4.0 PLANNING THE COST ESTIMATE

4.1 Introduction

The cost estimator, like any other professional, will perform more efficiently if he or she has knowledge of the challenge facing him and a plan for meeting the challenge. Chapter 4 provides a general discussion about prerequisites that assist the estimator in defining the estimating task and contribute to the overall conduct of a competent estimate.

4.2 Knowing the Purpose of the Estimate

The purpose of the estimate is determined by its ultimate use, which in turn will influence the level of detail required and the scope it encompasses. Ultimate use, level of detail, and scope are the subjects of the following discussion.

4.2.1 Ultimate Use of the Estimate

The ultimate use of an estimate is based on the specific requirement that it is intended to fulfill. Specific applications support trade studies, program change and funding level decisions, agency resource decisions, program reviews independent of advocacy, procurement strategy alternatives, and acquisition decision points.

Over time, estimates have been given formal titles and descriptions that indicate their ultimate use and purpose. These were detailed in Chapter 2, and include the Cost Benefit Analysis (CBA), Acquisition Program Baseline (APB), and Independent Government Cost Estimate (IGCE). Often a single estimate serves both of the general purposes described earlier.

Beyond the formality of these types of estimates are “what-if” exercises. These provide a quick-look estimate for exactly the same purposes that more formal estimates serve, but are accomplished in a much shorter period of time. The concern always associated with a “what-if” exercise is that as it “goes up the line” decision makers have a tendency to forget that the estimate was conducted under severe time constraints. Consequently, key decision makers may adopt the “what-if” as an official position, assuming that it possesses a level of competence equal to an estimate developed under normal circumstances. Being aware of this potential, the estimator should ensure that “what if” exercises are caveated properly and that management is knowledgeable of their limitations. Beyond this point, the estimator loses influence in the decision making process, but should have documented the estimate and any abnormal circumstances surrounding its accomplishment. This will provide a record that will assist in explaining (at a later date) why actual costs may have deviated from those estimated.

Finally, the estimator should include in the estimate’s presentation and documentation, a clear statement identifying its intended purpose. While this will not guarantee proper use, it will minimize misuse (e.g., using a quick “what-if” cost estimate as firm budget input). Also, estimates intended for different uses may have different review criteria and the time associated with these reviews should be considered when planning the estimate’s timetable.

4.2.2 Level of Detail Required

Given adequate time and resources to conduct the estimate, the level of detail is influenced by the estimate's ultimate use and data availability. From the perspective of ultimate use, an ICE (which typically is afforded the time and resources to conduct a thorough investigation) is expected to devolve to a lower level of detail than a "what-if" exercise. However, from the perspective of data availability, an ICE or "what-if" exercise on a production system for which a plethora of actual cost data exist should supply more detail than one conducted on a system that is still in the early stages of development.

Planning the estimate, which is discussed more fully in Section 4.6, should include tailoring the estimate detail to coincide with its ultimate use and data availability. Of course, each program must be assessed on its own when it comes to level of detailed data available. For a program entering development, it is quite typical to see a level of detail at the first indenture of the checklist (e.g., Prime Mission Equipment (PME), peculiar support, etc.). As the program enters the production phase and actual cost data become available from the development phase and production articles, a lower indenture of estimating is possible. For instance, if the estimate for PME used an engineering methodology, the estimate would contain a functional build-up for each hardware element. Similarly, support equipment requirements would be defined now by item and maintenance level. This level of detail would support analogy estimating or direct pricing rather than the application of a gross historic factor. The estimator must know the level of definition and data availability in the program requiring an estimate before choosing the appropriate estimating methodology.

A key point to keep in mind is that more detail does not always equal more accuracy. Certainly, as actual costs for the system being estimated accrue, more detail can be incorporated into the estimate. In this case, it is not the detail alone that increases accuracy but rather the combination of detail and actual cost data. This combination allows the estimator to gain an in-depth understanding of past cost behavior and to apply to the estimate only those elements of actual cost that will recur through program completion.

Prematurely pursuing extensive detail can be detrimental to the achievement of a quality estimate. In the absence of a detailed technical description of the system and a similar level of analogous cost data, it becomes highly difficult to identify and estimate all elements of cost. In this situation, it is appropriate to estimate at a relatively high system level that will allow the capturing, albeit not the specific identification, of lower level cost elements. This is the essence of parametric estimating tools that operate at a gross level of detail and are useful when the system lacks detailed technical definition and cost data.

Time provided to accomplish the estimate could become an overriding constraint on the level of detail achievable, regardless of the estimate's ultimate use and data availability. When defining the elements to be estimated and developing the estimating plan, the estimator must consider the effect of time constraints on the level of detail to incorporate into the estimate.

4.2.3 Scope of the Estimate

The scope provides boundaries for the development of an estimate. It describes the breadth of the analysis and provides a time frame for accomplishment.

Several factors drive the scope of the estimate:

- The elements that the recipient of the estimate wants included
- Criticality of the estimate
- Resources available
- Point at which the program is in acquisition

It is important that all stakeholders agree to the scope of an estimate, in order to avoid major changes once the analysis has begun. In addition, the cost estimator must have a full understanding of the scope prior to the analysis and should keep the scope in mind during the conduct of the analysis. The scope provides a focus for the estimator as the analysis progresses.

4.3 Understanding the Program

It is impossible to estimate credibly a system that does not have an adequate technical and programmatic description. An automobile sales person would not be expected to provide the customer with the price of a new auto until the customer defined the model and options desired. The same requirement applies to any system being estimated. It must be defined before the estimator can conduct a viable cost estimate. Obtaining the Mission Need Statement and the Requirements Document are good starting points for understanding what is to be estimated. This section will provide general guidelines and insights into the type of technical and programmatic information that is required to fully understand and estimate a typical FAA program.

4.3.1 System Purpose

Understanding the system's purpose provides the estimator with the ability to make an initial assessment of the relative magnitude of the system's cost. While knowledge of much greater technical and program depth is necessary to construct a credible estimate, an understanding of the system's purpose does provide the estimator with a mental sizing of its complexity and cost. For instance, if the system's purpose has a space application rather than ground or airborne, the experienced estimator will have visions of high reliability through design redundancy and extensive testing. This translates into greater program complexity and ultimately into higher costs.

4.3.2 Physical and Performance Characteristics

With the system's purpose defined, the next step in characterizing the system is to understand its physical and performance characteristics. Clearly an automobile's purpose is to provide ground transportation. To characterize a specific ground vehicle further, information regarding how many individuals it transports comfortably and its overall size (physical), as well as its acceleration from zero to 60 and average fuel consumption (performance), is required.

The same type of knowledge is required to develop a cost estimate for complex air traffic control systems since these characteristics directly influence cost. The list of descriptors varies depending on the system involved. Examples of a limited array of system physical and performance descriptors for various types of systems are presented in Table 4.1. The specific list of descriptors for the system being estimated will be dictated by the system itself (radar systems would not be described by maximum speed and altitude) and the methodology used to perform the estimate. Permeating all systems today is information technology cost. Descriptors that characterize information technology aspects of a system include memory size, processing speed, lines of code, language employed, expansion factors, proficiency of programmers, and others.

