OPERATING AND SUPPORT COST-ESTIMATING GUIDE

OFFICE OF THE SECRETARY OF DEFENSE

COST ASSESSMENT AND PROGRAM EVALUATION

SEPTEMBER 2020

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1. INTRODUCTION

1.1 Purpose

This guide was prepared by the Office of the Secretary of Defense (OSD) Director of Cost Assessment and Program Evaluation (DCAPE) for use by the Department of Defense (DoD) military departments and defense agencies in developing estimates of system Operating and Support (O&S) costs.

1.2 Applicability

This guide is focused on analytic methods and data for O&S cost estimates and analyses for a wide variety of DoD weapon systems.

1.3 Outline

The remainder of this guide is organized as follows:

- Chapter 2 provides an overview of the concepts of system life-cycle cost and system O&S cost.
- Chapter 3 provides the standard OSD O&S cost element structure. The cost element structure is an organized and defined taxonomy of O&S cost elements.
- Chapter 4 describes various categorizations of O&S cost elements, and associated O&S cost metrics, that are used for a variety of different purposes.
- Chapter 5 discusses the uses of O&S cost estimates and analyses in support of the defense acquisition process throughout the program life cycle.
- Chapter 6 provides a summary of the O&S cost and related data systems that are available to the DoD cost community, including contractor cost data reporting for major sustainment contracts.
- Chapter 7 provides a tutorial on the best practices for planning, conducting, presenting, and documenting O&S cost estimates.

This guide also has several appendices:

- Appendix A provides an optional, more detailed cost element structure for software maintenance.
- Appendix B provides terms and definitions for O&S-related indirect costs.
- Appendix C provides terms and definitions for acquisition cost elements associated with system product support.

- Appendix D provides a mapping from OSD O&S cost elements to budget appropriations.
- Appendix E provides a recommended analytic approach that can be used to support sustainment reviews of major weapon systems after initial operational capability.
- Appendix F provides background on DoD maintenance and logistics for major weapon systems.
- Appendix G provides an example of an O&S cost estimate at the component or black box level of detail.
- Appendix H describes the extensive and demanding statutory and regulatory requirements associated with O&S cost estimates and analyses, weapon system sustainment, and life-cycle product support.
- Appendix I provides information on rates for military and civilian manpower.
- Appendix J provides the references used throughout this guide.

This guide also has a list of abbreviations and a glossary.

2. OVERVIEW OF LIFE-CYCLE COSTS

2.1 Life-Cycle Cost Categories

Life-cycle cost is defined as the sum of four major cost categories: (1) research and development costs; (2) investment costs, consisting of procurement and military construction costs; (3) O&S costs; and (4) disposal costs.

Figure 2-1 depicts a notional profile of annual program expenditures by major cost category throughout the system life cycle for a program acquired using the Major Capability Acquisition pathway. The profile for an actual program will vary significantly by system type and the program's Adaptive Acquisition Framework pathway.

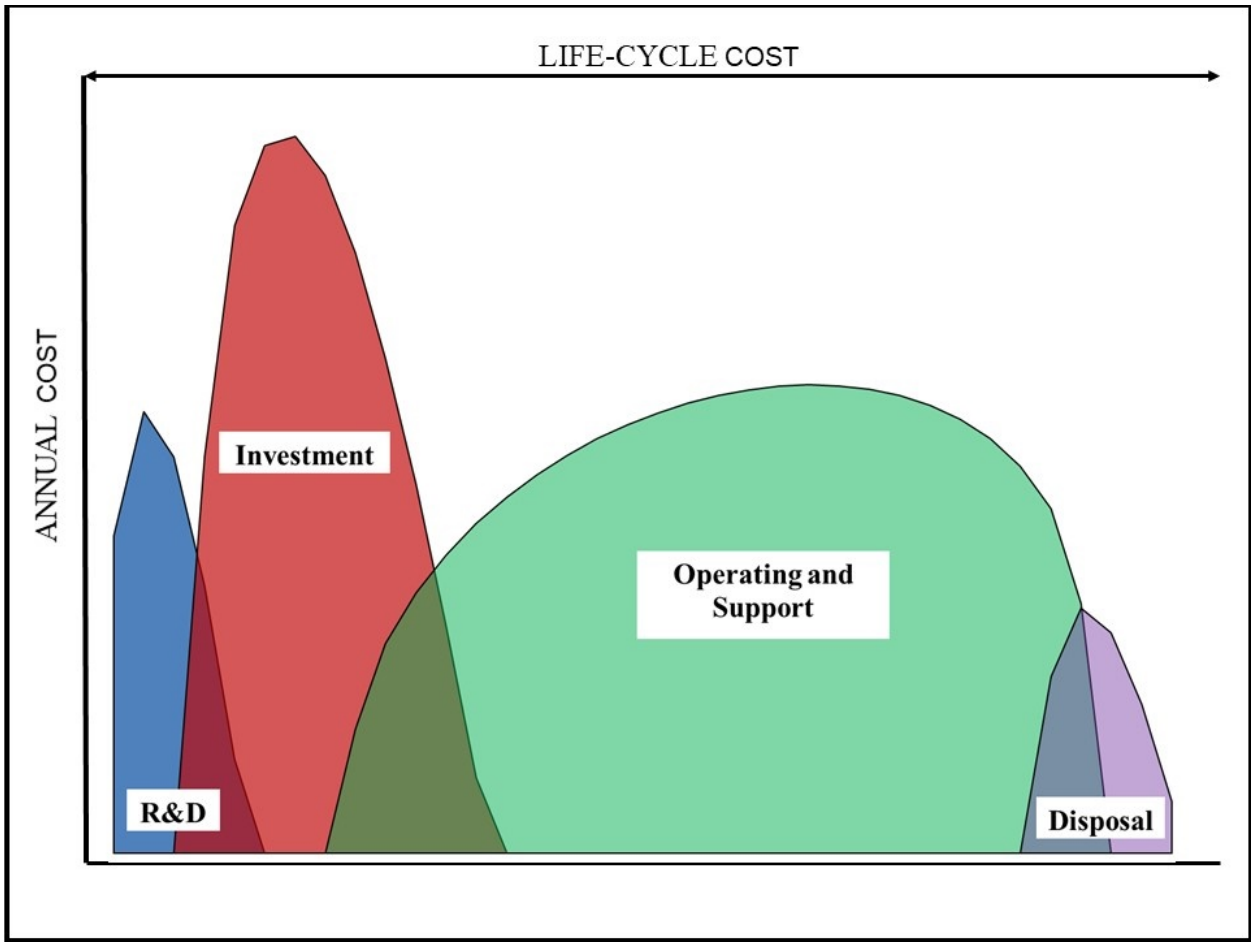

Figure 2-1. Illustrative System Life Cycle

These costs occur over the phases of an acquisition program as defined in the acquisition process. The research and development costs occur during the materiel solution analysis phase, the technology maturation and risk reduction phase, and the engineering and manufacturing development phase; the investment costs occur during the production and deployment phase; the O&S costs occur during the operations and sustainment phase; and the disposal costs occur during the disposal phase.

Note that in the standard terminology for life-cycle cost, there are acquisition logistics support costs that are part of the program's procurement cost. These costs are the initial investment and a vital enabler for a program's product support. Definitions for the acquisition logistics support cost elements are provided in MIL-STD-881D, *Work Breakdown Structures for Defense Materiel Items*, Appendix K (Common Elements). The acquisition cost elements are part of the Work Breakdown Structure (WBS) for each major system type (e.g., aircraft, ground vehicle, etc.). The acquisition logistics support cost elements are described in Appendix C of this guide.

2.2 Cost Categories as a Percentage of Life-Cycle Cost

For many types of programs, the system O&S costs will be the largest of the four cost categories. Figure 2-2 presents the percentage of program life-cycle cost associated with O&S costs (for eight system types).

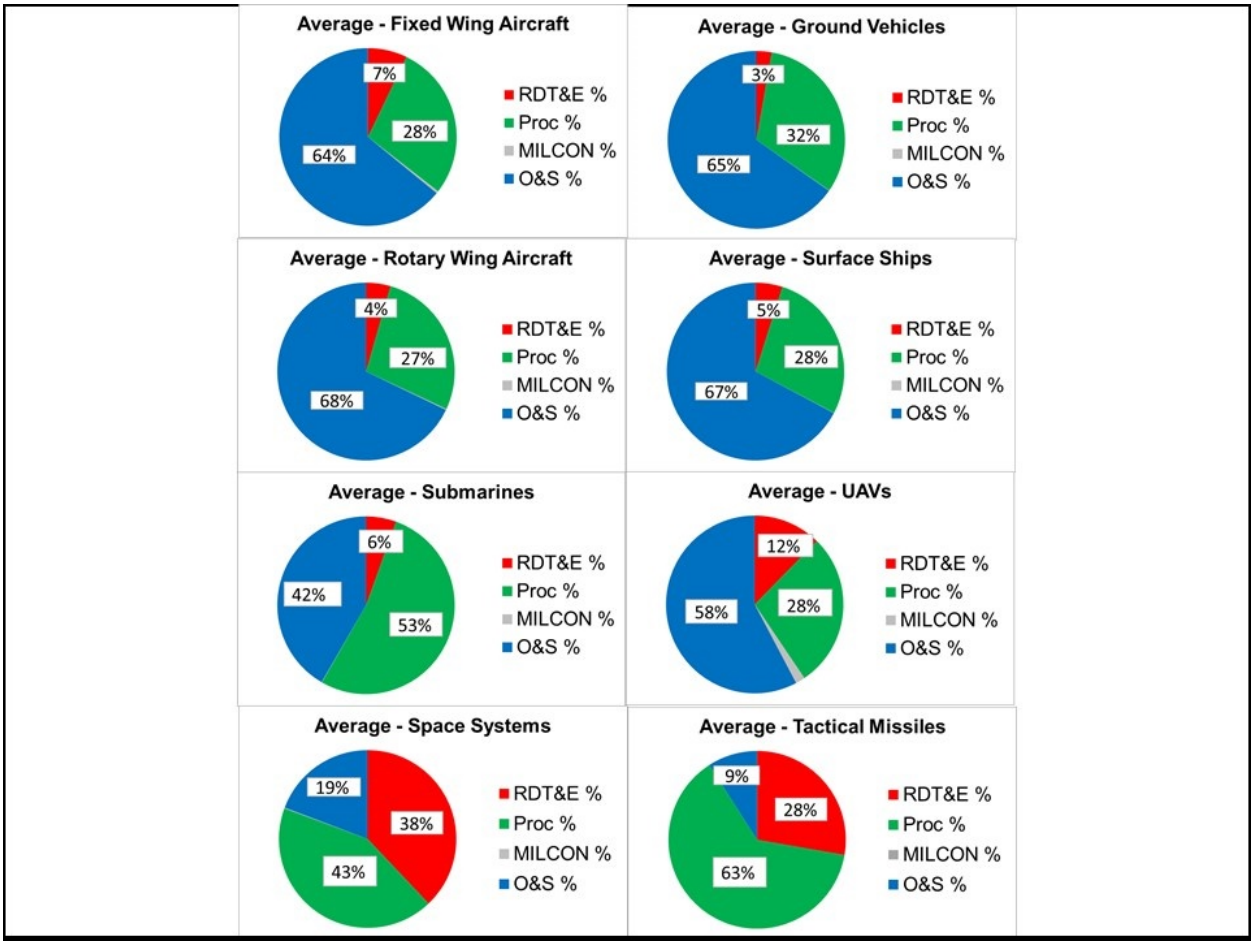

Figure 2-2. Major Cost Categories as % of Total Life-Cycle Cost for Selected System Types

The percentages are based on data taken from Selected Acquisition Reports (SARs). For programs still actively reporting at the time of the publication of this guide, the data were taken from the December 2019 SARs. For other programs, the data were taken from the last SAR for that program. In all cases, the data were converted to FY 2020 dollars before calculating the percentages displayed.

Note that in SARs, the investment cost category is not provided per se. Rather, the SARs provide separate costs for procurement and military construction. Military construction costs are normally not a significant life-cycle cost element in most programs.

The actual percentage will vary from program to program, albeit for some system types, such as space systems and tactical missiles, the percentages for O&S costs will be much lower. Space systems have O&S costs primarily associated with sustainment of the ground stations. Tactical missiles have O&S costs primarily associated with stockpile surveillance, storage costs, and sustaining engineering and program management. Nevertheless, given the relative importance of O&S costs for many DoD major weapon systems, this guide has been issued to stress that importance and provide advice on estimating and managing these costs.

2.3 Overview of O&S Cost Scope and Definitions

At the broadest level, O&S costs consist of all sustainment costs incurred from the initial system deployment through the end of system operations. This would include all costs of operating, maintaining, and supporting a fielded system. Specifically, this consists of the costs (organic (government civilian and military) and contractor) of personnel, equipment, supplies, software, and services associated with operating, modifying, maintaining, supplying, and otherwise supporting a system in the DoD inventory. These costs include those associated with the system-specific training of personnel necessary to support the system.

Chapter 3 of this guide provides further structure and definitions for the system O&S cost elements.

3. OSD COST ELEMENT STRUCTURE

3.1 Introduction

This chapter provides the OSD standard O&S cost element structure, with associated terms and definitions, which categorizes and defines cost elements that cover the full range of O&S costs that could occur in any defense system. This standard is intended to be used by the military departments and defense agencies when presenting O&S cost estimates to OSD and the Joint Staff. Such presentations include: briefings or documentation reviewed by Cost Assessment and Program Evaluation (CAPE), displays of system O&S cost estimates in the program SAR, and any other briefings, reports, or displays reviewed by OSD or the Joint staff. However, there is flexibility in that some programs may have situations where the cost element structure will need to be tailored to the specific circumstances of the program.

It is also intended that the military department cost data collection systems and activities conform to this standard as much as possible. However, in some cases, that may not always be possible. For example, the standard OSD cost element structure does not use Interim Contractor Support (ICS) or Contractor Logistics Support (CLS) as cost elements. It is intended that in cost estimates, the analyst will distribute any contractor sustainment costs to the appropriate functional cost element such as depot maintenance or sustaining/systems engineering. However, the military department Visibility and Management of Operating and Support Costs (VAMOSC) at the present time are not able to make such a distribution, and may have ICS or CLS as cost elements. For programs with significant ICS or CLS, it will be necessary for the analyst to augment the VAMOSC data with cost data reports from major sustainment contracts and other sources in order for the estimate to align with the standard structure. Cost data reporting for sustainment contracts is described in Chapter 6 of this guide.

The O&S cost element structure is divided into five major categories:

1.0 UNIT-LEVEL MANPOWER

Cost of operators, maintainers, and other support manpower assigned to operating units. Includes military, government civilian, and/or contractor manpower.

2.0 UNIT OPERATIONS

Cost of unit operating material (e.g., direct fuel and training material) and unit support services. Excludes all maintenance and repair material.

3.0 MAINTENANCE

Cost of all system maintenance other than maintenance manpower assigned to operating units. Consists of organic and contractor maintenance.

4.0 SUSTAINING SUPPORT

Cost of system support activities other than maintenance that can be attributed to a system and are provided by organizations other than the system's operating units.

5.0 CONTINUING SYSTEM IMPROVEMENTS

Cost of hardware modifications and software maintenance to keep the system operating and operationally current.

Beneath these five levels, the cost element structure is organized in a hierarchy. Figure 3-1 presents the next lower level in the hierarchy. Cost estimates, cost reporting, and cost data collection may be made at lower levels in the hierarchy, depending on the availability of data.

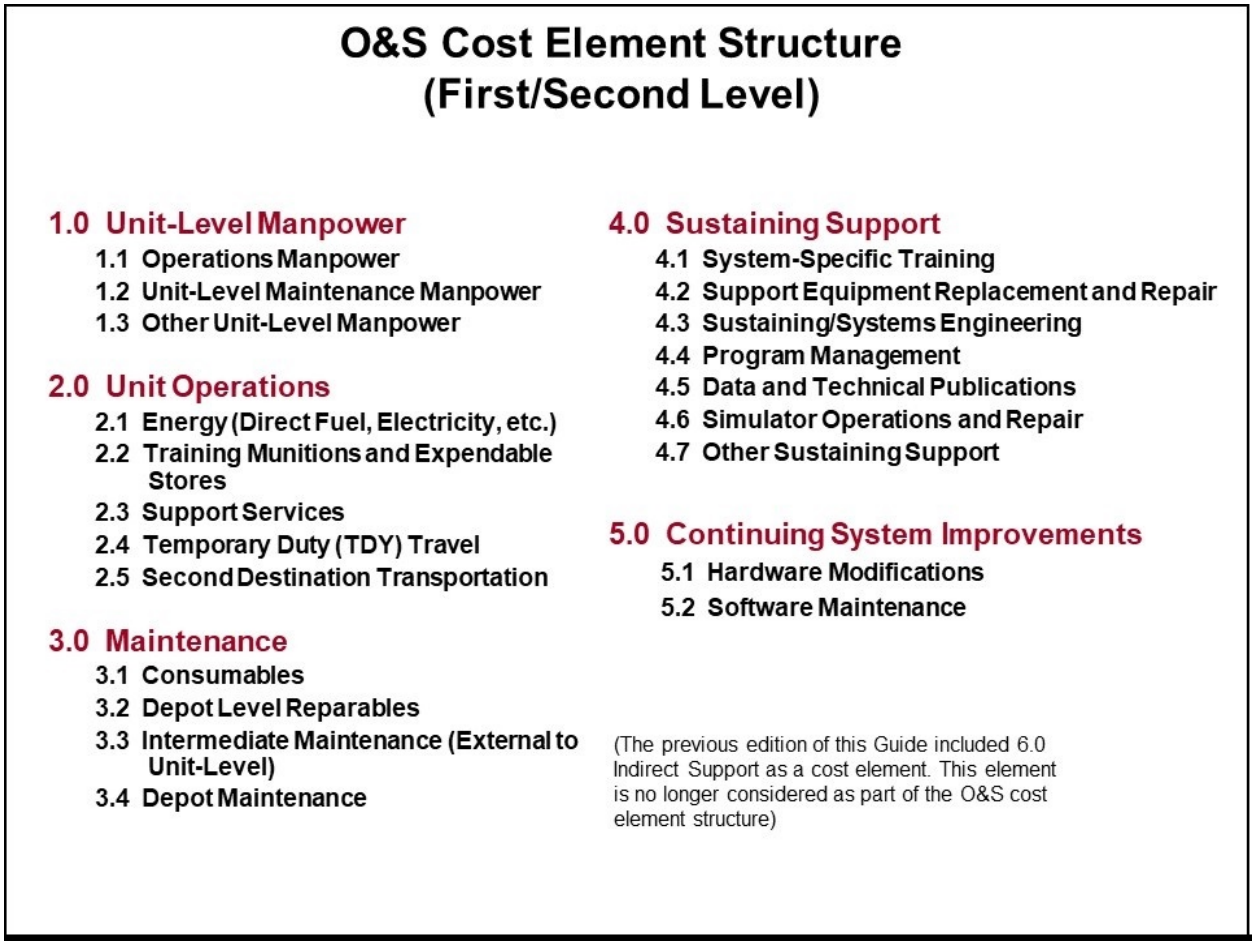

Figure 3-1. Second/Third Level of Cost Element Structure

Appendix D provides a mapping from the O&S cost elements to budget appropriations.

The next section explains the types of costs that are included in each major category and provides the subcategories at lower levels in the hierarchy.

3.2 Definitions

The definitions that follow are the ones provided by CAPE for O&S cost estimates and data collection. However, this document is a guide, not an instruction; therefore these definitions are not mandatory. Compliance is recommended, and deviations from these standard definitions should be adequately explained in the cost estimate documentation.

1.0 UNIT-LEVEL MANPOWER

The Unit-Level Manpower element includes the costs of all operator, maintenance, and other support manpower at operating units (or at maintenance and support units that are organizationally related and adjacent to the operating units). Unit-Level Manpower includes Active, Reserve, and National Guard military, government civilian, and contractor manpower costs.

While the cost elements in this category make the distinction between operators, maintainers, and other unit-level manpower, that distinction may not apply to all situations. For example, in O&S cost estimates for Navy ships, the ship manpower is typically estimated and documented for the entire crew as a whole, and is not broken down into operators, maintainers, and other support.

The scope of unit-level manpower consists of the lowest-level operating unit capable of independent system operations, and associated augmenting maintenance and support units (if any) integral to system operations. For systems owned by deploying units, the scope of unit-level manpower includes the operator, maintenance, and other support personnel who are consistently deployed with the systems to their deployment locations.[1] For example, for an Air Force aircraft, the scope of unit-level manpower includes the aircraft operating squadron and associated maintenance and support units in the same wing. As another example, for an Army tank, the scope of unit-level manpower includes the tank company (resident in an armored brigade combat team) and associated maintenance and support companies (resident in a brigade support battalion or combat sustainment support battalion supporting the brigade combat team). However, for some systems, such as ships, the unit-level concept does not apply, and unit manpower costs are estimated on an individual system basis.

Costs of military, government civilian, and contractor personnel should be shown separately in the estimate of unit-level manpower costs. For contractor manpower, Field Service Representatives (FSRs) assigned to support the local unit-level maintenance activities are

[1] For systems that deploy, the manpower that deploys with the system may be scenario dependent. The scope of unit-level manpower in an O&S cost estimate should include only the manpower that routinely deploys with the system, regardless of scenario.

included in cost element 1.2 (Unit-Level Maintenance), and FSRs assigned to support other local unit-level support activities are included in cost element 1.3 (Other Unit-Level).

The elements of unit-level manpower are defined below.

1.1 Operations

The costs of all military, civilian, and contractor manpower required to operate a system. For example:

- Aircraft and Helicopters. Aircrews including pilots, navigators, mission specialists, load masters, etc.
- Ships. Ship's company as specified in the Ship Manning Document (SMD) for each class of ship. On ships and submarines, all personnel are considered as both operators and maintainers. The costs of all ship personnel are reported under this element (1.1).
- Electronic Systems. Network warfare operator, microwave systems operator, ground surveillance radar crewmember.
- Armored Vehicles. Crew chief, commander, gunner, driver, loader.
- Space Systems. Operators at the ground station or similar facility.

For cases in which individuals operate more than one system, or have other duties, manpower costs should be allocated on a relative workload (i.e., manhours) basis.

Some types of weapon systems, such as tactical missiles, do not have operations manpower.

1.2 Unit-level Maintenance

The costs of all military, civilian, and contractor manpower that performs field-level maintenance on the system. For the Navy and Air Force, this element consists of the costs of organizational maintenance manpower and unit-level intermediate maintenance personnel. The costs of intermediate-level maintenance personnel resident in a support organization that is not unit-level relative to the operating unit, such as a Navy shore-based Regional Maintenance Center, are included in element 3.3 (Intermediate Maintenance (External to Unit-Level)). The Army does not conduct intermediate maintenance at the field level, but the field-level manpower costs would be captured here. For cases in which individuals maintain more than one system, manpower costs should be allocated among the systems on a relative workload (i.e., manhours) basis.

1.3 Other Unit-Level

The cost of all military, civilian, and contractor manpower that performs administrative, security, logistics, safety, engineering, and other mission support functions at the unit level.

These costs include only the costs of manpower positions that exist to wholly or predominantly support the system whose costs are being estimated. For systems that deploy, these costs include the costs of manpower positions that routinely deploy to support the system.[2]

Some examples are:

- Staff. Manpower required for unit command, administration, supervision, operations control, planning, scheduling, safety, quality control of crew training, and operational proficiency, etc. This may also include staff in a parent organization above the unit level where appropriate (i.e., staff is primarily dedicated to the system).
- Security. Manpower required for system security. Duties may include system-level entry control, close and distant boundary support, and security alert operations. (Does not include base level access control unless the entire facility exists solely to support the weapon system).
- Logistics. Manpower required for logistics support. Functions may include supply, transportation, inventory control, fuel handling, etc.
- Ordnance Support. Includes manpower providing munitions handling, weapons assembly, etc. Excludes any ordnance support manpower included in element 1.2 (unit-level maintenance).
- Other Support. Manpower required to provide system-specific fixed and mobile communications, information, intelligence, photo interpretation, and other special mission support. Note that manpower associated with operations or maintenance of simulators or training devices is captured in element 4.7.

For cases in which unit-level individuals support more than one system, manpower costs should be allocated among the systems on a relative workload (i.e., manhours) basis.

2.0 UNIT OPERATIONS

Unit Operations consists of the costs of operating material and various support services in support of the primary system at the unit level. Unit Operations includes the unit-level consumption of operating materials (direct energy, expendable stores, and training munitions), support services, Temporary Duty travel, and second destination transportation in support of the unit. Unit Operations costs provided through a system support contract should be separately identified from those provided organically for each cost element.

[2] For example, Air Force aircraft O&S cost estimates for unit-level manpower usually include the costs of security police that deploy with the aircraft. In this instance, the security police provide "inside-the-fence" protection directly tied to the mission of the aircraft. In contrast, Army tank O&S cost estimates for unit-level manpower normally would not include any costs for the sustainment brigade military police. In this instance, the military police provide broad "outside-the-fence" support to the theater commander not necessarily tied to the mission of the tank.

2.1 Energy (Fuel, Petroleum, Oil and Electricity)

Costs of fuel, petroleum, oil, and fuel additives used by systems in performing their normal missions. For fuel purchased from the Defense Logistics Agency (DLA), these costs include a surcharge for DLA overhead and operating expenses (transportation, storage, and inventory management). These costs may also include the cost of field-generated electricity and commercial electricity necessary to support the operation of a system, when it can be severed from the general energy consumption for the location.

2.2 Training Munitions and Expendable Stores

Costs of the unit-level consumption of training munitions, rockets, missiles, and expendable stores in the course of normal peacetime training missions. Includes the cost of live and inert ammunition, bombs, rockets, missiles, sonobuoys, and pyrotechnics expended in training and non-combat firings such as firepower demonstrations or exercises. This category also includes other expendable stores (such as chaff, flares, fuel tanks, and travel pods) that lose their identity in use and may be dropped from stock record accounts when issued or used. In some cases, may also include the costs of the replacement of war reserve munitions and missiles that have reached their shelf life.

2.3 Support Services

Costs of unit-level support services. These services may vary greatly from one unit to another. They may include but are not limited to:

- FSRs who support non-maintenance activities (such as training, data collection, and IT support) that are not accounted for in cost element 1.3 (Other Unit-Level Manpower).
- Unreimbursed food services, rations, postal services (postage/box rental), or laundry services.
- Lease or rental of administrative, computational, or support equipment or software.
- Lease costs of special facilities or land (e.g., for the storage of warheads and missiles).
- Unit-funded service contracts for administrative, computational, or support equipment.
- Communications services (e.g., data/voice links, dedicated lines, microwave channels), port services, and other unit-funded utilities not part of base operating support costs.

2.4 Temporary Duty (TDY) Travel

Refers to a military service member's or Department of Defense civilian employee's travel or other assignment at a location other than the traveler's permanent duty station as authorized by the Joint Travel Regulations. This type of assignment is usually of relatively short duration,

typically from two days to 189 days in length. Temporary duty assignments usually come with per diem pay, covering lodging, meals, and incidental expenses.

2.5 Second Destination Transportation

Costs of transportation in support of the unit. Typically includes the transportation costs for moving equipment, personnel, and supplies to and from training areas, remote operating sites, or test ranges. Excludes any transportation costs included in overhead in other cost elements, such as the overhead in the depot maintenance cost element for the transportation of systems for depot maintenance overhauls.

3.0 MAINTENANCE

Maintenance consists of the costs of labor (outside of the scope of unit-level) and materials at all levels of maintenance in support of the primary system. Any maintenance costs provided through support contracts should be separately identified from those provided by government sources for each cost element where applicable.

3.1 Consumables

This element captures the costs for consumables used to operate and maintain the primary system at the unit level. Typically, consumables are considered throw-away items (having a 100% condemnation rate) and are replaced by new items. The term *consumables* refers to materials/parts consumed in the maintenance or support of the primary system; examples include temperature sensors, fans, oil filters, valves, switches, probes, coolants, deicing fluids, lubricants, gaskets, capacitors, and batteries. Consumables can be system unique or items that are bought in bulk for multiple systems. The cost for this element includes the costs of direct material for the items, as well as transportation, storage, warehousing, inventory management, and other overhead.

Additionally, the costs of all other unit-level consumables are included. Illustrative examples include computer supplies, paper, charts, maps, and administrative supplies used for housekeeping and health and safety.

3.2 Depot Level Reparables (DLRs)

A DLR is a reparable item/component that is repaired at the depot level of maintenance. DLR costs are incurred largely at the unit level. Typically, when a DLR item requires maintenance, the item is removed from the system and replaced with another item from inventory. This remove and replace action usually takes place at the unit level. When unit maintenance turns in a “failed” item/component, that organization is charged with an exchange price. This exchange price includes the cost of direct labor and material for item repairs along with transportation, storage, inventory management, and other overhead. If unit maintenance does not have a “failed” item/component to return to the supply system, that organization is

charged with a standard price. The standard price includes the new item/component purchase price along with attrition, transportation, storage, inventory management, and other overhead. The DLR element captures the costs of repair of depot level reparable items, as well as the replacement of condemned DLR items.

3.3 Intermediate Maintenance (External to Unit-Level)

Consists of the costs of labor, material, and any other costs expended at intermediate maintenance locations (such as Navy afloat or ashore Intermediate Maintenance Activities) in support of the primary system. This cost element excludes any manpower or material costs for intermediate maintenance that is considered unit-level, as described earlier. Includes the costs for consumables, government labor, contractor maintenance, and any other intermediate-level maintenance costs not otherwise accounted for.

3.4 Depot Maintenance

Depot maintenance is the cost of labor, material, and overhead incurred in performing major overhauls or other similar depot-level maintenance on a system or any of its major end items (e.g., aircraft engines) at centralized repair depots, contractor repair facilities, or onsite by depot teams.

Some overhaul activities occur at time intervals ranging from several months to several years. For primary systems (e.g., aircraft, tracked vehicles, ships), these costs should be included in the estimate for the years in which they are expected to occur, accompanied by documentation on the cost per event and the time interval between overhaul events.

Costs of major end items that have different overhaul cycles (i.e., structural subsystems such as hull, frame, or airframe; power subsystems such as engines or drive train; and electronic/mechanical subsystems such as fire control system, armaments, guidance, or command and control equipment) should be estimated and identified separately within this element. In some cases, the interval between end item overhauls may be expressed in terms of system operating hours (and not calendar time).

