Chapter 3
Affordability and Life-Cycle Resource Estimates

3.0. Overview

3.0.1. Purpose

This chapter addresses acquisition program affordability and resource estimation. It provides explanations of the program and pre-program activities and information required by DoD Instruction 5000.2, and discusses the support and documentation provided by Office of the Secretary of Defense staff elements.

3.0.2. Contents

Section 3.1 is informational. It provides introductory background material intended for a general audience. It describes the concept of program life-cycle cost, and provides definitions of terms used by the DoD cost community.

The next five sections are more specialized; they discuss the specific milestone review procedures, expectations, and best practices for a variety of topics related to acquisition program affordability, cost, and manpower. Section 3.2 describes the basic policies associated with the consideration of affordability in the acquisition process, and offers one possible analytic approach to the preparation of affordability assessments. This section also explains the Department's full-funding policy, and describes the concept known as Cost as an Independent Variable. Section 3.3 describes the Analysis of Alternatives process. Sections 3.4, 3.4.1, and 3.4.2 discuss the Cost Analysis Improvement Group (CAIG), resident in the Office of the Secretary of Defense (OSD). The OSD CAIG prepares independent life-cycle cost estimates for major defense acquisition programs at major milestone reviews, and concurrently reviews cost estimates prepared by the program office and/or the DoD Component cost agency. Section 3.5 describes the review procedures for manpower estimates. Section 3.6 discusses procedures unique to major automated information systems.

The last section, 3.7, is intended for less experienced cost analysts working in the acquisition community. This section provides a recommended analytic approach for preparing a life-cycle cost estimate for a defense acquisition program.

3.1. Life-Cycle Costs/Total Ownership Costs

3.1.1. Introduction

Both DoD Directive 5000.1, *The Defense Acquisition System*, and DoD Instruction 5000.2, *Operation of the Defense Acquisition System*, make reference to life-cycle cost and total ownership cost. This section of the Guidebook explains the meaning of each these terms. The terms are similar in concept, but significantly different in scope and intent. For a defense acquisition program, life-cycle cost consists of research and development costs, investment costs, operating and support costs, and disposal costs over the entire life-cycle. These costs include not only the direct costs of the acquisition program, but also include indirect costs that would be logically attributed to the program. The concept of total ownership cost is related, but broader in

scope. Total ownership cost consists of the elements of life-cycle cost, as well as other infrastructure or business process costs not necessarily attributable to the program. The following paragraphs more carefully define and describe these concepts.

When programs are less mature (in pre-systems acquisition or system development and demonstration), program cost estimates that are supporting the acquisition system normally are focused on life-cycle cost or elements of life-cycle cost. Examples of such cases where cost estimates support the acquisition system at a macro level include affordability assessments (see section 3.2.2), analyses of alternatives (see section 3.3), cost-performance trades (see section 3.2.4), and establishment of program cost goals (see section 2.1). In addition, more refined and discrete life-cycle cost estimates may be used within the program office to support internal decision-making such as evaluations of design changes and assessment of producibility, reliability, maintainability, and supportability considerations. However, as programs mature (transition from production and deployment to sustainment), cost estimates that support the acquisition system or program management in many cases may need to be expanded in scope to embrace total ownership cost concepts. Examples of such cases are provided in section 3.1.5.

3.1.2. Life-Cycle Cost Categories and Program Phases

DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*, provides standardized definitions of cost terms that in total comprise system life-cycle costs. Life-cycle cost can be defined as the sum of four major cost categories, where each category is associated with sequential but overlapping phases of the program life-cycle. Life-cycle cost consists of (1) research and development costs, associated with the Concept Refinement phase, Technology Development phase, and the System Development and Demonstration phase, (2) investment costs, associated with the Production and Deployment phase, (3) operating and support costs, associated with the sustainment phase, and (4) disposal costs, occurring after initiation of system phase-out or retirement, possibly including demilitarization, detoxification, or long-term waste storage. Figure 1 depicts a notional profile of annual program expenditures by cost category over the system life-cycle.

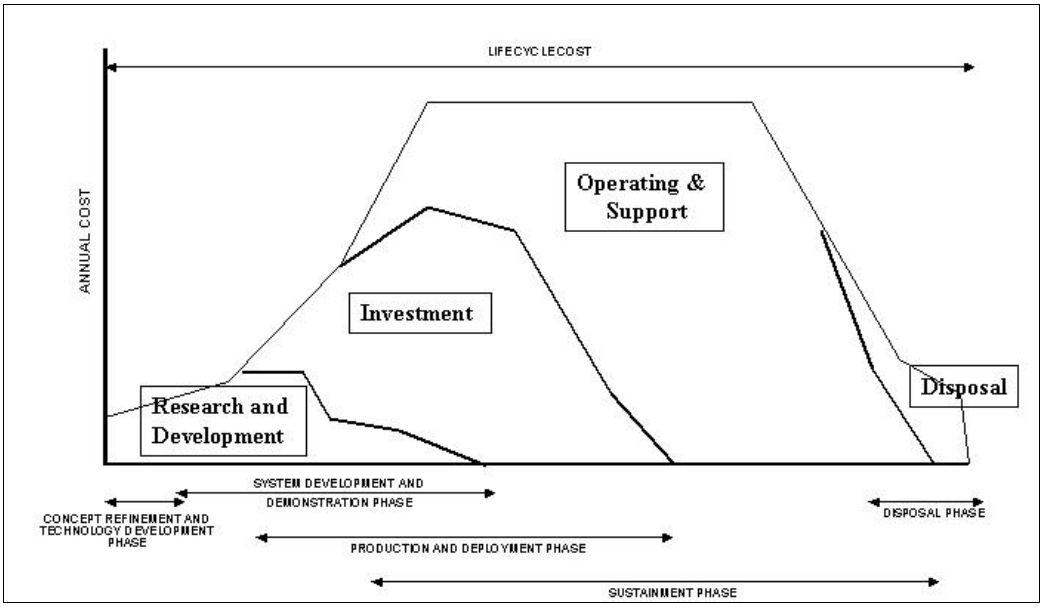

Figure 1. Illustrative Program Life Cycle

3.1.3. Life-Cycle Cost Category Definitions

The following paragraphs summarize the primary cost categories associated with each program life-cycle phase:

- Research and Development consists of development costs incurred from the beginning of the conceptual phase through the end of the System Development and Demonstration phase, and potentially into Low-Rate Initial Production. Typically includes costs of concept refinement trade studies and advanced technology development; system design and integration; development, fabrication, assembly, and test of hardware and software for prototypes and/or engineering development models; system test and evaluation; system engineering and program management; peculiar support (peculiar and common support equipment, peculiar training equipment/initial training, and technical publications/data) and initial spares and repair parts associated with prototypes and/or engineering development models.
- Investment consists of production and deployment costs incurred from the beginning of low rate initial production through completion of deployment. Typically includes costs associated with producing and deploying the primary hardware; system engineering and program management; peculiar support (peculiar and common support equipment, peculiar training equipment/initial training, and technical publications/data) and initial spares and repair parts associated with production assets; and military construction and operations and maintenance associated with system site activation.
- Operating and Support consists of sustainment costs incurred from the initial system deployment through the end of system operations. Includes all costs of operating, maintaining, and supporting a fielded system. Specifically, this consists of the costs (organic and contractor) of personnel, equipment, supplies, software, and services associated with operating, modifying, maintaining, supplying, training, and supporting a system in the DoD inventory. This includes costs directly and indirectly attributable to the system (i.e., costs that would not occur if the system did not exist), regardless of funding source or management control. Direct costs refer to the resources immediately associated with the system or its operating unit. Indirect costs refer to the resources that provide indirect support to the system's manpower or facilities. For example, the pay and allowances reflected in composite standard rates for a unit-level maintenance technician would be treated as a direct cost, but the (possibly allocated) cost of medical support for the same technician would be an indirect cost.
- Disposal consists of costs associated with demilitarization and disposal of a military system at the end of its useful life. These costs in some cases represent only a small fraction of a system's life-cycle cost and may not be considered when preparing life-cycle cost estimates. However, it is important to consider demilitarization and disposal early in the life-cycle of a system because these costs can be significant, depending on the characteristics of the system. Costs associated with demilitarization and disposal may include disassembly, materials processing, decontamination, hardware, collection/storage/disposal of hazardous materials and/or waste, safety precautions, and transportation of the system to and from the disposal site. Systems may be given credit in the cost estimate for resource recovery and recycling considerations.

The life-cycle cost categories correspond not only to phases of the acquisition process, but also to budget appropriations as well. Research and Development costs are funded from

RDT&E appropriations, and investment costs are funded from Procurement and MILCON appropriations. Operating and support costs are funded from Military Personnel, Operations and Maintenance, and Procurement appropriations. However, some major automated information system programs may use defense working capital fund (DWCF) financing in place of appropriated funding (such as DWCF capital funds instead of procurement funds, or DWCF operating funds instead of operations and maintenance funds). The cost categories used in most acquisition documents (such as Selected Acquisition Reports and Acquisition Program Baselines) and in most budget documents (such as budget item justifications) are based on the appropriation terms. (Note that the term "program acquisition cost" as used in acquisition documents is the sum of RDT&E, Procurement, and possibly MILCON costs.)

3.1.4. Implications of Evolutionary Acquisition

The application of life-cycle cost categories to program phases may need to be modified for programs with evolutionary acquisition strategies. DoD Instruction 5000.2, *Operation of the Defense Acquisition System*, describes the evolutionary acquisition approach for acquisition programs. In an evolutionary approach, the ultimate capability delivered to the user is provided in increasing increments. Evolutionary acquisition strategies (1) define, develop, produce and deploy an initial, militarily useful capability (Increment 1) based on proven technology, demonstrated manufacturing capabilities, and time-phased capabilities needs; and (2) plan for subsequent development, production and deployment of increments beyond the initial capability over time (Increments 2 and beyond). DoD Instruction 5000.2 offers two types of approaches to achieve evolutionary acquisition:

Spiral Development. The capability needs document(s) include a firm definition of the first increment, but the remaining interim increments and the precise end-state capabilities are not known at program initiation. The acquisition strategy defines the first increment of capability, and how it will be funded, developed, tested, produced, and supported. The acquisition strategy also describes the desired general capability the evolutionary acquisition is intended to satisfy, and establishes a management approach that will be used to define the exact capabilities needs for each subsequent increment.

Incremental Development. The capability needs documents(s) include a firm definition of the entire end-state capability, as well as firm definitions of interim increments, including an initial operating capability (IOC) date for each increment. In this case, the program acquisition strategy defines each increment of capability and how it will be funded, developed, tested, produced, and operationally supported.

For a program with evolutionary acquisition, the question often arises concerning the scope of the life-cycle cost estimate presented at a milestone review. In the case of incremental development, the entire acquisition program (including all future increments) is included in the scope of the program to be approved at the review. The entire program therefore typically is included in the corresponding life-cycle cost estimate. In the case of spiral development, the situation will vary somewhat depending on circumstances. Normally, the life-cycle cost estimate should attempt to reflect in the Cost Analysis Requirements Description (CARD) as much of the program as can be defined at the time of the milestone review, and any exclusions (for portions of the program that cannot be defined at that time) should be clearly identified.

In either case, the application of life-cycle cost categories and program phases (as described in section 3.1.2) may need to be modified to account for the evolutionary acquisition strategy.

Figure 2 depicts a notional profile of annual program expenditures by cost category for a program with evolutionary acquisition.