Table 4.1 Typical System Descriptors

Electronic	ADP
Frequency	Software
Operating Power	Processor Speed and Capacity
Cooling Power	Number of Positions
Packaging	Number of Sites
Data Rate	Communications Interfaces
Bit Error Rate	Availability/Reliability
Weight and Volume	Peripherals
Location	Maintenance Concept

Parametric models prescribe exact non-cost parameters as input that serves as the independent variable in the model's cost estimating relationships. Therefore, at a minimum, system characteristics must be described accurately. On the other hand, if using the analogous form of estimating, the estimator needs a comprehensive list of descriptors to assist in selecting the strongest analogy from predecessor or similar systems.

The importance of system descriptors tends to decline as the program matures and actual costs of the system being estimated become available. Consider an estimate being generated for five hundred production units with actual cost data available on one thousand units procured in subsequent year buys. Inherent in the actual cost data is the influence of the system's characteristics. Consequently, an engineering estimate of the next five hundred units could be developed with primary reference to the recurring aspects of the actual cost data and minimal knowledge of the system's physical or performance characteristics.

Clearly the most important input required for determining an estimating methodology early in a system's life cycle is a detailed description of its physical and performance characteristics. The challenge facing the estimator is obtaining this input. Unless the estimator also is technically competent to describe the system, the input of technical program personnel is crucial. However, during the early stages of a program, these individuals can only provide estimates of the system's physical and performance characteristics. Since these estimates form the foundation of the entire cost estimate, it is important to document clearly the fact that they are estimates upon which the system cost estimate depends. The importance of having done this will become evident when an estimate update is required to support a change in the system's physical and performance characteristics.

4.3.3 Technology Implications

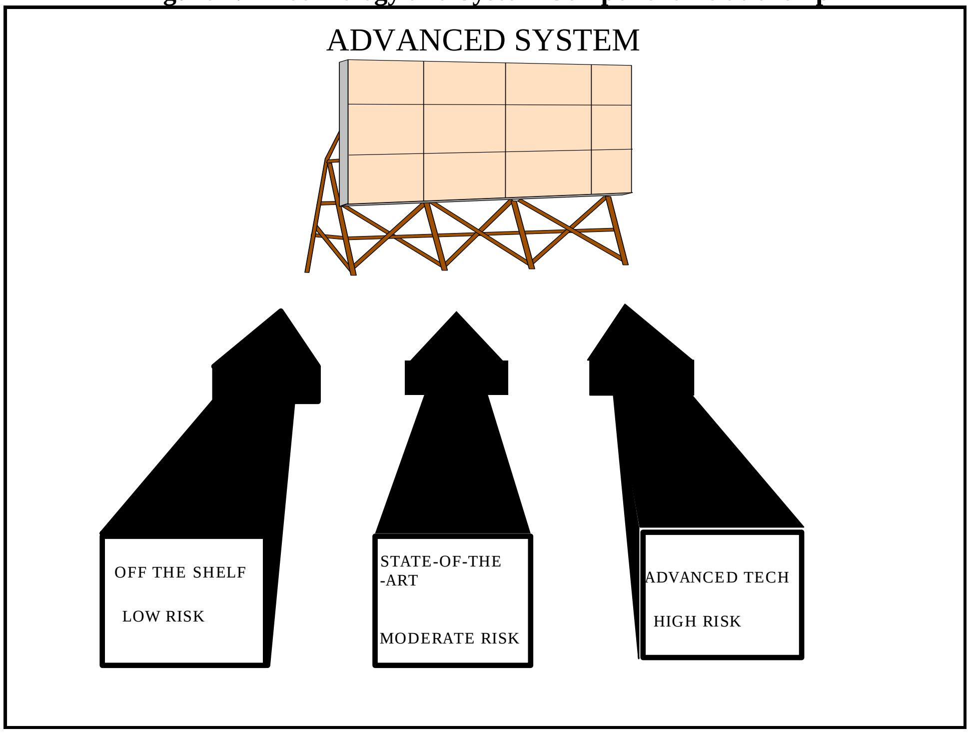
Information about the physical and performance characteristics of a system does not provide a complete knowledge base upon which to construct a quality estimate. It is also important to address the technology that must exist to make the system a reality. In other words, where does the new system reside in relation to the state-of-the-art?

At one end of the technology spectrum is the off-the-shelf item that uses existing technology. The term off-the-shelf is used for those items that do not require development and are available readily. For the estimator, off-the-shelf items represent one of the lesser-cost analysis challenges. In any system, not all subsystems, subassemblies, components, electronic modules, and parts are new. Many items that compose the system have been developed and purchased before and are available in the supply system or commercially through various suppliers and vendors. Estimates of the cost of these items normally use catalog prices or vendor quotes which the prime system contractor will have obtained and reflected in the bill-of-material. Estimates of this type can vary in complexity, however. If the majority of the estimate involves obtaining prices for off-the-shelf items, the estimator still must ascertain whether the items will be integrated into an existing system or used to build a new system, in which case there may be design and development required to make sure the interfaces work.

At the other end of the technology spectrum are the items that make up a system that is truly new and therefore, will undergo design, development, and test. The estimator must understand the key relationship of the item to the state of technology: whether the technology required for the new item lies behind or ahead of the leading edge of technology. If technology has advanced beyond the state required for the new item, then the estimating scenario is a new application of existing or mature technology. For the estimator, the focus will be on costing the manpower requirements (particularly engineering, material, and test facility time) to design, develop, and test the new item fully. The technical community will be required to make estimates of the end item’s physical and performance descriptors, which will allow the estimator to cost the new item directly or through the use of a parametric or analogy methodology. Since we are talking about a new application of a mature technology, risk would tend to be moderate. However, if severe schedule constraints exist, risk could increase dramatically. The estimator must be sensitive to cost and schedule risk whenever the system being estimated involves new design, development, and test.

So far, discussions have centered on those items composing a new system that either are off-the-shelf or use existing technology. In addition, there are new items that cannot be developed fully until specific technological advances are realized. These represent a significant challenge to program management, the technical community, and the estimator. They also add a high degree of risk to program schedule and cost. Typically the estimator will apply the same approach to these new items as to those for which mature technology exists. Specifically, the estimator will assume that the technology required to design, develop, and test the new item will arrive on schedule and be available to support the effort. While this assumption allows the estimate to proceed, the risk and attendant cost and schedule impact associated with it cannot be ignored. The estimate should include a risk assessment with excursions to depict the impact that will occur if the technology is not available as required. These technology and system component relationships are summarized in Figure 4.1.

Figure 4.1 Technology and System Component Relationship



The estimator should not take technology implications on a program lightly, since minor errors in the analysis of technological challenges can alter the estimate drastically. Overly optimistic technology forecasts should not trap the estimator. Advocates of the system will tend to understate the real technological challenge facing the successful development of the new system. Because of this optimism, the estimator may fail to state clearly the technology availability assumptions that underlie the estimate or perform less than rigorous risk analysis to depict the cost implications of a delayed technology arrival. The estimator should be the skeptic in this situation and provide management with a complete portrayal of assumptions and risks along with excursions that will demonstrate the cost and schedule impact of a technological delay.

4.3.4 System Configuration

Various configurations normally are available to achieve the physical and performance characteristics prescribed for a system. This is most evident in source selections when each bidder submits a different system configuration that will achieve the physical and performance characteristics specified in the Screening Information Request (SIR). Even though proposed configurations may meet the specified system characteristics, each is evaluated in detail to determine its strengths and weaknesses in terms of technical, operational, and support criteria. Configuration variances not only merit higher and lower scores in view of these evaluation criteria, but permeate the estimator's assessment of the cost to design, develop, produce, operate, and maintain these various configurations.