4.0 SUSTAINING SUPPORT

This category includes support activities provided by centrally managed organizations external to the units that own the operating systems. Sustaining support costs provided through a system support contract should be identified separately from those provided organically for each cost element. All efforts should be made to collect and report in accordance with this cost element structure for sustaining support. However, sustaining support cost elements may be combined as necessary if the costs cannot be made available at the level of detail called for in this guide.

4.1 System-Specific Training

The costs of system-specific specialty training of individuals in the system operating units or individuals who are replacing people in the system operating units due to attrition and normal rotation[3]. Training costs should include the costs of instructors, training support personnel, per diem and travel directly associated with the training, and any costs for trainees not accounted for elsewhere. For individuals already assigned to a system operating unit, any expenses for the travel of individuals from operational units to training assignment, and return, are included in the Temporary Duty Travel (element 2.3). The costs of maintenance or periodic refresh of the training equipment or devices is accounted for in element 4.7. The two cost elements below capture costs for training individuals prior to their first assignment in a system operating unit.

4.1.1 System-Specific Operator Training

The costs for training conducted in units designated as primary training sites for individuals to become proficient in specific system knowledge. This includes units such as Air Force wings assigned a primary mission of weapon-specific aircrew training, Navy air readiness training units, Navy Afloat Training Groups, and the Army Armor Center. These costs do not include skill training not related to a specific system, such as undergraduate aviation training.

4.1.2 System-Specific Maintenance Training

The costs of advanced system-specific training associated with maintenance functions in units designated as primary training facilities.

4.2 Support Equipment Replacement and Repair

The costs incurred to replace or repair unit-level support equipment associated with the primary system or its major subsystems[4]. The support equipment (e.g., tools and test sets) may be peculiar to the system or it may be common to a number of systems, in which case the costs must be allocated among the respective systems.

4.3 Sustaining/Systems Engineering

Costs reported in this element capture the government and contractor sustaining engineering to ensure the continuing viable operation of the system in the deployed environment. Most of the sustaining engineering effort during the sustainment phase will be a continuation of the earlier systems engineering effort that took place during the program Engineering and Manufacturing Development (EMD) phase and the production and deployment phase. Sustaining

[3] This element includes the costs of recurring training activities that occur during the operations and sustainment phase. However, the costs of initial training equipment and training course materials are regarded as investment costs, and not as an O&S cost.

[4] This includes replacement and repair of support equipment. However, the cost of initial support equipment procurement is an investment cost, not as an O&S cost.

engineering activities may be resident in the system program office organization, and/or they may be resident in external organizations. Examples of sustaining engineering activities include aircraft structural integrity monitoring or corrosion monitoring; planning and control of technical program efforts; continuing system requirements definition; safety and human systems integration engineering; obsolescence engineering; configuration management; and continuing specialty engineering, such as Reliability and Maintainability (R&M) Engineering. Specific modifications to hardware or software are included in element 5.0 (Continuing System Improvements). Sustaining engineering costs provided through a system support contract should be identified separately from costs associated with organic sources, if possible.

4.4 Program Management[5]

This element includes government and contractor costs for management activities associated with the administrative, business, and financial management of the program. Program management activities performed during the sustainment phase are, in most cases, a continuation of those performed during the EMD phase and the production and deployment phase. Program management activities may be resident in the system program office organization, and/or they may be resident in external organizations. Program management provided through a support contract should be identified separately from program management provided by organic sources, if possible.

4.5 Data and Technical Publications

The costs associated with maintaining and updating deliverable data and technical publications and manuals concerning the operation and support of the system[6].

4.6 Simulator Operations and Repair

Costs to operate and repair simulators and other training devices for the primary system or its major subsystems. This consists of the costs of labor, material, and overhead for simulator operations and repair. Also includes the cost of periodic replacement of simulator hardware and software.

4.7 Other Sustaining Support

Costs of any sustaining support not otherwise accounted for. This cost element may be used to identify expenses such as those listed below, if they apply to the system for which the estimate is being made:

- Test and evaluation[7] in support of deployed systems, such as range costs, test support, data reduction, and test reporting.

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[5] Cost elements 4.3 and 4.4 may be combined if these costs cannot be identified separately.

[6] This element addresses only data and publications maintenance. The cost of developing the data and publications is normally regarded as an investment cost, and not as an O&S cost.

- Air, sea, and land support not funded by the unit and provided by other activities to verify the proper operation of an electronic, communication, sensor, or other similar system.
- Communication services (e.g., data/voice links, dedicated lines, microwave channels), hardware, and software leases purchased on a DoD-wide or Service-wide basis for direct system-specific support of a system. Note that communications services purchased at the unit-level are contained in element 2.2 (Support Services).
- Centrally funded purchases for transportation of system materiel (end items and secondary items) not otherwise accounted for in the cost element structure.

It should be noted that costs for firing ranges or training ranges are not usually regarded as system costs and are not included in O&S cost estimates.

5.0 CONTINUING SYSTEM IMPROVEMENTS

This portion of the cost element structure includes the costs of hardware and software updates that occur after deployment of a system that improve a system's safety, reliability, or maintainability, or otherwise enable the system to meet its basic original operational requirements throughout its life.

It is intended that cost estimates for these improvements conform to the definitions provided in this guide. However, at the present time, the military department VAMOSC systems are not able to separate the costs for system improvements that include new operational capabilities from the costs for other system improvements. When using VAMOSC cost data in developing cost estimates, analysts must use additional data sources and strategies to remove the costs of system improvements that provide new operational capabilities.

These costs include government and contract labor, materials, and overhead costs. Costs should be separated into government and contractor costs within each cost element, if applicable.

5.1 Hardware Modifications

The cost of procurement, and installation of modification kits. May also include costs associated with the modifications for support equipment, training equipment, technical publications/data, and initial spares and repair parts (consistent with the approved modification content). This cost element only includes those modifications needed to achieve acceptable safety levels, overcome mission capability deficiencies, improve reliability, reduce maintenance costs, or maintain the system service life. It excludes modifications undertaken to provide additional operational capability not called for in the original system design or performance

[7] This is intended to record periodic testing of operational assets, structured to confirm that the system continues to retain its operational capabilities. This would not include testing to support development activities or testing integral to system hardware modifications or software maintenance.

specifications, or extend the system service life beyond what was originally planned. It also excludes retrofit modifications that update earlier fielded systems to the latest production configuration.

5.2 Software Maintenance

All cost and effort incurred to alter, sustain, and support the system software baseline. Includes software maintenance that changes the software baseline for adaptive, corrective, perfective, additive, and preventive maintenance. Includes efforts related to defect corrections, modifications, and patches applied to the software and software-specific support activities. Also includes costs for software licenses, hosting, and facilities. Excludes the costs of development of new requirements that are major enhancements or significant increases in capability.

Appendix A has an optional, more detailed cost element structure for software maintenance. This cost element structure includes correction of deficiencies, cybersecurity, independent verification and validation, program management, sustaining engineering, facilities, certification and accreditation, help desk support, hosting (in a traditional data center or in the cloud), and software licenses.

4. DIFFERENT METRICS OF O&S COSTS

4.1 Introduction

Various analyses, reports, and budget documents associated with system O&S costs use a wide variety of categorizations and metrics. A lack of standardization on these categorizations and metrics has resulted in confusion in their application. The remainder of this chapter is intended to clarify this situation.

4.2 O&S Cost Categorizations

A variety of O&S cost categorizations include or exclude different combinations of the O&S cost elements. These O&S cost elements, which are defined in Chapter 3, are shown again in Figure 4-1.

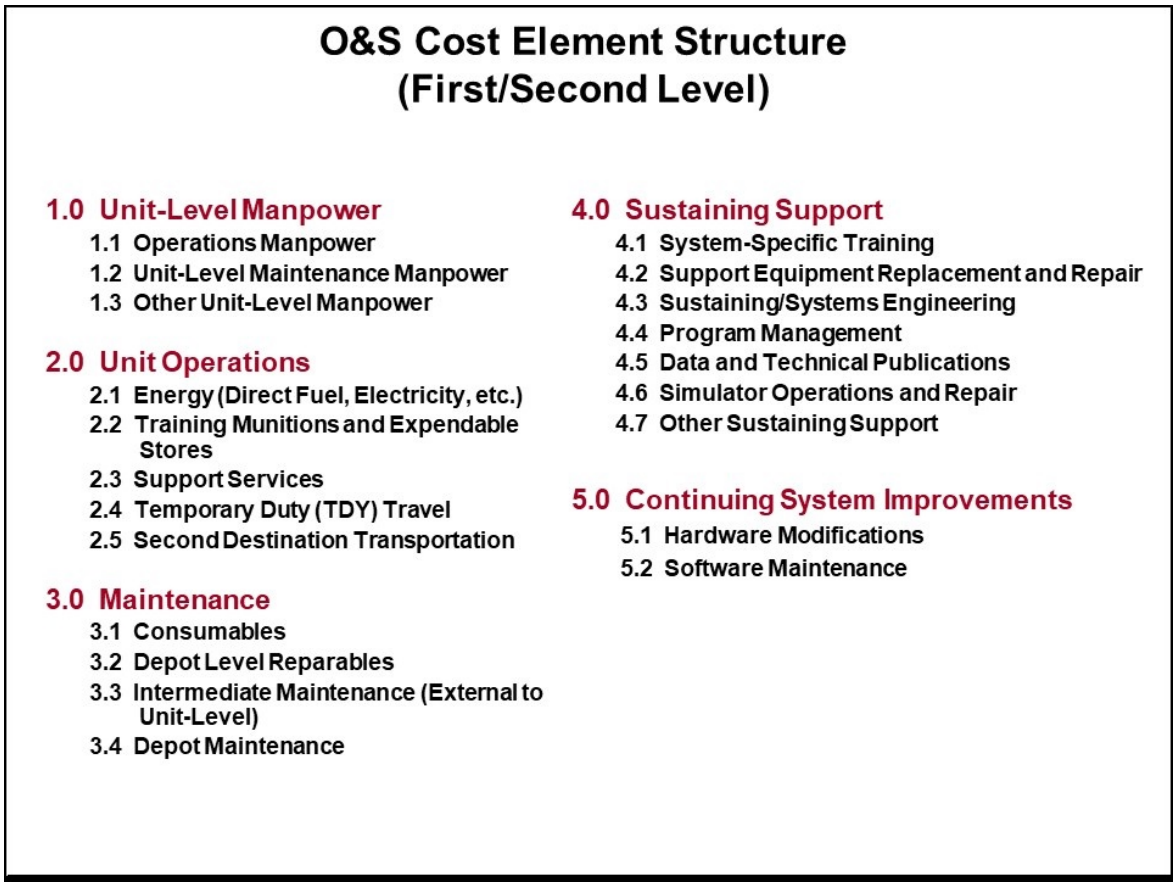

Figure 4-1. O&S Cost Elements

The remainder of this section provides standardized definitions for the O&S cost categorizations (i.e., groups of cost elements) commonly used. These categorizations have been developed for different purposes and provide different perspectives on those O&S costs relevant to each purpose. Table 4-1 shows the first three categorizations.

Table 4-1. Cost Element Composition of O&S Categorizations

Operating and Support	Parts Cost	OPTEMPO Programs
1.0 Unit-Level Manpower	1.0 Unit-Level Manpower	1.0 Unit-Level Manpower
1.1 Operations Manpower	1.1 Operations Manpower	1.1 Operations Manpower
1.2 Unit-Level Maint Manpower	1.2 Unit-Level Maint Manpower	1.2 Unit-Level Maint Manpower
1.3 Other Unit-Level Manpower	1.3 Other Unit-Level Manpower	1.3 Other Unit-Level Manpower
2.0 Unit Operations	2.0 Unit Operations	2.0 Unit Operations
2.1 Energy	2.1 Energy	2.1 Energy
2.2 Munitions & Stores	2.2 Munitions & Stores	2.2 Munitions & Stores
2.3 Support Services	2.3 Support Services	2.3 Support Services
2.4 Temporary Duty Travel	2.4 Temporary Duty Travel	2.4 Temporary Duty Travel
2.5 2nd Dest. Transportation	2.5 2nd Dest. Transportation	2.5 2nd Dest. Transportation
3.0 Maintenance	3.0 Maintenance	3.0 Maintenance
3.1 Consumables	3.1 Consumables	3.1 Consumables
3.2 Depot Level Reparables	3.2 Depot Level Reparables	3.2 Depot Level Reparables
3.3 Intermediate Maintenance	3.3 Intermediate Maintenance	3.3 Intermediate Maintenance
3.4 Depot Maintenance	3.4 Depot Maintenance	3.4 Depot Maintenance
4.0 Sustaining Support	4.0 Sustaining Support	4.0 Sustaining Support
4.1 System-Specific Training	4.1 System-Specific Training	4.1 System-Specific Training
4.2 SE Replacement and Repair	4.2 SE Replacement and Repair	4.2 SE Replacement and Repair
4.3 Sust./Systems Engineering	4.3 Sust./Systems Engineering	4.3 Sust./Systems Engineering
4.4 Program Management	4.4 Program Management	4.4 Program Management
4.5 Data and Technical Pubs	4.5 Data and Technical Pubs	4.5 Data and Technical Pubs
4.6 Simulator Ops and Repair	4.6 Simulator Ops and Repair	4.6 Simulator Ops and Repair
4.7 Other Sustaining Support	4.7 Other Sustaining Support	4.7 Other Sustaining Support
5.0 Continuing Improvements	5.0 Continuing Improvements	5.0 Continuing Improvements
5.1 Hardware Modifications	5.1 Hardware Modifications	5.1 Hardware Modifications
5.2 Software Maintenance	5.2 Software Maintenance	5.2 Software Maintenance

The first three categorizations are described below:

- **Operating and Support**. This categorization is used for most O&S cost estimates and reporting of O&S costs in program SARs.
- **Parts Cost**. This categorization simply captures the parts costs for consumable and reparable items. This is often expressed as a cost per unit of usage, where the unit of usage is flying hour, vehicle mile, or something similar.

- **OPTEMPO Programs**. This categorization appears in the budget documents that are used to justify the military service operating tempo (OPTEMPO) budgets. For example, the OP-20 budget exhibit is used for aircraft flying hours, the OP-25 is used for ground vehicle operations, and the OP-41 is used for ship operations. These exhibits are further described in Appendix E.

Table 4-2 shows the next three categorizations.

Table 4-2. Cost Element Composition of O&S Categorizations (cont.)

DoD Reimbursement Rates	Total Maintenance	Logistics Factors
1.0 Unit-Level Manpower	1.0 Unit-Level Manpower	1.0 Unit-Level Manpower
1.1 Operations Manpower	1.1 Operations Manpower	1.1 Operations Manpower
1.2 Unit-Level Maint Manpower	1.2 Unit-Level Maint Manpower	1.2 Unit-Level Maint Manpower
1.3 Other Unit-Level Manpower	1.3 Other Unit-Level Manpower	1.3 Other Unit-Level Manpower
2.0 Unit Operations	2.0 Unit Operations	2.0 Unit Operations
2.1 Energy	2.1 Energy	2.1 Energy
2.2 Munitions & Stores	2.2 Munitions & Stores	2.2 Munitions & Stores
2.3 Support Services	2.3 Support Services	2.3 Support Services
2.4 Temporary Duty Travel	2.4 Temporary Duty Travel	2.4 Temporary Duty Travel
2.5 2nd Dest. Transportation	2.5 2nd Dest. Transportation	2.5 2nd Dest. Transportation
3.0 Maintenance	3.0 Maintenance	3.0 Maintenance
3.1 Consumables	3.1 Consumables	3.1 Consumables
3.2 Depot Level Reparables	3.2 Depot Level Reparables	3.2 Depot Level Reparables
3.3 Intermediate Maintenance	3.3 Intermediate Maintenance	3.3 Intermediate Maintenance
3.4 Depot Maintenance	3.4 Depot Maintenance	3.4 Depot Maintenance
4.0 Sustaining Support	4.0 Sustaining Support	4.0 Sustaining Support
4.1 System-Specific Training	4.1 System-Specific Training	4.1 System-Specific Training
4.2 SE Replacement and Repair	4.2 SE Replacement and Repair	4.2 SE Replacement and Repair
4.3 Sust./Systems Engineering	4.3 Sust./Systems Engineering	4.3 Sust./Systems Engineering
4.4 Program Management	4.4 Program Management	4.4 Program Management
4.5 Data and Technical Pubs	4.5 Data and Technical Pubs	4.5 Data and Technical Pubs
4.6 Simulator Ops and Repair	4.6 Simulator Ops and Repair	4.6 Simulator Ops and Repair
4.7 Other Sustaining Support	4.7 Other Sustaining Support	4.7 Other Sustaining Support
5.0 Continuing Improvements	5.0 Continuing Improvements	5.0 Continuing Improvements
5.1 Hardware Modifications	5.1 Hardware Modifications	5.1 Hardware Modifications
5.2 Software Maintenance	5.2 Software Maintenance	5.2 Software Maintenance

These three categorizations are described below:

- **DoD Reimbursement Rates.** These costs are used to calculate reimbursement rates that are published each year in the annual DoD Fixed Wing and Helicopter

Reimbursement Rates. These forward-looking rates, expressed in terms of dollars per flight hour, are used to charge DoD customers that use the aircraft on a cost-reimbursable basis. The rates are slightly different for non-DoD customers. These rates are updated each year, and are posted on the OSD Comptroller website (https://comptroller.defense.gov/Financial-Management/Reports). These rates also include a portion of CLS that is regarded as variable with respect to flying hours. CLS is not an element in the O&S cost element structure, but is used in O&M appropriations. DoD 7000.14-R, *Financial Management Regulation*, Volume 11A, Chapter 6, Appendix E provides guidance on the reimbursement rates.

- **Total Maintenance**. This categorization is used by some organizations to help assess the efficiency of a system's maintenance activities from a broad perspective beyond element 3.0. This is often expressed as a cost per unit of usage.
- **Logistics Factors.** Some organizations use this particular categorization for analyses of resources and cost factors for certain weapon system logistics elements.

Table 4-3 shows the last two categorizations.

Table 4-3. Cost Element Composition of O&S Categorizations (cont.)

Direct Operating	Operational
1.0 Unit-Level Manpower	1.0 Unit-Level Manpower
1.1 Operations Manpower	1.1 Operations Manpower
1.2 Unit-Level Maint Manpower	1.2 Unit-Level Maint Manpower
1.3 Other Unit-Level Manpower	1.3 Other Unit-Level Manpower
2.0 Unit Operations	2.0 Unit Operations
2.1 Energy	2.1 Energy
2.2 Munitions & Stores	2.2 Munitions & Stores
2.3 Support Services	2.3 Support Services
2.4 Temporary Duty Travel	2.4 Temporary Duty Travel
2.5 2nd Dest. Transportation	2.5 2nd Dest. Transportation
3.0 Maintenance	3.0 Maintenance
3.1 Consumables	3.1 Consumables
3.2 Depot Level Reparables	3.2 Depot Level Reparables
3.3 Intermediate Maintenance	3.3 Intermediate Maintenance
3.4 Depot Maintenance	3.4 Depot Maintenance
4.0 Sustaining Support	4.0 Sustaining Support
4.1 System-Specific Training	4.1 System-Specific Training
4.2 SE Replacement and Repair	4.2 SE Replacement and Repair
4.3 Sust./Systems Engineering	4.3 Sust./Systems Engineering
4.4 Program Management	4.4 Program Management
4.5 Data and Technical Pubs	4.5 Data and Technical Pubs
4.6 Simulator Ops and Repair	4.6 Simulator Ops and Repair
4.7 Other Sustaining Support	4.7 Other Sustaining Support
5.0 Continuing Improvements	5.0 Continuing Improvements
5.1 Hardware Modifications	5.1 Hardware Modifications
5.2 Software Maintenance	5.2 Software Maintenance

These two categorizations are described below:

- **Direct Operating.** This element consists of all of the O&S cost elements except for energy, hardware modifications and software maintenance. Some organizations use this categorization to help assess the efficiency of a system's operations and maintenance activities (excluding energy). This is often expressed as a cost per unit of usage.
- **Operational.** Some organizations use this particular categorization for analyses of resources for weapon system operations.

Figures 4-2 and 4-3 summarize the various O&S cost categorizations.

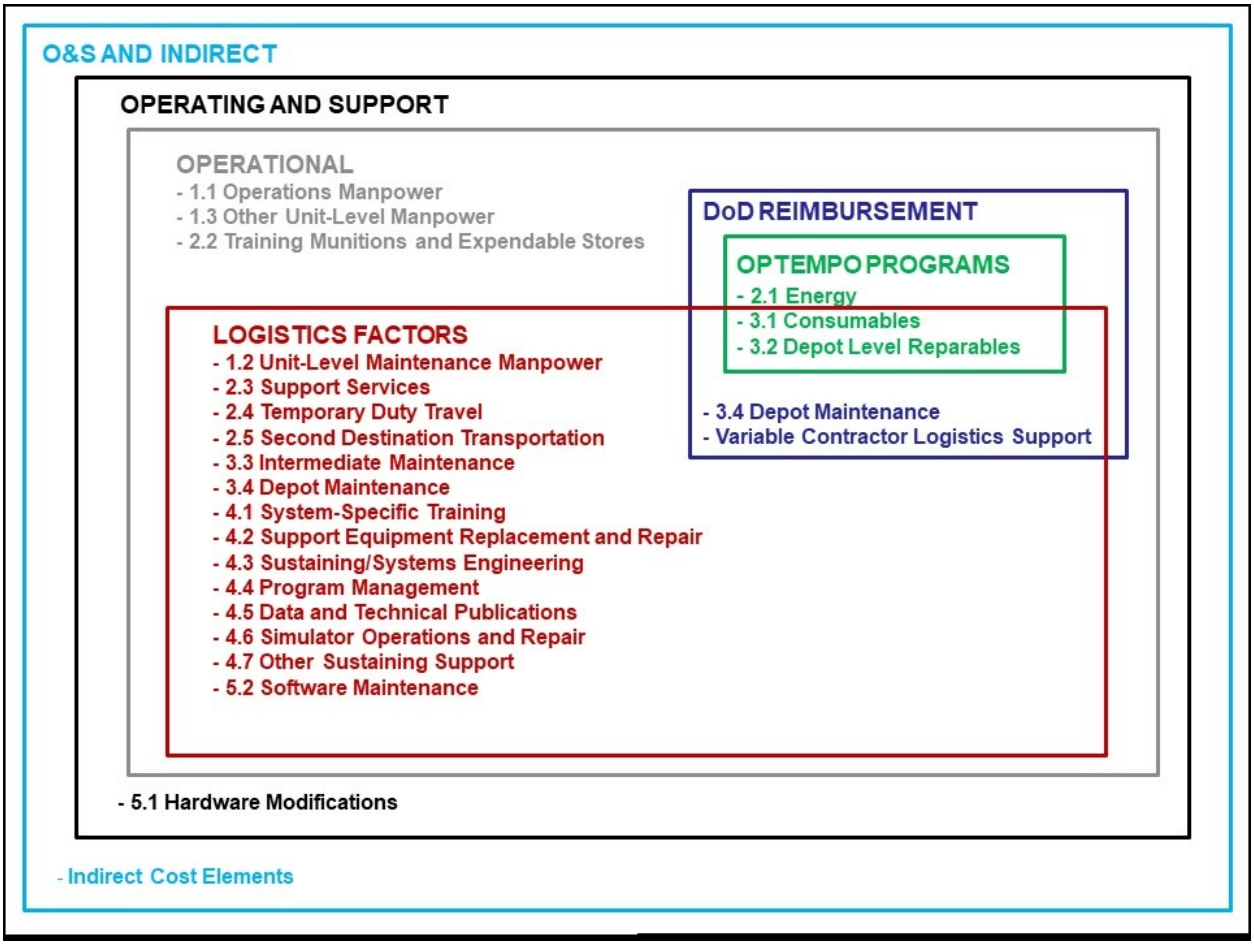

Figure 4-2. O&S Cost Categorizations

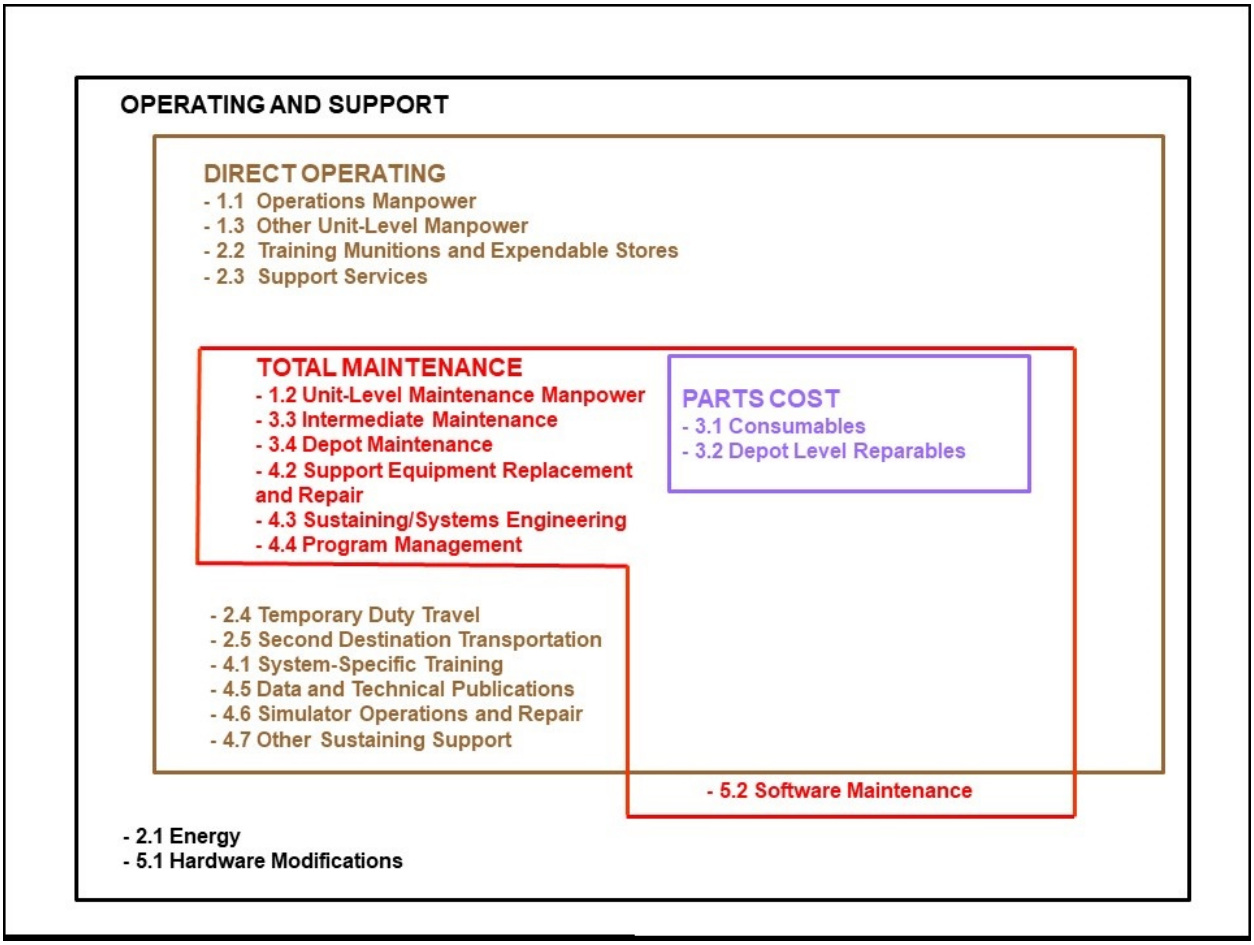

Figure 4-3. O&S Cost Categorizations (cont.)

4.3 O&S Cost Metrics

Measuring the magnitude of a system's O&S costs uses a wide variety of metrics. The most common metrics are usually some form of ratio. The numerator in the metric would be the cost categorization used. The denominator in the metric would be the unit of measure.

There are three types of metrics commonly used. The first type of metric is dollars per system per year, where a system is an aircraft, vessel, vehicle, or some other type of system. The second type of metric is dollars per unit of usage or OPTEMPO. Ship and submarine costs are not normally measured this way since "steaming hours" does not represent a consistent unit of measure across ship classes and these platforms have a high fixed cost that is largely insensitive to steaming hours. The third type of metric is dollars per typical or notional unit per year, where the unit is a squadron, platoon, or something equivalent.

One common use for these metrics is to compare the costs of a new system to its antecedent system or other systems. O&S cost metrics can be useful when comparing different systems, but such comparisons have to be made and conveyed carefully. When comparisons are

made without due diligence, confusion occurs and erroneous conclusions can be reached. This section provides some examples where such problems have commonly happened.

As one example, senior leaders may ask for data on cost per unit of usage, something like cost per flight hour for a group of similar systems. However, the leaders typically do not specify the categorization or content that should be used for the cost (numerator) in the metric. A term such as cost per flying hour means something different to different people. Some people in one part of the leader's organization might respond with a reimbursement rate, and other people in another part of the organization might respond with the complete O&S cost.

Figures 4-4 and 4-5 show an example of how the use of different categorizations produce very different results for cost per system per year, and cost per flying hour, for an aircraft.

