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The EMCBC Office of Cost Estimating is the content manager for this Guide. Any suggested changes should be submitted to: kevin.barry@emcbc.doe.gov

FORWARD

The purpose for this *Cost Estimating Handbook* (Handbook) is to provide uniform guidance and best practices for use when developing cost estimates for all work planned and executed within the Office of Environmental Management (EM). This Handbook describes the recommended best cost estimating methods and procedures for all programs and projects at EM when preparing cost estimates. The best practices presented in this Handbook can be used to develop high quality cost estimates to support all phases of EM's capital asset acquisition and life-cycle management activities, operating activities, and other costs estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of a system over its anticipated useful life span. This includes costs from pre-operations through operations to the end of the project/program life-cycle.

This Handbook does not impose new requirements or constitute EM Policy, nor is it intended to instruct estimators how to prepare cost estimates, and strict conformance is not required. However, information contained in this Handbook is based on guidance from the General Accounting Office (GAO) regarding development of high quality estimates and incorporates guidance and directives from the Department of Energy (DOE) and EM, as well as best practices from the Association for the Advancement of Cost Engineering (AACE) International and those implemented under the EM Cost Quality Program. The intent of this Handbook is to provide a consistent approach, specifically tied to work completed under EM's mission that supports the development of high quality cost estimates that provide an essential element for successful acquisition and project/program management within EM.

The main objective of the Handbook is to provide guidance for estimators, Federal Project Directors (FPDs), procurement officials, or other EM officials needing cost estimates. According to the GAO, "*The ability to generate reliable cost estimates is a critical function, necessary to support the Office of Management and Budget's (OMB) capital programming process. Without this ability, agencies are at risk of experiencing cost overruns, missed deadlines, and performance shortfalls...Furthermore, cost increases often mean that the government cannot fund as many programs as intended or deliver them when promised."*

As resources become scarce, competition for them will increase. It is imperative, therefore, acquisition programs deliver as promised, not only because of their value to their users but because every dollar spent on one program will mean one less available dollar to fund other efforts. The cost estimating principles and processes provided herein may be used to meet or adhere to Federal and EM requirements while utilizing industry standards and best practices.

This Handbook includes two parts. PART I includes descriptions of the type and purpose and use of EM cost estimates. PART II presents best practices as they relate to how to achieve the Characteristics of High Quality Estimates addressed in the GAO Cost Estimating and Assessment Guide published in 2009. PART II also includes details of specific practices used in the Environmental Management Consolidated Business Center (EMCBC) Office of Cost Estimating (OCE) to develop high quality estimates.

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COMMON ACRONYMS

AE	Acquisition Executive
A/E	Architect/Engineer
AACE	Association for the Advancement of Cost Engineering
ABC	Activity-based costing
ANSI	American National Standards Institute
APM	Office of Acquisition and Project Management
AS	Acquisition strategy
ASTM	American Society for Testing Materials
BOE	Basis of Estimate
CAP	Capital Asset Project
CD	Critical Decision
CDR	Conceptual Design Report
CER	Cost Estimating Relationship
CFO	Chief Financial Officer
CFR	Code of Federal Regulations
CM	Construction Management
CO	Contracting Officer
COA	Code of Accounts
CPB	Contract Performance Baseline
CPM	Contractor Project Manager
CPM	Critical Path Method
CSI	Construction Specifications Institute
DOD	Department of Defense
DOE	Department of Energy
EAC	Estimate at Completion
ECAS	Environmental Cost Analysis System
EIR	External Independent Review
EM	Environmental Management
EMAAB	EM Acquisition Advisory Board
EMCBC	Environmental Management Consolidated Business Center
ESAAB	Energy System Acquisition Advisory Board
ES&H	Environment, Safety, and Health
ETC	Estimate to Complete
EVMS	Earned Value Management System
FAR	Federal Acquisition Regulation
FPD	Federal Project Director
FTE	Full-Time Equivalents
GAO	Government Accountability Office
GFE	Government-Furnished Equipment

HCA	Head of Contracting Activity
ICE	Independent Cost Estimate
ICR	Independent Cost Review
IGCE	Independent Government Cost Estimate
IPR	Independent Project Review
IPT	Integrated Project Team
IT	Information Technology
KD	Key Decision
LEED	Leadership in Energy and Environmental Design
LCB	Life-cycle Cost Baseline
LCC	Life-cycle Cost
LCCE	Life-cycle Cost Estimate
LM	Legacy Management
LOE	Level of Effort
NPV	Net Present Value
NTB	Near Term Baseline
NNSA	National Nuclear Security Administration
OMB	Office of Management and Budget
OPC	Other Project Costs
PARS	Project Assessment and Reporting System
PB	Performance Baseline
PBC	Performance Based Contracts
PA	Program Authority
PBS	Project Baseline Summary
PDS	Project Data Sheet
PED	Project Engineering Design
PM	Project Management, Program Management or Contractor Project Manager
PMB	Performance Measurement Baseline
PME	Project Management Executive
PPBES	Planning, Programming, Budgeting and Execution System
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
SEB	Source Evaluation Board
SME	Subject Matter Expert
TEC	Total Estimated Cost
TPC	Total Project Cost
VE	Value Engineering
WBS	Work Breakdown Structure

1.0 PART I: COST ESTIMATE REQUIREMENTS, GUIDANCE, AND TYPES

1.1 INTRODUCTION

This Handbook was developed to assist cost estimators in the development of EM cost estimates and is presented in two parts. PART I includes descriptions of the type and purpose and addresses how estimates are used in EM. PART II presents best practices as they relate to how to achieve the Characteristics of High Quality Estimates addressed in the GAO Cost Estimating and Assessment Guide published in 2009. PART II also details specific practices used in the EMCBC Office of Cost Estimating to develop high quality estimates.

The Department of Energy (DOE) Office of Environmental Management (EM) is responsible for completing the safe cleanup of the environmental legacy brought about from five decades of nuclear weapons development and government-sponsored nuclear energy research. Integral to that responsibility is the need to safely disposition large volumes of nuclear waste, safeguard materials that could be used in nuclear weapons, deactivate and decommission several thousand contaminated facilitates no longer needed to support the Department of Energy's (DOE's or Department's) mission, and remediate extensive surface and groundwater contamination. In executing that mission, EM conducts its operations in a safe, secure, and compliant manner, and in accordance with cost and schedule commitments. The legacy cleanup mission is expected to continue through at least the year 2050.

It is important to recognize that once EM completion is achieved, the budget responsibility for subsequent long term remedial action (LTRA, sometimes referred to as Long Term Stewardship [LTS]) is transferred to the DOE Office of Legacy Management (LM) (for non-mission/closure sites) or to the appropriate DOE Landlord Program (for ongoing mission sites). Once this programmatic transfer occurs, EM is no longer responsible for those continuing life-cycle costs, and the recipient organization (e.g., LM, Office of Science, and National Nuclear Security Administration) assumes responsibility for management of those continuing costs. Since other organizations will be responsible for the LTRA, the EM's completion mission can be represented as Life-Cycle Baselines (LCBs).

1.2 LIFE-CYCLE COST (LCC)

Life-cycle costs (LCCs) are the sum total of the direct, indirect, recurring, nonrecurring, and other costs incurred or estimated to be incurred in the design, development, production, operation, maintenance, support, and final disposition of a system over its anticipated useful life span. This includes costs from pre-operations through operations to the end of the project/program life-cycle, or to the end of the alternative. Collecting, maintaining, and reporting accurate LCC data is necessary to comply with numerous laws and regulations, including the Government Management Reform Act of 1994, Federal Financial Management Improvement Act of 1996, Office of Management and Budget (OMB) Circular A 11, and DOE orders including DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets, and DOE Order 430.1C, Real Property and Asset Management. Effective LCC data is also crucial for EM's own portfolio management activities. This data is used to determine future year budget needs, manage changes in project scope and technical approach, and prioritize work activities. Lastly, a robust LCC is necessary for making a business case for programmatic budget decisions. This can be seen in OMB Circular A-94, "Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs," which provides guidance to the methods to determine cost-benefits and cost-effectiveness analyses, especially for Federal programs whose benefits and costs are distributed over time.

EM's methodology for estimating LCC has evolved significantly over time. The first comprehensive estimates of EM's projected scope, cost, and schedule were developed in the mid-1990s. These LCC estimates were based largely on program-wide estimates compiled at EM Headquarters using cost estimation models based on site-specific assumptions about future land use, treatment, storage, and disposal facility needs, regulatory requirements, and the technologies to be used at the site. By 1998, EM sites were instructed to group all their cleanup work scope into projects and to develop estimates of the LCC, schedule, and scope required to complete each project. These estimates were then grouped into Program Baseline Summaries (PBSs) so similar projects follow a standard nomenclature for project reporting purposes.

These baselines, along with other key information, were captured via Performance Management Plans (PMPs) in 2002. In 2008, project baselines were realigned across the EM Complex to reflect significant changes in assumptions related to cleanup. It should be noted that PBSs are used to categorize the various portions of the EM mission in broad budgetary terms and are very useful during budget discussions with Congress.

The EM Corporate Work Breakdown Structure (WBS) incorporates the PBS into a capital asset project identifier WBS to tie it back to the appropriate funding stream. However, each PBS is not typically only a capital asset project. Each PBS includes all planned expenditures including all DOE O 413.3B capital asset projects, and all programmatic and operating activities. PBS descriptions are included in Appendix A and include:

- PBS-0011, Nuclear Materials Stabilization and Disposition
- PBS-0012, Spent Nuclear Fuels (SNF) Stabilization and Disposition
- PBS-0013, Solid Waste Disposition
- PBS-0014, Liquid Waste Disposition
- PBS-0020, Safeguards and Security
- PBS-0030, Soil and Water Remediation
- PBS-0040, Nuclear Facility D&D

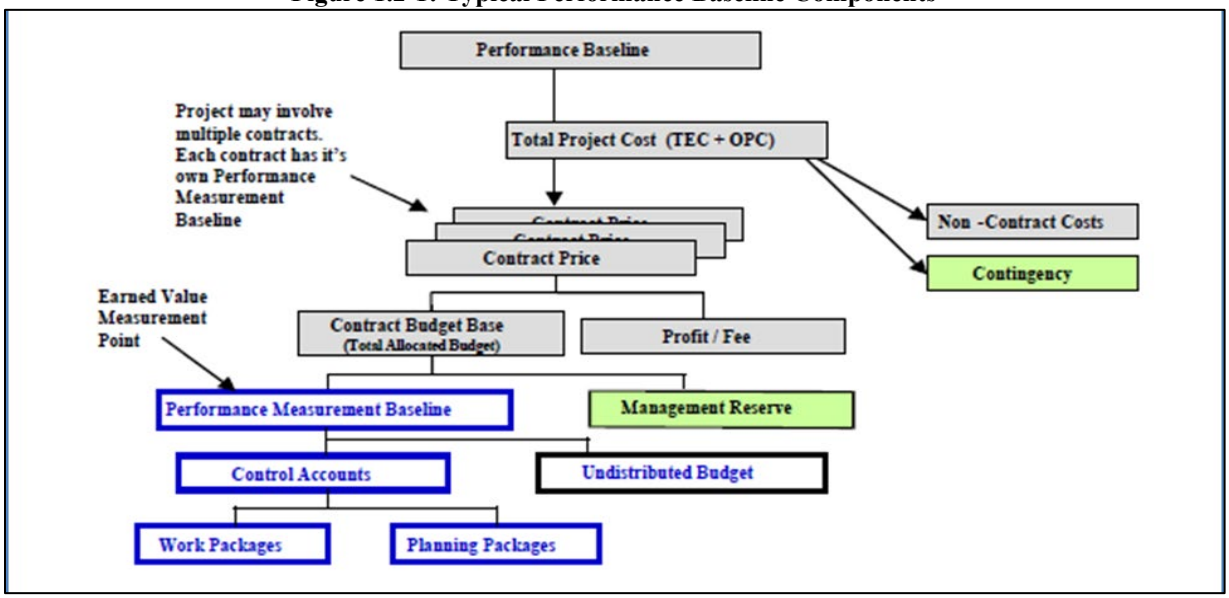
The life-cycle work scope for the EM program is communicated through data provided from the Operations/Field Office consistent with baseline planning estimates. The baseline elements form a complete summary picture for the EM program from 1997 through to program completion. In general, it is assumed estimates in the near term are more definitive than the longer-range baseline planning estimates for the out-years. EM's life-cycle planning data are used for:

- Environmental Liability Statement
- EM life-cycle cost and schedule reporting
- Programmatic analysis of cost and schedule
- Life-cycle context in the budget
- Analyzing complex-wide integration opportunities
- Communicating EM progress, status, and plans

All business processes related to the management of EM's LCC data depend on the quality of EM cost estimates.

Good EM program, project, and contract management practices rely on sound cost estimates to ensure adequate planning is accomplished to support successful planning and execution of every EM cleanup project. Figure 1.2-1 illustrates the various elements of a standard cleanup project that contributes to the life-cycle cost of any typical EM cleanup program, and how that project or program work is integrated with the contracts EM issues to plan and execute its work.

Figure 1.2-1: Typical Performance Baseline Components



1.2.1 EM Life-Cycle Cost Estimates

Life-cycle cost (LCC) estimates are critical components of the EM life-cycle baselines. These estimates are formulated for every PBS at every site. These PBSs are organized around specific types of work scope, such as treatment and disposal of waste, remediation of contaminated media, disposition of radioactive and hazardous waste and materials, providing federal oversight to the cleanup program, and performance of long-term remedial action (LTRA) once an environmental remedy is in place. Because the scope is complex and the schedules are long term, EM has developed multi-decade LCC estimates for the entire program. These estimates help illustrate the size and scope of the cleanup mission and are used to predict EM's total liability for environmental cleanup.

As part of EM's mission, work at each site has an established LCB tailored to the liabilities and desired end state specific to each site. These usually cover decades of cleanup work and are primarily used to support planning and programming functions. Although these baselines are established, estimates are needed to maintain these baselines so they accommodate significant changes affecting the planned work and completed work. An example of such a change was the infusion of American Recovery and Reinvestment Act (ARRA) Funding in 2009. Completion of the ARRA funded projects allowed EM to complete dozens of projects ahead of schedule, sometimes by several years.

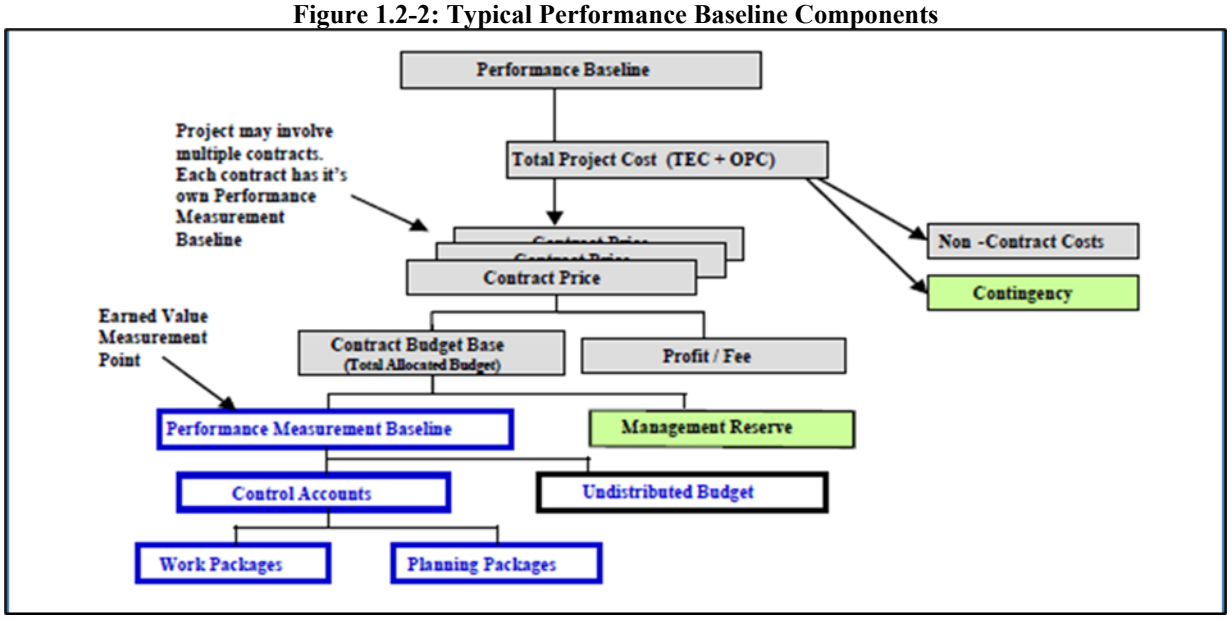
Life-cycle costs are an important consideration for all DOE projects and programs. Reliable life-cycle cost estimates (LCCE) and life-cycle cost analyses (LCCA) are critical functions for supporting DOE management decision-making, program planning, and alternative selection

processes. The estimates are important for communicating expectations and requirements to OMB, Congress, the GAO, and other external stakeholders.

