

FAA Life Cycle Cost Estimating Handbook

2.0 OVERVIEW OF COST ESTIMATING

2.1 Introduction

This chapter, along with Chapter 3, “Process and Methodology,” provides a basic overview of the cost estimating discipline. These chapters set the stage for more specific chapters by addressing the following questions:

- What is cost estimating?
- Why is it needed?
- When is it needed?
- How is the type of estimate defined?
- How is the estimate accomplished?

2.2 Cost Estimating Defined

Defining key cost estimating terms helps answer the question “What is cost estimating?” As presented in Chapter 1, the SCEA defined cost estimating as the art of approximating the probable cost or value of something based on information available at the time.

When an operational requirement is identified that calls for an acquisition of systems, software, facilities or services, FAA decision makers require estimates of all sorts - operational capability, technical characteristics, logistics requirements, schedules, and, of course, cost. A realistic cost estimate is an essential element in the decision making process because it can help decision makers determine the optimal course of action necessary to meet operational requirements. The cost estimate distills information into the common denominator of dollars. Whether cost estimating is viewed as an “art” or a “process,” its purpose is to predict future costs based on today’s knowledge. The rest of this handbook describes, in detail, the development of cost estimates to support FAA decision makers. This chapter addresses basic cost categories, types of cost estimates, and uses of cost estimates.

2.3 Cost Categories

To further define cost estimating, the reader is introduced to common terminology. The jargon of any profession enhances communication, so it is important for estimators to have common definitions and an understanding of cost estimating terms. This section defines well-known cost categories. Grouping costs into common categories satisfies different needs for cost data. For instance, depending on the decision at hand, management may want to see cost estimates categorized by phase of the life cycle (e.g., solution implementation phase versus the in-service management phase), frequency of occurrence (nonrecurring versus recurring), by cost allocation scheme (direct versus indirect), or by appropriation.

2.3.1 Life Cycle Cost (LCC)

To make intelligent acquisition decisions for the selection of a system to fulfill a specific need, it is necessary to look beyond the immediate cost of acquiring that system, software, facilities, or service. Suppose you are in the solution implementation phase of a given procurement and are considering various alternatives. To assist decision makers with an investment decision, should the estimate consider only the costs of the solution implementation phase? If this is done without considering in-service management phase costs, what may appear to be an expensive alternative among competing systems may be the least expensive when the cost of operating and supporting each is considered. For this reason, it is important to consider all relevant costs or each acquisition's LCC when making acquisition decisions. An acquisition's LCC has been captured when the estimate includes the total costs to acquire, install, operate, maintain, and dispose of it.

LCC elements reflect the program life cycle. Typically, there is an overlap of life cycle phases, but the costs can be identified with a certain phase based upon the effort they reflect. The acquisition portion of the life cycle is complete when a system is placed into operation. Therefore, total program acquisition costs refer to those costs incurred in the solution implementation phase. Because of shortfalls in available FAA O&M funds, acquisition costs may include the purchase of an initial set of spare and repair parts (one to three years supply), even though these costs really should be considered a part of the in-service management phase. When the user takes ownership of the system or services, the ownership or in-service management phase begins. Costs incurred in this period consist of operating and maintenance costs.

For example, the manpower cost for an air traffic control terminal is an operating and maintenance cost. This cost occurs day after day and year after year, as the air traffic controller uses the terminal. The effort expended to design and build that terminal is a program acquisition cost, incurred once to buy the system. The following paragraphs discuss these standard cost definitions in more detail.

Solution Implementation Costs

The activities conducted during solution implementation vary widely depending on the nature and scope of an acquisition program. For example, the activities associated with buying and deploying a commercial product may be much less than those associated with a product requiring development, if the product is not safety-critical in its FAA application. Conversely, if the product is needed in an FAA safety-critical application, there are significant costs associated with proving the safety and effectiveness of the COTS product that may well more than offset the cost advantages accruing from the economies of scale in the commercial market. The FAST contains generic process flowcharts for representative types of acquisition programs. (The FAST can be accessed via the Internet at <http://fast.faa.gov>.) Also included are instructions, templates, best practices, examples, and lessons learned. The types of cost elements in an estimate will depend on the type of acquisition program.

