12
LOGISTICS COST ESTIMATING

"Never invest your money in anything that eats or needs repairing."
Billy Rose

12.1 POLICY

On 15 March 1996, the Secretary of Defense promulgated the latest revision to the DoD 5000 series acquisition directives. The covering memo outlined six major themes contained in the updated documents. One of those major themes is that, "The acquisition process must consider both performance requirements and fiscal constraints. Accordingly, cost must also be an independent variable in programmatic decisions, with responsible cost objectives set for each program phase." This theme is to be known as Cost As an Independent Variable (CAIV).

Every issuance of the acquisition policy documents has emphasized this same theme, and correctly so. CAIV is the latest in a series of terms intended to put focus on life-cycle cost. Past and current initiatives have addressed Should Cost, Budget To Cost, and Design To Cost (DTC), with variations such as Design-to-unit Production Cost (DTUPC) and Design to Life-cycle Cost (DTLCC). Additionally, terms such as Life-cycle Cost Procurement (LCCP) and Life-cycle Cost Management (LCCM) have come into common usage as cost concepts have been applied in an effort to comply with policy documents. The current DoD 5000.2-R includes Program Acquisition Unit Cost, Average Procurement Unit Cost (undefined), and Average Unit Procurement Cost.

To understand what is new about Life-cycle Cost (LCC), review the way it is woven into the policy directives and consider the concept in the context of the overall agenda of acquisition reform in the mid 1990's. By 1991, when the policy directives were last updated, LCC was strongly encouraged and described on about 20 of the 900 pages in the policy directives. However, in 1991 LCC and DTC were encouraged but optional at all levels of acquisition program decision making. When the policy documents were overhauled for the 1996 issuance, the overall page count decreased to less than 100 pages; and LCC, under its new title CAIV, was mentioned approximately 25 times thoughout the documents. Clearly, the relative importance of LCC greatly increased; and, more importantly, it is now mandatory for the major acquisition category programs.

Many contemporary political issues dictate that control of the costs associated with both acquisition and ownership of weapons systems receive an unprecedented level of management attention. On 4 December 1995, the Under Secretary of Defense for Acquisition and Technology issued a memorandum on the subject of, "Reducing Life-Cycle Costs for New and Fielded Systems." The memorandum started with the statement that, "Reducing the cost to acquire and op-

erate the department's equipment while maintaining a high level of performance for the user is my highest priority."

Some readers may ask if this is just the same concept as the old 5000-series directives, which are described as "Design-To-Cost." In fact, the concept is the same, and the LCC analysis process is the same. But the emphasis and environment are different. What was optional in the old LCC directives is now mandatory, and a fundamental change has occurred in DoD-level acquisition strategy. For more than 30 years, DoD acquisitions were reactions to a constantly changing Soviet technological threat. To counter this threat DoD acquisitions experienced an evolving set of requirements because of the length of the acquisition life cycle, changes in the enemy's capabilities, and emerging technological opportunities. These factors regularly resulted in programs that experienced significant cost growth and the accompanying negative reactions of those who did not understand the reasons for the growth. Added to this is a current perception that some portion of the changes and cost growth was unwarranted. This has been referred to as the 110 percent solution to a requirement. Various contractor and program staff members were adding "bells and whistles" on systems to the point where "gold plating" was not unusual. In hindsight, it appears that serious discussions between the developer and the user, with a view toward holding cost growth down, did not always take place. CAIV is a change to the former trend. CAIV and LCC are likely to be much more of a cost-holding force for many socioeconomic reasons, including peace dividend mentality, user paying the support bill within Defense Working Capital Fund (DWCF), sustainment bill taking all of the budget (proportionally few defense dollars available for modernization), etc.

The objectives of CAIV follow:

- setting realistic but aggressive cost objectives early in each acquisition program,
- devising and employing a process for accomplishing cost-schedule-performance tradeoffs during each acquisition phase and at each milestone decision point,
- managing risks to achieve cost, schedule, and performance objectives,
- devising appropriate metrics for tracking progress in setting and achieving cost objectives,
- motivating government and industry managers to achieve program objectives, and
- establishing in-place additional incentives to reduce operating and support costs for fielded systems.