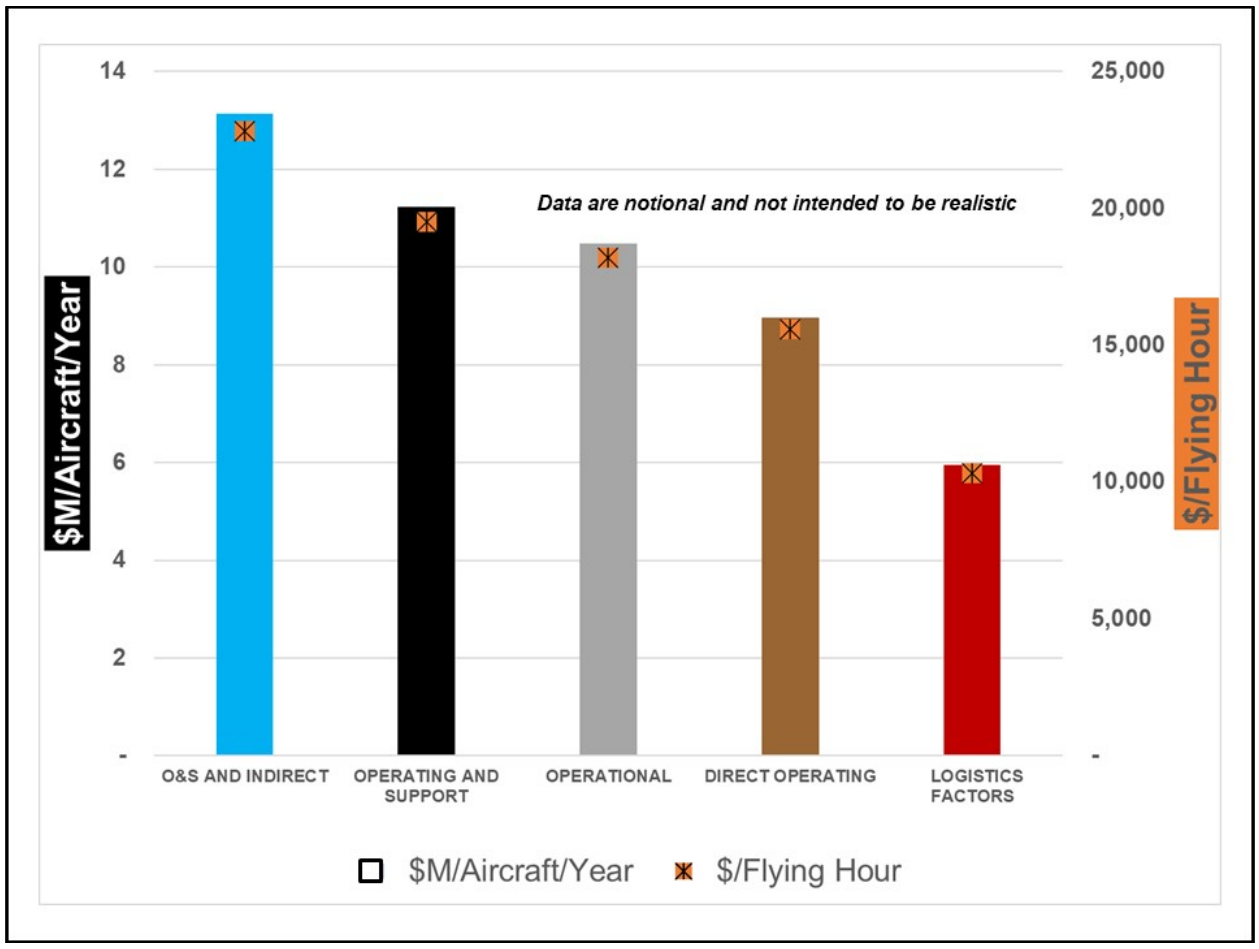

Figure 4-4. Examples of Aircraft O&S Cost Metrics

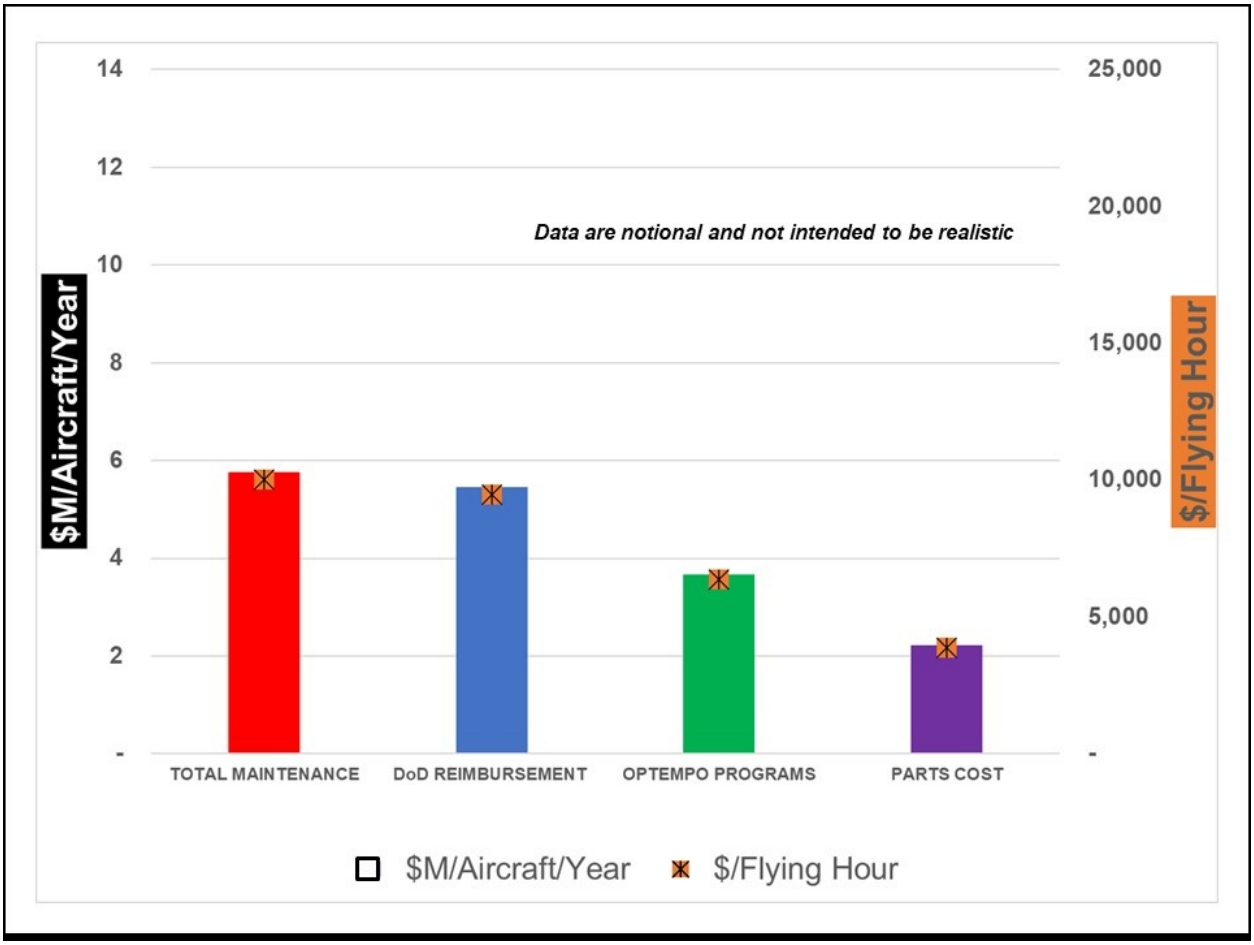

Figure 4-5. Examples of Aircraft O&S Cost Metrics (cont.)

Note that the values for cost per aircraft per year are displayed using the vertical axis on the left, and the values for cost per flying hour are displayed using the vertical axis on the right.

Other issues can arise with O&S cost metrics even when the same categorization is used. Even in such cases, the cost per unit of usage for different systems is usually not comparable when the systems have different usage or OPTEMPO rates. Not all of the CAPE O&S cost elements would vary with changes in usage, and therefore would remain fixed. The cost elements in the OPTEMPO Programs categorization (fuel, consumables, and DLRs) and the costs for training munitions and expendable stores are those most likely to vary with changes to system usage on a total cost basis, but remain constant on a cost per unit of usage basis. Some cost elements such as unit-level manpower, depot maintenance, and hardware modifications do not vary with usage, but do vary with changes in system quantity. And other costs, much of the sustaining support and software maintenance, for the most part do not vary with changes in usage or system quantity.

Figure 4-6 shows the effect of changes to system usage on some O&S cost metrics for an aircraft system.

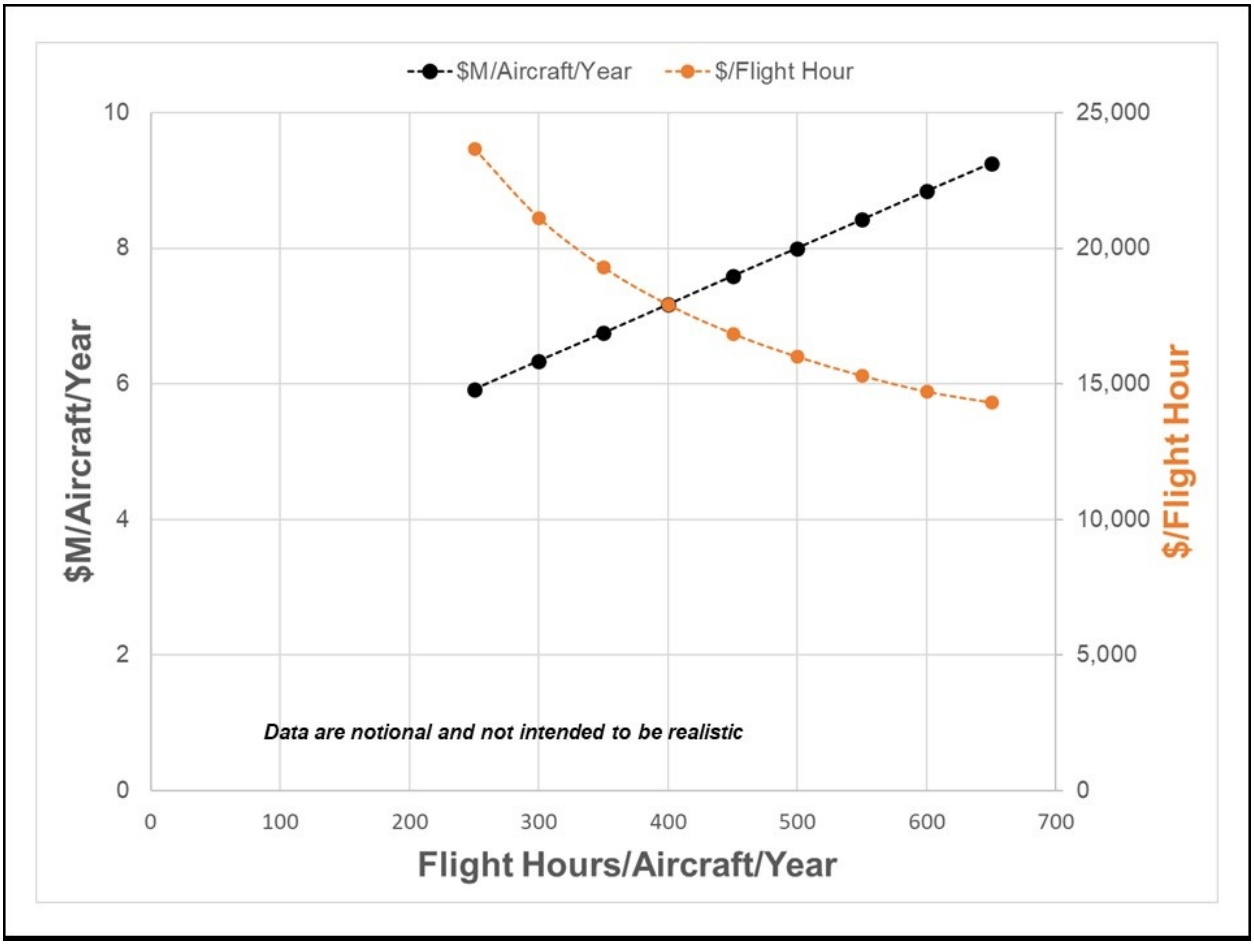

Figure 4-6. Effect of System Usage on O&S Cost Metrics

In this example, there are two O&S cost metrics. The first is $ million/aircraft/year, and the second is $/flight hour. The two metrics are displayed for increasing levels of system usage, ranging from 250 to 650 flight hours/aircraft/year. The $ million/aircraft values are displayed using the vertical axis on the left, and the $/flight hour values are displayed using the vertical axis on the right. The key point here is that the values of the $/flight hour metric decrease with increases in flying hours. This is because the fixed O&S cost elements are being divided over a larger base. Cost per unit of usage and cost per system per year can be useful, but have limitations. It is best to use an array of metrics along with total costs when conveying the comparative costs of systems.

The key point is that when making comparisons between systems with different usage rates, and comparing those on a cost per unit of usage, normalizing for usage should be considered when the systems are similar and have similar missions. Figure 4-7 shows an example of a normalization technique.

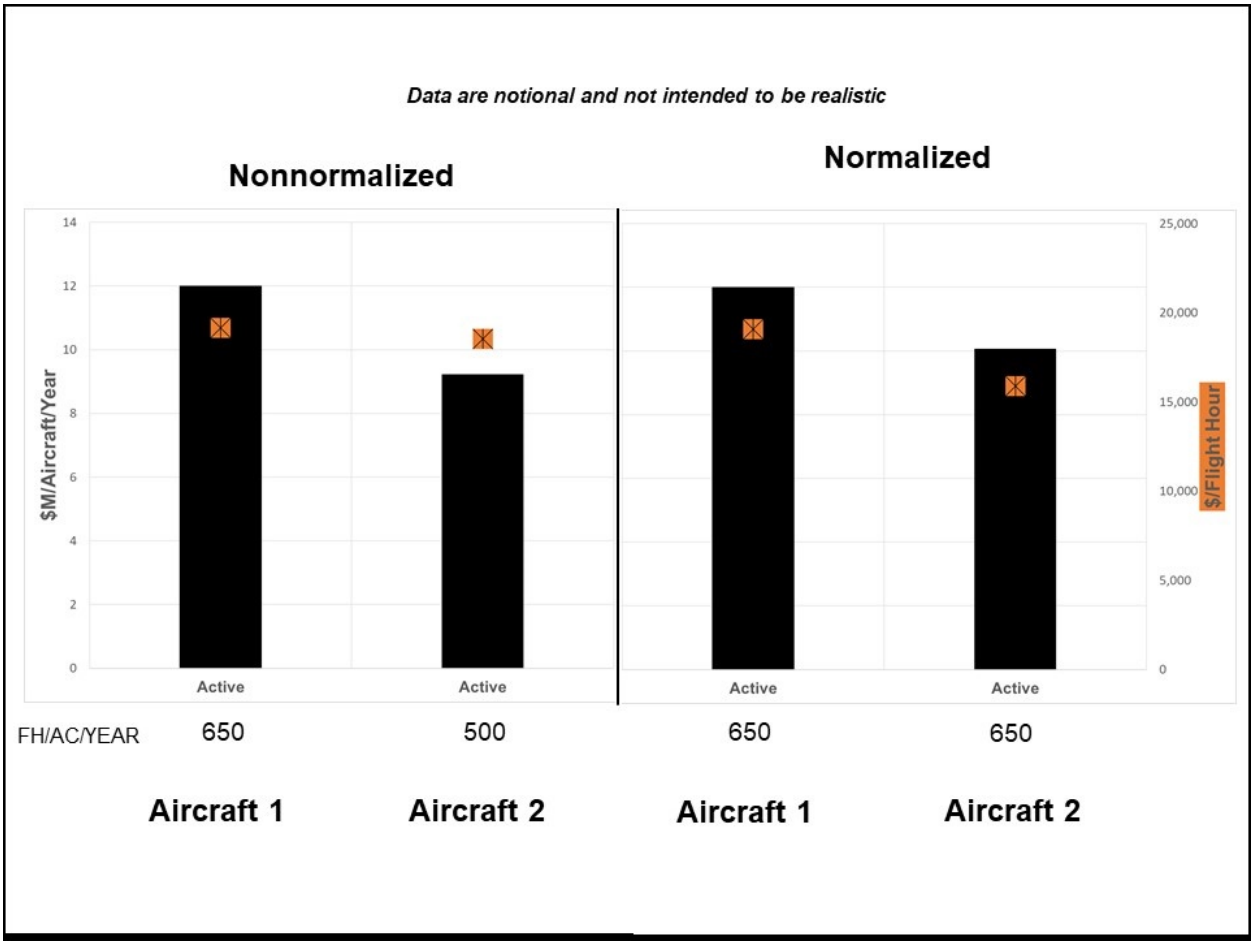

Figure 4-7. Example of Normalization of $/Flight Hour Metric

In this example, a comparison of O&S costs is being made between two aircraft with different usage (flying hour) rates. As before, $ million/aircraft/year is displayed using the vertical axis on the left, and the $/flight hour is displayed using the vertical axis on the right. Without normalization, the $/flight hour metric is seriously distorted and misleading. In this example, without normalization, the $ million/aircraft for Aircraft 2 is roughly 25 percent less than for Aircraft 1, and yet the $/flying hour for Aircraft 2 is only 3 percent less than for Aircraft 1.

With normalization of usage rate, it is possible to make more meaningful comparisons between Aircraft 1 and Aircraft 2. In this example, the normalization is made by recalculating the $/flight hour for the Aircraft 2 active duty using the same flying hour rate as the Aircraft 1 active duty aircraft. This was done by assuming that four cost elements (fuel, training munitions, consumables, and DLRs) vary with changes in flying hours on a total cost basis, but remain constant on a dollar per flight hour basis. It was also assumed that the other cost elements do not vary with changes in flying hours. This allows a more accurate comparison of the relative costs between Aircraft 1 and Aircraft 2. With normalization, both the $ million/aircraft and the $/flying hour for Aircraft 2 are roughly 15 percent less than for Aircraft 1.

More generally, O&S cost metrics can easily be misapplied and muddled, leading to erroneous comparisons and conclusions. There are two reasons for such confusion. First, any O&S cost metric is based on a given categorization. Second, it also depends on many different ground rules and assumptions. The confusion arises when the categorizations and ground rules are not clearly identified. Figure 4-8 provides an example of a $K/flight hour metric for an aircraft system.

How O&S Cost Metrics Get Muddled

Different O&S Cost Categorizations	Applications
DoD Reimbursement	Rates charged to customers on a cost-reimbursable basis
Operational	Service-specific analyses and reporting
Operating and Support	Estimates in acquisition process; SARs; JCIDS
O&S And Indirect	Broad force structure studies

Different Assumptions
Actual costs or estimates
Year dollars, then-year or constant
Timeframe: Current year, phase-in, steady state, phase-out
O&S cost categorization or content
Usage rate or operating tempo

Data are notional and not intended to be realistic

Aircraft $K/FH	24.0	68.6	58.7	35.4	42.6	39.9
Source	Reimbursement Rates	VAMOSC actuals	Extrapolation of actuals	Military department	CAPE ICE	Military department
Year Dollars	Then-Year	Then-Year	FY 2018	FY 2018	FY 2012	FY 2012
Timeframe	FY 2020	FY 2018	FY 2025	FY 2025	Steady state	Steady state
Categorization	Reimbursement	Operational	Operational	Operational	Operating and Support	O&S And Indirect
Usage (FH/AC/Year)	Not specified	194	250	250	250	250
Purpose	Billable rate for non-DoD organizations	Benchmark	Projection	"Stretch" Goal	Defense acquisition process; SAR	Business case analysis

Figure 4-8. Example of Various $/Flight Hour Metrics

In this example, there are six versions of the $K/flight hour metric, each with a significantly different numerical value. The differences arise due to dissimilar data sources, year dollars, timeframe of the metric, categorizations, and assumed usage or OPTEMPO.

The use of consistent, well-defined metrics normalized for major usage differences is important in communicating comparisons across weapon systems with senior leaders. It is a best practice in presenting these metrics to provide an accompanying description of the metric and normalization used to develop the comparison. Analysts should select the appropriate metric and

make normalization when necessary to ensure large usage or quantity differences do not mislead the audience.

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5. ROLE OF O&S COSTS

5.1 Acquisition Milestone and Other Reviews

For Major Defense Acquisition Programs (MDAPs)—which are one type of Major Capability Acquisition programs—life-cycle cost estimates are required to be presented to the Milestone Decision Authority (MDA) in advance of milestone reviews, and O&S costs are an important element in these estimates. Normally, in fact, there are two estimates that are prepared for these reviews. One estimate is the Component Cost Position (CCP), and the other estimate is an Independent Cost Estimate (ICE) prepared by either CAPE or the responsible Service cost agency or Defense Agency equivalent. When the preparation of the ICE is delegated by CAPE to the Component, CAPE reviews and approves the ICE. In cases where the ICE is delegated, the ICE may be incorporated into the CCP. For other acquisition programs below MDAP[8] dollar thresholds, cost estimates are prepared in accordance with guidance issued by each Service cost agency or Defense Agency equivalent.

Life-cycle cost estimates are also required for Middle Tier of Acquisition (MTA) programs. The MTA process provides two possible acquisition pathways: (1) rapid prototyping (prototypes with innovative technologies), and (2) rapid fielding (new or upgraded systems with minimal development). For the rapid prototyping programs likely to exceed MDAP dollar thresholds, CAPE will prepare an estimate of life-cycle costs for the program, or choose to delegate the authority for the conduct of the cost estimate to the Service cost agency or Defense Agency equivalent. For the rapid prototyping programs below the MDAP dollar thresholds, cost estimates will be prepared in accordance with guidance issued by the responsible Service cost agency or Defense Agency equivalent. For the rapid fielding programs likely to exceed MDAP or major system[9] dollar thresholds, CAPE will prepare an estimate of life-cycle costs for the program, or choose to delegate the authority for the conduct of the cost estimate to the Service cost agency or Defense Agency equivalent. For the rapid fielding programs below the major system dollar thresholds, estimates will be prepared in accordance with guidance issued by the responsible Service cost agency or Defense Agency equivalent.

Further details on CAPE policy and guidance for cost estimates for MDAPs and MTA programs are provided in DoD Instruction (DoDI) 5000.73, *Cost Analysis Guidance and Procedures*.

[8] An MDAP is a program with expenditures expected to exceed $525 million (FY 2020 constant dollars) for research, development, test and evaluation, or $3.065 billion (FY 2020 constant dollars) for procurement.
[9] A major system is a program with expenditures expected to exceed $200 million (FY 2020 constant dollars) for research, development, test and evaluation, or $920 million (FY 2020 constant dollars) for procurement.

5.2 Sustainment Reviews

Recent legislation now requires that each military department shall conduct a sustainment review of each major weapon system not later than five years after declaration of initial operational capability (IOC) and throughout its life cycle. Each sustainment review is required to include an ICE for the remainder of the life cycle of the program. Appendix E provides further information on sustainment reviews.

5.3 Other Roles of O&S Cost Estimates and Analyses

Over the years, the Congress has established extensive and demanding statutory requirements pertaining to O&S cost estimation, as well as sustainment or product support management, for major DoD weapon systems. There is also extensive regulatory guidance concerning the current DoD implementation of these statutory requirements, as well as other O&S and sustainment policy and procedures. The statutory and regulatory guidance associated with O&S cost analyses, sustainment considerations in system acquisition, and development of a product support strategy for major weapon systems is provided in Appendix H of this guide.

In particular, O&S cost analyses are to be used to influence system design with an emphasis on sustainment considerations. For all MDAPs, objectives and thresholds for reliability, availability, and maintainability are to be established as requirements to support system development. These requirements are to be established by trade studies that balance sustainment considerations with acquisition cost and what is achievable based on available technologies. O&S cost analyses also are to support design decisions to ensure that sustainment factors are fully considered at key life-cycle management decision points and that appropriate measures are taken to reduce O&S costs by influencing system design early in development, developing sound sustainment strategies, and addressing key drivers of costs.

Appendix H provides additional discussion about the role of O&S costs in the Joint Capabilities Integration and Development System (JCIDS).

Distinct from the ICE and CCP, program managers are required to develop a “should cost” estimate that is used as a management tool to control and reduce cost. “Should cost” management is intended to proactively target cost reduction and drive productivity improvements into programs. The “should cost” estimate challenges managers to identify and achieve savings below budgeted most-likely costs. For system sustainment, “should cost” targets will be established and reviewed annually based on an analysis of acquisition logistics costs and O&S cost elements. Guidance on “should cost” management is provided in DoDI 5000.85, *Major Capability Acquisition*.

5.4 Selected Acquisition Report

Estimates of O&S costs are updated each year for inclusion in the annual program Selected Acquisition Report (SAR). The SAR includes a comparison between the program and an

antecedent system (if applicable). This comparison is shown using a unitized cost metric. The most common unitized cost metric is $/system/year. Other unitized cost metrics are $/unit of usage and $/typical unit/year. In addition, the SAR provides a comparison between the current O&S cost estimate and the SAR baseline objective and threshold values for total O&S costs. The SAR O&S reporting also includes a cost variance that identifies each change, and the reason for it, between the current estimate and the prior estimate. Information on SAR reporting can be found in the *Annual Selected Acquisition Report Guidance*. This guidance states that the O&S costs reported in the SAR should conform to the cost element structure provided in this guide.

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6. SOURCES OF O&S COST DATA

This chapter describes some sources of O&S cost data that are commonly used in cost estimates.

6.1 VAMOSC Program

6.1.1 Background

Each military department has its own unique VAMOSC data system that tracks actual O&S costs for major weapon systems. The systems display time-phased data, at various levels of detail, by functional cost element (such as depot maintenance, fuel, consumables, and so forth). Each VAMOSC system provides not only cost data, but related non-cost data (such as system quantities and OPTEMPO) as well. VAMOSC users can analyze trends in O&S costs for each major system, and identify and assess major cost drivers. Each military department manages its own VAMOSC data system as follows:

- The Air Force VAMOSC system is known as the Air Force Total Ownership Cost (AFTOC) system. AFTOC provides O&S cost data for all manned and unmanned aircraft; aircraft engines; missiles; munitions; command, control, and communication systems; space systems; and other miscellaneous systems and programs. It also provides supplementary data such as aircraft quantities and flying hours, fuel consumption, numbers of personnel by skill/function, and other non-cost information. AFTOC is managed by the Deputy Assistant Secretary of the Air Force for Cost and Economics. See https://aftoc.hill.af.mil for additional information.
- The Army VAMOSC system is known as the Operating and Support Management and Information System (OSMIS). OSMIS provides O&S cost data for aviation, tracked and wheeled combat vehicles, artillery systems, engineering and construction equipment, communication and electronic systems, and other tactical systems and equipment. It also provides supplementary data such as system quantities; vehicle miles; aircraft flying hours; consumption for repair parts, fuel, and ammunition; and man-hours for intermediate and depot maintenance. OSMIS is managed by the Deputy Assistant Secretary of the Army for Cost and Economics. See https://www.osmisweb.army.mil for additional information.
- The Department of the Navy system is known as Naval VAMOSC and includes both Navy and Marine Corps platforms and systems. Naval VAMOSC provides O&S cost data for ships and shipboard systems, Navy and Marine Corps aircraft, weapons (missiles and torpedoes), military and civilian personnel, facilities, and Marine Corps

ground systems. Naval VAMOSC also provides key non-cost data such as personnel counts for ship crews and aircraft Type Model Series, system quantities, flying hours/ship steaming days, fuel consumption, and maintenance hours/days. Naval VAMOSC is managed by the Naval Center for Cost Analysis. See https://www.vamosc.navy.mil for more information.

The military departments provide training and documentation to their VAMOSC users. The training material consists of on-site presentations and online videos. The documentation consists of extensive user guides and manuals.

6.1.2 CAPE Policy Guidance

DoDI 5000.73, *Cost Analysis Guidance and Procedures,* provides the policy guidance for the military department VAMOSC systems. This guidance requires each military department to collect and manage actual O&S cost data for its fielded major systems. Each military department is responsible for the design, maintenance, administration, and quality control of its O&S cost data system and will make its VAMOSC data readily available to its registered users—DoD government personnel and contractor personnel when endorsed by an appropriate government sponsor—through online access. CAPE promotes standardization of O&S cost data collection, provides a forum for the exchange of ideas and research, and encourages the effective use of VAMOSC data in O&S cost estimates. The Deputy Director for Cost Assessment convenes and conducts annual reviews of the military departments' VAMOSC programs.

The VAMOSC systems should also use a documented and well-defined taxonomy or cost element structure. Cost element structures categorize and define specific cost elements that in total constitute the full range of potential O&S costs for any defense system. To the greatest extent feasible, the VAMOSC systems should support the CAPE cost element structure provided in Chapter 3 of this guide.

6.1.3 EVAMOSC

Recent significant legislation pertaining to weapon system O&S costs and associated O&S cost data systems created new VAMOSC requirements. Section 836 (Codification of Requirements Pertaining to Assessment, Management, and Control of Operating and Support Costs for Major Weapon Systems) of the National Defense Authorization Act (NDAA) for FY 2018 established that the DCAPE shall be responsible for developing and maintaining a database on (1) operating and support cost estimates, (2) supporting documentation, and (3) actual operating and support costs for major weapon systems. In addition, Section 832 (Implementation of Recommendations of the Independent Study on Consideration of Sustainment in Weapon Systems Life Cycle) of the NDAA for FY 2019 requires the Secretary of Defense to commence implementation of each recommendation of an independent assessment conducted by the MITRE Corporation (of the extent to which sustainment matters are considered in decisions related to requirements, acquisition, cost estimating, programming and budgeting,

and research and development for MDAPs). The MITRE recommendations pertaining to O&S cost data systems are for DoD to:

- Develop a common data repository for all sustainment-related data.
- Create and implement common data definitions, structure, and business rules for sustainment cost data.
- Provide a consistent, predictable funding stream for O&S cost databases, prioritizing department-wide accessibility.
- Develop a common data structure, taxonomy, and data dictionary for all three VAMOSC systems.
- Establish a common logon procedure for the VAMOSC systems and the Cost Assessment Data Enterprise (CADE[1]) data system.

As a result, CAPE has a statutory mandate to develop a comprehensive enterprise-wide O&S cost data system. The implementing solution is known as the Enterprise VAMOSC (EVAMOSC) system. This requirement presents an opportunity to address gaps in coverage from the current VAMOSC systems and serve a wider user community. CAPE formed a VAMOSC Data Working Group with the military departments. The vision is to collaboratively develop and implement a common taxonomy, data definitions, and business rules as collaboratively defined by the DoD cost community and codified in policy. To date, pilot programs have been used to establish and demonstrate preliminary concepts for the data structures and definitions that will establish data standardization across DoD. In the future, CAPE will award a contract for database design, implementation, and data platform services. This platform will incorporate modern data fusion and analytics technologies for ingesting, aggregating, standardizing, visualizing, reporting, and securing a large amount of data from an array of systems, including the current military department VAMOSC systems. Development of the EVAMOSC platform will occur incrementally between 2020 and 2025.