Because the system designer has many options, different configurations evolve to meet specified physical and performance characteristics. One designer may select to use more of the current inventory analog voice recorder that requires over 20 square feet of floor space at a site. Another system designer may use a new state-of-the-art digital voice recorder that requires only six square feet of floor space. Either approach could satisfy a requirement to provide more legal voice recording capacity at a site.

While the designer can achieve prescribed performance through various configuration options, these trade-offs each have an associated cost and therefore influence the system's estimate. Using an available recorder may be necessary to deliver an operational system within a certain time frame. However, the cost to create more recorder storage rack space at a site may be very expensive. Also, the life cycle cost of the analog configuration could be more expensive when parts become obsolete compared to the alternative that uses the new digital voice recorder.

While this example focused on a recorder in a source selection environment, the implication holds true for any system in any estimating environment. Understanding a system's configuration is a necessary prerequisite for identification of its cost drivers and for accomplishing a viable cost estimate. This is especially true when the estimate will use an analogy to an existing system for which actual cost data are available. The estimator needs to analyze the technical parameters of the existing system and its costs before an analogous estimate can be constructed. This is necessary to help identify configuration differences between the existing and proposed system, which in turn will provide the technical base upon which to develop cost complexity factors. These factors, when applied to the actual cost of the existing system's components, will provide an estimate of analogous components within the new system.

4.3.5 Interrelationships with other Systems

Very few systems operate independently. When systems are employed in an operational scenario, they become linked to one another either physically via mechanical, electrical, and other connections or non-physically via electronic signals. Prior to take-off, an airplane is linked physically to the air traffic control tower through visual identification. After takeoff it remains linked non-physically via radio and radar information received through electronic transmissions. While a satellite is not connected to other systems physically, it may (through data links) conduct two-way communication with ground stations, ships, and airplanes. These interfaces are important aspects of system design. If proper attention is not given to these interfaces during the early stages of design, the integration of the new and existing system may not be possible without costly redesign.

The level of difficulty associated with estimating the cost to integrate systems is a function of the degree to which the systems are disturbed by the integration. Communication linkages do not create disturbances as great as those created by the physical integration of two systems. Often these latter undertakings involve structural changes, increased power and cooling requirements, protection devices to avoid operating disruption of other system components, software updates, and modification of support equipment.

The interrelationship that a new system has with others significantly influences its design and may necessitate alterations to existing systems before this interrelationship can be realized. Consequently, when a total program estimate is required, the estimator must look beyond the immediate system to gain a technical description of integration requirements.

4.3.6 Support Concepts

The support concept for the system affects acquisition, as well as operating and support costs. As the upgrade of the NAS proceeds, the trend is toward more complex systems with a high degree of interdependency. This complexity dictates that increased emphasis be placed on early planning for integrated logistics support and its standardization across the NAS to preclude the cost and schedule impact of correcting deficiencies after equipment deployment and to minimize subsystem life cycle costs. To achieve this goal, the FAA requires an integrated process by which the support elements of a system/subsystem are planned early, acquired, verified, and deployed in a uniform and systematic manner. This process is known as National Airspace Integrated Logistics Support (NAILS).

The estimator must be aware that support of a system involves a number of elements. Supply support includes spare parts, repair parts, and special supplies to operate a NAS subsystem. A large cost element is maintenance, which includes labor and support facilities. In addition, support and test equipment, training, training equipment, technical data, packaging, handling, storage, and transportation must be addressed in the estimate.

Maintenance can be organic (in-house) or provided by a contractor, and the choice obviously will affect costs. If the choice is a contractor maintenance approach, the estimator needs to pay attention to the type and amount of contractor repair. There are various possibilities: a contractor repair service for certain exchange and repair items, a full contractor maintenance logistics support capability, or simply contractor depot logistics support. Even if an organic support concept is selected, the estimator must recognize that interim contractor support typically is required during the system’s early operational period. This is because support equipment and data generally are not developed until the system’s production configuration is fairly definite.

Consequently, early production systems delivered to the operational inventory must be supported by contractor equipment and data. This, combined with the fact that an organic capability cannot exist until an initial cadre of personnel is trained, sometimes requires contractor support for a period of several years.

Another consideration for the estimator is the number of maintenance levels that will be required to support the system. Two levels of maintenance (field and depot) are discussed below.

- Field. The organization that is operating the system performs this maintenance. It is best thought of as the servicing level of maintenance. It includes activities such as inspection, service, lubrication, adjustment, trouble-shooting, designated modifications, and the replacement of parts, minor assemblies, and subassemblies.

- Depot. This is the highest level of maintenance and is the responsibility of the FAA Depot. There are various FAA Depot branches that support the field at deployment of subsystems and assure subsystem readiness for operation. The Depot branches are: Storage and Transportation Branch, Engineering and Production Branch, Quality Control Branch, Supply Management Branch, and Cataloging Branch. There is also a systems engineering and integration contractor who shares responsibility with the depot. Depot maintenance occurs at organic or contractor facilities and is the overhaul level. It involves the support of field activities by providing resources (personnel, skill, facilities, and equipment) of a much more extensive nature than the field level possesses. It also includes the repair, modification, alteration, modernization, overhaul, rebuild, and reclamation of parts, assemblies, subassemblies, components, and end items, as well as the manufacture of parts, assemblies, components, and end items.

Each level of maintenance possesses a specific capability. For instance, given the above description, the organizational capability may be limited to that of removing a failed line replaceable unit (LRU) and replacing it with a serviceable unit drawn from field supply. In turn, the failed LRU would go to the Depot for repair. The estimator must be aware of how both levels of repair play in the estimate.

The support concepts and options discussed above are the ones that the estimator will encounter most frequently. However, as systems become more advanced and complex, so does their support. Because of this, innovative support approaches continue to evolve, each with its own cost implications that affect the system's life cycle estimates. The estimating of operating and support costs is the subject of Chapter 13.

4.3.7 Development, Test, and Production Quantities and Schedules

The estimator typically will have access to the system's development and production schedules and the quantities to be manufactured during these program phases. The estimator should analyze this information in detail and challenge any aspect that appears unreasonable.

The development schedule and quantities of test articles usually represent the areas that are most problematic to the estimator. The estimator should be suspicious of schedules that produce funding profiles that build and decline several times during the development program. One would expect a development program to build up gradually as design and development efforts commence; to continue this trend to support the test article manufacturing process; to decline to some constant level throughout testing; and to taper off as the development program completes.

Certainly, not every development program follows this smooth funding profile. The cost estimator should examine major peaks and valleys to understand their cause. It is highly inefficient and unlikely for a contractor to hire to a level, and then lay off workers only to rehire them to regain the original level of employment. Often schedule inconsistencies of this nature initially surface when the estimator highlights them through the funding profile. Therefore, the estimator should not feel reluctant to challenge these variances and to obtain either a rational explanation for their cause or a schedule revision that will produce an acceptable funding profile.

Quantities of required test articles are often understated because it is assumed that a single article can support multiple test events. While the article can withstand recurring test events, difficulty arises when a test event requires more time than initially envisioned and therefore, the article undergoing the test is not available in time to support the next event. When time tolerances between test events are close, the solution is to delay the follow-on test or to manufacture additional sets of development hardware. The estimator, in conjunction with individuals from the engineering and test community, should perform an in-depth analysis of the test schedule and hardware quantities to identify time and quantity constraints that would jeopardize achievement of the development schedule. If there is no relief from these constraints, the risk analysis section of the estimate should reflect their potential impact.

