid the "garbage in = garbage out" phenomena. The labor hours required for gathering input data, modeling time, labor and computer, and report preparation must be accounted for in the cost estimate.

F. Cost Estimating Methods for Research and Development Projects

Estimate detail will be a function of the project size, technical complexity and innovation of the project, number of alternatives to be evaluated, and the required accuracy of the estimate.

Several levels of cost estimating methods may be available to the cost estimator.

1. Scoping Estimate

This method is also known as "back-of-the-envelope," and it is a preliminary estimate that is developed during the preliminary design phase. Total project cost is estimated by multiplying the cost of a major piece of equipment by a factor. This technique was originally proposed by J. J. Lang. "Lang factors" range from about 4 to 5 and vary based on the type of process plant to be estimated.

2. Scaling Factors

Order-of-magnitude estimates require that major project units be known and sized. The estimate is prepared from major equipment purchase prices plus scaling factors. Estimate accuracy will be plus or minus 40 percent because data required for the estimate may not be available due to the "state-of-the-art" nature of the project.

Good results can be obtained from a scaling factor by using the logarithmic relationship known as the "six-tenths-factor rule," if the new piece of equipment is similar to one of another capacity for which cost data are available. According to this rule, if the cost of a given unit at one capacity is known, the cost of a similar unit with X times the capacity of the first is approximately $(X)^{0.6}$ times the cost of the initial unit.

$$\text{Cost of equip. } a = \text{cost of equip. } b \left(\frac{\text{capac. equip. } a}{\text{capac. equip. } b} \right)^{0.6}$$

The preceding equation indicates that a log-log plot of capacity versus equipment cost for a given type of equipment should be a straight line with a slope equal to 0.6. Figure 20-1 presents a plot of this sort for shell-and-tube heat exchangers. The application of the 0.6 rule of thumb for most purchased equipment is an oversimplification of a valuable cost concept since the actual values of the cost capacity factor typically vary from less than 0.2 to greater than 1.0. Because of this, the 0.6 factor should only be used in the absence of other information. In general, the cost-capacity concept should not be used beyond a tenfold range of capacity, and care must be taken to make certain the two pieces of equipment are similar with regard to type of construction, materials of construction, temperature and pressure operating range, and other pertinent variables.

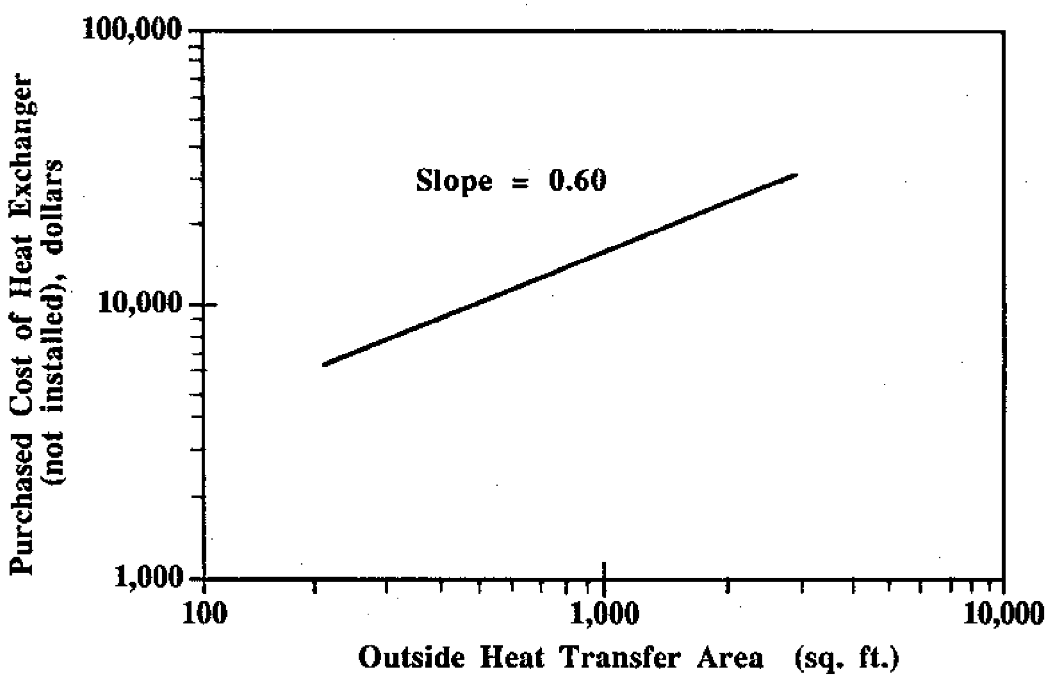


Figure 20-1. Application of "six-tenth-factor" rule to costs for shell-and-tube heat exchangers.

3. Detailed Estimate

Detailed estimates will be similar to an estimate prepared for engineering or construction bid purposes. This level of estimate will be costly to prepare but may have an accuracy of plus or minus 20 percent. It should be noted that detailed estimates may not be cost effective when determining economic feasibility between several technical alternatives.

4. Level of Effort

A level of effort estimate is made by determining how much of a resource is required for a given time. For example, the design of a large remediation project may take 150 engineers for a period of 5 years. Historical data can be referenced to determine resource loading.

3. REGULATORY COSTS

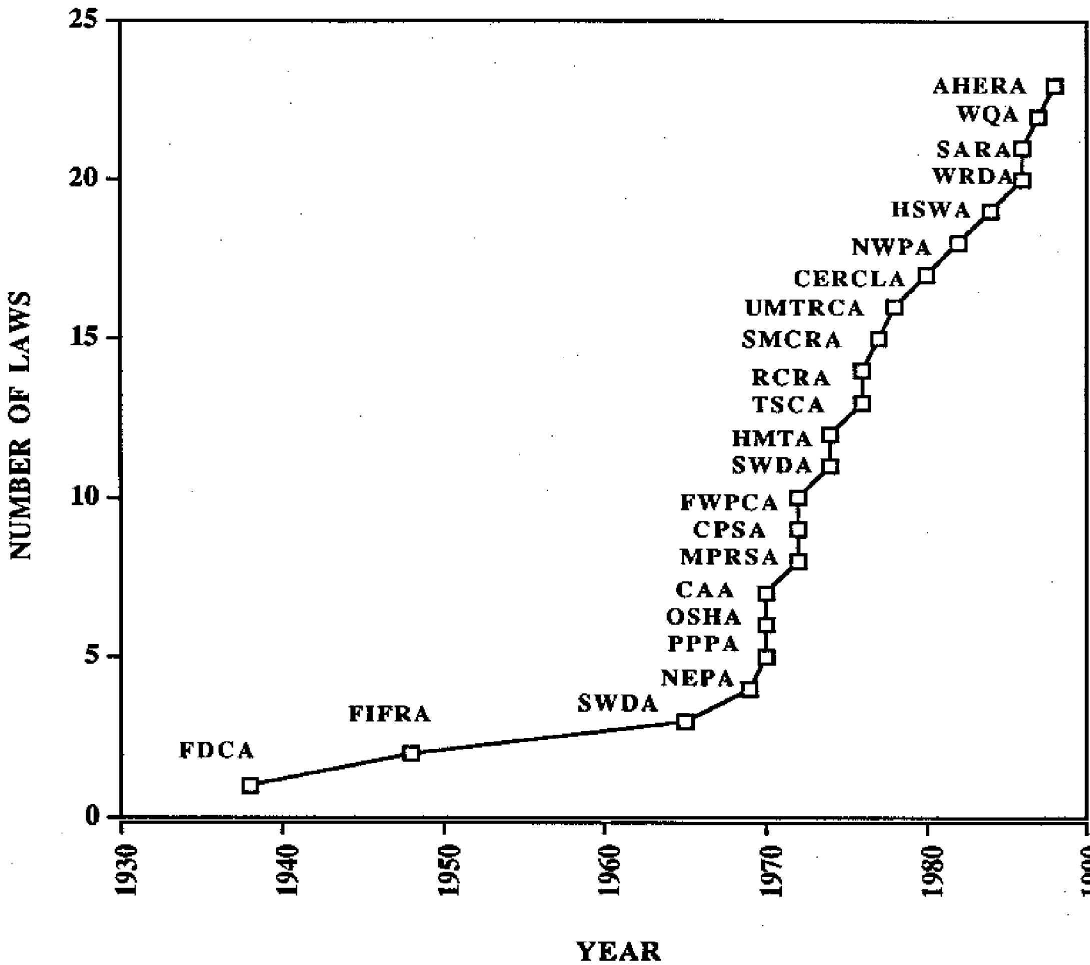
There are certain environmental and health and safety regulatory compliance costs associated with all facilities and projects. For conventional government projects, the facility must satisfy all federal, state, and local waste disposal, wastewater effluent disposal, and air emission limitations imposed by the applicable agencies. Regulations are even stricter for facilities that process or store radioactive materials. Construction sites must follow Occupational Safety and Health Administration rules. Environmental projects must protect human health and the environment during all phases of the project. Cost estimates must contain sufficient provisions for environmental and health and safety compliance. A familiarity with applicable regulations is required so a plan may be developed so the project may comply with those regulations.

A. Environmental Compliance Costs

The number and requirements of environmental regulations have increased dramatically in the past 20 years, as shown by Figure 20-2.

Several items should be considered when preparing environmental compliance cost estimates:

- type of project,
- project location, and
- waste generation, effluent characteristics, and air emissions from the project.



FDCA = Food, Drug, and Cosmetics Act (1938); FIFRA = Federal Insecticide, Fungicide, and Rodenticide Act (1948, 1972, 1975, 1983); SWDA = Solid Waste Disposal Act (1965); NEPA = National Environmental Policy Act (1969); PPPA = Poisonous Packaging Prevention Act (1970); OSHA = Occupational Safety and Health Act (1970); CAA = Clean Air Act (1970, 1977); FWPCA = Federal Water Pollution Control Act [Clean Water Act] (1972, 1977); MPRSA = Marine Protection, Research, and Sanctuaries Act (1972); CPSA = Consumer Product Safety Act (1972); SDWA = Safe Water Drinking Act (1974, 1986); HMTA = Hazardous Materials Transportation Act (1974, 1984); RCRA = Resource Conservation and Recovery Act (1976); TSCA = Toxic Substances Control Act (1976); SMCRA = Surface Mine Control and Reclamation Act (1977); UMTRCA = Uranium Mill Tailings Radiation Control Act (1978); CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act (1980); NWPA = Nuclear Waste Policy Act (1982); HSWA = Hazardous and Solid Waste Amendments (Amendments to RCRA) (1984); WRDA = Water Resources Development Act (1986); SARA = Superfund Amendments and Reauthorization Act (Amendments to CERCLA) (1986); WQA = Water Quality Act (1987); AHERA = Asbestos Hazard Emergency Response Act (1988).

Figure 20-2. Growth of Health and Environmental Protection Laws

Project location is significant to the project cost. If the project will disturb a wetlands area or if the project is located in an extremely environmentally conscious state, such as California, the estimator should account for increased environmental compliance costs in the project estimate. The project will be more expensive to complete and operate under these special conditions. Estimators are strongly advised to discuss the project with knowledgeable design staff and contact personnel familiar with environmental regulations that will affect the project.

A knowledge of wastes generated or air emissions during the project will facilitate the identification of environmental compliance design requirements and subsequent costs. For example, wastewater treatment may be required prior to effluent discharge into a stream or publicly owned treatment works. Air pollution control devices may be required for process equipment.

To estimate regulatory costs, an understanding of the types of costs that can be expected is needed. For example, permitting costs could include:

- labor to gather data,
- equipment for testing,
- analytical tests,
- time for interface with project personnel and outside consultant, if applicable,
- permit fee,
- annual permitting costs,
- upgrades to existing equipment, and/or
- new pollution control equipment.

Once a plan for regulatory compliance has been established, the regulatory costs can be estimated for that plan. This will establish a baseline for the costs, and regulatory changes that affect this baseline can be tracked and estimated throughout the project's life.

B. Health and Safety Compliance Costs

Employee health and safety regulations have followed the same general trends as environmental regulations towards increased regulation. As allowable worker exposure limits decrease, design cost estimates will have to account for specific engineering controls to minimize employee exposures to toxic or hazardous substances in the workplace, especially for facilities involved with radioactive materials. Past experience with “increased regulatory rigor” within DOE has shown that the costs associated with employee workspace controls, including industrial hygiene monitoring, is the most significant cost factor in a more rigorous health and safety program. This trend will continue. Planning is essential since retrofit costs can exceed original installment costs.

State-of-the-art, high-tech facilities may require additional initial employee exposure monitoring if unknown situations are encountered. Protective equipment must also be supplied and maintained for the employee. Environmental projects may have strict health and safety requirements, including routine medical surveillance, preparation of health and safety plans, and employee training. Employees may not be able to work 8 hours a day if daily decontamination of personnel and equipment is mandatory.

C. Compliance Costs and Scheduling

For some projects, a permit is required before the project can commence. For example, construction projects that will disturb more than 5 acres are now required to obtain a stormwater permit prior to commencing construction.

Project scheduling can be affected if operating permits are not received in a timely manner. Facilities may be shut down for violations of operating permits or failure to comply with existing regulations. The time required for regulatory review of the permit application must also be factored into the cost estimate.

4. SPECIALTY EQUIPMENT

Specialty equipment includes non-typical hardware or equipment such as glove boxes for radioactive handling or architectural specifications such as computer room floors or flag poles. None of these examples are common to conventional projects; however, in most cases, a good cost estimate can be developed with the help of vendor quotes.

Computerized modeling may be required as part of the permit process, and any cost estimate for the project should include consideration for an outside consultant’s modeling and report preparation costs.

CHAPTER 21

LEARNING CURVE

1. INTRODUCTION

It is a fundamental human characteristic that a person engaged in a repetitive task will improve his performance over time. If data are gathered on this phenomenon, a curve representing a decrease in effort per unit for repetitive operations can be developed. This phenomenon is real and has a specific application in cost analysis, cost estimating, or profitability studies related to the examination of future costs and confidence levels in an analysis. It could be used in estimating portions of a project, such as the production of magnets for the supercollider. This chapter discusses the development and application of the learning curve.

2. THE CURVE

The aircraft industry was the first to develop the learning curve. Based on comparison of manufacturing and aircraft industry learning curves, it is evident that a typical curve exists. It is an irregular line that starts high, decreases rapidly on initial units, and then begins to level out. The curve shows that there is progressive improvement in productivity but at a diminishing rate as the number produced increases. Figure 21-1 shows the appearance of the curve.

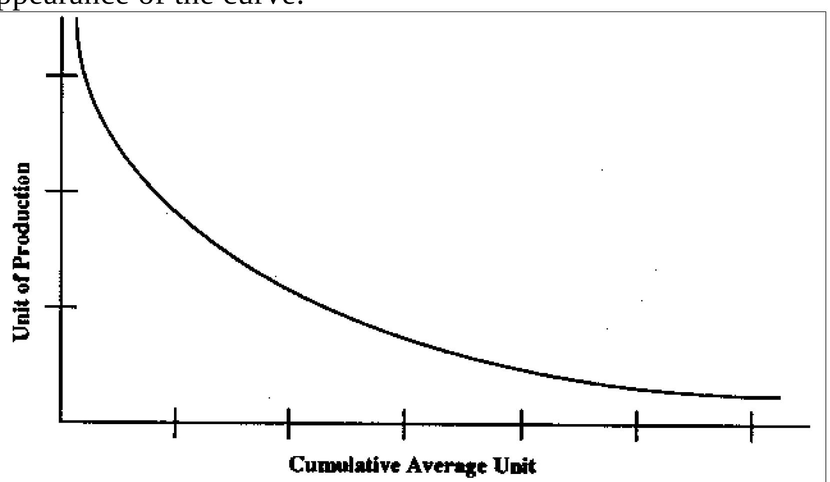


Figure 21-1. Curve Appearance

This suggests an exponential relationship between productivity and cumulative production. When this data is plotted on log-log paper, the data plots as a straight line. This suggests the relationship of the form:

$E_N = KN^S$

where E_N = effort per unit of production (i.e., manhours) to produce the Nth unit

K = constant, which is the effort to produce the first unit
s = slope constant, which is negative since the effort per unit decreases with production.

The above relationship will plot as a straight line on log-log paper.

Take the logarithms of both sides,

$$\log E_N = s \times \log N + \log K$$

which is the equation of a straight line

$$Y = sX + b$$

where $Y = \log E_N$, $X = \log N$, and $b = \log K$.

Figure 21-2 represents the data on log-log paper.

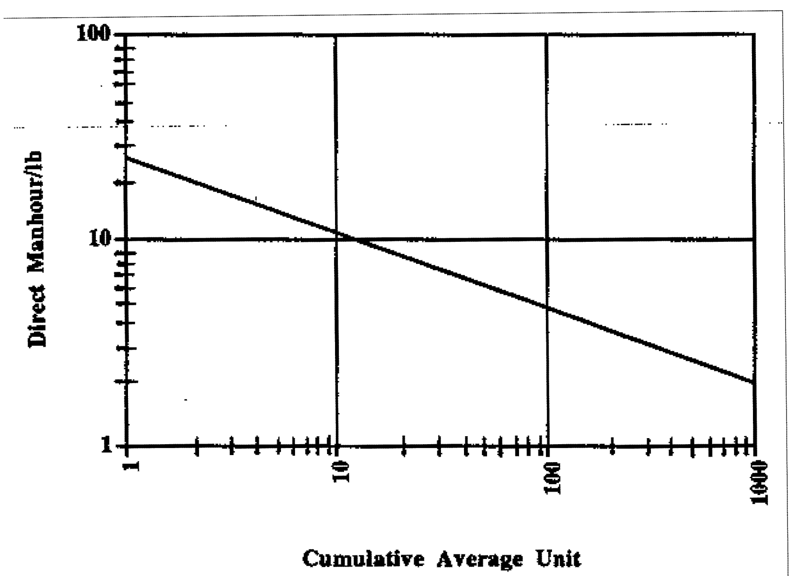


Figure 21-2. Data on Log-Log Paper

3. LEARNING CURVE FROM SINGLE-UNIT DATA

If the effort is available for each unit produced, any one of three curves can be plotted. They are the unit, the cumulative total, and the cumulative average. Following is Table 21-1, which includes single-unit data.

TABLE 21-1
PRODUCTION DATA

ITEM	UNIT HOURS	CUM. TOTAL HRS	CUM. AVG. HRS
1	10.0	10.0	10.0
2	8.0	18.0	9.0
3	7.3	25.3	8.4
4	6.3	31.6	7.9
5	6.0	37.6	7.5
6	5.6	43.2	7.2
7	5.6	48.8	7.0
8	5.0	53.8	6.7
9	5.1	58.9	6.5
10	4.5	63.4	6.3

From this data the unit, cumulative total, and cumulative average curves can be drawn.

A. Unit Curve

If a set of data is available for the effort required for single, individual units of production, the data can be plotted on log-log paper and the best line drawn with the eye. Having established the best line, any two points on the line can be used to determine, graphically or analytically, the slope of the line and K, which is the intercept at N = 1. This graphical method is quick, but it may require judgment when the data points are scattered.

The most accurate method for determining the best straight line is to use the least squares method.

B. Cumulative Total Curve

For this curve, the effort is described as cumulative total. This curve produces a line with a positive slope.

C. Cumulative Average Curve

The effort calculated for this curve is the cumulative average for each unit. It produces a curve that is usually a more regular curve than the unit curve.