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Acquisition Costs

The costs incurred during solution implementation fall into the broad category of acquisition costs. Depending on the type of acquisition (developmental, non-developmental, etc.), this category may or may not include research and development costs and production/installation costs.

NOTE:

Estimates generally are disaggregated into Acquisition and Operating and Maintenance pieces because the estimating methodologies for each phase tend to differ substantially.

Research and Development Costs. Requirements definition costs will be incurred for any kind of acquisition, developmental or non-developmental. If the FAA is purchasing a developmental item, it will incur costs of the following nature.

- Requirements definition
 - ⇒ Costs of defining mission need, preparing requirements documents, etc.
- Concept analysis
 - ⇒ Costs of identifying alternative system concepts and design approaches
- Design and demonstration
 - ⇒ Costs to design, produce, and test alternative engineering models
- Full scale development
 - ⇒ Engineering design, fabrication, manufacture, and test of development articles and related support
 - ⇒ Government test and contractor support
 - ⇒ Software development

Production and Installation Costs. Production cost includes the costs associated with the purchase of off-the-shelf or non-developmental items or the production of developmental items in the quantities required to support FAA objectives. Normally, the production category would include costs associated with the following:

- Government and contractor program management
- Land
- Real property improvements
- Prime mission products (equipment, software, services, etc.)
- Peculiar support equipment
- Common support equipment
- Equipment installation and test
- Software installation and test
- Initial stocks of consumables and spares
- Maintenance training of initial cadre of maintenance personnel
- Training of initial cadre of system operators
- Data

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In-Service Management Costs

Operating & Maintenance (O&M) Costs

The in-service management phase of the life cycle includes ownership costs of the operating and maintenance type. These costs start with system delivery and continue throughout its operational life. The following list identifies the majority of O&M cost elements. A more detailed explanation of this cost category can be found in Chapter 13.

Operating Costs. This cost area includes those costs incurred to operate a system, such as:

- Personnel
- Consumables
- Energy and utilities
- Facilities
- Telecommunications
- Computer service costs
- Training
- Travel

Support Costs. This cost area includes those costs required to maintain a system, such as:

- Personnel
- Consumables
- Energy and utilities
- Facilities
- Telecommunications
- Computer service costs
- Spares and support equipment
- Packaging, handling, and transportation
- Training
- Travel

Disposal Costs

These are the final costs incurred to terminate a program at the end of a system's life cycle. They include dismantling costs of all kinds, transportation and packaging costs to ship old assets from the dismantled site to the disposal site, site restoration costs, environmental cleanup costs, hazardous waste disposal costs, and storage costs for assets removed from an operational site prior to disposal.

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2.3.2 Nonrecurring and Recurring Cost

Nonrecurring costs are the capital expenses incurred prior to the production of the first unit of output. For example, nonrecurring costs could include initial engineering, system test, tooling, and pre-production activities. These capital costs exclude prepaid materials, supplies, and parts used to produce a unit of output. Nonrecurring costs can be defined broadly (program nonrecurring), or narrowly (nonrecurring costs on a specific contract). Whether narrowly or broadly defined, the one-time nature of nonrecurring costs is what distinguishes them from recurring costs.

NOTE:

A separation of nonrecurring and recurring costs is useful if costs of continued production are expected to be required at a later date (e.g., building a learning curve for future production estimates).

Recurring costs are the ongoing costs required to generate the first unit of output or acquire the first item and to operate and maintain the proposed system. These costs may occur either annually or periodically over the system's life. The major types of recurring costs are commercial acquisition costs, production costs, technology refreshment costs (i.e., periodic replacement of COTS components to ensure supportability), personnel costs, consumables, energy, and utility costs. These are repetitive in nature and occur when there are like costs on a repetitive basis. They are similar to variable costs because they vary based on quantity acquired. Recurring costs can be defined broadly (program recurring) or narrowly (recurring costs on a specific contract).

2.3.3 Direct and Indirect Costs

The above cost categories can be defined further as either direct or indirect costs. A direct cost is any item of cost that can be identified specifically with one end objective such as a product, service, program, function, or project. These costs may be charged directly to a given contract charge number. For example, if a company produces filing cabinets for sale, the sheet metal used to form the cabinets would clearly be a direct cost associated with the cabinets, and with no other product.