Another schedule concern arises when development and production programs run concurrently. Depending on its severity, this overlap can add considerable cost to early production buy-years and increase retrofit requirements because production articles are being manufactured while development testing is ongoing. Consequently, configuration revisions resulting from the test program retard the production learning process and require articles delivered to the operational inventory to undergo configuration update modification. The number and complexity of configuration changes determine the cost impact that concurrency has on total program cost.

Production schedules tend to be straightforward and normally have not been problematic to the estimator. However, the estimator should focus on basic and rate tooling. The estimate should be timephased to ensure funding is provided at the appropriate time to support build-up to the planned maximum production rate. Also the timephasing of the production estimate must recognize the need for advanced-buy funding to procure long lead requirements that protect the production schedule.

Beyond the foregoing discussion, the estimator should always be cautious of schedule over-optimism. This success orientation can lead to schedule slips and cost growth that will invalidate the highest quality estimating effort. The risk section, as discussed earlier, is the appropriate place to portray the cost consequences that accrue if schedule milestones slip.

Schedules are an extensive and integral part of any estimate. However, for the estimator to provide a deeper analysis, a complete schedule assessment should be conducted. While performing a detailed schedule assessment is ideal, time and resources often are not available to conduct one.

4.3.8 Program Implementation Plan

A program implementation plan is developed and maintained as an agreement between the program manager, NAS Transition and Implementation Service, and the regions. The plan addresses the requirements to support the deployment and operation of a product in the field.

Consider the procurement of one hundred operational articles. If the implementation plan establishes that these articles will be dispersed to ten main locations, the cost to acquire their support and maintenance will be significantly higher than if they were dispersed only to five locations. As dispersion increases so does the number of locations that must be capable of supporting the system.

If the situation is thought of in terms of fixed (or more accurately semi-variable) and variable requirements, it is easy to visualize. For instance, some support resources remain constant when the number of systems supported varies (within certain bounds). Consequently, the number of systems supported could increase from ten to twenty with no increase to the level of fixed resources. A case in point would be ann air traffic control computer at an Air Route Traffic Control Center (ARTCC). There has been a steady growth in air traffic, and the computers' capacity to handle the traffic growth is fixed. Therefore, there may be requirements for more capable computers, improved software, etc. The implementation plan for the upgrade of the air traffic control computers must project traffic growth by location. In this case, the air traffic control computer is fixed in terms of total air traffic supported but variable below that threshold.

Other requirements are strictly variable and change proportionately with the number of systems supported, regardless of dispersion. For example, each system may require its own operator's manual. The number of manuals procured now becomes a function of the number of operational systems deployed and is insensitive to the amount of air traffic.

The estimator must be aware of the effect that the implementation plan has on the total program estimate. The implementation plan has the most influence in production and O&M. This influence is strongest in the areas of support equipment, spares, data, trainers and training, as well as indirect support costs. Each of these areas should be estimated with knowledge of their fixed and variable elements and how the plan will affect the requirements for these resources.

4.3.9 Procurement Strategy

Procurement strategy involves structuring contracts and formulating a procurement approach that allows the government to reduce program risk and receive the most value per dollar spent. The two most prevalent acquisition strategies are "competition versus sole source" and "multi-year" procurements. The reason many programs pursue these strategies is because their payoff, in terms of cost savings, can be significant. For this same reason, the estimator must be prepared to understand these strategies fully and conduct a credible estimate of their impact on program costs.

Competition Versus Sole Source

Competition comes in many forms and can be introduced into a program anytime during its development and production phases. The type of competition strategy introduced and its timing will determine its ultimate effect on program costs.

Most programs start in a competitive mode by inviting bidders to participate in source selection for the development phase. While this up-front competition is beneficial, the program immediately finds itself in a sole source mode after the selection of a development contractor. Often a program will continue in this mode attempting to negotiate the best price possible with the single source throughout the acquisition program. However, there will be a distinct disadvantage when attempting to negotiate a favorable price when only one source is qualified to provide the required system.

To overcome this negotiating handicap, several procurement strategy alternatives have evolved which permit two or more sources to become qualified to deliver the required system. These alternatives allow price competition for a longer duration and are discussed below.

- Funding two or more contractors to design and develop a system in response to the stated requirement. At some point in the program, there will be a competitive evaluation with down-selection to a single contractor for the remaining program. The objective at this point will be to negotiate either a basic contract and/or priced options for a large portion of the remaining program while the advantage of a competitive environment exists. Beyond the negotiated basic contract and/or priced options, the program returns to a sole source mode.

- A variant of the previous alternative involves the continuation of two or more contractors throughout the entire acquisition phase, thus preserving the competitive environment. Generally, each contractor is guaranteed some fixed share of each year’s total buy with the remainder awarded to the lowest bidder. This allows the contractors to maintain a production capability while the customer maintains the program in a partially competitive mode.

Often, a program that is in sole source mode desires to establish a competitive mode. Achieving a competitive mode from this position typically is accomplished either through a second sourcing or a leader-follower approach. Qualifying a contractor through the second sourcing approach requires that the primary contractor provide for the transfer of technical data and a limited production run to the second source. This allows the second source to competitively produce a system that meets specifications. Leader-follower is similar. The customer pays the sole source contractor to qualify the second source through technical and manufacturing assistance.

There are advantages and disadvantages to the various acquisition strategies that enable a program to establish a competitive environment. The key question is whether or not the initial investment required to establish and maintain competing contractors is less than the savings that result from negotiating cost in a competitive environment. Determining the answer is the responsibility of the estimator. To assist the estimator in this regard, there are various studies on competition impacts as well as models to assess these impacts quantitatively. Much of this work relies on evidence that competition entices contractors into efficiencies that might not have been achieved otherwise.

Before the estimator applies any methodology or model to determine the cost impacts of dual source procurement, it is necessary to conduct an extensive analysis of the program. The first step that the estimator should undertake is to identify those program elements that will be subject to competition. If the sole source contractor were competing major portions of structure, then it would be inappropriate to apply the model at the system level. Likewise, if the system uses significant quantities of common government furnished equipment, these would be excluded from additional competitive consideration. In other words, the system must be disaggregated and each element analyzed to determine if a competitive environment for it already exists. If so, that system element would be removed from the analysis since the benefits from its ongoing competition should be inherent to the basic estimate.

Beyond this initial step, the next examination would be to determine the presence of capable and willing rival competitors. This analysis leads to assumptions regarding the market's competitive environment. The likelihood of realizing cost reductions due to dual sourcing increases if:

- Firms exist that possess the capability to manufacture the item to be competed

- These firms are willing to introduce cost efficiencies and reduce profits to make themselves competitive

At this point, selected methodologies and models can be applied intelligently to the basic sole source estimate to determine the gross cost savings that potentially could accrue to the program as a result of competition. However, even if the model indicates substantial savings in the manufacture of system elements included in the competitive procurement, this does not translate necessarily to a net savings to the program.

The following costs associated with competition must be considered as offsets to the initial calculation of savings:

- Maintenance of two or more contractors through the development phase
- Procurement of technical data package
- Technical assistance to the second source
- Qualification program
- Excess contractor capacity
- Economy of scale sub optimization
- Higher fixed cost burden per unit
- Split learning and purchases

The estimator's analysis must include these non-recurring and recurring costs and deduct them from gross savings to derive net program savings or loss resulting from the procurement strategy of competition.