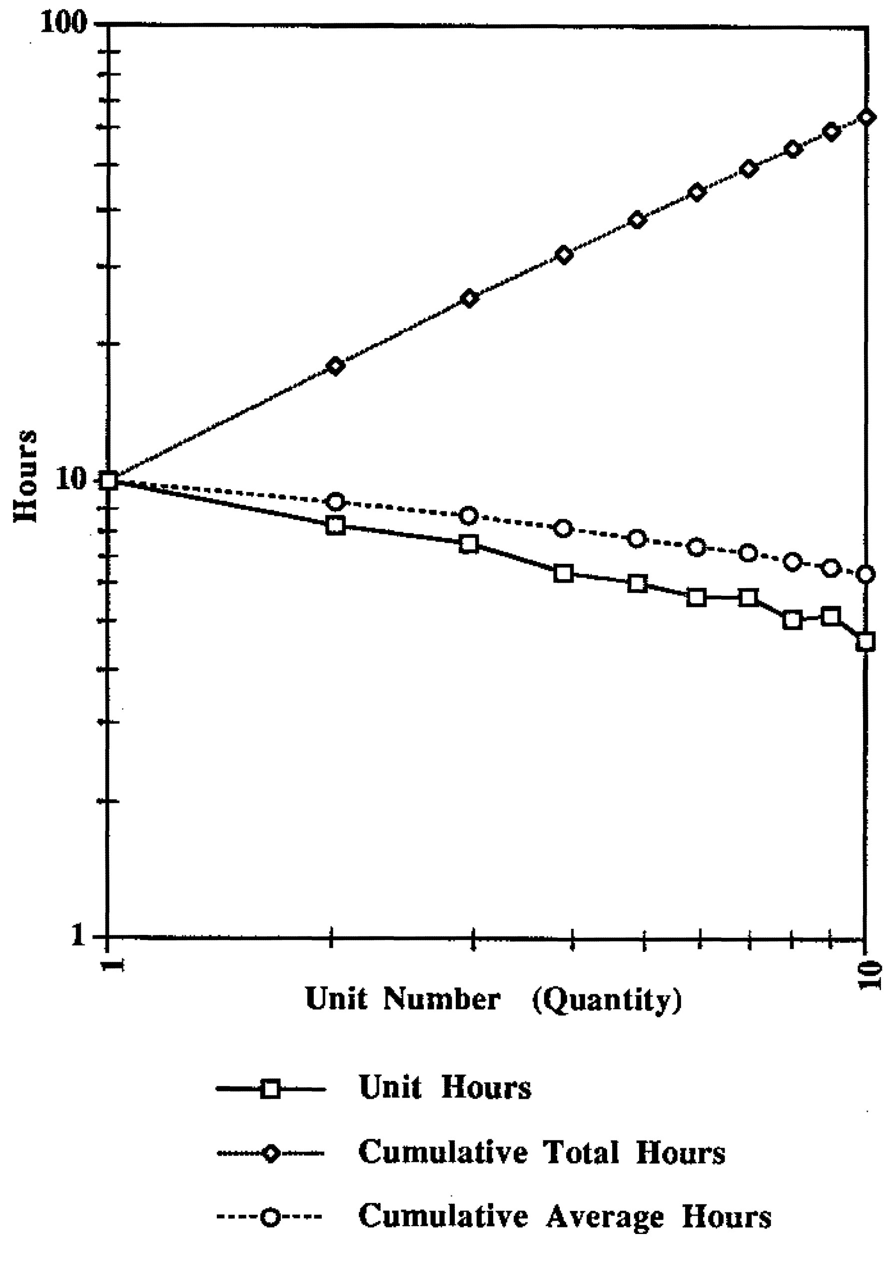


Figure 21-3. Curves on Log-Log Paper

4. EFFECTS OF DOUBLING PRODUCTION

The equation, $E_N = KN^s$, implies a constant fractional or percentage reduction in effort for doubled (or tripled, etc.) production. For example, for any fixed value for s gives:

$$E_1 = K(1^s)$$
$$E_2 = K(2^s)$$

$$\frac{E_2}{E_1} = \frac{K(2^s)}{K(1^s)} = 2^s$$

also,

$$E_2 = K(2^s)$$
$$E_4 = K(4^s)$$

$$\frac{E_4}{E_2} = \frac{K(4^s)}{K(2^s)} = 2^s$$

Every time production is doubled, the effort per unit required is a constant 2^s of what it was. It is common practice to express the learning-curve function in terms of the gain for double production. Thus, a 90 percent learning-curve function requires only 90 percent of the effort per unit every time production is doubled.

5. LEARNING CURVE TABLES

The learning curve will vary on different programs. A table of percentages for each type of program can be developed by taking the ratio of the average hours for the total program to the average hours for the first half of the total units. For example, the average hours for 200 units is 80 hours, and the average hours for the first 100 units was 100 hours each. Thus, 80/100 equals 80 percent. This is an 80 percent curve. Various curves are classified as 80 percent, 86 percent, 90 percent, etc., curves. If an 80 percent curve were plotted on arithmetic paper, we would expect a different-shaped curve for each project. If it is plotted on log-log paper, all curves will be straight lines. Tables for the various percentage curves can be developed so accurate figures can be calculated without using the more complicated mathematical formulas.

6. LEARNING CURVE FROM GROUPED DATA

Usually data are not available for the effort required to produce a single, individual unit. Instead, data are available for the average effort to produce a group or lot of units. From this the effort per unit for a lot can be calculated, but the effort per unit is not known. Before this data can be plotted, it is necessary to take each group and convert it to a point. This point within the group is associated with a “unit” number. The point can be referred to as the lot midpoint or the lot equivalent point. One method used to calculate the lot midpoint is to use the arithmetic mean of the first and last unit number in the lot. Once the lot midpoint is calculated, the curve can be drawn.

7. APPLICATION OF THE LEARNING CURVE

When estimating a project cost when one of the variables is a large quantity of a unit, the learning curve can be used. If the cost of production of the first units is known or if a percentage table can be assumed, the impact of several units being produced can be calculated. The effort can be defined as the cost to produce the item, and the cost impact can be evaluated.

CHAPTER 22

COST MODELS AND COST ESTIMATING SOFTWARE

1. INTRODUCTION

Discussions in previous chapters have made the following points about cost estimating methods.

- Cost estimating requires separate arithmetic operations, many of which must be performed in a specified sequence.

- These operations in turn require numeric inputs, or selected descriptive details of the specific estimate.

- Results of selected arithmetic operations are sometimes used as inputs for others in the estimation process.

It becomes apparent that if the above items are formalized, a specific methodology for obtaining cost estimates is the result. It is a method that produces the same results when the same inputs are used. This formalized methodology is basically a cost model, which forms the basis for estimating software.

2. DEFINITION OF A COST MODEL

A cost model is a set of mathematical relationships arranged in a systematic sequence to formulate a cost methodology in which outputs, namely cost estimates, are derived from inputs. These inputs include quantities and prices. Cost models can vary from a simple one-formula model to an extremely complex model that involves hundreds or even thousands of calculations. As an example of a very simple cost model or cost estimating relationship (CER), the cost of an item might be related directly to its weight; that is $C = DW$:

where C = cost of item
D = cost in dollars per pound of weight
W = weight in pounds

Here, D and W are inputs to the model and C is the output. Although this is a very simple model, it nevertheless performs the function of providing a cost estimate for given inputs.

Because the term cost model is used in various situations, it can have a variety of specific meanings. However, it still has the general connotation of an integrating device designed to facilitate the analytical process of obtaining cost estimates. In brief, it is a stylized representation of a part of the real world and can be used to gain insights into the cause-and-effect relationships existing in this world.

A distinction should be made between the term cost model and its representation in a computer program. Sometimes it is preferable to consider primarily the concept of the model and to treat the computer program as a less interesting tool. This distinction between the model and its representation on a computer may be especially useful in avoiding a tendency to focus attention on the wrong aspect—a common error when the advantages of a proposed cost model are being described. Speed and printed output are related to the computer, not to the use of the model. Although the term "cost model" is sometimes used to include the computer program, the advantages and limitations of cost models should not be confused with those of computers.

A. Types of Cost Models

Cost models can be classified in several ways. One basis for classification would be the complexity of manipulation of the inputs. On this basis, the very simplest cost model gives only a summary of facts provided by the analyst. The model may provide rules for subtotaling and totaling of information supplied as inputs. Models of this sort often use computers to perform the functions of an adding machine and typewriter. A slightly more complex model may require a minor amount of multiplication in order to find a few intermediate values to be summarized and displayed. Somewhat more complex models may involve choices of estimating techniques that depend on specific inputs. The most complex models may involve fairly sophisticated analytical techniques, such as nonlinear programming or probabilistic iterations.

Cost models can be categorized according to the function they serve. Some models are designed to assist long-range planners; others are for use in programming, where this term applies a more detailed level of planning and application in the near future. Still others are designed for budgetary use. The function to be served influences the design of the model in many ways, with the level of detail to be represented as one of the most obvious. A model designed for budget use would not usually be applied to long-range planning because it would require as inputs detail that is unavailable.

Cost models can also be classified according to the likelihood of repetitive use. Some are used for one application only. They may require considerable design and involved preparation of the input data, but they are developed for specific applications. Once the need has been met, the model is a thing of the past. It may still exist in files, and reference to it may be helpful in designing a later model. A model developed for a single use can be contrasted with a cost model designed to be used many times, and to give many cost estimates. The latter may require more care in design because of the likelihood that it will be used when the designer is not available; in other words, a model for general use should be user-oriented.

A cost model can be considered in the context of the subject matter that it is intended to represent. Some models deal with relatively minor parts of the total problem to be considered by a decision maker; others attempt to represent almost all of the problem areas faced by the decision maker.

1. Advantages

Just as there are many kinds of models, so are there many kinds of benefits that can be obtained from models. In cost analysis, one of the most important functions of a model is that of providing a framework for analysis. The analyst finds that construction of a model requires precision, and that the need to identify each functional relationship imposes a discipline. The attempt to establish specific mathematical expressions aids the analyst in recognizing those elements of the total problem that require the most effort. The development of a model thus serves to give insight.

Isaac Newton observed that free-falling objects accelerated downward, and his observation can be expressed in a mathematical relationship, or a simple model:

$$d = \frac{1}{2} gt^2$$

where $g = 32$ ft/sec^2
    t = time of fall in seconds
    d = vertical distance fallen in feet after t seconds

The model explains that gravitational acceleration at the earth’s surface is about 32 feet each second. This specific statement enables an observer to test Newton’s hypothesis by comparing actual observations with the model’s prediction. A cost model can be used similarly to test hypotheses about costs. The typical hypothesis, however, cannot be proved through use of a cost model. A series of tests can either show that it is unsatisfactory or let it remain as a reasonable hypothesis.

A model will give the same output when given the same inputs. This ability to reproduce outputs is a great advantage when compared with the use of unstructured best judgment to provide cost estimates. Both the user and the supplier of estimates usually prefer that a given problem yield the same result no matter how many times it is examined. Lack of reproducibility leads to lack of credibility.

The consistency of response inherent in cost models enables the analyst to make comparisons among alternatives. He can be sure that identical inputs are treated alike and that the differences in cost estimates (outputs) are based on differences in inputs. The ability to compare on a consistent basis is one of the most attractive features of cost models. However, the analyst must always be aware that the outputs are only as good as the assumptions of the model and the input data permit.

Cost-sensitivity analysis, an important analytical tool, tests the sensitivity of outputs to changes in one or more inputs. This is done usually through repetitive cost estimates that keep certain inputs unchanged while others are varied in a controlled manner. This sort of analysis can be performed only if there is a technique for using the inputs to obtain cost estimates)in other words, only if there is a cost model.

Another important analytical tool is called contingency analysis. Instead of changing one input to the cost model, the analyst changes one or more aspects of the problem. It might even require that the analyst change the basic assumptions of the model. In such cases, a more general model may be needed before estimates and comparisons can be completed. Contingency analysis is another kind of sensitivity testing. It helps to show whether the item (or system or force) that is being costed is appropriate for only one contingency or for a range of contingencies. An unambiguous, reproducible set of estimates is essential for both sensitivity and contingency analyses.

A model is an excellent tool for organizing research. It highlights those areas of cost-analysis methodology needing improvement or further research. At the same time, it provides a device for incorporating the results of current research into the methodology depicted by the model.

2. Limitations

The benefits that analysts can obtain by the proper use of cost models are impressive. However, there are undeniable limitations, and the development and use of cost models present problems that might not otherwise have to be met.

Most cost models are of expected value in nature (deterministic) (i.e., estimating relationships are expressed as direct mathematical functions so that the output is determined specifically when the inputs have been furnished). The numeric values used as inputs and in the estimating relationships are best estimates or expected values that are intended to represent a real world that is not so easily reproduced. Estimating relationships always involve uncertainty. Unfortunately, the use of a deterministic model may encourage the analyst to feel that he has a technique for estimating the only output that is correct. Failure to recognize inherent uncertainty could be a serious error in analysis, and the use of expected-value models may make such failures more likely.

Cost models may be broadened to address the problem of uncertainty;[1] however, analysts have found a fairly strong demand for point estimates of cost. No matter what supplementary information the cost analyst wants to supply, he is usually asked for one best estimate of the cost of each item, and no matter how desirable probabilistic cost models may seem in concept, the working analyst continues to find that he is asked to use expected-value cost models.

The model designer selects essential relations to include in his model, and, unfortunately, the model user might readily develop the habit of thinking about only those relations represented in the model. Of course, the designer should always be aware that the model is a simplification and that its use involves the assumption that all outside relations are unimportant (e.g., Newton's model of a falling object neglects atmospheric drag). However, repetitive use of the same model may focus undue attention on those functions that are represented and may lead to unexamined belief (or feeling) that no other functions can be of interest. For example, Newton's model also assumes g to be constant, although in fact, g is not exactly constant.

The preceding comments relate to problems that arise from misdirected attention on the part of the operator of a cost model. They are representative of an almost unlimited class of such problems. However, it can be argued that the use of a model does not necessarily increase the likelihood of misdirected attention. The advantages, or perhaps the necessity, of using cost models will usually outweigh the possible limitations. Models, as any tool, must be used with proper care, skill, and judgment.

B. Model Maintenance

A model must be an adequate representation of the current real world to be useful. An excellent model developed in the past to represent the world as it existed in the past may still be an excellent model of today's world, but the analyst who uses an existing model must be aware that, in effect, he is deciding that the model is still good. To make sure that the model will merit this confidence, proprietors of cost models must provide for continuing maintenance. They must make sure that the

1 P.F. Dienemann, "Estimating Cost Uncertainty Using Monte Carlo Techniques," The Rand Corporation, RM-4854-PR, January 1996.

estimating techniques that are in the models not only continue to be of the correct functional form but that they also continue to have the best numeric values for all coefficients or parameters. This assurance is not possible without a positive program to monitor relations in the real world. Every cost model imposes a duty on its operator, who must arrange (or be satisfied with existing arrangements) for an information system that can be expected to give appropriate notice when the model should be modified.

The need for information about values and relations that are inside the model is evident. A less obvious need is frequently a greater problem. The model operator must be ready to use the model for a fairly wide range of cases. This readiness requirement implies the availability of reasonable values for all inputs that might be needed. The model operator must have a continuing program to stay informed on the wide range of cases that can be studied using his model.

C. Computerized Cost Models

The application of computers to cost models offers many advantages to cost analysts who use these models. First, the computer is fast and relieves the analyst of much of the tedium of making numerous calculations (which also involve many chances for making errors). It should be noted that although the computer may be able to complete a job in a matter of seconds, the time required for developing and entering the inputs and processing the outputs may create a total turnaround time of several hours or days. Also, the input can be saved on magnetic tape or a diskette for future use, which facilitates revision and reprocessing.

In addition to the obvious advantages of speed and accuracy, a computerized cost model provides a useful documentation aid. Once the computer program is operable, the analyst has the cost methodology actually documented within the computer program. Cost-sensitivity analysis, which attempts to demonstrate the effect on the outputs of changes in the inputs, becomes much more practical when a computerized model is available to examine a range of cases and numerous variations in each case.

Another advantage of a computerized cost model is that in its development the analyst is often forced to make decisions that clarify potentially troublesome areas of the model that cannot always be foreseen and which might be overlooked. Other kinds of troublesome areas may exist in which estimating relationships are either unknown or seldom used. A computerized program can provide for these by means of throughputs. A throughput is a data input that has been calculated outside of the computer and that is intended to be included in the final tabulations and summaries without further processing. In other words, the computerized cost model must be a precise, bounded framework of a specific methodology. Often, either in the programming or initial operation of a model, these areas (including illogical steps) are highlighted because many runs can be made on the computer to explore many kinds of situations.

A computerized cost model program and data inputs may be stored in easily retrievable form on tape or disk. With occasional revision as the data and relationships require updating, they are available for use whenever necessary.

One of the disadvantages of using a computerized cost model is that sometimes the model is almost too automated for the benefit of the user. A model can never be a substitute for the ability of the analyst to perform the estimating job (i.e., his ability to develop reasonable and realistic inputs based on judgment and experience). The analyst must continue to be aware that the outputs of the model are only as good as the inputs that produced those outputs. Such outputs must always be judged in the context of the model that is used.

Generally, a large, complex model that is to be used many times is the most suitable for programming on a computer. For a model that is developed for one specific application, the question of whether to program such a model for computer use depends on several factors. Basically, one must decide whether the advantages of the computer model would offset the time and effort required for programming and verifying such a model. For some operations it might be advantageous to program the model even if it is to be used only once. In other cases, based on judgment of the analyst, it might be more expedient to use a desk calculator.

In developing a computerized cost model, analysts often faces the need to communicate the description of the model to the computer programmers. The analysts must not only show all of the mathematical relationships in the models to the programmers, but, perhaps even more important, they must also show the sequence of operations. Specifically, they must show the logic of the models. It must be realized that a computer, like a person, performs only one calculation at a time. There are no parallel paths in a computer program where several calculations are performed simultaneously; therefore, all calculations must be shown sequentially.

One way that analysts can communicate this information to programmers is through the use of flow charts that depict the sequence of operations through a program. Such charts can be used to depict various calculations according to their functions within the program. Once these are established, charts may be constructed in greater detail, including the estimating relationships. Finally, a highly detailed flow chart may be prepared that depicts every step of the program, including loops for repetitive calculations.

Figure 22-1 shows a simplified cost model flow chart that gives the sequence of operations for a computer program that calculates total facility costs. More detailed flow charts could be developed later. Generally, in developing a detailed flow chart, the analyst need only ask, "If I were doing this problem by hand, what is the first step I would perform; then what is the second step; what is the third step; etc.?" A computer performs in exactly the same way and must be told how to perform every step through a program.

3. ESTIMATING SOFTWARE

Computerized cost estimating began more than 25 years ago on mainframe computers. However, due to the cost and difficulty of running a mainframe computer, most estimating departments still used manual methods until personal computers (PCs) evolved. In the early 1980s, PCs developed sufficient speed and power to easily handle the amount of data generated in detailed cost estimates. As computerized cost estimating gained popularity, more and more software packages were developed, both commercially and in-house by DOE cost departments. The software ranges from parametric to detailed estimating packages, and many are owned by the DOE. Some were developed by the Office of Infrastructure Acquisition (FM-50).

A. Survey of Available Software

In the past, FM-50 has conducted a survey of available software, including DOE-owned and commercial packages. It was found that most cost-estimating programs are written for use in one of four categories:

- programs for use by general contractors,
- programs for use by architects,
- programs for check estimates on quotations received from contractors, and
- highly specialized programs related to cost estimating.

The general contractor programs are used for the preparation of cost estimates associated with design project bids. The architect programs are used to estimate the cost of projects prior to completion of project design. The check estimate programs are used to check the contractor’s cost estimate of a designed project or to do conceptual cost estimates. The specialized programs include such things as life-cycle costs, bid day, heavy-equipment rental/charge rates, cost program data bases, highly specialized cost estimating programs for painting, windows, etc., and design and cost programs for highly specialized equipment, etc.

Programs for use by architects differ from the contractor programs in three ways. They generally provide a national cost data base. They do not need the job-costing, accounting, inventory, etc., capabilities or interface. Also, a computer-aided drafting (CAD) interface benefits architects more than contractors.

Programs that perform check estimates or conceptual or budget estimates typically use algorithms and assemblies to generate estimates. They typically do not generate detailed estimates like the contractor or architectural application programs.

The specialty programs relate to cost estimating but cannot be categorized as one of the other three types. These include such things as programs to manage historical cost data, calculate contingency, or track escalation factors.

All of the cost estimating programs access and extract information from a summary cost data base. Users can extract the data and create the estimate (a secondary data base). The programs provide mechanisms for manipulating the estimate data base and for preparing or modifying the summary cost data base. All programs also contain various reporting functions.

Some of the cost programs can read drawings created by CAD or manufacturing programs. Such programs allow the draftsperson to attach to the drawing all the supporting information necessary to prepare the cost estimate. For example, in drawing a building floor plan, the draftsperson must draw doors, which require information about size, type, function, part number, manufacturer, etc. All this information can be attached to the drawing in a data base. As the CAD system generates the floor plan, it also generates a large volume of data that can be used by the cost estimator.

B. DOE-Owned Software Packages

DOE has developed several software packages for all levels of estimating. FM-50 developed (1) a statistical package for developing CERs, (2) a historical cost data management program, (3) a contingency analysis program, and (4) two detailed estimating programs. Other DOE-owned software packages are typically detailed estimating programs developed in-house by various cost departments.

1. The Enhanced Cost Estimating Relationship Program

The Enhanced Cost Estimating Relationship (ECER) Program operates on International Business Machines (IBM)-compatible equipment and formulates equations from data provided by the user. A simplified version of this program that uses statistical procedures to formulate cost equations was developed in 1985 (the CER program). Users needed only limited knowledge of statistics. The original program communicated with the user in simple, easy to understand terms, and the statistical aspects were handled “behind the scenes.” The program required minimal working knowledge of microcomputers.

ECER communicates with users in the same easy-to-understand terms, and it requires only a minimal working knowledge of personal computers. The

ECER program, however, was designed for users with a statistical background. ECER includes t and F factors, the Durbin-Watson statistic, confidence intervals, and correlation coefficients for the independent variables.

The program requires Microsoft or PC Disk Operating System (DOS) and Beginner's All-Purpose Symbolic Instruction Code, which are copyrighted and must be obtained separately and installed on the machine.