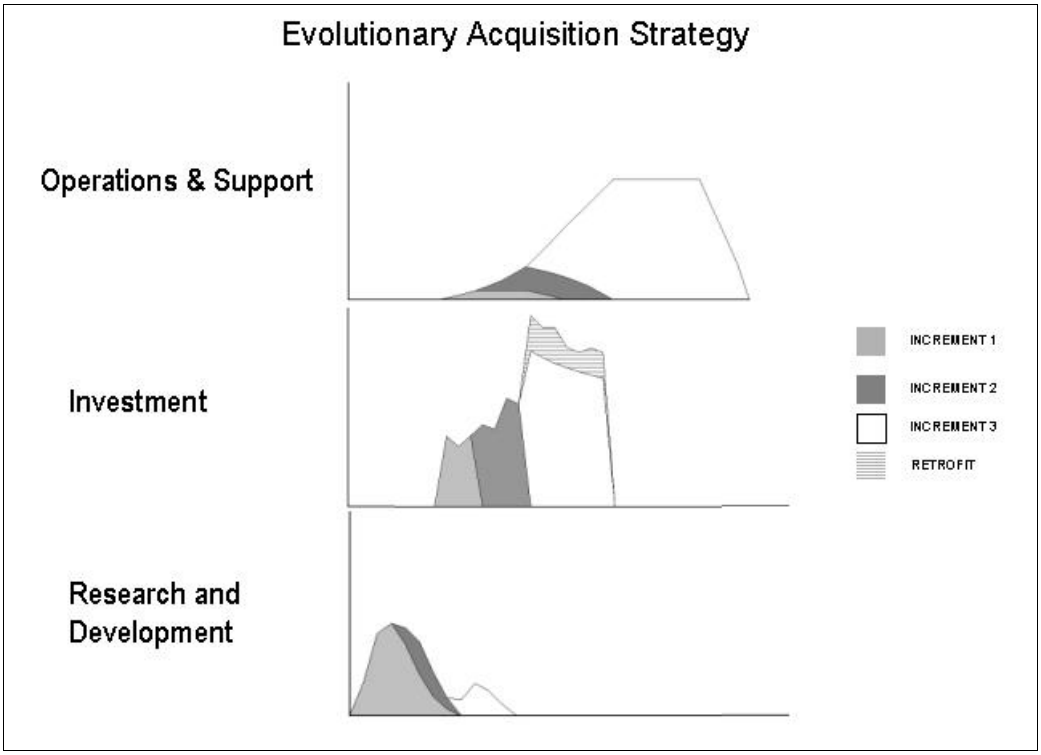

Figure 2. Illustrative Program Life Cycle under Evolutionary Acquisition

3.1.5. Total Ownership Costs

As explained earlier, total ownership cost consists of the elements of a program's life-cycle cost, as well as other infrastructure or business processes costs not necessarily attributable to the program. Infrastructure is used here in the broadest possible sense, and consists of all military department and defense agency activities that sustain the military forces assigned to the combatant and component commanders. Major categories of infrastructure are support to equipment (acquisition and central logistics activities), support to military personnel (non-unit central training, personnel administration and benefits, and medical care), and support to military bases (installations and communications/information infrastructure).

In general, traditional life-cycle cost estimates are in most cases adequate in scope to support decisions involving system design characteristics (such as system weight, material mix, or reliability and maintainability). However, in special cases, depending on the issue at hand, the broader perspective of total ownership cost may be more appropriate than the life-cycle cost perspective, which may be too narrow to deal with the particular context. As discussed previously, for a defense acquisition program, life-cycle costs include not only the direct costs of the program, but also include indirect costs that would be logically attributed to the program. In a typical life-cycle cost estimate, the estimated indirect costs would include only the costs of infrastructure support specific to the program's military manpower (primarily medical support and system-specific training) and the program's associated installations or facilities (primarily base operating support and facilities sustainment, restoration and modernization). Many other

important infrastructure activities (such as recruiting and accession training of new personnel, individual training other than system-specific training, environmental and safety compliance, contract oversight support from the Defense Contract Management Agency and the Defense Contract Audit Agency, and most management headquarters functions) are normally not considered in the scope of a traditional acquisition program life-cycle cost estimate. In addition, important central (i.e., wholesale) logistics infrastructure activities such as supply chain management are implicitly incorporated in a traditional life-cycle cost estimate, but their costs are somewhat hidden (because these costs are reflected in the surcharges associated with working capital fund arrangements and are not explicitly identified). However, there could easily be cases where consideration of such infrastructure activities would be important and would need to be explicitly recognized in a cost estimate or analysis. Examples of such cases are cost analyses tied to studies of alternative system support concepts and strategies; reengineering of business practices or operations; environment, safety, and occupational health considerations; or competitive sourcing of major infrastructure activities. In these cases, the traditional life-cycle cost structure may not be adequate to analyze the issue at hand, and the broader total ownership cost perspective would be more appropriate. For such instances, the typical life-cycle cost tools and data sources would need to be augmented with other tools and data sources more suitable to the particular issue being addressed.

3.2. Affordability

DoD Directive 5000.1 provides the fundamental acquisition policies for cost and affordability and program stability. Affordability can be defined as the degree to which the life-cycle cost of an acquisition program is in consonance with the long-range modernization, force structure, and manpower plans of the individual DoD Components, as well as for the Department as a whole. The remainder of this section discusses different aspects of affordability. Section 3.2.1 describes how affordability is considered during the identification of military capability needs, and at acquisition milestone reviews. Section 3.2.2 provides some recommended analytic approaches to the preparation of affordability assessments. Section 3.2.3 explains the Department's full-funding policy. And section 3.2.4 describes a process known as Cost As an Independent Variable, which can be used to ensure that life-cycle cost has equal consideration with performance and schedule in program decisions. (See section 5.1.3.5.)

3.2.1. Affordability Considerations

Affordability plays an important part in program decisions throughout the life-cycle. Even before a program is formally approved for initiation, affordability plays a key role in the identification of capability needs. Program affordability is part of the JCIDS analysis process, which balances cost versus performance in establishing key performance parameters. Moreover, all elements of life-cycle cost (or total ownership cost, if applicable) are included in the resulting capability needs document(s). Cost goals are established in terms of thresholds and objectives (see 2.1.1.1) to provide flexibility for program evolution and to support further Cost-as-an-Independent-Variable trade-off studies (see 3.2.4).

Affordability also is considered by the Milestone Decision Authority at each decision point. In part, this consideration ensures that sufficient resources (funding and manpower) are programmed and budgeted to execute the program acquisition strategy. The Milestone Decision Authority also examines the realism of projected funding over the programming period and beyond, given likely DoD Component resource constraints. To support this determination, the

DoD Components are required to submit affordability assessments. The affordability assessment is discussed in the next section.

3.2.2. Affordability Assessments

For major defense acquisition programs and major automated information system programs, affordability assessments are required at Milestones B and C (see DoD Instruction 5000.2, Enclosure 3). The purpose of the assessment is for the DoD Component to demonstrate that the program's projected funding and manpower requirements are realistic and achievable, in the context of the DoD Component's overall long-range modernization plan. Normally, this assessment requires a DoD Component corporate perspective, and so the affordability assessment should not be prepared by the program manager. Rather, the assessment typically should be conducted by resource analysts in the DoD Component headquarters or supporting organization. For a joint program, the affordability assessment should be prepared by the lead DoD Component, although it may be necessary to display separate analyses for each DoD Component, as appropriate.

The exact approach to the affordability assessment can vary, depending on the nature of the program. However, in general, the assessment should address program funding and manpower requirements over the six-year programming period, and several years beyond. The assessment also should show how the projected funding and manpower fits within the overall DoD Component plan for modernization and manpower. In most cases, the overall long-range modernization plan will be portrayed across the DoD Component's mission areas. The assessment then should use this information to examine, for the acquisition program's mission area, the projected modernization funding and manpower demands, as a percentage of the DoD Component's total funding and manpower. The assessment should highlight those areas where the projected funding or manpower share exceeds historical averages, or where the projected funding or manpower exceeds zero real growth from the last year of the programming period. For the issues highlighted, the assessment should provide details as to how excess funding or manpower demands will be accommodated by reductions in other mission areas, or in other (i.e., non-modernization) accounts. To illustrate this approach, this section provides a notional example of the type of analyses that could be incorporated in an affordability assessment. Although this example only addresses modernization funding, the approach for manpower would be similar.

In this hypothetical example, a major defense acquisition program is nearing Milestone B approval. For discussion purposes, this program arbitrarily is assumed to be a mobility program. A first step in the program's affordability assessment is to portray the projected annual modernization funding (RDT&E plus procurement, measured as total obligation authority, or TOA) in constant dollars for the six-year programming period, and, in addition, for an additional twelve years beyond that. Similar funding streams for other acquisition programs in the same mission area (in this example, mobility) also would be included. Figure 3 is a sample chart for this first step. In this example, the acquisition program nearing milestone approval is labeled "Mobility MDAP #3." Funding also is shown for the other modernization programs in the same mission area, consisting of three other major defense acquisition programs, three other (ACAT II) programs, and one miscellaneous category for minor procurement. In this example, there appears to be a significant modernization bow wave beginning around 2014, which would then be subject to further analysis and discussion in the assessment. The term "bow wave" refers to a

requirement for excess modernization funds during a period beyond the programming period, resulting from acquisition decisions made earlier.

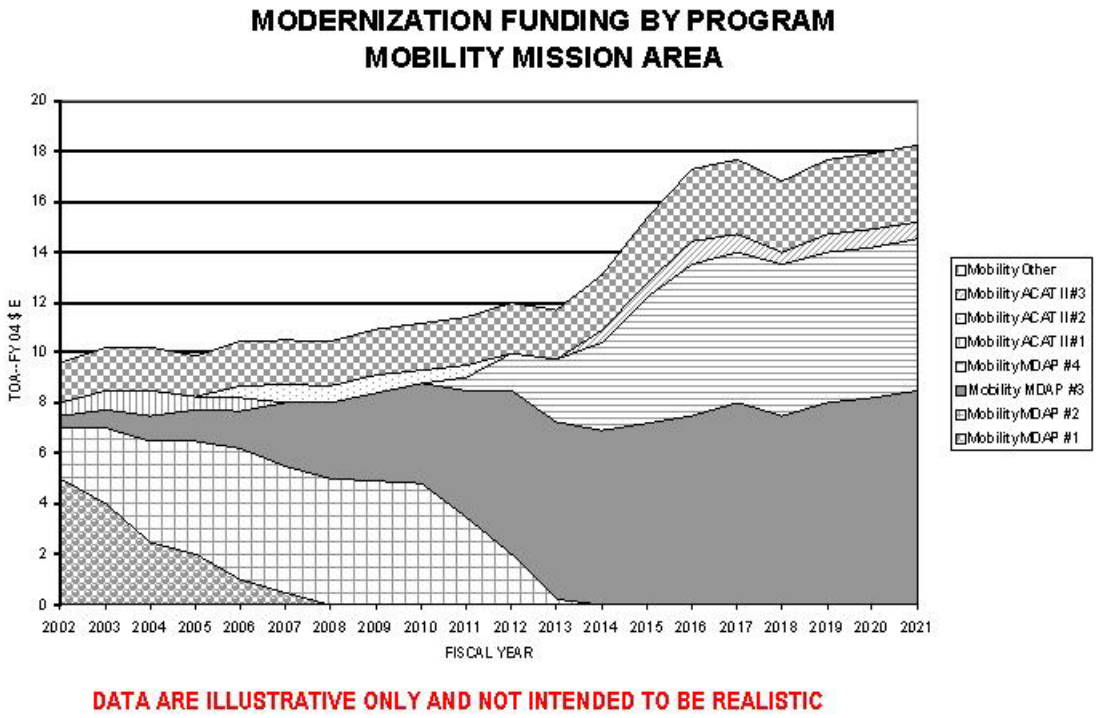

Figure 3. Sample Chart of Funding Streams by Program

The second step in this assessment is to portray DoD Component modernization funding stratified by mission areas, rather than by individual program. Figure 4 shows a notional example of this second step. The choice of mission areas will vary depending upon circumstances. Clearly, an analysis by an individual DoD Component would portray funding only for applicable mission areas. Also, for a DoD Component like the Army, where almost all of its modernization funding is in a single mission area (Land Forces), the mission area should be further divided into more specialized categories (such as digitization, helicopters, ground combat vehicles, etc.).

