1.0 COST ESTIMATING ENVIRONMENT

1.1 Introduction

With the advent of the Acquisition Management System (AMS) within the FAA came a new emphasis on investment analysis and cost estimating. The FAA was directed, in response to Section 348 of the 1996 Department of Transportation (DOT) Appropriations Act, to:

> *"develop an acquisition management system that addresses the unique needs of the agency and, at a minimum, provides for more timely and cost-effective acquisition of equipment and materials."*

The FAA AMS emphasizes certain guiding principles that impact heavily on the cost estimator. For example, emphasis is placed on full life cycle partnership between the acquisition and operational workforces; in-depth, comprehensive analysis of alternative solutions to mission needs; stable performance, cost, schedule, and benefit program baselines; and unified agency planning, programming, and budgeting within a long-range strategic framework.

These principles mean that cost estimates generally will be in life cycle terms. It also means that estimates will occur at major points in the life cycle of a program such as during mission analysis, investment analysis, or when there is a breach to the established program baseline. The cost estimate is a major consideration at the investment decision, when decision makers must choose among competing alternatives for limited resources. It is also the basis for the Acquisition Program Baseline (APB), the National Airspace System (NAS) Architecture, and the budget request. In fact, the cost estimate and the budget it supports are the traditional "yardsticks" by which program affordability, progress, and success are measured.

The life cycle processes addressed in the AMS revolve around and focus on the cost (estimate) of an item and the availability of adequate funding levels at the proper time. In other words, a reasonable and supportable budget is essential to the efficient and timely execution of acquisition programs. Such budgets are founded on competent estimates developed by the cost estimating community. Once management has approved the budget and its underlying estimate, they will measure the performance of programs in relation to this cost position. Therefore, it is mandatory that estimates accurately reflect program financial requirements. A less than competent estimate can impact a program's viability seriously.

The Society of Cost Estimating and Analysis (SCEA) provides the following definition of cost estimating: "The art of approximating the probable cost or value of something based on information available at the time." In practice, cost estimators usually focus on longer-term projections, such as developing program cost estimates prior to an investment decision. This handbook focuses on providing the cost estimator with the essential tools needed to support the FAA cost estimating requirements as outlined in the AMS.

1.2 Acquisition Policy

The federal government and airport service users pay for FAA's multi-billion dollar major system acquisitions. With such a taxpayer investment at stake, it is not surprising that numerous policy statements and rules exist regarding the acquisition of these systems. Acquisition policy is designed to instill discipline and sound management into the acquisition process. As stewards of public moneys, it is incumbent upon each individual cost estimator involved in the acquisition of these systems to assure that taxpayer dollars are spent prudently.

1.2.1 Executive Acquisition Policy

Public Law 104-50 directed the FAA to develop an AMS to address the unique needs of the agency. The law exempts the FAA from many acquisition regulations, including the Federal Acquisition Regulations, although the FAA has the discretion to adopt the portions of acquisition law into its system, as the FAA deems appropriate.

1.2.2 FAA Policy

The FAA AMS is a fully coordinated set of policies, processes, guidelines, and computer-based tools that guides the acquisition workforce through the entire acquisition life cycle. The FAA Acquisition System Toolset (FAST), an online information system available via the Internet (http://fast.faa.gov), provides access to the AMS. It is important for the cost estimator to be familiar with the AMS.

1.3 FAA Life Cycle Acquisition Management Process

The preceding discussion highlighted the policy that spawned the FAA life cycle acquisition management process. The process itself is a logical flow of activity that represents an orderly progression from the identification of a requirement through the disposal of the system that satisfied the requirement. This section provides a definition for an FAA program, identifies the acquisition decision makers, and outlines the life cycle acquisition process. The role of the FAA cost estimator is highlighted throughout the discussion.