The ECER program performs regression analyses on data sets by three different independent variable functions. The equations analyzed by the program are shown in Table 22-1. The program generates equation coefficients and correlation coefficients for these equations. Although the program selects an equation with the largest overall correlation coefficient, the user can analyze any of the available equations.

The data base capabilities of the ECER allows users to enter values for up to 15 variables. When developing the equations, users must select up to three independent and one dependent variables. Users must also specify which of the variables must be escalated. ECER has two modes, automatic and interactive. In the automatic mode when users chose three independent variables, the computer finds the best fit equation for each level: three variables, two variables, and one variable. Then the ECER program selects the "best" (highest R) equation for each level and prints the statistical results for each of the three equations. ECER also saves the regression analyses results on the disk so that they can be recalled later. The results that are printed and saved include the correlation coefficient, adjusted correlation coefficient, t's for Y and each of the independent variables, the Durbin-Watson statistic, F, table values of F and the Durbin-Watson statistic, and actual and predicted Y's. The interactive mode prompts users through the regression analysis. It also allows users to estimate the dependent variable by inputting values for the independent variables. The program displays the predicted value of Y and the confidence interval.

An option allows the user to update the costs to a common date by using previously loaded cost indices. The cost indices can be loaded by month or year. The cost indices may also be edited, and the user may store multiple escalation indices and then specify which index is to be used for a given set of data. This allows the user to store indices for different types of commodities as well as indices projecting different rates of inflation that can be used for sensitivity analysis.

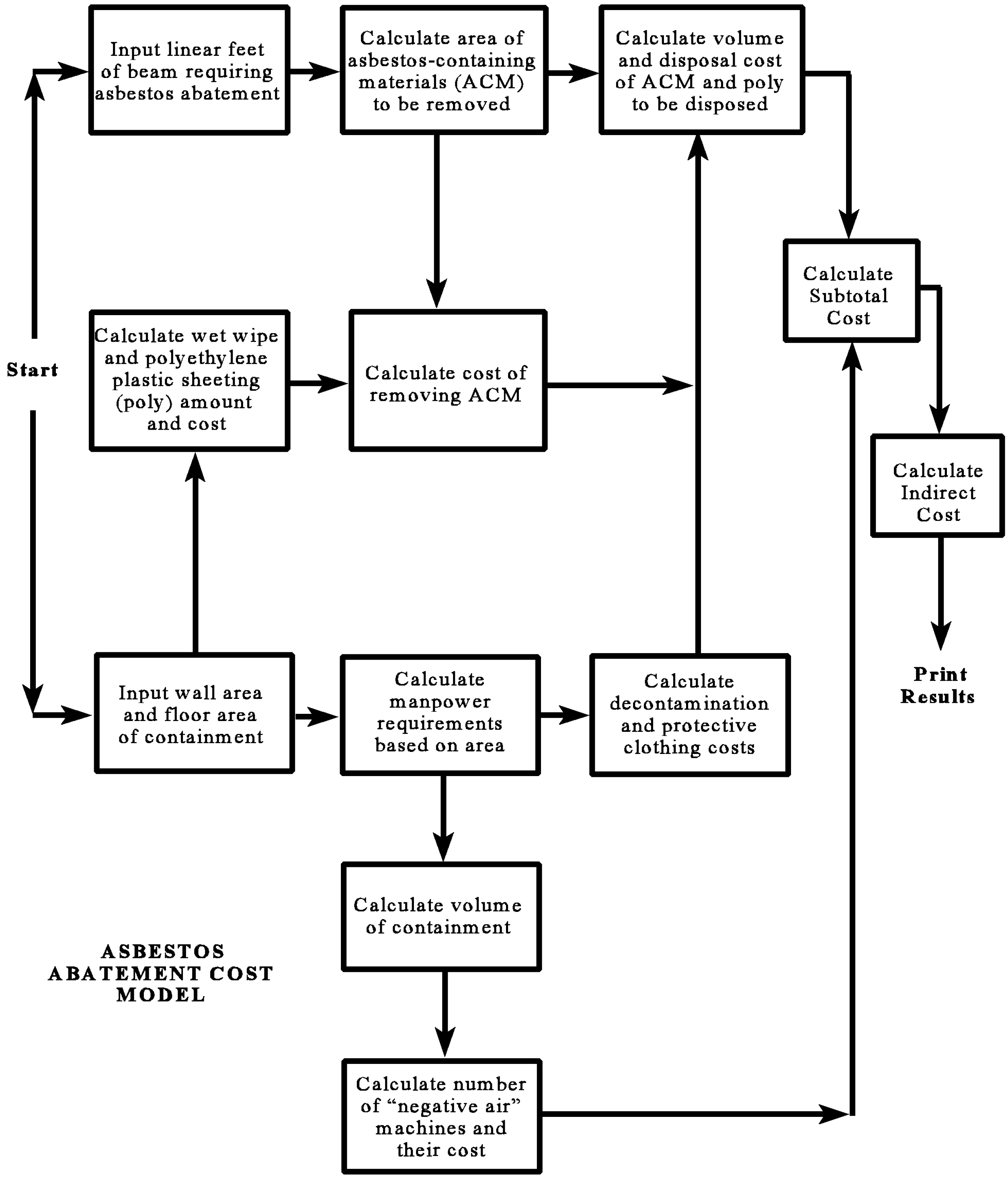


Figure 22-1. Simplified Cost Model Flow Diagram.

TABLE 22-1

EQUATIONS ANALYZED BY THE ECER PROGRAM

Three Independent Variables

1. COST = a + b1x(X1) = b2x(X2) + b3x(X3)
2. COST = a + b1x(X1) = b2x(X2) + b3/(X3)
3. COST = a + b1x(X1) = b2x(X2) + b3xLOG(X3)
4. COST = a + b1x(X1) = b2x(X2) + b3x(X3)
5. COST = a + b1x(X1) = b2x(X2) + b3/(X3)
6. COST = a + b1x(X1) = b2x(X2) + b3xLOG(X3)
7. COST = a + b1x(X1) = b2xLOG(X2) + b3x(X3)
8. COST = a + b1x(X1) = b2xLOG(X2) + b3/(X3)
9. COST = a + b1x(X1) = b2xLOG(X2) + b3xLOG(X3)
10. COST = a + b1/(X1) = b2x(X2) + b3x(X3)
11. COST = a + b1/(X1) = b2x(X2) + b3/(X3)
12. COST = a + b1/(X1) = b2x(X2) + b3x(X3)
13. COST = a + b1/(X1) = b2/(X2) + b3x(X3)
14. COST = a + b1/(X1) = b2/(X2) + b3x(X3)
15. COST = a + b1/(X1) = b2/(X2) + b3x(X3)
16. COST = a + b1/(X1) = b2xLOG(X2) + b3x(X3)
17. COST = a + b1/(X1) = b2xLOG(X2) + b3/(X3)
18. COST = a + b1/(X1) = b2xLOG(X2) + b3xLOG(X3)
19. COST = a + b1xLOG(X1) = b2x(X2) + b3x(X3)
20. COST = a + b1xLOG(X1) = b2x(X2) + b3x(X3)
21. COST = a + b1x(X1) = b2x(X2) + b3x(X3)
22. COST = a + b1x(X1) = b2x(X2) + b3x(X3)
23. COST = a + b1xLOG(X1) = b2x(X2) + b3/(X3)
24. COST = a + b1xLOG(X1) = b2x(X2) + b3xLOG(X3)
25. COST = a + b1xLOG(X1) = b2x(X2) + b3x(X3)
26. COST = a + b1xLOG(X1) = b2x(X2) + b3/(X3)
27. COST = a + b1xLOG(X1) = b2x(X2) + b3xLOG(X3)

Two Independent Variables

1. COST = a + b1x(X1) + b2x(X2)
2. COST = a + b1x(X1) + b2/(X2)
3. COST = a + b1x(X1) + b2xLOG(X2)
4. COST = a + b1/(X1) + b2x(X2)
5. COST = a + b1/(X1) + b2/(X2)
6. COST = a + b1x(X1) + b2xLOG(X2)
7. COST = a + b1xLOG(X1) + b2x(X2)
8. COST = a + b1xLOG(X1) = b2/(X2)
9. COST = a + b1xLOG(X1) + b2xLOG(X2)

One Independent Variable

1. COST = a + b1x(X1)
2. COST = a + b1/(X1)
3. COST = a + b1xLOG(X1)

In most statistical programs, once the data are entered and the program is run, those data cannot be changed. If a new data point is found, or one of the old data points needs to be changed, the entire data set must be reentered. This statistical program provides the flexibility for the user to change a single data point or add additional points without reentering the rest of the data.

2. The Historical Cost Data Base Management Program

The Historical Cost Estimating program operates on IBM-compatible PCs. It is a vehicle for organizing and storing cost estimates done in the past. The program is tailored to each user to allow the estimates to be stored in their format. Normally, estimates are broken down into 10 or 20 major codes of accounts for storage in this program. Users also input their own escalation factors, which are then used to automatically escalate the cost data to the desired year.

To use this program to estimate the cost of a new project, the user first selects one or more projects in the historical file that are similar to the project requiring an estimate. The program provides several ways to locate data so that the user can easily find the appropriate projects. The user inputs the date for the new costs and the program escalates the similar projects to that date. The user also inputs a cost driver (such as square footage for buildings) for the new project. The program then ratios the costs of the historically-selected projects to the cost of the new project.

The program outputs the cost of the new project using the same code of accounts used to load the historical projects. The user can change any of the costs or quantities to reflect unique attributes of the new project.

3. The Independent Cost Estimating Contingency Analyzer

The Independent Cost Estimating Contingency Analyzer (ICECAN) uses a Monte Carlo method to calculate the contingency that should be added to an estimate for a given probability of budget overrun. Estimators enter one or more costs and their associated probabilities for the different parts of an estimate. The probability distribution for a cost variable can be any one of four types: fixed, normal, discrete, or step-rectangular. The following parameters are input for each distribution.

a. Fixed - a single cost value is entered. The probability of 100 percent is not entered. The cost will be this fixed value in all samples.

b. Normal - a mean (or average) cost value is entered. The probability is assigned a standard deviation.

c. Discrete - up to 19 cumulative probabilities (i.e., the final entry must be 1.0) are entered. Up to 19 cost values are entered such that the probability of cost value I occurring is equal to the difference between probability entries I and I-1.

d. Step-rectangular - up to 20 cumulative probability/cost value pairs as above. The probability of a variable having a linearly distributed value between cost value I-1 and cost value I is the difference between probability value I and probability value I-1. The user must supply the base cost.

When all of the cost and probability data are entered, the program asks the user to select the number of iterations. ICECAN executes the model by taking the specified number of samples. For each sample, ICECAN calculates the total cost by randomly selecting values for each cost variable based on the probabilities entered. The frequency distribution of the total cost is used to calculate the required contingency based on the desired possibility of overrunning the budget.

4. Detailed Cost Estimating Programs

Two detailed estimating programs were developed by FM-50: the Holmes & Narver (H&N) and Los Alamos National Laboratory (LANL) programs. The H&N program was developed jointly with the H&N Cost Department at the Nevada Test Site. The LANL program was developed jointly with the Los Alamos National Laboratory Cost Department. A third program called Automated Estimating System (AES) was developed by the Martin Marietta Cost Department at Oak Ridge National Laboratory (ORNL).

a. The H&N Cost Estimating Program: The H&N Cost Estimating program is used to create cost estimates by pulling detailed cost items from the Corps of Engineers' Computer-Aided Cost Engineering System (CACES) data base. Any data base can be formatted so that it can be used with the program. The program can conduct yearly updates of the data base. The program uses rate tables, which contain labor and equipment rates used in the cost estimate. The user can also create custom rate table adders. The program contains four estimate reports. However, the reports can be modified by the user to fit any format. Users can scan through the data base by using a look-up routine. With the look-up routine, the user chooses the main division, then the subdivision, then scrolls that portion of the data base until the desired record is located.

The hardware requirements include an IBM-compatible PC with one diskette drive, a fixed disk with at least four megabytes of disk space, and a 132-column printer. An 80286 or 80386 processor is recommended.

b. LANL Estimating System: The LANL program was originally written by the Los Alamos National Laboratory to run on a Data General mini-computer and is used by the Cost Department at Los Alamos for all their estimating. DOE funded Los Alamos to develop a PC version of this program. FM-50 converted the Corps of Engineers' CACES data base so it could be read by the LANL program. The hardware required includes a DOS-compatible PC with at least 5 megabytes of hard disk space, 512K internal memory, and a math co-processor.

The program provides a large selection of output formats. A user can load a single estimate and, by tagging individual line items to appear in different places, output up to four distinct formats (e.g., a Construction Specification Index output and a DOE code of accounts output). As each line item is called up, the user may change any parameter in the data base. Although DOE can supply the user with a site-specific data base, the program does not allow the user to make any permanent changes in the data base or to add any items to the data base.

The data base used in the program is the same one used nationwide by the U. S. Corps of Engineers. This is a very detailed data base containing approximately 19,000 line items. The data base is updated annually by the Corps. Every line item in the data base is keyed to one of approximately 200 selected line items that are used to create a site-specific data base. To obtain a site-specific material data base, the user finds the cost in his area for each of the 200 line items, and a program is then run to adjust the 19,000 line items based on these 200 items. The user can also submit local labor rates which can be incorporated into the data base.

c. AES: The AES was developed by Martin Marietta at ORNL. Through a special agreement with DOE, Martin Marietta maintains all rights to the commercial use of this program, but DOE estimators and DOE contractors are free to use the program on DOE projects. The hardware required includes a DOS compatible PC with a hard disk.

AES is a detailed estimating program that can access the CACES data base. The user inputs the item description, quantity, unit cost, installation hours, and craft code or selects an item from the data base. The program has a craft rate data base that the user inputs. Several rates can be entered for each craft and called upon when doing estimates.

The estimate is broken down into separate work breakdown structures by the user. Users can input headings and subheadings in place of costs in the line items that will be printed in the output. The program allows the user to input escalation rates and start and end dates for the work breakdown structures. The program outputs an expenditure schedule for the project by quarter. Several S-shaped project expense rate curves are stored in the program, which may be specified by the user to scale the expenditure rate through the life of the project.

C. Commercial Software

In addition to the DOE-owned software, many companies market software for cost estimating. Like the DOE-owned software, they cover all types of estimating. The survey report discussed earlier in this chapter discusses many of the programs available and also provides an overview of the trends in estimating software. The survey contains descriptive information of several programs. A copy of the latest survey is available from FM-50.

CHAPTER 23

LIFE-CYCLE COST ESTIMATE

1. INTRODUCTION

Life-cycle costs (LCCs) are all the anticipated costs associated with a project or program alternative throughout its life. This includes costs from pre-operations through operations or to the end of the alternative. This chapter contains a discussion of life-cycle costs and the role they play in planning. Further information about the discount rates to be used in LCC analysis can be found in OMB Circular A-94, "Economic Analysis."

2. LIFE-CYCLE COST ANALYSIS

LCC analysis has had a long tradition in the Department of Defense. It has been applied to virtually every new weapon system proposed or under development. Industry has used LCC to help determine which product will cost less over the life of a product. For example, an R&D group has two possible configurations for a new product. Both configurations have the same R&D. One product has a lower manufacturing cost, but higher maintenance and support costs. LCC analysis can help to make decisions about which alternative has the lowest LCC.

A. Definition

LCC analysis is the systematic, analytical process of evaluating alternative courses of action early on in a project, with the objective of choosing the best alternative to employ scarce resources. The courses of action are for the entire life of the project and are not for some arbitrary time span (e.g, the 5-year plan). Figure 23-1 shows the stages of life-cycle cost over the life of a building.

By applying the principles of LCC analysis, it is possible to evaluate several building designs and select the one with the lowest LCC.

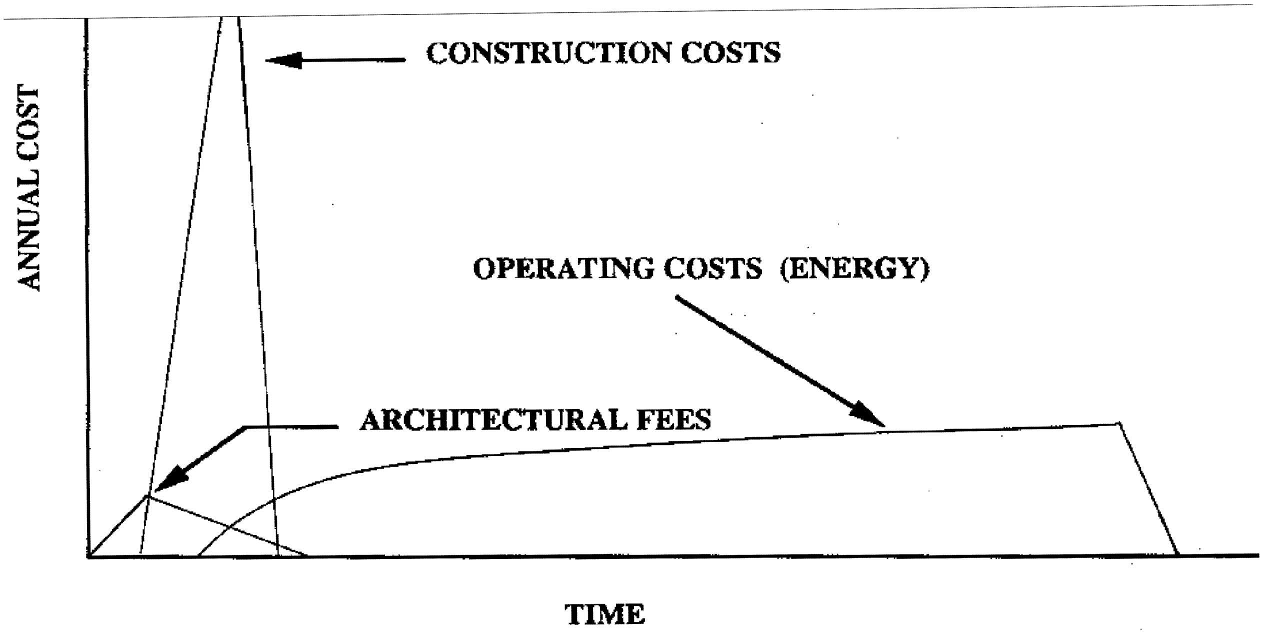


Figure 23-1. Stages of LCC

B. Process

LCC analysis is employed to evaluate alternative design configurations, alternative manufacturing methods, alternative support schemes, etc. The LCC process includes—

- defining the problem or project (scope),
- defining the requirements of the cost model being used,
- collecting historical data/cost relationships/cost data,
- defining the schedule, and
- developing the estimate and analyzing the results.

A successful LCC application will—

- forecast future resource needs, which when evaluated can identify potential problems or impacts;

- influence R&D or preliminary design decision making; and

- support future strategic planning and budgeting.

C. Limitations

LCC analyses limitations include—

- estimating early in the life of a project when the degree of accuracy has a broad range,

- assuming that the alternative has a finite life cycle,

- that the high cost to perform the LCC analysis may not be appropriate for all projects, and

- a high sensitivity to changing requirements.

D. Common Errors Made in Life-Cycle Cost Analysis

LCC analysis is an integral part of strategic planning. Therefore, we need to understand the common errors made during LCC analysis so effective decisions can be made. The following lists some of the common errors made when performing LCC analysis that could affect the outcome:

- omission of data,
- lack of a systematic structure or analysis,
- misinterpretation of data,
- wrong or misused estimating techniques,
- a concentration of wrong or insignificant facts,
- failure to assess uncertainty,
- failure to check work,
- estimating the wrong items, and
- using incorrect or inconsistent escalation data.

E. Typical System Profile

LCC analysis must be performed early in a project's life, or it loses its impact to make a cost effective decision on which alternative is best. Figure 23-2 shows that at the end of R&D, just prior to production or operations, 95% of the cumulative LCC has been committed.

Figure 23-3 is based on a typical DOD communication system acquisition profile. It shows that for each $7 to $12 that is put into R&D, $27 to $28 go for production, and $60 to $66 go for operation and support. Since most of the LCC is the operational support, it is evident that, for LCC to be effective, it must be implemented early in the program.