As an interim measure, CAPE is developing a Consolidated VAMOSC Tool (CVT) that allows each military department's VAMOSC data to be retrieved and analyzed in a common framework using a common tool. The first version of this tool was made available in August 2019, and is applicable to Navy ships and aircraft, Air Force aircraft, and all Army weapon systems. The tool can convert military department VAMOSC cost and programmatic data into the standard OSD CAPE structure. It can also calculate commonly used cost metrics and display the data graphically.

6.2 Cost Reporting for Sustainment Contracts

6.2.1 Background

[1] Information on CADE can be found at the CADE public website at https://cade.osd.mil.

Section 832 (Assessment, Management and Control of Operating and Support Costs for Major Weapon Systems) of the NDAA for FY 2012 directed that DoD will establish standard requirements for the collection and reporting of data on O&S costs in an appropriate format for major weapon systems by contractors performing weapon system sustainment functions, and develop contract clauses to ensure that contractors comply with such requirements. In response, CAPE has implemented the initiatives described in the remainder of this chapter. The details of the CAPE implementation guidance are provided in DoDI 5000.73.

6.2.2 CSDR for Sustainment

In 2012, CAPE extended Cost and Software Data Reporting (CSDR) data collection to apply to most major weapon system sustainment contracts and subcontracts above specified dollar thresholds. This reporting is important because the military department VAMOSC systems provide limited visibility into actual costs when a weapon system is sustained through a CLS contract or a similar arrangement. The VAMOSC systems may in some cases collect and display CLS costs in aggregate, but without providing any details by cost element, such as depot maintenance or sustaining engineering. Since then, CAPE has continued to improve the collection and reporting of contractor actual costs for major sustainment, logistics, and maintenance contracts.

Most recently, cost data reporting for sustainment contracts has been modernized by an initiative known as FlexFiles. In Flexfile reporting, monthly time-phased data (dollars and hours) are submitted directly from contractor's accounting systems at a low-level of detail (i.e., account, work package, or charge code) that is below the WBS level of detail. The data are submitted using the contractor native functional categories for direct costs and overhead. Flexfile reporting provides continuity with the prior reporting by requiring tags (based on a contractor allocation) to the standard government WBS and functional categories. Additional information on the FlexFiles initiative is available on the CADE public website at https://cade.osd.mil/policy/flexfile.

Figure 6-1 shows the structure of the Flexfile report for sustainment.

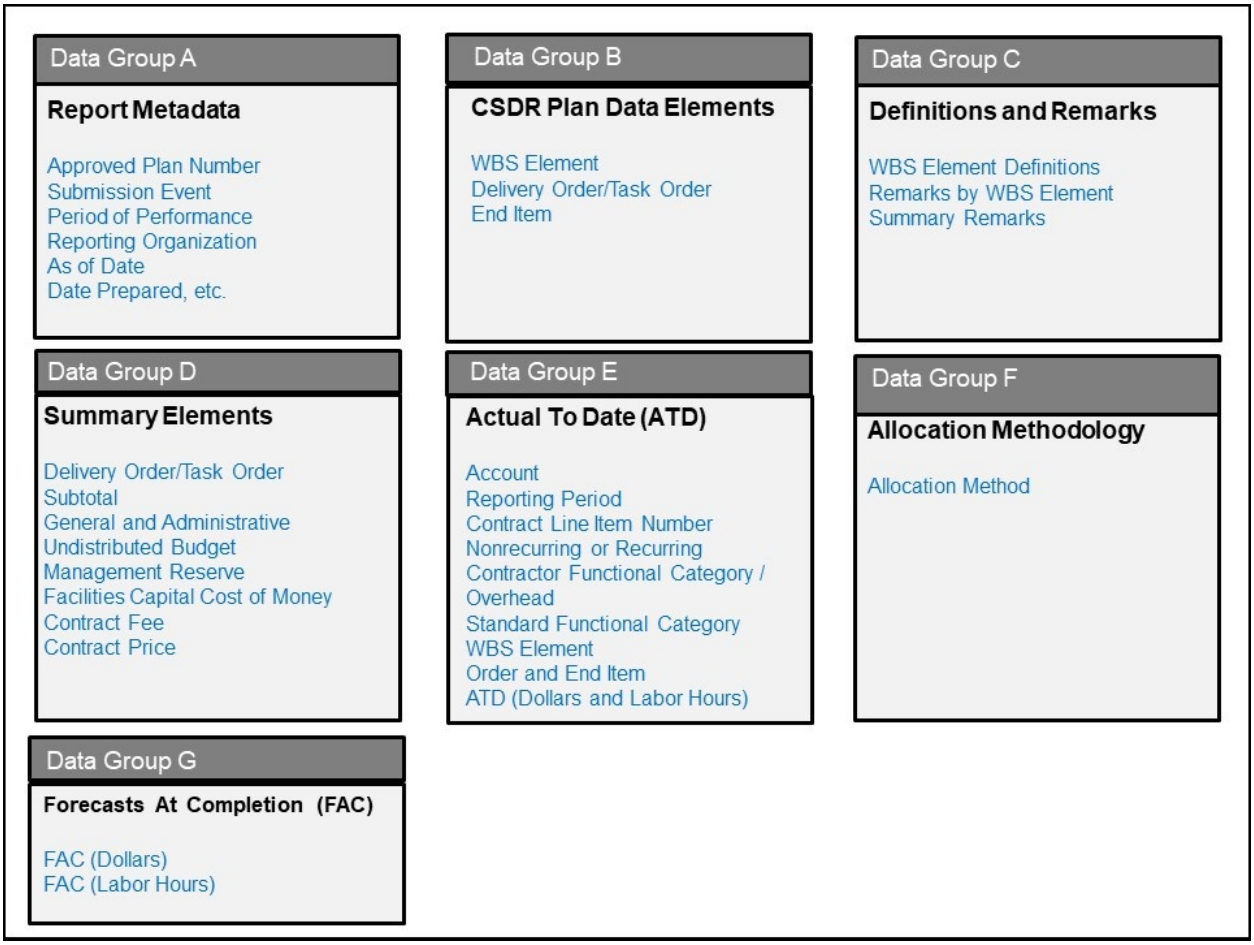

Figure 6-1. Flexfile Report for Sustainment Data Elements

CAPE and the Service cost agencies have developed templates for CSDR plans for each weapon system commodity type (such as aircraft, electronic system, or missile). These templates are known as standard plans. There is also a standard plan for the Cost Data Summary Report for sustainment. The standard plans are available on the CADE public website at https://cade.osd.mil/policy/csdr-plan. The sustainment standard plan provides the WBS that is used in sustainment cost reporting. Figure 6-2 provides an extract of the standard plan WBS for maintenance (O&S cost element 3.0).

11. WORK BREAKDOWN STRUCTURE (WBS)		
a. WBS CODE	b. WBS LEVEL	c. WBS ELEMENT NAME
1.3	2	Maintenance
1.3.1	3	Consumables and Repair Parts
1.3.1.1	4	Airframe/Hull/Vehicle Consumables and Repair Parts
1.3.1.2	4	Propulsion Consumables and Repair Parts
1.3.1.3	4	Electronics/Avionics Consumables and Repair Parts
1.3.1.4	4	Other Major Subsystem Consumables and Repair Parts 1..n (Specify)
1.3.1.5	4	Other Consumables and Repair Parts
1.3.2	3	Depot Level Reparables (DLRs) / Repair of Reparables (RORs)
1.3.2.1	4	Airframe/Hull/Vehicle DLRs
1.3.2.2	4	Propulsion DLRs
1.3.2.3	4	Electronics/Avionics DLRs
1.3.2.4	4	Other Major Subsystems DLRs 1..n (Specify)
1.3.2.5	4	Other DLRs
1.3.3	3	Intermediate Maintenance
1.3.3.1	4	Intermediate Maintenance Consumable Materials and Repair Parts
1.3.3.2	4	Intermediate-Level Government Maintenance
1.3.3.3	4	Intermediate-Level Contractor Maintenance
1.3.3.4	4	Other Intermediate-Level Maintenance
1.3.4	3	Depot Maintenance
1.3.4.1	4	Scheduled Overhaul
1.3.4.1.1	5	Airframe/Hull/Vehicle Scheduled Overhaul
1.3.4.1.2	5	Propulsion Scheduled Overhaul
1.3.4.1.3	5	Electronics/Avionics Scheduled Overhaul
1.3.4.1.4	5	Other Major Subsystems Scheduled Overhaul 1..n (Specify)
1.3.4.1.5	5	Other Scheduled Overhaul
1.3.4.2	4	Unscheduled Overhaul
1.3.4.2.1	5	Airframe/Hull/Vehicle Unscheduled Overhaul
1.3.4.2.2	5	Propulsion Unscheduled Overhaul
1.3.4.2.3	5	Electronics/Avionics Unscheduled Overhaul
1.3.4.2.4	5	Other Major Subsystems Unscheduled Overhaul 1..n (Specify)
1.3.4.2.5	5	Other Unscheduled Unscheduled Overhaul

Figure 6-2. CSDR Sustainment WBS for Maintenance

The entire CSDR contractor WBS for sustainment for all of the O&S cost elements is provided in the standard plan for sustainment. This WBS is consistent with the O&S cost element structure provided in Chapter 3 of this guide, but provides considerably more detail.

The Flexfile report also stratifies the data by standard functional categories for direct labor, material, and overhead. Using pivot tables, the analyst can structure the data where the WBS elements can be displayed as rows in a matrix, and the functional categories can be displayed as columns. Figure 6-3 provides the standard functional categories for sustainment.

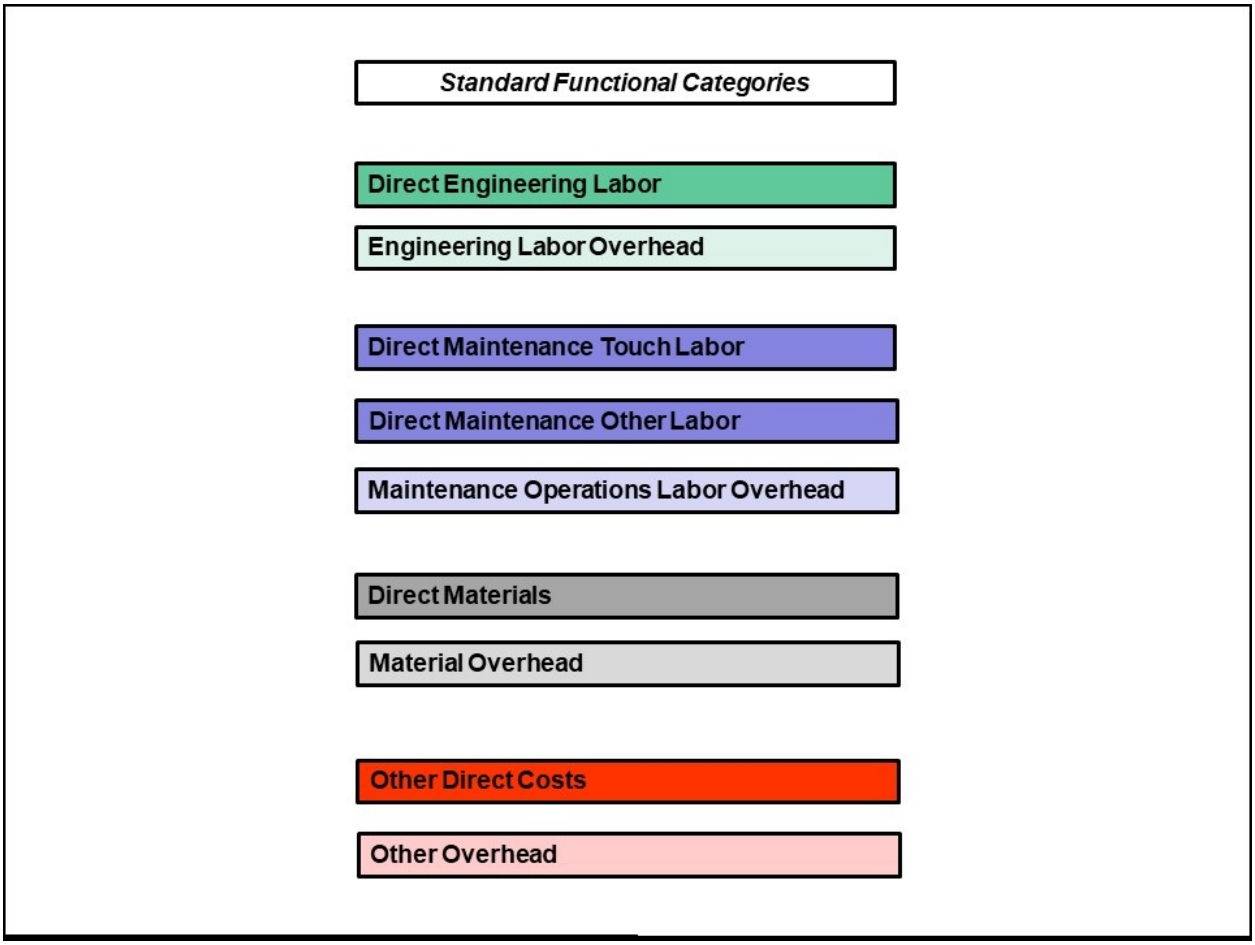

Figure 6-3. CSDR Standard Functional Categories for Sustainment

CSDR reporting for sustainment is required on major contracts, subcontracts, and government-performed efforts worth more than $50 million (then-year dollars) for current and former MDAPs and major systems. Commercial items are exempt if the program manager requests and obtains approval from CAPE for a reporting waiver. Additional information on CSDR sustainment data can be found on the CADE public website at https://cade.osd.mil/policy/sustainment.

6.2.3 Maintenance and Repair Parts Data Report

An additional data report known as the Maintenance and Repair Parts Data Report has been developed to collect detailed cost and technical data for maintenance events and repair parts, similar to the data already collected by maintenance data collection systems for major weapon systems supported under organic maintenance. This report will collect for each maintenance event (1) maintenance data such as reason for failure, maintenance type, and labor hours; and (2) repair data such as the name and repair or replacement cost of the repair part.

Figure 6-4 provides the structure for this report.

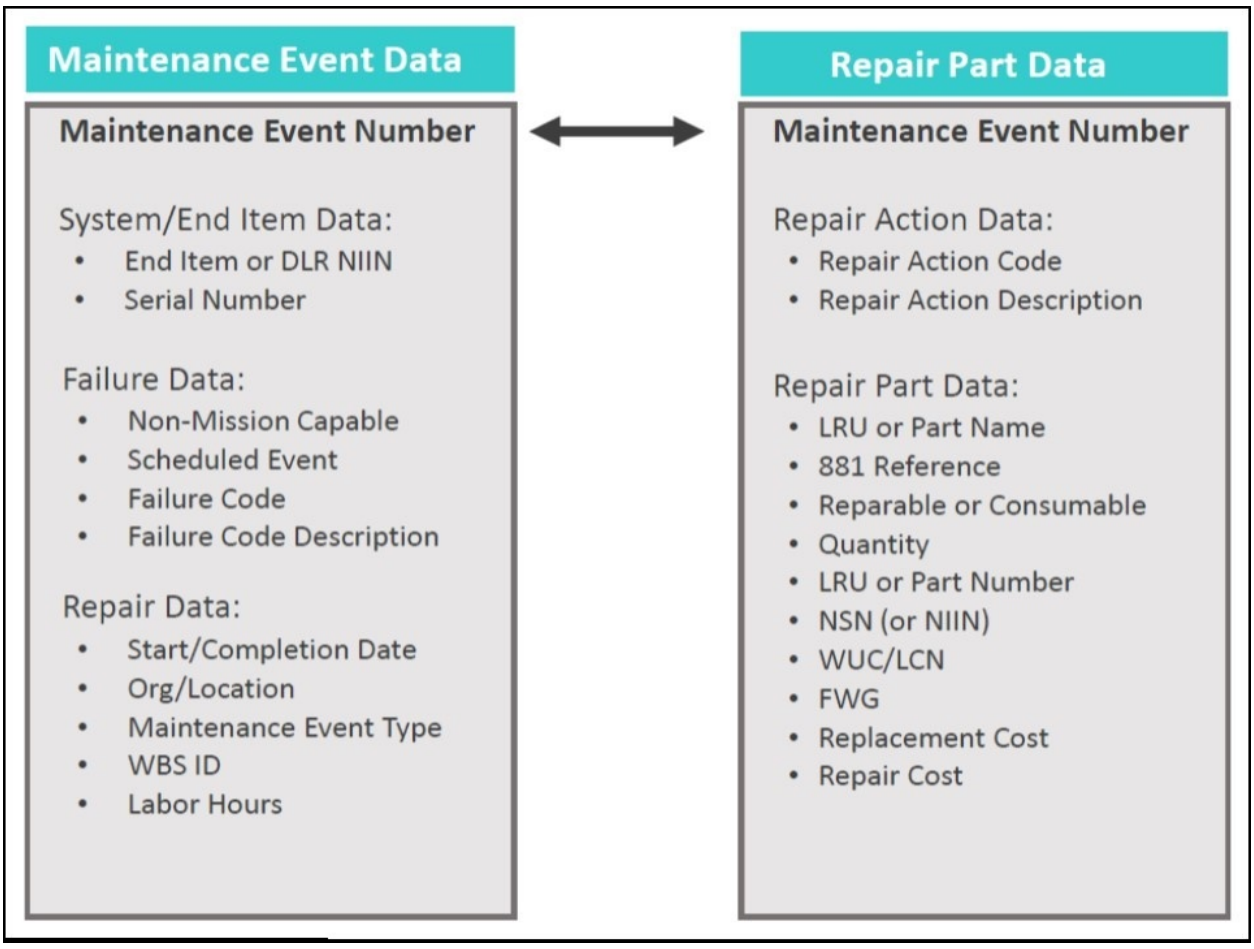

Figure 6-4. Maintenance and Repair Parts Report Data Elements

The latest version was completed in November 2017. A Maintenance and Repair Parts Data Report is required on all sustainment contracts and government-performed efforts worth more than $50 million (then-year dollars) for programs that exceed MDAP and major system level thresholds when equivalent information cannot be provided by the program manager. The various acronyms shown in Figure 6-4 are spelled out in the Abbreviations section of this guide. Additional information on the Maintenance and Repair Parts Data Report can be found on the CADE public website at https://cade.osd.mil/policy/maintandrepair.

6.2.4 Contractor Reporting for Software Maintenance

The Software Resources Data Reporting (SRDR) system collects software cost metrics data (such as software size, schedule, and labor hours) for software development efforts (contracts, subcontracts, and government-performed efforts) valued at more than $20 million (then-year dollars), for programs that exceed MDAP and major system dollar thresholds, and MTA programs anticipated to exceed $100 million (then-year dollars) in acquisition expenditures. SRDR reporting has been expanded to include major software maintenance activity. SRDR

reporting for maintenance is required for contracts, subcontracts, and government-performed efforts for programs with previous SRDR development reporting, software maintenance efforts of more than $20 million, and programs that exceed MDAP and major system level thresholds.

Figure 6-5 provides the structure for this report.

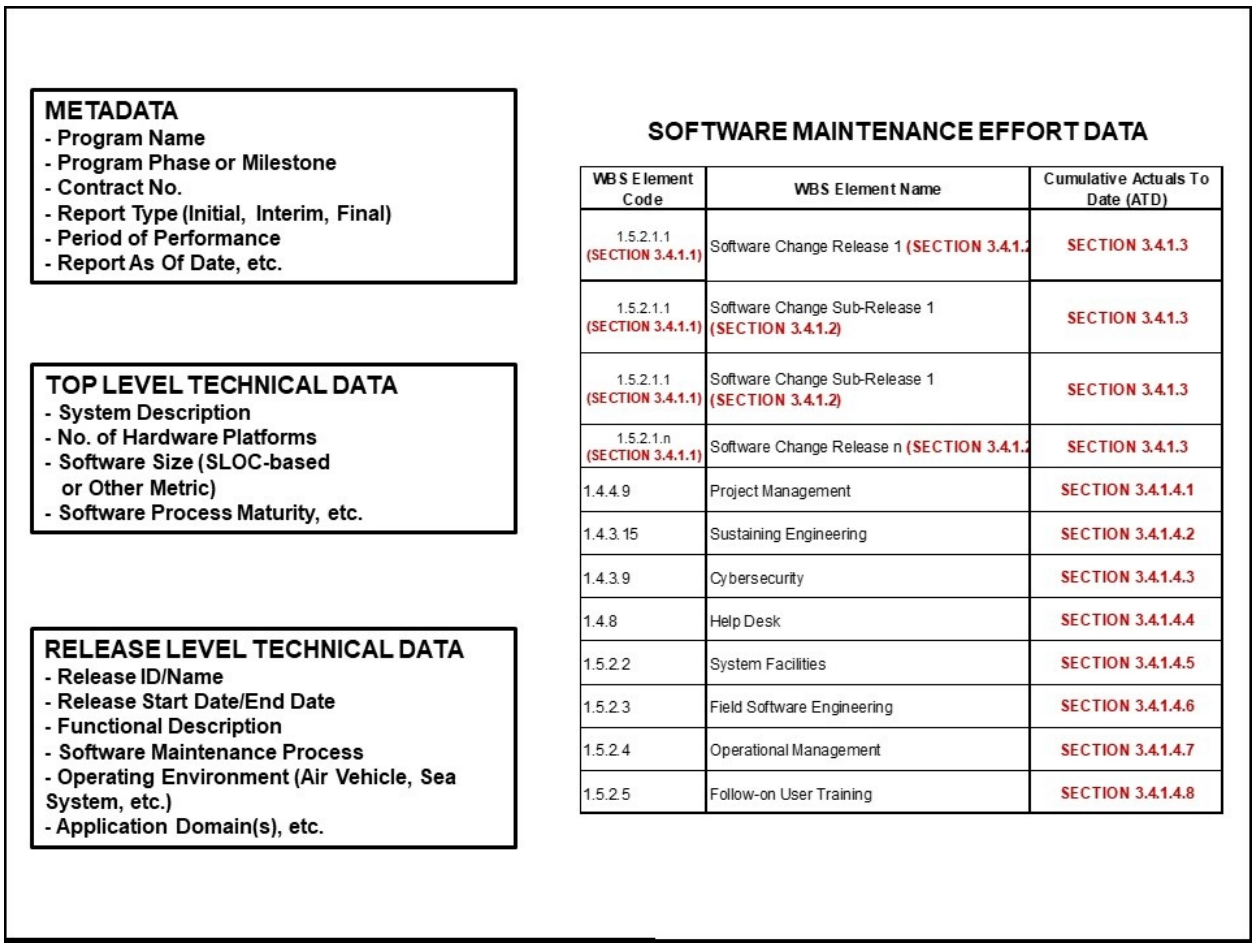

Figure 6-5. Software Maintenance Report Data Elements

Additional information about the software maintenance report can be found on the CADE public website at https://cade.osd.mil/policy/srdr.

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7. O&S COST ESTIMATING PROCESS

7.1 Introduction

This chapter describes a recommended analytic approach for planning, conducting, documenting, and presenting an O&S cost estimate.

A more comprehensive discussion on the cost estimating process in general is provided in the *DoD Cost Estimating Guide*. The guide provides important background, including a review of relevant policy established in statutes and instructions, and an explanation of standard cost terms and definitions. The Guide takes the reader through each critical step in the cost estimating process: (1) program definition, (2) cost estimate planning, and the establishment of the basis for the cost estimate (3) identification, collection, and validation of data, (4) selection of estimating methods and models, (5) model validation and sensitivity analysis, (6) risk and uncertainty, and (7) documentation and presentation of results. The Guide also provides an extensive list of references, including various best practices checklists, and relevant training and education opportunities at Defense Acquisition University and other institutions. The intent of this chapter is to augment (not replace) the guide with additional discussion focused on O&S cost estimation.

Figure 7-1 shows the recommended analytic approach for the O&S cost estimating process.

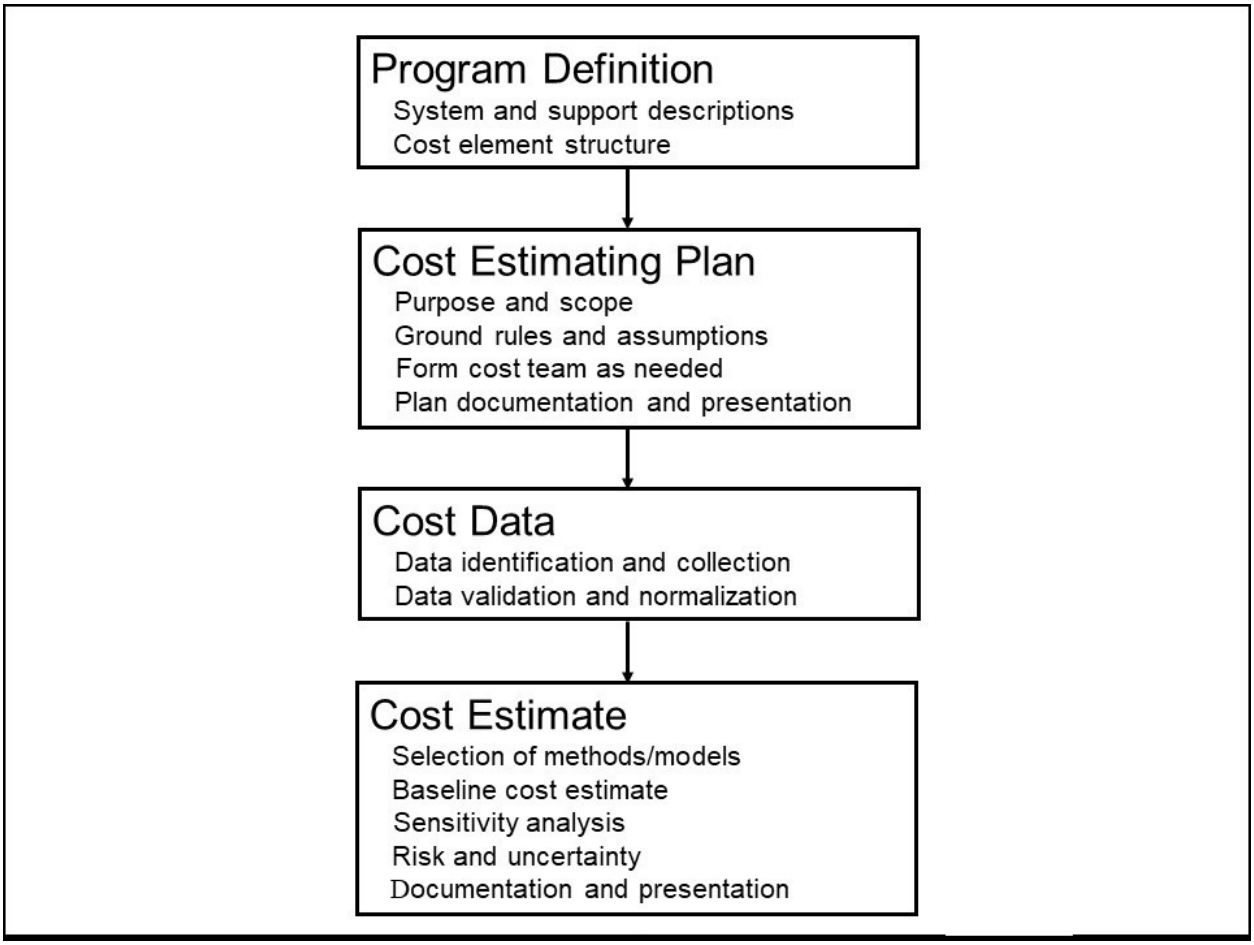

Figure 7-1. Recommended O&S Cost Estimating Process

The remainder of this chapter describes this process further.

7.2 Program Definition

7.2.1 System and Support Descriptions

One of the early steps in a cost estimate is to define the system characteristics and program content (i.e., describe what it is that will be costed). Figure 7-2 provides a list of the topics that are commonly addressed prior to the initiation of an O&S cost estimate.

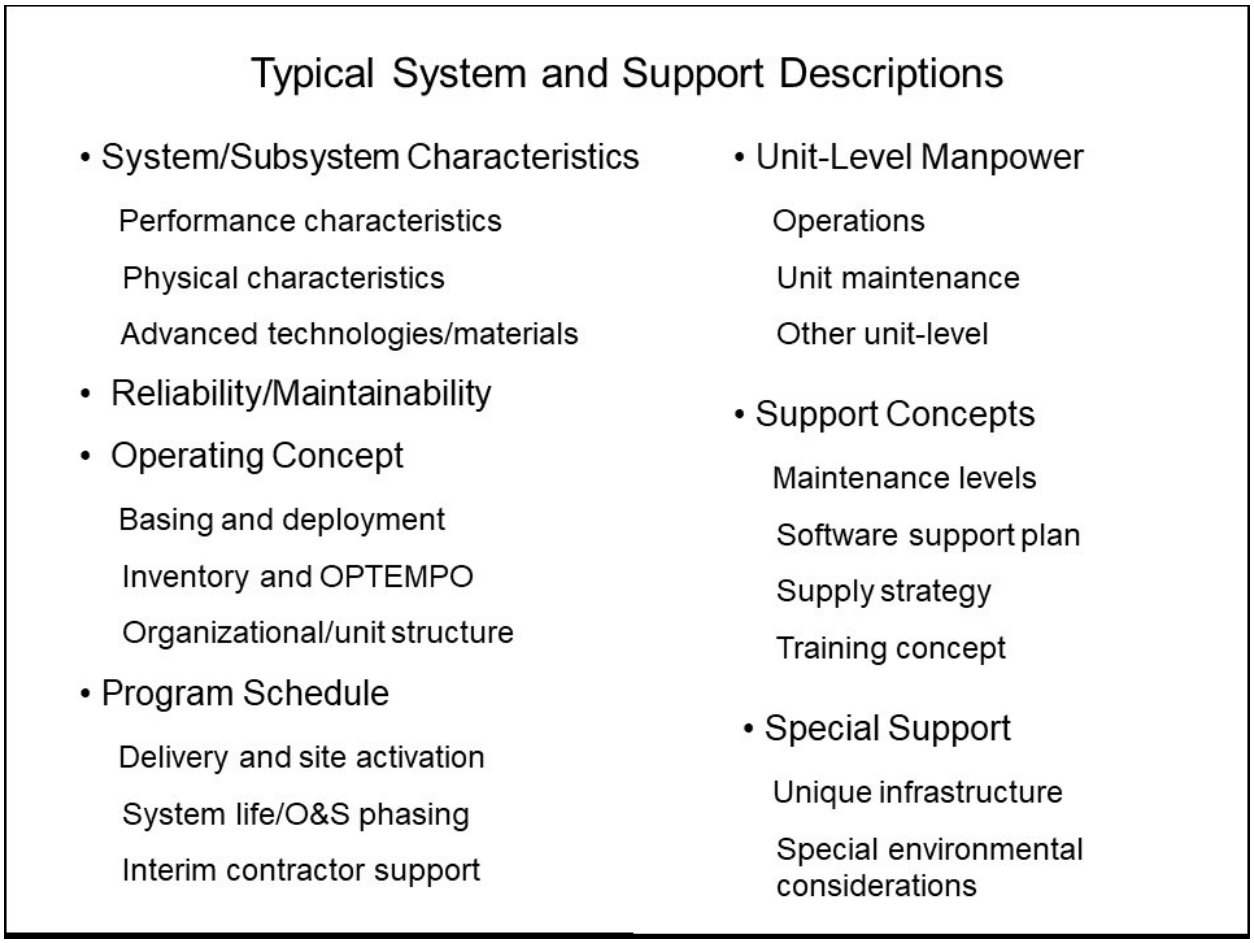

Figure 7-2. Typical System Characteristics and Program Content

For MDAPs approaching an acquisition milestone review, the program office is required to define its program in a comprehensive formal written document known as a Cost Analysis Requirements Description (CARD). The CARD narrative document is augmented by a CARD table that provides the key technical, programmatic, and operational characteristics of an acquisition program using concise tabular entries for the data. CAPE has developed CARD table templates for each commodity type (aircraft, ground vehicle, etc.). Guidance for the CARD document and CARD table templates is available on the CAPE public website at https://cade.osd.mil/policy/card. The CARD is also required for sustainment reviews. For MTA programs, the CARD is not required; however, the program management office is required to submit a program description with sufficient level of detail upon which to base a cost estimate. For other programs preparing an O&S cost estimate, an abbreviated version of the CARD format, with appropriate tailoring, provides a useful and flexible framework for developing a written program description suitable to support an O&S cost estimate.