1.3.1 The Program

The term acquisition program is defined in the FAA AMS as:

> *"a sponsored, fully funded effort initiated at the investment decision of the life cycle acquisition management process by the Joint Resources Council (JRC). An acquisition program is created in response to an approved Mission Need Statement. The goal of an acquisition program is to field a new capability that satisfies requirements, cost, schedule, and benefits stated in an Acquisition Program Baseline. Typically an acquisition program is a separate budgeted line item and may have multiple procurements and several projects, all managed within the single program."*

The FAA has three major categories of acquisition programs: systems and software, services, and facilities. Within the three categories, there are different types of acquisition programs with tailored processes (e.g., simple purchases of commercial equipment, non-developmental item hardware with developmental software, full developmental programs, leased services, major new facilities, and modification of existing facilities). An understanding of the type of program is crucial in developing a cost estimate. Simply stated, the choice of estimating methodology and the availability of data will be influenced greatly by the type of acquisition program. For example, a simple purchase of commercial equipment is much easier to estimate than a full developmental program. Estimating the cost of commercial equipment may involve research to obtain price quotes from vendors and some analysis, perhaps to adjust for quantity discounts and/or inflation. On the other hand, estimating the cost of a full developmental program may require the formulation of many ground rules and assumptions, an extensive data collection effort, the development of mathematical models, and detailed risk analysis.

The FAA AMS stresses commercial and non-developmental solutions to mission needs and provides a framework for evolutionary development so the upgrade of complex systems can be done efficiently and cost effectively. There is an emphasis on pre-planned product improvements (P3I). Hence, the estimator can expect to see activity in this area of estimating.

1.3.2 Acquisition Decision Makers

A key element in the FAA acquisition reform process was to place decision making and accountability at the appropriate level. The approach adopted is one of centralized policy decision making and decentralized program execution. This approach was designed to provide for both program stability and efficient execution. The following discussion identifies the key decision makers and the role of the cost estimator within the context of the FAA acquisition life cycle.

The Joint Resource Council (JRC) makes corporate level investment and resource allocation decisions, based on investment analysis prepared by an Investment Analysis Team (IAT). The JRC focuses on such corporate level issues as mission need decisions to determine what capability the FAA will pursue; investment decisions; APB change decisions; approval of the FAA Research, Engineering & Development (RE&D) and Facilities & Equipment (F&E) budget submissions; participation in the development of the FAA operations budget submissions; and approval of the NAS Architecture baseline. The corporate level nature of the decisions the JRC makes requires corporate level membership. As such, the JRC has as its members: Associate Administrators of the FAA lines of business, the Acquisition Executive, the Chief Financial Officer, Legal Counsel, and some Assistant Administrators.

The JRC is assisted in the investment analysis phase by many organizations. The major players are the Investment Analysis Staff (IAS), the Systems Engineering/Operational Analysis Team (SEOAT), and the IAT. Each of these teams is discussed in more detail below.

In recognition of the importance of the investment decision to the future of the NAS, the FAA created an Investment Analysis Staff to coordinate the activities in the investment analysis process and be the center of the agency's cost estimating capability. The IAS provides standards and guidance for the investment analysis, including how cost estimates are to be prepared. The IAS also is responsible for the FAA's investment corporate history (repository for cost data) and for developing tools and techniques for cost estimating. The Director of the IAS determines readiness for an investment decision and approves the Investment Analysis Report (IAR), which is presented to the corporate decision making body, the JRC.

An IAT is an ad hoc team assembled for each specific investment analysis. It draws experts from the IAS, sponsoring FAA organizations, the Integrated Product Development System, and other organizations. This team conducts the detailed analysis of alternatives during the investment analysis phase.

The SEOAT is a team of senior level managers representing the FAA's lines of business, systems engineering, and other appropriate acquisition functional disciplines responsible for supporting the JRC in establishing and maintaining year-round prioritization of all ongoing acquisition programs, performing affordability assessments for new proposed programs, preparing annual budget submissions, and preparing recommendations for reprogramming of funds. The SEOAT plays a crucial role during the investment analysis phase as the organization responsible for the affordability assessment.