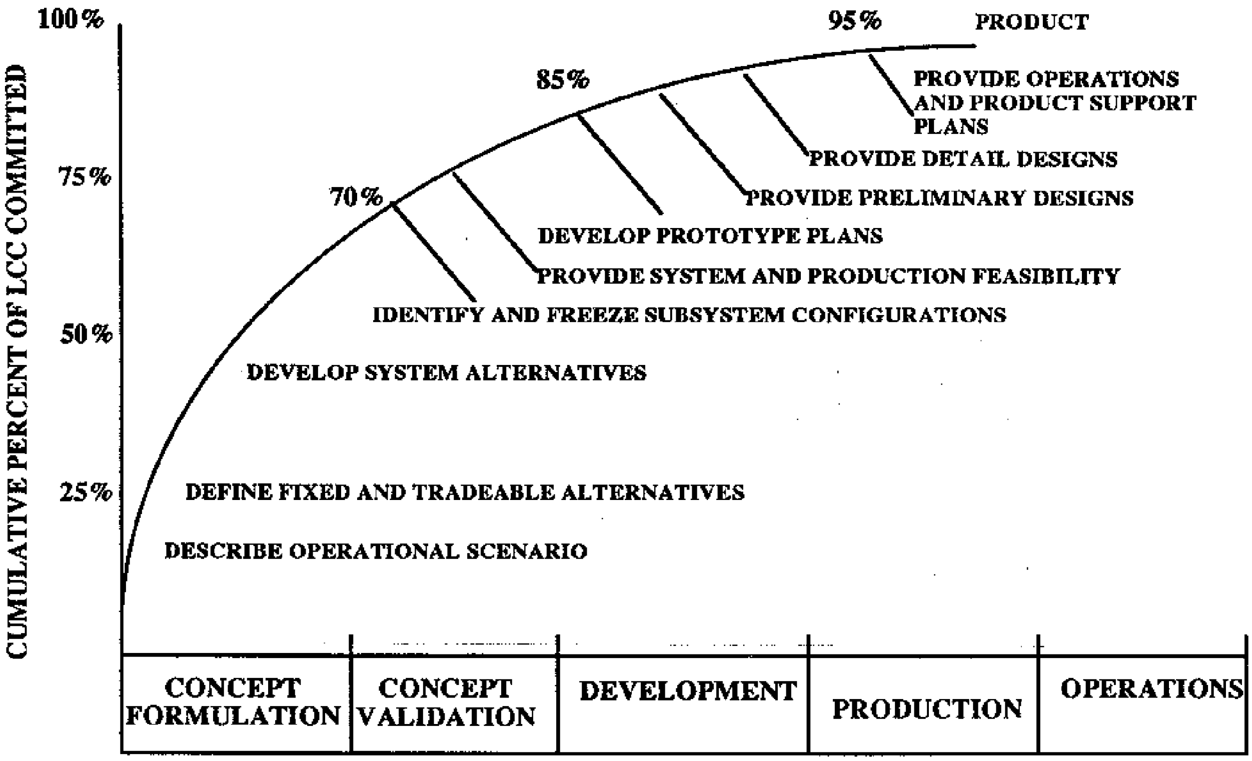


Figure 23-2. Actions Affecting LCC

F. Life-Cycle Cost Analysis Methods

LCC analysis consists of defining the LCC of each element and reducing each element cost to a common basis. Section 2 has discussed the definition of LCC. This section discusses the methods of reducing the LCC to a common basis using present worth calculations.

In LCC analysis, escalation and discount rates must be considered. The most used method of LCC analysis uses the net present worth method. In this method, costs are estimated in current dollars, escalated to the time when they would be spent, and then corrected to a present worth using a discount rate. When the inflation and discount rates are equal, LCC can be computed as current dollars, totaled for the project life and compared. When the escalation and discount rate are different, the escalation and present worth calculations must be performed. The following example assumes that the discount and escalation rates are different.

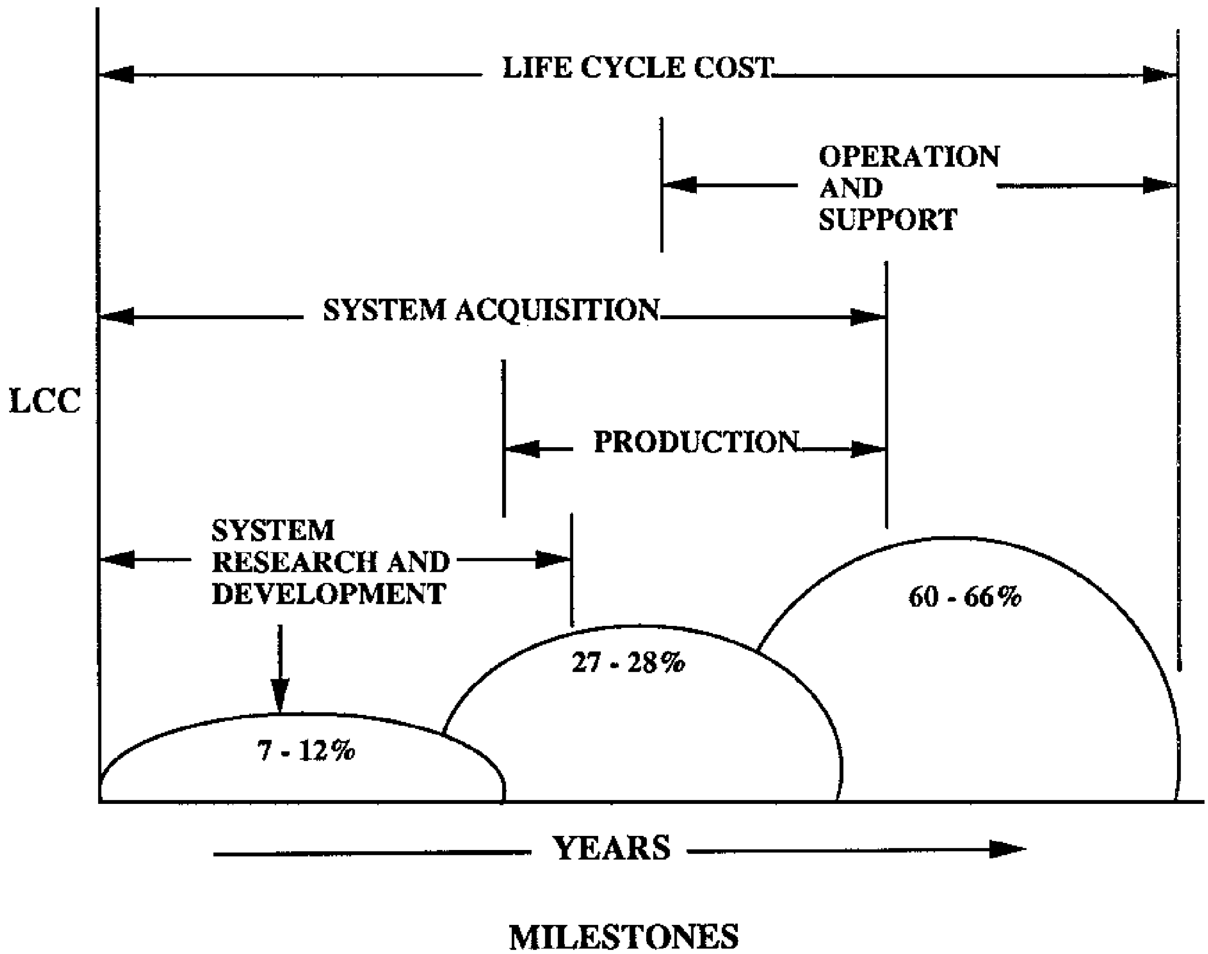


Figure 23-3. LCC Profile for System Acquisition

G. Example Life-Cycle Cost Analysis

The purchase of an automobile is given as a short simplified example of LCC analysis.

1. Definition of Scope:

Buyer wants to purchase an automobile.

Buyer has sufficient funds to purchase an automobile up to $25,000.

Definitive features are miles per gallon, estimated salvage value, costs of licenses and inspections, insurance, and estimated maintenance costs.

2. Assumptions:

All money is spent at the end of a year for a given year.

Buyer will trade the car in after four years.

All models use the same grade of gasoline at $1.25 per gallon.

The user drives 22,000 miles per year.

Discount rate is 10 percent.

Prices escalate 4 percent per year.

Insurance costs escalate 3 percent per year.

Salvage value is in dollars at the time of salvage.

3. Data collected:

CAR A: Purchase price of the car is $17,000, fuel usage is 24 miles per gallon, recommended maintenance is every 5,000 miles or 3 months, the average maintenance cost is estimated to be $250, and salvage value is $8,000.

CAR B: Purchase price of the car is $24,000, fuel usage is 26 miles per gallon, buyer would receive a dealer's special service package, which would give him free maintenance and service for the 4 years with unlimited mileage, and the salvage is $14,000.

CAR C: Purchase price of this used auto is $13,000, fuel usage is 15 miles per gallon, recommended maintenance is every 10,000 miles or 6 months and initial cost of $800 is estimated to remedy some problems, the average maintenance cost is estimated to be $350, and the salvage value is $5,000.

CAR D: Purchase price of the car is $11,000, fuel usage is 18 miles per gallon, recommended maintenance is every 7,500 miles or 5 months, and the average maintenance cost is estimated to be $125.00. The salvage value is $4,500. Installation cost of natural gas system is $3,200.

The following can be summarized:

	CAR A	CAR B	CAR C	CAR D
Purchase price	$17,000	$24,000	$13,000	$11,000*
Salvage value	($8,000)	($14,000)	($5,000)	($4,500)
Miles/Gallon	24	26	15	18
Miles Btwn Tune ups	5,000	5,000	10,000	7,500
Insurance/Year	$950	$1,350	$800	$700

SOLUTION:

Initial cost	$17,000	$24,000	$13,000	$14,200
Salvage	($6,010)	($10,518)	($3,757)	($3,381)
Total Annual Costs (4 Yrs)	$11,595	$8,805	$12,243	$8,489
TOTAL	$22,585	$22,287	$21,486	$19,308

* Plus $3,200 initial cost of system.

From this LCC analysis, Car D is the most economical for the buyer. From this simplified LCC analysis its benefits and purpose can be recognized.

SUPPORTING CALCULATIONS FOR ANNUAL COSTS:

For converting the future values to present worth, a uniform capital recovery (UCR) factor will be applied. Using 10 percent rates, the UCR for the years 2, 3, and 4 are as follows.

UCR Year 2 (one year of capital recovery) $$\frac{1}{(1 + .1)^1} = .9091$$

UCR Year 3 (two years of capital recovery) $$\frac{1}{(1 + .1)^2} = .8264$$

UCR Year 4 (three years of capital recovery) $$\frac{1}{(1 + .1)^3} = .7513$$

FUEL

CAR A: 22,000 miles/24 miles per gallon = 917 gallons x $1.25/gallon = $1,146 for year one

	Action Costs		**Present Worth**
$1,146 for year one		x 1	= $1,146
$1,146 x 1.04	= $1,192 for year two	x .9091	= $1,084
$1,192 x 1.04	= $1,240 for year three	x .8264	= $1,025
$1,240 x 1.04	= $1,290 for year four	x .7513	= $969
Total - Car A:	$4,868		$4,224

CAR B: 22,000 miles/26 miles per gallon = 846 gallons x $1.25/gallon = $1,058

	Actual Cost		**Present Worth**
$1,058 for year one	= $1,058 for year one	x 1	= $1,058
$1,058 x 1.04	= $1,100 for year two	x .9091	= $1,000
$1,100 x 1.04	= $1,144 for year three	x .8264	= $945
$1,144 x 1.04	= $1,190 for year four	x .7513	= $894
Total - Car B:	$4,492		$3,897

CAR C: 22,000 miles/15 miles per gallon = 1,467 gallons x $1,25/gallon = $1,834

	Actual Cost		**Present Worth**
$1,834 for year one	= $1,834 for year one	x 1	= $1,834
$1,834 x 1.04	= $1,907 for year two	x .9091	= $1,734
$1,907 x 1.04	= $1,983 for year three	x .8264	= $1,639
$1,983 x 1.04	= $2,062 for year four	x .7513	= $1,549
Total - Car C:	$7,786		$6,756

CAR D: 22,000 miles/18 miles per gallon = 1,222 gallons x $0.79/gallon = $965

	Actual Cost		**Present Worth**
$965 for year one	= $ 965 for year one	x 1	= $ 965
$965 x 1.04	= $1,004 for year two	x .9091	= $ 913
$965 x 1.04	= $1,044 for year three	x .8264	= $ 863
$964 x 1.04	= $1,086 for year four	x .7513	= $ 816
Total - Car D:	$4,099		$3,557

MAINTENANCE

22,000 miles per year x 4 years = 88,000 miles

CAR A: 88,000 miles/5,000 miles per maintenance = 17.6 (use 17 maintenance visits since the last one will be at the end of ownership).

This equates to 4.25 maintenance visits per year.

	Actual Cost		Present Worth
$1,063 for year one	= $1,063 for year one	x 1	= $1,063
$4.25 x $250	= $1,106 for year two	x .9091	= $1,005
$1,106 x 1.04	= $1,150 for year three	x .8264	= $ 950
$1,150 x 1.04	= $1,196 for year four	x .7513	= $ 899
Total - Car A:	$4,515		$3,917

CAR B:

$0

CAR C: 88,000 miles/10,000 miles per maintenance = 8.8 (use 8 maintenance visits since the last one will be at the end of ownership).

This equates to 2 maintenance visits per year of ownership.

	Actual Cost		Present Worth
$350/maint. x 2	= $ 700 for year one	x 1	= $ 700
$700 x 1.04	= $ 728 for year two	x .9091	= $ 662
$728 x 1.04	= $ 757 for year three	x .8264	= $ 626
$757 x 1.04	= $ 787 for year four	x .7513	= $ 591
Total - Car C:	$2,972		$2,579

CAR D: 88,000 miles/7,500 miles per maintenance = 11.7 (use 11 maintenance visits since the last one will be at the end of ownership).

This equates to 2.75 maintenance visits per year.

	Actual Cost		**Present Worth**
$125/maint. x 2.75	= $ 344 for year one	x 1	= $ 344
$344 x 1.04	= $ 358 for year two	x .9091	= $ 325
$358 x 1.04	= $ 372 for year three	x .8264	= $ 307
$372 x 1.04	= $ 387 for year four	x .7513	= $ 291
Total - Car D:	$1,461		$1,267

INSURANCE

CAR A:

	Actual Cost		**Present Worth**
$ 950 for year one		x 1	= $ 950
$ 950 x 1.03	= $ 979 for year two	x .9091	= $ 890
$ 979 x 1.03	= $1,008 for year three	x .8264	= $ 833
$1,008 x 1.03	= $1,039 for year four	x .7513	= $ 781
Total - Car A:	$3,976		$3,454

CAR B:

	Actual Cost		**Present Worth**
$1,350 for year one		x 1	= $1,350
$1,350 x 1.03	= $1,391 for year two	x .9091	= $1,265
$1,391 x 1.03	= $1,433 for year three	x .8264	= $1,184
$1,433 x 1.03	= $1,476 for year four	x .7513	= $1,109
Total Ins. - Car B:	$5,650		$4,908

CAR C:

	Actual Cost		**Present Worth**
$ 800 for year one		x 1	= $ 800
$ 800 x 1.03	= $ 824 for year two	x .9091	= $ 749
$ 824 x 1.03	= $ 849 for year three	x .8264	= $ 702
$ 849 x 1.03	= $ 874 for year four	x .7513	= $ 657
Total - Car C:	$3,347		$2,908

CAR D:

			Actual Cost		Present Worth
$ 700 for year one				x 1	= $ 700
$ 700 x 1.03	= $ 721 for year two			x .9091	= $ 655
$ 721 x 1.03	= $ 743 for year three			x .8264	= $ 614
$ 743 x 1.03	= $ 765 for year four			x .7513	= $ 575
Total - Car D:	$2,929				$2,544

SALVAGE

	Actual Cost		Present Worth
CAR A	$ 8,000	x .7513	= $ 6,010
CAR B	$14,000	x .7513	= $10,518
CAR C	$ 5,000	x .7513	= $ 3,757
CAR D	$ 4,500	x .7513	= $ 3,381

The purchase of an automobile was chosen as an example of an LCC estimate to present an annual and fixed cost comparison. The use of this simplified LCC analysis demonstrates the vital role LCC analysis plays in evaluating alternative courses of action.

CHAPTER 24

ACTIVITY BASED COSTING

1. INTRODUCTION

Activity Based Costing (ABC) is a method for developing cost estimates in which the project is subdivided into discrete, quantifiable activities or a work unit. The activity must be definable where productivity can be measured in units (e.g., number of samples versus manhours). After the project is broken into its activities, a cost estimate is prepared for each activity. These individual cost estimates will contain all labor, materials, equipment, and subcontracting costs, including overhead, for each activity. Each complete individual estimate is added to the others to obtain an overall estimate. Contingency and escalation can be calculated for each activity or after all the activities have been summed. ABC is a powerful tool, but it is not appropriate for all cost estimates. This chapter outlines the ABC method and discusses applicable uses of ABC.

2. ACTIVITY BASED COSTING METHODOLOGY

For many years, construction firms and industry trade groups have collected cost data from a multitude of different construction projects. The amount of work associated with that cost was also collected with the cost data. For example, collected data included the cost of the paint, labor, equipment, and overhead to paint a room, the amount of surface area painted, and the manpower required to paint the room. This practice allowed construction professionals to obtain a cost per area and manpower per area. These costs are based on an activity, such as painting, and are known as ABC. ABCs are discussed in detail in the following sections.

A. Activity Based Costing Definition

ABC can be defined by the following equation:

$$C/A = HD + M + E + S$$

where C/A = Estimated cost per activity
- H = Number of labor hours required to perform the activity one time
- D = Wages per labor hour
- M = Material costs required to perform the activity one time
- E = Equipment costs to perform the activity one time
- S = Subcontracting costs to perform the activity one time

The total cost for performing the activity will be based on the number of times the activity is performed during a specific time frame.

Cost estimators have assembled large databases of activity based cost information. The R.S. Means Company updates its published cost references on a yearly basis, and they are an excellent source of ABC information for the construction industry.

B. Use of Activity Based Costing Methodology

ABC methodology is used when a project can be divided into defined activities. These activities are at the lowest function level of a project at which costs are tracked and performance is evaluated. Depending on the project organization, the activity may coincide with an element of the work breakdown structure (WBS) or may combine one or more elements of the WBS. However, the activities must be defined so there is no overlap between them. After the activity is defined, the unit of work is established. All costs for the activity are estimated using the unit of work.

The estimates for the units of work can be done by performing detailed estimates, using cost estimating relationships, obtaining outside quotes for equipment, etc. All costs including overhead, profit, and markups should be included in the activity cost.

C. Identification of Activities

When defining an individual activity, the cost estimator must balance the need for accuracy with the amount of time available to prepare the estimate. An estimator may be able to develop an extremely accurate cost estimate by defining smaller and smaller activities; however, the amount of time required to prepare ABC estimates for each of these activities may not justify the increased accuracy. The total estimated project cost may be sufficiently accurate if 10 activities are used instead of 15. On the other hand, reliable cost information may not be accessible if the activity categories are too general. Since the activity is the basis for the estimate, it is very important that the activity be selected correctly.

D. Example of an Activity Based Costing Estimate

To get a better understanding of how an ABC estimate is developed, assume that you have been asked to prepare a cost estimate for a site evaluation. To verify that there is no contamination at the site, subsurface soil samples will have to be collected. The area of the site is known, and the guidelines for the number of samples per unit area has also been given.

1. Site: Atlas Metals (now out of business)

2. <u>Objective</u>: Collect and analyze subsurface soil samples to determine if contamination exists from past usage of the 1,000 square-foot-yard area.

3. <u>Sampling Requirements</u>: One sample per 100 square feet, and sample depth is 5 feet.

The following activities would be involved:

- mobilize equipment and personnel,
- drill hole for sample,
- collect sample,
- decontaminate equipment between samples,
- prepare all samples for analysis,
- demobilize equipment and personnel,
- analyze samples.

Equipment needs are as follows:

- Hand-held auger for sample collection
  ($100.00/day flat rate)

- Safety equipment for site personnel
  (gloves, safety glasses, and protective equipment at
  $10.00/person/day)

Material needs are as follows:

- Sampling containers and labels
  ($1.00/sample)

- Water to clean the auger between samples
  (5 gallons/sample at $.30/gallon)

The auger requires two people to operate it. Site mobilization and demobilization will take a total of 1 hour. Local labor rate is $15.00/hour for all disciplines. A 2-person crew can prepare 10 samples for analysis in one hour. The laboratory charges $1,000.00/sample for analysis.

- Number of hours required to perform the activity = 12 hours
- Wages per labor hour = 2 x $15.00 x 2.5 = $75.00/hour
- Labor cost per sample = (12 x 75) ÷ 10 = $90.00/sample
- Materials costs = (10 x $1.00 + 2 x (2 x $10.00) + 10 x 5 x $.30) x 1.2 = $78.00
- Materials cost per sample = $7.80/sample
- Equipment costs = (2 days x $100.00/day) x 1.2 = $240.00
- Equipment cost per sample = $24.00/sample
- Subcontractor cost per sample = ($1,000.00 x 1.15) = $1,150.00
- C/A = (HD + M + E + S)/sample
- C/A = $90.00 + $7.80 + $24.00 + $1,150.00 = $1,271.80/sample

If the area requiring sampling increases or decreases, the number of samples can be recalculated using this ABC.