There may be other program documents besides the CARD that can be referenced for program definition. Examples include the Product Support Strategy, Acquisition Strategy, or

Independent Logistics Assessment. However, it is important to verify that any other source documents are current and not in conflict with the CARD.

In cases where there are gaps or uncertainties in the various program descriptions, this should be acknowledged in the written document. This applies to uncertainties in either general program concepts or specific program data. For uncertainties in program concepts, one or more specific candidate concepts (such as organic versus contractor depot maintenance concepts) should be assumed for cost estimation purposes. For uncertainties in numerical data, ranges that bound the likely values (such as low, most likely, and high estimates of system reliability) should be included. Any assumptions made should be coordinated with the program subject-matter experts and other stakeholders. Dealing with program uncertainty will facilitate future sensitivity analyses in the O&S cost estimate.

7.2.2 Cost Element Structure

Another early step in the O&S cost estimating process is the establishment of the cost element structure that will be used as the format for the 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. In instances with both program office and independent cost estimates, a common cost element structure facilitates meaningful comparisons.

One of the decisions in the choice of the cost element structure is the level of detail for the estimate. For programs early in the acquisition process, the cost element structure will typically be less detailed. For more mature programs, the cost element structure will typically be more detailed.

Chapter 3 of this guide describes the standard CAPE cost element structure, with associated terms and definitions, which the components should use when presenting O&S cost estimates to OSD, including the display of system O&S cost estimates in the program SAR.

Appendix C describes the WBS taxonomy that is used for acquisition logistics costs.

7.3 Cost Estimating Plan

7.3.1 Purpose and Scope

The plan for the estimate should describe the intended use of, and the target audience for, the cost estimate. Some of the possible purposes for an O&S cost estimate include the following: a milestone or other review in the acquisition process, a sustainment review, support to cost versus capability trades or Analyses of Alternatives (AoAs), support to the product support strategy business case analysis, and the development of a program or budget estimate for sustainment resources. The scope of the estimate identifies the level of detail and fidelity that are

required to achieve the purpose of the estimate. The purpose and scope determine the resources required to complete the remaining steps of the cost estimating process.

The plan will also include a preliminary assessment of required data necessary to support the cost estimate. However, data needs and availability are not always clear at the beginning, and data requirements and sources often evolve during the development of the estimate. Issues pertaining to O&S cost data are discussed later in this chapter.

7.3.2 Ground Rules and Assumptions

There are usually several ground rules that must be established and assumptions that must be made before the actual O&S cost estimating can begin. Ground rules are guidance from program management or understandings from program subject matter experts that characterize the program. Assumptions are additional presumptions made by the cost analyst as necessary. The analyst should coordinate the assumptions with all stakeholders. Additional discussion about ground rules and assumptions, including examples, is provided in the *DoD Cost Estimating Guide*. Some of the common ground rules and assumptions that need to be documented are:

System Life. The term *system life*, sometimes called expected service life, refers to the duration of the system sustainment phase. For most O&S cost estimates, the estimate should extend over the full life expectancy of the system. Figure 7-3 and Figure 7-4 display representative life expectancies for some of the common classes of major weapon systems. These numbers are taken from actual current programs as documented in their December 2019 SARs and from historical programs as documented in the last SAR for that program. These numbers are illustrative and are not necessarily intended to be prescriptive for future programs. Actual life expectancies will vary, and will depend on the system's fatigue/durability requirements or specifications. For many programs, the planned service life can be found in the CARD. Any assumptions about mid-life upgrades or service life extension programs that are associated with the current planned system life also should be noted.

Nominal Service Life Durations

COMMODITY	SUB-COMMODITY	Service Life (years)
Fixed Wing Aircraft		
	Aircraft - Fighter	20-30
	Aircraft - Cargo	25-30
	Aircraft - Tanker	40
	Aircraft - C4ISR	20 - 25
	Aircraft - CSAR	30
	Aircraft - Trainer	30-40
Rotary Wing Aircraft		
	Helicopter - Attack	20 - 30
	Helicopter - Utility	25 - 30
	Helicopter - Cargo	20 - 30
	Helicopter - CSAR	25
	Helicopter - ASW/ASuW	25
UAVS		
	Aircraft - UAV	20
Surface Ships		
	Ship - Carrier	50
	Ship - Destroyer	35-45
	Ship - Other Combatant	25
	Ship - Amphib Assault	40
	Ship - Cargo/Ammo	40
	Ship - Replenishment Oiler	40

Figure 7-3. Nominal System Life Durations

Nominal Service Life Durations (cont.)

COMMODITY	SUB-COMMODITY	Service Life (years)
Submarines		
	Submarine - Attack	33
	Submarine - SSBN	40
Ground Systems		
	Tactical Vehicle	20-30
	Combat Vehicle	20-30
	Artillery Vehicle	20-25
	Recovery Vehicle	40
Space Systems		
	Space - SATCOM	15-20
	Space - Surveillance	35
	Space - Navigation	10
	Space - Weather	15
Tactical Missiles		
	Missile - Surface to Surface	10-20
	Missile - Air to Surface	15-25
	Missile - Air to Air	20-25
	Missile - Surface to Air	30
	Missile - Anti-Radiation	15-25

Figure 7-4. Nominal System Life Durations (cont.)

O&S Phasing. The O&S phasing will include a phase-in period, the period during which the system is in steady-state operations, and a phase-out period. The timing of these three periods should be consistent with the planned deployment and retirement schedule. Figure 7-5 provides an example of this phasing for a system with a 20-year life expectancy. In this example, the program has a 4-year phase-in period, 16 years of steady-state operations with an inventory of 50 systems, and a 4-year phase-out period.

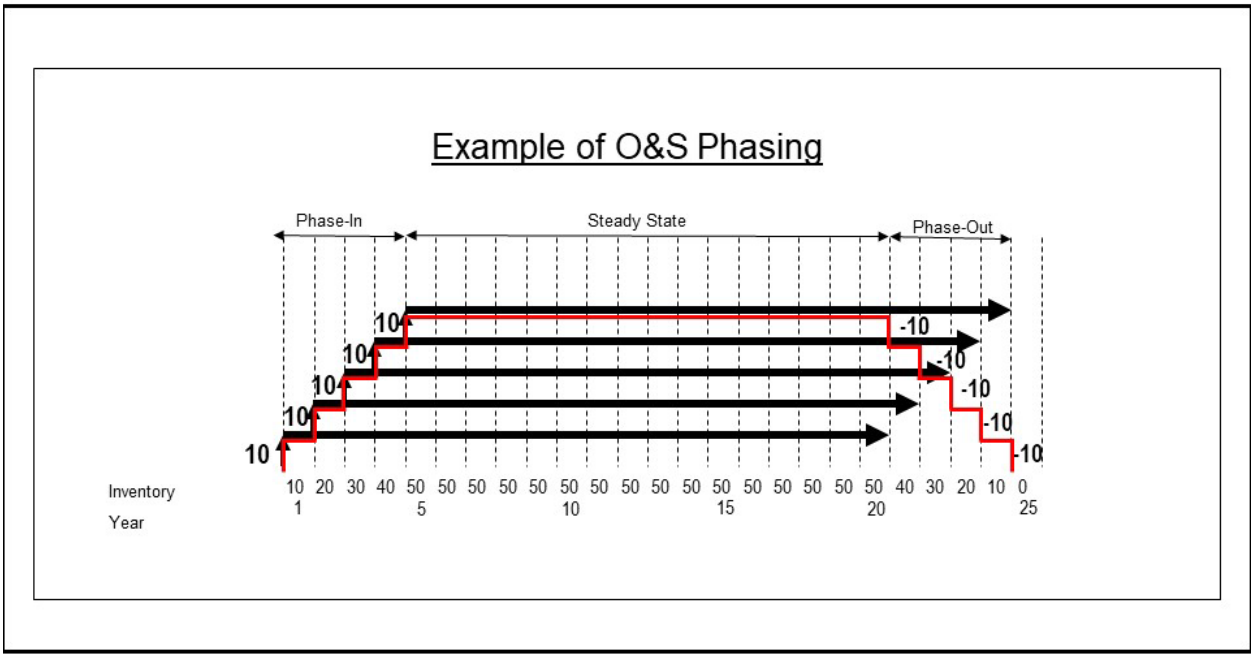

Figure 7-5. Example of O&S Phasing Convention

Year Dollars/Inflation/Price Escalation. Inflation refers to an increase in the general price level across the economy as a whole. To account for inflation in budgeting and cost estimates, each year the Under Secretary of Defense (Comptroller) issues inflation guidance derived from forecasts made by the administration and issued by the Office of Management and Budget (OMB).

Price escalation refers to changes in prices of a specific good or service—in other words, any economic activity smaller in scope than the economy as a whole. Escalation accounts for not only inflation, but also any real price change experienced in such an economic activity.

The cost community now considers the use of both inflation and appropriate escalation indices in cost estimates to be a best practice. This approach is intended to provide the most realistic forecast of future prices, taking specific markets, products, and contractors into consideration. To institutionalize this practice throughout the Department, CAPE published *Inflation and Escalation Best Practices for Cost Analysts* in April 2016. CAPE then continued to work with the military department cost organizations to implement these best practices. A second publication, *Inflation and Escalation Best Practices for Cost Analysis: Analyst Handbook*, was published in January 2017. This document is a more in-depth handbook explaining specific processes, computations, and data sources that analysts can use in the preparation and documentation of inflation and price escalation in cost estimates. This information is important for weapon system cost estimates, program cost reporting thresholds, and general programming and budgeting. At the time of the publication of this guide, the two inflation and escalation publications are being updated to clarify terminology and include more step-by-step instructions.

The handbook also provides links to the latest inflation calculators. These current publications are available on the CAPE website (https://www.cape.osd.mil) at "Public Reports."

Inflation and price escalation are especially important in O&S cost estimating due to the long time periods over which costs can grow. Analysts should assess the sensitivity of their estimates to their long-term inflation and escalation assumptions, and adhere to established best practices to ensure all inputs are normalized properly. Although all costs to be used for budgeting must be reported in then-year dollars, analysts may also wish to present some information in constant-year dollars or constant prices to remove the effects of inflation and price escalation (the combined effects of inflation and real price change), respectively; in some cases, normalizing for these forces helps visualize trends and cost drivers. Constant-year dollars should also be used to set program baseline values.

The indices used to adjust for inflation or price escalation should be specified and documented. See Figure 7-6 below for a general guide on the indices to use for reporting O&S costs, and refer to the *Inflation and Escalation Best Practices for Cost Analysis: Analyst Handbook* for more detailed guidance on how to apply inflation and price escalation in cost estimates.

	INDEX SELECTION GUIDE	
	TY$→TY$	**TY$→CY$**
Appropriation / Cost Category	*(Forecasting Escalation)*	*(Removing Inflation)*
RDT&E	RDT&E Escalation (Weighted by RDT&E Outlays)	GDP Deflator (Weighted by RDT&E Outlays)
Procurement	Procurement Escalation (Weighted by Procurement Outlays)	GDP Deflator (Weighted by Procurement Outlays)
Military Personnel	Military Personnel Escalation (Raw)	GDP Deflator (Raw)
Civilian Personnel	Civilian Personnel Escalation (Raw)	GDP Deflator (Raw)
Fuel	Fuel Escalation (Raw)	GDP Deflator (Raw)
Operations & Maintenance (excluding personnel & fuel)	O&M Escalation (Weighted by O&M Outlays)	GDP Deflator (Weighted by O&M Outlays)

Figure 7-6. Inflation/Escalation Index Selection Guide

For example, an estimate of military pay costs would require both a military pay index (escalation) and the GDP deflator. Given a salary of $100,000 in FY 2021 (Constant Price, or CP21$), an analyst must provide then-year (TY$) and constant-year 2021 (CY21$) estimates of the same person's salary in FY 2022-2025. Indices from the FY 2021 President's Budget Green Book are provided below, along with the annual estimate results; the CY21$ estimate preserves the forecasted real price change, or the portion of military pay escalation that is not explained by

inflation. Note that the selection of an index with a base year matching that of the CY$ estimate simplifies the calculations, and the use of an index with a different base year would require additional calculations (see the *Inflation and Escalation Best Practices for Cost Analysis: Analyst Handbook* for further guidance).

Fiscal Year	Salary Input (CP21$)	2021 Military Pay Index (Escalation)	2021 GDP Deflator (Inflation)	TY$ Estimate (multiply CP$ by escalation index)	CY21$ Estimate (divide TY$ by inflation index)
2021	100,000	1.0000	1.0000	= 100,000 * 1.0000 = **100,000**	= 100,000 / 1.0000 = **100,000**
2022	100,000	1.0270	1.0200	= 100,000 * 1.0270 = **102,700**	= 102,700 / 1.0200 = **100,686**
2023	100,000	1.0537	1.0404	= 100,000 * 1.0537 = **105,370**	= 105,370 / 1.0404 = **101,278**
2024	100,000	1.0811	1.0612	= 100,000 * 1.0811 = **108,110**	= 108,110 / 1.0612 = **101,875**
2025	100,000	1.1092	1.0824	= 100,000 * 1.1092 = **110,920**	= 110,920 / 1.0824 = **102, 476**

7..3.3 Team Members and Assignments

Ideally, O&S cost estimates are prepared by a multi-disciplinary team with functional skills in cost analysis, financial management, logistics, engineering (including reliability and maintainability), and other talents. The team also should include participants providing stakeholder input from major affected organizations, such as the system's operating command or other user organization, product support center, maintenance depot, training center or command, and so forth. Each team member should have well-defined roles and responsibilities.

7.3.4 Documentation of the Cost Estimate Plan

Ideally, the plan for the cost estimate will be prepared in a written document. This will be an important element of the documentation of the cost estimate that will be required later, since the written plan describes the process followed to achieve the estimate results. In addition, a presentation of the plan is typically presented at some kind of kick-off meeting for the estimate. It is important that the plan for the O&S cost estimate be reviewed by all appropriate stakeholders 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. However, in real life, it is most likely that the original plan is going to change over the course of the estimate. Any changes from the original plan should be noted in the final documentation of the cost estimate.

7.4 Cost Data

7.4.1 Data Identification and Collection

The cost estimating process includes the identification of the best data available that is appropriate for the purpose and scope of the estimate. For programs that are early in the acquisition process, the planning for the O&S cost estimate should identify and document the needed cost, performance, and technical data for appropriate legacy systems in order to support estimates using analogies or cost estimating relationships (CERs) described later in this chapter. For programs that are later in the acquisition process, plans for O&S cost estimates should establish requirements for predictions by contractor, program office, or other external support organizations for O&S cost factors, reliability and maintainability parameters, and other suitability and logistics support factors. Plans should also address associated test and evaluation requirements and experience to date for the same factors and parameters. For mature programs, the best sources of available data that reflect actual cost experience for the program should be identified.

There are many possible sources of data that can be used in O&S cost estimates. For currently fielded major systems, historical cost data for the most part is available from the VAMOSC data system managed by each military department as discussed in Chapter 6. However, the VAMOSC systems provide limited visibility into CLS costs. In many cases, it may be necessary to augment VAMOSC data with CSDR data for costs of major sustainment, logistics, and maintenance contracts. Additionally, in many cases, for weapon systems supported by a mix of organic maintenance and CLS, it is necessary for the analyst to fuse the two data sources into a consistent understanding of the total costs for each major cost element.

The cost estimate often will require reliability and maintainability data, which can be obtained from the military department maintenance data collection systems or from test results. In addition, VAMOSC data for unit-level manpower is often supplemented with information from unit manning documents or tables of organization and equipment. In such cases, it is necessary to apply manpower rates to the unit manning documents. Manpower rates are discussed in Appendix I of this guide.

7.4.2 Data Validation and Normalization

O&S cost data, such as VAMOSC and CSDR data, should 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 organization or location (such as major command or base) so that abnormal outliers in the data can be identified, investigated, and considered as appropriate.

Data that can be used for detailed bottom-up engineering estimates often come from contractor databases (such as logistics management data systems). It is important for analysts to understand the sources and business rules used in the generation of the data. Appropriate government personnel should validate this type of data before use, at least for the high-cost items. This is especially important in cases when the hardware being costed is not mature (e.g., not yet tested or deployed). The validation should address the completeness of the component

population, the realism of component reliability and maintainability estimates, the validity of the component unit prices, and so forth.

It may also be necessary to normalize historical data to adjust for accounting or definitional changes that have occurred over time. In such cases, the earlier data may need to be adjusted in order to be comparable to the current data. For example, a system may have a change in its support concept where the mix of organic and CLS sustainment has changed, or where the source of CLS is changed from the prime contractor to a major subcontractor. As another example, there could be force structure changes such as a change in active-reserve mix.

In addition, system O&S cost estimates generally reflect peacetime conditions. DoD considers the incremental costs due to a contingency to be part of the cost of the contingency, not part of the operating cost of the system. However, for some systems in recent years, the usage or OPTEMPO reported in the VAMOSC data systems or other data sources may capture a combination of peacetime and contingency operations. In such cases, the actual usage and associated costs may need to be adjusted to the peacetime level. On the other hand, the actual usage and associated costs may represent a new more or less permanent reality, and should be considered the new norm for the program or its replacement. The cost validation process should establish the appropriate assumption, most likely with the help of subject matter experts. The different levels of usage should also be considered in the sensitivity analysis and risk/uncertainty discussed later in this chapter.

7.5 Cost Estimate

7.5.1 Methods or Models

Several techniques may be employed to estimate the O&S costs of a weapon system. The cost estimation techniques selected typically depend on the acquisition phase and maturity of the program. In the earlier acquisition phases, cost estimates are commonly based on analogies and parametric CERs. In some cases, as the program definition is refined, the use of analogies and parametric estimates may be improved by increasing the level of detail of the cost estimate, where, for some cost elements, distinct estimates are made for major subsystems and components. As the program enters subsequent acquisition phases, it is desirable to incorporate any actual cost experience available from early fielded systems. Emerging test and evaluation results, including projections of reliability and maintainability performance, also can be used to refine O&S cost estimates.

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 primary method. For mature systems, using a build-up method or extrapolation from actuals method described later, analogy and parametric estimates are often used as cross-checks.

Each of the four most common estimating techniques is described in the remainder of this section.

Analogy. An analogy is a technique used to estimate a cost based on historical data for one analogous system. An analogy may also be used to estimate the cost of a subsystem such as a propulsion or electronic warfare 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 by using factors (sometimes called scaling parameters) that represent differences in size, performance, technology, reliability and maintainability, complexity, or other attributes. Adjustment factors based on quantitative data are usually preferable to adjustment factors based on judgments from subject-matter experts.

Figure 7-7 provides an example of an analogy for an estimate of DLR cost.

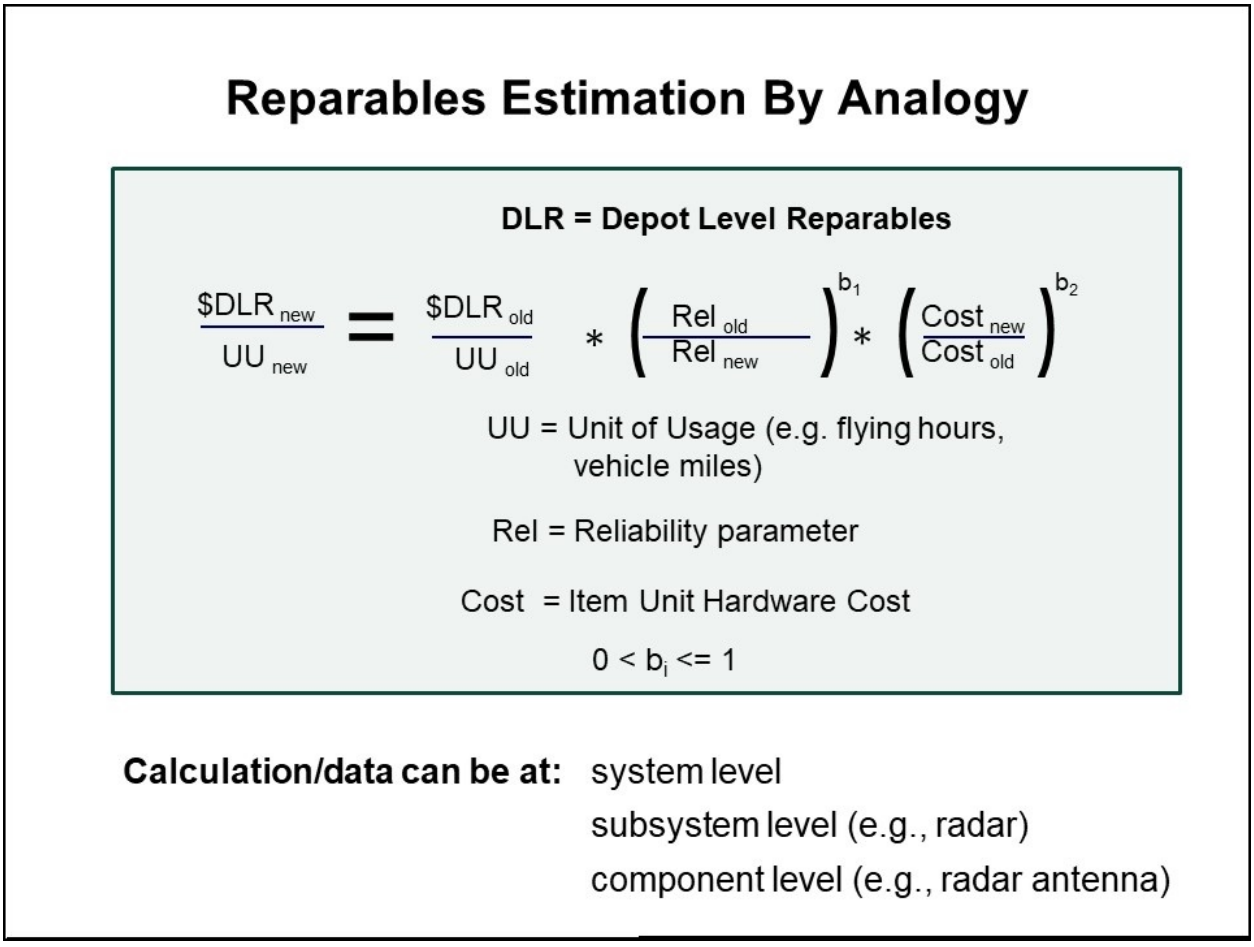

Figure 7-7. Example of Analogy Cost Estimate

In this example, the cost is estimated on a dollar per unit of usage basis. The cost for the old system is used to estimate the cost for the new system. There are two scaling parameters. The first is

reliability. Common reliability parameters include Mean Time Between Failure, Mean Time Between Removal, and Mean Time Between Maintenance. However, the actual effect on cost would be a failure rate, removal rate, or maintenance rate. Since reliability parameters are usually expressed as a reciprocal, this leads to the reversal in the reliability ratio, where the value for the old system is in the numerator and the value for the new system is in the denominator. The second scaling parameter is unit hardware cost. Unit hardware cost is typically expressed as prime mission product, recurring flyaway, or simply flyaway. The exponents b_1 and b_2 may optionally be used to account for diminishing returns on the effects of the scaling parameters. Typically, the values of these exponents would come from relevant studies or analyses such as the regression analysis discussed in the next section. The analogy approach could be used for the entire weapon system, or could be used for a subsystem or component.

Unit hardware cost, along with system reliability, is commonly used in analogies and parametric estimates that are discussed later in this chapter. The unit hardware cost is used to represent a proxy for system size and complexity. Historically, many new systems have had superior reliability relative to the antecedent systems being replaced, due to advancements in new technologies. However, improvements in reliability are typically more than offset by increases in unit hardware cost. The increases in unit hardware cost indicate an increase in complexity, which results in an increase in maintenance and other O&S costs. Table 7-1 shows an example of this pattern for two replacement systems.

Table 7-1. Comparison of Replacement Systems to Antecedents

	Reliability	Improvement in Reliability	Unit Hardware Cost	Increase in Unit Hardware Cost	DLRs + Consumables ($ per Usage Metric)	Increase in DLRs + Consumables
Antecedent System #1	1.50		35		1,800	
Replacement System #1	2.25	50%	75	114%	2,200	22%
Antecedent System #2	1.50		40		14,000	
Replacement System #2	3.75	150%	200	400%	20,000	43%

Parametric. The parametric technique uses regression to develop CERs. A CER is an equation used to estimate a given cost element using an established relationship with one or more independent variables. The relationship is 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. The strength of a parametric estimate lies in the relevance and quality of the data and in the validity of the assumed behavior between the

independent variables and the dependent variable. The analyst should also consider the number of data observations sufficient to form a statistically meaningful data set.

Figure 7-8 provides an example of a CER for an estimate of DLR cost.

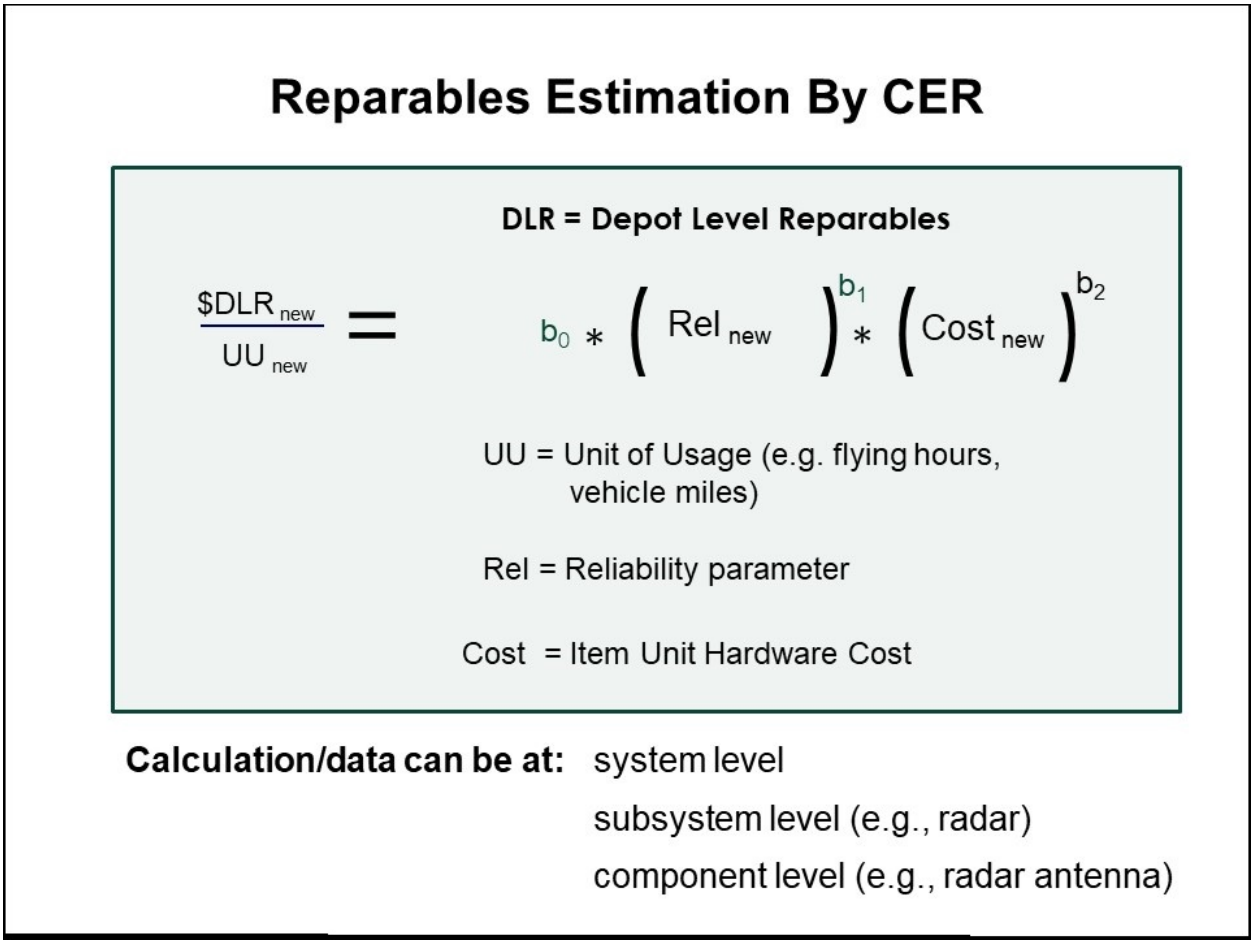

Figure 7-8. Example of Cost Estimate by CER

In this example, the DLR cost, which is the dependent variable in the regression, is estimated on a dollar per unit of usage basis. The independent variables are reliability and unit hardware cost. To perform the regression, it is necessary to assemble the data (both the dependent variable and the independent variables) for a group of historical systems relevant to the system being estimated. The functional form of the equation is nonlinear, but can be converted to a linear form by taking logarithms of both sides of the equation. The regression using the data for the historical systems then provides the three coefficients (b_0, b_1, and b_2). The equation for the CER can then be used to estimate the DLR cost for a new system.