Within each LCB, each site may include operating activities and a number of Capital Asset Projects (CAPs) as defined under DOE O 413.3B. Refer to section 1.2.5 for more detailed information concerning CAPs.

The performance baseline is a quantitative expression reflecting the total scope of a project with integrated technical, schedule, and cost elements; the established risk-adjusted, time-phased plan against which the status of resources and the progress of a project are measured, assessed, and controlled; a Federal commitment to OMB and Congress. Once established, performance baselines are subject to change control. Components of the performance baseline are shown in Figure 1.2-2.

Figure 1.2-2: Typical Performance Baseline Components



1.2.2 EM Life-Cycle Cost Estimate Maintenance and Updates

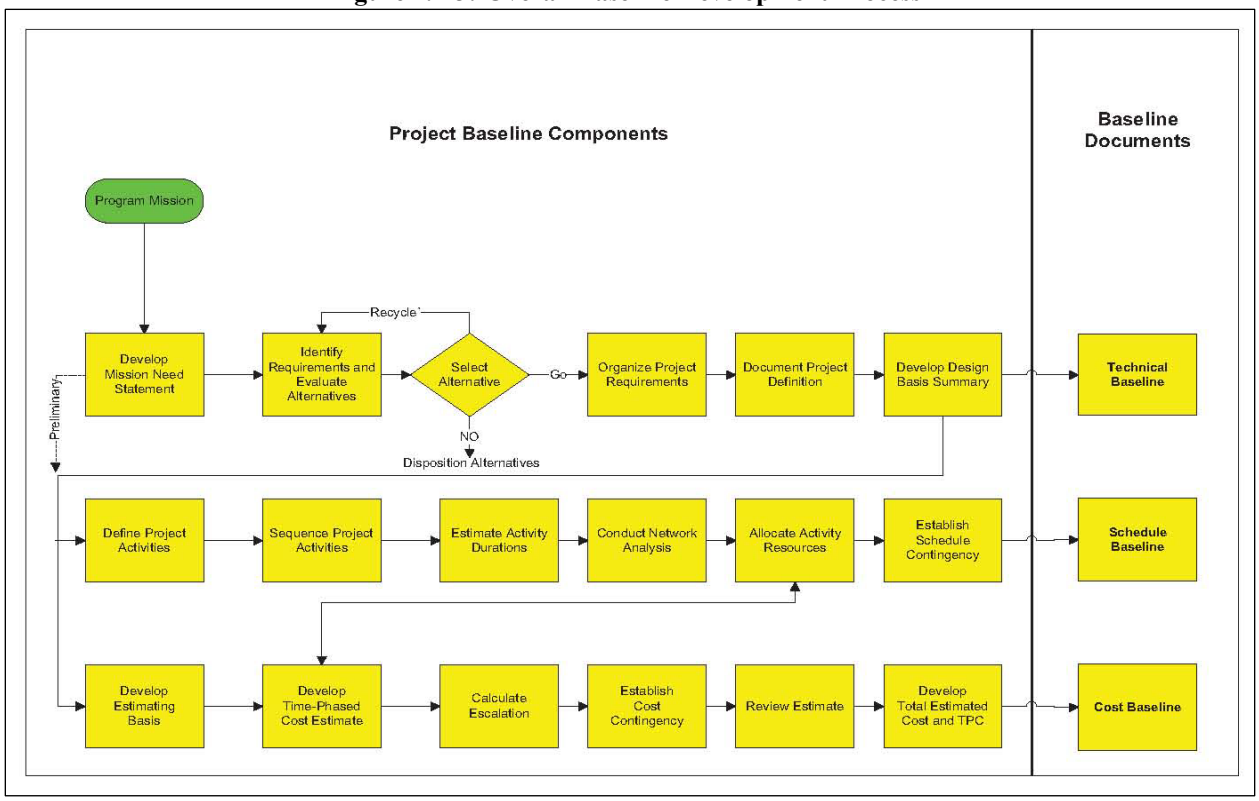
Because scope is complex and schedules are long term, EM developed multi-decade LCC estimates for the entire program. These estimates help illustrate the size and scope of the cleanup mission and are used to predict EM's total liability for environmental cleanup.

Much of EM's work is Operating Activities performed in a facility built in accordance with DOE O 413.3B practices, undergone extensive testing and start-up processes, and will likely operate to process and treat hazardous or radioactive materials, prior to the final disposition of the waste form or asset. The facility is then subject to deactivation, decommissioning, and demolition prior to any remediation of contaminated soil or groundwater which would also be necessary to achieve site cleanup objectives. Throughout the life-cycle of an EM asset such as this, the life-cycle cost estimate is updated as needed to support program, project, and contract management needs. For guidance on preparing life-cycle cost analyses, refer to the EM Guide to Computing and Reporting the Life-Cycle Cost of Environmental Management Projects (NISTIR-6968).

1.2.3 EM Capital Asset Projects

EM projects include construction and cleanup projects. These projects include capital assets and their disposition. DOE O 413.3B, "Program and Project Management for the Acquisition of Capital Assets" provides requirements for project estimates. This DOE Directive establishes cost estimating requirements to support the Department's acquisition of capital assets. EM Capital Asset Projects include both cleanup and construction projects which are planned and executed in accordance with DOE O 413.3B, therefore any EM cost estimates prepared to support cleanup and construction projects must comply with DOE O 413.3B (Appendix A) established cost estimating requirements.

Figure 1.2-3: Overall Baseline Development Process



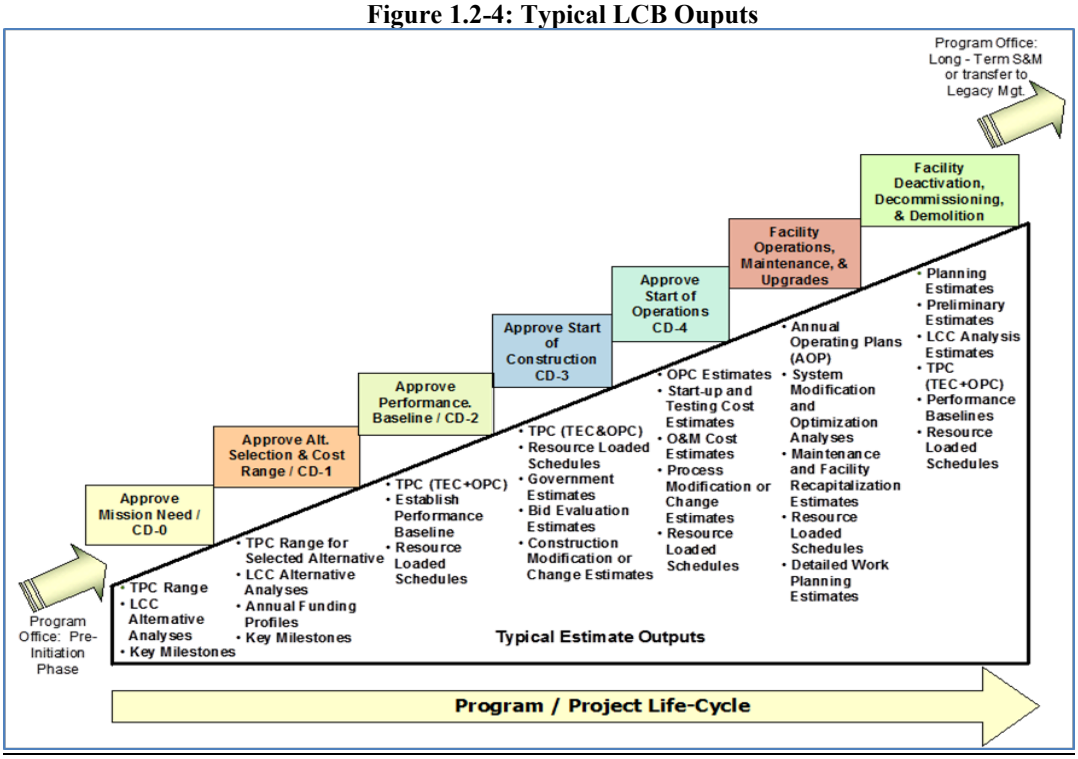
DOE O 413.3B requires a cost estimate with appropriate range shall be provided at each Critical Decision (CD) gateway, but the degree of rigor and detail for a cost estimate should be carefully defined, depending on the degree of confidence in project scale and scope reasonable to expect at each stage of project development. The following cost estimates are required at each CD gateway (see Figure 1.2-4 below):

- CD-0, Approve Mission Need, requires a rough-order of magnitude (ROM) cost estimate range be developed to determine the Acquisition Executive (AE) authority and does not represent the Performance Baseline (PB).
- CD-1, Approve Alternative Selection and Cost Range, requires a cost estimate range be provided for the cost-effective preferred solution that will meet the mission need. The recommended alternative should provide the essential functions and capabilities at an optimum life-cycle cost, consistent with required cost, scope, schedule, performance, and risk. Therefore, life-cycle cost analyses are required for the alternatives under consideration, to

ensure the preferred alternative provides the essential functions and capabilities at an optimum life-cycle cost.

- CD-2, Approve Performance Baseline, establishes the performance baseline for the project and provides reasonable assurance the design will be implementable within the approved performance baseline. The risk adjusted cost estimate (based on identified and assessed risks and uncertainties) approved at CD-2 is used to support the project's approved performance baseline, which includes the Total Project Cost (TPC), scheduled CD-4 (Approve Start of Operations or Project Completion) date, scope, and minimum Key Performance Parameters (KPPs) that must be achieved at CD-4.
- CD-3, Approve Start of Construction/Execution, is a continuation of the project execution phase. The risk adjusted cost estimate should be updated to reflect final design, project execution approaches, acquisition strategies, and planned start-up and testing requirements that have been more fully defined since the CD-2 TPC was established.
- CD-4, Approve Start of Operations or Project Completion, is the achievement of project completion criteria defined in the Project Execution Plan (PEP). The Estimate at Completion (EAC) should be updated and compiled for inclusion with the Project Closeout Report (PCR).

Figure 1.2-4: Typical LCB Ouputs



Throughout the project planning and execution phases it is important to ensure EM's cost engineers/estimators continually update the estimate with actual data as it becomes available, revising the estimate to reflect any changes, and analyzing differences between estimated and actual costs to continuously improve EM's ability to accurately estimate future program costs. The final approved EAC should be submitted to EM's Environmental Cost Analysis System (ECAS). Figure 1.2-4 illustrates the estimating outputs as they relate to a program/project life-cycle.

1.3 DOE AND EM ESTIMATING REQUIREMENTS, GUIDANCE, AND USES

For the purposes of this Handbook, a cost estimate is the summation of individual cost elements, using established methods and valid data, to estimate the future costs of a program or project, based on what is known today. The management of a cost estimate involves continually updating the estimate with actual cost data as it becomes available, revising the estimate to reflect changes in technical scope or approach, and analyzing differences between estimated and actual costs to continuously improve EM's ability to accurately estimate future program costs.

EM's cost estimation requirements and recommended best practices are established by various DOE Directives, EM Head of Contracting Activity (HCA) Directives, DOE Guides, and Other Federal and Industry cost estimating best practices.

The key requirements that establish the requirements for credible cost estimates and a reliable process for creating them within EM include:

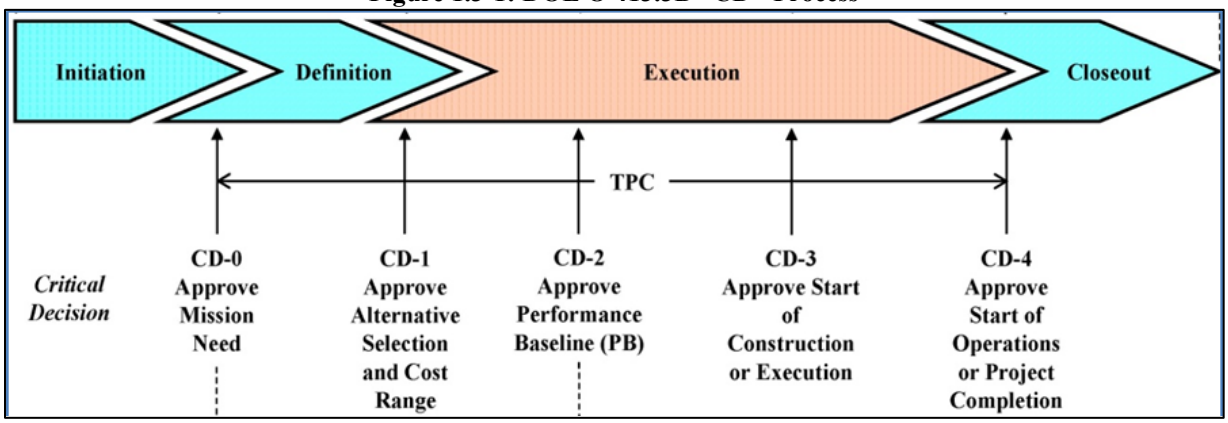
- DOE Order 413.3B – Program and Project Management for the Acquisition of Capital Assets
- DOE Order 430.1C – Real Property and Asset Management
- Federal Acquisition Regulations (FAR).
- DOE G 413.3-21A – DOE Cost Estimating Guide.
- Head of Contracting Activity Directive 2.0, Independent Government Cost Estimates
- GAO Cost Estimating and Assessment Guide, GAO-09-3SP.
- DOE Life-Cycle Cost Handbook
- DOE Office of Project Management Oversight and Assessments, Cost Estimating Handbook, PM-HBK-08-2017.

1.3.1 DOE Order 413.3B and DOE G 413.3-21A

DOE Order 413.3B establishes cost estimating requirements to support the Department's acquisition of capital assets. EM Capital Asset Projects include both cleanup and construction projects which are planned and executed in accordance with DOE O 413.3B, therefore any EM cost estimates prepared to support cleanup and construction projects must comply with DOE O 413.3B established cost estimating requirements.

DOE O 413.3B requires a cost estimate, or cost range, shall be provided at each CD gateway, but the degree of rigor and detail for a cost estimate should be carefully defined, depending on the degree of confidence in project scale and scope that is reasonable to expect at that stage of project development. The following figure (Figure 1.3-1) illustrates how the CD process progresses for projects.

Figure 1.3-1: DOE O 413.3B "CD" Process



Throughout the project planning and execution phases it is important to ensure EM's cost engineers/estimators continually update the estimate with actual data as it becomes available, revising the estimate to reflect any changes, and analyzing differences between estimated and actual costs to continuously improve EM's ability to accurately estimate future program costs. The final approved EAC should be submitted to EM's ECAS.

DOE G 413.3-21, "DOE Cost Estimating Guide" was developed to support development of cost estimates associated with DOE O 413.3B requirements. This DOE guide provides uniform guidance and best practices that describe the methods and procedures that could be used in all programs and projects at DOE for preparing cost estimates. This guidance is applicable to all phases of the Department's acquisition of capital asset management activities. Practices relative to estimating life-cycle cost are described. Life-cycle costs include all the anticipated costs associated with a project or program alternative throughout its life, i.e., from authorization through operations to the end of the facility/system life-cycle. It provides guidelines for various methods of estimation (including both detailed and parametric approaches), describes the phases of cost estimate development, and highlights the requirements for various types of cost estimates.

1.3.2 DOE Order 430.1C– Real Property Asset Management

This DOE order requires sound cost estimating practices be used to support the management of DOE real property (facilities and infrastructure). It requires the "results of real property asset site planning and performance must be documented in a 10-Year Site Plan kept current and covers a 10-year planning horizon." The plan includes all planned facility and infrastructure repair, maintenance, and replacement costs. It also requires life-cycle cost analysis be used when evaluating alternatives, and mandates cost estimates for deferred maintenance on real property be prepared using "nationally recognized cost estimating systems or the DOE Condition Assessment Information System."

It is important to note for non-mission/closure sites, LM agreed the Site Transition Plan (STP) meets the DOE O 430.1C requirement for a disposition plan and includes surveillance and maintenance and long-term stewardship (LTS) resource requirements to meet the DOE O 430.1C requirement for a 10-Year Site Plan.