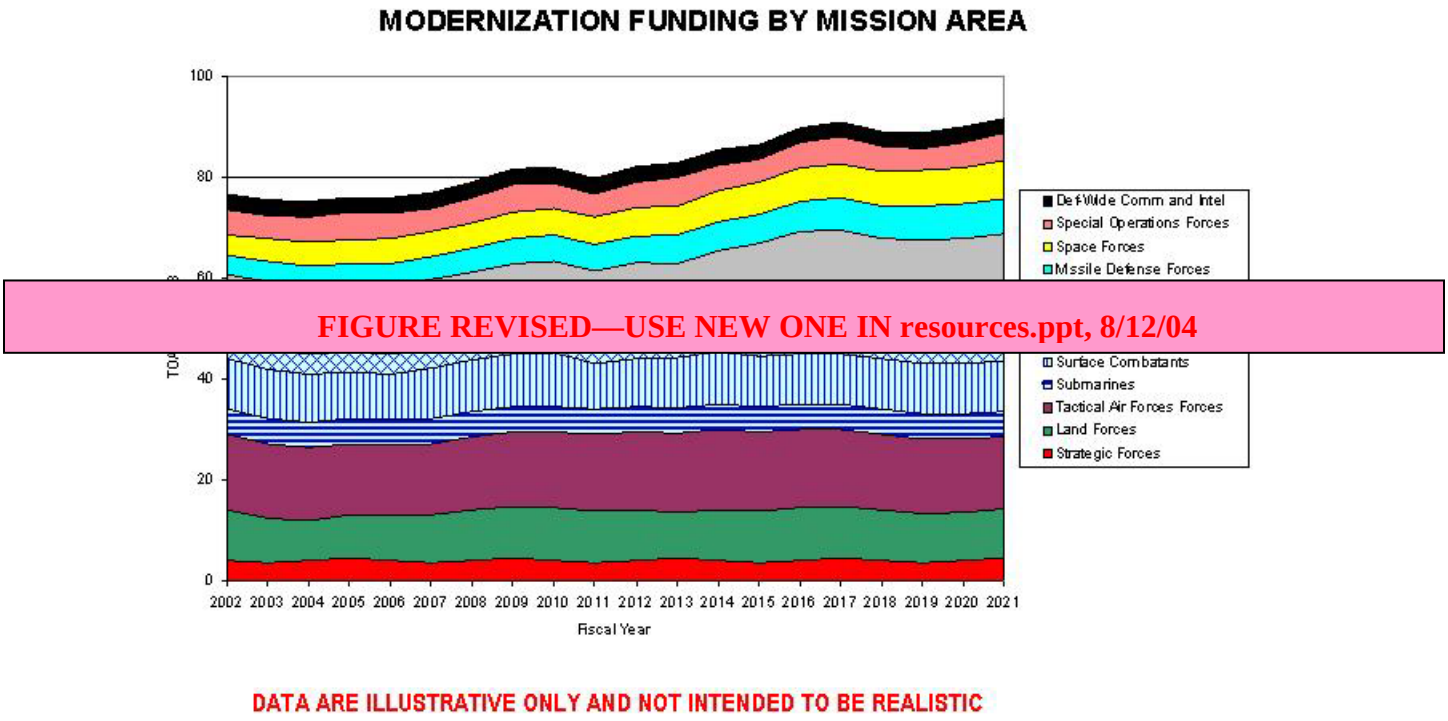

Figure 4. Sample Chart of Funding Streams by Mission Area

For this example, Figure 4 shows funding growth in three mission areas (space, missile defense, and mobility). What remains to be determined is whether this projected growth is realistically affordable relative to the DoD Component's most likely overall funding (top-line). The third step in this assessment is to portray annual modernization funding compared to the DoD Component actual or projected funding top-line, as shown in Figure 5. There are three distinct time periods considered in this figure. The first is a twelve-year historical period, the second is the six-year programming period, and the third is the twelve-year projection beyond the programming period. What this chart shows for this example is that the assumed mobility programs are projected to require a significantly higher share of DoD Component funding in the years beyond the programming period. In such a circumstance, the DoD Component would be expected to rationalize or justify this projected funding growth as realistic (by identifying offsets in modernization for other lower priority mission areas, or perhaps identifying savings in other accounts due to business process improvements or reforms).

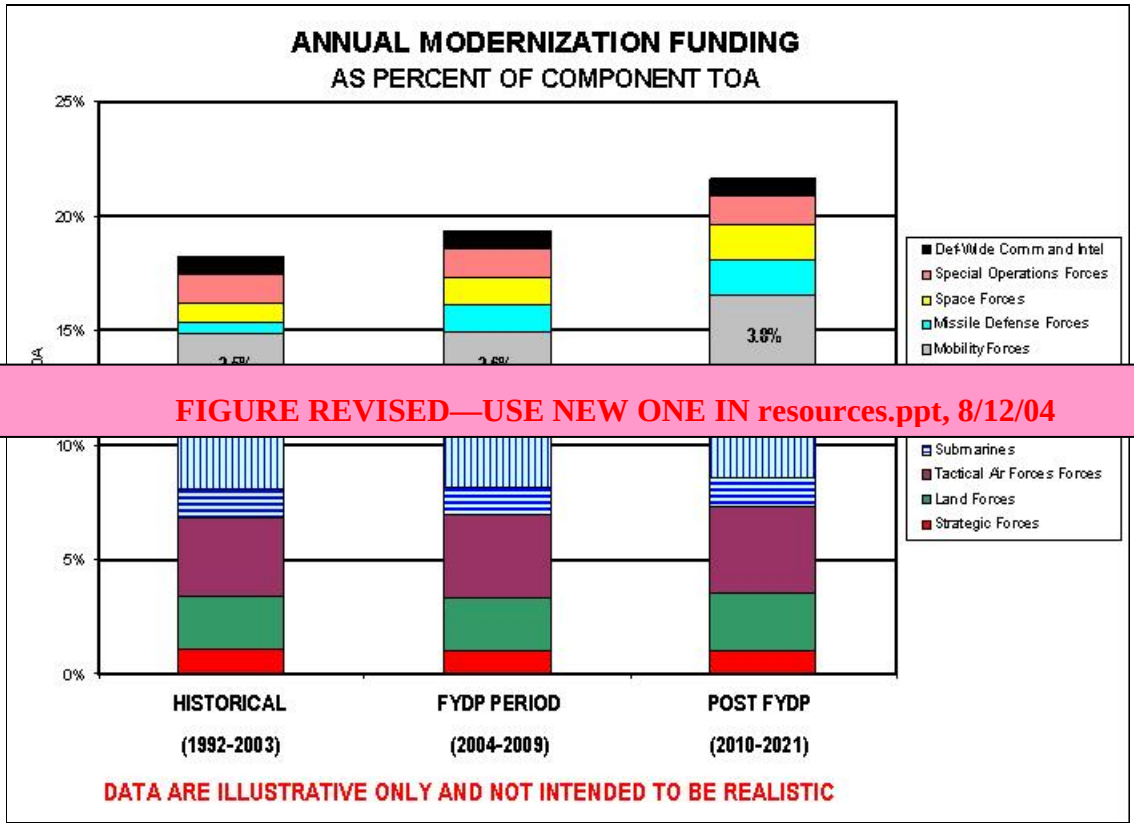

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Figure 5. Sample Annual Modernization Funding

In preparing affordability assessments, one possible source of data for resource analysts to consider is the Future Years Defense Program (FYDP). The FYDP is an OSD resource database with future projections of resources (funding, manpower, and forces) over the programming period by program, where each program is associated with one (or a few) FYDP entities known as program elements. For acquisition programs, there are usually separate program elements for development and procurement. The FYDP also has comparable historical data going back several years. The FYDP data structure also provides options for assigning FYDP program elements to mission areas. One common approach for assigning resources to mission areas is the use of Defense Mission Categories. Further information on the FYDP, as well as Defense Mission Categories, can be found at the web site for the FYDP Structure Management System. Note: Access to this web site requires a ".mil" address. For projections beyond the FYDP programming period, many DoD Components (or their major commands) have long-range modernization roadmaps which can be incorporated in the assessment. In addition, annual funding projections beyond the FYDP for major defense acquisition programs can be obtained from the appropriate Selected Acquisition Reports.

The approach used in this example would need to be modified for a major automated information system, since most likely the mission areas associated with weapon systems would not apply. An alternative would be to portray AIS modernization funding by warfighting capability area or business domain (such as logistics, accounting and finance, or human resources management, etc.)

3.2.3. Full Funding

It has been a long-standing DoD policy to seek full funding of acquisition programs, based on the most likely cost, in the budget year and out-year program years. Experience has shown that full funding is a necessary condition for program stability. DoD Directive 5000.1, affirms this full funding policy. Moreover, DoD Instruction 5000.2 requires full funding—defined as inclusion of the dollars and manpower needed for all current and future efforts to carry out the acquisition and support strategies—as part of the entrance criteria for the transition into system development and demonstration.

Full funding and program stability is especially important in joint and international acquisition programs. Underfunding or program instability on the part of one DoD Component can lead to unintended cost growth or instability for another DoD Component in a joint program, or even for another nation in an approved international cooperative program commitment. DoD Instruction 5000.2, Enclosure 9, imposes very strict approval requirements that must be met before DoD Components are permitted to terminate or make significant reduction to their share of approved international or joint programs. DoD Components contemplating termination of an international program should be aware of the termination provisions in the international agreement for that program. Current practice requires the nation terminating its participation in the program to pay substantial termination costs. Therefore, any DoD Component considering unilateral withdrawal from an international agreement must take into account the resultant costs that would be incurred.

Full funding is assessed by the Milestone Decision Authority at each decision point. As part of this assessment, the MDA reviews the actual funding (in the most recent President's Budget submission or Future Years Defense Program position) in comparison to the (time-phased) program office cost estimate. In addition, the MDA considers the funding recommendations made by the OSD Cost Analysis Improvement Group (for ACAT ID programs) or the DoD Component cost analysis team (for ACAT IC programs). If the MDA concludes that the current funding does not support the acquisition program, then the acquisition decision memorandum may direct a funding adjustment and/or program restructure in the next FYDP update.

3.2.4. Cost As an Independent Variable

As stated in DoD Directive 5000.1, all participants in the acquisition system are expected to recognize the reality of fiscal constraints, and to view cost as an independent variable. Cost in this context refers to life-cycle cost, which should be treated as equally important to performance and schedule in program decisions. To institutionalize this principle, program managers should consider developing a formal Cost As an Independent Variable (CAIV) plan as part of the acquisition strategy. This section describes one possible approach for developing such a plan.

The implementation steps in a CAIV plan will depend on the type of system and its current stage in the acquisition framework. In general, however, a CAIV plan would include the following elements:

Set Cost Goals. The CAIV plan would include cost goals for unit production cost and operating and support costs. The unit production cost goal typically would be established for a specified quantity of systems and a specified peak production rate. The O&S cost goal typically would be an annual cost per deployable unit (e.g., battalion or squadron) or individual system (e.g., ship or missile). The goals should be challenging but realistically achievable. The goals in the CAIV plan might be the same as the cost goals in the acquisition program baseline, or

possibly might be more aggressive. Conceivably, the APB goals might be more conservative for programs with a greater degree of risk, to provide some margin for error.

Perform Trade-off Studies. Cost, schedule, and performance may be traded off within the "trade space" between thresholds and objectives documented in the capability needs document. The CAIV plan would show the timing, content, and approach for the specific trade studies to be performed. Over time, as the system design matures, the trade studies become more refined and specialized.

Establish Cost Performance Integrated Product Team. Although led by the program manager, the CAIV process requires collaboration with other acquisition and logistics organizations as well as the user. The CAIV plan would establish a Cost Performance Integrated Product Team, which most likely would receive considerable support from the system contractor. The Cost Performance IPT would monitor the CAIV implementation and oversee the trade studies.

Provide Incentives. The elements of the acquisition strategy should describe incentives to the contractor that directly support, or are at least complementary to, the CAIV plan. Such incentives might include award fees, sharing of cost savings, or other (positive or negative) incentives. Chapter 2 provides further discussion on contract incentives.

Establish Metrics. The CAIV plan should address how metrics will be established to track progress and achievement of unit production and O&S cost goals. The plan should identify how progress toward achieving the goals will be monitored and reported. The plan also should describe how cost estimates will be updated and refined over time, and compared to the original cost goals. The plan should identify specific organizational responsibilities, and identify related major events where progress toward achieving goals will be assessed.