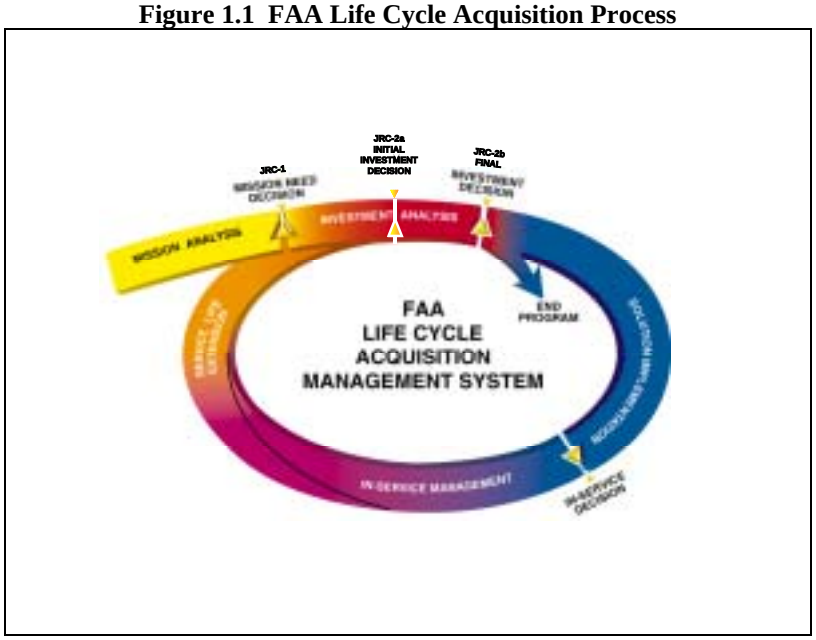
The cost estimator plays a key role during the entire acquisition process, but clearly the estimator's role is highlighted during the investment analysis phase. The Integrated Product Teams (IPTs) and the Product Team (PT) will need estimators to represent them on the IAT, specifically to help them build the life cycle cost estimates for their candidate solutions. The dedicated IAS consists of professional cost estimators, so the estimator will be involved in the full range of this organization's activities, including support to the IAT during investment analysis, and building databases, estimating tools and techniques, and standard agency-wide estimating guidelines.

1.3.3 Life Cycle Acquisition Phases

A brief description of each acquisition phase follows. The focus here will be on major cost estimating activities and products to which cost estimates are input during each phase. For an in-depth discussion of the acquisition life cycle, the reader should consult the FAA AMS document, available through the FAST. The FAST also includes detailed process descriptions of each of the life cycle phases.

The life cycle acquisition process is organized into a series of phases and decision points. This process is depicted in Figure 1.1. The process is shown as circular to convey the idea that a mission need is defined and then translated into the most advantageous solution, which goes through a continuous loop of evolution and improvement until it is retired.

Figure 1.1 FAA Life Cycle Acquisition Process



The life cycle acquisition process starts when the FAA determines that there is a potential need to expend funds to meet a mission capability shortfall or to take advantage of a technological opportunity. This determination is made at the conclusion of the mission analysis phase. Once the mission need is approved, the process of investment analysis starts. Cost estimating activities are conducted and products prepared to support two decision points of the investment analysis phase. The JRC 2a decision point, known as the initial Investment Decision, requires an initial IAR, initial APB, initial Requirements Document (RD), initial Acquisition Strategy Paper, and Action Plan/Exit Criteria for the final Investment Decision. In support of the initial Investment Decision, the FAA collects cost, schedule, benefits, human factors, and safety data, and conducts an alternatives analysis. This analysis is documented in the IAR and includes life cycle cost estimates of each candidate solution. The analysis is also used to develop the APB. At this decision point, the JRC selects a candidate solution for implementation; however, there is no variance tracking performed against the initial APB. During the JRC 2b decision point, known as final Investment Decision, the cost estimators address the Action Plan/Exit Criteria, refine APB parameter estimates, and collect operational data in order to finalize the documents prepared in support of the initial Investment Decision. Remember that an alternative has been selected, so the data at this point is focused on that selected alternative. At the final Investment Decision, the APB is approved and the program has an official baseline. From that point on, variance tracking is conducted. The process then moves out of the planning and into the execution phases of the life cycle. Corporate level decision making is still required when there are breaches to the APB established at the Investment Decision, or significant program changes.