1.3.3 EM Cost Estimates for Procurement Actions

EM HCA Directive 2.0 establishes the EM's Corporate Cost Estimating Policy for contracts. HCA Directive 2.0 states it is EM Policy that an Independent Government Cost Estimate (IGCE) shall be prepared and furnished to the Contracting Officer (CO) at the earliest practicable time for each proposed contract action anticipated to exceed ten million dollars as an aid in proposal analysis unless otherwise requested by the HCA. In addition, the directive establishes the estimate shall be prepared in as much detail as though the Government were competing for the award. The CO may also request an IGCE at their discretion to aid in proposal evaluation for procurement actions with an anticipated value below five million dollars. The estimate shall be prepared in sufficient detail to allow comparisons to and/or reconciliation with Offeror/Contractor's submitted proposals.

It is the policy of EM that the IGCE will be used as the Government's own estimated cost/price of the proposed acquisition. Its purposes are to: (1) serve as the basis for reserving funds for the contract as part of acquisition planning; (2) serve as a basis for comparing costs or prices proposed by offerors; (3) assist in determining cost/price realism and/or reasonableness; (4) assist in determining whether the offeror/contractor understands the scope and contract requirements; and (5) assist in establishing the Government's initial negotiation position.

An IGCE is an estimate prepared for evaluating and validating contractor proposals presented during the Acquisition or Contract Management phase and represents a specific scope of work that will be accomplished over a specific timeframe. The IGCE is based on the scope of work outlined in the solicitation and established contract requirements. The IGCE shall be a high quality estimate that is credible, well-documented, accurate and comprehensive.

For all EM Priced Contract Actions, the IGCE should be prepared using the process identified in the GAO, Cost Estimating and Assessment Guide (http://www.gao.gov/products/GAO-09-3SP). The GAO Guide establishes a consistent methodology based on best practices and can be used across the federal government for developing, managing, and evaluating capital program cost estimates. The methodology outlined in this guide is a compilation of best practices federal cost estimating organizations and industry use to develop and maintain reliable cost estimates throughout the life of a government acquisition program. A key component of the guide is the identification and description of the twelve steps of a high quality cost estimating process.

1.3.4 EM Cost Estimate Uses

Estimates are provided for many different purposes, such as budgets, projects, and contracts. Budget estimates are used for preliminary planning and budget formulation. Project estimates and/or proposals can be for support of new baseline, a Baseline Change Proposal (BCP), a pre-Independent Project Review (IPR), or a pre-External Independent Review (EIR). With contracts, estimates can be for pre-award and post-award actions or modifications. An EM Cost estimate is also used to help the CO in determining cost/price fairness and reasonableness. They can support FAR based and/or maintenance and operations (M&O) type contracts.

An EM Cost Estimate has two general purposes:

- Help Managers and Contracting Officers evaluate affordability and performance against established or approved plans, as well as the selection of alternative systems and solutions

- Support the budget process by providing estimates of the funding required to efficiently execute a program

The purpose of a cost estimate is determined by its intended use (e.g., studies, budgeting, proposals, etc.), and its intended use determines its scope and detail. Cost estimates should have general purposes such as:

- Help the DOE and its managers evaluate and select alternative solutions
- Support the budget process by providing estimates of the annual funding and phased budget requirements required to efficiently execute work for a project or program
- Establish cost and schedule ranges during the project development phases
- Establish a Project Performance Baseline to obtain CD-2 approval and to measure progress following the CD-2 approval
- Support Acquisition Executive approval for acquisition of supplies, services, and contracts
- Provide data for value engineering studies, independent reviews, and evaluate the reasonableness of contractor-submitted baseline change requests

1.4 COST ESTIMATOR RESPONSIBILITIES

Regardless of the purpose, intended use, or the type of cost estimate, it is the cost estimator's responsibility to ensure the estimate is credible, well documented, accurate, and comprehensive. In the context of a high quality estimate, this means:

- Credible – Estimates are considered credible if they clearly identify limitations because of uncertainty or bias surrounding the data or assumptions. Major assumptions should be varied and other outcomes recomputed to determine how sensitive outcomes are to changes in the assumptions.
- Well-documented – Cost estimates need to be well documented, traceable to original sources, and easily repeatable or updated. Rigorous documentation also increases an estimate's credibility and helps support an organization's decision making.
- Accurate – Estimates should be based on an assessment of most likely costs, adjusted properly for inflation, and contain few, if any, minor mistakes.
- Comprehensive – Cost Estimators should make sure the cost estimate is complete and accounts for all costs likely to occur. They should confirm its completeness, its consistency, and the realism of its information to ensure all pertinent costs are included.

It is EM's practice that Cost Estimators are assigned to Acquisition Integrated Project Teams (AIPTs) and Source Evaluation Boards (SEBs) during the acquisition process. In accordance with HCA Directive 2.0, when an AIPT or SEB is established for the priced contract action, a cost engineer/estimator who is responsible for leading the development of the IGCE shall be included on the AIPT. The Acquisition Planning Manager (APM), CO, and AIPT shall provide all necessary acquisition documentation (i.e., statement of work (SOW) or performance work statement (PWS) that describes scope, contract terms and conditions, contract clauses, etc.) that will be used as the basis for the contractor's proposal to the cost engineer/estimator to be used as the basis for the IGCE. Input from the program or project-specific technical and business disciplines is also essential to ensure a high quality estimate.

Cost Estimators are generally responsible for:

- Developing the cost estimate in accordance with established DOE policies, guides, recommended practices, and directives.
- Developing the Basis of Estimate (BOE) that describes how the cost estimate was developed, and defines the information used in support of establishing the estimated costs. The BOE may be used to support cost realism and/or pricing analysis.
- Understanding the scope and the requirements that serve as the basis for the cost estimate, this should include a sufficiency review to ensure sufficient scope definition is made, details are available to develop the estimate.
- Serving as the subject matter expert for the cost estimate, including assisting Managers, FPDs, COs, etc., with understanding the basis and contents of the estimate. In addition, assist with interpretation and applying estimates for use in cost/price realism and cost/price analysis; and application of the estimate for planning and budgeting purposes.
- Maintaining and disposing of the estimate in accordance with established DOE Records Management requirements (DOE 0 243.1 C).

2.0 PART II: EM COST ESTIMATING PRACTICE

2.1 INTRODUCTION

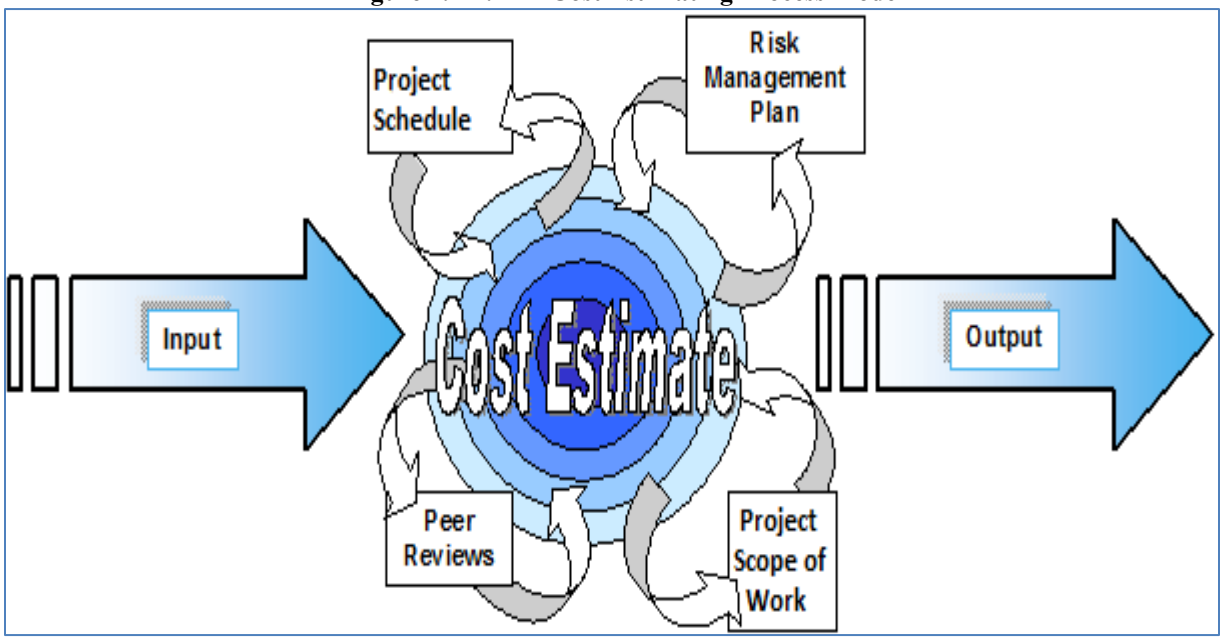
PART II of this Handbook includes detailed recommended practices for EM cost estimators to use to develop high quality estimates using the GAO recommended "twelve steps" and to address DOE and EM guidance and directives.

The project scope description should identify the scope of the current cost estimate. List which of the standard WBS Elements are covered by the estimate. Identify whether the estimate covers prime contractor costs, other contractor costs, activity costs, and the costs for other EM Organizations. If the Statement of Work (SOW) was provided, include the document, or at least relevant excerpts from the document in the appropriate Appendix for future reference.

2.2 EM COST ESTIMATING PROCESS MODEL

The EM Cost Estimating Process Model (Figure 2.2-1) provides a diagram tracing the information flow and workflow in the cost estimate development. The process is a representation of a system for EM cost estimating, including standardizing activities and documenting deliverables. The cost estimating process is a flow or transfer of information and work. Descriptions of the information and work elements in the cost estimate process model are provided briefly here, and in more detail throughout the remainder of this Handbook.

Figure 2.2-1: EM Cost Estimating Process Model



Input - The input to a cost estimate consists of the set of documentation necessary to develop the estimate. This documentation begins with the request for the estimate, which also provides its purpose. Additional input documentation defines the scope and provides information on the

specific requirements. Input documentation may include a performance work statement, project plans and specifications, a project schedule, supporting reports and studies, and historical data. Some cost estimates require a site visit by members of the estimating team as part of collecting input documentation.

Developing the estimate – This iterative process involves several elements.

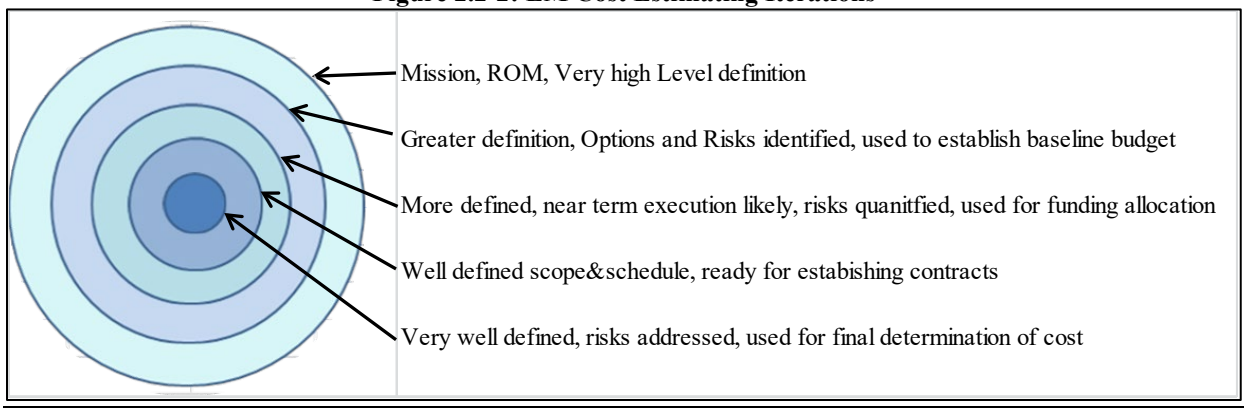
- Scope - To fully develop and document the estimating scope and requirements, beyond information provided in the input documentation, the estimating team may have to engage one or more subject matter experts (SMEs), research historical costs for similar work, or even develop suitable technical approaches for the work. These tasks are performed in conjunction with subject matter experts and those familiar with the requirement. At times the estimating team must identify or make assumptions concerning the scope of work, and SME input is needed in making these assumptions as well.
- Schedule - The schedule provides the planned time for completing the work scope, along with key milestones. Estimates associated with extended time frames must account for possible escalation of costs, and incorporate risks associated with uncertain future conditions.
- Peer Review -. Once the estimate package is assembled, an independent peer review from other cost estimators or SMEs is performed, to help to ensure a high quality estimate. The estimating team then incorporates comments from the peer review back into the estimate, to improve it. In developing the cost estimate, the cost estimating team utilizes appropriate qualitative and quantitative techniques to analyze input information, estimate cost, and produce documentation supporting the estimate.
- Risk - Estimate uncertainty is analyzed and items from the risk management plan are also considered when evaluating the estimate. When available to the estimating team, the program or project risk management plan provides insight into the risks associated with the work scope. The estimating team, interacting with SMEs, must determine how these risks may affect the estimate.

Output - The initial input is typically revised to reflect cost related impacts associated with evolving scope, schedule, peer reviews, and risk analysis before achieving the desired output. The output from the cost estimating process consists of a complete cost estimate documentation package, which includes the basis of the estimate, the numerical cost estimate itself, and other information and work products created and used in developing the estimate.

As noted in PART I, EM cost estimates can be developed at various stages within a project life-cycle. The "developing the estimate" portion of the process shown reflects the iterative nature of

cost estimates as the target in the center of Figure 2.2-2. Regardless of the life-cycle stage, the cost estimating process is the same.

Figure 2.2-2: EM Cost Estimating Iterations



The cost estimating process is typically an iterative process based on the life-cycle stage of the requirement and the estimate. Over the life of the project, program or contract, cost estimates become increasingly more definitive, and reflect the scope and schedule of work packages and planning packages as they are developed. Essentially, as a project, program, or contract matures and proceeds toward execution of the scope, the estimate should become more complex by providing greater detail, increasing levels of bottom-up estimating, and less uncertainty in the estimate. This is directly correlated to the increasing detail and more definitized scope as the life-cycle progresses. The greater the detail provided in defining the scope, the higher the class of the estimate. Often estimates are developed to support management decisions that must be made. Management direction could include reworking the scope to reduce requirements which would prompt another iteration of the scope and estimate. These critical points for projects and programs are discussed in PART I.

EM accomplishes its mission with the aid of a number of contractors. In accordance with HCA Directive 2.0, IGCE's are required to support procurement actions for contracts needed to execute work. This requirement is for new awards, and it also applies to post award contract actions to modify the contract. Modifications may be needed to address requests for equitable adjustment, Requests for Proposal (RFPs) to revise scope, or other changed conditions. This can also prompt several iterations in reviewing and revising the estimate to ensure scope, contract, and estimate are aligned.

2.3 DEVELOPING HIGH QUALITY ESTIMATES

It is EM policy that its cost estimates be developed as high quality estimates. In recent years, EM elected to follow the guidance in the GAO's Cost Estimating and Assessment Guide (GAO-09-3SP) to develop high quality estimates. From the GAO Cost Estimating and Assessment Guide, there are twelve key steps essential to producing high quality cost estimates. The steps are discussed in detail in this section and are shown in the following Table 2.3-1.

Table 2.3-1: GAO Twelve Steps for a High Quality EstimateTable

GAO Cost Estimating & Assessment Guide(GAO-09-3SP): 12-Steps to High Quality Estimate	
1	Define the estimate's purpose
2	Develop an estimating plan
3	Define the Project (or Program) characteristics
4	Determine the estimating structure (WBS)
5	Identify ground rules and assumptions
6	Obtain data
7	Develop a point estimate and compare to an independent cost estimate
8	Conduct sensitivity analysis
9	Conduct risk and uncertainty analysis
10	Document the estimate
11	Present the estimate for management approval
12	Update the estimate to reflect actual costs and changes

2.3.1 Step 1: Define the Estimate's Purpose

The purpose of a cost estimate is determined by its intended use, and its intended use determines its scope and detail. Cost estimates have two general purposes:

- Help managers evaluate affordability and performance against plans, as well as the selection of alternative systems and solutions, and
- Support the budget process by providing estimates of the funds required to efficiently execute a program.

More specific applications include providing data for trade studies, independent reviews, and baseline changes. Regardless of why the cost estimate is being developed, it is important the program's purpose links to the agency's missions, goals, and strategic objectives. The purpose of the program should also address the benefits it will deliver, along with the appropriate performance measures for benchmarking progress.