Multi-year Procurement

The essence of multi-year procurement is to authorize the contractor to purchase materials and parts to support several system buy years, thus achieving savings through economic order quantity procurements. Without approval for multi-year procurement, the contractor only has authority to purchase in support of a single buy year. Therefore, purchases for several buy years cannot be aggregated into an economic order quantity and attendant savings cannot be realized.

When multi-year procurements are authorized, the estimator is confronted with two challenges. The first is the determination of the cost reduction (quantity discount) that results from buying materials and parts in greater volume. A quantity discount allows the consumer to realize a lower per unit cost when greater quantities are purchased. Often the estimator can obtain direct quotes from vendors and suppliers that describe the discount that is applicable to quantity purchases of various sizes. In the absence of this information, the estimator may have to rely on a historical multi-year savings factor.

The second challenge facing the estimator involves a rephasing of the funding profile. Rephasing is needed because the government must indemnify the contractor against loss if an out year buy of systems for which material and parts were purchased under multi-year provisions is canceled. The rephasing of funds usually is based on the contractor's termination liability to vendors and suppliers that may amount to something less than the full value of the items involved. Termination liability means obligating sufficient contract funds to cover the contractor's expenditures plus non-cancelable commitments. In the case of a multi-year contract terminated before completion of the current fiscal year deliveries, termination liability would include an amount for both current year termination charges and out year cancellation charges. Policy regarding the application of multi-year procurement and indemnification requirements tends to undergo revision from time to time. Because of this, the estimator is well advised to seek the latest guidance from local procurement and budget offices.

Lease versus Buy

Lease versus Buy is another option available to reduce program risk and cost. Leases are classified into a variety of types. The three major classifications are operating, sale and lease back, and financial or capital leases.

Operating leases are characterized by the lease period being less than the economic life of the item. Therefore, the lease payments do not amortize the item fully or recover its full cost over the life of the lease period. Operating leases normally allow the lessee to cancel the lease within a short period of time without any penalties or surcharges. The only requirement is that the lessee return the item leased to the lessor. In addition, the lessee generally does not acquire an ownership interest in the item.

A sale and lease back arrangement occurs where a particular organization owning land, buildings, or equipment sells to a bank or financial institution (buyer) and immediately leases back the item. The seller or lessee receives the purchase price for the item sold to the buyer. The lessee continues to occupy or use the equipment but now remits a lease payment to the lessor (buyer). The lease payments amortize the sales price and provide the lessor an adequate rate-of return over the life of the lease.

According to *Financial Accounting Standards Board Statement (FASB) No. 13*, paragraph 7, a lease that satisfies any one of the following criteria is a capital lease. Otherwise, the lease is an operating lease.

Common Characteristics of Capital Leases:
• Usually will not provide for maintenance service • Non-cancelable • Fully amortized

- Ownership of the leased asset is transferred to the lessee at the end of the lease period.

- The lease gives the lessee the option of purchasing the leased asset at less than fair value at some point during or at the end of the lease period.

- The period of the lease is 75 percent or more of the service life of the leased asset.

- The present value of the minimum lease payments is 90 percent% or more of the fair value of the leased asset.

The decision maker often considers qualitative factors in evaluating a lease versus buy analysis. Factors that the government may want to consider are as follows:

- Leasing increases the tax base of the community (Leasing under section 801 of Public Law 98-115 for family housing).

- Leasing can provide a catalyst for community growth (Leasing under section 801 of Public Law 98-115 for family housing).

- Leasing provides flexibility.

- Leasing provides a lower initial government outlay.

- Leasing can shift the risk of obsolescence to the lessor.

A lease versus buy analysis provides a decision maker with data to choose the most financially sound option. Ignoring qualitative concerns, the lease option with the smallest present value should be chosen. To perform this type of economic analysis, consult FAA APO 82-1, *Economic Analysis of Investment and Regulatory Decisions - A Guide.*

There are other acquisition strategies available to reduce program risk and cost including warranties and contract incentives. Procurement strategy panels are charged with tailoring a procurement strategy to meet the needs of specific programs. To conduct a competent cost analysis, the estimator must take the time to understand the intricacies of the procurement strategy and incorporate their cost implication in the estimate.

4.3.10 Identification of Predecessor or Similar Systems

As technical and programmatic information is gathered, the estimator gains an intimate understanding of the system to be estimated. The primary purpose for having gained this understanding is to equip the estimator with the knowledge required to identify other systems that possess similar characteristics. The identification of analogous systems, for which there exists detailed technical and cost data, is an important step in formulating a credible estimate.

The data collected will be used either to calibrate a parametric estimating tool or to estimate the system directly using analogy methodology. In the first instance, it is important to ensure that the parametric model performs as an accurate predictor of costs for the development, production, operation, and support of the system. To assist the model in overcoming error that is inherent to its construction, it is important to test it against a system that is most analogous to the one being estimated. The procedure simply involves the use of the analogous system's known technical and performance parameters as input to the model to determine if its output accurately portrays the analogous system's actual cost.

Given that computed cost deviates from actual cost, a correction factor or multiplier can be calculated to bring them into alignment. The estimator uses this factor to calibrate the in-progress estimate. Application of the factor compensates for inherent model error and enhances the estimate's accuracy. Some parametric models have this calibration process built into their routines. Regardless of how the correction factor is derived, this calibration process is a mandatory step in the generation of competent estimates through parametric methodology. Further, it must be performed every time a different system is estimated since the model's inherent error is not consistent throughout its estimating range.

In the next instance, the data collected will be used to estimate the system directly using analogy methodology. Chapter 10 discusses this methodology in detail; therefore, it will not be repeated here.

4.4 Establishing Ground Rules and Assumptions

Whenever an estimate is undertaken, it is necessary to create a series of statements that define the conditions upon which the estimate will be based. When conditions are directed upon the estimator, they become the ground rules by which the estimate will be conducted. In the absence of a firm ground rule, the estimator has the privilege of establishing assumptions that fill this void and allow the estimate to proceed.

When exercising this privilege, the estimator must ensure that assumptions are not arbitrary but rather are founded on expert judgments rendered by experienced program and technical personnel. To do otherwise could create a need to revise the entire estimate. This extensive impact is possible since many assumptions profoundly influence cost and the rejection of even a single assumption by management could invalidate many aspects of the estimate. To minimize this potential, the estimator must seek competent opinions regarding the formulation of specific assumptions and formally advise management of them as early and as far up the line as possible. Beyond this, the estimator should present and document all ground rules and assumptions.

Because of the potentially significant cost implications of key assumptions and ground rules, it is a good practice to do a sensitivity analysis of them in the risk analysis section of the estimate. It is necessary for management to understand the decision making implications if these key assumptions and ground rules do not hold in practice.

The list of ground rules and assumptions is unique for each program. Therefore, this section addresses only the ground rules and assumptions that generally are established. From this core, a complete set can be tailored to satisfy the requirements of a specific program estimate. The core elements discussed are the program schedule, cost limitations, timephasing, base year, inflation indices, government versus contractor furnished equipment, and contractor relationships.

4.4.1 Program Schedule

The ideal situation is to have the time, resources, and authority to perform an in-depth schedule assessment before the estimate begins. This is desirable because of the optimism that often is inherent to program schedules. The manufacturing and technical community should be involved in the schedule assessment. Once a complete schedule assessment exists, there is opportunity to introduce risk-reducing revisions as appropriate. This will provide the estimating team with a schedule that has a high probability of achievement and, therefore, a low probability of invalidating the estimate.