The challenge to the acquisition logistician is to champion the implementation of these concepts actively and aggressively through participation in the various Integrated Process Teams (IPTs). Knowledgeable use of Life-cycle Costing can be the catalyst in assuring affordability of systems when fielded for operations by the user.

12.2 LIFE-CYCLE COST (LCC) OVERVIEW

The life cycle of a system begins with the determination of a mission requirement and includes research and development (R&D), production, deployment, operation, support, and eventual disposal or demilitarization by the Department of Defense (DoD). Program phases may overlap considerably; in particular, R&D may not be completed before procurement begins.

12.2.1 LCC Analysis Is an Iterative Process

The LCC estimate must reflect program changes as they occur. LCC Management (LCCM) is the program office discipline used to incorporate LCC in program office decision making. The lead acquisition logistics manager will generally be tasked to provide Operating and Support (O&S) cost support for the LCC estimate.

12.2.1.1 LCC Breakdown. For purposes of cost estimating, LCC is typically divided into research and development, procurement, O&S, and disposal. The following descriptions provide a brief summary of the costs associated with each life-cycle phase (see Figure 12-1):

- R&D. R&D consists of those costs incurred from program initiation at the conceptual phase through the end of engineering and manufacturing development. R&D costs include the cost for feasibility studies, modeling, tradeoff analyses, engineering design, development, fabrication, assembly and test of prototype hardware and software, system test and evaluation, associated peculiar support equipment, and documentation.

- Procurement. Procurement includes the costs associated with producing or procuring the prime hardware, support equipment, training, data, initial spares, and facilities.

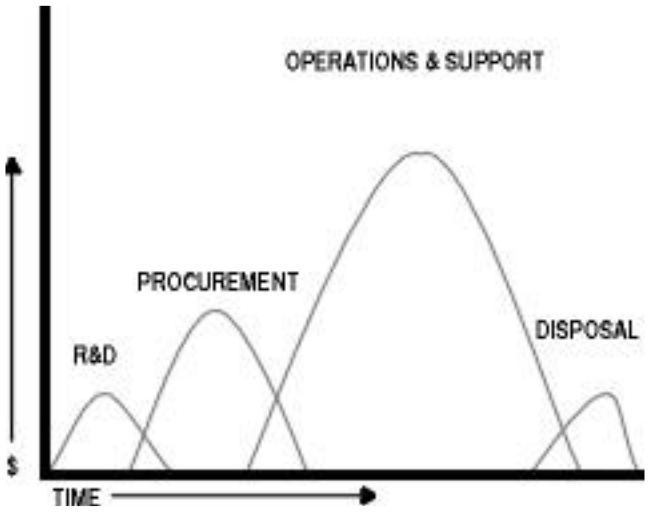

Figure 12-1: Growth in Weapon System Life-Cycle Cost

- O&S. O&S consists of all costs incurred by the DoD to field/deploy the system including personnel, consumable and reparable parts, fuel, shipping, and maintenance.

- Disposal. Disposal captures costs associated with deactivating or disposing of a materiel system at the end of its useful life. Disposing of a materiel system can result in additional costs or a salvage value depending on the disposition. This cost is normally insignificant compared to the total LCC. The main exceptions to this include disposal of nuclear waste, missile propellants, and other materials requiring expensive detoxification or special handling.

12.2.1.2 Design to Cost (DTC) Establishes LCC as a Design Parameter. DTC requires the establishment of cost goals and strives to incorporate these goals into the system design. Initial DTC activity focuses on identifying system cost drivers, potential risk areas, and cost/schedule/performance tradeoffs. As development continues, efforts focus on identifying areas requiring corrective actions. Cost reduction techniques are applied to such areas to keep costs within an acceptable range.