If an estimate is needed to support a procurement action, EM defers to Head of Contracting Activity (HCA) Directive 2.0 (HCA 2.0.). Under HCA 2.0 the purpose of the estimate is to:

- Serve as the basis for reserving funds for the contract as part of acquisition planning
- Serve as a basis for comparing costs or prices proposed by offerors
- Assist in determining cost/price realism and/or reasonableness
- Assist in determining whether the offeror/contractor understands the scope and contract requirements
- Assist in establishing the Government's initial negotiation position

Access to information concerning the Government estimate shall be limited to Government personnel whose official duties require knowledge of the estimate. An exception to this rule may be made during contract negotiations to allow the contracting officer to identify a specialized task and disclose the associated cost breakdown figures in the Government estimate, but only to the extent deemed necessary to arrive at a fair and reasonable price. The overall amount of the Government's estimate shall not be disclosed except as permitted by agency regulations.

2.3.2 Step 2: Develop an Estimating Plan

Estimators should develop and tailor an estimate plan whose scope coincides with data availability and the estimate's ultimate use.

- Determine the cost estimating team and develop its master schedule
- Determine who will do the independent cost estimate
- Identify information and SME input needed to support development of the estimate
- Outline the cost estimating approach
- Develop the estimate timeline

Regardless of an estimate's ultimate use and its data availability, time can become an overriding constraint on its detail. When defining the elements to be estimated and when developing the plan, the cost estimating team must consider its time constraints relative to team staffing. Without adequate time to develop a competent estimate, the team may be unable to deliver a product of sufficiently high quality. The more detail required, the more time and staff the estimate will require.

After the customer defines the task, the cost estimating team should create a detailed schedule that includes realistic key decision points or milestones and provides margins for unforeseen, but not unexpected, delays. The essential point is the team must attempt to ensure the schedule is reasonable. If this is not possible, the schedule must be highlighted as having curtailed the team's depth of analysis and the estimate's resulting confidence level.

The estimating team should be composed of people who have experience in estimating all cost elements of the program. Since this is seldom possible, the team leader should be familiar with the team members' capabilities and assign tasks accordingly. If some are experienced in several areas, while others are relatively inexperienced in all areas, the team leader should assign the experienced estimators' responsibility for major sections of the estimate while the less experienced estimators work under their supervision. The following table (Table 2.3-2) shows how a typical estimating team could be set up.

Table 2.3-2: Typical Cost Estimaitng Team

Name/Title	Organization	Phone No./e-mail	Role
Senior Cost Estimator/ Engineer	EMCBC	(513) XXX-XXXX TBDi@emcbc.doe.gov	Author and Lead Estimator
Cost Estimator/ Engineer	EMCBC	(513) XXX-XXXX TBDi@emcbc.doe.gov	Peer Review

Name/Title	Organization	Phone No./e-mail	Role
Lead Cost Engineer	EMCBC	(513) XXX-XXXX TBDi@emcbc.doe.gov	QA/QC Review & Approval
Contract Cost & Price Analyst	EMCBC	(513) XXX-XXXX TBDi@emcbc.doe.gov	Cost Pricing Analysis
Contracting Officer	EMCBC or Site	(XXX) XXX-XXXX TBDi@emcbc.doe.gov	Contracting Officer
Subject Matter Expert	EMCBC, HQ or Site	(XXX) XXX-XXXX TBDi@emcbc.doe.gov	Technical Support
Subject Matter Expert	EMCBC, HQ or Site	(XXX) XXX-XXXX TBDi@emcbc.doe.gov	Technical Support

2.3.3 Step 3: Define the Project (or Program) Characteristics

To determine an estimate's scope cost estimators must identify the customer's needs, that is if the estimate is required by law or policy or is requested. For example, FAR 36.203 dictates an independent Government estimate of construction costs shall be prepared and furnished to the contracting officer at the earliest practicable time for each proposed contract and for each contract modification anticipated to exceed the simplified acquisition threshold. The contracting officer may require an estimate when the cost of the required work is not anticipated to exceed the simplified acquisition threshold. The estimate shall be prepared in as much detail as though the Government were competing for the award.

The program manager and the cost estimating team should work together to determine the scope of the cost estimate, see Table 2.3-3. The scope will be determined by such issues as the time involved, what elements of work need to be estimated, and how much cost estimating detail will be included. Where the program is in its life-cycle will influence the quantity of detail for the cost estimate as well as the amount of data to be collected. For example, early in the life-cycle the project may have a concept with no solid definition of the work involved. A cost estimate at this point in the life-cycle will probably not require extensive detail. As the program becomes better defined, more detailed estimates should be prepared.

Table 2.3-3: GAO Key Point "Scope"

GAO Cost Estimating & Assessment Guide (GAO-09-3SP): KEY POINTS	
Clear identification of task	• An estimator must be provided with the system description, ground rules and assumptions, and technical and performance characteristics. • Estimate's constraints and conditions must be clearly identified to ensure the preparation of a well-documented estimate.
Broad participation in preparing estimates	• All stakeholders should be involved in deciding mission needs and requirements, and in defining system parameters and other characteristics. • Data should be independently verified for accuracy, completeness, and reliability.

2.3.4 Step 4: Determine the Estimating Structure (WBS)

A well-developed Work Breakdown Structure (WBS) is essential to the success of all acquisition programs. A comprehensive WBS provides a consistent and visible framework that improves

communication; helps in the planning and assignment of management and technical responsibilities; and facilitates tracking engineering efforts, resource allocations, cost estimates, expenditures, and cost and technical performance. A WBS is the cornerstone of every program because it defines in detail the work necessary to accomplish a program's objectives. Establishing a master WBS as soon as possible for the program's life-cycle that details the WBS for each phase provides many program benefits:

- Segregating work elements into their component parts
- Clarifying relationships between the parts, the end product, and the tasks to be completed
- Facilitating effective planning and assignment of management and technical responsibilities
- Helping track the status of technical efforts, risks, resource allocations, expenditures, and the cost and schedule of technical performance within the appropriate phases, since the work in phases frequently overlaps
- Helping ensure contractors are not unnecessarily constrained in meeting item requirements
- Providing a common basis and framework for the earned value management (EVM) system

A WBS is a necessary program management tool because it provides a basic framework for a variety of related activities like estimating costs, developing schedules, identifying resources, determining where risks may occur, and providing the means for measuring program status using EVM. Furthermore, a well-structured WBS helps promote accountability by identifying work products independent of one another. It also provides the framework to develop a schedule and cost plan that can easily track technical accomplishments in terms of resources spent in relation to the plan as well as completion of activities and tasks enabling quick identification of cost and schedule variances.

Table 2.3-4: GAO Key Point "WBS"

GAO Cost Estimating & Assessment Guide (GAO-09-3SP): KEY POINTS	
Standardized structure for the estimate	• A standard work breakdown structure, as detailed as possible, should be used, refining it as the cost estimate matures and the system becomes more defined. • The work breakdown structure ensures no portions of the estimate are omitted and makes it easier to make comparisons to similar systems and programs.

- ***Product Oriented WBS*:** A WBS deconstructs a program's end product into successive levels with smaller specific elements until the work is subdivided to a level suitable for management control. By breaking work down into smaller elements, management can more easily plan and schedule the program's activities and assign responsibility for the work. It also facilitates establishing a schedule, cost, and EVM baseline. Establishing a product oriented WBS is a best practice because it allows a program to track cost and schedule by defined deliverables, such as a hardware or software component. This allows a program manager to identify which components more precisely are causing cost or schedule overruns and to mitigate the root cause of the overruns more effectively.

- ***WBS Development:*** A WBS should be developed early to provide a conceptual idea of program size and scope. As the program matures, so should the WBS. Like the technical baseline, the WBS should be considered a living document. Therefore, as the technical

baseline becomes further defined with time, the WBS will also reflect more detail. For example, as specification requirements become better known and the statement of work is updated, the WBS will include more elements. As more elements are added to the WBS, the schedule is capable of greater definition, giving more insight into the program's cost, schedule, and technical relationships.

- ***WBS Dictionary*:** It is important each WBS be accompanied by a dictionary of the various WBS elements and their hierarchical relationships. A WBS dictionary is simply a document that describes in brief narrative format what work is to be performed in each WBS element. Each element is presented in an outline to show how it relates to the next higher element and what is included to ensure clear relationships. With minor changes and additions, the WBS dictionary can be converted into a statement of work. Although not the normal approach, the dictionary may also be expanded by the program manager to describe the resources and processes necessary for producing each element in cost, technical, and schedule terms. Also, since the WBS is product related, it is closely related to, and structured somewhat the same as, an indented bill of materials for the primary product. Like the WBS, its dictionary should be updated when changes occur. After the program's baseline is developed, updating the WBS should be part of a formal process, as in configuration management.

- ***Standardized WBS:*** In August of 2010, EM issued instructions to establish a corporate WBS structure at all EM sites (Appendix A). This structure incorporates the site PBS and unique identifier for each project in the baseline. Below this level, the WBS will generally follow the scope requirements and cost instructions used to develop the estimate. Standardizing the WBS is considered a best practice because it enables an organization to collect and share data among programs. Standardizing work breakdown structures results in more consistent cost estimates, allows data to be shared across organizations, and leads to more efficient program execution. WBS standardization also facilitates cost estimating relationship development and allows for common cost measures across multiple contractors and programs. Not standardizing WBSs will cause extreme difficulty in comparing costs from one contractor or program to another, resulting in substantial expense to government estimating agencies when collecting and reconciling contractor cost and technical data in consistent format. The standardized WBS logic should support the engineering perspective on how the program is being built. The WBS should be a communication tool that can be used across all functions within the program. To foster flexibility, WBS standardization should occur at a high level, such as WBS level 3, so lower levels can be customized to reflect how the specific program's work will be managed.

- ***Environmental Cleanup and Construction Project WBS Development:*** Use of the Environmental Cost Element Structure (ASTM Standard E2150) at the lower levels of the WBS structure is encouraged as a "Best Practice" by EM, which will help to organize the cost estimate and assist in the later collection of actual costs. Similarly, using other work breakdown structures, such as the Construction Specifications Institute Master Format system 7 or the ASTM International UNIFORMAT II system, whose data are organized and coded, will provide these benefits for construction projects.

- ***WBS and Scheduling:*** The WBS should be used as the outline for the integrated master schedule, using the levels of indenture down to the work package level. Since the WBS defines

the work in lower levels of detail, its framework provides the starting point for defining all activities and tasks used to develop the program schedule.

- ***WBS and EVM*:** By breaking the work into smaller, more manageable work elements, a WBS can be used to integrate the scheduled activities and costs for accomplishing each work package at the lowest level of the WBS. This is essential for developing the resource-loaded schedule that forms the foundation for the EVM performance measurement baseline. This framework can be used to monitor and control costs based on the original baseline and to track where and why there were differences. In this way, the WBS serves as the common framework for analyzing the original cost estimate and the final cost outcome. When estimators use cost, schedule, and technical information organized by the WBS hierarchical structure, they can summarize data to provide management valuable information at any phase of the program.

- ***WBS and Risk Management*:** the WBS is also valuable for identifying and monitoring risks. During the cost estimating phase, the WBS is used to flag elements likely to encounter risks, allowing for better contingency planning.

2.3.5 Step 5: Identify Ground Rules and Assumptions

Cost estimates are typically based on limited information and therefore need to be bound by the constraints that make estimating possible. These constraints usually take the form of assumptions that bind the estimate's scope, establishing baseline conditions the estimate will be built from. Because of the many unknowns, cost estimators must create a series of statements that define the conditions the estimate is to be based on. These statements are usually made in the form of ground rules and assumptions.

- ***Ground Rules:*** Ground rules represent a common set of agreed upon estimating standards that provide guidance and minimize conflicts in definitions. When conditions are directed, they become the ground rules by which the team will conduct the comprehensive technical baseline with all the necessary ground rules for conducting the estimate.

- ***Assumptions:*** Without firm ground rules, the estimator is responsible for making assumptions that will allow the estimate to proceed to development. In other words, assumptions are required only where no ground rules are provided. Assumptions represent a set of judgments about past, present, or future conditions postulated as true in the absence of positive proof. The estimator must ensure assumptions are not arbitrary; they are founded on expert judgments rendered by experienced program and technical personnel. Many assumptions profoundly influence cost; the subsequent rejection of even a single assumption by management could invalidate many aspects of the estimate. Therefore, it is imperative cost estimators brief management and document all assumptions well, so management fully understands the conditions the estimate was structured on. Failing to do so can lead to overly optimistic assumptions that heavily influence the overall cost estimate, to cost overruns, and to inaccurate estimates and budgets.

2.3.6 Step 6: Obtain Data

Data is the foundation of every cost estimate. Data quality affects the estimate's overall credibility. Depending on the data quality, an estimate can range anywhere from an educated judgment to a

highly defensible cost position. Before collecting data, the estimator must fully understand what needs to be estimated. This understanding comes from the purpose and scope of the estimate, the technical baseline description, the WBS, and the ground rules and assumptions. Once the boundaries of the estimate are known, the next step is to establish an idea of what estimating methodology will be used. Only after these tasks have been performed should the estimator begin to develop an initial data collection plan.

Table 2.3-5: GAO Key Point "Data"

GAO Cost Estimating & Assessment Guide (GAO-09-3SP): KEY POINTS	
Availability of valid data	• Numerous sources of suitable, relevant, and available data should be used. • Relevant, historical data should be used from similar systems to project costs of new systems; these data should be directly related to the system's performance characteristics

- ***Data Collection:*** Data collection is a lengthy process and continues throughout the development of a cost estimate. Many types of data need to be collected—technical, schedule, program, and cost data. Once collected, the data needs to be normalized. Data can be collected in a variety of ways, such as from interviews with SMEs, site and/or facility walkthrough, engineering studies and plans, databases of past projects, engineering build-up estimating analysis, surveys, data collection instruments, and focus groups. Key points include:
  - The data needs to be well documented.
  - Cost data should be continually supplemented with written vendor quotes, contract data, and actual cost data for each new program. Moreover, cost estimators should know the program acquisition plan contracting processes, and marketplace conditions, all of which can affect the data. This knowledge provides the basis for credibly using, modifying, or rejecting the data in future cost estimates.
  - Knowing the factors that influence a program's cost is essential for capturing the right data.
  - To properly identify cost drivers, it is imperative cost estimators meet with the engineers and other technical experts. In addition, by studying historical data, cost estimators can determine through statistical analysis the factors that tend to influence overall cost.
  - Cost estimates must be based on realistic schedule information. Some costs such as labor, quality, supervision, rented space and equipment, and other time-related overheads depend on the duration of the activities they support. In addition to data for the estimate, backup data should be collected for performing cross-checks.
  - Scheduling insufficient time can affect the estimator's ability to collect and understand the data, which can then result in a less confident cost estimate.
  - The cost estimator may have to change the estimating approach to fit the available data.
- ***Types of Data:*** In general, the three main types of data are cost data, schedule or program data, and technical data. Key points include:

- Cost data generally include labor dollars (with supporting labor hours and direct costs and overhead rates), material and its overhead dollars, facilities capital cost of money, and profit associated with various activities.
- Schedule or program data provide parameters that directly affect the overall cost. For example, lead-time schedules, start and duration of effort, delivery dates, outfitting, testing, initial operational capability dates, operating profiles, contract type, multiyear procurement, and sole source or competitive awards must all be considered in developing a cost estimate.
- Technical data define the requirements for the equipment being estimated, based on physical and performance attributes, such as length, width, weight, horsepower, and size.
- Cost data must often be derived from program and technical data. Moreover, program and technical data provide context for cost data, which by themselves may be meaningless.
- It is essential that cost estimators plan for and gain access, where feasible, to cost, technical, and program data to develop a complete understanding of what the data represent. Without this understanding, a cost estimator may not be able to correctly interpret the data, leading to greater risk the data can be misapplied.

- ***Sources of Data*:** Since all cost estimating methods are data-driven, estimators must know the best data sources. Estimators should use primary data sources whenever possible. Primary data is obtained from the original source, can usually be traced to an audited document, is considered the best in quality, and is ultimately the most useful. Secondary data is derived rather than obtained directly from a primary source. Key Points include:
  - While secondary data should not be the first choice, it may be all that is available. Therefore, the cost estimator must seek to understand how the secondary data was normalized, what the data represents, how old is the data, and whether the data is complete. If these questions can be answered, the secondary data may be useful for estimating and would certainly be helpful for cross-checking the estimate for reasonableness.
  - Sources of historical data include business plans, catalog prices, contract performance reports, contract funds status reports, cost and software data reports, forward pricing rate agreements, historical cost databases, market research, program budget and accounting data from prior programs, supplier cost information, historical or current vendor quotes, and weight reports.
  - Historical data provides the cost estimator insight into actual costs on similar programs, including any cost growth since the original estimate. As a result, historical data can be used to challenge optimistic assumptions. For example, a review of the average labor rates for similar tasks on other programs could be a powerful reality check against assumptions of skill mixes and overall effort. In addition, historical data from a variety of contractors can be used to establish cost trends of a specific contractor across a variety of programs.
  - Historical data also provides contractor cost trends relative to proposal values, allowing the cost estimator to establish adjustment factors if relying on proposal data for estimating purposes. Additionally, insights can be obtained on cost accounting structures to allow an

understanding of how a certain contractor charges things like other direct costs and overhead.