As part of the Reduction of Total Ownership Costs (R-TOC) Program, the R-TOC working group has developed templates that could be used as guidelines in the development of CAIV implementation plans. The use of these templates is optional. The templates may be found at the DoD R-TOC web site.

3.3. Analysis of Alternatives

For a major defense acquisition program (ACAT I), an Analysis of Alternatives (AoA) is required at major milestone decision points (DoD Instruction 5000.2). For a major automated information system program (ACAT IA), current law (Pub. L. 107-248, Section 8088, or successor provision) requires an AoA at Milestones A and B and at the full-rate production decision (or their equivalents) (DoD Instruction 5000.2).

AoAs are an important element of the defense acquisition process. An AoA is an analytical comparison of the operational effectiveness, suitability, and life-cycle cost of alternatives that satisfy established capability needs. Initially, the AoA process typically explores numerous conceptual solutions with the goal of identifying the most promising options, thereby guiding the Concept Refinement Phase (see section 3.3.3). Subsequently, at Milestone B (which usually represents the first major funding commitment to the acquisition program), the AoA is used to justify the rationale for formal initiation of the acquisition program. An AoA normally is not required at Milestone C unless significant changes to threats, costs, or technology have occurred, or the analysis is otherwise deemed necessary by the Milestone Decision Authority. For a joint

program, the lead DoD Component normally is responsible for the preparation of a single comprehensive analysis.

The Office of the Director, Program Analysis and Evaluation (OD/PA&E), provides basic policies and guidance associated with the AoA process. For potential and designated ACAT I and IA programs, OD/PA&E prepares the initial AoA guidance, reviews the AoA analysis plan, and reviews the final analysis products (briefing and report). After the review of the final products, OD/PA&E provides an independent assessment to the Milestone Decision Authority (see DoD Instruction 5000.2).

3.3.1. AoA Plan

The first major step leading to a successful AoA is the creation and coordination of a well-considered analysis plan. The plan should establish a roadmap of how the analysis will proceed, and who is responsible for doing what. A recommended outline for the AoA plan would resemble the following:

- Introduction
  - Background
  - Purpose
  - Scope
- Ground Rules
  - Scenarios
  - Threats
  - Environment
  - Constraints and Assumptions
- Alternatives
  - Description of Alternatives
  - Nonviable Alternatives
  - Operations Concepts
  - Support Concepts
- Determination of Effectiveness Measures
  - Mission Tasks
  - Measures of Effectiveness
  - Measures of Performance
- Effectiveness Analysis
  - Effectiveness Methodology
  - Models, Simulations, and Data
  - Effectiveness Sensitivity Analysis
- Cost Analysis
  - Life-Cycle Cost Methodology
  - Models and Data
  - Cost Sensitivity and/or Risk Analysis
- Cost-Effectiveness Comparisons

    - Cost-Effectiveness Methodology
    - Displays or Presentation Formats
    - Criteria for Screening Alternatives
- Organization and Management
    - Study Team/Organization
    - AoA Review Process
    - Schedule

Of course, every AoA is unique, and the above outline may need to be tailored or streamlined to support a given situation.

The introduction to the AoA plan describes the developments that led to the AoA, including relevant analyses that preceded it. It should reference the applicable capability needs document(s) and other pertinent documents, such as any applicable AoA guidance. It also should identify in general terms the level of detail of the study, and the scope (breadth and depth) of the analysis necessary to support the specific milestone decision.

The ground rules described in the analysis plan include the scenarios and threats, as well as the assumed physical environment and any constraints or additional assumptions. The scenarios are typically derived from defense planning scenarios, augmented by more detailed intelligence products such as target information and enemy and friendly orders of battle. Environmental factors that impact operations (e.g., climate, weather, or terrain) are important as well. In addition, environment, safety, and occupational health factors associated with the use of chemical and/or biological weapons may need to be considered as excursions to the baseline scenario(s).

The analysis plan also should document the range of alternatives to be addressed in the analysis. In many cases, there will be a minimum set of alternatives required by the initial analysis guidance. Additional direction during subsequent AoA reviews may insert yet other alternatives. Practically, the range of alternatives should be kept manageable. Selecting too few or too many are both possibilities, but experience has shown that selecting too many—exceeding the available resources of effectiveness and/or cost analysts—is the greater concern. The number of alternatives can be controlled by avoiding similar but slightly different alternatives and by early elimination of alternatives (due to factors such as unacceptable life-cycle cost or inability to meet key performance parameters). In many studies, the first alternative (base case) is to retain one or more existing systems, representing a benchmark of current capabilities. An additional alternative based on major upgrades and/or service-life extensions to existing systems also may be considered. For each alternative, evaluating its effectiveness and estimating its life-cycle cost requires a significant level of understanding of its operations and support concepts. The operations concept describes the details of the peacetime, contingency, and wartime employment of the alternative within projected military units or organizations. It also may be necessary to describe the planned basing and deployment concepts (contingency and wartime) for each alternative. The support concept describes the plans for system training, maintenance, and other logistics support.

The analysis plan should describe how the AoA will establish metrics associated with the military worth of each alternative. Military worth often is portrayed in AoAs as a hierarchy of mission tasks, measures of effectiveness, and measures of performance. Military worth is

fundamentally the ability to perform mission tasks, which are derived from the identified capability needs. Mission tasks are usually expressed in terms of general tasks to be performed to correct the gaps in needed capabilities (e.g., hold targets at risk, or communicate in a jamming environment). Mission tasks should not be stated in solution-specific language. Measures of effectiveness are more refined and they provide the details that allow the proficiency of each alternative in performing the mission tasks to be quantified. Each mission task should have at least one measure of effectiveness supporting it, and each measure of effectiveness should support at least one mission task. A measure of performance typically is a quantitative measure of a system characteristic (e.g., range, weapon load-out, logistics footprint, etc.) chosen to enable calculation of one or more measures of effectiveness. Measures of performance are often linked to key performance parameters or other parameters contained in the approved capability needs document(s). They also may be linked to system contract specifications.

The analysis plan spells out the analytic approach to the effectiveness analysis, which is built upon the hierarchy of military worth, the assumed scenarios and threats, and the nature of the selected alternatives. The analytic approach describes the level of detail of the effectiveness analysis. In many AoAs involving combat operations, the levels of effectiveness analysis can be characterized by the numbers and types of alternative and threat elements being modeled. A typical classification would consist of four levels: (1) *system performance*, based on analyses of individual components of each alternative or threat system, (2) *engagement*, based on analyses of the interaction of a single alternative and a single threat system, and possibly the interactions of a few alternative systems with a few threat systems, (3) *mission*, based on assessments of how well alternative systems perform military missions in the context of many-on-many engagements, and (4) *campaign*, based on how well alternative systems contribute to the overall military campaign, often in a joint context. For AoAs involving combat support operations, the characterization would need to be modified to the nature of the support. Nevertheless, most AoAs involve analyses at different levels of detail, where the outputs of the more specialized analysis are used as inputs to more aggregate analyses. At each level, establishing the effectiveness methodology often involves the identification of suitable models (simulation or otherwise), other analytic techniques, and data. This identification primarily should be based on the earlier selection of measures of effectiveness. The modeling effort should be focused on the computation of the specific measures of effectiveness established for the purpose of the particular study. Models are seldom good or bad per se; rather, models are either suitable or not suitable for a particular purpose. It also is important to address excursions and other sensitivity analyses in the overall effectiveness analysis. Typically, there are a few critical assumptions that often drive the results of the analysis, and it is important to understand and point out how variations in these assumptions affect the results. As one example, in many cases the assumed performance of a future system is based on engineering estimates that have not been tested or validated. In such cases, the effectiveness analysis should describe how sensitive the mission or campaign outcomes are to the assumed performance estimates.

The AoA plan also describes the approach to the life-cycle cost analysis. The cost analysis normally is performed in parallel with the operational effectiveness analysis. It is equal in importance in the overall AoA process. It estimates the total life-cycle cost of each alternative, and its results are later combined with the operational effectiveness analysis to portray cost-effectiveness comparisons. When the costs of the alternatives have significantly different time periods or distributions, appropriate discounting methods should be used to calculate the life-cycle cost of each alternative. A recommended analytic approach for preparing a life-cycle cost

estimate is provided in section 3.7 of this chapter. What is important to emphasize is that the cost analysis is a major effort that demands the attention of experienced, professional cost analysts.

Typically, the last analytical section of the AoA plan deals with the planned approach for the cost-effectiveness comparisons of the study alternatives. In most AoAs, these comparisons involve alternatives that have both different effectiveness and cost, which leads to the question of how to judge when additional effectiveness is worth additional cost. Cost-effectiveness comparisons in theory would be simplified if the analysis structured the alternatives so that all the alternatives have equal effectiveness (the best alternative is the one with lowest cost) or equal cost (the best alternative is the one with greatest effectiveness). In actual practice, the ideal of equal effectiveness or equal cost alternatives is difficult or impossible to achieve due to the complexity of AoA issues. A common alternative for the comparison is a scatter plot of effectiveness versus cost. Figure 6 presents a notional example of such a plot.

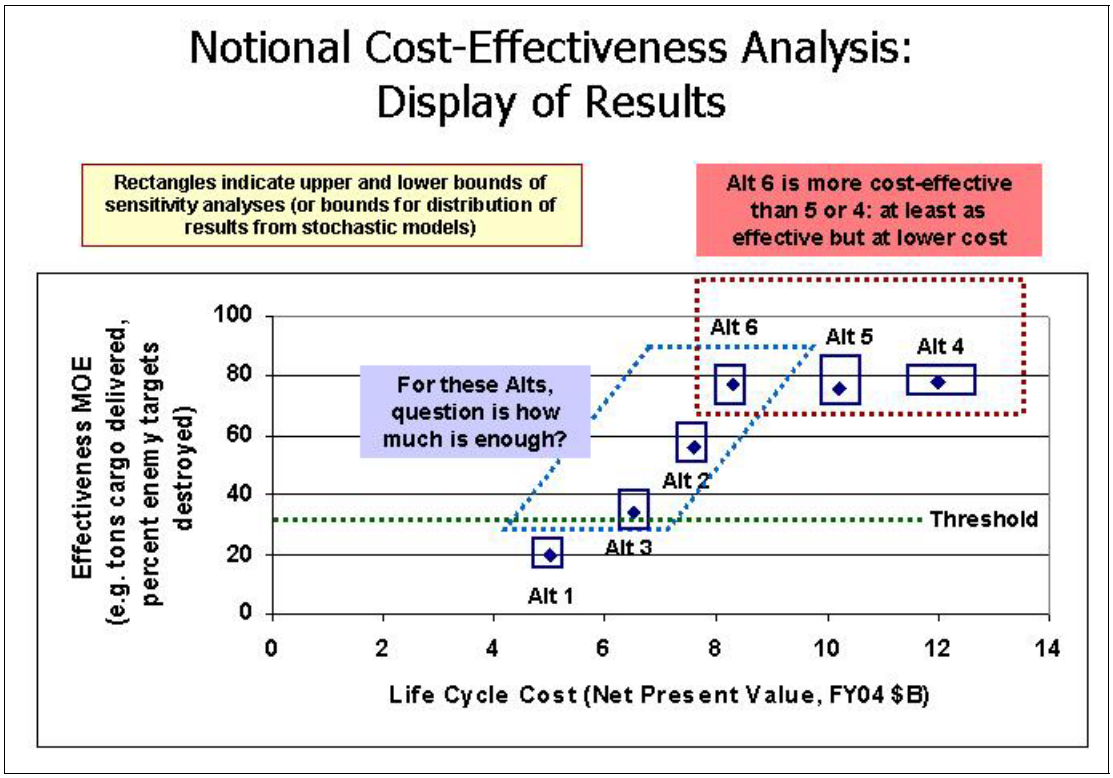

Figure 6. Sample Scatter Plot of Effectiveness versus Cost

Note that the notional sample display shown in Figure 6 does not make use of ratios (of effectiveness to cost) for comparing alternatives. Usually, ratios are regarded as potentially misleading because they mask important information. The advantage to the approach in the figure above is that it reduces the original set of alternatives to a small set of viable alternatives for decision makers to consider.