12.2.1.3 Depth and Accuracy of Estimates. The depth and accuracy of cost estimates depend on the acquisition program phase and the use of the estimate. At Milestone I, very little will be known about the detailed design of the proposed system. However, affordability of the program must be evaluated, alternatives compared, and DTC goals established. The most significant impact on costs can be achieved prior to Milestone I. This is when major decisions, such as the selection of a manned vs. an unmanned system are made. Such decisions lock in major costs for the system. The opportunity to influence cost diminishes as the program matures. See Figure 12-2 and Figure 12-3.

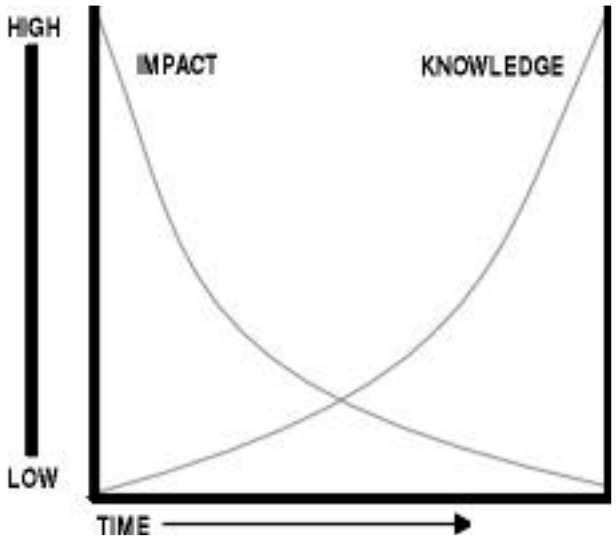

Figure 12-2: Entire Acquisition Time Line

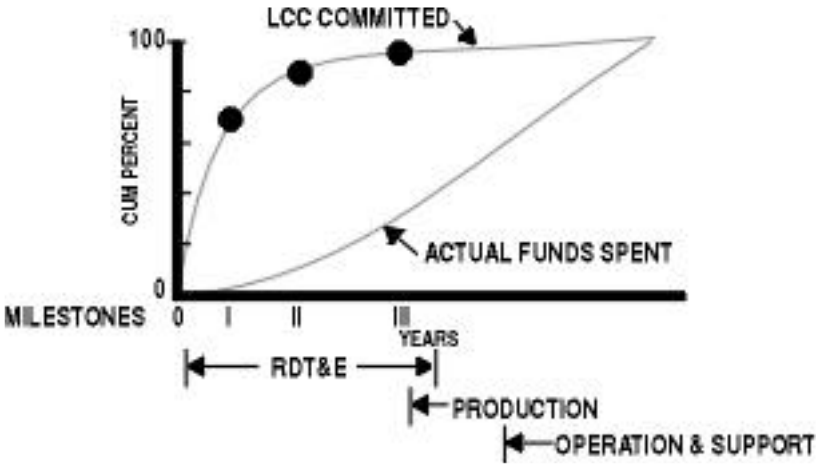

Figure 12-3: Early Impact of Decisions on Life-Cycle Cost

12.3 OPERATIONS & SUPPORT (O&S) COST OVERVIEW

O&S costs are those incurred by the DoD for the peacetime operations and maintenance of a system throughout its life cycle. Major determinants of O&S costs are design characteristics, reliability, maintainability, and mission requirements.

12.3.1 Uses of O&S Cost Information

O&S cost information is used for a variety of purposes throughout the acquisition process, including the following:

- support of the design-to-cost program,
- support of milestone decisions,
- discrimination among alternative designs,
- support of budget estimates, and
- conducting Tradeoff Analysis.