  - Cost data reports are often used in estimating analogous programs, from the assumption that it is reasonable to expect similar programs at similar contractors' plants to incur similar costs. This analogy may not hold for the costs of hardware or software but may hold in the peripheral WBS areas of data, program management, or systems engineering.
  - A number of government agencies and industry trade associations publish cost data that are useful in cost estimating.

- ***Data Applicability:*** Because cost estimates are usually developed with data from past programs, it is important to examine whether the historical data applies to the program being estimated. Over time, modifications may have changed the historical program so it is no longer similar to the new program. Many times, estimates are not based on actual data but are derived by subjective engineering judgment. All engineering judgments should be validated before being used in a cost estimate. Validation involves cross-checking the results, in addition to analyzing the data and examining the documentation for the judgment.

- ***Data Normalization:*** The purpose of data normalization (or cleansing) is to make a given data set consistent with and comparable to other data used in the estimate. Since data can be gathered from a variety of sources, they are often in many different forms and need to be adjusted before being used for comparison analysis or as a basis for projecting future costs. Cost data is adjusted in a process called normalization, stripping out the effect of certain external influences. The objective of data normalization is to improve data consistency, so comparisons and projections are more valid and other data can be used to increase the number of data points.

- ***Data Documentation:*** After the data is collected, analyzed, and normalized, it must be documented and stored for future use. Properly documented estimates describe the data used to estimate each WBS element, and this information can be used as a good starting point for the new estimate. Previous estimates can provide the cost estimator with valuable data and can also save time, since they provide a structure from which to develop the new cost estimate. They also help avoid reinventing the wheel, since the estimator can leverage off the work of others. However, the cost estimator will still have to perform follow-on work before fully relying on this data.

- ***Cost Units:*** Cost units primarily adjust for inflation. Because the cost of an item has a time value, it is important to know the year in which funds were spent. In addition to inflation, the cost estimator needs to understand what the cost represents. For example, does it represent only direct labor, or does it include overhead and the contractor's profit?
  - *Inflation Adjustments*: In the development of an estimate, cost data must be expressed in like terms. This is usually accomplished by inflating or deflating cost data to express them in a base year that will serve as a point of reference for a fixed price level. Applying inflation is an important step in cost estimating. Thus, it is imperative that inflation assumptions be well documented, and the cost estimator always performs uncertainty and sensitivity analysis to study the effects of changes on the assumed rates.

Table 2.3-6: GAO Key Point "Inflation"

GAO Cost Estimating & Assessment Guide (GAO-09-3SP): KEY POINTS	
Recognition of inflation	• The estimator should ensure economic changes, such as inflation, are properly and realistically reflected in the life-cycle cost estimate.

- *Selecting the Proper Indexes:* There are many sources available for escalation data/indexes. Below is a sampling of available sources. As part of the estimate planning effort work with your project team/management to decide what source(s) are appropriate for your situation.
  - Department of Defense Green Book
  - U.S. Army Corps of Engineers Indexes
  - Office of Management and Budget
  - Consumer Price Index
  - DOE Project Management organization Escalation Studies

2.3.7 Step 7: Develop a Point Estimate

The three commonly used methods for estimating costs are analogy, engineering build-up, and parametric. An analogy uses the cost of a similar program to estimate the new program and adjusts for differences. The engineering build-up method develops the cost estimate at the lowest level of the WBS, one piece at a time, and the sum of the pieces becomes the estimate. The parametric method relates cost to one or more technical, performance, cost, or program parameters, using a statistical relationship. The method to select depends on where the program is in its life-cycle. Early in the program, definition is limited, and costs may not have accrued. Once a program is in production, cost and technical data from the development phase can be used to estimate the remainder of the program. Table 2.3-7 gives an overview of the strengths, weaknesses, and applications of the three methods.

Table 2.3-7: Cost Estimating Methodology

Method	Strength	Weakness	Application
Analogy	• Requires few data • Based on actual data • Reasonably quick • Good audit trail	• Subjective adjustments • Accuracy depends on similarity of items • Difficult to assess effect of design change • Blind to cost drivers	• When few data are available • Rough-order-of-magnitude estimate • Cross-check
Engineering build-up	• Easily audited • Sensitive to labor rates • Tracks vendor quotes • Time honored	• Requires detailed design • Slow and laborious Cumbersome	• Production estimating • Software development • Negotiations

Method	Strength	Weakness	Application
Parametric	• Reasonably quick • Encourages discipline • Good audit trail • Objective, little bias • Cost driver visibility • Incorporates real-world effects (funding, technical, risk)	• Lacks detail • Model investment • Cultural barriers • Need to understand model's behavior	• Budgetary estimates • Design-to-cost trade studies • Cross-check • Baseline estimate • Cost goal allocations

- ***Analogous Cost Estimating Method:*** An analogy takes into consideration that no new program, no matter how state of the art it may be technologically, represents a totally new system. Most new programs evolve from programs already fielded with new features added on or that simply represent a new combination of existing components. The analogy method uses this concept for estimating new components, subsystems, or total programs. That is, an analogy uses actual costs from a similar program with adjustments to account for differences between the requirements of the existing and new systems.

  A cost estimator typically uses this method early in a program's life-cycle, when insufficient actual cost data are available but the technical and program definition is good enough to make the necessary adjustments. Adjustments should be made as objectively as possible, by using factors (sometimes scaling parameters) that represent differences in size, performance, technology, or complexity. The cost estimator should identify the important cost drivers, determine how the old item relates to the new item, and decide how each cost driver affects the overall cost. All estimates based on the analogy method, however, must pass the "reasonable person" test—that is, the sources of the analogy and any adjustments must be logical, credible, and acceptable to a reasonable person. In addition, since analogies are one-to-one comparisons, the historical and new systems should have a strong parallel. Analogy relies a great deal on expert opinion to modify the existing system data to approximate the new system. If possible, the adjustments should be quantitative rather than qualitative, avoiding subjective judgments as much as possible. An analogy is often used as a cross-check for other methods. Even when an estimator is using a more detailed cost estimating technique, an analogy can provide a useful sanity check.

- ***Engineering Build-Up Cost Estimating Method:*** The engineering build-up cost estimating method builds the overall cost estimate by summing or "rolling up" detailed estimates done at lower levels of the WBS. Because the lower-level estimating associated with the build-up method uses industrial engineering principles, it is often referred to as engineering build-up and is sometimes referred to as a grassroots or bottom-up estimate. An engineering build-up estimate is done at the lowest level of detail and consists of labor and materials costs that have overhead and fee added to them. In addition to labor hours, a detailed parts list is required. Once in hand, the material parts are allocated to the lowest WBS level, based on how the work

will be accomplished. In addition, quantity and schedule must be considered to capture the effects of learning.

Typically, cost estimators work with engineers to develop detailed estimates. The cost estimator's focus is to get detailed information from the engineer in a way that is reasonable, complete, and consistent with the program's ground rules and assumptions. The cost estimator must find additional data to validate the engineer's estimates. An engineering build-up method is normally used during the program's production because the program's configuration must be stabilized, and actual cost data are required to complete the estimate. The underlying assumption of this method is that historical costs are good predictors of future costs. The premise is that data from the development phase can be used to estimate the cost for production.

- ***Parametric Cost Estimating Method:*** In the parametric method, a statistical relationship is developed between historical costs and program, physical, and performance characteristics. The method is sometimes referred to as a top-down approach. Types of physical characteristics used for parametric estimating could be weight, power, and lines of code. Other program and performance characteristics include site deployment plans for information technology installations, maintenance plans, test and evaluation schedules, technical performance measures, and crew size. These are just some examples of what a cost driver for a particular program could be.

  Sources for these cost drivers are often found in the technical baseline, cost analysis requirements document, or cost analysis data requirement. The important thing is that the attributes used in a parametric estimate should be cost drivers of the program. The assumption driving the parametric approach is the same factors that affected cost in the past will continue to affect future costs. This method is often used when little is known about a program except for a few key characteristics.

  Using a parametric method requires access to historical data, which may be difficult to obtain. If the data are available, they can be used to determine the cost drivers and to provide statistical results and can be adjusted to meet the requirements of the new program. Unlike an analogous method, parametric estimating relies on data from many programs and covers a broader range. Confidence in a parametric estimate's results depends on how valid the relationships are between cost and the physical attributes or performance characteristics. Using this method, the cost estimator must always present the related statistics, assumptions, and sources for the data. The goal of parametric estimating is to create a statistically valid cost estimating relationship using historical data.

2.3.8 Step 8: Conduct Sensitivity Analysis

Sensitivity analysis should be included in all cost estimates because it examines the effects of changing assumptions and ground rules. Since uncertainty cannot be avoided, it is necessary to identify the cost elements that represent the most risk and, if possible, cost estimators should quantify the risk. This can be done through either a sensitivity analysis or an uncertainty analysis. Typically performed on high-cost elements, sensitivity analysis examines how the cost estimate is affected by a change in a cost driver's value.

Sensitivity analysis involves recalculating the cost estimate with different quantitative values for selected input values, or parameters, to compare the results with the original estimate. If a small change in the value of a cost element's parameter or assumption yields a large change in the overall cost estimate, the results are sensitive to that parameter or assumption. Therefore, a sensitivity analysis can provide helpful information for the system designer because it highlights cost sensitive elements . In this way, sensitivity analysis can be useful for identifying areas where more design research could result in less production cost or where increased performance is implemented without substantially increasing cost. This type of analysis is called a "what-if" analysis and is often used for optimizing cost estimate parameters.

The sensitivity analysis addresses some of the estimating uncertainty by testing discrete cases of assumptions and other factors that could change. By examining each assumption or factor independently, while holding all others constant, the cost estimator can evaluate the results to discover which assumptions or factors most influence the estimate. A sensitivity analysis also requires estimating the high and low uncertainty ranges for significant cost driver input factors. To determine what the key cost drivers are, a cost estimator needs to determine the percentage of total cost each cost element represents. The major contributing variables within the highest percentage cost elements are the key cost drivers that are varied in a sensitivity analysis.

A credible sensitivity analysis typically has five (5) steps:

1) Identify key cost drivers, ground rules, and assumptions for sensitivity testing
2) Re-estimate the total cost by choosing one of these cost drivers to vary between two set amounts: for example, maximum and minimum or performance thresholds
3) Document the results
4) Repeat steps 2 and 3 until factors identified in step 1 are tested independently
5) Evaluate the results to determine which drivers affect the cost estimate most

2.3.9 Step 9: Conduct Risk and Uncertainty Analysis

An uncertainty analysis should be performed to capture the cumulative effect of additional risks. Because cost estimates predict future program costs, uncertainty is always associated with them. For example, data from the past may not always be relevant in the future, because new manufacturing processes may change a learning curve slope or new composite materials may change the relationship between weight and cost. Moreover, a cost estimate is usually composed of many lower-level WBS elements, each of which comes with its own source of error. Once these elements are added together, the resulting cost estimate can contain a great deal of uncertainty. The DOE G 413.3-7A contains guidance for addressing risks on capital asset projects.

Table 2.3-8: GAO Key Point "Risk"

GAO Cost Estimating & Assessment Guide (GAO-09-3SP): KEY POINTS	
Provision for program uncertainties	• Uncertainties should be identified, and allowance developed to cover the cost effect. • Known costs should be included and unknown costs should be allowed for.

Risk and uncertainty refer to the fact that because a cost estimate is a forecast, there is always a chance the actual cost will differ from the estimate. Moreover, lack of knowledge about the future

is only one possible reason for the difference. Another equally important reason is the error resulting from historical data inconsistencies, assumptions, cost estimating equations, and factors typically used to develop an estimate. Recognizing the potential for error and deciding how best to quantify it is the purpose of risk and uncertainty analysis. It is inaccurate to add up the most likely WBS elements to derive a program cost estimate, since their sum is not usually the most likely estimate for the total program, even if they are estimated without bias. Yet summing costs estimated at the detailed level to derive a point estimate is the most common approach to estimating a total program. Simulation of program risks is a better way to estimate total program cost.

- ***Risk*** is the chance of loss or injury. In a situation that includes favorable and unfavorable events, risk is the probability an unfavorable event will occur.

- ***Uncertainty*** is the indefiniteness about the outcome of a situation. It is assessed in cost estimate models to estimate the risk (or probability) that a specific funding level will be exceeded.

Quantitative risk and uncertainty analysis provide a way to assess the variability in the point estimate. Using this type of analysis, a cost estimator can model such effects as schedules slipping, missions changing, and proposed solutions not meeting user needs, allowing for a known range of potential costs. Having a range of costs around a point estimate is more useful to decision makers, because it conveys the level of confidence in achieving the most likely cost and informs them on cost, schedule, and technical risks.

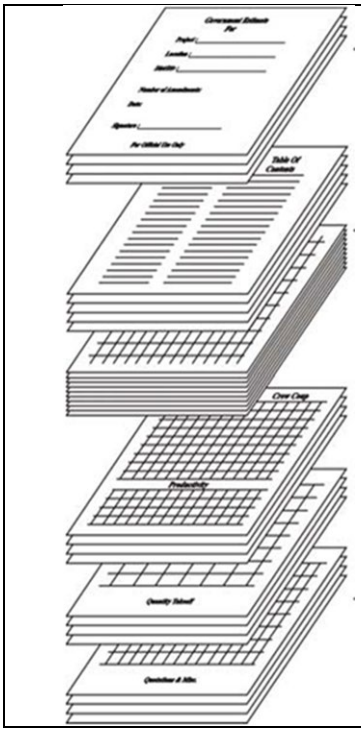
Using an uncertainty analysis, a cost estimator can easily inform decision makers about a program's potential range of costs. Management, in turn, can use this data to decide whether the program fits within the overall risk range of the agency's portfolio.

2.3.10 Step 10: Document the Estimate

Estimate documentation is developed as a complex package related to the estimate. When prepared correctly, an experienced person can use information in the estimating package to understand and assess the estimate, independent of any other supporting documentation. An independent reviewer can establish a full understanding of the estimate including the cost associated with the technical approach used as the basis for the estimate and can recreate the estimate or make adjustments based on the details in this documentation. This is very important during the technical evaluation of costs associated with procurement actions. The typical cost estimate documentation package is presented in Figure 2.3-1.

Figure 2.3-1: Cost Estimate Document Package

	< Executive Summary (if needed) • Title Page • Approval / Signature page • BOE Summary
	< Basis of Estimate Report • See discussion later
	< Detailed Cost Estimate (from cost estimating system) • Detailed report from cost estimating system



- Includes summary by major elements of cost
- Includes summary and details throughout the WBS
- Includes unit cost and pricing details
- Include notes and documentation as needed

< Estimate Scoping Documentation

- PWS/SOW, Drawings, Technical Information, etc.

< Estimate Supporting Documentation

- Quantity takeoffs
- Miscellaneous calculations, Quotes

< Miscellaneous Documents

- Quotes received (material, equipment, subcontracts)
- Alternative or validation estimates
- Analysis (GAO assessment, sensitivity, etc.)
- Estimate Plan

Executive Summary: More complex estimates may require an executive summary that can be used to assist managers and other stakeholders with understanding the information in the estimating package. The executive summary can be used to develop presentations or may draw information from presentations to management regarding the estimate that is a GAO recommended practice for high quality estimates. The title page should be consistent with the BOE title page format but should also include a clear identification that it is the executive summary. The signature page should include the estimate approver and may include an interim level manager if the estimate is presented to higher level management.

The BOE summary should be in sufficient detail to capture the key points of the estimate. These should include but not be limited to an overview of the estimate scope and purpose; higher level cost summary and estimate range; key or significant risks that can impact cost; and analysis of key cost drivers by major element of cost. Charts and tables can be used to present information more concisely. The executive summary should capture key elements of the estimate but should be as concise as possible, typically a few pages in length.