3. APPLICATION OF ACTIVITY BASED COSTING

As can be seen from the example, ABC can be a useful cost estimating tool for non-conventional and construction projects. However, there are some activities that are more appropriately estimated using other cost estimating techniques. For example, site security may always be required at some facilities regardless of the number of employees at the facility or work being conducted at the facility.

ABC estimating is especially useful in instances where the number of activities is uncertain or may change during the estimate process. Referring back to the ABC estimate example, if the number of samples changed, it would be fairly easy to recalculate the cost of the sampling.

CHAPTER 25

GUIDELINES FOR ENGINEERING, DESIGN, AND INSPECTION COSTS

1. INTRODUCTION

Engineering, design, and inspection (ED&I) activities begin with the preliminary design (Title I). Pre-Title I activities are not considered part of ED&I activities. ED&I activities include the engineering and design activities in Title I & II and the inspection activities associated with Title III. A more detailed description of the Title I, II, and III activities can be found in Chapter 3 of this volume.

Architectural/Engineering (A/E) activities are part of the ED&I activities. A/E activities are services that are an integral part of the production and delivery of the design plans, specifications, and drawings. Federal statutes limit the A/E costs to a percent of total construction cost, and these statutes have specific definitions of what activities are included in A/E costs. Activities that are not an integral part of the production of the design plans, specifications, or drawings may still be ED&I activities but are not A/E activities.

This chapter defines ED&I and A/E activities and discusses how to estimate and track them.

2. ED&I ACTIVITIES

To estimate ED&I costs, the estimator must understand what activities are included in ED&I.

Following is a list of ED&I activities:

- Preliminary and final design calculations and analyses
- Preliminary and definitive plans and drawings
- Outline specifications
- Construction cost estimates
- Computer-aided Drafting (CAD) and computer services
- A/E internal design coordination
- Design cost and schedule analyses and control
- Design progress reporting

- Regulatory/code overview by A/E
- Procurement and construction specifications
- Surveys (surveying), topographic services, core borings, soil analyses, etc., to support design
- Travel to support design
- Reproduction during design
- Design kickoff meeting
- Constructability reviews
- Safety reviews by A/E
- Value engineering
- Identification of long lead procurements
- Design studies not included in Pre-Title I
- Preliminary safety analysis report if not included in the Conceptual Design Report
- Design change control
- Modification of existing safety analysis report
- Design reviews (not third party)
- Acceptance procedures
- Certified engineering reports
- Bid package preparation
- Bid evaluation/opening/award
- Inspection planning
- Inspection services
- Review shop drawings
- Preparation of as-built drawings

3. WAYS TO ESTIMATE ENGINEERING, DESIGN, AND INSPECTION COSTS

Different methods may be used to estimate ED&I costs. Some common methods are: count drawings and specifications, full time equivalents (FTEs), and percentage.

A. Count Drawings and Specifications Method

When using this method, the estimator calculates the number of drawings and specifications representing a specific project. The more complex a project is, the more drawings and specifications it will require, and, therefore, more ED&I Costs will be associated with it.

B. Full Time Equivalent Method

The FTE method utilizes the number of individuals that are anticipated to perform the ED&I functions of a project. The manhour quantity is calculated and multiplied by the cost per labor hour and the duration of the project to arrive at the cost.

C. Percentage Method

When using this method, the estimator simply calculates a certain percentage of the direct costs and assigns this amount to ED&I. Federal statutes limit the A/E portions of ED&I costs to 6 percent of construction costs. Total ED&I percentages are usually from 15 to 25 percent.

D. Documenting Engineering, Design, and Inspection Costs

DOE Headquarters developed the A/E Cost Standard Form as a tool to be used for estimating and compiling actual costs on all conventional construction projects and the conventional portions of nonconventional projects. The DOE ad hoc working group refined a U. S. Navy form to develop this standard for estimating A/E services. The form, definitions, and instructions for the A/E Cost Standard Form have been published and distributed and are included as Attachment 25-1 to this chapter. The following conditions apply to the use of the cost standard or form.

1. All conventional line-item construction projects will use the standard. General plant projects are excluded.

2. Conventional construction projects include such things as warehouses, laboratories, office buildings, non-process related utilities, sewage and water treatment facilities, parking lots, roof repair, roads, etc. Conventional construction does not mean the projects are necessarily simple, nonsophisticated, or standard, but that simply from a design point of view, prior industry experience exists. Nonconventional projects include projects that are first of a kind and the level of effort is not easily predictable.

3. In calculating the design/construction cost percentage ratio, equipment, equipment installation, and other nonconstruction costs will be excluded from the construction cost estimate. Therefore, construction costs included in the calculation will be limited to those construction items for which the A/E contractor has design responsibility. This method is used for determining contract performance. Additional costs for other design, drawings, and specifications (either in-house or outside source) will be documented and included in the total design/construction cost ratio, thereby measuring project performance.

4. The cost standard will be used in the construction of budget estimates and all subsequent estimates and in the management of the cost baselines.

5. A/E contracts will be structured in accordance with the cost standard to segregate design, drawings, and specification costs from the other A/E costs, so that tracking and analyzing actual costs can be accomplished by categories.

6. Any site overhead allocated to construction projects will be identified and documented separately from all other components of project costs so that DOE cost analyses will be comparable to those of other Federal agencies and commercial organizations.

7. The cost standard should be used on all new projects. Project managers will not be required to restructure already completed projects into the format. However, they are encouraged to restructure cost data on completed projects whose cost components are organized in a manner similar to the cost standard format.

8. The A/E Cost Standard Form was designed to provide a standard format for developing cost estimates, structuring contractor proposals, and tracking the cost performance of A/E contracts and other A/E activities. Federal statutes limit A/E cost to 6 percent of construction costs. The A/E services provided under this statute are design, drawings, and specifications. While it is our intention to minimize all A/E costs, it is our goal to keep these specific costs within the 6 percent limit. By collecting costs in this format, the Department can compare its cost performance to other agencies on a comparable basis. Therefore, field offices should ensure that all cost estimates, actual cost data collected during design and construction, and all A/E contracts are segregated to show both total ED&I costs and the subcomponents of design, drawings, and specifications. Also, each site should maintain adequate documentation on actual design and construction costs to facilitate local analysis on the site's overall performance.

   Field Office managers and individual project managers are responsible for ensuring that cost estimates, contracts, and cost management of A/E services are structured according to the above standard. Subsequent historical cost data will be used for project analysis and to support local cost databases. These data should help assess contractor performance, improve future cost estimates, and generate recommendations for reducing the A/E costs, on a site-wide basis.

   With A/E costs or activities being defined, data can be gathered on a more comparable basis. This will allow for easier evaluation, as well as support for the development of local cost databases for A/E costs.

E. Considerations When Estimating

ED&I costs are directly related to the magnitude and complexity of the project. The following items should be considered.

1. Comprehensiveness of the Functional/Operational Requirements

Project understanding is improved when comprehensive functional/operational (F/O) requirements are provided. For the F/O requirements to be well done, each item must be thought through by those who review the design and will use, operate, and maintain the facility or system.

2. Quality Level

Quality level, as defined below, is significant particularly as it affects the analysis, documentation, and inspection required. Design costs are increased by the additional work that may be required by the following levels.

a. Quality Level I

Applied to nuclear system, structure, subsystem, item, component, or design characteristics that prevent or mitigate the consequences of postulated accidents that could cause undue risks to the health and safety of the public.

b. Quality Level II

Any other system, structure, subsystem, item, or component that as a result of failure could cause degradation of required performance, such as plant operation, test results, and performance data.

c. Quality Level III

Items designated for minimal impact applications.

3. Design Planning Tabulation

Design Planning Tabulation (DPT) sets forth a number of important items that affect ED&I costs. The DPT sets the code requirements the design will meet, reviews to be held, quality levels, and documents to be issued.

4. Design Layout

Design layout costs are affected by the availability of existing documents and the accuracy of these documents. The need for an engineer to make detailed layouts rather than having it done by draftsmen/designers also affects cost.

5. Engineering Calculations

The amount and detail of calculations required is an important engineering cost factor. The need for review of these calculations by others and their documentation and storage can affect ED&I cost significantly.

6. Drafting

The drawing format and the method of accomplishment of the work depicted (i.e., by maintenance, lump sum construction contract, or cost plus construction contract) will affect the detail and time required to prepare drawing(s). The type of drawing and the discipline of work are also big factors in time required. The number of drawings involved is a direct indication of drafting time and cost. The availability of standard details, etc., can reduce costs appreciably. Quality Level I or II requirements can also add to drafting requirements and thus time.

7. Specification Preparation

The availability of draft specifications for the items of work involved or the need to develop new specifications must be considered. Projects requiring preliminary proposals require both an outline specification, which is normally prepared with Title I, and a detailed technical specification. Performance specifications for both the design and installation by a subcontractor of facilities and systems, such as fire protection, will reduce engineering costs. Design costs incurred by the subcontractor are classified as subcontract construction costs.

8. Checking

The need for field investigation can be a significant engineering cost. If drafting must be checked by checkers within that section, the time must be considered and costs added. Projects requiring inter-discipline checks must have time/cost provisions. Checks made by engineers must also be considered.

9. Cost Estimating

Time required for estimating is affected by the detail of the project, particularly the number of items involved and the areas in which good information from historical data or test hooks on cost are available. Specialty items usually require additional effort and cost.

10. Design Reviews

The number of design reviews and action taken will affect costs. If the design is so formal that a committee is established for the review and the designers must present their designs step by step, the additional costs required for review must be included.

11. Safety Analysis Report

When a Safety Analysis Report (SAR) is required, the engineering costs are contingent upon similar documents having been prepared previously or the requirements to develop new ones.

12. Reports

Engineering costs for preparing reports such as preliminary proposals, design status reports, etc., must be included in the ED&I funds.

13. Government Furnished Equipment

Engineering costs for providing documents required for procuring Government Furnished Equipment (GFE) items must be included. These costs include specifications. Time required for engineering is more than if the item had been included with the other technical documents due to document control and the need to include in the technical documents information on the item being furnished.

14. Off-Site A/E

If an off-site A/E is to be used for the design, travel costs for field investigation, design reviews, and management of the design should be considered. Cost is a percentage of construction cost. If changes are required, onsite A/E may have to make the changes, which could lead to problems in interpreting or understanding the basis of the original design.

15. Inspection

Included as part of Title III, all construction work, including procurement and installation of associated equipment, shall be conducted in all cases prior to acceptance. Inspection should be made at such times and places as may be necessary to provide the degree of assurance required to determine that the materials or services comply with contract and specification requirements, including quality level requirements. The type and extent of inspection needed will depend on the nature, value, and functional importance of the project and its component parts, as determined by project requester/proposer. Specifically, the following should be considered.

16. Duration

Duration is the number of actual construction days anticipated for the project. Unforeseen conditions, such as delays in start-up and waiting for materials, are not included in this duration.

17. Labor Density

Labor density is the ratio of estimated costs of materials to costs of labor. In general, construction with a high labor density will require more inspection.

18. Complexity

A project having a high degree of instrumentation of a large amount of "code equivalent" welding will require more inspection per dollar of labor than will earth work or ordinary concrete work.

19. Overtime

The time schedule of utility outages, reactor windows, and the overall project schedule may require overtime.

20. Adequacy of Plans and Specifications

If the technical package is clear, with a minimum of ambiguities, and will require few field changes, the inspection cost will be lower.

21. Offsite Fabrications

Inspection costs will increase if source inspections are required. Supplies and services shall be inspected at the source where:

a. inspection at any other point would require uneconomical disassembly or nondestructive testing;

b. considerable loss would result from the manufacture and shipment of unacceptable supplies or from the delay in making necessary corrections;

c. special instruments, gauges, or facilities required for inspection are available only at source;

d. inspection at any other point would destroy or require the replacement of costly special packing and packaging;

e. a quality control system is required by the contract, or inspection during performance of the contract is essential;

f. it is otherwise determined to be in the best interest of the Government.

22. Location of the Job

Travel time to and from the job must be taken into consideration.

23. Guideline

ED&I costs have been between 15 percent and 26 percent of the total construction cost for detailed design.

24. Performance Specification

This type of specification requires the subcontractor to supply the amount of detail required to complete the project. The amount of ED&I required for a performance specification is appreciably less than that required for the detailed design.

F. Engineering

Although these services may seem similar to conventional engineering, design, and inspection, there are several important differences that distinguish cleanup design from engineering design on other projects. These differences need to be underscored when estimating cost and schedule requirements. Major factors to be considered by the estimator include the following.

1. The regulatory process requires rigorous examination of design alternatives prior to the start of cleanup design. This occurs during remedial investigation/feasibility studies under CERCLA to support a record of decision (ROD) or during corrective measure studies under RCRA to support issuance of a permit. Cleanup design executes a design based on the method identified in the ROD or permit. This often narrows the scope of preliminary design and reduces the cost and schedule requirements. The estimator needs to assess the extent to which design development is required or allowed in cleanup design. In some cases, the ROD or permit will be very specific as in the case of a disposal facility where all features, such as liner systems, as well as configuration, are fixed. In other cases, such as when treatment options like incineration are recommended, considerable design effort may be required.

2. Requirements for engineering during construction including, construction observation, design of temporary facilities, quality control, testing, and documentation, will often be higher than for conventional construction. This results from the need to conduct construction activities for environmental projects in compliance with rigid regulations governing health and safety, quality assurance, and other project requirements.

CHAPTER 25

ATTACHMENT 25-1

A/E COST STANDARD FORM USAGE GUIDANCE

The Architect/Engineer (A/E) Cost Standard Form was designed to provide a standard format for the collection of A/E costs. Federal statutes limit the A/E costs to a percent of total construction cost, and these statutes have specific definitions of what is included in A/E costs. By collecting costs in the format of this form, the Department will be consistent with the definition of A/E costs used by other Federal agencies and will be able to determine what is being spent on A/E costs on a uniform basis throughout the Department.

The form, attached, is divided into three sections:

- Section A - Design
- Section B - Title III Services
- Section C - Engineering Services

Some departments may use different names for some of the functions described in the form. If this is the case, a crosswalk sheet can be developed and used to aid in converting the terms used locally to fit those in this form. If necessary, items can be added to each section. Sheets should be attached to completely define any items added. Minimal additions or changes are anticipated in Sections A and B, while Section C will more commonly have additions.

This form is used to collect Engineering, design, and inspection (ED&I) costs according to DOE Order 2200.6. Pre-Title I activities are not a part of ED&I. Pre-Title I activities include surveys, topographical services, core borings, soil analysis, etc., that are necessary to support design. These activities are charged to operating costs. Other costs that, according to DOE Order 2200.6, are not part of operating costs, include project management, the maintenance and operation of scheduling, estimating, and project control systems during design and construction, and the preparation, revision, and related activity involved in producing the final safety analysis report.

The attached "A/E Cost Standard Form - Engineering and Design Activities" table lists the Title I, Title II, and Title III activities and groups them in Sections A, B, or C as they appear on the A/E Cost Standard Form

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The following will discuss each section individually.

Section A - Design

Section A includes the Title I and Title II costs directly related to developing the design drawings and specifications necessary for the project. Note that Section A includes only the cost of labor hours that are necessary to perform this design work. If, because of project requirements, other disciplines are required, they can be added. Note that other Title I and Title II costs can be covered in Section C.

Section B - Title III Services

Section B includes the costs for reviewing shop drawing submittals, inspection services, and the preparation of as-built drawings.

Section C - Engineering Services

Section C includes the support services required during the Title I, Title II, and Title III project work. This includes such activities as the energy conservation study, cost engineering, value engineering services, travel, computer equipment costs, etc. Note that the Computer Aided Drafting (CAD) operator's time is included in Section A. Note also that some of the activities in Section C, such as travel and per diem, can occur in Title I, Title II, and Title III work.

Design Schedule

The design schedule should be filled out in the bottom left-hand portion of the form under Section C. The cost summary is filled out to the right of the design schedule and includes the costs of Sections A, B, and C, which are added together to generate a total ED&I cost.

A/E COST STANDARD

DOE Architect-Engineer
Cost Standard Form

A/E Firm Name:	Consultant's Name(s):	A/E Contract No:	
Project Title:		DE No:	Field Office:
Location:		Est.Const.Cost:	

Section		Engineering Discipline	Est. No. Dwgs.	Hourly Rate	Title I			Title II			Total Design	
					Est. Hrs.	Estimated Cost		Est. Hrs.	Estimated Cost		Est. Hrs.	Estimated Cost
						A/E	Consultant		A/E	Consultant		
SECTION A DESIGN	DRAWINGS	Project Engineer										
		Architect										
		Stru Engineer										
		Mech Engineer										
		Elec Engineer										
		Civil Engineer										
		Fire Engineer										
		Coordination QC										
		Arch Draftsman										
		Stru Draftsman										
		Mech Draftsman										
		Elec Draftsman										
		Civil Draftsman										
		Fire Draftsman										
		Total Drawings										
	SPECS	Spec Writer										
		Typist										
		Total Specifications										
	Total Est. Cost A/E & Consultant											
	Overhead A/E _____			Consult. ______%								
				Subtotal								
				Profit _____%								
				Subtotal								
				Total cost of section A (Design)			$ _____ sheet		% of ECC _____ %			

COMPUTE COST PER SHEET AND DESIGN PERCENTAGE OF ESTIMATED CONSTRUCTION COST

ENGINEERING SERVICES SUMMARY SHEET (PROVIDE BACK-UP FOR EACH ITEM)		TITLE I	TITLE II	TITLE III	TOTAL
Section B Title III Services	Review of Shop Drawing Submittals				
	Inspection Services				
	Prepare As-Built Drawings				
	Total Cost of Section B				
SECTION C ENGINEERING SERVICES	Inspection Planning				
	Design QA Plan				
	Reproduction During Design				
	Constructability Reviews				
	Certified Engineering Reports				
	Design Studies Not Included in Pre-Title I				
	Project Schedules				
	Cost Engineering				
	Value Engineering Services				
	Travel to Support Design				
	Other (Specify)				
	Total Cost of Section C				

DESIGN SCHEDULE		COST SUMMARY				
	30% Submit/Rev = ____ wks		Total Section A (Design)				
	60% Submit/Rev = ____ wks		Total Section B (Title III)				
	90% Submit/Rev = ____ wks		Total Section C (Engr Serv)				
	Final Submit /Rev = ____ wks TOTAL = _____ wks		GRAND TOTAL - Fee Proposal				
SIGNATURE		APPROVAL			DATE	

A/E COST STANDARD FORM
ENGINEERING AND DESIGN ACTIVITIES

	TITLE I ACTIVITIES	TITLE II ACTIVITIES	TITLE III ACTIVITIES
S	Preliminary Design Calculations and Analyses	Final Design Calculations and Analyses	
E	Preliminary Drawings	Definitive Drawings	
C	Preliminary Plans	Definitive Plans	
T	Outline Specifications	Procurement and Construction Specs	
I	CAD and Computer Services (operators)	CAD and Computer Services (operators)	
O	A/E Internal Design Coordination	A/E Internal Design Coordination	
N	Design Cost and Schedule Analysis and Control	Design Cost and Schedule Analysis and Control	
	Design Progress Reporting	Design Progress Reporting	
A	Regulatory/Code Overview by A/E		
S	Design QA Plan and Overview	Travel to Support Design	Inspection Services
E	Travel to Support Design	Reproduction During Design	Review Shop Drawings
C	Reproduction During Design	Designs Reviews, QA, and Overview (not Third Party)	Prepare As-Built Drawings
T	CAD and Computer Services (support)	CAD and computer Services (support)	
I	Project Schedules	Project Schedules	
O	Construction Cost Estimates	Constructability Reviews	
N	Constructability Reviews	Safety Reviews by A/E	
S	Safety Reviews by A/E	Construction Cost Estimates	
	Value Engineering	Acceptance Procedures	
B	Identify Long Lead Procurements	Certified Engineering Reports	
	Design Studies Not Included in Pre-Title I	Bid Package Preparation	
and	Preliminary Safety Analysis Report if Not Included in the CDR		
	Design Change Control	Design Change Control	
C		Inspection Planning	

Note: This representative list of functions was developed from FAR and DOE definitions.
All functions meet FAR criteria, and the categories are segregated according to the FAR.

APPENDIX A

DICTIONARY

A/E & Construction Performance Appraisals. Reviews of architect/engineer (A/E) and/or construction contractor performance during the project. (Also see Performance Evaluation of A/E.)

A/E Internal Design Coordination. Coordination of design effort within the A/E firm.

A/E Selection Scope of Work for Off-site A/E. Project criteria required by the A/E for subcontractors used by the A/E.

Abandoned Design and Construction. Project costs shall include costs incurred because of the cancellation of all or part of a contract or purchase order to procure, manufacture, or assemble an item of Plant and Capital Equipment (PACE). These costs, less any salvage credits, shall be distributed over the remaining units of property within the project for project accounting purposes, except where such distribution significantly distorts the cost of the remaining property units. Where such distortion occurs, the costs of the abandoned project or project segment may be closed from construction work in progress to abandoned projects. All charges to abandoned projects shall be approved by the Head of the Field Element.