12.3.2 Depth and Accuracy of Estimates

As part of LCC estimating, the detail and accuracy of the O&S cost estimate also depends on the acquisition program phase at the time the estimate is initiated/revised/completed and the intended use of the O&S estimate. As a system is developed and designs and support concepts are evolved, O&S cost estimates and cost comparisons should become increasingly accurate. By Milestone II, the subsystem O&S cost drivers should be identified. Cost drivers are characteristics of a system or subsystem that influence a major share of the system cost. An understanding of the system's design is necessary for identification of system cost drivers.

The O&S cost estimates prepared for Milestone III are based on system design characteristics, deployment schedule, and operation and maintenance concepts. Operating experience obtained during system test and evaluation is used to verify progress in meeting O&S cost goals and to identify problem areas.

12.3.3 Summary of the LCC Analysis Process

The analysis process follows these steps:

- defining the problem (the requirement for the analysis);
- analyzing the goals of the analysis;
- selecting the elements of cost to include in the analysis and select or construct a model;
- collecting required model input data;
- runing the model, including "what-ifs" and sensitivities;
- performing analysis of model output data and developing conclusions; and
- documenting the analysis results and making recommendations.

12.4 O&S COST METHODOLOGY

Before initiating an O&S cost estimate, the methodology for the estimate must be determined. This methodology will depend on the purpose of the estimate, the system under analysis, the acquisition phase, and the data available. Using this information, a procedure for accomplishing an estimate could begin by:

- establishing a set of study objectives;
- determining the O&S cost of similar systems and budgeted or programmed O&S costs of the new system.
- reviewing, if applicable and available, the Analysis of Alternatives; and
- performing a "should cost" or cost reduction exercise.

12.4.1 Develop Ground Rules, Facts Bearing on the Problem, and Assumptions

Ground rules, facts bearing on the problem, and assumptions (where needed facts are not available) are based on the way the system will be operated, maintained, and supported in peacetime. The ground rules, facts, and assumptions include descriptions of relevant missions and system characteristics and manning, maintenance, support, and logistics *policies*. All ground rules, facts, and assumptions must be clearly stated and documented.

The intended use of the system should be determined in order to identify the pertinent support characteristics; planned logistics resources; and, in turn, the related cost. As stated in the USAMC Logistic Support Activity prepared *DoD Handbook: Acquisition Logistics* (MIL-HDBK-502), "Determining the best set of planned logistics resources for a system is the function of the acquisition logistics discipline of systems engineering. It is accomplished through analysis of those *design characteristics, which generate a need for, or are associated with, providing operational support to the total system.* These design characteristics are developed by many different disciplines pursuing a wide range of systems engineering activities. Individually they may be viewed as hardware, software, or support-system design characteristics. Collectively they represent the "supportability" of a total system." For example, in estimating O&S cost for ground-based radar system maintenance requirements, consideration must be given to the need for a 24-hour-a-day, 365-day-a-year mission. The acquisition logistics discipline of systems engineering would likely perform tradeoff analyses between system redundancy and the costs of maintenance manpower/spares required to ensure affordable mission availability is met. The O&S cost would be developed accordingly.

12.4.2 Select Comparable System

A comparable system may be an operational program with a mission similar to the proposed program. It is often the system being replaced, unless another system provides a better reference for the analysis. There are a variety of sources within each Service for obtaining technical, performance, and cost data on comparable systems. The assumptions, ground rules, and cost estimating methodologies for both the comparable and proposed systems must be related. This is essential in order to identify differences in resource consumption due to differences in system characteristics. Caution is necessary when considering data from a system acquired prior to the implementation of Acquisition Reform. Comparable system data are then adjusted to better approximate the proposed system.

12.4.3 Identify O&S Cost Drivers

System O&S cost drivers must be identified early in the system life cycle. These vary from program to program but are defined as those elements in the program that have a major impact on system LCC. As the program matures, these drivers should influence system design choices. As the design matures, O&S cost drivers will change. Alternative approaches, design tradeoffs, and sensitivity of O&S costs to changes should be evaluated within the "Analysis Of Alternatives" (AOA).