The execution phases consist of solution implementation, in-service management, and service life extension. During solution implementation, the approved alternative is fielded. This phase may be a lengthy, complicated phase with activities ranging from full development and production of new systems to integration of off-the-shelf equipment into the NAS Architecture. During the in-service management phase, the solution is operating in the field. This phase lasts as long as the product is in use. During this phase, IPTs have great flexibility for sustaining and

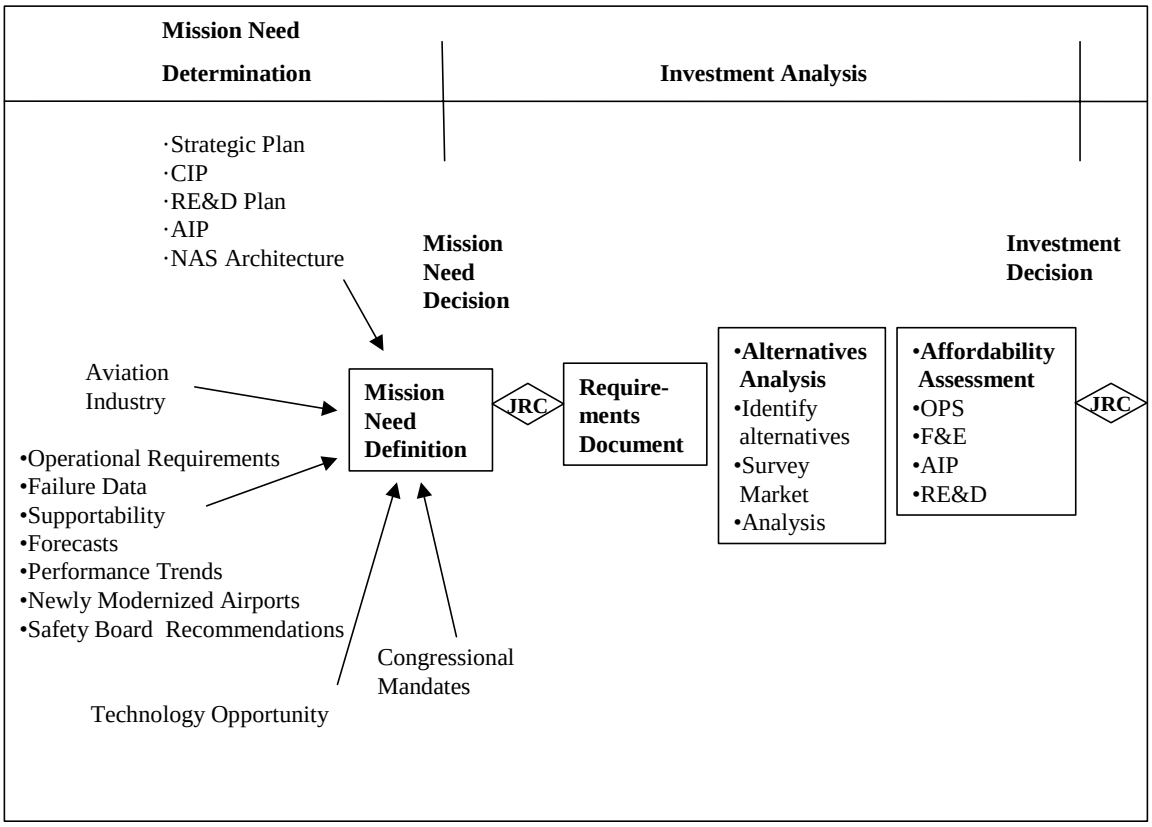
enhancing the fielded capability without the need for corporate level approval. Pre-planned product improvements may be implemented as stipulated at the Investment Decision. Sustainment resources may be used to upgrade fielded products. The objective is evolutionary product development and rapid insertion of new technology. The service life extension phase starts when the FAA projects that the current capability will be unable to satisfy demand for services or when another solution offers potential for improving safety, lowering costs, or improving effectiveness. This should trigger action to support the investment analysis process leading to a new investment decision. With this, the loop is closed; and the acquisition life cycle has come full circle.