In the absence of a detailed schedule assessment, the estimator must accept the schedule provided. While it is always important to depict the schedule and its source as a ground rule, this is important particularly if there is no opportunity to assess the risk of the schedule. Management needs to be well aware that the estimate's confidence level is only as high as the probability of achieving the directed schedule. Without a thorough schedule "scrub", the probability of achieving the schedule is more questionable.

As an intermediate approach, the estimator can seek assistance by performing a high-level quick-look schedule assessment. This will identify obvious inconsistencies that, along with a risk analysis, can be highlighted to management during estimate presentation.

Whatever the situation may be, the estimator must present and document the program schedule and its source. Also, any other pertinent schedule information that may have a bearing on the estimate's outcome and confidence level should be included.

4.4.2 Cost Limitations

The estimator will seldom find a management directed cost limitation for a program of given scope. However, there will be occasions when management desires to establish a program and technical baseline that will allow a system to be delivered within a certain cost limitation. Tailoring the program, through a process of weighing program alternatives in relation to their cost, is highly desirable and results in a program technical and cost baseline that becomes a management objective.

When management directs a certain baseline for an estimate, it is important to note as a ground rule all conditions that led to the baseline. Even though these conditions may appear to depart radically from traditional program approaches, the estimator is responsible for basing the estimate on the directed baseline. However, this responsibility does not restrict the estimator from performing a risk assessment on various baseline conditions and presenting it for management's consideration.

Other areas of cost limitation that the estimator may encounter are constraints from the current budget, planning wedge, or out-year funding level. This is often imposed to avoid reprogrammings, budget revisions, or exceeding fiscal ceiling limitations in a particular year.

There is nothing wrong with these types of cost constraints. They are not challenging for the estimator as long as there is flexibility to shift program content to stay within the limitations. If this flexibility is not available and the estimate exceeds the limitation imposed for a particular year, the estimator must reflect this funding shortfall to management. Regardless of its nature, whenever a program scope or cost limitation exists, the estimate's ground rules and assumptions should contain the details.

4.4.3 Timephasing

Much of the foregoing discussion of schedules relates to the subject of timephasing. Timephasing is the spreading of the total estimate over the program schedule. Scheduled activity in a given year drives the requirement for money in that year. Clues to schedule anomalies and risk become more evident when the estimate is timephased. The estimator should question unusual peaks and valleys or exceptionally high funding levels required in a particular year.

In addition to schedule conditions, cost limitations discussed in the preceding section also influence the timephasing of the estimate. If there is a cost limitation in a given year, the estimator will have to take action to spread the work scheduled to stay beneath the cost limitation. In both cases these conditions and their effect on timephasing need to be addressed in the estimate.

4.4.4 Inflation Indices and Base Years

Dollar value provides a yardstick for the estimate. This yardstick must remain unchanged for all quantities measured if resulting measurements are to be meaningful and comparable with each other. The value of the dollar rarely is constant from one year to the next. Changes in the prices of goods and services continuously affect the purchasing power of the dollar. Chapter 5 addresses in detail how to "normalize" estimates to account for changes in the prices of goods and services.

Any normalizing to account for inflation involves the use of a price index of some sort, which is a measure of relative value. The estimate should document in the ground rules and assumptions the base year in which the estimate is made and the price index used to adjust to current year dollars. A current dollar estimate is an estimate expressed in the prices of the current year. The estimate will be expressed in the constant dollars of the base year of the estimate. Typically, the base year is the year in which the program started or in which the first estimate was done. Constant dollars are expressed without inflation in the prices of that base year. By comparing constant to current year dollars, management can see how much the cost growth in a program is due simply to price level changes and how much to other factors. Price level changes are often beyond the control of management, while other types of cost growth may be within the control of management.

4.4.5 Government versus Contractor Furnished Equipment

Arrangements between the government and contractor regarding responsibilities for providing required equipment and material must be delineated clearly as an estimating condition. The government frequently agrees to provide major elements of equipment and material to support contractor efforts. These items can range from common items of supply, to complex electronic components, to delivery of newly developed propulsion units. If the government becomes delinquent in providing these items, it is responsible for the costs incurred by the contractor as a result of this delivery failure. Depending on the exact source of the equipment and material, as well as the causes responsible for its late delivery, the government may be able to seek damages from its source of supply.

This arrangement has different implications than when the contractor is responsible for acquiring all the equipment and material necessary to fulfill the contract. In this case, the terms and conditions of the contract determine how the consequences of late deliveries affect the contractor. In contrast, the program cost impacts resulting from late delivery of equipment and material will most likely be greater when the government, rather than the contractor, is responsible for these items. The estimator cannot predetermine the occurrence of late deliveries and attendant cost implications. Therefore, it is important to present, as an estimate condition, the assumption that no adverse impacts will accrue to the program as a result of the government providing major elements of hardware.

4.4.6 Contractor Relationships

An accepted approach is to conduct the estimate initially without regard to specific contractual relationships. This baseline estimate can then be adjusted for the business and acquisition strategies selected for the program.

Each contract type must be analyzed for its cost influence on the baseline estimate. For instance, some contracts have fixed values or ceilings that represent the limit of government liability. If the baseline estimate for program portions covered by these types of contracts exceeds the fixed or ceiling value, the estimate frequently is reduced to this value. This is logical since the government is only responsible to the contractor for the fixed or ceiling value. Beyond these amounts, the contractor assumes responsibility for cost incurred. The only mitigation to this would be if the estimate exceeded the fixed or ceiling value by a significant amount. In this case, the amount of risk or engineering change order dollars included in the estimate may be increased to accommodate the potential for a higher than normal flow of contract changes. This is a technique a contractor may use to cover costs incurred in excess of negotiated fixed values and ceilings.

Government and contractor sharing arrangements and award fee reservation of funds are also considerations that will influence the baseline estimate and its timephasing. Since the total array of contract influence is too massive to detail in this handbook, the estimator must become acquainted with the specific contract type or types applicable to the estimate being conducted. Because the estimate depends on the specific relationships involved, these should be detailed in the ground rules and assumptions section. It is also appropriate throughout the estimate presentation and documentation to clearly depict and provide rationale for these adjustments.

4.5 Selecting the Methodology

Armed with the knowledge of system and estimate aspects discussed to this point, the estimator is prepared to enter into the initial stage of estimate planning. Once the estimating approach is selected, a viable plan (Section 4.6) can be developed. Attempting to establish an estimating plan without having conducted this preplanning phase diligently may lead to estimate dead-ends and re-dos. These inefficiencies are time-consuming and represent estimator-imposed constraints that are entirely unnecessary and could hinder accomplishment of a quality estimate. Time spent in the next four areas of the estimating process represents an investment that provides returns that contribute heavily to the realization of a competent estimate. These involve defining the elements of cost, choosing estimating methods, determining risk analyst’s strategy, and identifying crosscheck methods.

4.5.1 Defining the Elements of Cost

An estimate must have a structure for collecting and displaying life cycle costs. For organizations like the FAA that have a large volume of acquisition programs, there is a distinct advantage to having a standard approach for describing those acquisitions. All parties involved in the effort can refer to a common language for describing the entire system. A standard work breakdown structure (WBS) facilitates the assimilation of data in a format useful for preparing future estimates and comparability studies. IPTs can refer to the standard elements to ensure that they have considered buying all the elements typically required for a system.