12.5 DETERMINE COST-ESTIMATING TECHNIQUE

When estimating the O&S cost of a system, there are several techniques that may be applied. The choice of technique depends on the maturity of the program and the data available. Most O&S analyses are accomplished using a combination of three estimating techniques: analogous system, parametric, and engineering. The latter is sometimes called a "bottoms up" or "grass roots" estimate and uses accounting-type data. As the program progresses from concept development to production, more-detailed cost data become available. Initial estimates are then updated with a prototype test or actual operational data. Regardless of the estimating technique applied, appropriate documentation must accompany the estimate. The following is a summary of each of these estimating techniques.

12.5.1 Analogous System

In this technique, a currently fielded system (a comparable system) that is similar in design and/or operation to the proposed system is identified. Taking the fielded system's data and adjusting them to account for any differences then develops the cost of the proposed system. The analogous system may be a composite of several fielded systems. This technique of cost estimation is widely used. One drawback to analogous system estimation is the amount of detailed technical and engineering data required. The analogous system approach places heavy emphasis on the opinions of "experts." Therefore, it is necessary to document clearly the rationale used to determine the composition of the analogous system and the adjustment factors used.

12.5.2 Parametric

The parametric approach employs Cost-Estimating Relationships (CERs) to develop estimates using regression analysis. A CER is an equation that relates one or more characteristics of an item to some element of its cost. For example, a study of existing avionics equipment may yield a CER relating avionics unit cost to the weight of the avionics system. This CER could then be used to predict avionics unit cost for a new system, which has weight that needs estimated. Normally analogy or parametric estimating is used early in the life cycle of a system, when item specific data is not known. CERs must be examined to ensure they are current (i.e., reflect acquisition reform), appropriate for the range of data being estimated, and applicable to the system. If they are improperly applied, the result could be serious estimating errors.

12.5.3 Accounting Estimates

The accounting method uses engineering estimates of reliability, maintainability, and component cost characteristics (optempo rates) to build estimates from the "bottom-up" for each cost category. Accounting estimates require detailed system data. The system is typically broken down into lower-level components, and estimates of each component are made. Although this method can be complex and time consuming, it is the method of choice when detailed system data is available.

12.6 SELECTING THE MOST APPROPRIATE COST MODEL

As with the choice of methodology, the selection of an O&S cost model also depends on the purpose of the estimate, the system under analysis, the acquisition phase, and (most importantly) the data available.

12.6.1 Desired Characteristics

Although no single O&S model can be used for all purposes, an O&S model should have as many of the following characteristics as possible:

12.6.1.1 Consistency. A consistent model conforms to current O&S cost-estimating practices. This allows the proposed system to be compared to an analogous system.

12.6.1.2 Flexibility. The model should be constructed so that it is useful in the early phases and can evolve to accommodate more-detailed information as the program continues through its life cycle.

12.6.1.3 Simplicity. The model should require only the minimum data necessary to estimate the O&S cost. More complex models can be used as more data becomes available.

12.6.1.4 Usefulness. The model should provide useful information to the decision makers in their evaluation of support and design tradeoffs.

12.6.1.5 Completeness. O&S models should include all applicable costs for a system's operation and support over its useful life.

12.6.1.6 Validity. The model should be capable of providing logical, reproducible results.

12.6.2 Cost Models in Wide Use

Three O&S cost models widely used in the DoD are the Cost Analysis Strategy Assessment (CASA) model, the Air Force's Cost-Oriented Resources Estimating (CORE) model, and the Logistics Support Costs (LSC) model. A sampling of models selected to illustrate the characteristics for a credible O&S cost model follows:

12.6.2.1 CASA. CASA is designed as an engineering estimate or accounting model. No CERs are used. The model conforms to the requirements of the Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG) guidelines for cost elements. The model uses some 90 algorithms and 190 variables to capture all relevant operating and support costs. It is flexible which means most of the inputs are optional so the model's capability can be tailored to the needs of the LCC analyst. Also, the model uses fixed formulas so the analysis is completely repeatable. It is general purpose and has been used in all of the Services to support analysis needs on a wide variety of systems and equipment.