Finally, the AoA plan should address the AoA study organization and management. Often, the AoA is conducted by a working group (study team) led by a study director and staffed appropriately with a diverse mix of military, civilian, and contractor personnel. The program office may provide assistance or data to the AoA study team, but the responsibility for the AoA

should not be assigned to the program manager, and the study team members should not reside in the program office. In some cases, the AoA may be assigned to a federally funded research and development center or similar organization. The AoA study team is usually organized along functional lines into panels, with a chair for each panel. Typical functional areas for the panels could be threats and scenarios, technology and alternatives (responsible for defining the alternatives), operations and support concepts (for each alternative), effectiveness analysis, and cost analysis. In most cases, the effectiveness panel occupies the central position and integrates the work of the other panels. The study plan also should describe the planned oversight and review process for the AoA. It is important to obtain guidance and direction from senior reviewers with a variety of perspectives (operational, technical, and cost) throughout the entire AoA process.

The analysis plan is fundamentally important because it defines what will be accomplished, and how and when it will be accomplished. However, the plan should be treated as a living document, and updated as needed throughout the AoA to reflect new information and changing study direction. New directions are inevitably part of the AoA process, and so the analysis should be structured so as to be flexible. Frequently, AoAs turn out to be more difficult than originally envisioned, and the collaborative analytical process associated with AoAs is inherently slow. There are often delays in obtaining proper input data, and there may be disagreements between the study participants concerning ground rules or alternatives that lead to an increase in excursions or cases to be considered. The need to scale back the planned analysis in order to maintain the study schedule is a common occurrence.

3.3.2. AoA Final Results

The final results of the AoA initially are presented as a series of briefings. The final AoA results are provided to OD/PA&E no later than 60 days prior to the milestone decision meeting (Defense Acquisition Board or Information Technology Acquisition Board review). Providing emerging results to OD/PA&E prior to the final briefing is wise to ensure that there are no unexpected problems or issues. The AoA final results should follow all of the important aspects of the study plan, and support the AoA findings with the presentation. In particular, all of the stated AoA conclusions and findings should follow logically from the supporting analysis.

Usually, in addition to a final briefing, the AoA process and results are documented in a written final report. The report serves as the principal supporting documentation for any decisions made as a result of the AoA. The report also may serve as a reference for future AoAs. The final report can follow the same format as the study plan, with the addition of these sections:

- Effectiveness Analysis
  - Effectiveness Results
- Cost Analysis
  - Life-Cycle Cost Results
- Cost-Effectiveness Comparisons
  - Cost-Effectiveness Results
  - Assessment of Preferred Alternative(s)

By following the same format, much of the material from the (updated) study plan can be used in the final report.

3.3.3. Role of the AoA in Concept Refinement

The analysis of alternatives process is expected to play a key role in support of the Concept Refinement phase. After a program has an approved concept decision, the analysis of alternatives process is expected to contribute to the refinement of the initial concept and the identification of critical associated technologies, based on a balanced assessment of technology maturity and risk, and cost, performance, and schedule considerations (as shown in Figure 7).

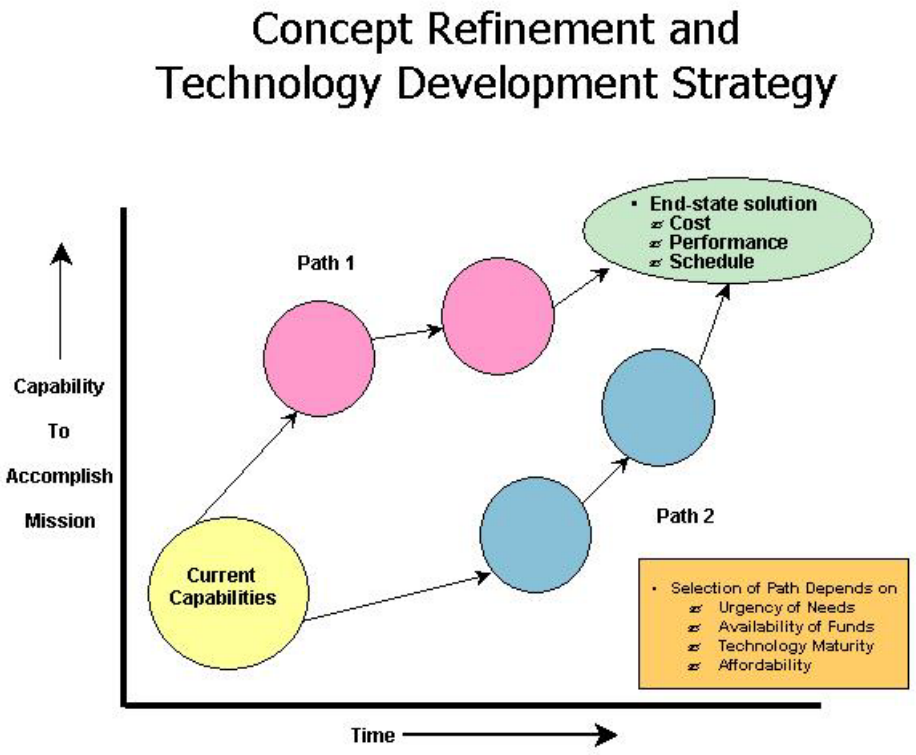

Figure 7. The Role of the AoA in Concept Refinement

The analysis plan required by DoD Instruction 5000.2 for the Concept Decision is satisfied by an AoA plan that addresses the issues unique to the program's Concept Refinement phase and Technology Development Strategy. The AoA plan should build upon the prior analyses conducted as part of the Joint Capabilities Integration and Development System (JCIDS). The JCIDS process is briefly described in section 1.3, and is fully described in CJCS Instruction 3170.01. The JCIDS analysis process that leads to an approved Initial Capabilities Document (ICD) includes an assessment known as the Functional Solution Analysis (FSA). The FSA identifies both materiel and non-materiel potential solutions that address the documented gaps in validated capability needs. The last step of the FSA, known as the Analysis of Materiel Approaches (AMA), provides a preliminary assessment of candidate materiel approaches. The result of the AMA is a prioritized list of materiel approaches (or combination of approaches) that is documented as part of the ICD. In this way, the ICD can be used to establish boundary conditions for the scope of alternatives to be considered in the subsequent AoA. These constraints should be crafted to provide a fair balance between focusing the AoA and ensuring that the AoA considers novel and imaginative alternatives.

3.3.4. AoA Considerations for Major Automated Information Systems

DoD Instruction 5000.2 requires an analysis of alternatives (AoA) for MAIS programs at major milestone decisions. Much of the discussion on AoAs provided earlier is more applicable to weapon systems, and should be modified somewhat for MAIS programs.

To satisfy the requirement for an AoA at Milestone A for MAIS programs, the Functional Solution Analysis (FSA) completed according to the JCIDS process will meet the analytic intent of the AoA. In some cases, more detailed analyses among the most promising alternatives will be needed in an AoA, based on OD/PA&E's assessment of the FSA. In either case, the analysis should include a discussion as to whether the proposed program (1) supports a core/priority mission or function performed by the DoD Component, (2) needs to be undertaken because no alternative private sector or governmental source can better support the function, and (3) supports improved work processes that have been simplified or otherwise redesigned to reduce costs, improve effectiveness, and make maximum use of commercial off-the-shelf technology. The analysis should be tied to benchmarking and business process reengineering studies (such as analyses of simplified or streamlined work processes, or outsourcing of non-core functions).

For all MAIS AoAs, one alternative should be the status quo alternative as used in the economic analysis, and one alternative should be associated with the proposed MAIS program. Other possible alternatives could be different system, network, and/or data architectures, or they might involve different options for the purchase and integration of commercial-off-the-shelf products, modifications, and upgrades of existing assets, or major in-house development.

Most likely, the effectiveness analysis in a MAIS AoA will not involve scenario-based analysis as is common for the weapon system AoAs. The effectiveness analysis for an MAIS program should be tied to the organizational missions, functions, and objectives that are directly supported by the implementation of the system being considered. The results of the AoA should provide insight into how well the various alternatives support the business outcomes that have been identified as the business goals or capabilities sought. In some cases, it may be possible to express the variation in effectiveness across the alternatives in monetary terms, and so effectiveness could be assessed as benefits in the economic analysis framework. In other cases, the effectiveness might be related to better or more timely management information, leading to improved decision-making (which can be difficult or impossible to quantify). In these cases, a common approach is to portray effectiveness by the use of one or more surrogate metrics. Examples of such metrics might be report generation timeliness, customer satisfaction, or supplier responsiveness. In addition to management information, the effectiveness analysis also may need to consider information assurance or interoperability issues.

The cost analysis supporting the AoA should follow the economic analysis framework. The life-cycle cost estimates of the alternatives considered in the AoA should be consistent with and clearly linked to the alternatives addressed in the economic analysis. Both the effectiveness analysis and the cost analysis should address the risks and uncertainties for the alternatives, and present appropriate sensitivity analysis that describes how such uncertainties can influence the cost-effectiveness comparison of the alternatives.

The appropriate sponsor or domain owner should lead the development of the AoA for a MAIS program. Experience has shown that the MAIS programs for which the sponsor or domain owner engages with OD/PA&E early in the process are much more likely to be

successful than those that select a preferred alternative before contacting OD/PA&E or before completing the AoA.

The Acquisition Community Connection web site has additional information on the AoA.

3.4. Cost Analysis Improvement Group

10 U.S.C. 2434 requires that an independent life-cycle cost be prepared and provided to the milestone decision authority before the approval of a major defense acquisition program to proceed with either system development and demonstration, or production and deployment. In DoD Directive 5000.4, *Cost Analysis Improvement Group*, the specific responsibility for fulfilling this requirement for such an independent cost estimate is assigned to the OSD Cost Analysis Improvement Group (for ACAT ID programs, pre-MDAP projects approaching formal program initiation as a likely ACAT ID program, and ACAT IC programs when requested by the USD(AT&L)). DoD Instruction 5000.2 specifies that the CAIG independent cost estimate will be provided in support of major milestone decision points (Milestone B, Milestone C, or the full-rate production decision review). In addition, the DAB Milestone Decision Authority also may request the CAIG to prepare other independent cost estimates, or conduct other ad-hoc cost assessments, for programs subject to DAB review or oversight, at any time. Overall, the CAIG serves as the principal advisory body to the Milestone Decision Authority on all matters concerning an acquisition program's life-cycle cost.

The CAIG also has other more general responsibilities in its charter, as described in DoD Directive 5000.4. Some of these major responsibilities are:

- Establish substantive guidance on the preparation of life-cycle cost estimates subject to CAIG review (this guidance can be found in DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*). This guidance includes standard definitions of cost terms in the management of DoD acquisition programs.
- Sponsor an annual DoD-wide Cost Research Symposium, where all DoD Components describe their plans for performing or sponsoring cost research. This symposium facilitates the exchange of cost research, and helps avoid duplication of effort between the DoD Components.
- Establish policy guidance on the Contractor Cost Data Reporting (CCDR) system, and monitor its implementation to ensure consistent and appropriate application throughout the DoD. The CCDR system is fully explained in DoD 5000.4-M-1, *Contractor Cost Data Reporting (CCDR) Manual*. This manual can be found at the Defense Cost and Resource Center (DCARC) web site.
- Establish policy guidance on the Software Resources Data Reporting (SRDR) system, and monitor its implementation to ensure consistent and appropriate application throughout the Department of Defense. DoD Instruction 5000.2 requires SRDR reporting for major contracts and sub-contracts associated with major software elements within ACAT I and ACAT IA programs. The SRDR system is briefly described in section 3.4.2.3, and is fully explained in the draft SRDR Manual. This manual can be found at the Defense Cost and Resource Center (DCARC) web site.
- Establish policy guidance on the Visibility and Management of Operating and Support Costs (VAMOSC) Program, and monitor its implementation by each military department. In support of this program, each military department has developed and

maintains a historical operating and support (O&S) cost data collection system. Guidance on the VAMSOC program is contained in DoD 5000.4-M, Chapter 4.