Work Breakdown Structure

The FAA Standard Work Breakdown Structure may be found on FAST at http://FAST.FAA.gov. WBS diagrams and definitions that reflect the breakdown structure are available online for use by the cost estimators in developing the life cycle costs required for investment analyses and studies. These documents continue to be refined as the WBS is used.

Program Work Breakdown Structure

The Program Work Breakdown Structure (PWBS) is the total WBS for the program. To define all of the effort needed for the total program, the government IPT includes the PWBS in the solicitation. As such, the Statement of Work (SOW) in the solicitation should clearly relate to the PWBS to avoid confusion between the two descriptions of the effort.

Contractor Work Breakdown Structure

The company that wins a contract will extend the PWBS to lower levels of detail as required to accomplish the SOW. This extension of the PWBS is called the Contractor Work Breakdown Structure (CWBS). The CWBS extends to whatever level the contractor deems necessary to manage the work effectively.

In the case of associate contractors, each will develop a CWBS from the PWBS provided in the RFP. For example, the air-to-ground/ground-to-ground switch manufacturer's CWBS will address only those WBS elements applicable to their contract.

Organizational Breakdown Structure

The WBS is primarily product oriented. There are some summary level functions such as Systems Test and Evaluation and System/Project Management, but focus is on products like airframe, data, support equipment. The contractor will have some sort of Organizational Breakdown Structure (OBS) by which human resources are managed. A very common form of OBS is the traditional functional form, where an organization is disaggregated into engineering, manufacturing, etc. There are other forms of OBS, and a contractor is free to manage human resources according to their judgment. However, functional breakouts of the WBS should not show up in the CWBS. Functional costs will show up as costs are accumulated through the CWBS, but the WBS itself is primarily product-oriented.

The Integration of the OBS and the WBS: A Key Management Point

To manage work with a WBS approach the contractor integrates the OBS with the CWBS. The contractor will assign responsibility for each piece of work represented by each element in the WBS. That responsible manager will manage resources in accordance with the company OBS and policies in order to accomplish the WBS element of work.

Application of the WBS to an Estimate

The following provides several general thoughts on this subject and provides references to other handbook areas that address this topic.

- The WBS should be used as the method of insuring that all portions of the program are considered in the estimate.

- The WBS is extremely useful in assigning portions of the estimating effort to team members who may be specialists in certain areas. The same thought carries through if multiple services or commands are partial participants in the estimate.

- For the estimator, the WBS becomes a tool for structuring the cost estimate. During the investment analysis phase, before the program is developed, the WBS will be described at a fairly high level and will not include a CWBS. Once a program exists, the estimate typically will proceed into a lower level of detail.

- Actual costs incurred during the development and production of a system are the source of invaluable data to support cost research and engineering or analogous estimating methodologies. Using a standard WBS to collect these actual costs simplifies the task of estimators of future systems.

It is against this structured hardware element framework that a program’s costs are estimated, budgeted, collected, and reported. Therefore, it is the estimator’s primary reference in identifying the program elements to be estimated. Within this reference, the estimator’s task is to identify those WBS elements that capture the estimate’s scope and represent the appropriate level of detail, given its purpose and data availability.

In the event that no PWBS exists, the estimator's task becomes more involved. The reference is still to WBS elements, but now the estimator is an active participant in constructing it for the program. With the guidance provided in the FAA Standard Work Breakdown Structure and knowledge of the program to be estimated, the estimator can contribute significantly to WBS formation. Once the WBS is constructed, the estimator will proceed with normal cost element selection for the estimate.

4.5.2 Choosing the Method Best Suited to Each Cost Element

In any estimate, it is typical to employ a variety of estimating methods. A program early in development that has not been defined in detail technically may use parametric methods to estimate the majority of its content. Even so, for those elements that have adequate technical definition, the estimating methodology may make use of analogy or of catalog pricing for off-the-shelf items.

A program entering production typically will use an engineering methodology that relies on the use of actual recurring costs incurred during the manufacture of development articles. While grass roots methods may be predominant in this case, the estimator also may employ parametrics or analogies to estimate items such as electronic components. Historical factors are often the preferred estimating method for cost elements like program management, systems engineering, support equipment, data, and training.

For estimates on one-of-a-kind systems such as those in space programs, methodology selection becomes limited. Since each article tends to represent a significant technological advance over predecessor systems, detailed engineering methods have no application. Consequently, parametric and some analogy techniques are used almost exclusively to estimate the cost of these special programs.

Combining discussions in this and the previous section, the following summarizes the steps leading to estimating methodology selection.

- Step 1. Know in detail the composition of each estimating methodology, its preferred application, and the models and techniques that are available to assist in its application.

- Step 2. Gain a full understanding of the system to be estimated through a comprehensive characterization of its technical and programmatic parameters.

- Step 3. Establish an estimating framework from selection of those WBS cost elements that capture the estimate's desired scope and level of detail.

- Step 4. Analyze each element to determine the depth of its technical definition, relationship to technology, and analogy to other articles.

- Step 5. Identify the methodology that is best suited to estimate the cost of each element.

4.5.3 Risk and Uncertainty Analysis

The steps outlined in the preceding section will allow the estimator to intelligently select the most appropriate estimating methodology for each cost element. In addition to this, a prudent estimate will include a risk analysis.

Prudence calls for risk and analysis because uncertainty increases with the distance into the future that projections are made; consequently, the risk of producing forecasts that deviate from actual outcomes increases. To account for uncertainty, the FAA investment analysis process requires a sensitivity analysis and risk assessment of the minimum, most likely, and maximum expected cost.

The estimate planning process should identify the preferred risk analysis strategy. Typically, the risk analysis process will involve identifying the cost drivers, identifying a range of input values to allow for the uncertainty in the cost drivers, and performing sensitivity analysis to highlight the magnitude of effects resulting from possible changes in these cost drivers. In the planning process, the cost drivers can be identified, assumptions can be made about risk, and cost risk models can be chosen. Chapter 8 discusses risk and uncertainty analysis in detail.

4.5.4 Identifying Crosscheck Methods for the Cost Drivers

It is a good practice to crosscheck the results generated by the primary estimating tools with alternate methodologies. The process of crosschecking simply involves the application of an estimating approach other than that selected as the primary method.

Typically a crosscheck is used for those cost elements that contribute heavily to the total estimate or that have a high cost risk. Major cost elements, often referred to as cost drivers, need cross-checking since inaccuracy in these areas can have a significant impact on the estimate.

In the case of a parametric estimate, an acceptable high-level crosscheck would be to demonstrate that the development program estimate is similar to the actual costs incurred on an analogous program. Another crosscheck would be to determine that the estimated average unit production cost is reflective of those for predecessor systems after normalizing for quantity buy differences. This type of gross crosscheck for early program estimates is intended to convey that the primary estimating method generated results that appear reasonable in view of experience on similar programs.

This does not mean necessarily that there will always be a close tolerance between the estimated program and those serving as crosschecks. The estimated program may possess characteristics that require its estimate to be higher or lower than the predecessor program. When significant differences do exist, however, it is the estimator's responsibility to understand them and determine their acceptability. If it is acceptable due to program characteristic differences, then the estimator must be able to present and document this rationale. If it is unacceptable, a complete review of the estimate and the validity of the crosscheck program is required.

If the estimator employs analogy as the primary estimating methodology, then a parametric estimate may be selected as the crosscheck method. When actual program costs become available, an engineering methodology may be used to estimate remaining development and production costs with analogy and/or parametric methods serving as a check of the engineering estimate results.