12.6.2.2 CORE. CORE is designed to provide a cost-estimating technique to be used to develop aircraft O&S cost estimates. CORE uses data available from standard USAF data systems (consistency). It allows the estimating techniques to vary as the program progresses through the phases of acquisition (flexibility), and it estimates all common O&S cost elements (completeness). It uses the format, cost element structure, and procedures generally required for milestone briefings (usefulness).

12.6.2.3 LSC. The LSC uses consistent data for comparable systems available from standard USAF data sources (consistency) and also contains built in factors allowing the model to be used when little item-specific data is available. As the program matures and item-specific data evolves, the factors are replaced, which results in an improved O&S cost estimate (flexibility). The LSC model addresses spares, depot maintenance, and transportation in detail. Manpower, support equipment, and training are addressed only superficially; fuel and other costs of operation are not included in the model.

12.7 DATA SOURCES

Various sources of data are available to accomplish O&S cost estimates. As with budget estimation, which is normally based on actual contract expenditures on similar acquisitions, O&S costs come from the reporting of information from field use of similar systems. The data source will depend on the type of analysis and model being used. With the advent of widespread use of LCC in the early 1970s, the Navy began development of the Visibility and Management of Operating and Support Costs (VAMOSC) data reporting system. Over the years VAMOSC has been underfunded and repeatedly "re-engineered" as organizations and their reporting capability have continually come and gone. Each of the Services' centers for cost analysis is involved in VAMOSC-associated work. In mid-1996 the OSD CAIG and the Navy Center for Cost Analysis teamed to investigate, once again, the VAMOSC for a major re-engineering in support of the CAIV initiative. Many of their recommended improvements are already being implemented. The following are types of data drawn from VAMOSC and other Service databases. The final paragraph of this chapter lists each Service Component's cost center.

12.7.1 Comparable System Data

Comparable system data are used in accomplishing analysis before specific system details are available. The logistics manager must adjust comparable system data to reflect the changes expected in the proposed system. For example, if the proposed system incorporates built-in test (BIT) while the comparable system does not have this capability, the comparable system data on fault isolation labor-hours would have to be adjusted to reflect BIT use in the proposed system.

12.7.2 Engineering Estimates

As the system definition matures, system-specific data replaces comparable system data. System engineers are the primary source for item-specific reliability and maintainability data plus performance estimates. This data is followed by test and evaluation data and then by actual field data.

12.7.3 Usage Data

The program will need to make provision for a consistent source of logistics and other data for O&S cost analyses. The program analysis database should include specific data on costs, reliability, maintainability, training, support equipment, provisioning, packaging, facilities, etc. The program data may or may not be consistent with some Service-specific O&S cost models. Some program data may have to be adjusted to account for model definition or format differences.

12.7.4 Cost and Planning Factors

The Military Departments maintain cost and planning factors, which can be used to estimate resource requirements and costs associated with force structures, missions, and activities.

2.8 COMPLETING THE O&S COST ESTIMATE

Once the technique, model, and data are in hand, it is time to estimate and evaluate the relevant O&S costs. Applying the available data to the model selected generates an estimate. The accuracy of an O&S cost estimate is affected by uncertainties from many sources. It is important to identify and bound the scope of variables that contribute to uncertainty. Each variable should be examined independently, and cross-checks should be performed to ensure that the estimate is credible.

12.8.1 Sensitivity Analysis

To identify those element outputs that are particularly vulnerable to relatively small changes in driver input values, sensitivity analysis varies the data inputs of certain cost drivers. This analysis is performed to identify the magnitude of the uncertainty in the O&S cost estimate and to identify areas that require further management attention. Sensitivity analysis can also determine the effects of data uncertainties and changes in ground rules and assumptions.