Mission Analysis Phase

Performing mission analysis requires an overall understanding of NAS Architecture, Congressional mandates, and FAA strategic plans. Mission analysis is done by each of FAA's lines of business: Air Traffic Services, Commercial Space Transport, Regulations and Certification, System Safety, Airports, Administration, and Research and Acquisition. As shown in Figure 1.1, mission analysis is depicted off of the main life cycle path to underline that it is a continuous. The front-end acquisition process is an independent process from which needs emerge and is outside the environment of individual program execution. Mission analysis is the comprehensive process undertaken to identify and prioritize the most critical FAA service deficiencies. Each need is documented in a Mission Need Statement (MNS). The MNS clearly describes the capability shortfall and the impact of not satisfying the shortfall. It also assesses the criticality and timeframe of the need. All of this information assists the FAA in prioritizing the need in conjunction with other agency needs and in determining which needs to approve for the next step in the process, investment analysis. This process is depicted in Figure 1.2.

Cost Estimator's Role in Mission Analysis

Figure 1.2 The Front-end Acquisition Process



During the mission analysis phase, cost estimators will be called upon to assist in determining a range of rough order of magnitude life cycle cost estimates to serve as "placeholders" representing the mission need in the NAS Architecture. Also, the estimator can expect to be involved in assisting with the quantification of the benefits for satisfying the mission need. Examples of how to quantify such benefits include number of lives saved and reduced equipment downtime. Furthermore, the FAA AMS states that the cost of not addressing the need should be estimated.

Investment Analysis Phase

As shown in Figure 1.2, the receipt of an approved MNS starts the activities identifying the most advantageous solution. This is known as the investment analysis phase. Investment analysis generates the information used by the JRC to determine the best overall solution for satisfying a mission need, called the Investment Decision. Principal investment analysis activities are to:

- Determine initial requirements
- Finalize requirements
- Identify alternatives and survey market
- Determine viability of nonmaterial solutions
- Analyze alternatives

- Assess affordability,
- Develop APBs
- Prepare the IAR
- Select an optimal solution
- Initiate a program

An agency decision on whether to fund and implement the selected solution completes the investment analysis phase.

Cost Estimator's Role in Investment Analysis

The cost estimator contributes significantly in this phase. The IAS, serving as the FAA's cost estimating center, leads the effort to identify and analyze candidate solutions that satisfy the mission need. As a member of the IAT, cost estimators from the IPT, assisted by estimators from the IAS, will develop life cycle cost estimates of the candidate solutions. Also, they will be involved heavily with the cost benefit analysis of all candidate solutions. The estimator's input will be a significant piece of the IAR, which goes to the JRC for selection of the solution. Each organization represented on an IAT has a role in developing an APB. The APB includes the cost, schedule, performance, and benefit baselines that each candidate solution is intended to achieve. During this phase, an affordability assessment is developed by the SEOAT, which compares the life cycle cost estimates to the NAS Architecture estimates developed during mission analysis. Only affordable solutions that fall within the boundaries of the NAS Architecture range of estimates go forward to the JRC.

Cost Estimating Products from Investment Analysis

The investment analysis products that are used in future phases and that have heavy cost estimating input are the IAR; the APB (for performance, cost, schedule, and benefits) for the selected solution; the Basis of Estimate (BOE) and an adjusted NAS Architecture and budget planning documents. The IAR allows decision makers to choose the optimum solution to a mission need. A critical tool to help with this choice is the cost-benefit analysis prepared with heavy input from the cost estimator. Once a solution has been implemented, the life cycle cost estimate for the chosen solution becomes the APB against which program performance is measured for the rest of the life cycle. The BOE, which documents the data upon which the estimates were made, is a key product that is provided even though it is not mandatory. It is important in support of any follow-up analysis, such as rebaselining. The NAS Architecture and budget documents are adjusted to reflect the APB estimates for the chosen solution. The FAA's AMS intends to fully fund programs, since full funding of programs is a prerequisite to stable program management. Credible estimates are crucial ingredients to these documents and to the entire life cycle acquisition process.