A more complete and advanced discussion about the development and application of CERs can be found in the *Joint Agency Cost Estimating Relationship Development Handbook*.

Build-up Estimate. This technique uses discrete estimates of labor and material costs for

maintenance and other support functions. The system being costed normally is broken down into lower-level components (such as parts or assemblies), each of which is costed separately. The component costs are then aggregated using simple accounting equations to estimate the total system cost (hence the common name "bottom-up" estimate). For example, system maintenance costs could be calculated for each system component using data inputs such as system OPTEMPO, component mean time between failure or maintenance, component mean labor hours to repair, and component mean material cost per repair. Engineering estimates require extensive knowledge of a system's components characteristics, and a sizeable amount of detailed data. An example of a build-up estimate is provided in Appendix G of this guide.

Extrapolation from Actuals. With this technique, actual cost experience or trends (from prototypes, engineering development models, and/or early production items) are used to project future costs for the same system. Such projections may be made at various levels of detail, depending on the availability of data. In some cases, it may be necessary to account for growth in reliability and maintainability.

There are other methods in addition to the four discussed in this section, including expert opinion, head-count (level of effort), and industrial engineering standards. These other methods are described in the *DoD Cost Estimating Guide*.

7.5.2 Baseline Cost Estimate

The complete O&S cost estimate is composed of the individual estimates for each cost element. The framework holding the estimate together is the cost element structure. The analyst populates the cost element structure with the selected estimating methods supported by inputs from the data collection process. The analyst then applies inflation, price escalation, and phasing methods as needed. Often, an estimate may use a comprehensive cost model built in Excel or a cost estimating software application such as Automated Cost Estimating Integrated Tools (ACEIT).

Usually the development of the baseline cost estimate is an iterative process. Starting the baseline cost estimate as early as possible helps focus discussion among the team members, inspires timely questions, and uncovers weaknesses in the estimating methods or gaps in the data collection process.

The term *baseline cost estimate* is used because this estimate serves as the point of departure for the sensitivity analysis and risk/uncertainty assessment discussed in the next two sections.

7.5.3 Sensitivity Analysis

Sensitivity analysis attempts to demonstrate how the cost estimate would react to changes in cost drivers. 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 fuel consumption increases with system weight growth. In good sensitivity analyses, the cost-driver values are not changed by arbitrary plus/minus percentages, but rather by a careful assessment of the plausible ranges of values.

Figure 7-9 shows an example of a sensitivity analysis for an aircraft system.

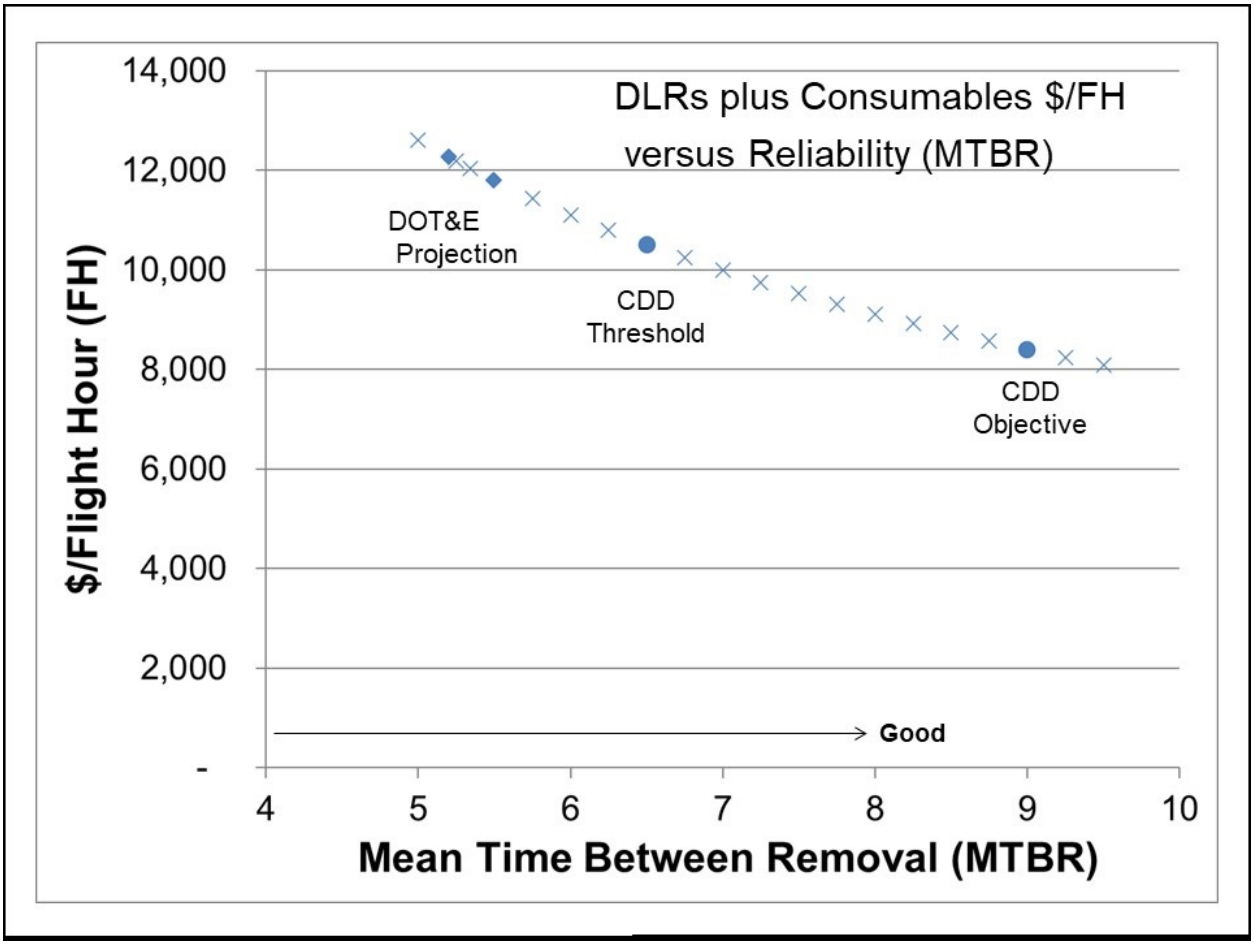

Figure 7-9. Example of Sensitivity Analysis

In this example, the costs being considered are costs for DLRs plus costs for consumables. These costs are expressed on a dollars-per-flight hour basis. The sensitivity analysis is focused on aircraft reliability, which has been identified as a concern. In this example, the aircraft is undergoing test and evaluation. For this aircraft, the Director of Operational Test and Evaluation (DOT&E) projection for reliability at maturity, based on test experience to date, is provided as a range of values. The entire range of the projection is significantly deficient relative to the threshold and objective reliability requirements established in the Capability Development Document (CDD).

In most cases, maintenance costs do not vary linearly with reliability. In this example, achieving the CDD threshold represents a 22 percent improvement in reliability compared to the DOT&E projection. Such an achievement is estimated to reduce the costs for DLRs plus consumables by 13 percent.

Figure 7-10 shows a second example of sensitivity analysis that considers both reliability and maintainability for the same aircraft system.

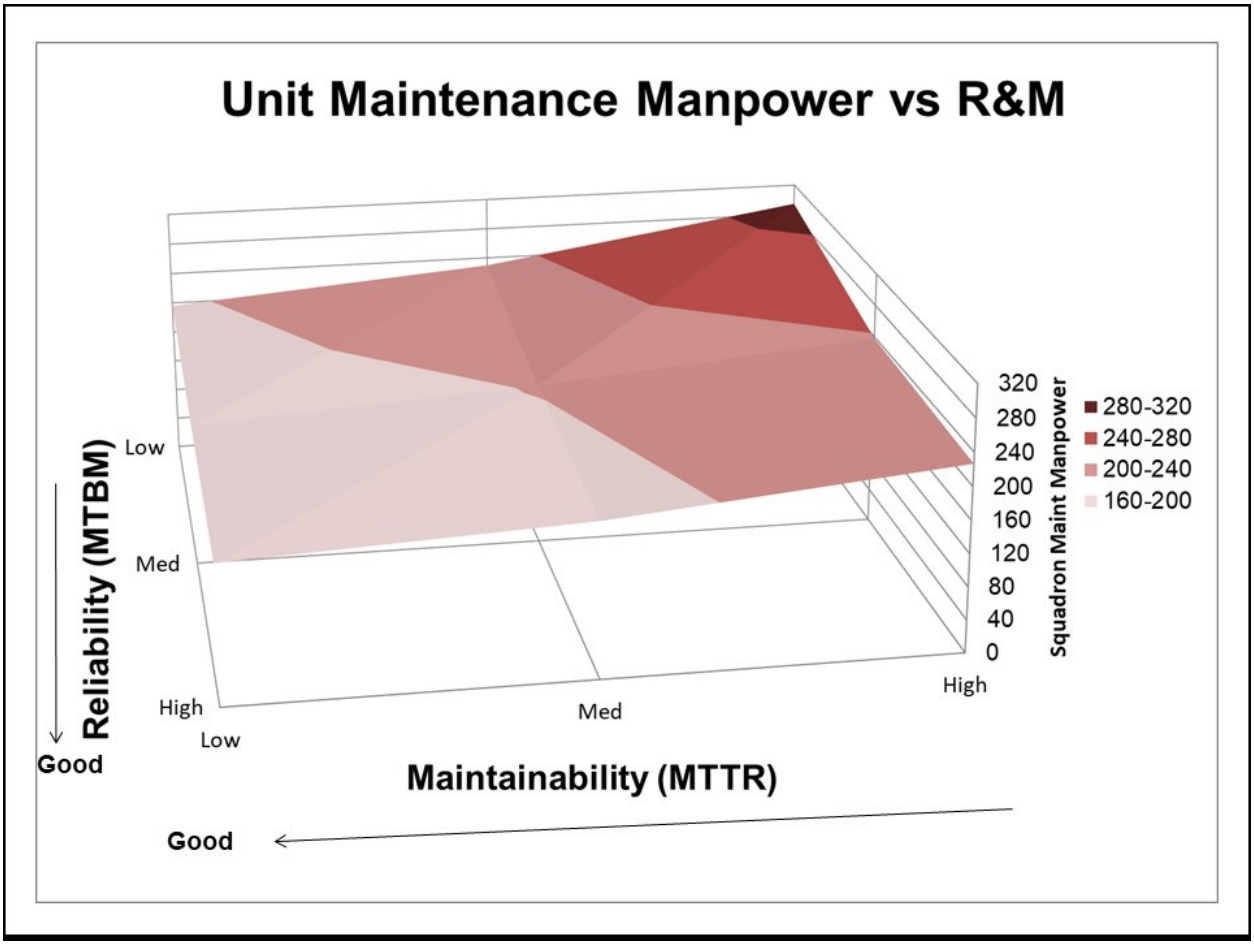

Figure 7-10. Second Example of Sensitivity Analysis

In this example, the output measure being considered is maintenance manpower per squadron. Here, both reliability (measured as Mean Time Between Maintenance (MTBM)) and maintainability (measured as Mean Time to Repair (MTTR)) are varied. These results were derived from a simulation model of aircraft squadron operations and maintenance. The level of maintenance manpower is a decision variable in the simulation. For given reliability and maintainability, the model is used to establish the minimum level of manning necessary to achieve targets for sortie generation rates.

In most cases, maintenance manpower does not vary linearly with improvements in reliability or maintainability. Typically, a given percentage of a reliability or maintainability improvement would result in a lower percentage manpower reduction. This is because the workload for maintenance manpower is not limited to touch labor for replacements and repairs, but also includes other activities such as weapons loading, inspections, and overhead such as quality control and supervision. In this example, the increase in reliability between medium and high represents a 50 percent improvement. This reliability improvement at the medium level of maintainability results in only a 7 percent reduction in maintenance manpower.

In addition, for many systems, the maintenance manpower system can also vary with the number of systems in the operating unit. Typically, there can be an economies of scale effect as the unit size is increased. However, this is not true for all system types.

More generally, sensitivity analysis helps identify where the analyst should focus risk and uncertainty analysis. That topic is briefly introduced in the next section.

7.5.4 Risk and Uncertainty

A program risk is a potential event or condition that may have an effect on cost, schedule, and/or performance. A risk has three characteristics: a triggering event or condition, the probability that event or condition will occur, and the consequence of the event or condition should it occur. Uncertainty is the indefiniteness of the outcome of a situation. In the context of cost estimating, uncertainty refers to the range of possible values for the eventual cost outcome.

Cost analysts address risk and uncertainty in different ways. The *DoD Cost Estimating Guide* provides a summary of the most common methods used to address them. One of the methods described is simulation. A simulation model is used to capture the uncertainty in parametric CERs, CER inputs, any other cost drivers, program schedule, and other identified risk events (and the probability of occurrence and the consequence of it for each event) that impact the cost model. A simulation model can be used to develop a so-called S-curve, which is the cumulative distribution function of the system cost. A complete description of this approach is provided in the *Joint Agency Cost Schedule Risk and Uncertainty Handbook*. The handbook provides several examples of this approach.

7.5.5 Documentation and Presentation

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 analysis, as the program moves from one acquisition milestone to the next. The key standard is that an outside professional cost analyst should be able to replicate the estimate, given the documentation.

The documentation should address all aspects of the cost estimate: a brief summary of the program definition and a reference to the CARD; the background described in the cost estimating plan, including all ground rules and assumptions; the selection of cost data sources and cost estimating methods; the actual estimate computations; and the results of the sensitivity and risk/uncertainty analyses.

Typically, a presentation concerning an O&S cost estimate would include the following:

- **O&S Cost Summary.** The presentation will begin with a brief summary of ground rules and assumptions (such as O&S period, number of deployed systems, operations and support concepts, etc.), and follow with a brief table-format summary of total O&S costs in constant dollars by cost element and sub-elements.
- **Estimating Methods for Major Cost Elements**. The presentation will include a discussion of estimating methods (and source data) for the high-cost cost elements and sub-elements.
- **Sensitivity Analysis.** This section of the presentation would include an identification of the major cost-drivers (such as system reliability and maintainability) associated with the high-cost cost elements and sub-elements, and show the sensitivity of the costs to changes in cost-drivers.
- **Risk/Uncertainty Analysis.** If conducted, a formal quantitative assessment of risk and uncertainty such as an S-curve display would be provided here in the presentation.
- **Time-Phased O&S Display**. The presentation will include a display of time-phased O&S costs by major time periods (such as phase-in, steady-state, and phase-out periods), as well as a display of annual steady-state recurring O&S costs[1]. These costs are displayed in then-year dollars when used to support a comparison to program funding in the budget.
- **Annualized Steady-State Costs for Typical Unit.** The presentation should include a display of the annual system O&S costs for a typical deployable or operating unit (such as squadron or battalion) or single system (such as ship or missile), compared to similar costs for the predecessor and/or reference system. This is one of the presentation formats often used in the program SAR.

[1] In the steady-state period, annual O&S costs may or may not be constant. In some cases, variations may occur due to long overhaul cycles or other reasons. In these cases, annual-steady state O&S costs would be calculated as the average annual O&S cost over the steady-state period.

- **Cost Track to Prior Estimate.** If applicable, the presentation should also include a comparison between the current O&S cost estimate, and the most recent previous estimate. Major differences should be explained.
- **Comparison to Program Baseline.** Where applicable, the presentation should include comparisons between the current estimate and any ADM metrics, SAR baselines, cost Key System Attributes (KSAs), etc.

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APPENDIX A
Software Maintenance Cost Elements

Introduction

This appendix provides an optional, more detailed cost element structure for software maintenance.

Definitions

5.2 Software Maintenance

The rollup of the costs of the lower level elements.

5.2.1 Software Changes

The rollup of the costs of the lower level elements.

5.2.1.1 Release 1...n (Specify)

The rollup of the costs of the lower level elements.

5.2.1.1.1 Correction of Deficiencies

This element captures software change costs associated with the correction of deficiencies, defects, and cybersecurity. It can also capture the cost of any refactoring (restructuring the existing body of code without altering behavior).

5.2.1.1.2 Enhancements

This element captures software change costs associated with minor enhancements.

5.2.1.1.3 Independent Verification and Validation (IV&V)

This element captures all costs associated with software release IV&V. IV&V is a review secured through a separate contract with a third party that ensures that the system is well-engineered and meets agreed upon requirements (verification) and that the system meets the users' needs (validation).

5.2.2 Software Program Management

Includes all costs associated with the management of software, including the implementation, delivery, and sustainment of software.

5.2.3 Software Sustaining Engineering

Includes all costs associated with software-specific sustaining engineering. Costs reported in this element may include, but are not limited to, contract engineering services, studies, and technical advice. This element does not include effort associated with directly changing the software baseline but may support the activities associated with those changes.

5.2.4 System Facilities

This element includes the system-specific cost associated with establishing and operating an environment such as a Software Integration Laboratory (SIL) for software maintenance-related development and testing.

5.2.5 Field Service Engineers

This element includes the cost associated with on-site support of a deployed software product or system in its operational environment.

5.2.6 Certification and Accreditation

This element includes activities such as Cybersecurity, Information Assurance Vulnerability Management (IAVM), Airworthiness, Safety, and Networthiness. Cybersecurity, formerly Information Assurance (IA), and the Risk Management Framework (RMF) for DoD Information Technology, formerly DoD Information Assurance Certification and Accreditation Process (DIACAP), are processes that verify the software system against externally defined domain performance criteria.

5.2.7 Help Desk

This element captures the costs of providing help desk support for end users. Cost may include effort associated with answering and filtering help desk calls, troubleshooting, account management, system administration, software upgrades, and break/fix.

5.2.7.1 Tier 1

This element captures the costs of providing Tier 1 help desk support to end users. This element includes the cost of support provided by a central call center for basic customer issues such as solving usage problems and fulfilling service desk requests that need IT involvement. If no solution is available, Tier 1 personnel escalate incidents to a higher tier.

5.2.7.2 Tier 2

This element captures the costs of providing Tier 2 help desk support to end users. This element includes the cost of support provided by experienced and knowledgeable support personnel who assess issues and provide solutions for problems that cannot be handled by Tier 1. Typically, Tier 2 personnel have an in-depth functional knowledge of the product or service. If no solution is available, Tier 2 support escalates the incident to Tier 3.

5.2.7.3 Tier 3

This element captures the costs of providing Tier 3 help desk support to end users. This element includes the cost of support provided by highly skilled product specialists who have an expert knowledge of the application and can resolve issues or problems and fix defects in the production baseline by changing the system software.

5.2.8 Hosting

This element includes all costs associated with hosting, either in a traditional data center or in the cloud. Includes activities associated with computing resources and servers that execute all or some portion of an application from a central location across a network. Also includes storage and services necessary to maintain and manage server hardware and operations. If system is cloud hosting, specify if costs represent infrastructure as a service, platform as a service, or software as a service.

5.2.9 Software Licenses

This element includes the cost associated with license procurement and license maintenance fees for all licenses necessary to operate and maintain the system. This includes licenses in the development environment as well as the deployed software system.

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APPENDIX B
Indirect Support Cost Elements

Introduction

Indirect support costs are those installation and personnel support costs that cannot be identified directly (in the budget or Future Years Defense Program) to the units and personnel that operate and support the system being analyzed, but nevertheless can be logically attributed to the system and its associated manpower.

Such indirect costs are not included in operating and support (O&S) cost estimates made in support of the defense acquisition process. However, indirect support costs are often considered in workforce mix cost comparisons, product support business case analyses, and broad force structure studies such as those focused on active-reserve mix. These costs also may be considered and addressed separately in programming and budgeting. These indirect costs may optionally be collected in the VAMOSC systems, at the discretion of each military department.

Since indirect support costs lack direct visibility with the system under consideration, they are often allocated, either on a per-capita or some other basis. Some O&S cost estimates attempt to partition the indirect support costs into fixed and variable elements, and use only the variable costs in the estimate. The intention is to include only the costs that would likely change for the action being analyzed (e.g., new system development is initiated).

The remainder of this appendix provides terms and definitions for indirect support cost elements.

Definitions

6.0 INDIRECT SUPPORT

6.1 Installation Support

The costs of services funded and provided by the host installation that support the day-to-day operations of the system's force unit. Excludes the costs of personnel support services purchased by the unit that are reflected in element 2.2 (Support Services). Consists of:

6.1.1 Base Operations Support

The costs of services for functions such as base physical security, base administration, maintenance of installation equipment, base transportation, and other base and personnel support services.

6.1.2 Base Communications

The costs of local communication services provided by the host installation. May be combined with 6.1.1 (Base Operations Support) if it cannot be identified separately.

6.1.3 Facilities Support

The costs of facilities sustainment, restoration and modernization (formerly known as real property maintenance).

6.2 Personnel Support

The costs for the management, acquisition, initial training, and quality of life programs necessary to maintain a quality force.

6.2.1 Personnel Administration

The costs of programs that acquire and administer the DoD workforce.

6.2.1.1 Personnel Management

The costs of programs to administer the DoD military and civilian workforce. Major activities include reassigning on-board personnel, and managing end strength and occupational skills to the levels needed.

6.2.1.2 Acquisition of New Personnel

The costs for recruiting, examining, and processing individuals into the military service and for advertising in support of recruiting activities.

6.2.1.3 Personnel Not Available For Duty (Transients, Prisoners, Patients, Students)

The costs for military personnel placed in the personnel holding account because they are not available for assignment to a unit for medical or disciplinary reasons, or are about to be discharged. Includes military personnel not assigned to a unit because they are in transit to the next permanent duty station, to schooling, or other training.

6.2.2 Personnel Benefits

Consists of the costs for operations and maintenance of family housing, dependent and family support programs, and DoD commissaries and exchanges.

6.2.2.1 Family Housing

The costs for operations and maintenance of dwelling units, community facilities, roads, driveways, walkways, and utilities for use by family housing occupants.

6.2.2.2 Dependent Support Programs

The costs of child development centers, youth development programs, family centers, family advocacy programs, counter-drug demand reduction programs, and other similar

programs necessary to support the families of military service members. Includes the education of dependents of federal employees in overseas assignments and for eligible dependents of federal employees residing on federal property where an appropriate public education is unavailable in the nearby community. These education costs are primarily funded by the DoD Education Activity (DoDEA).

6.2.2.3 Commissaries and Exchanges

The appropriated costs of employee salaries and other expenses at defense commissaries. These costs are primarily funded by the Defense Commissary Agency (DeCA).

6.2.3 Medical Support

The costs for medical care for active duty personnel and their dependents. Includes provisions for in-house patient care in regional defense facilities, station hospitals, and medical clinics; and dental facilities; as well as care in non-defense facilities. Also includes costs for private-sector care such as TRICARE or other similar activities. Medical care is funded by a combination of the military departments and the Defense Health Program. The active-duty composite rates described in Appendix I also provide an acceleration factor to account for the costs of medical support.

6.3 General Training and Education

The costs for institutional or schoolhouse training and education not associated with a specific weapon or other system. Consists of the costs of:

6.3.1 Recruit and Initial Officer Training

The costs of programs that provide basic military training and indoctrination to enlisted recruits, and of programs that provide basic military training and indoctrination to officer candidates (through college commissioning programs, officer candidate/training schools, and the three military service academies).

6.3.2 General Skill Training

The costs of programs that teach (1) entry-level job skills after completion of initial military training, and (2) intermediate and advanced job skills later in the career.

6.3.3 Professional Military Education

The costs of programs that provide (1) professional military education at each level of career progression, and (2) advanced academic degrees needed for work in specific organizations and tasks.

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APPENDIX C
Definitions for Acquisition Logistics Support Cost Elements

This appendix provides cost terms and definitions for acquisition logistics support cost elements procured during the system production and deployment phase. In the standard terminology for life-cycle cost, acquisition logistics support costs are procurement costs that are the initial investment for a program's product support that will support the sustainment that takes place during the system operations and sustainment phase.

Figure C-1 shows the placement of a program's acquisition logistics support costs as part of its procurement cost.

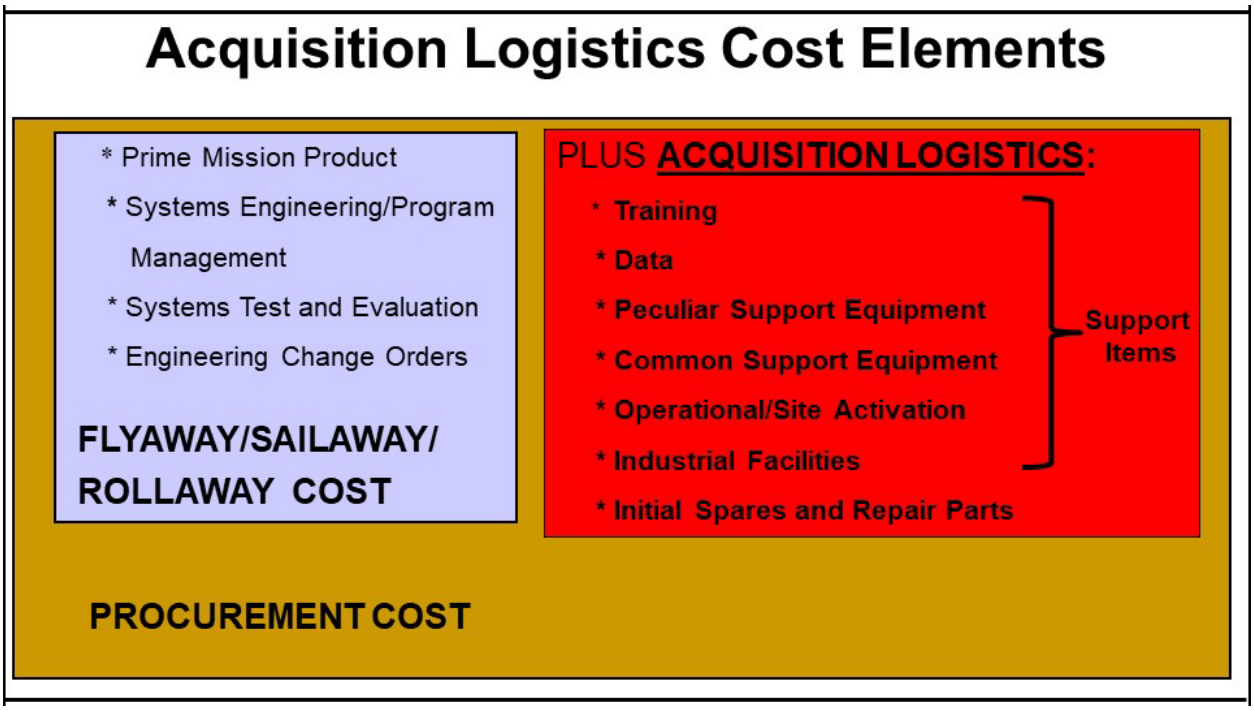

Figure C-1. Acquisition Logistics in a Procurement Cost Estimate

Basic terms and definitions for the acquisition logistics support cost elements are provided in MIL-STD-881D, *Work Breakdown Structures for Defense Materiel Items*, Appendix K (Common Elements). These cost elements are defined as follows:

- **Training**. Consists of operational and maintenance training equipment, training courses and course materials, and other training services.

- **Data**. The deliverable data procured by the Government as required on a contract data requirements list. This typically includes technical publications, engineering data, management data, and other support data. This may also include the Government's license rights to contractor intellectual property.
- **Peculiar Support Equipment**. Items and associated software required to support and maintain the weapon system or portions of the system, and which are not common support equipment.
- **Common Support Equipment**. Items and associated software required to support and maintain the weapon systems or portions of the system, and which are presently in the DoD inventory for support of other systems.
- **Operational/Site Activation**. Facilities, materials, and services required to house, service, and launch prime mission equipment at the initial system sites or bases.
- **Industrial Facilities**. The construction, conversion, or expansion of industrial facilities for production, inventory, and contractor depot maintenance when that service is for the specific system.
- **Initial Spares and Repair Parts**. Repairable spares and repair parts required as initial stockage to support and maintain newly fielded systems during the initial phase of service. This includes pipeline and war reserve quantities, at all levels of maintenance and support.

Although these acquisition logistics support costs are for the most part procurement funded, they nevertheless are a critical investment necessary for a program's overall sustainment and product support package. Figure C-2 shows a graphical depiction of this concept.