Acceptance. The inspection of a unit or facility for acceptance with a documented listing of the specific testing to be accomplished or work remaining, including the furnishing of any outstanding submittals or technical and record data, to be completed by the construction contractor.

Acceptance Testing. The performance of all necessary testing to demonstrate that installed equipment will operate satisfactorily and safely in accordance with plans and specifications. It includes required hydrostatic, pneumatic, electrical, ventilation, and mechanical functioning and run-in tests of portions of systems, and finally of completed systems.

Acceptance Test Procedure and Plan. A test procedure and plan developed for the acceptance of the facility from the contractor. This test procedure describes the individual testing methods and results that must be met for individual components of the facility to be accepted, such as the testing of concrete, soil analysis, and the level of contamination. Acceptance of the individual components must be completed prior to final acceptance.

Accounting. Salaries, travel, and other expenses for accountants, timekeepers, clerks, and their secretarial support. This is an indirect cost.

Action Plan. A plan describing the implementation of a specific cleanup action.

Activity Based Costing (ABC). A cost estimating method where the project is divided into discrete activities, and a cost estimate is prepared for each activity.

Activity Data Sheet. The activity data sheet (ADS) supports the Environmental Restoration Planning, Budgeting, and Control System and relates to the program summary work breakdown structure (WBS) at a specified level. It is the basic building block for program life-cycle planning. An assessment ADS and a cleanup ADS define a remediation project. Management activities that are not associated with a specific remediation project are specified on separate ADSs.

Additions and Improvements to Structure. Any additions or improvements to a structure, such as adding a new wing to a building. This does not include the additional equipment improvements to a structure, such as adding insulation to a building.

Administration. Salaries, travel, and other expenses for the overall administration personnel (e.g., office manager) of the project. This is an indirect cost.

Agreement in Principal. During negotiations not all details may be decided, but an agreement in principal may be reached. This occurs when most of the contract language is approved by all parties. There may still be some outstanding items that have not been agreed upon during this phase of negotiations.

Aircraft Operation. Aircraft operations specifically for the construction project. This is an indirect cost.

Applicable or Relevant and Appropriate Requirement (ARAR). Requirements, including cleanup standards, standards of control, and other substantive environmental protection requirements and criteria for hazardous substances, as specified under Federal and State law and regulations, that must be met when complying with the Comprehensive Environmental Response, Compensation, and Liability Act (from the Superfund Amendments and Reauthorization Act).

As-built Drawings (Prior to and after construction). A set of drawings that are marked-up by the contractor building a facility or fabricating a piece of equipment that show how the item or facility was actually built versus the way it was originally designed. At the completion of a project, the as-built drawings describe what was actually built.

As Low As Reasonably Achievable (ALARA). A radiation protection principle applied to radiation exposures, with costs and benefits taken into account.

Asbestos Hazard Emergency Response Act (AHERA). 1986 Act requiring school districts to analyze asbestos problems.

Audit. A planned and documented activity performed to determine by investigation, examination, or evaluation of objective evidence the adequacy of and compliance with established procedures, instructions, drawings, and other applicable documents and to determine the effectiveness of implementation. An audit should not be confused with surveillance or inspection activities performed for the sole purpose of process control or product acceptance.

Baseline. A quantitative definition of cost, schedule, and technical performance that serves as a base or standard for measurement and control during the performance of an effort; the established plan against which the status of resources and the effort of the overall program, field program(s), project(s), task(s), or subtask(s) are measured, assessed, and controlled. Once established, baselines are subject to change control discipline (modified).

Baseline (Configuration). A configuration document package that is fixed at a specific time during the life cycle of a system and defines a formal departure point for control of future changes in performance, design, production, construction, and related technical requirements.

Best Available Technology (BAT) or Best Demonstrated Available Technology (BDAT). Treatment technologies that have been shown through actual use to yield the greatest environmental benefits among competing technologies.

Bid Evaluations. A review of all bids submitted by prospective contractors. The bids are opened and studied. After selection of the winning bid, the bid is awarded.

Bid Package. A set of documents that contain the scope of work, specifications, drawings, and general conditions for a project or job. Prospective contractors should be able to review the bid package and develop their cost estimates and schedules for the work.

Bid Package Preparation. All time and materials used to prepare the bid package.

Bonds. Bonds required for construction (e.g., performance, bid, payment). This is an indirect cost.

Buried Contingency. Some estimators have sought to hide contingency estimates in order to protect the project so that the final project does not go over budget because the contingency has been removed by outside sources. This is commonly known as buried contingency.

CAD Services (and computer). Drawings generated by computer-aided drafting and design (CAD) services. These services include the software, hardware, associated materials, and the system operator.

Camp Operations. Operation of construction camp facilities. This is an indirect cost.

Candidate Projects. A list of projects submitted by the operating offices for approval. Submitting candidate projects to Headquarters is part of the budgeting process.

Candidate Sheets. Recommended capital facility upgrades submitted by the operating plant management to support plant/program milestones and commitments.

Capital Review Board. An evaluation and review group that reviews candidate projects prior to submittal to the U. S. Department of Energy (DOE).

Certified Engineering Reports. As a deliverable from the A/E, all engineering reports and drawings must be certified. The certification is a signed statement attesting to the accuracy of the information in the document.

Change Control for Design. The procedures that must be followed to change the baseline design. Scope, cost, and schedule impacts of the change are defined. Levels of approval required to authorize the change depend on the magnitude of the change.

Commissioning Costs. Costs associated with authorizing a facility to operate. These usually include fuel or raw material costs, review costs, team costs, etc., and are project-specific. Commissioning costs are usually found in estimates for nuclear facilities.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Federal statute (also known as Superfund) enacted in 1980 and reauthorized in 1986, that provides the statutory authority for cleanup of hazardous substances that could endanger public health, welfare, or the environment. CERCLA addresses the uncontrolled releases of hazardous substances to the environment and the cleanup of former or otherwise inactive waste sites.

Compressed Air Costs. Construction and operation of the compressed air system used for construction and temporary facilities. This is an indirect cost.

Computer Systems (software and hardware). Automated data processing to assist operators who monitor and run the equipment or facilities. This includes software and hardware developed for the facility.

Conceptual Design Estimate. A budget or conceptual design estimate is required to request congressional authorization for funding. This request is required for each line item construction project and each contingency-type project.

Conceptual Design Plan. Pre-authorization activity that describes the basis for the conceptual design.

Conceptual Design Report (CDR). The CDR is a document that describes the project in sufficient detail to produce a budget cost estimate and to evaluate the merits of the project. A conceptual design report shall be prepared for line item construction projects prior to inclusion of the project in the DOE budget process.

Conceptual Project Schedule. A schedule that is developed during pre-authorization activities and is based on the conceptual design of the facility.

Configuration Management Plan. A plan to ensure and document that all components of a project interface both physically and functionally.

Constructability Review. Formal review to determine feasibility of constructing a proposed project.

Construction. The act of erecting, renovating, reconditioning, or demolishing a building or other facility, including the labor, materials, and equipment required to complete the task. This is a direct cost. Costs will be charged to plant and capital equipment - construction.

Construction Contractors. Salaries, travel, and other expenses of engineers, engineering assistants, and their secretarial support responsible for engineering and design performed by the construction contractor. When work normally performed by an architect/engineer is performed by a construction contractor, the associated costs are charged to the applicable engineering, design, and inspection accounts. This is an indirect cost.

Construction Coordination and Planning. Management activities that work to keep the project on schedule and on budget during project construction. These activities include, for example, ensuring that construction equipment and supplies are available when needed.

Construction Equipment. Major pieces of equipment used during construction that are not associated with a single work operation. Specific-purpose equipment would be charged to the appropriate direct account. This element includes rental or depreciation, repairs, fuels and lubricants, erection, dismantling, shipping, and operator and assistant wages. This is an indirect cost only if not associated with a particular work operation.

Construction Equipment Maintenance. Maintenance of major pieces of equipment (as defined above) used during construction. This is an indirect cost.

Construction Facilities. Facilities that are constructed, rented, renovated, etc., strictly for use during the construction phase of the project (e.g., structures, roads, utility connections, parking, walkways). Facilities that remain in place or use after completion of construction should be charged elsewhere (e.g., permanent plant construction, sitework, operating expense).

Construction Management. Construction management covers those services provided by the organization responsible for management of the construction effort during Title I and Title

II design, and continuing through the completion of construction. Construction management services are further defined in DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM.

Construction Project Data Sheet (Schedule 44). This form is submitted to DOE Headquarters for review and, if approved, the project is included in the budget submitted to the Office of Management and Budget (OMB). The completed conceptual design estimate normally serves as the basis for preparation of this form.

Construction Status Reports and Meetings. Any meeting or conference called for the purpose of reviewing construction project status. Status reports are issued at regular intervals during the construction and describe project status relative to existing budget, schedule, and scope.

Consumables. Expendable supplies used during construction (e.g., rope, tarps, drill bits, grinding wheels, gloves, hoses, rags, soap, fuels, lubricants). This is an indirect cost.

Contamination Restrictions. Time lost due to radiation dose rates. This is a direct cost.

Contingency. The amount budgeted to cover costs that may result from incomplete design, unforseen and unpredictable conditions, or uncertainties. The amount of the contingency 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.

Contract Administration. The maintenance and oversight of a project to ensure that all provisions of the contract are met.

Contractor. Includes all persons, organizations, departments, divisions, and companies having contracts, agreements, or memoranda of understanding with the DOE or other federal agency.

Contract Fee. Fee earned by the contractor. It may be based on dollar value or other unit of measure such as manhours. This is an indirect cost.

Contractor Support Related to Design and Construction. Support provided by a contractor during design and construction, such as activities involving project and construction management.

Contribution to Welfare Plans. Health insurance, retirement plans, education, and training that is typically an addition to base salary, in the form of a percent added or unit cost per hour. This is an indirect cost.

Contributions In-Kind. Instead of being paid with money for services supplied, an exchange of a commodity is given. An example of this is if a contractor would demolish an old house, he receives the lumber for payment of his services.

Control Systems for Construction Activities. Any system used to track progress and/or expenses during construction against the baseline budget and schedule.

Corrective Action. A measure taken to rectify and prevent recurrence of conditions that adversely affect quality and mission accomplishments.

Cost Estimate. A statement of costs estimated to be incurred in the conduct of an activity, such as a program, or the acquisition of a project or system. The estimate can be in the form of proposals by contractors or Government agencies, a response to a program opportunity notice, or a DOE estimate.

Cost Plus Award Fee (CPAF) Contract. A contract where the contractor recovers actual costs incurred for completed work and is awarded a fee based on performance. Actual costs include general administration, overhead, labor and fringe benefits, other direct costs, and materials, including mark-up.

Cost Plus Fixed Fee (CPFF) Contract. A contract where the contractor recovers actual costs incurred for completed work. The fee awarded is predetermined and set by the contract.

Cultural Resources Review. An archaeological survey performed to ground disturbing activities at a proposed project construction site.

Davis-Bacon Administration. Administration of the Davis-Bacon Act, which regulates minimum wage rates on federal projects.

Decision Progress Reporting. Project status reporting using decision tree analyses.

Decommissioning. The process of removing a facility from operation, followed by decontamination, entombment, dismantlement, or conversion to another use.

Decontamination. The removal of hazardous material (typically radioactive or chemical material) from facilities, soils, or equipment by washing, chemical action, mechanical cleaning, or other techniques.

Definitive Estimate. An estimate conducted during the latter stages of a project when engineering may be as much as 40 percent complete. The actual cost is usually within plus 15 percent to minus 5 percent of the definitive estimate.

Demolition. Destruction and removal of facilities or systems from the construction site. This is a direct cost.

Depletable Resources. A resource that is used up during a job.

Design and Construction Errors and Omissions. Errors and omissions are sometimes found in a design during the construction process. These typically lead to change orders. A contractor's change order would normally be approved if it is caused by errors and omissions in the owner's design package.

Design Calculation and Analysis. These are the calculations and analyses used to support the design. For example, calculations would be shown to support the sizing of the heating, ventilation, and air conditioning (HVAC), heating and cooling units, fans, and ducts.

Design Changes/Controls. The process by which changes to the design are recorded and controlled after the design has been approved. Associated changes to the budget and schedule are documented as part of this procedure.

Design Cost and Scheduling Analysis and Control. Tracking and analysis of the cost and schedule of activities that occur during the design phase of a project.

Design Kickoff. A design kickoff meeting is held with DOE, the A/E, and any site contractors prior to any Title I design activities. This meeting initiates the design effort.

Design Quality Assurance (QA) Plan. Project plan for ensuring the quality of formal design. Components of design QA usually include checkprinting and review of design elements by senior A/E staff.

Design Review. A systematic review of project design to ensure it is meeting the requirements of the objective.

Design Review by Project Team. An internal review conducted by a project team selected to review the design effort.

Design Review Support by Operating Contract. During the design, an operating contractor reviews the design. This would be an operability type design review.

Detailed Estimate. This estimate is developed for the total project based on the completed design package. This estimate is used to verify the contractor's figures in both a lump sum or negotiated fee project. It is also used to track costs during the construction phase of the contract.

Direct Costs. Any costs that can be specifically identified with a particular project or activity, including salaries, travel, equipment, and supplies directly benefitting the project or activity.

Disposal. There are two types of disposal that could be associated with construction and remediation type projects. Includes regular construction debris as well as hazardous waste that must be disposed of.

Disposal of Radioactive Waste. Cost of compliance with regulatory requirements for radioactive waste disposal.

Document. Any written or pictorial information describing, defining, specifying, reporting, or certifying activities, requirements, procedures, or results. A document is not considered to be a quality assurance record until it satisfies the definition of a quality assurance record.

Drawings. As part of an A/E design effort, drawings are typically a deliverable. These are design drawings that depict how a facility should look after the construction is complete. Also referred to as as-built drawings.

Drinking Water and Sanitation. Supply of drinking water and toilet facilities during construction or operation activities. This is an indirect cost.

Economic Escalation. Cost increases caused by unit price increases. Whereas the cost of projects can increase because of poor management, scope growth, and schedule delays, economic escalation is concerned only with forecasting price increases caused by an increase in the cost of labor, material, or equipment necessary to perform the work.

Economic/Life Cycle Cost Analysis. An analysis of the direct, indirect, recurring, non-recurring, 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.

Energy Conservation Report. A report that analyzes the different energy systems in a project to achieve a design that minimizes energy use. Typically, systems that use less energy require more capital cost. This study balances the energy savings against the increased capital cost to arrive at an optimum design.

Energy System Acquisition Advisory Board (ESAAB). ESAAB supports the Acquisition Executive by providing advice, assistance and recommendations at key decision points for each major system acquisition and designated major projects. The ESAAB provides a single forum for the discussion of issues and alternatives and is designed to ensure coordinated, objective senior level management advice to the Acquisition Executive. DOE Order 4700.1, PROJECT MANAGEMENT SYSTEM, can be referenced for further information.

Energy System Acquisition Advisory Review (ESAAR). An annual review for environmental projects that reflects the project status and activity for the prior and upcoming fiscal years.

Engineering and Design Studies. Engineering and design studies are conducted throughout a project from pre-authorization through construction to determine the best alternative from an engineering perspective. An example of an engineering study would be to evaluate waste water treatment techniques to determine which one would be the best to achieve the required level of treatment.

Engineering, Design, and Inspection (ED&I). Activities begin with the preliminary design (Title I). Pre-title I activities are not considered part of ED&I activities. ED&I activities include the engineering and design activities in Title I & II and the inspection activities associated with Title III.

Engineering Support (A/E). During the construction of the project, additional technical expertise may be required. This assistance is A/E engineering support.

Environmental Cleanup Costs. All costs associated with an environmental remediation project after the assessment phase.

Environmental Restoration. Cleanup and restoration of sites contaminated with hazardous substances during past production or disposal activities.

Environmental Restoration Management Contractor (ERMC). A contractor responsible for the management and execution of the Environmental Restoration Program for a site.

Environmental, Safety and Health (ES&H) Crosscut. A review of applicable environmental, safety, and health regulations or requirements to determine the impacts of these requirements and regulations on the project. Air and water quality, land disturbances, ecology, climate, public and occupational health and safety, and socioeconomic factors (including non-availability of critical resources and institutional, cultural, and aesthetic considerations) are some of the areas considered.

Equipment and Refurbishment or Equipment Repair. The restoration or replacement of a deteriorated item of PACE such that it may be utilized for its designated purpose. The cost of repair is normally charged to an operating expense account and includes amounts for labor and associated supervision and materials and transportation costs, as well as indirect and other costs incurred in such repairs, but it does not include the costs to replace items of PACE designated as retirement units.

Escalation. A time-related increase in the amount of labor hours required to produce a given unit of work output, aggregate demand exceeding aggregate supply, external pressures on the market such as droughts or cartels, wage-price spiral, an increase in the cost of labor, or a decrease in the availability of good or services. These factors independently or in unison will increase the cost of a good or service.

Escorts. Personnel to escort uncleared construction workers in a security restricted area. This is a direct cost.

Evaluation of RCRA/EPA/State Permit Regulations. An analysis of applicable federal, state, and local environmental regulations to determine what permits are required for the project. (Note: RCRA = Resource Conservation and Recovery Act, EPA = Environmental Protection Agency.)

Expense Funding. Funding from the Operating Office expense funds.

Facility. A single project that includes any buildings and functional systems, such as equipment, process systems and associated piping, landfills, and impoundments. A facility is usually associated with a unique process or operation at a given location.

Feasibility Study. The objectives of the feasibility study are to identify the alternatives for remediation and to select and describe the alternative that satisfies the applicable or relevant and appropriate requirements for mitigating confirmed environmental contamination. Successful completion of the feasibility study should result in the development of a remedial design to implement the selected remedial actions.

Fire Protection. Fire protection equipment and systems provided during construction that do not become part of the permanent plant. This is an indirect cost.

"First Level" Codes. Sometimes called **"primary levels,"** represent the major cost categories. The major components or categories of work for each of the primary levels on each project are listed and assigned a "secondary level." Codes are then broken down by work elements or bills of material and each work element or bill of material (BM) is assigned a "third level" or fine detail level.

Freight. Delivery service provided to move materials and equipment from the supplier's point of origin to the job site. This is a direct cost.

Full Time Equivalents (FTE). A method of calculating labor costs where the number of employees is multiplied by the rate and duration to calculate cost.

Funding Profile. A representation of the project costs over the life of the project.

General Cleanup. General area cleanup and yard cleanup. Cleanup associated with a particular work operation is charged directly to the associated account. This is an indirect cost, only if not associated with a particular work operation.

Government Estimates. Determines the reasonableness of competitive bids received in connection with fixed-price construction contracts, and serves as a control in evaluating cost estimates prepared by a prime cost-type construction contractor. Sometimes called engineer's estimate.

Hazardous Ranking System (HRS). A U.S. EPA scoring system used for a number of environmental decisions, including ranking disposal sites for cleanup.

Hazardous Waste. As defined in RCRA, a solid waste, or combination of solid wastes, that because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

Heat. Heating, ventilation, and air conditioning for construction and temporary facilities. This is an indirect cost.

Holiday and Vacation Pay. Paid legal holidays and charged vacation pay. This is an indirect cost.

Identification of Long Lead Procurements. The identification of those items of equipment and/or construction materials that must be ordered prior to the estimated physical construction start to ensure availability at the time needed so as not to delay construction performance.

Identification of Project Record Requirements. The identification of document control and filing requirements.

Improvements to Land. The cost of general site clearing, grading, drainage, and facilities common to the project as a whole (such as roads, walks, paved areas, fences, guard towers, railroads, port facilities, etc.), but excluding individual buildings, other structures, utilities, special equipment/process systems, and demolition, tunneling, and drilling when they are a significant intermediate or end product of the project.

Independent Cost Estimate (ICE). 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.

Indirect Costs. Costs incurred by an organization for common or joint objectives and that cannot be identified specifically with a particular activity or project.

Initial Complement of Furnishings. Includes furniture and other furnishings to make a facility operable as per the original intent.

Inspection. Examination or measurement to verify whether an item or activity conforms to specified requirements.

Inspection Planning. Planning for the survey of a unit, facility, or area to determine overall compliance with contract drawings and specifications.

Installations/Alterations. Installation and/or modification of project equipment during construction activities.

Insurance. Insurance, other than payroll, carried by the contractor in connection with the construction work (e.g., vehicle and property damage, liability, builders risk). This is an indirect cost.

Integrated Project Schedule. An integrated project schedule contains all the elements of the overall project, including the design and engineering, procurement, construction, R&D,

safety, environmental, and operations activities. An integrated project schedule would cover pre-authorization through construction activities.

Interest Penalties. Contractual financial penalties for failure to pay invoices in a timely fashion.

Intermediate Estimate. An estimate conducted at the intermediate stages of a project or the beginning of the design stage.

Item. An all-inclusive term used in place of any of the following: appurtenance, assembly, component, equipment, material, module, part, structure, facility, subassembly, system, subsystem, or unit.