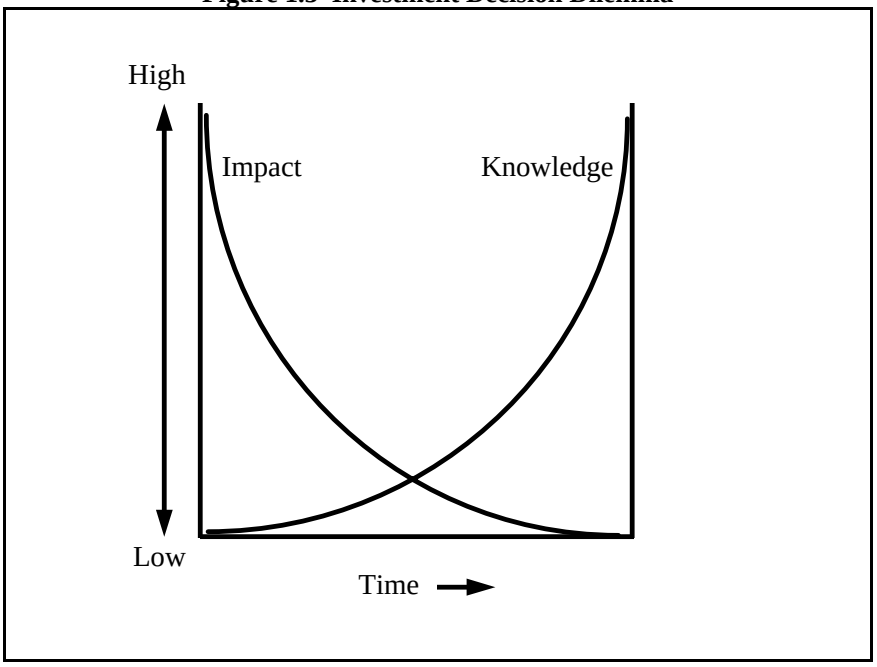
FAA acquisition policy mandates rigorous analysis of requirements, market capability, and affordability during investment analysis to determine whether mission need can be satisfied with commercial or non-developmental products as a first priority. Greater use of commercial products minimizes cost and risk to the government, and delivers new capabilities to the user more quickly. FAA acquisition policy also attempts to maintain a healthy tension between the

pull of requirements and the push of technology that enables the organization to satisfy requirements. Whether the product or service to be acquired is non-developmental or requires research and development expenditures by the government, the estimator will play an important role during investment analysis.

Cost Estimator's Dilemma During Investment Analysis

Evaluating viable solutions during mission analysis and investment analysis, particularly when the solutions require large developmental expenditures or where a good historical database does not exist, presents difficulties for the cost estimator. Decision makers seek precise cost estimates for solutions that have not been well defined, making precision impossible. This typical situation, depicted in Figure 1.3, presents a significant dilemma. During mission analysis and investment analysis, the impact of decisions has great influence over a solution's final content, configuration, and cost. However, during this time frame, there is a limited amount of specific program knowledge available to assist in rendering these important decisions. For instance, the cost estimate may (from necessity) be based upon technical generalizations and historic cost data that may not capture the technology and potential cost of the proposed system adequately. Yet, cost and performance trade studies developed using these early estimates will influence the selection of the "optimum" solution and dictate the system design and configuration that ultimately will be developed and produced. Once the program is established, the system's technical definition will become more refined, and actual program cost data will become available.