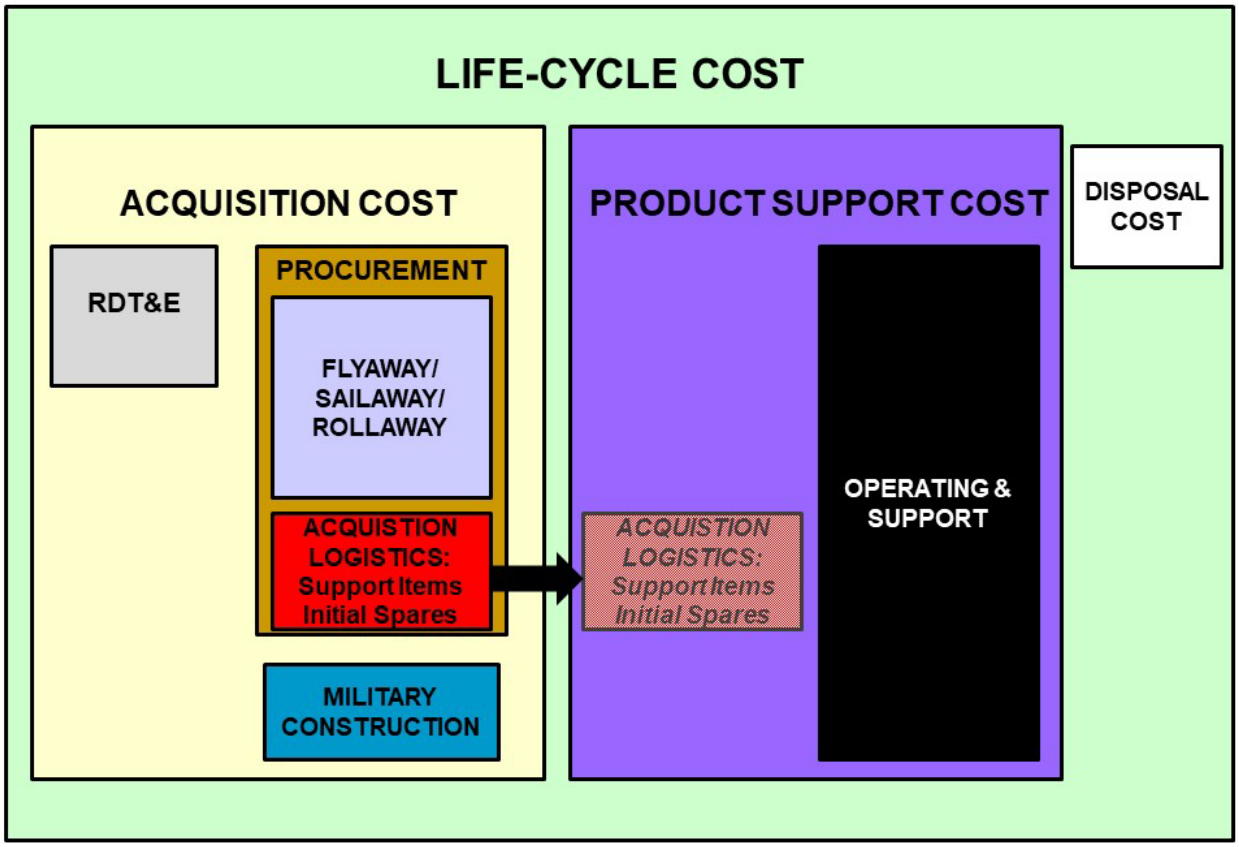

Figure C-2. Acquisition Logistics Costs in a Life-Cycle Cost Estimate

There is a transition between the investments in the acquisition logistics support cost elements and the support in the O&S cost elements. Often, much of this transition is provided by Interim Contractor Support (ICS). ICS is temporary contractor support provided before a permanent support solution (organic or contractor) is established. This support consists of labor, material and overhead for maintenance, supply management, and other support functions during the early fielding of the system.

Additional background about ICS, Contractor Logistics Support (CLS), and Performance-Based Logistics (PBL) is provided in Appendix F.

Table C-1 illustrates the transition from the acquisition logistics cost elements through various functions to the O&S cost elements.

Table C-1. Transition from Acquisition Logistics to O&S

Acquisition Logistics Cost Elements	Transition Function	O&S Cost Element
Training (Equipment)	Repair of Training Equipment	Simulator Operations and Repair
Training (Services)	Interim Training (Training the Trainers)	System-Specific Training
Data	Interim Updates to Data and Technical Publications	Data and Technical Publications
Support Equipment	Repair of Support Equipment	Support Equipment Replacement and Repair
Operational Site Activation (Local Manpower)	Field Service Representatives	Unit-Level Manpower
Operation Site Activation (Other Support)	Site Activation Support	Support Services
Industrial Facilities	Conversion or Expansion of Industrial Facilities	Maintenance (overhead for depreciation)
Initial Spares and Repair Parts (Reparables)	Repair of Reparable Items	Depot Level Reparables
Initial Spares and Repair Parts (Reparables)	Depot Activation	Depot Level Reparables
Initial Spares and Repair Parts (Consumables)	Replacement of Consumable Items	Consumables

Note that the costs for the sustainment of the industrial facilities for the inventory control points and maintenance depots are captured in the overhead for facilities depreciation in the maintenance cost elements (consumables, depot level reparables, and depot maintenance).

APPENDIX D
Mapping from O&S Cost Elements to Budget Appropriations

Introduction

This appendix provides a mapping from individual O&S cost elements to the major appropriation categories: Research, Development, Test, and Evaluation (RDT&E); Procurement; Military Personnel; and Operations and Maintenance (O&M). This mapping is important because it permits an O&S cost estimate to project required funding resources by fiscal year by appropriation for the weapon system. In particular, one specific chart, known as the Program Funding and Quantities chart, displays for a program cost estimate a comparison between required versus programmed funding by fiscal year for each appropriation. This chart is updated at each milestone review throughout the acquisition process. The Program Funding and Quantities chart[1] is described in the *DoD Cost Estimating Guide*.

O&S Cost Element Structure Mapping

Figure D-1 provides a notional mapping from cost element to appropriation category, although the specific mapping for each program might vary.

[1] The Program Funding and Quantities chart is known colloquially as the Spruill chart, named after Dr. Nancy Spruill, a prominent senior acquisition official for many years and originator of the chart format.

					Military	Operations &
			RDT&E	Procurement	Personnel	Maintenance
	CAPE O&S Cost Element					
1.0	Unit-Level Manpower					
1.1	Operations Manpower				X	
1.2	Unit-Level Maintenance Manpower				X	X
1.3	Other Unit-Level Manpower				X	X
2.0	Unit Operations					
2.1	Energy (Direct Fuel, Electricity, etc.)					X
2.2	Training Munitions and Expendable Stores			X		X
2.3	Support Services					X
2.4	Temporary Duty (TDY) Travel					X
2.5	Second Destination Transportation					X
3.0	Maintenance					
3.1	Consumables					X
3.2	Depot Level Reparables					X
3.3	Intermediate Maintenance (External to Unit-Level)				X	X
3.4	Depot Maintenance					X
4.0	Sustaining Support					
4.1	System-Specific Training			X	X	X
4.2	Support Equipment Replacement and Repair			X		X
4.3	Sustaining/Systems Engineering				X	X
4.4	Program Management				X	X
4.5	Data and Technical Publications			X		X
4.6	Simulator Operations and Repair				X	X
4.7	Other Sustaining Support					X
5.0	Continuing System Improvements					
5.1	Hardware Modifications			X		X
5.2	Software Maintenance				X	X

Figure D-1. Mapping of O&S Cost Elements to Appropriation Categories

Notes:

1. For manpower costs, military personnel appropriations are used for military personnel, and O&M funds are used for contractor and government civilian personnel.
2. Some cost estimates or cost data reports might have Interim Contractor Support (ICS) or Contractor Logistics Support (CLS) as cost elements. Normally, ICS costs are funded with procurement appropriations, and CLS costs are funded with O&M appropriations.
3. Training munitions may be funded with Ammunition Procurement, Weapons Procurement, or O&M appropriations.

4. For Navy ships and submarines, most overhauls and availabilities are treated as depot maintenance in the cost element structure, and are funded with O&M appropriations. Fleet modernization costs are treated as hardware modifications, and are funded with procurement ("Other Procurement") funds. However, for a Navy procurement appropriation known as Shipbuilding and Conversion, Navy (SCN) may be used for major ship service-life extension programs. SCN funding is also used for the Refueling and Complex Overhaul (RCOH) of nuclear-powered carriers. In addition, the cost estimates for ships with nuclear reactors normally do not include the costs associated with the Department of Energy/National Nuclear Security Administration.
5. Civilian and contractor support, which is O&M funded, can be used for operations manpower for a few system types such as space systems and some unmanned aerial vehicles.

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APPENDIX E
Analytic Support for Sustainment Reviews

Introduction

10 U.S.C. 2441 (Sustainment Reviews), added by the National Defense Authorization Act (NDAA) for FY 2017, requires the military departments to conduct a sustainment review of each major weapon system not later than five years after declaration of initial operational capability (IOC) of a Major Defense Acquisition Program (MDAP) and throughout the life cycle of the weapon system to assess the product support strategy, performance, and operating and support (O&S) costs of the weapon system. For any review after the first one, the Secretary concerned shall use availability and reliability thresholds and cost estimates as the basis for the circumstances that prompt such a review. In 10 U.S.C. 2379f (Major Weapon System Defined), the term *major weapon system* means a weapon system acquired pursuant to an MDAP.

Each sustainment review is required to include the following elements:

- An independent cost estimate for the remainder of the life cycle of the program.
- A comparison of actual costs to the amount of funds budgeted and appropriated in the previous five years, and if funding shortfalls exist, an explanation of the implications on equipment availability.
- A comparison between the assumed and achieved system reliabilities.
- An analysis of the most cost-effective source of repairs and maintenance.
- An evaluation of the cost of consumables and depot level reparables (DLRs).
- An evaluation of the costs of information technology, networks, computer hardware, and software maintenance and upgrades.
- As applicable, an assessment of the actual fuel efficiencies compared to the projected fuel efficiencies as demonstrated in tests and operations.
- As applicable, a comparison of actual manpower requirements to previous estimates.
- An analysis of whether accurate and complete data are being reported in the cost systems of the military department concerned, and if deficiencies exist, a plan to update the data and ensure accurate and complete data are submitted in the future.

Current DoD guidance concerning sustainment reviews is provided in DoD Instruction (DoDI) 5000.85, Appendix 3D (“Product Support”).

There is also an additional statutory provision that establishes a requirement to update estimates of O&S costs periodically throughout the life cycle of a major weapon system. This provision is described at the end of this appendix.

Analytic Methods for Sustainment Reviews

The purpose of this appendix is to describe suggested analytic methods that could be used in support of such reviews. Specific remarks and examples are provided for each element required to be addressed in the review. The examples provided in this appendix concern major weapon systems. However, in some cases, the sustainment review could address a system upgrade. The analytic approach and examples would need to be tailored for that situation. The cost analyst would need to work with the sponsor of the sustainment review to establish the expectations and approach for a sustainment review of a system upgrade.

Independent Cost Estimate

The Office of Cost Assessment and Program Evaluation (CAPE) has established procedures for independent cost estimates (ICEs) for sustainment reviews in the most recent revision to DoDI 5000.73, *Cost Analysis Guidance and Procedures*. In this guidance, a sustainment review is supported by an ICE. There are three possibilities for the responsibility for the ICE. CAPE may choose to either prepare the ICE, review and approve a Service cost agency or Defense Agency equivalent ICE, or delegate the responsibility for the ICE to the DoD Component. If CAPE does not choose to conduct or approve the ICE, the ICE is prepared in accordance with the policies and procedures of the Service cost agency or Defense Agency equivalent. In any case, the ICE should be briefed at the sustainment review, and a copy of the ICE report should be provided to CAPE within seven days of the sustainment review. Additional guidance and timelines are provided in DoDI 5000.73. General discussion about the planning, conducting, documenting, and presenting an O&S cost estimate is provided in Chapter 7 of this guide.

Comparison of Actual Costs and Funds Budgeted

After the program enters Engineering and Manufacturing Development (EMD) and is approaching Low-Rate Initial Production (LRIP), preliminary information and projections about the system support can be used to establish an initial baseline for sustainment resource requirements. This information may initially be based on engineering estimates, but can be updated after IOC and beyond with test results and actual cost experience to ensure realistic funding of sustainment resource requirements.

For the programming process, in the Future Years Defense Program (FYDP), most of a system or unit O&S cost (such as unit manpower and unit operations) is typically programmed in a primary program element associated with the system or unit. Examples of primary program elements are F-16 squadrons, guided missile destroyers, and heavy armored brigade combat

teams. Comparisons between most likely cost and programmed funding can be made and presented for these direct costs. Other O&S costs (e.g., some depot maintenance and some training units) are centrally programmed (i.e., not programmed by the individual weapon system or unit accounts). It is more difficult, if not impossible, to compare these system or unit costs to programmed funding. Care must be taken to fully understand the scope and content of the programmed funding in the primary program element.

Figure E-1 shows an example of such a comparison for a Navy ship.

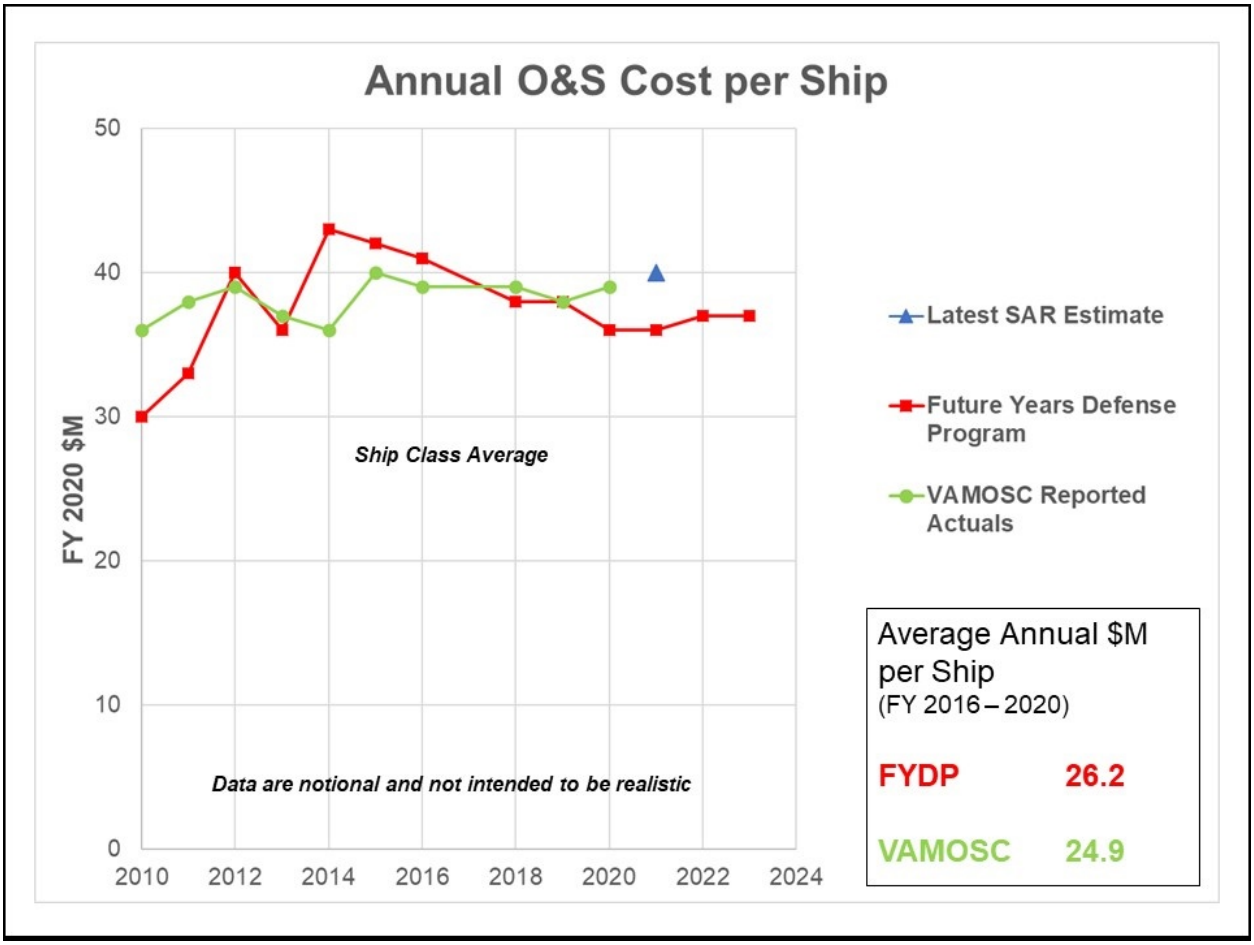

Figure E-1. Sample System O&S Comparison of Funding to Actual Cost

This figure provides a comparison of the programmed funding reflected in the most recent FYDP, the actual costs obtained from the Naval Visibility and Management of Operating and Support Costs (VAMOSC) data system, and the most recent program Selected Acquisition Report (SAR) estimate. These costs are based on the O&S categorization described in Chapter 4 of this guide. For many mature programs that have completed their procurement, SAR reporting will have ceased and a current SAR estimate will not be available. The figure displays the trends associated with the annual costs and programmed funding, as well as a comparison of the

averages between the two over the last five years. This example is shown for the ship class average. In some cases, it would be necessary to stratify the data by flight or block.

The comparison of programmed funding to actual cost experience for individual weapon systems is not always possible. For most Army and US Marine Corps (USMC) ground systems, the unit structure (and associated program element) is not oriented toward individual weapon systems, but rather is associated with a more aggregate unit (e.g., heavy brigade combat team) that is equipped with multiple weapon systems. For these types of weapon systems, an alternative approach would be to address funding for selected individual cost elements for that system from budget data.

For the budget process, analytic support to the budget process is not usually conducted in terms of the aggregate total system O&S cost, but rather at lower levels of detail—normally, individual high-cost Operations and Maintenance (O&M) elements, and system or unit manpower. These two areas are discussed further later in this appendix. The analyses presented later in this appendix are illustrative examples of the kinds of analyses that could also be used to support a sustainment review. Additional remarks about methods for addressing how any funding shortfalls affect equipment availability are provided later in this appendix.

Comparison of Assumed and Achieved Reliabilities

In tracking system reliability, normally each program may select the reliability metric or metrics to be used. It is important for analysts to understand the definition and ground rules for each reliability metric.

Figure E-2 provides an illustrative example of a track of the reliability for an aircraft.

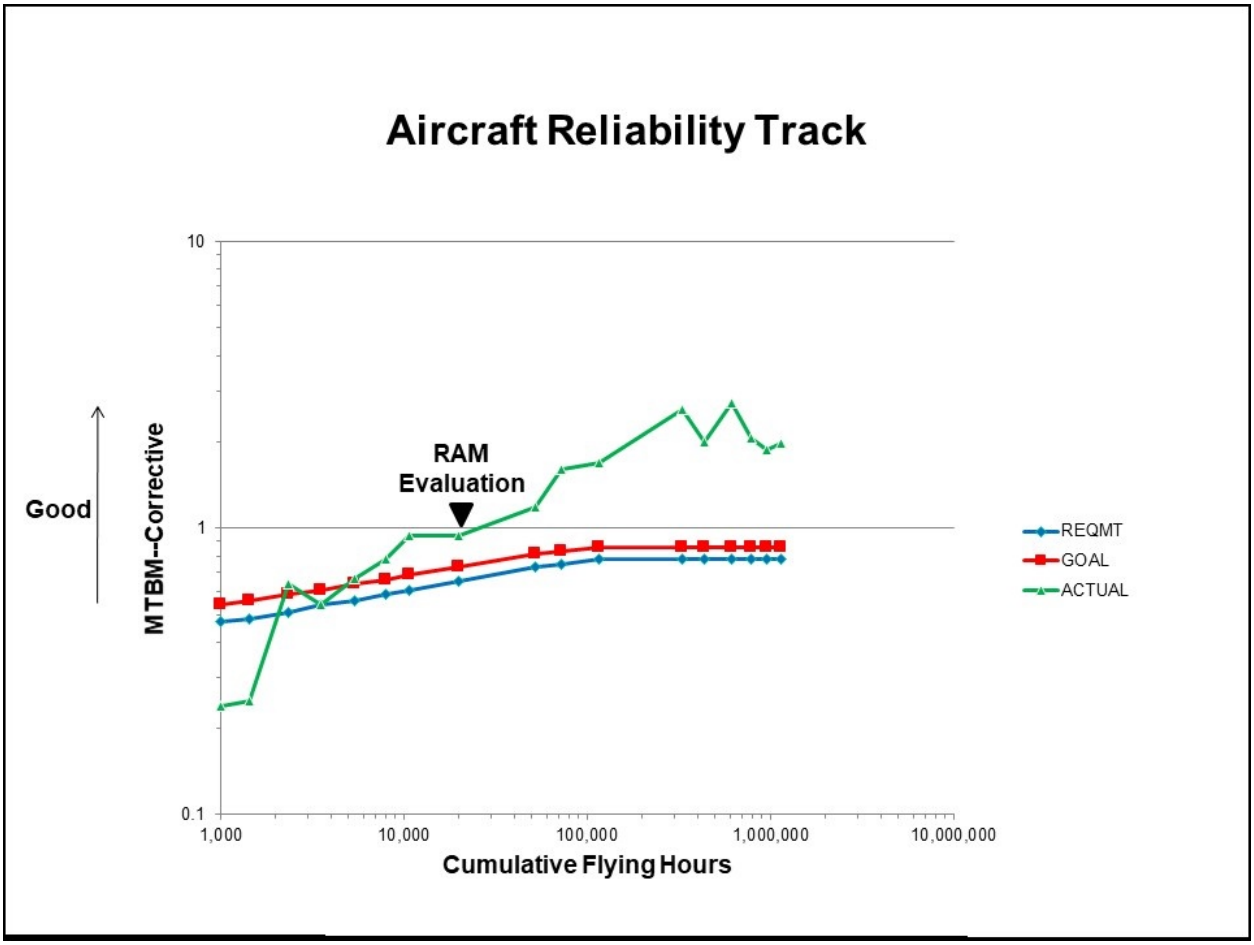

Figure E-2. Track of Aircraft Reliability Metric

In this example, reliability is measured as Mean Time Between Maintenance (MTBM) events, where the events are corrective maintenance actions. The program has two baseline values for reliability that are part of the contract specification. The first reliability value is the minimum requirement or threshold (which must be met), and the second is the desired goal or objective that is slightly better than the requirement. Typically, there would be appropriate incentives (such as award fees associated with performance demonstrated in a Reliability, Availability, and Maintainability (RAM) Evaluation) for the contractor to surpass the minimum requirement. The reliability growth curves associated with the specification values assume that the reliability is improved over time due to design changes to correct deficiencies discovered in test and evaluation, or due to improvements in parts quality as the production process matures, up to the point of reliability maturity (which is assumed to occur at 100,000 cumulative flying hours in this example). The track also shows the actual test data for the same points in time as the program baseline (requirement and goal). In this example, the early reliability was deficient relative to the baseline, but over time the contractor was able to address the problem and reach a reliability value at maturity that significantly surpassed the specification values.

As part of the Defense Acquisition Executive Summary (DAES) reporting system, programs undergoing test and evaluation are required to provide quarterly reports on their status in achieving program requirements (goals and thresholds) for reliability. Each program may select its own reliability metric and associated definition. These reports provide the results from test data relative to reliability growth curves consistent with program requirements. These reports are available to analysts with access to the DAES system. More importantly, cost analysts can obtain assessments concerning test results for reliability and maintainability from the Director of Operational Test and Evaluation (DOT&E) annual report and from reports from other military department test organizations. For mature programs, reliability data may be obtained from a maintenance data collection system such as the Air Force Reliability and Maintainability Information System (REMIS) or the Navy DECision Knowledge Programming for Logistics Analysis and Technical Evaluation (DECKPLATE) maintenance data management and warehousing system.

Analysis of Cost-Effective Source of Repairs and Maintenance

Every MDAP program manager or product support manager is required to develop and implement an affordable and effective performance-based product support package. This package is described in the product support strategy, the primary document used to describe the program plans for sustainment across the life cycle. Guidance on the product support strategy is provided in DoDI 5000.85, Appendix 3D ("Product Support).

The product support strategy is supported by a business case analysis, which is an annex to the strategy. A business case analysis is a type of economic analysis that a program manager may use when deciding among any number of product support alternatives. It is a structured approach to identify the cost, benefits, and risks of the alternatives. To ensure accurate results, the business case analysis depends on valid O&S cost data and estimates as well as user requirements and related supportability analysis results.

The business case analysis may consider alternatives of organic, contractor, or some combination for sources of sustainment support. In addition, the business case analysis may evaluate other sustainment alternatives, such as choice of contract type, various technical data rights strategies, and whether or not to establish competition—or the option of competition—for the supported system or major subsystems.

Further information may be found in the *DoD Product Support Business Case Analysis Guidebook*.

Evaluation of Costs of Consumables and DLRs

Each military department provides an annual budget submission for its O&M appropriations. Much of the submission consists of numerous detailed budget justifications. These justifications provide visibility into various O&M activities, and can be used in analyses to

help ensure that the O&M accounts are executable, properly priced, and adequately funded for proper readiness.

For the major weapon systems, several specific budget reports provide visibility into system inventories; usage or operating tempos (OPTEMPOs); and funding for DLRs, consumables, fuel, and depot maintenance. The specific report format is tailored to the type of weapon system involved. The instructions, terms, and definitions for these reports are provided in the DoD *Financial Management Regulation*, Volume 2A, Chapter 3. Figure E-3 provides a summary of the key O&M budget justification documents.

Annual Budget Reports for Weapon System O&M Accounts

Report	Title	Components Reporting	
OP-20	Flying Hour Program	All	
• Report Detail……..Aircraft Series (e.g. F-16C), O&M Sub-Activity Group (SAG), FYDP Program Element (PE)			
• Programmatic Data…….Aircraft Quantity, Flying Hours (Funded and Required), Funded Hours/Crew/Month • Funding Data……..Fuel, Reparables, Consumables			
OP-25	Ground Vehicles Operation	Army/USMC	
• Report Detail……..Major Fighting Vehicle (e.g.. M1), O&M SAG, FYDP PE			
• Programmatic Data…….Vehicle Quantity, Barrels of Fuel, OPTEMPO Miles (Funded and Required) • Funding Data……..Fuel, Reparables, Consumables			
PB-61	Depot Maintenance Program	All	
• Report Detail……..Maintenance Activity (Aircraft, Ground Vehicles, Ships, Missiles, Ordnance, Other), Maint. Type (Airframe, Engine, Vehicle, Software, Other, etc.)			
• Programmatic Data……Units Programmed (Airframe, Engines, Vehicles, etc.) • Funding Data……..Maintenance Activity and Type, Funded and Required			
OP-41	Ship Operating Cost Data	Navy	
• Report Detail……Ship Type, O&M SAG, FYDP PE			
• Programmatic Data…….Ship Quantity, Steaming Days (Funded/Required) • Funding Data……..Repair Parts, Fuel, Consumables, Nuclear Fuel			

Figure E-3. Key O&M Budget Justification Reports

- The OP-20 report is used for aviation assets by all of the military departments. The OP-20 combines information on aircraft inventories and flying hours with funding for consumables, DLRs, and fuel.
- Similarly, the OP-25 presents data for ground vehicles. These include information on vehicle quantities and miles driven, with funding for consumables, DLRs, and fuel.

- The PB-61 report provides information on the depot maintenance accounts, including planned or completed overhauls and the funding associated with depot maintenance. The report for Navy ships provides information on overhauls, restricted availabilities, and phased maintenance availabilities.
- Specific to ships, the OP-41 report provides operating information about ship quantities and steaming days, with funding for DLRs, fuel, and consumables.

Information extracted from the various O&M budget reports can be compared to actual cost experience to assess the funding adequacy for the major O&M cost elements. Figure E-4 shows an example of such an assessment for the funding for DLRs for an aircraft system.

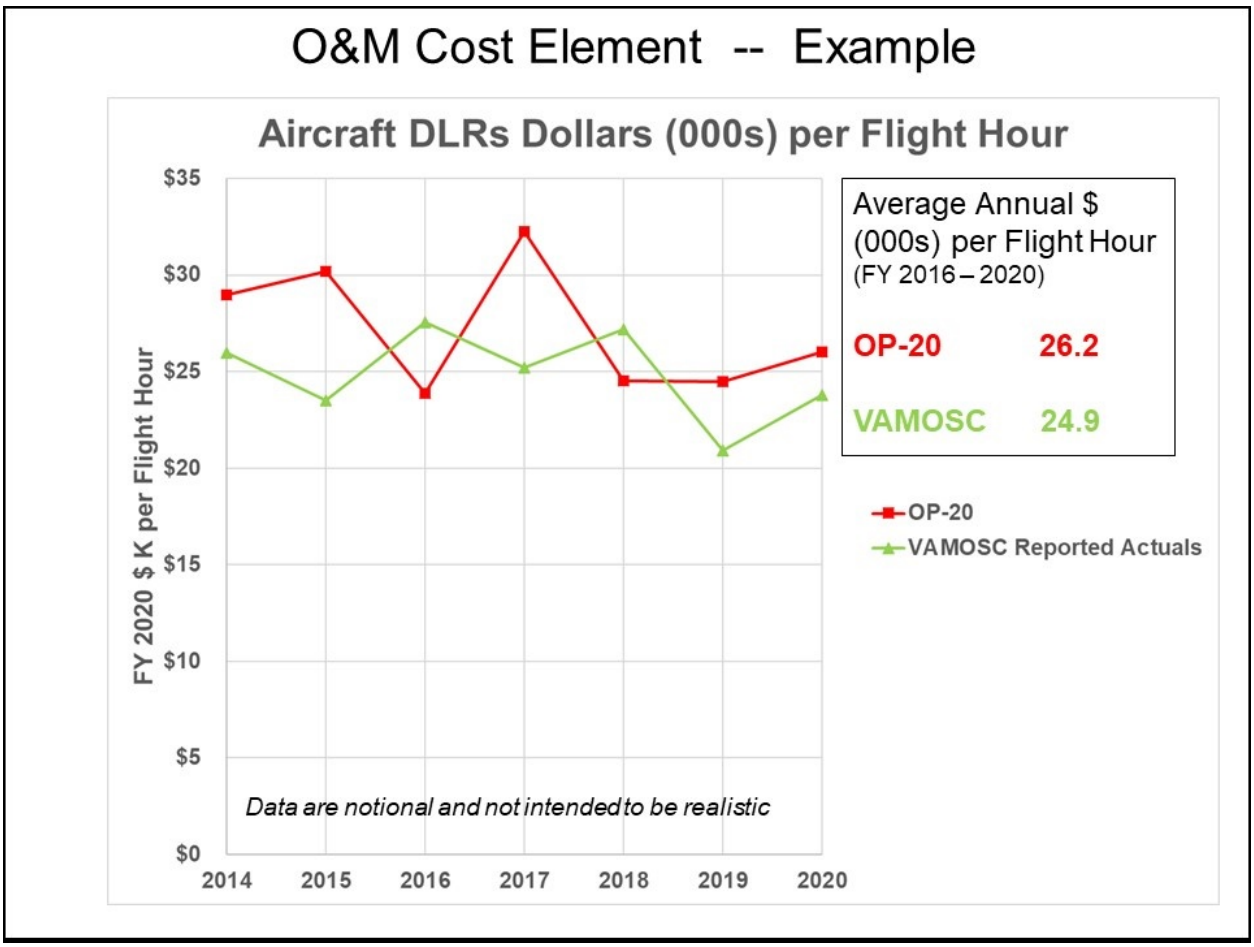

Figure E-4. Sample Budget Assessment for an O&M Cost Element

The actual cost data could be taken from a VAMOSC system. The figure displays the trends associated with the annual costs and the budgeted funding. In addition, the averages for costs and funding over the last five years are shown in the box on the right. Similar charts could be prepared for depot maintenance, fuel, consumables, and other cost elements.