NOTE:

Estimating methods tend to differ for direct versus indirect costs, just as they do for other categories of cost.

Conversely, an indirect cost is a cost that cannot be specifically and consistently identified to direct work orders. Indirect costs are also known as overhead or burden. They are accrued and accounted for in cost pools, and allocated to end products or services over a direct cost base, such as dollars or hours. A typical example of an overhead cost is facility power. Lights and heat must be available to keep a building operating, regardless of what particular projects are in work. Therefore, this cost is allocated in a consistent, objective manner to all projects in work for a given period of time. For an estimator, this means that indirect costs will be calculated by applying an overhead rate to a direct cost base. For example, factory overhead (such as utilities) may be applied to the direct manufacturing hours or dollars expended on all jobs in the factory.

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Each company will have different cost accounting methods, but it is very common to see costs segregated into direct and indirect categories. The cost estimator must be aware of these categories, since both play a sizable role in a typical estimate. This type of cost breakout is especially important during source selection. Competing contractors will have different rates and allocation bases and government analysts need to understand how the rates are applied in order to do a correct cost analysis of these contractor proposals.

2.3.4 Fixed and Variable Costs

A common way of classifying costs is to break them into fixed and variable costs. In particular, this classification of costs is used in doing break-even analysis, such as in making an investment decision.

In his book, *Cost Estimator's Reference Manual*, Rodney Stewart defines fixed cost as that group of costs involved in a repetitive process that remain relatively constant

regardless of the quantity of output. For example, general plant maintenance costs tend to be fixed from month to month, regardless of how many units are produced in a given month. Machine maintenance costs will also be fixed up to a point, but clearly will be affected more by quantity of output being processed on the machine. This might be considered a semi-fixed cost. The timeframe of consideration for a given analysis will affect the classification of costs as fixed or variable (in the long run all costs are variable).

NOTE:

In some analyses, an estimator may want to determine the effect of rate of production on costs, such as when the government proposes stretching programs out in order to live within current funding constraints. In this scenario, it would be necessary to be able to break costs into fixed and variable categories.

Variable costs are those that vary in direct relationship to the rate of output. Following through on the plant example used above, a clear variable cost would be the amount of labor hours expended in a machining process. Those labor hours are expended only if output goes through the machining process.

2.3.5 Costs Categorized by Appropriation

NOTE:

There is overlap among all the cost categories. An experienced cost estimator will recognize the nuances among the categories. For example, nonrecurring costs are those costs generated to incur the first item of output. Thus, they include many costs in the fixed category like plant construction and tooling. However, they also include variable costs of labor and material to produce the first unit of output. Classifying costs as recurring versus nonrecurring facilitates the use and development of learning curves, a method discussed in Chapter 9. Classifying costs into fixed and variable categories is essential to doing a break-even analysis to determine if an investment is advisable.

Cost estimates are prepared at various stages of the acquisition process, but ultimately will be used to justify funding for an acquisition. In other words, the cost estimate eventually will have to be compared to a budget to see if an acquisition is affordable. Thus, there is a need to categorize cost estimates by budget category. For a government agency, this means cost estimates will have to be presented by appropriation since that is how Congress allocates money to agencies. The FAA has four appropriations, already mentioned in Chapter 1: the Research,