Figure 1.3 Investment Decision Dilemma



This "information known versus information required" mismatch is inherent to the early stages of the system acquisition process or where an organization is in the early stages of building a good historical cost estimating database. Thus, the mismatch presents to the cost estimator a

significant challenge, which is to formulate accurate estimates early in the life cycle and with limited data in order to assist management in rendering correct decisions before a major commitment of money is made. The estimator must respond to these challenges through proper selection of estimating methodology. The estimating methodology used later in the life cycle typically will rely on predicting trends from actual program cost data, while estimates early in the life cycle are forced to rely on parametric or mathematical modeling or analogous systems.

To alleviate this dilemma, the FAA must develop sophisticated tools and good historical databases. This can be accomplished best by creating a centralized organization responsible for agency-wide standards for developing cost estimates, applying margins for risk mitigation and other cost growth factors, defining the elements of cost estimates, etc. This will ensure that cost estimates are consistent in their content and calculations, and absent of random errors that emerge if different organizations develop their own unique cost models. Establishing a centralized cost estimating capability will allow for a central repository of historical cost information – leading, in turn, to refinement of cost estimates over time because of the availability of more and better data.

The FAA has recognized this need for a centralized focus on cost estimating through the creation of an IAS, which will work with the FAA line of business that have justified a mission need to expend funds. Also, the IAS is proceeding with plans to further develop the corporate history.

Solution Implementation Phase

After the most advantageous solution from investment analysis is selected and a program is approved, the solution implementation phase begins. It ends after the new capability is developed, procured, tested, and is ready to go into service. Implementation is the responsibility of the IPT.

Cost Estimator's Role During Solution Implementation

During the implementation phase, the cost estimator will be involved in a number of activities. The IPT must manage the APB and report to the acquisition executive any anticipated breaches before they occur. Potential breaches can occur because of Congressional mandates, changes in requirements, unanticipated development problems that impact schedule, or cost growth on contracts. The cost estimator potentially will be involved in explaining cost impacts or reasons for cost growth in all of these scenarios. There will be acquisition reviews during which the cost estimator may be involved in reporting the cost status of the program.

In-Service Management Phase

The in-service management phase begins when the new system, software, or facility goes into service in the NAS, and continues for as many years as the product is in use by the operators. During this period, IPTs are responsible for many things. They include developing and incorporating planned improvements; inserting new technology upgrades; developing engineering changes to fix problems; and planning, programming, and budgeting resources for the operators to sustain the fielded products. The IPTs also are responsible for monitoring and

assessing performance, cost of ownership, and support trends; planning and preparing for service life decisions to correct capability shortfalls; and seeking technology opportunities to enhance the fielded capability.

Cost Estimator's Role and Products during In-Service Management

In addition to monitoring cost of ownership and supporting budget estimates, the cost analyst can expect to be involved in a new investment analysis process anytime there is a significant program change during this phase. This would occur if there were a breach of a program's established APB. An investment analysis would be performed if the current capability must be increased to such an extent that sustainment funding is not sufficient or when another solution offers potential for lowering costs significantly or improving effectiveness. When a new investment analysis is necessary, the IPT must prepare for a new FAA investment decision. The decision may be to dispose of the current system and replace it with a new one, extend its service life, or continue as is. The IPT will have to work with the IAS to identify all reasonable alternative solutions for attaining the needed capability. The IPT will have to revalidate the existing mission need, but a new MNS is not required. An IAR is required. This will, of course, involve life cycle cost estimates of all alternatives and a cost benefit analysis to identify the best solution. At the service life extension or disposal decision point, the program has come full circle in the program life cycle acquisition process and a decision to extend the service life or replace the system will require a new investment analysis.

The FAA acquisition process is an organized and effective means to initiate and conduct acquisition programs. From the cost estimator's viewpoint, it is important to recognize the role that life cycle cost estimates play in the entire process. It should be clear that the cost estimate is an integral part of program formulation, decision milestones, program execution, and a program's status is measured in relation to the program's initial estimate as reflected in the APB. Therefore, the initial estimate must attempt to forecast accurately the actual costs that will be incurred during the conduct of the program. If the estimating community strives for something less than this goal, it will not provide management of the information required for competent decision making and may provide Congress, review authorities, and the public an inadequate yardstick to measure program progress and performance.