Key Decision 0. The project milestone required for requesting conceptual design funding in the internal review budget cycle.

Key Decision 1. The project milestone denoting that the project has received approval in the internal review budget process.

Key Decision 2. The project milestone denoting that the project has been approved to start final/detailed design and long-lead procurement.

Key Decision 3. The project milestone denoting that the project has been approved to start construction or enter full-scale development.

Key Decision 4. The project milestone denoting that the project is operationally ready.

Land and Rights. The purchase price and other acquisition costs required to obtain the land and/or land rights necessary for a project. This includes removal costs less salvage realized in disposing of any facilities acquired with the land.

Letter of Instruction. Design guidance document for the A/E to follow. This document is produced by the PM and describes any required design deviations from the Design Criteria Manual.

Laundry. Cleaning of contaminated clothing. This is an indirect cost.

Legal. Salaries, travel, and other expenses of lawyers and legal fees. This is an indirect cost.

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.

Light and Power. Light and power for construction and temporary facilities. This is an indirect cost.

Main Plant. This term is used to describe the building, facility, or plant, which must be capitalized.

Maintenance of General Construction Plant. Maintenance and operation of general construction plant facilities not chargeable to other accounts. Includes depreciation of general site improvements and temporary land improvements. This is an indirect cost.

Management and Operating (M&O) Contractor/M&O Support During Construction. Technical support from project M&O contractor during facility construction and start-up.

Material Handling. The receipt, offloading, and storage of materials. The final movement to the point of installation is charged to the appropriate direct account. This is an indirect cost.

Material Procurement Rate. Percent markup on purchased materials.

Medical and First Aid. Medical personnel, first aid supplies, and hospital expenses. This is an indirect cost.

Milestone. A important or critical event and/or activity that must occur in the project cycle to achieve the project objective(s).

Motor Pool Operations. Operation of a pool for motor vehicles for general and administrative services. Automobiles operated specifically for other services are not to be included here. This is an indirect cost.

National Emission Standards for Hazardous Air Pollutants (NESHAP). Clean Air Act limits for release of hazardous pollutants for which no ambient air quality standard is applicable.

National Environmental Policy Act (NEPA) of 1969. This act established the requirement for conducting environmental reviews of federal actions that have the potential for adverse impact on the human environment. NEPA requires that DOE perform an environmental review, with public participation, of proposed major federal actions that may have an impact on the human environment. This review usually results in an environmental assessment or environmental impact statement.

Negotiations of Fixed Price Contract Changes. Contract negotiations between DOE and a contractor on a fixed price contract during the contract period.

Non-Conformance Reports (NCRs). A report that documents a contractor's failure to comply with the contractual requirements.

Office Supplies and Expenses. Expenses of administrative offices, including stationery, forms, blueprints, reproduction equipment and supplies, furniture, photography, telecommunications services and personnel, janitorial services, heating and air-conditioning, lighting, water and sewage, depreciation of office facilities and equipment, repairs and maintenance of office buildings and equipment, messenger and mail services, and office employees not chargeable to other accounts. This is an indirect cost.

Operable Unit (OU). A discrete portion of a DOE installation identified as a group of release sites placed together for the purpose of remediation as a single project. OUs may represent geographical portions of an installation, or they may represent a specific installation problem, such as surface/subsurface groundwater contamination. Cleanup of an installation may be divided into a number of OUs, depending on the complexity of the problems associated with the installation. An OU may represent all or part of discrete locations such as Waste Area Groups (WAGs) and Solid Waste Management Units (SWMUs). OUs usually contain more than one release site, may be in close geographic proximity to other OUs, and may exhibit similar waste characteristics and types of releases. Release sites do not have to be contiguous to be included in a specific OU.

Operation Test Plans. Plans developed to fully test the operation during start-up as well as tests to be conducted to check the operations of the system once the facility is in operation.

Operations and Maintenance (O&M). Activities required to maintain the effectiveness of response actions.

Operational Readiness Review. Facility audit to verify that the facility is ready to commence operation.

Operator Training. Training provided for the operating contractor personnel in order to run and maintain a facility. This includes all required health and safety and specialized training by a vendor.

Order-of-Magnitude Estimate. An estimate conducted during the preliminary stages of a project.

Other Project Costs (OPC). All other costs related to a project that are not included in the Total Estimated Costs, such as supporting research and development, pre-authorization costs prior to start of Title I design, plant support costs during construction, activation, and startup.

Outside Contractor Support. Support of DOE activities using outside contractors instead of DOE personnel.

Parametric Estimate. Parametric estimating requires historical data bases on similar systems or subsystems. Statistical analysis is performed on the data to find correlations between cost drivers and other system parameters, such as design or performance parameters. The analysis produces cost equations or cost estimating relationships that can be used individually or grouped into more complex models.

Payroll Insurance. Contractor's contribution to social security taxes. This is an indirect cost.

Performance Evaluation of A/E. To ensure that the design effort is completed on time and within budget, the A/E performance must be evaluated. The performance is evaluated during design by using the number of drawings that are expected to be produced and the number of manhours required for each drawing. These hours are tracked to give an indication of the performance of the A/E. Another performance evaluation is to assess that the facility is being designed in accordance with the functional design criteria.

Permits, Licenses. Permits and licenses required for construction and transportation permits, equipment operating (e.g., building, street, utility, environmental, and transportation permits; equipment operating licenses). This is an indirect cost.

Permits After Title I. Permits obtained for construction are permits after Title I.

Permits Prior to Title I. Permits prior to Title I include all those permits required during the design phase of a project. It may also include permits that must be obtained prior to construction.

Personnel. Salaries, travel, and other expenses of personnel for recruitment employment and employee relations activities. This is an indirect cost.

Physically Handicapped Review. Review of design for barrier-free design/construction features for facility accessibility by the handicapped.

Pilot Plant. A pilot plant is a small-scale demonstration plant that is used to evaluate a process and better define the process design parameters.

Planning Estimate. A cost estimate for general planning and budgeting purposes only. Planning estimates will be used when there is a need for an order-of-magnitude estimate, but sufficient definitive information is lacking that would allow the development of a total estimated cost. Planning estimates are developed for each project (program) at the time of project identification. Since these are developed before 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 ensure that the order of magnitude is correct, since a tendency exists to avoid changing, particularly upward, this estimate once established.

Plant and Capital Equipment (PACE) Fund. For conventional construction projects, this is a fund that provides for the plant and its basic equipment/furnishings.

Plant Forces Work Review. Determines whether part or all of the project work will be performed by plant forces as defined by the Davis-Bacon Act.

Pre-title I Activities. Pre-title I activities are defined in a variety of DOE references as all activities taking place prior to the start of the preliminary design. This includes siting and related engineering studies conducted to establish project scope, feasibility, need, etc., as well as all activities that produce formal deliverables, such as conceptual design reports.

Preliminary Assessment/Site Investigation (PA/SI). One of the first stages in remediating a site. The PA/SI is designed to evaluate all known information about the site and to conduct a preliminary investigation of the extent and nature of the contamination at the site. The purpose is to determine if further action or investigation is appropriate. Data collected during this period is used to build an HRS score for the site.

Preliminary Safety Analysis Report (PSAR). For complex or expensive projects, a preliminary safety analysis is prepared and approved before construction begins. The analysis must be accompanied by a report that documents the analysis.

Premium Pay. Incremental wage increases for such things as overtime, shift differential, and general foreman. This is a direct cost.

Prime Contractors. DOE's major contractors; principally, DOE's management and operations contractors.

Procedure. A document that specifies or describes how an activity is to be performed.

Procurement. Salaries, travel, and other expenses of those responsible for field purchasing and expediting of materials, supplies, and equipment. This is an indirect cost.

Procurement and Construction Specifications. A deliverable of the design effort is the procurement and construction specification or requirement. These documents allow a contractor to procure all equipment necessary for construction.

Procurement Coordination. Coordination of equipment and materials between purchasing staff and project management to ensure that schedule and cost requirements are being fulfilled.

Procurement Document. Purchase requisitions, purchase orders, drawings, contracts, contract task orders, specifications, or instructions used to determine requirements for purchase (modified).

Productivity. Consideration for factors that affect the efficiency of construction labor (e.g., location, weather, work space, coordination, schedule). This is a direct cost.

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 qualitative terms, with respect to work force, material, and facility requirements. Programs are typically made up of technology-based activities, projects, and supporting operations.

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 responsible authority 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 Participant. Any organization, contractor, or individual who is responsible for meeting assigned program objectives.

Project. A unique major effort within a program that has firmly scheduled beginning, intermediate, and ending date milestones; prescribed performance requirements; prescribed costs; and close management, planning, and control. The project is the 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.

Project Assessment and Reporting. Project status reporting and comparison against budgeted or scheduled project forecasts.

Project Closeout. The final phase of a project where all project contracts are closed and all records finalized for storage.

Project Management. Project management covers those services provided to the DOE on a specific project, beginning at the start of design and continuing through the completion of construction, for planning, organizing, directing, controlling, and reporting on the status of the project. It includes 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 Management Plan (PMP). The PMP is the document that sets forth the plans, organization, and systems that those responsible for managing the project shall utilize. The content and extent of detail of the PMP will vary in accordance with the size and type of project and state of project execution.

Project Schedules. Schedules may be developed for each phase of the project, such as design, procurement, and construction. These schedules would indicate the sequence required to finish the activities during the allotted time. Project schedules may also be used in the performance evaluation of contractors.

Project Support. Support covers those activities performed by the operating contractor for internal management and technical support of the project manager.

Project Validation. Headquarters review and validation of line item projects for constructability, costs, and schedule.

Protective Clothing. Materials and time required for construction forces to dress and undress for work in contaminated areas. This is a direct cost.

Quality. The totality of features and characteristics of an item or service that bears on its ability to satisfy given needs or fitness for intended use, which includes conformance to requirements.

Quality Assurance. All those planned and systematic actions necessary to provide adequate confidence that a facility, structure, system, or component will perform satisfactorily in service.

Quality Control. All those actions necessary to control and verify the features and characteristics of a material, process, product, or service to specified requirements. Quality control is the process through which actual quality performance is measured and compared with standards.

RCRA Facility Assessment (RFA). The initial RCRA process to determine whether corrective action for a RCRA past practice unit is warranted or to define what additional data must be gathered to make this determination; analogous to a CERCLA Preliminary Assessment and Site Inspection.

RCRA Facility Investigation (RFI). The RCRA process to determine the extent of hazardous waste contamination; analogous to the Comprehensive Environmental Response, Compensation, and Liability Act remedial investigation.

Radiation Control Timekeepers. Personnel who monitor employee exposure to radioactive materials and ensure that regulatory limits are not exceeded.

Radiation Protection by Operation Contractor. Personnel protective equipment and monitoring devices supplied by the operating contractor for protection against employee exposure to radioactive materials.

Regulatory Overview by A/E. An evaluation of all applicable local, state, and federal environmental and health and safety regulations by the A/E during project design.

Regulatory Requirements (non NEPA). A full regulatory compliance check is conducted on all steps of the overall project to ensure that all work is conducted in accordance with all current regulations. This includes federal, state, and local regulations.

Remedial Action. A subactivity (CERCLA term) in a remedial response involving actual implementation, following remedial design, of the selected source control and/or off-site remedial effort.

Remedial Design. The final design specifications and drawings are developed for remediation work. All engineering required to perform the remediation is completed.

Remedial Investigation (RI). The CERCLA process of determining the extent of hazardous substance contamination and, and as appropriate, conducting treatability investigations. The RI is often done in conjunction with the feasibility study.

Reporting Time. Time given to employees to report for work when no work is available because of weather or other conditions. This is an indirect cost.

Reproduction. Copying or duplication of project documents during project design.

Request for Project Authorization. A request for project activity authorization is submitted to the field office manager or designee for approval prior to the initiation of work or contracting the work. The authorization procedure in DOE Order 4700.1 should be followed.

Requirements for Safety Analysis Determination. Safety analyses must include the identification of hazards, assessment of risks, and methods for risk elimination or control. The line organization is responsible for preparing the safety analyses, obtaining an independent review of each analysis, and authorizing the construction operation and subsequent significant modification.

Research and Development (also called Development). The development and testing of systems and pilot plants judged to be technically and economically desirable as a means of achieving principal program 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 a technical feasibility and economic potential during the technology phase.

Resource Conservation and Recovery Act (RCRA). Addresses the management of regulated hazardous waste and requires that permits be obtained for DOE facilities that treat, store, or dispose of hazardous waste or mixed waste; establishes standards for these facilities; and requires corrective actions (e.g., remediation) of past releases of hazardous waste from regulated waste management units.

Retroactive Pay. This account is used only when actual distribution of retroactive pay adjustments would be burdensome or the specific projects affected are closed. This is a holding account; only unallocatable costs should remain in this account.

Review Support by Management and Operating (M&O) Contractor. Review of design drawings prior to construction by M&O contractor.

Risk. The combined effect of the probability and consequences of failure of an item expressed in qualitative or quantitative terms.

Risk Estimate. A description of the probability that organisms exposed to a specific dose of chemical will develop an adverse response (e.g., cancer).

Risk/Health Assessment. The potential for realization of unwanted negative consequences of events. Public health risk assessment is a quantitative or qualitative evaluation of data from sources, such as toxicology and epidemiology, to predict the effects of public exposure to environmental factors that pose a potential hazard to the health and well-being of the public. Environmental and/or health effects resulting from exposure to a chemical or physical agent (pollutant) are combined with toxicity assessment results to provide an overall estimate or risk to the public. The process includes identification of the threat's source, determination of the threat's potential extent or magnitude, and resolution of probability that the defined undesirable situation will ensue from the exposure.

Safeguard and Security Systems. Safeguards against potential environmental damage and methods for mitigating environmental hazards must be developed. Security systems must be designed to protect the public from endangerment as well as protection for the facility.

Safety. All safety programs conducted during the course of the construction contract. Welding glasses, gloves, temporary railing, and other safety measures should be charged to the appropriate related cost account rather than to this account. This is an indirect cost.

Safety Review by A/E. A review by the A/E during the design phase for safety aspects of a project.

Sales Tax. State and local sales and use taxes. This is an indirect cost.

Scaffolding. General purpose scaffolding. Scaffolding erected for a particular work operation should be charged to the appropriate account. This is an indirect cost, only if not associated with a particular work operation.

Scope Change. A change in task objectives, plans (project or field work), or schedule that results in a material difference from the terms of an approval to proceed previously granted by higher authority. Under certain conditions, change in resource application may constitute a change in scope.

Security. Salaries, travel, and other expenses of security guards and associated equipment. This is an indirect cost.

Security and Restrictions. Time lost due to security limitations and restrictions. This is a direct cost.

Short Form Project Data Sheet. Short form project data sheets are brief overviews of projects that contain the project mission requirements, total estimated costs, other costs, tentative project schedule, and the amount of funding requested in the budget.

Significant Alterations. Any alteration or betterment of a facility that needs to be capitalized. (Reference DOE Order 2200.6, Chapter 6)

Signup and Termination Pay. Recruitment costs and severance pay. This is an indirect cost.

Site. A geographic entity comprising land, buildings, and other facilities required to perform program objectives. Generally a site has, organizationally, all of the required facility management functions (i.e., it is not a satellite of some other site). For purposes of this document, site and installation are synonymous.

Site Inspection. The purpose of the site inspection is to acquire the necessary data to confirm the existence of environmental contamination at identified potential sites and to assess the associated potential risk to human health, welfare, and the environment. The data collected at each site must be sufficient to support the decision for either continuing with a remedial investigation/feasibility study or for removing the site from further investigation through a decision document.

Site Investigation (final site selection). Acquisition of title and in some cases lessor interests in real property requires a formal site selection. Site selection and acquisition of real property must follow DOE policy as stated in DOE Order 4300.1, Real Property Management. This element describes any plans for site selection and real property acquisition and ultimate disposal, including the party responsible for the property, with particular emphasis on any implications of these actions on project contract provisions. Also included are plans to contract for utility services for the sites including a statement concerning whether or not such services will necessitate an increase in capacity for local utilities.

Site Selection Report. A report containing all activities included in the site selection. This includes a report pertaining to the acquisition or real property as well as any environmental site assessments that were conducted.

Sitework. Improvements made exterior to the structures on site. Includes such things as utilities, landscaping, irrigation, lighting, railroads, roads, and walks. This is a direct cost if permanent; otherwise, it is indirect.

Small Tools. Small hand tools and power tools, boxes, protective clothing, maintenance, and toolroom operation. This is an indirect cost.

Software. The programs, procedures, rules, and any associated documentation pertaining to the operation of a computer system.

Spares (initial and startup). During startup or shakedown of equipment and a facility, several spare parts need to be on site to keep equipment up and running. After startup, an initial set of spare parts is inventoried as part of the project costs.

Special Equipment. The installed cost of large items of special equipment and process systems such as vessels (e.g., towers, reactors, storage tanks), heat transfer systems (e.g., heat exchangers, stacks, cooling towers, desuperheaters, etc.), package units (e.g., waste treatment packages, clarifier packages, sulfurization, demineralization, etc.), and process piping systems.

Standard Equipment. Items of equipment in which only a minimum of design work is required, such as "off-the-shelf" items. Examples include office furniture, laboratory equipment, heavy mobile equipment, etc. Includes spare parts that are made part of the capital cost. This is a direct cost.

Startup. Startup covers one time-costs incurred by the M&O contractor during the transition period between the completion of construction and operation of the facility.

Statement of Work for M&O Contractor Project Management Activities. The contractual statement of work describing the project management activities that the M&O contractor must deliver.

Storage. Retention and monitoring of waste in a retrievable manner pending final disposal.

Strategic Facility Assessment. A review that determines whether a facility is "mission essential" in conjunction with the planned upgrade to the facility.

Subproject Designation. A term used to divide a project into separately manageable portions of the project.

Superfund. The fund set up by CERCLA for cleanup of abandoned hazardous waste sites; a colloquial term used to describe CERCLA.

Superfund Amendments and Reauthorization Act (SARA). The 1987 Act amending and reauthorizing CERCLA for responding to hazardous waste sites and increasing the size of the fund.

Superintendence. Salaries, travel, and other expenses of those supervising construction, including construction superintendents, assistants, and their secretarial support. Only general superintendents are included here. Superintendents assigned to specific portions of the project are charged directly to the appropriate direct cost accounts. This is an indirect cost, only if not associated with a particular work operation.

Surveys, Geological Studies, and Test. Topographical and other field surveys, soil tests, load tests, geological studies, test borings, and other subsurface investigations. This is an indirect cost.

Task. As defined by the Environmental Restoration Program, an assigned piece of work to be finished within a certain time. A task is a unique entity of work that addresses either the assessment effort or cleanup effort for remediating an OU. An assessment task can consist of up to four subtasks representing the first four remediation phases, usually accomplished in series. A cleanup task consists of two subtasks representing the remaining two remediation phases. The subtasks are the basic building blocks in the program and as such, are individually planned, approved, executed, and controlled. It is defined at the fourth WBS level: remediation task summary.

Taxes Other Than Payroll. Business and property taxes. This is an indirect cost.

Temporary Decontamination and Disposal Facilities. Facilities that are provided as part of an environmental cleanup job that will not become part of the permanent facilities of that project. These temporary facilities would be for the decontamination of personnel, equipment, and temporary disposal facilities until all permits and approvals for disposal have been obtained.

Termination Costs. All costs associated with terminating a project prior to completion are termination costs. Termination costs include disposition of unfinished facilities or hardware and settlement of all contracts and subcontracts. Disposition can include mothballing, dismantling, or disposal.

Title I Design. The preliminary stage of project design. In this phase, the design criteria are defined in greater detail to permit the design process to proceed with the development of alternate concepts and a Title I design summary, if required.

Title I Design Estimates. An intermediate estimate used to verify that the Title I design details still remain within the project funding.

Title II Design. The definitive stage of project design. The approved Title I concept and the supporting documentation prepared for Title I forms the basis of all activity in Title II. Definitive design includes any 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.

Title II Design Estimates. The estimate is used to certify bids or to be used in contract negotiations. As Title II design specifications and drawings are developed, the Title II estimate is completed.

Title III Design. The inspection portion of project ED&I. The activities identified in DOE Order 4700.1, PROJECT MANAGEMENT SYSTEMS, for inclusion in Title III can be separated into two categories: office support and field services.

Total Estimated Cost (TEC). An estimate of the total cost of a task, demonstration, or program. The total estimated cost differs from a planning estimate in that it is based on definitive information regarding technical scope, contracting methods, schedule, and resource requirements. As such, once a task is approved, its total estimated cost is baselined and becomes subject to change control procedures.

Total Project Cost (TPC). Consists of all costs specific to a project incurred prior to the start-up of facility operation. All research and development, operating, plant, and capital equipment costs specifically associated with a project.

Transfer and Moving or Relocation. Transfer and relocation costs associated with the project personnel to the job site area (costs are incurred by the receiving location). This is an indirect cost.