3.4.1. CAIG Milestone Reviews

For programs subject to CAIG review that are approaching major milestone decision points, the OSD CAIG conducts a comprehensive assessment of program life-cycle cost. The assessment is based not only on the preparation of the CAIG independent cost estimate, but also on a review of the program manager's life-cycle cost estimate (LCCE) and the DoD Component cost position, if applicable. This section provides a brief summary of the major events associated with an OSD CAIG review, and also provides additional clarifying discussion on the procedures for each event. A more comprehensive description of the CAIG review process is found in DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*.

Table 1 provides a brief summary of the major events and timelines associated with an OSD CAIG review leading to a DAB milestone decision review:

Table 1. CAIG Major Events and Timelines Associated with a DAB Milestone Decision Review

Event	Date
• OSD CAIG Review Kick-off Meeting o Draft Cost Analysis Requirements Description (CARD) Delivered by DoD Component	180 days before OIPT meeting
• CAIG Briefs Preliminary Independent LCCE to PM o Draft Documentation of Program Office Estimate/DoD Component Cost Position Delivered by DoD Component o Final CARD Delivered by DoD Component	45 days before OIPT meeting
• OSD CAIG Review Meeting o PM briefs program defined in CARD and Component Cost Position o CAIG Briefs Final Estimate of Independent LCCE to PM	21 days before OIPT meeting
• Final Documentation of Program Office Estimate/DoD Component Cost Position Delivered by DoD Component	10 days before OIPT meeting
• OSD CAIG Report Delivered to OIPT Members	3 days before OIPT meeting

The CAIG review process begins roughly six months before the planned DAB milestone review. At that time, the draft Cost Analysis Requirements Description (CARD) is provided to the CAIG for review. The CARD is used to describe formally the acquisition program for purposes of preparing both the program office cost estimate (and the Component cost position, if

applicable) and the OSD CAIG independent cost estimate. The CAIG staff promptly evaluates the CARD for completeness and consistency with other program documents (such as capability needs documents). The expectation is that the CARD should be sufficiently comprehensive in program definition to support a life-cycle cost estimate. Normally, the CAIG staff provides any necessary feedback to the DoD Component if any additional information or revisions are needed. If the CARD is found to be deficient to the point of unacceptability, the CAIG Chair will advise the Overarching Integrated Product Team (OIPT) leader that the planned milestone review should be postponed.

At roughly the same time that the draft CARD is submitted, the CAIG announces its upcoming review in a formal memo. The memo initiates a working-level kick-off meeting that is held with representatives from the program office cost estimating team, the CAIG independent cost estimate team, and other interested parties (typically DoD Component or OSD staff members). The purpose of the meeting is to discuss requirements and issues for the upcoming milestone review, the scope of the cost estimates, and ground rules and assumptions on which the estimates will be based. Much of the discussion will focus on material provided in the draft CARD. This ensures that both cost teams have a common understanding of the program to be costed. In addition, ground rules are established for CAIG interactions with the program office. The CAIG also coordinates any travel or visit requirements with appropriate DoD Component points of contact.

Per DoD Instruction 5000.2, the CAIG will brief the preliminary independent LCCE to the program manager (PM) 45 days before the OIPT meeting. In a similar timeframe, the program office should provide their estimate to the CAIG, and, if required, the DoD Component should provide the DoD Component Cost Position. The CAIG report eventually submitted to the Overarching Integrated Product Team and to the Defense Acquisition Board provides not only the OSD CAIG independent cost estimate, but also an evaluation of the program office cost estimate (and DoD Component cost position, if applicable). It is therefore important for the DoD components to submit well-documented cost estimates that are ready for review. The specific standards for the cost documentation are described in DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*. In general, the documentation should be sufficiently complete and well organized that a cost professional could replicate the estimate, given the documentation. Along with the draft documentation of the program office cost estimate, the DoD Component provides an updated (and final) CARD to the CAIG. The expectation is that at this point no further changes to program definition will be considered. At the same time that the documents are provided, the CAIG staff will provide feedback and identify any emerging cost issues to the program manager and DoD Component staff, in part based on the CAIG work to date on its independent cost estimate.

Per DoD Instruction 5000.2, the CAIG will brief the final independent estimate to the PM 21 days before the OIPT meeting. At this time, the program office should provide their final estimate to the CAIG, and, if required, the DoD Component should provide the final DoD Component Cost Position. Other invited OSD and Joint Staff representatives may attend these reviews/exchanges. A typical presentation format for the CAIG review meeting would include:

- Program overview and status
- Program office acquisition cost estimate
  - Summary of results
  - Methodology for high-cost elements

- Rationale for DoD Component cost position, if any
- Comparison of (time-phased) program office cost estimate to current funding
- Operating and Support (O&S) cost estimate

In addition, at the CAIG meeting, the CAIG staff provides any further feedback to the program office and DoD Component staff. If appropriate, the CAIG will provide a presentation of the major areas of difference between its independent cost estimate and the program office cost estimate and/or DoD Component cost position.

The CAIG's final report is delivered to the OIPT leader at least three days before the OIPT meeting. Immediately thereafter, it is distributed to the OIPT members and also is available to the DoD Component staff. The expectation is that any issues had already emerged in prior discussions and that the final CAIG report should not contain any surprises. The report normally is two to three pages, and typically includes the following:

- Summary of program office cost estimate
- Summary of CAIG independent cost estimate
- Comparison or reconciliation of the two estimates
- Assessment of program risks
- Comparison of (time-phased) CAIG cost estimate to current program funding
  - Recommendations concerning program funding

3.4.2. CAIG Reporting Requirements

3.4.2.1. Cost Analysis Requirements Description

A sound cost estimate is based on a well-defined program. For ACAT I and ACAT IA programs, the Cost Analysis Requirements Description (CARD) is used to formally describe the acquisition program (and the system itself) for purposes of preparing both the program office cost estimate (and the DoD Component cost position, if applicable) and the OSD CAIG independent cost estimate. DoD Instruction 5000.2, Enclosure 3 specifies that for major defense acquisition programs the CARD will be provided in support of major milestone decision points (Milestone B, Milestone C, or the full-rate production decision review). In addition, for major AIS programs, the CARD is prepared whenever an Economic Analysis is required. The CARD is prepared by the program office and approved by the DoD Component Program Executive Officer (PEO). For joint programs, the CARD includes the common program agreed to by all participating DoD Components as well as all unique program requirements of the participating DoD Components. DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*, Chapter 1, provides further guidelines for the preparation of the CARD.

The CARD typically provides both narratives and tabular data, roughly following the following outline:

- System description and characteristics
  - System work breakdown structure
  - Detailed technical and physical description
  - Subsystem descriptions, as appropriate
  - Technology maturity levels of critical components

- System quality factors
  - Reliability/Maintainability/Availability
- PM's assessment of program risk and risk mitigation measures
- System operational concept
  - Organizational/unit structure
  - Basing and deployment description (peacetime, contingency, and wartime)
- System support concept
  - System logistics concept
    - Hardware maintenance and support concept
    - Software support concept
  - System training concept
- Time-phased system quantity requirements
- System manpower requirements
- System activity rates (OPTEMPO or similar information)
- System milestone schedule
- Acquisition plan or strategy

For each topic listed above, the CARD should provide information and data for the program to be costed. In addition, the CARD should include quantitative comparisons between the proposed system and a predecessor and/or reference system for the major topics, as much as possible. A reference system is a currently operational or pre-existing system with a mission similar to that of the proposed system. It is often the system being replaced or augmented by the new acquisition. For a program that is a major upgrade to an existing weapon platform, such as an avionics replacement for an operational aircraft, the new system would be the platform as equipped with the upgrade, and the reference system would be the platform as equipped prior to the upgrade. For major AIS programs, the CARD format described above may need to be tailored.

Naturally, the level of detail provided in the CARD will depend on the maturity of the program. Programs at Milestone B are less well-defined than programs at Milestone C or at full-rate production. In cases where there are gaps or uncertainties in the various program descriptions, these uncertainties should be acknowledged as such in the CARD. This applies to uncertainties in either general program concepts or specific program data. For uncertainties in program concepts, nominal assumptions should be specified for cost-estimating purposes. For example, if the future depot maintenance concept were not yet determined, it would be necessary for the CARD to provide nominal (but specific) assumptions about the maintenance concept. For uncertainties in numerical data, ranges that bound the likely values (such as low, most likely, and high estimates) should be included. In general, values that are "to be determined" (TBD) are not adequate for cost estimating. Dealing with program uncertainty in the CARD greatly facilitates subsequent sensitivity or quantitative risk analyses in the life-cycle cost estimate.

For programs employing an evolutionary acquisition strategy, the CARD should be structured to reflect the specifics of the approach. For programs in incremental development, the entire acquisition program, including all increments, is included in the scope of the program to be approved at the program initiation milestone review. The entire program therefore typically is

included in the CARD and in the subsequent program life-cycle cost estimate. For programs in spiral development, the situation will vary somewhat depending on circumstances. Normally, the CARD should attempt to include as much of the program as can be described at the time of the decision review, and clearly document any exclusions for portions of the program that cannot be defined.

Clearly, much of the information needed for the CARD is often available in other program documents. The CARD should stand-alone as a readable document, but can make liberal use of appropriate references to the source documents to minimize redundancy and effort. In such cases, the CARD should briefly summarize the information pertinent to cost in the appropriate section of the CARD, and provide a reference to the source document. The source documents should be readily available to the program office and independent cost estimating teams, or alternatively can be provided as an appendix to the CARD. Many program offices provide controlled access to source documents through a web site (perhaps at a "dot" MIL web address or on the SIPRNET).

3.4.2.2. Contractor Cost Data Reporting (CCDR)

CCDR is the primary means within the Department of Defense to systematically collect data on the development and production costs incurred by contractors in performing DoD acquisition program contracts. Often, CCDR data from historical programs is used to make parametric cost estimates for future acquisition programs. CCDR reporting is required by DoD Instruction 5000.2, Enclosure 3, for major contracts and sub-contracts (regardless of contract type) associated with ACAT ID and IC programs. Specific dollar thresholds for CCDR can be found in section 11.3.2.1 of this Guidebook. Detailed procedures and other implementation guidance are found in DoD 5000.4-M-1, *Contractor Cost Data Reporting (CCDR) Manual*. This manual (as well as downloadable report formats and definitions, specific report examples, and other related information) can be found at the Defense Cost and Resource Center (DCARC) web site. The DCARC is the OSD office responsible for administering the CCDR system. Access to CCDR data is provided by the DCARC to DoD government cost analysts who are registered users.

3.4.2.3. Software Resources Data Reporting

SRDR is a recent initiative. The SRDR is intended to improve the ability of the Department of Defense to estimate the costs of software intensive programs. SRDR reporting is required by DoD Instruction 5000.2, Enclosure 3, for major contracts and sub-contracts (regardless of contract type) associated with high-cost software elements within ACAT I and ACAT IA programs. Specific dollar thresholds for SRDR can be found in section 11.3.3. of this Guidebook. Data collected from applicable contracts include type and size of the software application(s), schedule, and labor resources needed for the software development. Further information is provided in the draft SRDR Manual, which can be found (along with downloadable report formats and definitions, specific report examples, and other related information) at the Defense Cost and Resource Center (DCARC) web site. The DCARC is the OSD office responsible for administering the SRDR system. Access to SRDR data is provided by the DCARC to DoD government cost analysts who are registered users.

3.5. Manpower Estimates

For Major Defense Acquisition Programs, 10 U.S.C. 2434 requires the Secretary of Defense to consider the estimate of the personnel required to operate, maintain, support, and provide system-related training, in advance of approval of the development, or production and deployment of the system. To satisfy this requirement, Table E3.T1, "Statutory Information Requirements," of DoD Instruction 5000.2, directs the development of a manpower estimate at Milestones B and C and at the Full-Rate Production decision review. Further guidance is provided in the USD(P&R) memorandum, "Interim Policy and Procedures for Strategic Manpower Planning and Development of Manpower estimates," dated December 10, 2003.

Manpower estimates serve as the authoritative source for out-year projections of active-duty and reserve end-strength, civilian full-time equivalents, and contractor support work-years. As such, references to manpower in other program documentation should be consistent with the manpower estimate once it is finalized. In particular, the manpower estimates should be consistent with the manpower levels assumed in the final affordability assessment and the Cost Analysis Requirements Description.