Other forms of crosschecks involve the use of historical factors to test the reasonableness of an estimate conducted using another method. For example, a typical estimating methodology for support equipment is to use analogies and/or catalog prices. You can convert this estimate into a factor, for example, as a percentage of prime mission hardware. This factor can then be compared to other factors computed on the same basis for predecessor programs. If all factors fall into an acceptable range, the crosscheck validates the primary estimating method. This technique is applicable to data, training equipment, systems engineering, program management, and other costs that can be estimated in detail and then converted to a factor of an appropriate program element like recurring hardware.

Regardless of the crosscheck methodology used, its purpose is to demonstrate that alternate methods generate similar results, thus increasing confidence in the estimate. As a program matures and its technical definition becomes more refined, and actual costs become available, estimates of the remaining program become more accurate. In the same vein, the results of primary and crosscheck methods should become closer as the program matures. When wide margins exist, the estimator must investigate how to correct unacceptable out-of-tolerance conditions or how to explain what makes the variance acceptable.

4.5.5 Cost Estimating Checklist

The foregoing discussion shows that the formation of a competent estimate is an involved process. The omission of one or several of the steps could introduce inefficiencies and errors in the estimating process. To avoid this, a comprehensive Detailed Estimate checklist is included in Appendix 4A.

4.6 Developing the Estimating Plan

To approach an estimate effectively, an estimating plan should be developed. The estimating plan introduces structure to the task, provides management an exposure to the approach adopted for the estimate's conduct, and serves as a contract between the estimator and requester. The following sections provide a general discussion of those plan aspects that require emphasis - the estimating team, approach, and timetables

4.6.1 Developing the Estimating Team

Up to this point, for the sake of simplicity, the text has assumed that one estimator would accomplish the estimate. This generally will not be the case. An estimating team is more likely to be assembled for the purpose of performing the estimate. The exact size and composition of the estimating team will depend on the type of procurement (non-developmental versus developmental), and the time and resources available to produce the estimate. An FAA estimating team would consist primarily of members from the line of business with the need, the Investment Analysis Staff, and IPTs who have candidate solutions. Ideally, the estimating team should have people with expertise in estimating all cost elements. This seldom is the case. Therefore, the team leader must assign available resources efficiently, ensuring a balance of technical and estimating expertise.

When making team assignments, it is important to recognize that each estimate is a learning experience. Therefore, individuals should be used in a manner that not only ensures a competent estimate, but also broadens the experience base of each estimator. A common approach in building a team is to assign experienced estimators the responsibility over major areas of the estimate with less experienced estimators working under their control. In addition, it is a good idea to give estimators an opportunity to participate in areas outside their current experience. This can be achieved by assigning an individual primary responsibility for an area within their experience base and a secondary responsibility for a portion of an unfamiliar area.

Structuring the optimal estimating team involves careful consideration of the capabilities of available resources in light of the estimating task. Responsibilities of participating organizations should be assigned formally at appropriate levels of management, via correspondence that clearly states the estimating task and schedule for its accomplishment and review. Beyond this, each team member's area of responsibility should be made known to all members of the Investment Analysis Team.

4.6.2 Planning the Estimating Approach

The scope, ground rules and assumptions, inputs required for analysis, and estimating methods are the core of the estimating approach. As the approach evolves, it is important that management has a full understanding of the approach to avoid confusion and unnecessary revisions to the estimate after it is completed. Management should be informed of any assistance required in gathering data and of clarification needed to refine the set of ground rules and assumptions.

4.6.3 The Estimate Timetable

The estimator must be afforded adequate time to develop a competent estimate. Constraints on time and resources required to conduct the estimate are a condition that could jeopardize the team's ability to deliver a quality product.

Once the requester establishes the task, the estimator should understand the due date. A detailed schedule leading to this date can then be evolved. Earlier, the estimator was cautioned on the devastating impact over-optimism could have on program schedules. This same caution applies to estimate schedules. Consequently, the estimator should create a schedule with realistic milestones that provide margin for delays. The schedule should also recognize travel time to briefing locations and reworks directed by review authorities. Since these delays and activities always consume time, it is appropriate to consider them in the schedule.

Frequently, estimators are willing to compress the estimate schedule to meet a due date. Compression is risky if additional resources are not available to perform the effort that would have been accomplished by fewer estimators over a longer period. The key point to remember is that the estimator's acceptance of the schedule constraint does not remove the requirement to deliver an estimate that is complete and possesses a high degree of competence. Therefore, the estimator should always strive for approval of a reasonable schedule. If this is not possible, the constraint should be highlighted under ground rules and assumptions as a condition that curtailed the estimating team's depth of analysis and the estimate's confidence level. Once the estimate timetable has been established, its milestones will be reflected in the Investment Analysis Plan.

4.7 Summary

This concludes the discussion of how to plan for a cost estimate. The planning stage is an important one. It is during the estimate planning that the estimators will discuss key estimate considerations such as estimating constraints and methodologies. The estimators also will characterize the system and obtain the WBS.

4A. DETAILED ESTIMATE CHECKLIST

Administrative

- Is this a totally new estimate or an update of a prior estimate?
- What is the purpose of the estimate?
- What is the scope of the estimated program?
- Who performed the estimate? Position, title, and grade?
- How many manhours were required to deliver the estimate?
- Has anyone else reviewed it? If so, what were the findings?

Basis for Estimate Assessment

Depending on the specific program, the assessment should address either the estimate as a whole or the lowest level cost elements used to build up the estimate. The depth of the review will vary depending on the complexity and importance of the estimate and the time available for the review. When time for the review is limited, the reviewer should identify the largest cost elements quickly and focus his attention on them - searching to insure that no large cost elements are missing. At the very least, the reviewer should address the following questions:

- Completeness:
  - ⇒ Are all pertinent costs included in the estimate? (e.g., GFE, support equipment, test centers, management reserve, warranty, contractor support)
  - ⇒ Have the latest available actual costs, proposals, etc., been used to develop or check the estimate?
  - ⇒ Has the estimate been summarized by appropriation and fiscal year?

- Reasonableness:
  - ⇒ Are the methods used to develop all cost element estimates appropriate?
  - ⇒ Is the estimate developed from proper historical costs using accepted methods and logical approaches?
  - ⇒ Are the assumptions, including learning curve slopes, production rates, usage rates, etc., reasonable?

- Consistency:
  - ⇒ Is the scope of the cost estimate defined clearly and is it consistent with the directed program? How does it differ from direction?
  - ⇒ Are all differences between the previous and current estimates identified and explained adequately so they can be understood fully?

- ⇒ Is the estimate consistent with the latest schedule estimate?
- ⇒ Have the appropriate inflation rates been used?

- <u>Documentation:</u>
  - ⇒ Is the estimate documented in a clear and complete manner?
  - ⇒ Are the latest actual data values and sources clearly shown in the documentation?
  - ⇒ Can the estimating methods used to develop the estimate or update previous estimates be followed easily?
  - ⇒ How does the estimate compare with the approved program funding?

- <u>General:</u>
  - ⇒ To what extent were contractor estimates used as a basis for the estimate?
  - ⇒ What adjustments were made to the contractor estimates?

NOTE:
Planning wedge estimates should be identified clearly as such and supported by the source and best available basis for the wedge values used, such as continuing at same level of effort, increased over prior year because...etc.