Basis of Estimate Report **-** The BOE is a key part of the cost estimate documentation. The BOE is generated by the estimating team and should be sufficiently completed and well organized such that a cost estimating professional can use the documentation by itself to understand and assess the estimate. The AACE under the Total Cost Management (TCM) framework identifies a BOE document as a required component of a cost estimate. The BOE is characterized as the one deliverable that defines the scope of the project, and ultimately becomes the basis for change management. A well-written BOE achieves the goals associated with a high quality estimate by clearly and concisely stating the purpose of the estimate being prepared (i.e., cost study, project options, funding, etc.), the project scope, pricing basis, allowances, assumptions, exclusions, cost

risks and opportunities, and any deviations from standard practices. In addition, the BOE is a documented record of pertinent communications that have occurred and agreements made between the cost estimator and other project stakeholders. The BOE establishes the context of the estimate and supports review and validation. The typical BOE should:

- Describe the estimate's purpose, expected use, and who requested the estimate.
- Be factually complete and concise.
- Be able to support your facts and findings.
- Identify estimating team members and their roles.
- Describe any specifically requested estimates (i.e., Costs by Contract Line Item Number (CLIN), costs by year, costs by program or project elements, etc.); essentially these are the requestors specific estimating needs.
- Describe the tools, techniques, estimating methodology, and data used to develop the cost estimate. Some estimates will require a detailed technical approach be developed in conjunction with SMEs for some or all of the proposed work and this should be documented as well.
- Identify other projects referenced or benchmarked during estimate preparation.
- Supporting documentation should include estimating plans, scoping and technical documents, quantity take off work sheets, and other supporting documentation.

Table 2.3-9: BOE Key Points

No.	Description
1	Be complete but be concise. Details are always good, but be careful—if it's too long or too wordy it won't be read.
2	Be able to support your facts and findings.
3	Identify estimating team members. They may be able to answer questions regarding the estimate if you're not available.
4	Describe the techniques and data used to develop the cost estimate. The BOE (along with the project scope) should provide the information necessary for another estimator to replicate the estimated cost.
5	Identify other referenced projects.
6	Make every effort to develop the BOE while the estimate is being prepared. It is always easier to record your facts and findings while they are fresh in your mind.
7	Always remember—for many reviewers, the BOE is the only document used to judge the quality of the estimate.

8	Perform Quality Assurance and Quality Control Reviews, to determine whether an estimate is comprehensive. An objective review must be performed to certify the estimate's criteria and requirements are met, since they create the estimate's framework. This step also infuses quality assurance practices into the cost estimate.

Complex Estimate BOE's – The EMCBC BOE Template is recommended to be used as a best practice for complex estimates. Estimates can be considered complex if the total expected value exceeds $10 million (although some estimates exceeding this value may have a simple scope allowing use of the tailored BOE), includes multiple projects, includes technically difficult work, or when the estimator decides the complex BOE format is needed to fully describe the estimate. The BOE Template includes the following sections:

- Title and Signature Pages (Author, Reviewer, Approver)
- Foreword or Abstract (if needed)
- Table of contents
- Introduction
  - Overview
  - Technical Description
- Approach
  - Objective
  - Estimating Team Composition
  - Project Scope Description
  - Schedule
- Ground Rules and Assumptions
- Cost Estimate Summary and Analysis
  - Execution Approach
  - Estimating Methodology
  - Cost Estimate Classification
  - Estimate Summary
  - Cost Reasonableness-Traceability & Benchmarking
  - Risk Adjustment-Sensitivity & Uncertainty Analysis
- BOE Appendices
  - Detailed Cost Report
  - Scoping Information
  - Supporting Calculations
  - Supporting Documents
  - Miscellaneous Documents (including Estimate Plan)

Introduction - In the introduction, the overview section includes features that facilitate its use and includes all the following information:

- Purpose
- Title of Project
- Physical Location

- Sponsors of the Project (Requester)
- Contract/RFP/Modification Number
- Elements Included in the Report

The purpose should provide a brief, concise description of the total project. The type of project should be identified (i.e., new facilities, addition to existing, revamp of existing, etc.), as well as the type and capacity of the process units, the location of the facility, and the overall timing of the project. The author should also indicate the primary estimating methodology used to prepare the cost estimate, as well as the purpose, and classification of the cost estimate in summary form.

Sponsors or persons requesting the estimate should provide references to contracts, solicitations, projects, or programs. A high level overview of major estimate elements should also be included as part of the overview.

The technical description should also be included in the introduction. This should include a brief technical and programmatic description of the system or alternative whose costs are being estimated. Identify any program documents used to prepare the estimate. Items to include:

- **Requirements** - What the program is supposed to do
- **Purpose** - How the program will fulfill its mission
- **Technical Characteristics** - What it will look like
- **Development Plan** – Where and how the program will be built
- **Acquisition Strategy** - How the program will be acquired
- **Operations Plan** - How the program will operate
- **Risk** - Which characteristics affect cost the most

The Estimating Approach - Describe the objective of the cost estimate being documented. Identify the organization that requested the estimate, briefly describe the specific tasking for the estimate, and cite any relevant correspondence. If the estimate being documented updates a prior estimate, identify the prior estimate. A prior estimate is normally available when a program is being re-baselined. Cost estimates have two general purposes:

- Help managers evaluate affordability and performance against plans, as well as the selection of alternative systems and solutions
- Support the budget process by providing estimates of the funding required to efficiently execute a program

Provide a table of the individuals involved and their roles for the development of the estimate. Include Cost Estimators, Contracting Officers, Technical & Subject Matter Experts, Reviewers, and any others involved in the process. The team composition should also include contact information for team members.

The project scope description should identify the scope of the current cost estimate. List which of the standard WBS Elements are covered by the estimate. Identify whether the estimate covers prime contractor costs, other contractor costs, activity costs, and the costs for other EM

organizations. If the SOW was provided, include the document or at least relevant excerpts from the document in the appropriate Appendix to the BOE report for future reference.

A WBS is the cornerstone of every program because it defines in detail the work necessary to accomplish a program's objectives. The WBS reflects the requirements, resources, and tasks that must be accomplished to develop a program; the WBS structure used in the estimate should reflect the tasks described in the SOW.

For each WBS Element, include the WBS Number, Title, and Element Description. The technical approach selected to perform the work should be included as needed at the appropriate WBS level. For large estimates it may be necessary to provide a detailed technical approach and BOE at lower levels in the WBS. A detailed WBS dictionary may need to be included in the BOE appendices as well. The WBS dictionary may be supplied by the estimate requestor, but the estimator may have to develop the document. A semi-detailed description of the scope of work should be provided for each major segment of the project. Identify any major pieces of process equipment or components. It's also good practice to indicate the primary trades involved with the project. Be as thorough as necessary, without being overly descriptive, to adequately explain the scope of work being estimated.

Specific items that should be addressed in the technical portions of the BOE include:

- *Design Basis* - Company standards will typically specify what information is required for the classification of the estimate being prepared. In this section, the estimating team will identify the types and status of engineering and design deliverables provided to prepare the estimate including any design basis assumptions. Two attachments to the estimate should be referenced here as well. The first is an estimate deliverables checklist aligned with the company standard project processes. The second attachment should be a listing of all engineering drawings (including revision number and date), as well as other design information, such as specifications, equipment lists, etc.
- *Planning Basis* - This section documents the project management, engineering, design, procurement, fabrication, and construction approaches to the project. The contracting and resource strategies should be identified, as well as any assumptions made regarding the work week and overtime. Any assumptions made regarding constructability, modularization, and use of specialized construction equipment should also be noted here. The overall project schedule and key milestones should be identified.
- *Cost Basis* - Describe the methods and sources used for determining all material and labor pricing. Identify the following:
  - Pricing sources for all major equipment (vendor quotes, historical data, etc.)
  - Bulk material and commodity pricing sources, including any discount strategies
  - Pricing source for all labor hours, and all labor productivity adjustments; provide appropriate detail if productivity varies by trade and/or location within the project (plant, etc.)
  - Pricing source for all equipment costs and all productivity adjustments; provide appropriate detail if productivity varies from industry standards and the reasons for the variance
  - All wage rates used (including crew/craft rates, craft mix, etc.); identify all items included in all-in rates (if used)

  - Indirect Pricing source and methodology for construction indirects
  - Start-up Pricing source for all start-up costs
  - Home Office Pricing source and methodology for all home office costs (project management, engineering, design, etc.); document the basis for any contractor fee costs
  - Miscellaneous Pricing source and methodology for costs such as freight, taxes, duties, etc.; pricing source for any owner's costs included in the estimate
  - Currency exchange rates if applicable; pricing and calculations for any escalation costs provided; any other pricing factors or external influences that may have a significant impact on project cost should be identified
  - Escalation indices used, and the method of calculation (including duration)
  - Location factors used and the basis for these factors
  - Influence of local market conditions
  - Capital costs vs. expense costs, or other categorization as necessary
  - Any other pricing factors or external influences that may have a significant impact on project cost should be identified

- *Allowances* - In this section, identify the level and types of allowances used in the estimate. Describe the basis for the common estimating allowances such as, material take-off allowances; overbuy allowances; design allowances for engineered equipment, process technology development, congestion allowances, working height allowances, etc. This section should also describe any other costs not detailed in the body of the estimate, such as lump-sum allowances for specific areas of scope or any other factored costs not described elsewhere in the estimate basis.
- *Exclusions* - In this section the estimating team should document all potential items of cost which might be associated with the project but for which no costs were included in the estimate. Asbestos abatement, removal of hazardous wastes, acquisition of land, taxes, financing costs, licensing costs, are examples of potential items that may be identified.
- *Exceptions* - Here the estimating team should identify any anomalies to standard cost estimating practices defined by the company for which you are providing the estimate. This section should document any significant deviations from the project and/or engineering deliverables required for the applicable class of estimate. A good practice is to provide a checklist as an attachment to the BOE that will document any exceptions that are identified. This checklist should correspond to the company's standard estimating practices.

The proposed schedule for completion or execution of the work scope associated with the estimate should be included. List the key acquisition events and milestones for the years covered by the cost estimate. Summarize the quantities to be purchased and installed by fiscal year as needed. Include as an attachment any additional schedules that provide clarification of the project or were obtained in support of developing the estimate. The person requesting the estimate should provide the schedule and milestones.

Ground Rules and Assumptions **-** List key technical and programmatic conditions as well as estimating ground rules and assumptions that underpin the estimate as a whole. Identify specific cost elements excluded from the cost estimate and any deviations from standard practices here with the rationale for the deviations. Include a description of any allowances included in the estimate, and the calculations to decide the size of the allowance to be made. Include the sources

or cost basis used for all material and labor pricing. Describe the source of inflation rates used to adjust "Constant Year" cost estimates into "Then Year" dollars. (BLS/Consumer Price Index/etc.) Also provide an explanation as to how the rates were applied. Any other assumptions made by the estimator, but not documented elsewhere in the cost estimate basis, should be included in this section. This may include such assumptions as an adequate labor supply being available, adequate funding available, site conditions, etc.

Cost Estimate Summary and Analysis **-** Provide an explanation of how the overall execution approach will be accomplished. Specifically discuss areas where multiple approaches could be selected and why the selected approach was used. Provide explanation of approach chosen for selected tasks as needed at appropriate levels in the WBS. For each WBS Element, include the WBS Number, Title, and Element Description. The technical approach selected to perform the work should be included as needed at the appropriate WBS level.

Provide a summary of the primary methodologies (Analogy, Engineering Build-Up, Parametric, level of effort, etc), factor libraries, models and data sources used to estimate program or alternative costs, and briefly state why they were selected. To facilitate the documentation, parameter values and factors used consistently throughout the estimate (e.g., labor rates, overhead factors, contract award fee percentages, quantities, etc.) can be presented in a summary table.

Use the items listed below to assist in documenting the estimate methodologies for those used:

- **Labor Rates** – identify direct and indirect labor rates, what costs are included in the rates, and how the rates were determined
- **Labor Hours** – describe how labor hours were estimated
- **Material Purchases** – list the materials and purchased parts, the source of estimated prices, and any crosschecks performed
- **Subcontracts** – summarize the work to be performed, how the price was determined
- **Cost Factors/Cost Estimating Relationships (CERs)** – describe their source and how they were applied
- **Cost Models** – describe any estimating models used and how they were applied
- **System Analogs** – identify the analogous systems and how and why they were used
- **Estimator Judgment** – specify who provided the estimate/information and any justification
- **Contractor Cost Estimate** – identify whether contractor estimates were used and describe any crosschecks performed to confirm reasonableness

Identify the appropriate estimate classification for the estimate. The recommended practice to classify the estimate is to use an industry standard to establish the class of each estimate. The Association for the Advancement of Cost Engineering International (AACE) established a classification system for cost estimates. The BOE report should include the AACE table, for reference, and the reasons or justification used in the selection of the estimate classification. For complex estimates a weighted average of estimate classification may be required.

An estimate summary should be included. Include a table for the estimated costs of the point estimate at a summary level (WBS Level 2 or 3; to be tailored for audience/purpose). This table should include then-year dollars that track to the WBS and Methodology descriptions. Columns

for major cost drivers (Hours, Material, Equipment, Subcontractor, Other Direct Costs, etc.) can be included as well to provide additional information.

To provide a cost reasonableness review, the IGCE should be compared to a similar project or previously developed estimate. The review can assess the differences regarding the primary cost elements, the relative percentage of the total cost, the underlying basis of estimate for each cost element, and more. Estimates being updated or based on a previously developed estimate should be compared to the current estimate to provide traceability due to the changes made to the effort. Provide an overview of the major differences between this estimate and the last published estimate prepared for this project. Identify the cost impacts due to scope changes, pricing updates, labor productivity adjustments, estimate refinement, etc. A more detailed reconciliation report can be provided as an additional attachment if necessary.

Some estimates covering work similar to what was performed at other sites may need further analysis. Benchmarking may be used to document any comparisons of resulting metrics, ratios, and factors with similar projects, historical data, and industry data. Projects used in the benchmark comparisons should be similar in process type and overall value. If significant variations of the estimated project costs versus the benchmarks exist, those inconsistencies should be identified and commented upon. A more detailed benchmark analysis report may be included as an attachment to the Basis of Estimate document.

EM work carries inherent risks that can affect cost. Include analysis which examines the effects of changing assumptions and ground rules. Since uncertainty cannot be avoided, identify the cost elements that represent the most risk, and if possible, quantify the risk using sensitivity and uncertainty analysis. Describe how the high-confidence cost estimate was generated. Specifically, summarize how the standard cost methodologies were adjusted for cost estimating, technical, schedule, and other risks. Describe any risk analyses conducted by the Project Team (e.g., Monte Carlo simulation, identification of risk mitigation strategies) and how their results were used to create the most likely cost estimate. Describe the process used to distribute risk dollars among WBS Elements and over fiscal years. Specify the percentile confidence of the risk-adjusted estimate. Address the following items in this section:

- *Risks and Opportunities* - Any areas of the estimate containing significant risk or opportunity should be identified. If a formal risk analysis study was prepared it should be described here. This section should identify those cost elements identified with high or very high risk or opportunity values.
- *Contingencies* - Contingency is a cost element of the estimate used to cover uncertainties and unforeseeable elements of cost within the defined project scope. Contingency covers inadequacies in project scope definition, estimating methods, and estimating data. Contingency specifically excludes changes in project scope, and unforeseen major events such as earthquakes, prolonged labor strikes, etc. The amount of contingency included in the estimate should be identified, as well as the methods used to determine the contingency amount. If risk analysis techniques were used to develop the contingency amount, the associated confidence level should also be identified. In DOE the contingency may be funded or unfunded but in either case it is not included in a contracted action. Contingency is reflected in the project or program baseline and may also be shown in budgetary estimates.

- *Management Reserve* (MR) – MR is the contractor's management reserve established after a contract award from within the Contract Budget Base (CBB) to effectively manage contract work scope. MR is not a separately priced element in a contractor's cost proposal. The expectation is the contractor's proposal takes into consideration any performance risk associated with the delivery of the proposed scope of work.

Several supporting documents will generally be included as an appendix to the BOE report. These include:

- Detailed Cost Report: The report should be an output of the cost estimating software used to develop the estimate. The preferred estimating tool in EM is the USACE Micro Computer Aided Cost Estimating System (MCACES) version 2, commonly referred to as MII. This report should include:
  - Summary by major elements of cost (labor, material, equipment, subcontracts, other direct costs, contractor markups, and owner markups)
  - Summary costs and details throughout the WBS
  - Unit cost and pricing details
  - Notes and documentation as needed
- Scoping information: PWS/SOW, drawings, technical Information, solicitation documents, photos, technical characterization and/or design reports, etc.
- Supporting Calculations can include:
  - Quantity takeoffs and calculations
  - Unit conversions
  - Productivity calculations
  - Miscellaneous calculations (volumetric, rad equivalents, haul calculations, etc.)
  - Quotes from subcontractors or vendors and how they are incorporated into the estimate
- Supporting Documents: Document the drawings, manuals, texts, notes, specifications, and other references used in developing the estimate; identify the revisions and date of issue for key documents.
- Miscellaneous Documents: Document the Estimate Plan, drawings, manuals, texts, notes, specifications, and other references used in developing the estimate. Identify the revisions and date of issue for key documents. Include any other attachments that may be necessary or required (reconciliation report, benchmarking report, risk analysis report, etc.).