Organizational responsibilities in preparing the manpower estimate vary by DoD Component. Normally, the manpower estimate is prepared by an analytic organization in the DoD Component manpower community, in consultation with the program manager. The manpower estimates are approved by the DoD Component manpower authority (for the military departments, normally the Assistant Secretary for Manpower and Reserve Affairs).

For ACAT ID programs, a preliminary manpower estimate should be made available at least three to six months in advance of the Defense Acquisition Board (DAB) milestone review in order to support the development of cost estimates and affordability assessments. The final manpower estimate should be submitted to the Under Secretary of Defense (Personnel and Readiness) in sufficient time to support the Overarching Integrated Product Team (OIPT) review in preparation of the DAB meeting. Normally this would be three weeks prior to the OIPT review meeting. The USD(P&R) staff will review the final manpower estimate and provide comments to the OIPT.

The exact content of the manpower estimate is tailored to fit the particular program under review. A sample format for the manpower estimate is displayed in the table below. In addition, the estimate should identify if there are any resource shortfalls (i.e., discrepancies between manpower requirements and authorizations) in any fiscal year addressed by the estimate. Where appropriate, the manpower estimate should compare manpower levels for the new system with those required for similar legacy systems, if any. The manpower estimate also should include a narrative that describes the methods, factors, and assumptions used to estimate the manpower.

MANPOWER ESTIMATE
(Program Title)
SERVICE[1]

	FYxx[2]	FYxx+l	FYxx+2	FYxx+3	FYxx+4	… [3]
OPERATE:[4]						
Military						
Officers						
Enlisted						
Civilian						
Contractor						
Sub-Total						
MAINTAIN:						
Military						
Officers						
Enlisted						
Civilian						
Contractor						
Sub-Total						
SUPPORT:						
Military						
Officers						
Enlisted						
Civilian						
Contractor						
Sub-Total						
TRAIN: [4]						
Military						
Officers						
Enlisted						
Civilian						
Contractor						
Sub-Total						
TOTAL:						

3.6. Major Automated Information Systems Economic Analysis

3.6.1. Introduction

An automated information system (AIS) is an acquisition program that acquires information technology that is not embedded in a weapon system. AIS programs normally are involved with and directly related to information storage, processing, and display—requiring resources for

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[1] Provide separate estimates for Active and Reserve Components for each Service.
[2] Report manpower by fiscal year (FY) starting with initial fielding and continuing through retirement and disposal of the system (to include environmental clean-up).
[3] Until fielding is completed.
[4] Provide estimates for manpower requirements and authorizations. Provide deltas between requirements and authorizations for each fiscal year.

hardware, software, data, telecommunications, etc. AIS programs that meet the specified dollar thresholds in DoD Instruction 5000.2, Enclosure 2, qualify as major automated information systems (MAISs). MAIS programs that are subject to review by the Office of the Secretary of Defense (OSD)—through the Information Technology Acquisition Board (ITAB)—are designated Acquisition Category (ACAT) IAM. Other MAIS programs— delegated to the appropriate DoD Component acquisition executive—are designated ACAT IAC. In some cases, an ACAT IA program also meets the definition of a Major Defense Acquisition Program (MDAP). The USD(AT&L) and the ASD(NII)/DoD CIO decide who shall be the Milestone Decision Authority (MDA) for such programs. Regardless of who is the MDA, the statutory requirements that apply to MAIS programs and/or MDAPs (see DoD Instruction 5000.2, Enclosure 3) apply to such programs.

DoD Instruction 5000.2, Enclosure 3, requires that an Economic Analysis be performed in support of the Milestone A, Milestone B, and full-rate production decision reviews. The purpose of the Economic Analysis is to determine the best AIS program acquisition alternative, by assessing the net costs and benefits of the proposed AIS program relative to the status quo. In general, the best alternative will be the one that meets validated capability needs at the lowest life-cycle cost (measured in present value terms), and/or provides the most favorable return on investment.

Whenever an Economic Analysis is required, the DoD Component responsible for the program also is required to provide a DoD Component Cost Analysis, which is an independent estimate of program life-cycle costs. Normally, the Economic Analysis is prepared by the AIS program office, and the DoD Component Cost Analysis is prepared by an office or entity not associated with the program office or its immediate chain of command.

3.6.2. OD(PA&E) Review Procedures

For ACAT IAM programs, both the Economic Analysis and the DoD Component Cost Analysis are subject to independent review and assessment by the Office of the Director, Program Analysis and Evaluation (OD(PA&E)) resident in OSD. The purpose of the OD(PA&E) assessment is to provide the milestone decision authority with an independent determination that (1) the estimates of life-cycle costs and benefits are reasonable and traceable, (2) the return on investment calculation is valid, and (3) the cost estimates are built on realistic program and schedule assumptions.

3.6.2.1. Kick-Off Meeting

The review process normally begins with a kick-off meeting held with the OD(PA&E) staff, representatives from the AIS program office, the DoD Component Cost Analysis Team, and any DoD Component functional or headquarters sponsors. The purpose of the meeting is to reach a common understanding on the expectations for the upcoming activities and events leading to the Information Technology Acquisition Board milestone review. As a starting point, the DoD Component staff and/or sponsors' representatives should review the contents of the most recently approved capability needs documents, and explain any prior analysis (such as an analysis of materiel approaches) used to justify the need for a materiel solution (that will be met by the AIS program).

At the kick-off meeting, the DoD Component staff and/or sponsors' representatives also should be prepared to explain the planned approach for the upcoming Economic Analysis. To

facilitate this dialogue, the AIS program office should prepare and provide a brief Economic Analysis development plan. The development plan should document the organizational responsibilities, analytic approach, ground rules and assumptions, and schedule for the economic analysis. The development plan should identify the specific alternatives that will be compared in the Economic Analysis. Normally, at least one alternative should be associated with the proposed AIS program, and one alternative should be associated with the status quo (no modernization investment). It may well be the case that the status quo alternative represents an unacceptable mission posture—it may cost too much to sustain, be unable to meet to meet critical capability needs, or be unsupportable due to technological obsolescence. Nevertheless, the status quo concept, applied over the same time frame (life-cycle) as the proposed AIS program, is used for comparative purposes in the Economic Analysis. The Economic Analysis development plan should document the DoD Component Cost Analysis approach and schedule as well.

As part of the Economic Analysis development plan, the program office should propose the cost element structure that will be used to organize and categorize cost estimates in the Economic Analysis. The cost element structure provides a hierarchal framework of defined cost elements that in total comprise the program life-cycle cost. The cost element structure should include phase-out costs associated with the status quo (legacy or predecessor) system. These costs would be incurred in managing, preserving, and maintaining the operations of the status quo system as it runs parallel to the phasing in of the new system. The status quo phase-out cost elements are not used in the estimate of the status quo alternative. A sample of a generic cost element structure is available from the OD(PA&E) staff.

Typically, the Economic Analysis and DoD Component Cost Analysis teams use a set of standard spreadsheet templates developed and provided by the OD(PA&E) staff. These templates provide (1) standard and self-documenting formats for data inputs, (2) a consistent approach to net present value and return on investment computations, and (3) automatic generation of standard output tables and charts. The use of the standard templates should be discussed at the kick-off meeting.

3.6.2.2. Use of the CARD for AIS Programs

As soon as possible after the kick-off meeting, the draft Cost Analysis Requirements Description (CARD) is provided to the OD(PA&E) staff for review. The CARD is used to define and describe the AIS program for purposes of preparing both the Economic Analysis and the DoD Component Cost Analysis. For an AIS program, the CARD typically would address the following elements:

- Program description
- Program operational concept
- Program data management requirements
- Program quantity requirements
- Program manpower requirements
- Program fielding strategy
- Program milestone schedule
- Program acquisition plan or strategy

Procedures for the preparation of the CARD are described in DoD Instruction 5000.2. Additional guidelines on CARD preparation are found in DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*, Chapter 1. However, these guidelines are for the most part oriented toward weapon systems, and may need to be tailored somewhat for automated information systems. The system description in the CARD should address both hardware and software elements. The CARD should describe each major hardware item (computers, servers, etc.), noting those items that are to be developed, and those items that are off-the-shelf. The CARD also should describe each software configuration item (including applications as well as support software) and identify those items that are to be developed. For software items to be developed, the CARD should provide (1) some type of sizing information (such as counts of source lines of code or function points) suitable for cost estimating, and (2) information about the programming language and environment. In addition, the CARD should describe any special (physical, information, or operations) system security requirements, if applicable.

Clearly, much of the information needed for the CARD is often available in other program documents. The CARD should stand-alone as a readable document, but can make liberal use of appropriate references to the source documents to minimize redundancy and effort. In such cases, the CARD should briefly summarize the information pertinent to the Economic Analysis in the appropriate section of the CARD, and provide a reference to the source document.

3.6.2.3. OD(PA&E) Assessment

To facilitate the OD(PA&E) review and assessment, the Economic Analysis and DoD Component Cost Analysis teams should provide written documentation early enough to permit a timely report to the Overarching Integrated Product Team and Information Technology Acquisition Board. Normally, the documentation is provided 30 to 60 days prior to the OIPT meeting. The documentation serves as an audit trail of source data, methods, and results. The documentation should be easy to read, complete and well organized—to allow any reviewer to understand the estimate fully. The documentation also serves as a valuable reference for future cost analysts, as the program moves from one acquisition milestone to the next. Use of the OD(PA&E) standard templates described earlier minimizes the burden of creating formal written documentation.

After review of the documentation, the OD(PA&E) staff provides feedback to the program office and DoD Component staff. Subsequently, the OD(PA&E) staff prepares a written report containing the findings of their independent assessment to the milestone decision authority. Depending on the circumstances, the report may contain recommended cost and benefits positions, and it may raise funding or schedule issues. The expectation is that any issues raised have already emerged in prior discussions and that the final OD(PA&E) report should not contain any surprises.

3.7. Principles for Life-Cycle Cost Estimates

Section 3.4.1 of this Guidebook primarily focused on procedures associated with life-cycle cost estimates for major defense acquisition programs—subject to review by the Cost Analysis Improvement Group (CAIG)—prepared in support of major milestone or other program reviews held by the Defense Acquisition Board. This section is more generally applicable, and describes a recommended analytic approach for planning, conducting, and documenting a life-cycle cost estimate for a defense acquisition program (whether or not the estimate is subject to CAIG review).

The recommended analytic approach for preparing a life-cycle cost estimate is shown in Figure 8:

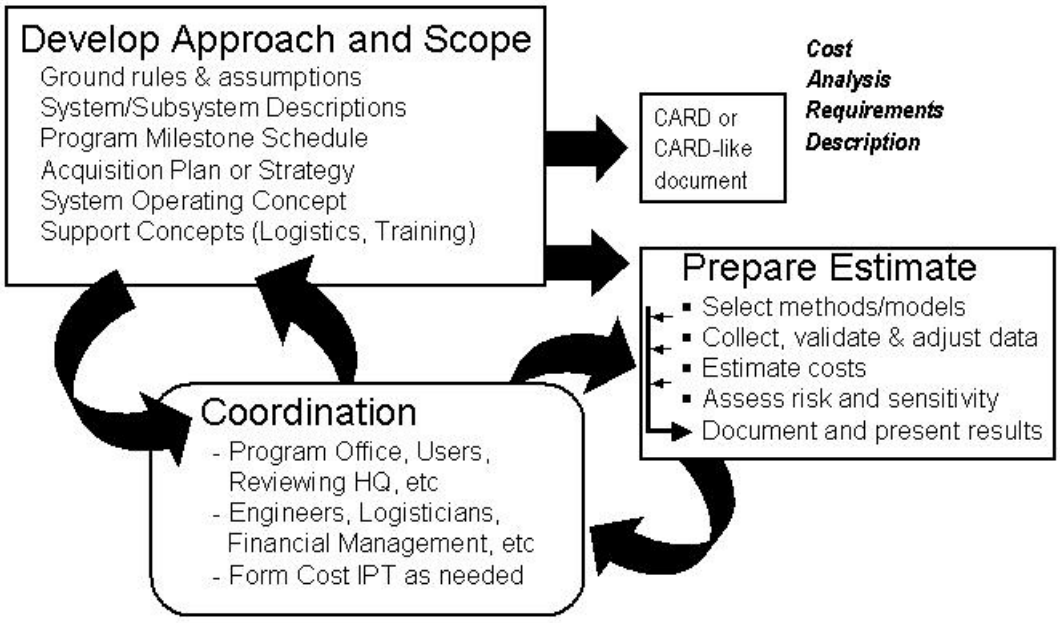

Figure 8. A Recommended Analytic Approach for Life-Cycle Cost Estimates

The remainder of this section describes this process.