Transportation of Workers. Transporting employees engaged in the construction work to and from the job site. This is an indirect cost.

Travel. Travel to other locations for project purposes.

Treatment. Any activity that alters the chemical or physical nature of a waste to reduce its toxicity or prepare it for disposal.

Trips to Vendor/Fabricators. Travel to vendor/fabricator manufacturing facilities to review and/or inspect vendor work on project equipment.

User Move-In. User move-in costs are those associated with moving employees and equipment, including computers, into new facilities.

Utilities (specific to a project). Water, gas, electrical and sewer beyond a point of 5 feet outside building.

Value Engineering. Value engineering is a proven management technique using a systemized approach to seek out the best functional balance between the cost, reliability, and performance of a product or project.

Value Engineering After to Title I. Value engineering performed during the construction phase of a project after Title I.

Value Engineering Prior to Title I. Value engineering performed during the design phase of a project before Title I.

Vendor Submittals. Documents provided by vendors on their equipment and materials. These documents are used to determine whether or not the equipment meets the specifications of the purchase order.

Vulnerability Assessments. An evaluation of the vulnerability of a facility that would allow a hostile agent within the plant to gather intelligence of national security interest.

Warehousing. Operation of the on-site construction warehouse facilities. Rental and operation of off-site facilities. This is an indirect cost.

Waste Handling to Point of Disposal. Waste handling to the point of disposal includes all activities from when waste is generated up until the time it would be properly disposed. This includes all waste handling, temporary storage, packaging activities, and transportation.

Water. Water for construction. This is an indirect cost.

Welding Tests. Welding certification tests conducted at the job site or elsewhere. This is an indirect cost.

Work Orders. Issued to contractors providing indefinite delivery services. This type of contract is designed to have work orders written describing a service or deliverable that is to be provided by the indefinite delivery contractor.

Work Breakdown Structure (WBS). A breakdown of a project into those subelements that define the project. The WBS provides a consistent organization framework throughout the project.

APPENDIX B

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APPENDIX C

EXAMPLES OF COST ESTIMATION PACKAGES

1. INTRODUCTION

Estimates can be performed in a variety of ways. Some of these are for projects for an undefined scope, a conventional construction project, or where there is a level of effort required to complete the work. Examples of cost estimation packages for these types of projects are described as follows.

2. EXAMPLE OF AN ENVIRONMENTAL MANAGEMENT COST ESTIMATION PACKAGE

Following is an example of a well-documented cost estimation package. The data is from the example estimate from the EM-30 Cost and Schedule Estimating Guide and is for a level-of-effort-type estimate. To demonstrate the estimate building process, this example walks through the steps for a fictitious hazardous waste drum storage area.

A. Purpose

The purpose of this estimate is to prepare an FY95 operating budget for the operation of the hazardous waste drum storage facility at the XX site.

B. Technical Scope

The hazardous waste drum storage facility consists of a metal building (100 feet by 40 feet) over a concrete pad. The facility has a capacity of over 500 waste drums, single-stacked. Operations associated with this facility include transporting hazardous waste in 55-gallon drums and smaller containers from 22 points of generation within the site to the storage building via truck: off-loading the waste containers; visually inspecting them; collecting samples from 10 percent of the containers; labeling and dating the containers based upon their contents; preparing hazardous waste manifests; preparing the wastes to meet U.S. Department of Transportation (DOT) shipping regulations and the waste acceptance criteria of the receiving facility; staging the containers for off-site shipment within 90 days of their being filled; and checking them out of the inventory system as they are loaded onto the contractor's truck for off-site shipment. Ancillary activities associated with the facility include waste profiling, record keeping, housekeeping, small spill cleanup, training, and security.

For the past 3 operating years (1990, 1991, and 1992), this facility has received, stored, and prepared an average of 4,300 drums per year. A similar level of activity is anticipated in FY95.

The estimator must make some assumptions in the preparation of the estimate. They are as follows.

- The amount of waste generated by the production areas served by this storage facility will be the same as last year (4,300 drums).

- Ninety percent of the waste will be packaged in 55-gallon drums in good condition for off-site shipment. Ten percent of the waste materials will require consolidation, repackaging, or overpacking.

- Waste containers, with the exception of overpack drums and a limited number of drums used to consolidate wastes, will continue to be provided by the waste generating unit.

- Motor vehicles, including a stake-body truck with power-lift gate, a pick-up, and a fork lift, will continue to be supplied by the motor pool.

- There will be no significant changes in regulations affecting this facility.

C. Work Breakdown Structure

The work breakdown structure is established as follows:

1. Activity Data Sheet (ADS) 9876, Hazardous Waste Management

1.2. U.S. Department of Energy (DOE) Facility X, Waste Management Operations

1.2.4. Hazardous Waste Storage, TDD 4809

1. On-Site Transportation (1243.0111000)

- Drives a stake-body truck to 1 or more of the 22 satellite accumulation areas in the production facilities.
- Checks labels and documentation for each container upon arrival.
- Transports the hazardous waste in 55-gallon drums and smaller containers from satellite accumulation areas to the truck via handcart.
- Loads the waste containers onto the truck using a power-lift tailgate and secures the containers to the truck. In most cases, multiple drums will be collected from the same building at the same time.
- Upon collecting a full load of containers from various areas, returns to the drum storage building and unloads the drums for check-in.

2. Security Escort (1243.0112000)

Required to accompany on-site waste transporter into restricted production areas to collect waste containers for transfer to the storage facility.

3. Waste Container Acceptance (1243.0113000)

- Visually inspects container for damage to ensure it is properly labeled and dated.
- Enters container identification number and contents description into the computerized inventory control system.
- Collects a waste sample from 10 percent of all containers received for verification of contents and sends sample to on-site laboratory.
- Consolidates, repackages, or overpacks any drums that require special treatment (approximately 10 percent of all drums received).
- Sorts and moves drums to an appropriate location within the building based on waste type and compatibility.
- Checks waste sample analyses against waste profiles as received from laboratory.

4. Inspection and Inventory Check (1243.0114000)

- Conducts a walk-around visual inspection of all drums in the storage building; checks for leaks, spills, or other damage.
- Spot checks dates on drum labels to ensure compliance with the 90-day storage limit.
- Counts the drums and cross-checks with the inventory control system.
- Checks the inventory control system to ensure that no drums are stored longer than 90 days after filing.

5. Drum Preparation (1243.0115000)

- Prepares and labels drums to conform to DOT and U.S. Environmental Protection Agency regulations.
- Moves drums to staging area to await pick-up by contractor.

6. Record Keeping Reporting; Environmental, Health and Safety Compliance (1243.0116000)

- Performs all record keeping and information submissions to maintain compliance with Federal and state environmental and health and safety requirements associated with operating a "less-than-90-day" hazardous waste storage area.
- Develops new or updated standard operating procedures as needed for handling and storing new or changing waste streams.
- Prepares or updates waste characterization profiles as waste streams change, or as required by Federal and state regulations.
- Acts as regulatory liaison during inspections or incident responses.

7. Safety and Technical Training (1243.0117000)

Each employee working at this facility (either full-time or part-time) must attend Occupational Safety and Health Administration-approved hazardous waste worker health and safety training/refresher annually, hazardous waste response training/refresher annually, DOE security training/refresher annually, and miscellaneous one-time procedures improvement seminars.

D. Backup

On-Site Transportation (1243.0111000) (Variable Cost)
1991 - 2,155 labor-hours/4,288 drums
Average Time - 0.5 labor-hours per drum
FY95 Number - 4,300 drums per year
Labor Rate - $45.38/labor-hour

Security Escort (1243.0112000) (Variable Cost)
1991 - 2,150 labor-hours/4,288 drums
Average Time - 0.5 labor-hours per drum
FY 95 Number - 4,300 drums per year
Labor Rate - $51.26/labor-hour

Waste Container Acceptance (1243.0113000) (Variable Cost)
1991 - 4,503 labor-hours/4,288 drums
Average Time - 1.05 labor-hours per drum
FY95 Number - 4,300 drums per year
Labor Rate - $47.04/labor-hour

Inspection and Inventory Check (1243.0114000) (Fixed Cost)
1991 - 531 labor-hours/265 inspections
Average Time - 2.0 labor-hours per drum
FY95 Number - 260 inspections per year (1 per work day)
Labor Rate - $47.04/labor-hour

Drum Preparation (1243.0115000) (Variable Cost)
1991 - 2,573 labor-hours/4,288 drums
Average Time - 0.6 labor-hours per drum
FY95 Number - 4,300 drums per year
Labor Rate - $47.04/labor-hour

Record Keeping; Reporting; Environmental, Health and Safety Compliance (1243.0116000) (Fixed Cost)
1991 - 2,052 labor-hours per waste stream
Average Time - 114 labor-hours per waste stream
FY95 Number - 18 waste streams per year
Labor Rate - $47.04/labor-hour

Safety and Technical Training (1243.0117000) (Fixed Cost)
- 1991 - 349 labor-hours/7 employees
- Average Time - 50.0 labor-hours per employee
- FY95 Number - 7 employees
- Labor Rate - $47.04/labor-hour

Basis for Activity Time Estimates

The time estimates for each of the activities listed above have been developed by calculating the average time spent on each activity per unit of work. Time sheet summaries that capture activity time data were used to determine the total time spent by all employees on each activity. The time sheet summaries also provided the average hourly labor rate spent for each activity. The storage facility logbook and computerized inventory system were used to determine the number of times a work unit was performed. For example, time sheet summaries show that for 1991, 2,155 hours were spent transporting 4,288 drums (including all other work associated with transportation) from the satellite accumulation areas to the storage facility. This averages to 0.502 hours per drum. For the purpose of this estimate, therefore, we have assumed that transporting each drum requires 0.5 hours of work.

Work sheets, time sheet summaries, and storage facility inventory records supporting each of the time estimates are on file in the central file of the Waste Management Office, Budget File Number 1.2.4.3.93.

Supplies Needed for FY95

55-gallon drums (50 @ $35.00)	$1,750.00
Overpack drums (15 @ $65.00)	$975.00
Sample bottles (450 @ $1.75)	$790.00
Office supplies	$350.00
Chemical absorbent (100 bags @ $6.00)	$600.00
Hand tools, miscellaneous	$500.00
Coveralls, gloves, booties, safety glasses, and shoes	$5,000.00
SUBTOTAL	$9,965.00
Tax (5%)	$500.00
TOTAL	$10,465.00

Number of drums 4,300

Price per drum $2.43

Basis for Material Estimates

Material estimates are based upon the quantities actually used during 1991 and price quotes from local vendors and suppliers. Copies of the price quotes and quantity calculations are on file in the central file of the Waste Management Office, File Number 1.3.5.2.92.

Subcontracts for FY95

Laboratory Analytical Support

Fingerprint analysis (430 @ $150) $64,500
Number of drums 4,300
Price per drum $15.00
Waste profile analysis (36 @ $350) $12,600

E. Indirects

We have used an indirect rate of 25 percent for this cost estimate. This percentage includes an allocated cost for all functions, such as general site security, power usage, and site administrative costs. Record keeping for this operation, safety and technical training, and drum storage security escorts are included as direct costs.

F. Estimate, Time-Scaled Logic Diagram, and Resource Loaded Schedule
Following is the Cost Estimate (Table C-1), the Time-Scaled Logic Diagram (Table C-2), and the Resource Loaded Schedule (Table C-3). These documents complete the cost estimation package.

DOE Location X
Job No. XXXXXXXXX

HAZARDOUS WASTE STORAGE OPERATIONS
FACILITY OPERATIONS & MAINTENANCE
REPORT UC3: UNIT COST/ESTIMATE DETAIL BY FACILITY

Page: 1
Date: 12/01/92 14:14
By DGS & MAH

-Work Breakdown- Facility Standrd.WKPKG	Description	Quantity	Labor Hours	Labor	Material	Analytic Lab Cost	Overhead	Total Dollars
1	ADS 9876 Facility Ops/Maint.							
1243	FY 95, Storage Operations							
1243 .0111000.	On-site transportation .5 labor hours per drum	4300 drums	0.500 2150	22.69			5.67 24387	28.36 121933
1243 .0112000.	Security escort .5 labor hours per drum	4300 drums	0.500 2150	25.63 110209			6.41 27552	32.04 137761
1243 .0113000.	Waste container acceptance, including label, sample, inspect, repack, verifications	4300 drums	1.050 4515	49.39 212386	2.43 10449	15.00 64500	16.71 71834	83.53 359169
1243 .0114000.	Inspection and inventory check; 2 labor hours per inspection, 260 inspections per year	260 ea	2.000 520	94.08 24461			23.52 6115	117.60 30576
1243 .0115000.	Drum prep for offsite transportation	4300 drums	0.600 2580	28.22 121363			7.06 30341	35.28 151704
1243 .0116000	Recordkeeping, reporting, and compliance per waste stream type	18 ea	114 2052	5362 96526		700.00 12600	1515 27282	7578 136408
1243 .0117000.	Safety and technical training average 50 hours/person/year	350 hr	1.000 350	47.04 16464			11.76 4116	58.80 20580
Total FY 95, Storage Operations			14,317	678,955	10,449	77,100	191,627	958,131
Total ADS 9876 Facility Ops and Maintenance			14,317	678,955	10,449	77,100	191,627	958,131
Report Total			14,317	$678,955	$10,449	77,100	191,627	$958,131

Table C-1. Cost Estimate.

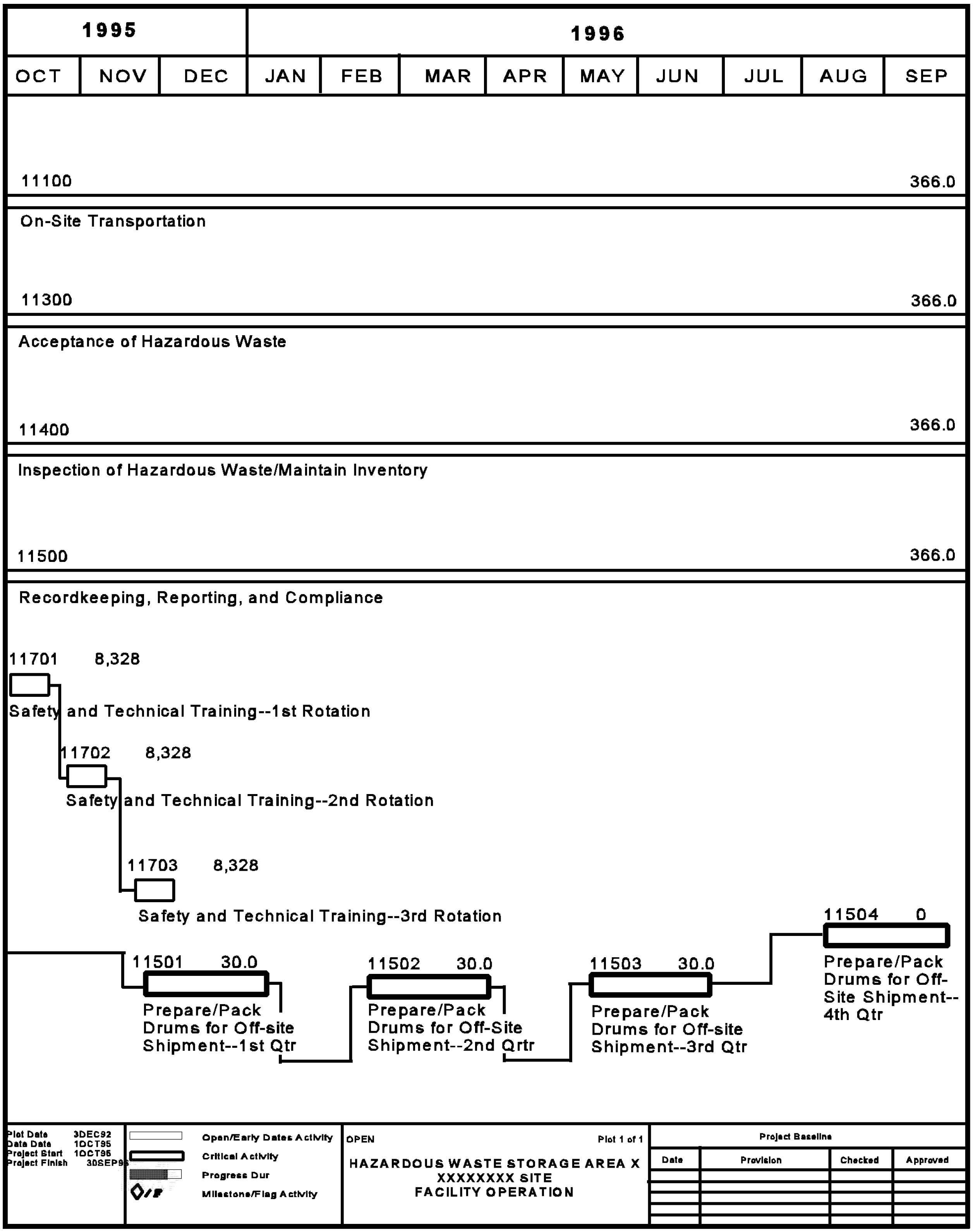

Figure C-1. Time-Scaled Logic Diagram.

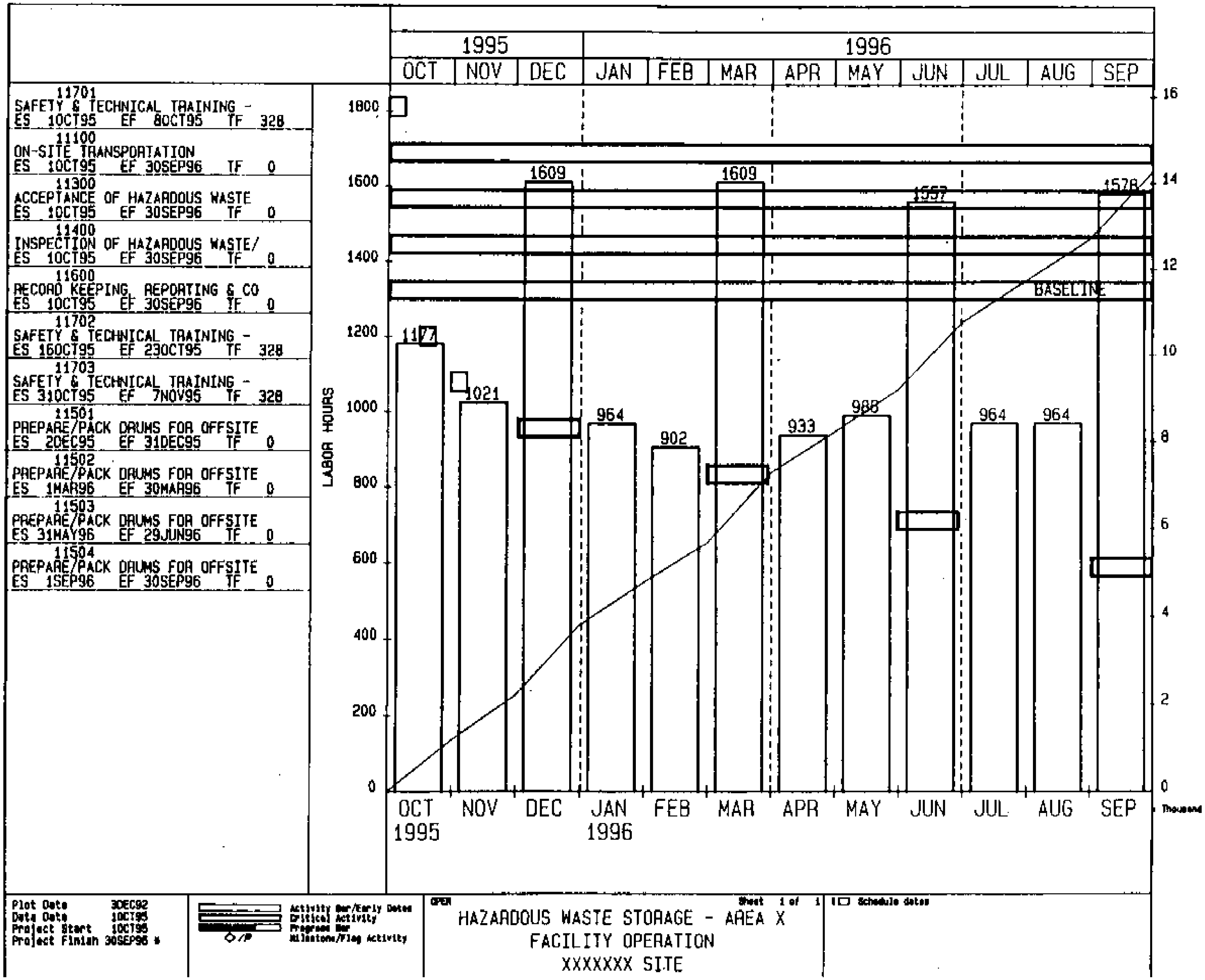

Table C-2. Resource-Loaded Schedule.