Other BOE Documentation - A well-documented estimate will withstand scrutiny. If rigorous documentation and estimate procedures are followed, the credibility of a cost estimate increases. It is important to document all steps of the cost estimating process. The particulars of performing a cost estimate may vary, depending on local historical perspectives, professional judgment, available resources, and specific DOE program/field office requirements. In essence, the estimate package can include any documentation not previously addressed to ensure reviewers have a full understanding of the estimate. Additional documentation not previously addressed could include:

- Support contract information or rate agreements establishing rates to be included in the estimate
- Wage determinations, General Services Administration (GSA) schedules, etc.
- Subcontract agreements, utility agreements, etc.

2.3.11 Step 11: Present the Estimate for Management Approval

Management approval of estimates developed for initial budgeting or baseline definition is a defined step in the project management process. Revised estimates typically developed if project requirements change, or as a design is developed, should also be reviewed by management staff, revised as necessary to reflect management comments, and then approved. Each revised estimate shall then be incorporated into project cost baselines through the established project change management process.

A cost estimate is not considered valid until management has approved it. Since many cost estimates are developed to support a budget request or decide between competing alternatives, it is vital management is briefed on how the estimate was developed, including risks associated with the underlying data and methods. Therefore, the cost estimator should prepare a briefing for management with enough detail to easily defend the estimate by showing it is accurate, complete, and high in quality.

The briefing should present the documented estimate with an explanation of the program's technical and program baseline. The briefing should be clear and complete, making it easy for those unfamiliar with the estimate to comprehend its level of competence. The briefing should focus on illustrating to management, in a logical manner, what the largest cost drivers are. Slides with visuals should be available to answer more probing questions. A best practice is to present the briefing in a consistent format to facilitate management's understanding of the completeness of the cost estimate, as well as its quality. Moreover, decision makers who are familiar with a standard briefing format will be better able to concentrate on the briefing's contents, and on the cost estimate, rather than focusing on the format itself.

The cost estimate briefing should succinctly illustrate key points that center on the main cost drivers and the final cost estimate's outcome. The presentation must include program and technical information specific to the program, along with displays of budget implications, contractor staffing levels, and industrial base considerations, to name a few.

2.3.12 Step 12: Update the Estimate to Reflect Actual Costs and Changes

Government cost estimating and EVM are often conducted by different groups that barely interact during system development. Therefore, it is considered a best practice to link cost estimating and EVM analysis. Joining forces, cost estimators and EVM analysts can use each other's data to update program costs and examine differences between estimated and actual costs. Scope changes, risks, and opportunities can be presented to management in time to plan for or mitigate them. Program status can be compared to historical data to understand variances. Finally, cost estimators can help EVM analysts calculate a cumulative probability distribution to determine the confidence level in the baseline.

Keeping the estimate fresh gives decision makers accurate information for assessing alternative decisions. Cost estimates must also be updated whenever requirements change, and the results should be reconciled and recorded against the old estimate baseline. Several key activities are associated with updating the cost estimate:

- Documenting all changes that affect the overall program estimate so differences from past estimates can be tracked
- Updating the estimate as requirements change, or at major milestones, and reconciling the results with the program budget and EVM system
- Updating the estimate with actual costs as they become available during the program's life-cycle
- Recording reasons for variances so the estimate's accuracy can be tracked
- Recording actual costs and other pertinent technical information—source line of code sizing, effort, schedule, risk items—so they can be used for estimating future programs
- Obtaining government program office feedback, assessing lessons learned on completion, and recording the lessons so they are available for the next version of the estimate

After these activities are completed, the estimator should document the results in detail, including reasons for all variances. This critical step allows others to track the estimates and to identify when, how much, and why the program costs more or less than planned. Further, the documented comparison between the current estimate (updated with actual costs) and the old estimate allows the cost estimator to determine the level of variance between the two estimates. In other words, it allows estimators to see how well they are estimating and how the program is changing over time.

2.4 STORE ESTIMATE DATA IN DATABASE

Environmental Management (EM) projects are capturing an increasingly large amount of public funds. To improve cost estimating and cost management of environmental management projects in DOE, the Applied Cost Engineering (ACE) team of the Environmental Management program, in coordination with the Environmental Cost Engineering Committee (EC2) developed an Environmental Cost Element Structure (ECES). This structure provides a common set of elements that can be used to describe the technical and administrative components with related costs for completed EM projects. Cost collection for these projects and cost estimates for planned and active projects are expedited by using ECES.

The ACE team also developed the ECAS to create and maintain a database of completed DOE EM projects. ECAS was developed to store and report data using the ECES structure and cost driving parameters (secondary parameters) down to level 3 elements and lower (level 5) if necessary. The system will provide detailed reporting of ECAS data to enable users to develop estimates for future projects, establish benchmarks, and promote improved cost control and cost management.

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GLOSSARY OF TERMS

- **Activity-based costing (ABC)** -Costing using a method to ensure budgeted amounts in an account truly represent all the resources consumed by the activity or item represented in the account. The project is divided into activities and an estimate is prepared for each activity. Also used with detailed, unit cost, or activity-based cost estimating.
- **Analogous Estimating-** This technique uses parameters such as duration, budget, size, weight, and complexity from a previous, similar project as the basis for estimating the same parameter or measure for a future project. This technique is generally less costly and time consuming than other estimating techniques, but it is also generally less accurate.
- **Assumptions -** Factors used for planning purposes considered true, real, or certain. Assumptions affect all aspects of the planning process and of the progression of the project activities. (Generally, the assumptions will contain an element of risk.)
- **Baseline** - A quantitative definition of cost, schedule, and technical performance that serves as a standard for measurement and control during the performance of an activity; the established plan against which the status of resources and the effort of the overall program, field programs, projects, tasks, or subtasks are measured, assessed, and controlled. Once established, baselines are subject to change control discipline.
- **Basis (basis of estimate, or BOE)** - Documentation that describes how an estimate, schedule, or other plan component was developed, and defines the information used in support of development. A basis document commonly includes a description of the scope; methodologies; references and defining deliverables; assumptions and exclusions; clarifications; adjustments; and level of uncertainty.
- **Bottom-Up Estimating-** Work within an activity is decomposed into individual resources, resource needs are estimated, then aggregated into a total quantity for each of the activities resources, which are added to other resource estimates and rolled up to arrive at a total cost for the activity.
- **Budgeting** - A process for allocating estimated resource costs into accounts (i.e., the cost budget) against which cost performance will be measured and assessed. Budgeting often considers time-phasing in relation to a schedule or time-based financial requirements and constraints.
- **Buried contingency** - Costs that may have been hidden in the details of an estimate to protect a project from the removal of explicit contingency and to ensure the final project does not go over budget. To reviewers, buried contingency often implies inappropriately inflated quantities, lowered productivity, or other means to increase project costs. Buried contingency should not be used.
- **Capital Assets**: Land, structures, equipment, systems, and information technology (e.g., hardware, software, and applications) used by the Federal government and having an estimated useful life of 2 years or more. Capital assets include environmental restoration (decontamination and decommissioning) of land to make useful leasehold improvements and land rights, and assets whose ownership is shared by the Federal government with other entities (does not apply to capital assets acquired by state and local governments or other entities through DOE grants).
- **Conceptual design** - The concept that meets a mission need; requires a mission need as an input. Concepts for meeting a mission need are explored and alternatives considered before arriving at the set of alternatives that are technically viable, affordable, and sustainable.

- **Conceptual Design Report (CDR)** - Documentation of conceptual design phase outcome; forms the basis for a preliminary baseline.
- **Confidence (confidence level)** - The probability a cost estimate or schedule can be achieved or bettered. This is typically determined from a cumulative probability profile (see Cumulative Distribution Function) that is the output from a Monte Carlo simulation.
- **Construction** - A combination of engineering, procurement, erection, installation, assembly, demolition, or fabrication to create a new facility or to alter, add to, rehabilitate, dismantle or remove an existing facility; includes alteration and repair (dredging, excavating, and painting) of buildings, structures, or other real property and construction, demolition, and excavation conducted as part of environmental restoration or remediation. Construction normally occurs between Critical Decisions 3 and 4 (does not involve the manufacture, production, finishing, construction, alteration, repair, processing, or assembling of items categorized as personal property).
- **Contingency** - The portion of a project budget available for uncertainty within the project scope but outside the scope of the contract. Contingency is budget not placed on contract. Contingency is an amount derived from a structured evaluation of identified risks, to cover a likely future event or condition, arising from presently known or unknown causes, within a defined project scope. Contingency is controlled by the government.
- **Contract** - A mutually binding agreement that obligates the seller to provide a specified product and obligates the buyer to pay for it.
- **Contract fee** - Fee earned by the contractor based on dollar value or another unit of measure, such as man hours; an indirect cost.
- **Contractor** - A person, organization, department, division, or company having a contract, agreement, or memorandum of understanding with DOE or another Federal agency.
- **Control account (or cost account)** - The point at which budgets (resource plans) and actual costs are accumulated and compared to earned value for management control purposes; a natural management point for planning and control that represents work assigned to one responsible organization on one work breakdown structure element.
- **Cost accounting -** Historical reporting of actual and/or committed disbursements (costs and expenditures) on a project. Costs are denoted and segregated within cost codes defined in a chart of accounts. In project control practice, cost accounting provides a measure of cost commitment and expenditure that can be compared to the measure of physical completion (earned value) of an account.
- **Cost estimating** - A process used to quantify, cost, and price the resources required by the scope of an asset investment option, activity, or project. As a predictive process, estimating must address risks and uncertainties. The output of estimating is used primarily as input for budgeting, cost or value analysis, decision making in business, asset and project planning, or project cost and schedule control.
- **Direct cost** - Costs identified with a particular project or activity; includes salaries, travel, equipment, and supplies directly benefiting the project or activity.
- **DOE contingency** - Cost contingency for risks within the project's baseline but outside the contractor's management control. DOE contingency is held by DOE.
- **DOE schedule contingency** - Duration allowance used to adjust schedule for realized risks within the project baseline, and outside the contractor's control.

- **Earned Value Management System (EVMS)** - The integrated set of processes used to implement the standard and its criteria. In its simplest form, EVMS can be implemented without any software. Software simply enhances productivity, allows the implementation of EVMS more economically, and facilitates managing complex projects. EVMS is not software.
- **Escalation** – The provision in actual or estimated costs for an increase in the cost of equipment, material, labor, etc., due to continuing price level changes over time. Inflation may be a component of escalation, but non-monetary policy influences, such as supply-and-demand, are often components.
- **Estimate –** The assessment of the most likely quantitative result. (Generally, it is applied to costs and durations with a confidence percentage indication of likelihood of its accuracy.)
- **Estimate-at-Completion (EAC) -** The current estimated total cost for project authorized work. EAC equals the actual cost to a point in time plus the estimated costs to completion.
- **Estimate to Complete (ETC)** - The current estimated cost for remaining authorized work to complete the project.
- **Estimate uncertainty** - The inherent accuracy of a cost or schedule estimate. Represents a function of the level of project definition available, the resources used (skill set and knowledge), and time spent to develop the cost estimate and schedule, and the data (e.g., vendor quotes, catalogue pricing, historical databases, etc.) and methodologies used to develop the cost estimate and schedule.
- **Facilities** - Buildings and other structures; their functional systems and equipment; site development features such as landscaping, roads, walks, and parking areas; outside lighting and communications systems; central utility plants; utility supply and distribution systems; and other physical plant features.
- **Hotel loads** - A term used to identify the cost associated with level of effort activities and fixed costs that will be incurred until a given piece of work is complete. These costs can include the costs for project management and administration and other direct costs associated with generic facilities, rentals, money, or opportunity lost from the facility not being complete, and other indirect costs not part of the direct production activities.
- **ICE (Independent Cost Estimate)** - A cost estimate, prepared by an organization independent of the project proponent, using the same detailed technical and procurement information to make the project estimate. It can be used to validate the project estimate to determine whether it is accurate and reasonable.
- **ICR (Independent Cost Review)** – An independent evaluation of a project's cost estimate that examines its quality and accuracy, with emphasis on specific cost and technical risks. It involves the analysis of the existing estimate's approach and assumptions.
- **IGCE (Independent Government Cost Estimate)** – The government's estimate of the resources and their projected costs a contractor would incur in the performance of a contract. These costs include direct costs such as labor, supplies, equipment, or transportation and indirect costs such as labor overhead, material overhead, as well as general and administrative expenses, profit, or fee. (Refer to FAR 36.203 and FAR 15.406-1).
- **Indirect cost** - Costs incurred for common or joint objectives which cannot be identified with a particular activity or project.
- **Inflation** - The proportionate rate of change in a general price, as opposed to the proportionate increase in a specific price.
- **Initiation** - Authorization of the project or phase of the project.

- **Integrated project team (IPT)** - A cross-functional group organized to deliver a project to a customer (external or internal).
- **Integrated Safety Management System (ISMS)** - A management system designed to ensure environmental protection and worker and public safety are appropriately addressed in the planning, design, and performance of any task.
- **Legacy Costs-** Costs incurred by an organization in prior years under different leadership or when the entity's priorities and resources were different. While it can refer to other commitments as well, it primarily refers to obligations to pay health care costs and pensions under defined benefit plans for current employees and retirees. Legacy costs are paid as future work, are executed, and add to the total project cost. Newer, less-established entities have few or no problems with legacy costs, because they have less pension and health care liabilities.
- **Level-of-Effort (LOE) –** Baseline scope of a general or supportive nature for which performance cannot be measured or is impracticable to measure using activity-based methods. Resource requirements are represented by a time-phased budget scheduled in accordance with the time the support will likely be needed. The value is earned with the passage of time and is equal to the budget scheduled in each time period.
- **Life-cycle** – The stages of an object's or endeavor's life. A life-cycle presumes a series of beginnings and endings, with each end implying a new beginning. In life-cycle cost or investment analyses, the life-cycle is the length of time over which an investment is analyzed.
- **Life-Cycle Cost -** The overall estimated cost for a particular program alternative over the time period corresponding to the life of the program, including direct and indirect initial costs plus any periodic or continuing cost of operation and maintenance. The sum total of the direct, indirect, recurring, nonrecurring, and other 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 the use of existing sites or facilities, restoration, and refurbishment, costs should be included.
- **Life-Cycle Cost Analysis (LCCA)** - Assessment 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. LCCA considers all costs (capital, operating, and decommissioning expenses for the duration of a project) for various alternative approaches, including inflation and discount rates.
- **Line-item projects** – Projects specifically reviewed and approved by Congress.
- **Major system (MS)** – A project or system of projects having a total project cost of $750 million or greater or designated by the Deputy Secretary as a major system.
- M**anagement reserve (MR)** - Determined by the contractor and represents the amount of the contractor budget used for cost contingency arising from estimate uncertainties and realized risk events within the contractor's contractual obligations. Developed by the contractor after contract award, MR is maintained separately from the performance measurement baseline and is utilized by means of the contractor's change control process.
- **Operations Activities-** Non-capital asset projects and operations that include treatment, stabilization, packaging, storage, transportation and disposition of waste and nuclear materials; the operation of environmental remediation systems such as groundwater treatment systems; post-construction and post-closure care of remediated land burial sites; long-term environmental stewardship including environmental monitoring and institutional controls; and

facility shutdown and deactivation activities. Operations Activities represent both: non-capital asset activities that are project-like with definable start and end dates, discrete scopes of work, and measurable accomplishments; and, routine or re-occurring facility or environmental operations.