3.7.1. Develop Approach and Scope

The first step in preparing a credible cost estimate is to begin with the development of a sound analytic approach. During this planning phase, critical ground rules and assumptions are established, the scope of the estimate is determined, and the program to be costed is carefully defined and documented. The program definition includes not only a technical and physical description of the system (and perhaps major subsystems), but also a description of the system's program schedule, acquisition strategy, and operating and support concepts. In some cases, it is necessary to state explicitly the costs to be included, and the costs to be excluded. For example, when systems have complex interfaces with other systems or programs (that are outside the scope of the system being costed), the interfaces should be carefully defined.

For programs that will be reviewed by the OSD CAIG, the program office is required to define its program in a comprehensive formal written document known as a Cost Analysis Requirements Description, or CARD. The format for this document is briefly summarized in section 3.4.2.1 of this Guidebook, and is completely described in DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*. For programs preparing a cost estimate not subject to OSD CAIG review, the CARD format, with appropriate tailoring, nevertheless provides a useful and flexible framework for developing a written program description suitable for a life-cycle cost estimate. Much of the necessary information to prepare a written program description can be extracted and synthesized from common program source documents and contract specifications. The written program description should stand-alone as a readable document, but can make liberal use of suitable references to the source documents to minimize redundancy and effort.

Part of the system definition typically includes the program work breakdown structure. The program WBS is a hierarchy of product-oriented elements (hardware, software, data, and services) that collectively comprise the system to be developed or produced. The program WBS relates the elements of work to each other and to the end product. The program WBS is extended to a contract WBS that defines the logical relationship between the elements of the program and corresponding elements of the contract work statement. The WBS provides the framework for program and technical planning, cost estimating, resource allocation, performance measurement, technical assessment, and status reporting. In particular, the contract WBS provides the reporting structure used in contract management reports (such as cost performance reports or reports in the Contractor Cost Data Reporting system). Further information can be found in MIL-HDBK-881 (Work Breakdown Structure), which is available at the Defense Cost and Resource Center web site.

Another step in developing the analytic approach to the cost estimate is establishing the cost element structure that will be used as the format for the operating and support (O&S) cost estimate. The cost element structure describes and defines the specific elements to be included in the O&S cost estimate in a disciplined hierarchy. Using a formal cost element structure (prepared and coordinated in advance of the actual estimating) identifies all of the costs to be considered, and organizes the estimate results. The cost element structure is used to organize an O&S cost estimate similar to the way that a work breakdown structure is used to organize a development or production cost estimate. A standard cost element structure used by the OSD CAIG can be found in DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*. Although each DoD component (military department or defense agency) may have its own preferred cost element structure, it is expected that each DoD Component will have a cross-walk or mapping structure so that any presentation to the CAIG can be made using the standard structure in DoD 5000.4-M.

It also is important that the analytic approach to the cost estimate be documented and reviewed by all potentially interested parties, before the actual work on preparing the cost estimate begins. This helps ensure that there are no false starts or misunderstandings later in the process. Normally, cost estimates are sponsored by a system program office and are prepared by a multi-disciplinary team with functional skills in financial management, logistics, engineering, and other talents. The team also should include participants or reviewers from major affected organizations, such as the system's operating command, product support center, maintenance depot, training center or command, and so forth. Typically, the analytic approach to the cost estimate has a written study plan that includes a master schedule (of specific tasks, responsible parties, and due dates). For sufficiently complex efforts, the estimating team may be organized as a formal Integrated Product Team (IPT). For independent cost estimates, the team may be smaller and less formal, but the basic principle—complete coordination of the analytic approach with all interested parties—still applies.

3.7.2. Prepare the Estimate

The remainder of this section describes the typical steps in preparing a life-cycle cost estimate. The discussion summarizes the steps entailed in selecting estimating techniques or models, collecting data, estimating costs, and conducting sensitivity or risk analysis.

In addition, the importance of good documentation of the estimate is explained.

Throughout the preparation of the estimate, coordination with all interested parties remains important. Frequent in-progress reviews or meetings are usually a good practice.

3.7.3. Select Methods and/or Models

A number of techniques may be employed to estimate the costs of a weapon system. The suitability of a specific approach will depend to a large degree on the maturity of the program and the level of detail of the available data. Most cost estimates are accomplished using a combination of the following estimating techniques:

- Cost Estimating Relationship (CER). A CER is a technique used to estimate a cost using an established relationship with one or more independent variables. The relationship may be mathematically simple (e.g. a simple ratio) or it may involve a complex equation (often derived from regression analysis of historical systems or subsystems). CERs should be current, applicable to the system or subsystem in question, and appropriate for the range of data being considered.
- Analogy. An analogy is a technique used to estimate a cost based on historical data for an analogous system or subsystem. In this technique, a currently fielded system, similar in design and operation to the proposed system, is used as a basis for the analogy. The cost of the proposed system is then estimated by adjusting the historical cost of the current system to account for differences (between the proposed and current systems). Such adjustments can be made through the use of factors (sometimes called scaling parameters) that represent differences in size, performance, technology, and/or complexity. Adjustment factors based on quantitative data are usually preferable to adjustment factors based on judgments from subject-matter experts.
- Engineering Estimate. With this method, the system being costed is broken down into lower-level components (such as parts or assemblies), each of which is costed separately for direct labor, direct material, and other costs. Engineering estimates for direct labor hours may be based on analyses of engineering drawings and contractor or industry-wide standards. Engineering estimates for direct material may be based on discrete raw material and purchase part requirements. The remaining elements of cost (such as quality control or various overhead charges) may be factored from the direct labor and material costs. The various discrete cost estimates are aggregated by simple algebraic equations (hence the common name “bottoms-up” estimate). The use of engineering estimates requires extensive knowledge of a system’s (and its components’) characteristics, and lots of detailed data.
- Actual Costs. With this method, actual cost experience or trends (from prototypes, engineering development models, and/or early production items) are used to project estimates of future costs for the same system. These projections may be made at various levels of detail, depending on the availability of data. Cost estimates that support a full-rate production milestone decision should be based on actual cost data to the greatest extent possible. A common mistake is to use contract prices as a substitute for actual cost experience. Contract prices should not be used to project future costs unless it is known that the contract prices are associated with profitable ventures, and that it is reasonable to assume that similar price experience will be obtained for subsequent contracts.

In many instances, it is a common practice to employ more than one cost estimating method, so that a second method can serve as a cross-check to the preferred method. Analogy estimates are often used as cross-checks, even for mature systems.

3.7.4. Collect, Validate, and Adjust Data

There are many possible sources of data that can be used in cost estimates. Regardless of the source, the validation of the data (relative to the purpose of its intended use) always remains the responsibility of the cost analyst. In some cases, the data will need to be adjusted or normalized. For example, in analogy estimates, the reference system cost should be adjusted to account for any differences—in system characteristics (technical, physical, complexity, or hardware cost) or operating environment—between the reference system and the proposed system being costed.

Actual cost experience on past and current acquisition programs often forms the basis of estimates of future systems. The Contractor Cost Data Reporting (CCDR) system is the primary means within the Department of Defense to systematically collect data on the development and production costs incurred by contractors in performing DoD acquisition program contracts.

CCDR reports can provide for each contract a display of incurred costs to date and estimated incurred costs at completion by elements of the work breakdown structure, with nonrecurring costs and recurring costs separately identified. In addition, CCDR reports can display incurred costs to date and estimated incurred costs at completion by functional category (manufacturing, engineering, etc.). Each functional category is broken out by direct labor hours and major cost element (direct labor, direct material, and overhead). The CCDR manual (which provides report formats and definitions, specific report examples, and other related information) can be found at the Defense Cost and Resource Center (DCARC) web site. The DCARC is the OSD office responsible for administering the CCDR system.

For currently fielded major systems, historical O&S cost data for the most part is available from the Visibility and Management of Operating and Support Costs (VAMOSC) data system managed by each DoD Component. The data can be displayed in several different formats, including the CAIG standard cost element structure described previously. Data can be obtained for entire systems, or at lower levels of detail. VAMOSC provides not only cost data, but related non-cost data (such as OPTEMPO or maintenance man-hours) as well. This type of data is useful for analogy estimates (between proposed systems and appropriate predecessor or reference systems) and for "bottoms-up" engineering estimates (for fielded systems or components, possibly adjusted for projected reliability and maintainability growth). VAMOSC data should always be carefully examined before use in a cost estimate. The data should be displayed over a period of a few years (not just a single year), and stratified by different sources (such as major command or base). This should be done so that abnormal outliers in the data can be identified, investigated, and resolved as necessary.

3.7.4.1. Estimate Costs

With the completion of the steps described earlier in this chapter, the actual computations of the cost estimate can begin. It is important to assess critically the outputs from the estimating methods and models, drawing conclusions about reasonableness and validity. Peer review is often helpful at this point. For complex cost estimates, with many elements provided from

different sources, considerable effort and care are needed to deconflict and synthesize the various elements.

3.7.4.2. Assess Risk and Sensitivity

For any system, estimates of future life-cycle costs are subject to varying degrees of uncertainty. The overall uncertainty is not only due to uncertainty in cost estimating methods, but also due to uncertainties in program or system definition or in technical performance. Although these uncertainties cannot be eliminated, it is useful to identify associated risk issues and to attempt to quantify the degree of uncertainty as much as possible. This bounding of the cost estimate may be attempted through sensitivity analyses or through a formal risk analysis.

Sensitivity analysis attempts to demonstrate how the cost estimate would change if one or more assumptions change. Typically, for the high-cost elements, the analyst identifies the relevant cost-drivers, and then examines how costs vary with changes in the cost-driver values. For example, a sensitivity analysis might examine how maintenance manning varies with different assumptions about system reliability and maintainability values, or how system manufacturing labor and material costs vary with system weight growth. In good sensitivity analyses, the cost-drivers are not changed by arbitrary plus/minus percentages, but rather by a careful assessment of the underlying risks. Sensitivity analysis is useful for identifying critical estimating assumptions, but has limited utility in providing a comprehensive sense of overall uncertainty.

In contrast, quantitative risk analysis can provide a broad overall assessment of variability in the cost estimate. In risk analysis, selected factors (technical, programmatic and cost) are described by probability distributions. Where estimates are based on cost models derived from historical data, the effects of cost estimation error may be included in the range of considerations included in the cost risk assessment. Risk analysis assesses the aggregate variability in the overall estimate due to the variability in each input probability distribution, typically through Monte-Carlo simulations. It is then possible to derive an estimated empirical probability distribution for the overall life-cycle cost estimate. This allows the analyst to describe the nature and degree of variability in the estimate.

3.7.4.3. Document and Present Results

A complete cost estimate should be formally documented. The documentation serves as an audit trail of source data, methods, and results. The documentation should be easy to read, complete and well organized—to allow any reviewer to understand the estimate fully. The documentation also serves as a valuable reference for future cost analysts, as the program moves from one acquisition milestone to the next.

The documentation should address all aspects of the cost estimate: all ground rules and assumptions; the description of the system and its operating and support concepts; the selection of cost estimating methods; data sources; the actual estimate computations; and the results of any sensitivity or risk analyses. The documentation for the ground rules and assumptions, and the system description, should be written as an updated (final) version of the CARD or CARD-like document described earlier. The documentation for the portion of the cost estimate dealing with data, methods, and results often is published separately from the CARD or CARD-like document, but if that is the case, the two documents should be completely consistent.