12.8.2 Documenting the Results

Detailed documentation of the cost estimate is essential to an O&S estimate. The documentation serves as the audit trail of the ground rules, facts bearing on the problem and assumptions, estimating techniques, model selection basis, data sources, sensitivity analysis, and results. The documentation should explain the methods used to establish the bounds and the elements included in the sensitivity analysis. The documentation provides sufficient information for the replication and confirmation of the estimate by an experienced analyst.

12.8.3 Making Revisions

The O&S cost estimate is revised prior to each milestone review to incorporate all changes to the program since the last milestone or revision. Keeping an estimate current at all times is essential. Therefore, as major program changes occur, the O&S estimate is revised (even if an O&S cost impact is not readily apparent). For example, a decision to change to composite material may result in less maintenance required but more expensive repair techniques.

12.9 USES FOR THE O&S COST ESTIMATE

The O&S Cost estimate is a large part of the total program LCC. O&S cost estimates are required whenever the LCC estimate is prepared. Annual program office estimate requirements vary, but usually include O&S costs.

12.9.1 Analysis Of Alternatives (AOA)

The analysis is to aid decision makers in judging whether or not any of the proposed alternatives to an existing system offer sufficient military and/or economic benefit to be cost worthy.

12.9.2 Tradeoffs

Once a baseline estimate is complete, the impact of program changes on O&S costs can be evaluated. When combined with schedule and performance data and an objective function, the estimate may support a CAIV-based tradeoff exercise. An example of a design tradeoff is an Engineering Change Proposal (ECP). The ECP analysis is used to assess the cost implications of a proposed design change. The decision to accept or reject the ECP is made after considering the effect on program costs. Comparing the cost of the baseline configuration with the cost of the proposed configuration assesses the ECP. Areas of uncertainty are identified and appropriate sensitivity analyses performed.

12.9.3 Independent Cost Estimate (ICE)

An ICE is a cost estimate prepared by an objective nonprogram office team. The decision makers use the ICE primarily to identify any inconsistencies with the program office estimate. An O&S cost estimate is a major portion of these ICE efforts.

12.9.4 Milestone Reviews

During a milestone review, program LCC is carefully scrutinized to determine program readiness to proceed to the next acquisition phase. Both the program office estimate and the ICE are reviewed to determine if the program is still likely to meet requirements and is still cost-effective. A recommendation is provided to the decision makers following this review.

12.9.5 Source Selection

O&S estimates should be an integral part of the most probable cost for each proposal under consideration during source selection. These most probable costs are used by the source selection authority in award.

12.9.6 Budgeting

Budgeting for O&S cost elements is one use of the estimate. The current DoD trend is to track cost estimating more closely with budgeting. An effort is underway to incorporate the O&S cost estimate into the Acquisition Program Baseline (APB).

12.10 REFERENCES

1. " Acquisition Logistics," *Department of Defense Handbook* (MIL-HDBK-502), prepared by USAMC Logistic Support Activity, ATTN: AMXLS-ALD, Building 5307, Redstone Arsenal, AL 35898-7466. WEB: http://www.logsa.army.mil:80/logsa.htm

2. Service Cost Centers:

   Army
   U.S. Army Cost and Economic Analysis Center
   5611 Columbia Pike
   Falls Church, Virginia 22041
   Tel: DSN 761-3336/7/8; Comm (703) 681-3336/7/8
   E-Mail: TRMATEER@aol.com
   WEB: http://www.asafm.army.mil

   Navy
   Navy Center for Cost Analysis
   1111 Jefferson Davis Highway
   Arlington, Virginia 22202-4306
   TEL: Comm (703) 604-0293
   E-Mail: downsirene@ncca.navy.mil
   WEB: www.ncca.navy.mil/ncca.htm

   Air Force
   Air Force Cost Analysis Agency
   1111 Jefferson Davis Highway
   Arlington, Virginia 22202
   TEL: Comm (703) 604-0387
   E-Mail: WEEKS@afcaanet.afcaapo.hqaf.mil
   WEB: http://www.saffm.hq.af.mil/SAFFM/