- **Operation** - An ongoing endeavor or activity that uses strategic assets for a defined function or purpose.
- **Other project costs (OPC)**- All other costs related to projects not included in the TEC. OPCs will include but are not limited to research and development; pre-authorization costs prior to start of conceptual design; plant support costs during construction; activation and startup; National Environmental Policy Act (NEPA) documentation; PDS; CDR; surveying for siting; and evaluation of Resource Conservation and Recovery Act (RCRA)/Environmental Protection Agency (EPA)/State permit requirements.
- **Parametric Cost Estimating**- This technique uses a statistical relationship between historical data and other variables (e.g., square footage in building construction) to calculate an estimate or activity parameters such as cost, budget, and duration. This technique can produce higher levels of accuracy depending on the sophistication and underlying data built into the model.
- **Performance-based management, contracting, and budgeting** - Cost and performance tied to quantities, establishing a baseline, and regularly reported to assess performance.
- **Performance baseline -**A quantitative expression reflecting the total scope of a project with integrated technical, schedule, and cost elements; the established risk-adjusted, time-phased plan against which the status of resources and the progress of a project are measured, assessed, and controlled; a Federal commitment to OMB and Congress. Once established, performance baselines are subject to change control. The cost portion of a performance baseline represents a project's total project cost after CD 2.
- **Performance Work Statement (PWS) -** A narrative description of contracted products or services which defines the requirements. May be called SOW.
- **Point Estimate -** An Estimate which measures a single numerical value rather than a range of values.
- **Preliminary design** - Continues the design effort using conceptual and project design criteria as bases for project development; develops topographical and subsurface data and determines the requirements and criteria that will govern the definitive design; includes preparation of preliminary planning and engineering studies, preliminary drawings and outline specifications, life-cycle cost analyses, preliminary cost estimates, and scheduling for project completion. Preliminary design provides identification of long-lead procurement items and analysis of risks associated with continued project development and occurs between CD-1 and CD-2.
- **Program** - An organized set of activities directed toward a common purpose or goal undertaken or proposed in support of an assigned mission area and characterized by a strategy for accomplishing definite objectives, which identifies the means of accomplishment, particularly in quantitative terms, with respect to manpower, materials, and facilities requirements. Programs usually include an element of ongoing activity and are typically made up of technology, projects, and supporting operations.
- **Project** - A unique effort that supports a program mission, having defined start and end points, undertaken to create a product, facility, or system, and containing interdependent activities planned to meet a common objective or mission. A project is a basic building block in relation to a program 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 two categories: major system projects and other projects. Projects include planning and execution of construction, renovation, modification, environmental restoration, decontamination and decommissioning efforts, and large capital equipment or technology development activities. Tasks that do not include the above elements, such as basic research, grants, ordinary repairs, maintenance of facilities, and operations are not considered projects.

- **Project execution plan (PEP)** - The plan which establishes roles and responsibilities and defines how a project will be executed.
- **Project Management** - A structure in which authority and responsibility for executing a project are vested in a single individual to provide focus on the planning, organizing, directing, controlling, and closing of all activities within a project.
- **Range (cost estimate range)** – An expected range of costs for a project or its components. Ranges may be established based on a range of alternatives, confidence levels, or expected accuracy, and are dependent on a project's stage of development, size, complexity, and other factors.
- **Reconciliation** - Comparison of a current estimate to a previous estimate to ensure differences between them is appropriate and reasonably expected. A formal reconciliation may include an account of those differences.
- **Resource** - A consumable (other than time) required to accomplish an activity; include real or potential investment in strategic assets including time, money, human, and physical resources. A resource becomes a cost when it is invested or consumed in an activity or project.
- **Review** - Determination of project or system acquisition conditions based on evaluation of project scope, cost, schedule, technical status, and performance in relation to program objectives, approved requirements, and baseline project plans. Reviews provide critical insight into the plans, design, cost, schedule, organization, and other aspects of a project.
- **Risk** - Factor, element, constraint, or course of action that introduces an uncertainty of outcome, either positively or negatively that could impact project objectives. This definition for risk is strictly limited for risk as it pertains to project management applications in the development of the overall risk management plan and its related documentation and reports.
- **Risk register** - Database for risks associated with the project. (Also known as risk database or risk log.)
- **Scope** - The sum of all that is to be or has been invested in and delivered by an activity or project. In project planning, the scope is usually documented (i.e., the scope document), but it may be verbally or otherwise communicated and relied upon. Generally limited to that which is agreed to by the stakeholders in an activity or project (i.e., if not agreed to, it is out of scope.). In contracting and procurement, scope includes all an enterprise is contractually committed to perform or deliver.
- **Sensitivity analysis** - Considers all activities associated with one cost estimate. If a cost estimate can be sorted by total activity cost, unit cost, or quantity, sensitivity analyses can determine which activities are "cost drivers" to answer the question: "If something varies, what most affects the total cost of the project?"
- **Statement of Work (SOW)** – A narrative description of contracted products or services which defines the requirements. May be called PWS.
- **Total Estimated Cost (TEC)** - 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 is not limited to project, design and construction management during conceptual, preliminary and final design; contract modifications (to include equitable adjustments) resulting in changes to these costs; design and construction management reporting; contingency and economic escalation for TEC-applied elements; contractor support directly related to design and construction; and equipment rental and refurbishment.

- **Total Project Cost (TPC)** - All costs between CD-0 and CD-4 specific to a project incurred through startup of a facility, but prior to the operation of the facility. Thus, TPC includes TEC and OPC.
- **Work Breakdown Structure (WBS)** - Product-oriented grouping of project elements that organizes and defines the total scope of the project; a multi-level framework that organizes and graphically displays elements representing work to be accomplished in logical relationships. Each descending level represents an increasingly detailed definition of a project component. Components may be products or services. The structure and code that integrate and relate all project work (technical, schedule, and cost) and are used throughout the life-cycle of a project to identify and track specific work scope. Note: WBS should not be developed or organized along financial or organizational lines. It should be broken into organized blocks of work scope, and scope related activities. Financial and/or organizational identification needs should be attached as separate codes that relate to the WBS element.
- **Work package** - A task or set of tasks performed within a control account.

Appendix A: EM CORPORATE WORK BREAKDOWN STRUCTURE

The organization and work scope of the entire EM program is defined by EM's Corporate Work Breakdown Structure (CWBS) which follows ANSI Standard 748-A, Section 3 for organization and definition of work. The CWBS comprises four hierarchal levels. Level 1, at the highest level, is the EM Program. Level 2 is the site level. Level 2 (Site) is presented in Table A-1 below and identifies each EM site, associated two letter identifier, and is where the majority of EM work is being accomplished or being completed.

Table A-1: EM Corporate WBS

ID.	DESCRIPTION	ID.	DESCRIPTION
AL	Argonne National Laboratory	NT	Nevada Test Site
BC	Consolidated Business Center	OR	Oak Ridge Reservation
BL	Brookhaven National Laboratory	PA	Paducah Gaseous Diffusion Plant
ET	Energy Technology Engineering Center	PO	Portsmouth Gaseous Diffusion Plant
FN	Fernald	RF	Rocky Flats
HQ	Headquarters	RL	Hanford-Richland Operations
ID	Idaho National Laboratory	RP	Hanford-Office of River Protection
LA	Los Alamos National Laboratory	SP	Separations Process Research Unit
LB	Lawrence Berkeley Laboratory	SR	Savannah River Site
MB	Miamisburg Mound	WP	Carlsbad-Waste Isolation Pilot Plant
MO	Moab UMTRA Project	WV	West Valley Demonstration Project

Level 3 uses the PBS numbers implemented in 2003, which are intended to define projects by program areas (i.e., Spent Nuclear Fuel, Tank Waste, D&D, etc.) at each site. EM Management was interested in analyzing costs by program area across the complex to take advantage of economies of scale and to unify program management efforts. The Level 3 PBSs used at EM sites are shown below in Table A-2.

Table A-2: Level 3 Program Baseline Summary Descriptions

PBS No.	DESCRIPTION
0011	Nuclear Materials Stabilization and Disposition which includes the management and disposition of nuclear materials, and includes the safe surveillance and maintenance.
0012	Spent Nuclear Fuels (SNF) Stabilization and Disposition which includes providing safe shipping, receipt, storage, and disposition of SNF and heavy water. The scope includes all programmatic and physical support efforts related to safe receipt and storage of SNF.
0013	Solid Waste Disposition which includes receipt, treatment, storage, and disposal of legacy and newly generated low-level waste (LLW) mixed low-level waste (MLLW), transuranic (TRU) waste, hazardous waste, and sanitary waste. This also includes both contact handled (CH) and remotely handled (RH) wastes.
0014	Liquid Waste Disposition which includes treatment and permanent disposal of radioactive liquid waste (LW) stored in storage tanks, including the management of waste in the Tank Farms through transfers, evaporation, and storage to manage tank space safely and efficiently.
0020	Safeguards & Security which includes protective forces, physical security systems, information and personnel security, cyber security, and law enforcement.
0030	Soil and Water Remediation includes waste regulated under the Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). This also includes the remediation, if warranted, of groundwater and surface water. Non-nuclear facility demolition and disposal (D&D) may also be included under this PBS.
0040	Nuclear Facility D&D which includes the deactivation, decontamination, and decommissioning of surplus EM owned nuclear, radiological, and industrial buildings and structures.

Level 4 contains each site's Analytical Building Blocks (ABB), and each ABB has been identified as either a capital asset project or a subdivision of EM Operating Program. The EM program is primarily managed at the project/activity level (i.e., WBS Level 3). It is at this level baselines are developed, reviewed, and managed. Most projects and activities are associated with a single primary contract, but some have multiple primary contracts. In these cases, there may be more than one contract-specific Contract Performance Baseline (CPB) that makes up a larger program or site-specific life-cycle baseline.

Table A-3:Example EM Corporate WBS Items

Corporate WBS Identifier	Title	Description
EM.RL.0041.A001	River Corridor Closure Project	Capital Asset cleanup project to complete the cleanup of assigned areas within a 220 square mile area located at Hanford, Richland Site Office.
EM.RL.0030.A004	GW Facility D&D	Deactivation and Decommissioning of interim and/or final groundwater cleanup remedies at the end of their life-cycle at Hanford, Richland Site Office.
EM.SR.0014C.A001	Salt Waste Processing Facility	Line item Capital Asset Project at the Savannah River Site.
EM.SR.0020.A001	Safeguards & Security	Site wide protective forces, law enforcement, physical and personal security, nuclear materials security, and related items at the Savannah River Site.
EM.OR.0040.C003	ETTP Main Plant D&D	East Tennessee Technology Park, Main Plant D&D
EM.OR.0013B.A002	LLW & MLLW Disposition	Treat, Store, Dispose LLW & MLLW at the Oak Ridge Reservation.
EM.ID.0013.A003	CH MLLW/LLW Disposition	Treat, Store, Dispose of Contact Handled LLW & MLLW at the EM portion of the Idaho National Lab Site.

Life-cycle cost estimates are critical components of the EM life-cycle baselines. These estimates are formulated for every PBS at every site. These PBSs are organized around specific types of work scope, such as treatment and disposal of waste; remediation of contaminated media; disposition of radioactive and hazardous waste and materials; providing federal oversight to the cleanup program; and performance of long term remedial action (LTRA) once an environmental remedy is in place. Because the scope is complex and the schedules are long term, EM developed multi-decade LCC estimates for the entire program. These estimates help illustrate the size and scope of the cleanup mission and are used to predict EM's total liability for environmental cleanup.

All business processes related to the management of EM's LCC data depend on the quality of EM cost estimates.

Appendix B: EM COST ESTIMATION RESOURCES AND TOOLS

EM provides cost estimators with a variety of tools and resources to facilitate compliance with the aforementioned cost estimation requirements. These include standardized cost estimation frameworks, highly detailed historical cost data records from across the program, commercial and government estimation tools, and a supervisory office devoted to promoting cost estimation excellence within EM.

EM Cost Estimation Tools

EM's cost estimators have access to a variety of industry-standard tools to improve the quality and consistency of cost estimates. These include "parametric" systems for producing preliminary cost estimates based on the broad definition of project parameters, systems for building detailed cost estimates from the ground up based on the cost of each sub-element, databases for labor and materials rates, and records of regional cost factors. Parametric estimation and standard rate tools can be particularly valuable for formulating estimates for future work not yet under contract. By putting the right tools in the hands of professional cost estimators, EM helps ensure the production of quality estimates. In addition to spreadsheets used to develop worksheets and/or various portions of the estimate, the EMCBC OCE uses the following items in its estimating toolkit:

- Environmental Cost Element Structure (ECES)
- Environmental Cost Analysis System (ECAS)
- Remedial Action Cost Engineering and Requirements (RACER ®)

MII, Micro-Computer Aided Cost Estimating System (MCACES), Second Generation (MII). MII is the second generation of the Micro-Computer Aided Cost Estimating System (MCACES)

Table B-4: Cost Estimating Toolkit Summary

Item	Description
Environmental Cost Element Structure (ECES) RE: ASTM-2150	A key to effective cost estimation is to break down large projects into very small discrete work elements and then determine the cost for those individual work elements. To facilitate and standardize this process, EM worked with the Interagency Environmental Cost Engineering Committee (which includes the Navy, Air Force, Environmental Protection Agency, National Aeronautics and Space Administration, DOE, and the Army Corps of Engineers) to develop the Environmental Cost Element Structure (ECES). ECES is a standardized hierarchical list of elements (tasks, items, or products) that may be required to accomplish an environmental cleanup project. Use of this standardized cost element structure by estimators yields many important benefits. Use of the ECES adds a uniform code or identifier, as an extension of the WBS, which allows the costs and secondary parameters associated with work activities to be identified in a uniform and consistent format. It facilitates the review of cost estimates by independent experts, improves rigor and detail of estimates, and allows for effective use of historical data when formulating estimates.

Item	Description
	ADJE2150A Adjunct to E2150 Environmental Cost Element Structure at Levels 3, 4, and 5 and Definitions: The adjunct materials include a table with all five levels of the ECES structure. The descriptions, however, focus on the detailed elements of work established at Levels 3, 4, and 5. The descriptions indicate what items are included and as appropriate, not included for the element and refer to those elements that are more applicable when performing environmental management work. Each detailed element also includes the phase number, a list of subordinate elements, supplemental notes as required, and units of measure (UOM). ASTM E2637-13 Standard Guide for Utilizing the Environmental Cost Element Structure Presented by Classification E2150: The Environmental Cost Element Structure (ECES) covered by Classification E2150 (and Adjunct E2150) provides a consistent and comprehensive structure across all phases of environmental remediation projects and is a tool to improve the cost management of those projects. This guide is intended to facilitate the application of the ECES to any environmental remediation project, without regard to project size. Although it is assumed the user is familiar with Classification E2150, much of the content of the classification is repeated in this guide to relieve the user of the burden of back-and-forth referencing during use. It is assumed, however, all users of this guide will have at hand both Classification E2150 and the Adjunct E2150.
Environmental Cost Analysis System (ECAS)	It is essential for EM to effectively document and learn from operational experiences over the last two decades. To leverage historical cost information to support the formulation of today's cost estimates, EM developed the Environmental Cost Analysis System (ECAS). This system uses commercial-off-the-shelf (COTS) software developed as a database to store historical cost data for EM projects activities in the areas of facility decontamination and decommissioning, environmental remediation, nuclear materials, and waste management. ECAS is still under development and currently includes over 270 projects in a standardized format for cost and non-cost secondary parameters providing details on the projects. Importantly, the data is stored based on the standardized ECES, which facilitates the use of historical data to estimate costs for current projects and activities by allowing a crosswalk of similar activities between projects. ECAS helps EM cost estimators produce high quality, consistent cost estimates that reflect lessons learned from experience. ECAS was developed in its current form by the EMCBC Office of Cost Estimating and is maintained by the EMCBC Office of Information Resource Management.
Remedial Action Cost Engineering	RACER software is a windows-based environmental remediation/ corrective action cost estimating system. RACER uses commercial-off-the-shelf (COTS) developed software adapted to estimate all phases of environmental

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and Requirements (RACER ®)	remediation projects from site investigation through site closeout. The system enables users to develop and update cost estimates; evaluate and compare the cost of various treatment options; quantify environmental liability for budgeting or regulatory/ financial disclosures; and develop a consistent approach for project budgeting. The system is used by DOE, the Department of Defense (DOD), Department of the Interior (DOI) and the Environmental Protection Agency (EPA). The EMCBC Office of Cost Estimating maintains the RACER licenses for EM.
MII, Micro-Computer Aided Cost Estimating System (MCACES), Second Generation (MII)	MII is the second generation of the Micro-Computer Aided Cost Estimating System (MCACES). MII is one of several modules of an integrated suite of cost engineering tools called Tri-Service Automated Cost Engineering Systems (TRACES). It interfaces with other Personal Computer based support modules and databases used by the Tri-Service Cost Engineering community. MII provides an integrated cost estimating system (software and databases) that meets the U.S. Army Corps of Engineers (USACE) requirements for preparing cost estimates. MII is the preferred cost estimating software tool for EM estimates. The EMCBC Office of Cost Estimating maintains the MII licenses for EM.