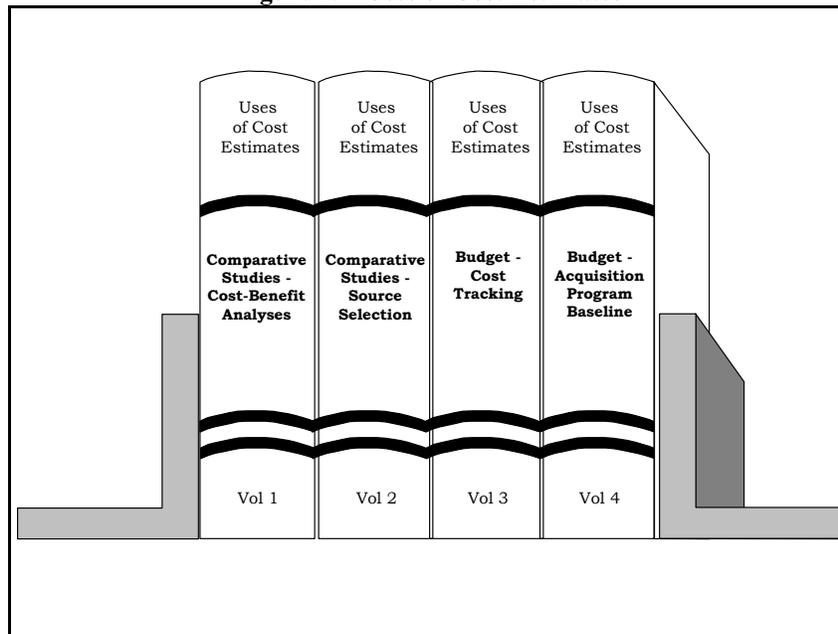
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Engineering, and Development (RE&D) appropriation, the Facilities and Equipment (F&E) appropriation, the Airport Improvement Program (AIP), and the Operations (OPS) appropriation.

2.4 Uses and Types of Estimates

The previous paragraphs provided a brief definition of cost estimating and described various categories of costs the cost estimator is likely to encounter. This narrative answered the question “What is cost estimating?” Now to the question “Why and when is cost estimating needed?” The answer is straightforward. In spite of all the names and labels ascribed to various estimates, they fall into two major “use” categories: comparative studies for planning purposes and budget estimates that allow plans to be translated into action. These uses dictate when estimates will be prepared. Comparative studies are done when there is a new mission need, a revalidation of an existing mission need, or such a change in program that it makes sense to evaluate alternative solutions to the mission need. Figure 2.1 presents a high level view of how cost estimates are used. Each of these uses will be discussed below.

Figure 2.1 Uses of Cost Estimates



The use of an estimate at a particular point in time depends on where a program is in its life cycle. If a program is in the investment analysis phase, estimates will be prepared to support that decision making process. Once decision makers choose a course of action, they must translate estimates into an APB to manage the program and into a budget in order to obtain funding. Many estimates eventually turn into budget estimates.

The requirements of the mission need drive costs. Comparative studies during the investment analysis phase are particularly useful in that they can help avoid “requirements creep” by focusing attention on the cost impact of those requirements. But programs are not stagnant; and requirements creep, changes in mission need, and enhanced technologies are facts of life. The FAA AMS has published a number of guiding principles, which include evolutionary product

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improvement and faster insertion of new technology. To support these principles, cost estimating is an ongoing process throughout the life of a program. It is an overriding input during the investment analysis phase, but requirements for cost estimates will continue during other phases as the need arises - if there is a program change due to a new technological development, a service life extension decision, or a baseline breach. The following paragraphs discuss each “use” category in more detail.

2.4.1 Use Category 1: Comparative Studies (Alternatives Analysis)

Comparative studies or alternatives analyses are an integral part of any investment analysis since they provide decision makers with the information they need to make good choices. Decision makers face various options in trying to solve problems. Comparative studies are designed to provide decision makers with the information they need to choose among these options. Typically, these studies involve technical, performance, and cost comparisons. In comparative studies, the cost estimate is a valuable tool and is often the critical selection criterion.

Comparative studies are particularly valuable in the early stages of planning when the primary objective is to establish an efficient and economical course of action, i.e., in the investment analysis phase. However, comparative studies are not restricted to the early planning activities and, in fact, are used throughout all phases of a system’s life cycle. Even after a system has been in operation, comparative cost studies (called “trade studies” by systems engineers) are often the determining factor in deciding whether to modify a system to increase its performance and life (service life extension) or to acquire a new system. Comparative studies also are used in selecting various in-service management phase choices, such as whether to use in-house or contractor support. Comparative studies are used in source selection when the decision rendered is translated into a contractual obligation. In source selection the government must have an independent government estimate to assist in the best choice of contractor.

2.4.2 Use Category 2: Program Execution

Cost estimates used for the comparative analysis will become refined at some point in the acquisition life cycle to allow management of the actual execution of the approved program. In other words, once a decision has been made to select one of the alternatives used in a comparative study, money will be made available to give the program life. The next major “use” category for estimates can be defined as program execution. Once the decision has been made to pursue a certain course of action, the IPT will establish an acquisition program baseline that includes the life cycle cost estimate of the program. Management will measure progress of a program by comparing actual performance against the cost, schedule, and technical baseline in the acquisition program baseline. As the program moves through different life cycle phases, the acquisition program baseline is updated to reflect the current program. If there is a baseline “breach,” a “mini” investment analysis is triggered. The affordability assessment process allows funding to be made available to translate plans into action. Since this program execution process is ongoing, the IPT is wise to structure the acquisition program baseline estimate to allow for easy “what-if” drills. This will make affordability assessments easier to calculate when requirements may be reduced or stretched out to accommodate reduced budgets.

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Many cost estimates start as decision making tools at major program decision points and end up as the foundation for acquisition program baselines and budget estimates. The primary differences between an estimate prepared for comparative studies and one prepared for budget purposes are in the detailed time phasing of costs. The budget estimate is more detailed, and time phasing is more involved and precise. Also, budget estimates must display costs by appropriation, which is how Congress allocates money to accomplish its objectives.

2.4.3 Types of Analyses and Estimation

The following types of cost estimates can be used for comparative studies and as the basis for program execution estimates. In fact, the IPT estimator or budget analyst should be able to reconcile the most current cost estimate in the APB with the budget estimate.

Cost Benefit Analysis

The Cost Benefit Analysis (CBA) is an integral part of the Investment Analysis Report developed in the investment analysis phase. The CBA analyzes the relationship between LCC and the operational benefits and cost savings of concepts or alternatives that are technically feasible and can meet the mission need. The purposes of the CBA are to:

- Facilitate decision making among decision makers and staffs, at all levels, by early identification and discussion of all reasonable concepts and alternatives to meet mission need;
- Determine whether a program is justified economically;
- Aid decision making by indicating clearly the relative advantages and disadvantages of the concepts/alternatives being considered; and
- Document acquisition decisions by providing the analytical underpinning or rationale for decisions on a program.

The CBA must contain an LCC estimate for each alternative and the reference system identified as candidates to satisfy the mission need. The CBA also contains an analysis of the benefits of each alternative. Finally, the CBA will present certain financial measures or ranking criteria to assist the decision maker in choosing among the alternatives. A separate chapter on how to prepare a CBA is included in this handbook.

Acquisition Program Baseline

The APB is the contract between the providing and user organizations concerning what the acquisition program will provide, how much it will cost, and when it will deliver products and services. It defines the performance, supportability, and benefit requirements of the program and sets the cost and schedule boundaries within which the program is authorized to proceed. The APB is established at the Investment Decision and represents the solution chosen by the JRC.

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The APB contains a performance baseline that defines mission-critical performance parameters, a schedule, a benefits baseline, and a cost baseline. The cost baseline includes a time-phased life cycle cost estimate and a funding baseline. The funding baseline is included in the NAS Architecture. Both the funding and life cycle cost baselines are presented as a single “ceiling” value. They include all costs (RE&D, F&E, and OPS) that will be spent on the system over its entire life. The life cycle costs are broken out by year, WBS element, and life cycle phase.

Independent Government Cost Estimate

Once the investment decision is rendered, the government actively begins to translate the requirements into contractual obligations. Requests for proposal are issued to industry and source selection occurs. The government should then prepare an Independent Government Cost Estimate (IGCE) of the most probable cost of contracting with industry for a given product, service, or mission (sometimes called the “should cost” estimate).

2.5 Summary

This chapter defined cost estimating, discussed the importance of a cost estimate in the FAA decision making process, and identified cost categories as they relate to acquisition program phases. Also, the two basic uses of cost estimates (comparative studies and program execution studies) were addressed, and different types of cost estimates were discussed. The chapter answered the first four questions posed in the introduction. The final question, “How is the estimate accomplished?” will be answered in Chapter 3, “Process and Methodology.”