The O&M budget reports and the VAMOSC data address funding and costs for organic maintenance, but do not address Contractor Logistics Support (CLS). For systems with significant CLS, it would also be necessary to obtain system CLS funding from the O&M budget and CLS costs from the Cost and Software Data Reporting (CSDR) reports for sustainment and the Maintenance and Repair Parts Data Report discussed in Chapter 6 of this guide.

Figure E-5 shows an alternative approach for addressing the costs of consumables and DLRs.

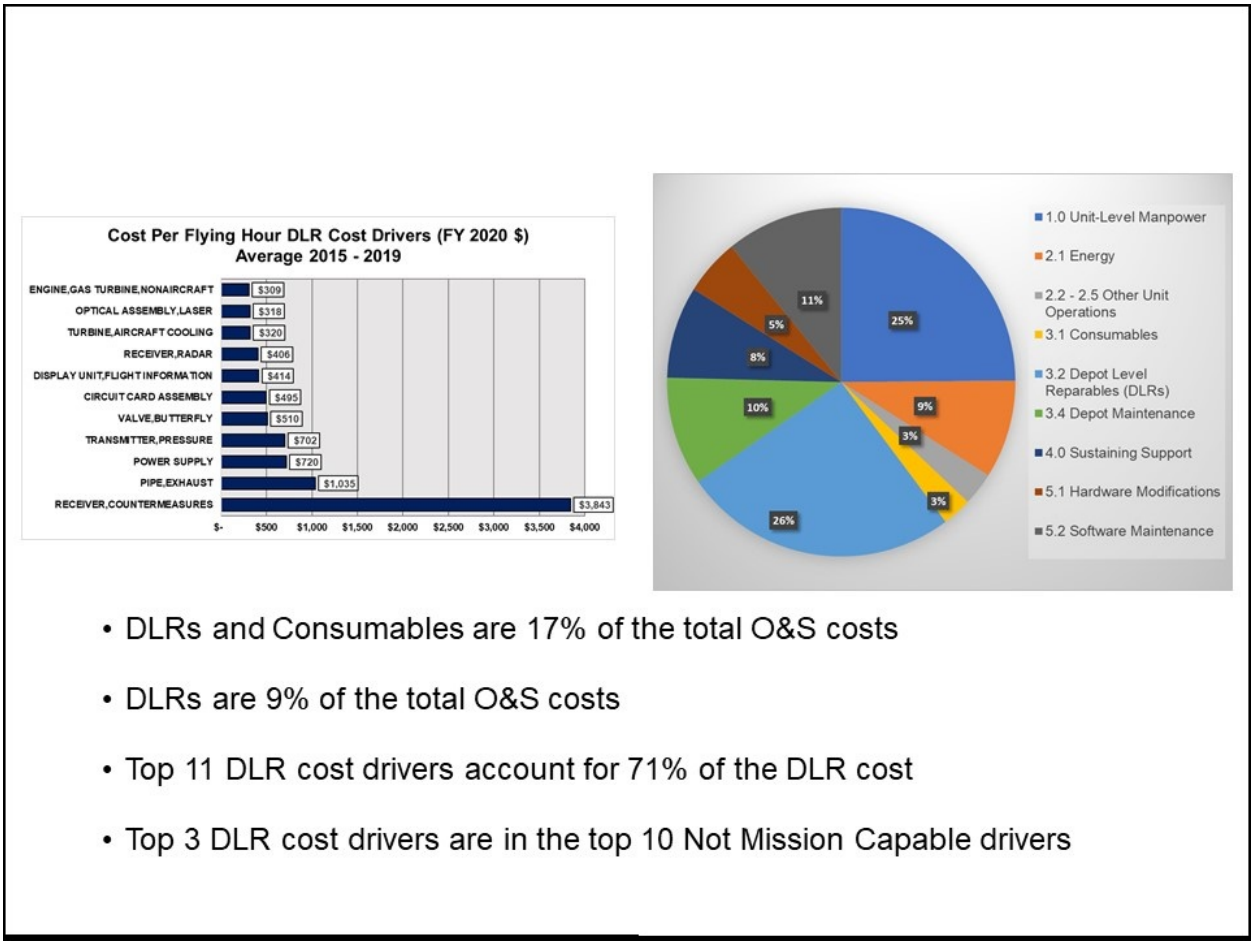

Figure E-5. Alternative Approach for Consumables and DLRs

The pie chart on the right shows the percentage breakdown of the major O&C cost elements. The bar chart on the left shows the top DLR cost drivers.

In making such assessments, it is important to determine that the funding supports a proper level of readiness. The various budget reports summarized in Figure E-3 only provide some of the information to help make such a determination. For example, in assessing the adequacy of funding for depot maintenance, it would be important to ensure that the funding was not resulting in growth of maintenance backlogs. Similarly, for O&M cost elements such as fuel, DLRs, and

consumables, it would be important to ensure that the funding supported the required OPTEMPO and availability for the system.

Evaluation of Costs of Information Technology, Networks, Computer Hardware, and Software Maintenance and Upgrades

For this assessment, it is likely that it will be necessary to identify the applicable components in the weapon system relevant to this particular element of the sustainment review. This could include embedded prime mission product components such as sensors, data links and communication relays, SATCOM antennas, and processors and memory devices; ancillary equipment such as servers, workstations, and laptops; and hardware/software used for malfunction detection and isolation. These items would not only be identified for a baseline configuration, but also for any planned upgrades and technology insertion. For the individual components, it would then be necessary to obtain relevant data pertaining to sustainment such as reliability and supply support, item cost to repair and cost to replace, training workload and frequency, technical data and support equipment, software maintenance, and any contractor logistics data. In some cases, the sustainment review ICE could also be a source of data. These data could then be used to construct a cost estimate by using an accounting model at the component level of detail such as the model described in Appendix G of this guide.

Assessment of Fuel Efficiency

It was previously noted that fuel consumption can often be a major high-cost O&M element for many systems, and the earlier section of this appendix already discussed an approach for the assessment of the costs of such elements. What is unique to fuel is that metrics for fuel efficiency are normally associated with fuel consumption, and not in dollars. This is because the price of fuel can vary quite a bit from one year to the next.

For example, for an aircraft system, fuel consumption would normally be assessed in terms of gallons per flight hour. The track of actual fuel efficiencies compared to previous projections could be displayed in a format similar to the format shown in Table E-1.

Table E-1. Track of Aircraft Fuel Efficiency

Year	Event	Fuel Gallons per Flight Hour
2003	Milestone B Estimate	2,290
2007	Milestone C Estimate	2,370
2014	Full-Rate Production Decision Estimate	2,450
2019	Current Operations (FY 2015–2019)	2,740

The various VAMOSC systems provide data on fuel consumption for most weapon systems.

Comparison of Actual Manpower to Previous Estimates

Manpower is an important element in system O&S costs, since manpower often accounts for a large fraction of the total program O&S cost. For example, for Navy surface ships, ship manpower accounts for, on average, roughly 40 percent of the ship's total O&S cost. Manpower estimates serve as the authoritative source for a program's projected manpower requirements. The manpower estimate (formerly known as the Manpower Estimate Report) is approved by the cognizant military department manpower authority (normally the Assistant Secretary for Manpower and Reserve Affairs).

The manpower estimate provides the program manpower needed for system operations, maintenance, support, and system-related training. The manpower is provided separately for active-duty officer and enlisted end-strength, reserve officer and enlisted drill and full-time end-strength, civilian full-time equivalents, and contractor support work-years. If applicable, it is also necessary to display the manpower requirements by Component (Active, Guard, or Reserve). Each military department has its own process to continually review and update program manpower requirements as the program matures and begins operations. These requirements are typically documented in some form of unit manning document or table of organization and equipment, although the specific format will vary among the military departments. Although the manpower estimate described earlier does not include grade structure or skill level, the unit manning document typically does. For example, in the case of surface ships, the Navy publishes a Ship Manning Document for each class (and configuration) of ship. The Ship Manning Document provides manpower requirements in terms of grade, occupation, and skill level, predicated on the program's required capabilities and operational environment, computed workload, and productivity assumptions (such as standard workweeks, leave policy, etc.). The Navy reviews its Ship Manning Documents each year, and updates them when there are significant changes to the mission, operational concept, or ship configuration.

It is important to verify that the approved manning levels are programmed and funded as the program nears system operations and beyond. One way to accomplish this would be to

compare the approved manning levels, the programmed manpower authorizations as reflected in the FYDP, and (when available) the actual manning. Figure E-6 shows such a comparison for a Navy surface ship.

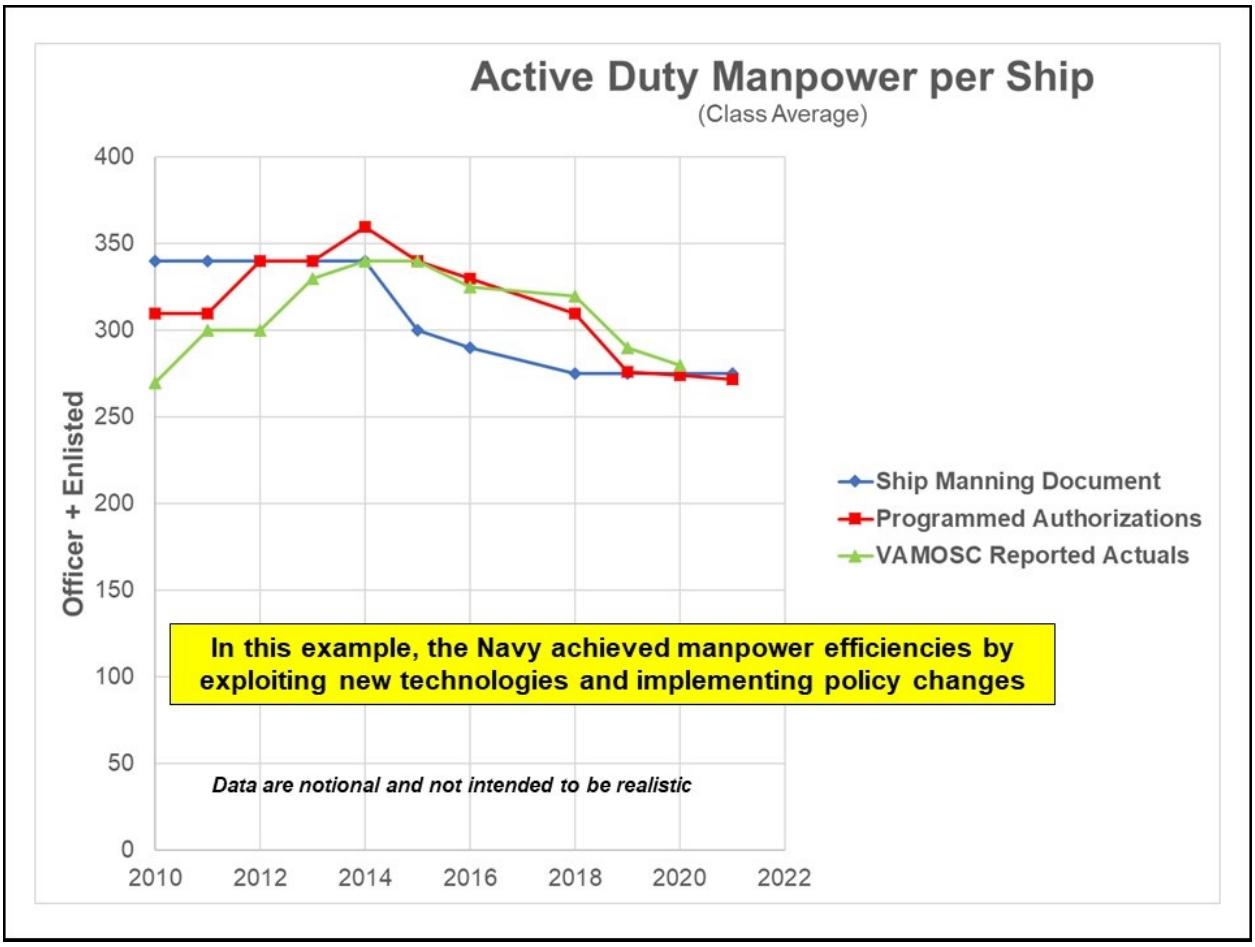

Figure E-6. Assessment of Ship Manning

In this example, the data are provided for the ship class average. Again, in some cases, the data would need to be stratified by flight or block.

The actual manning can be provided by the Naval VAMOSC data system. In general, the approved manning, programmed manning, and actual manning should be reasonably consistent on average over a multiple-year period, although there may be variations among the three in any one year due to lags in programming, budgeting, and execution. In this example, the approved manning, programmed manning, and actual manning align quite closely. If that were not the case, it would be appropriate to investigate the reasons for and implications of any significant discrepancies.

Analysis of Data Accuracy and Completeness

For currently fielded major systems, historical O&S cost data for the most part are available from the VAMOSC data system managed by each military department. 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 organization or location (such as major command or base). This should be done so that abnormal outliers in the data can be identified and documented, investigated, and resolved as necessary.

VAMOSC data are sometimes supplemented with other data. As noted in Chapter 6 of this guide, CSDR data collection and reporting now applies to major weapon system sustainment contracts and subcontracts above specified dollar thresholds. There are also more specialized reliability and maintainability data, which can be obtained from military department maintenance data collection systems. In addition, VAMOSC data for unit-level manpower are often supplemented with information from more detailed unit manning documents or tables of organization and equipment.

Post-IOC O&S Cost Estimates

10 U.S.C. 2337a (Assessment, Management, and Control of Operating and Support Costs for Major Weapon Systems) requires the military departments to update estimates of O&S costs periodically throughout the life cycle of a major weapon system, to determine whether preliminary information and assumptions remain relevant and accurate, and identify and record reasons for variances. This provision also requires the military departments to conduct periodic reviews of O&S costs of major weapon systems after such systems achieve IOC to identify and address factors resulting in growth in O&S costs and adapt strategies to reduce such costs.

CAPE guidance concerning this provision is provided in DoDI 5000.73. This guidance states that:

- After IOC, DoD Components must continue to track O&S costs and update O&S cost estimates yearly throughout an MDAP's or major system's life cycle to determine whether preliminary information and assumptions remain relevant and accurate and to identify and record reasons for variances.
- O&S cost estimates are independently reviewed at post-IOC reviews.
- Each O&S cost estimate must be compared to earlier estimates and the program's sustainment goals. This comparison must identify the reasons for significant changes.

A notional example of such a comparison (based on an actual case study) follows. Figure E-7 shows an example of a track of various O&S cost estimates that were made for an aircraft program.

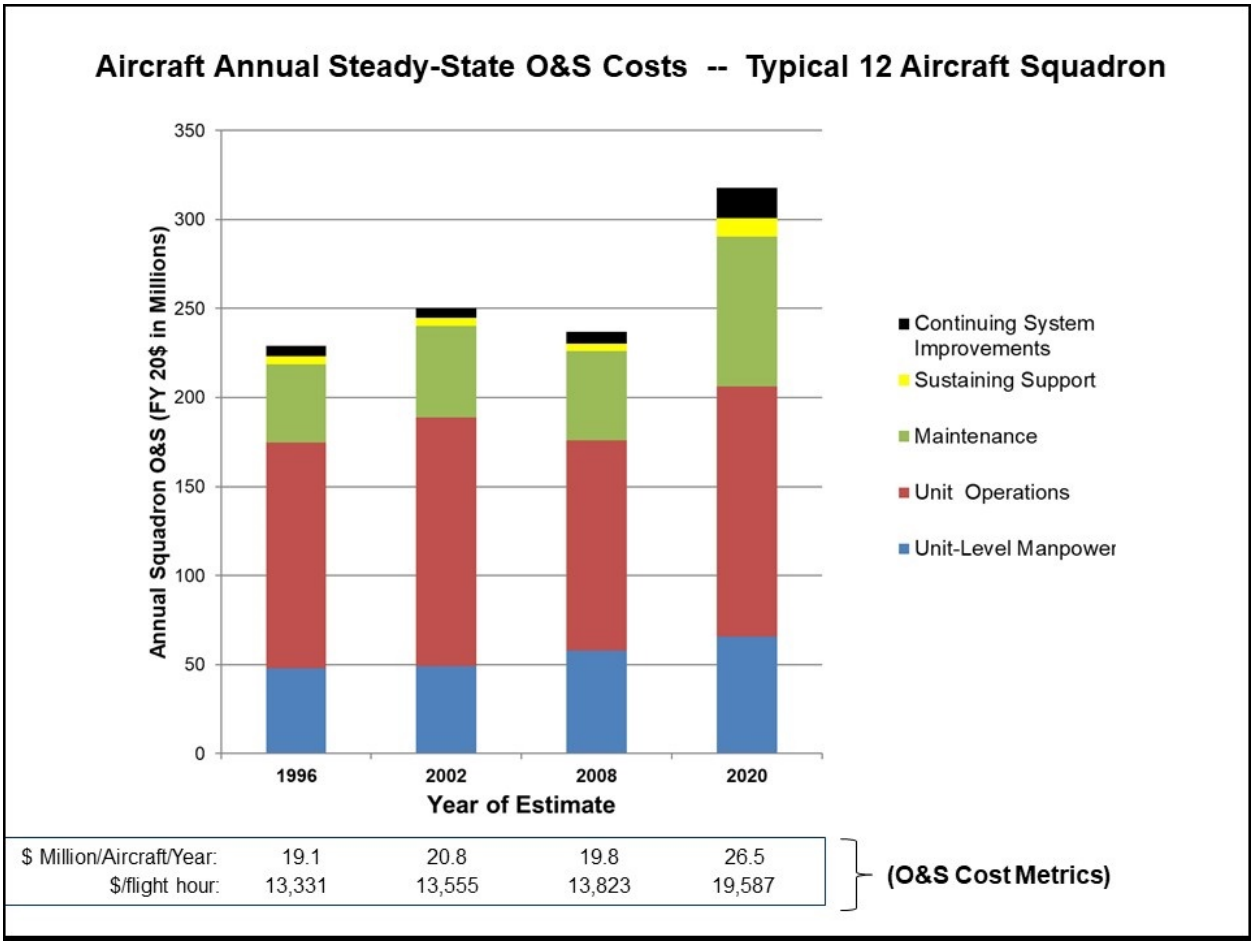

Figure E-7. Track of O&S Cost Estimates

The chart shows the annual steady-state O&S costs for a typical aircraft squadron, where the costs are broken down and displayed using the standard direct cost elements described in Chapter 3 of this guide. The chart shows a comparison of four cost estimates made at different points in time. The first estimate supported a Milestone B decision in 1996, the second estimate supported a Milestone C decision in 2002, the third estimate supported a Full-Rate Production decision in 2008, and the fourth estimate supported a sustainment review in 2020. Alternatively, the track of O&S costs could be displayed as cost per system per year, or cost per unit of usage or OPTEMPO (in this case, flight hour). The earlier cost estimates included indirect costs; these indirect costs have been removed for this comparison.

In this example, the fourth (current O&S) cost estimate is significantly higher than the earlier estimates. The various reasons for the cost growth between the current estimate (2020) and the Milestone B estimate (1996) were identified. Figure E-8 displays the results of this assessment.

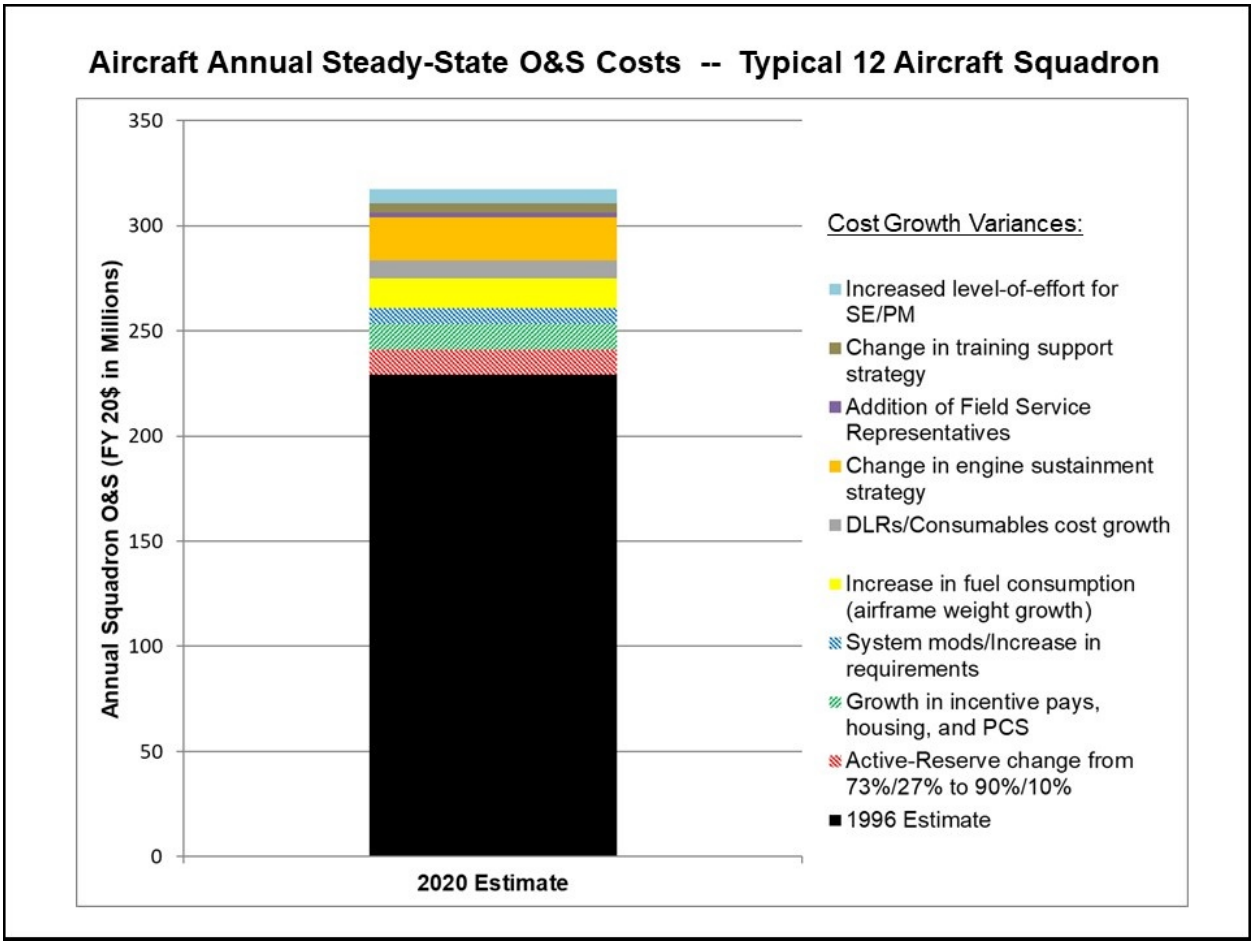

Figure E-8. Assessment of O&S Cost Growth

The Milestone B estimate is shown at the bottom of the stacked bar chart. The variances that result in the cost growth reflected in the current estimate are displayed individually. In this example, a key difference between the two estimates is that the Milestone B estimate had assumed an organic maintenance strategy, whereas the current estimate is based on a Contractor Logistics (CLS) strategy. These variances between the two estimates are as follows:

- Change in active-reserve mix.
- Unanticipated real growth (or price escalation) in manpower costs per military member for incentive and special pays, housing, and Permanent Change of Station (PCS) moves.
- Unanticipated modification costs associated with safety upgrades necessary to meet evolving flight-worthiness standards mandated by the Federal Aviation Administration.
- Higher fuel consumption, due to airframe weight growth during development.
- Higher dollars per flight hour for DLRs and consumables due to cost growth from major suppliers.

- Higher costs for engine depot maintenance associated with the CLS strategy (relative to comparable organic support).
- Addition of significant resources for contractor field service representatives, with no offset in organic maintenance manpower.
- Higher costs for training support associated with the CLS strategy.
- Significant increase in the level of effort for sustaining engineering and program management associated with the CLS strategy.

For programs that have submitted recent SARs, the SARs can be a useful source of the reasons for cost variances in the program O&S cost estimates over time. The SAR O&S reporting includes a cost variance analysis that identifies each change, and the reason for it, between each estimate and the prior year's estimate. In the *Annual Selected Acquisition Report Guidance*, the reasons for the variances are classified into the following categories:

- Programmatic/planning factors,
- Cost estimating methodology,
- Cost data update,
- Labor rates,
- Energy rates,
- Technical inputs, and
- Other.

The SAR annual guidance provides further discussion about these categories.

In this example, the change in active-reserve mix would be matched with the programmatic/planning factors category. The growth in military manpower costs would be matched with the labor rate category. Modifications due to new requirements, and the increase in fuel consumption, would be matched with the technical inputs category. The growth in costs for DLRs and consumables would be matched with the cost data update category. The other variances are due to an increase in level-of-effort due to the CLS strategy, and would be matched with the cost data update category.

APPENDIX F
DoD Maintenance and Supply

Background

Introduction

This appendix is intended to provide a brief introduction to the concepts, terminology, and processes for DoD maintenance and supply chain management for major weapon systems. Effective maintenance and supply chain management are critical in ensuring weapon system readiness. Figure F-1 portrays an overview of this idea.

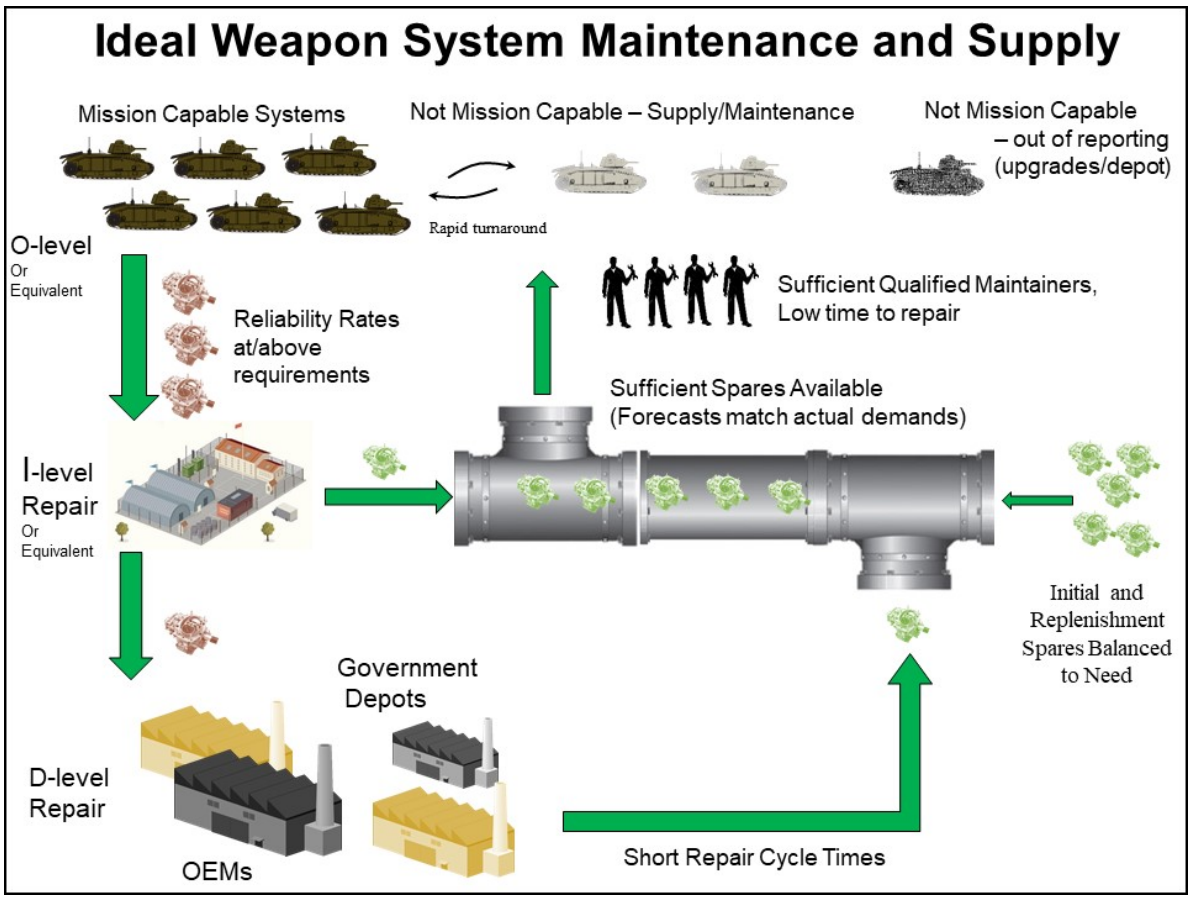

Figure F-1. Overview of DoD Maintenance and Supply

Achieving system availability goals requires responsive maintenance that is adequately resourced in terms of maintenance manpower and is supported by an effective supply chain that provides timely delivery of reparable and consumable items.

DoD maintenance is conducted at different levels. The next three sections introduce the different levels of maintenance. Note that the organizational concepts and terminology vary somewhat by military service.

Unit-Level Maintenance

Unit-level maintenance is field-level maintenance conducted by personnel in the system operating unit (e.g., squadron, ship, or company) or a nearby support unit. Unit-level maintenance consists of organizational maintenance and sometimes unit-level intermediate maintenance. Organizational maintenance or on-equipment maintenance includes the removal and replacement of system reparable or consumable components, and also includes minor adjustments or fault/failure diagnoses that are performed in-place on the system. Organizational maintenance also includes other support activities such as inspections, servicing, handling, and preventative maintenance. Intermediate maintenance or off-equipment shop-type work consists of limited repair of components that have been removed from the system by organizational maintenance personnel. The Army employs a two-level maintenance concept (field and sustainment) and does not use the terms "organizational maintenance" and "intermediate maintenance" in doctrine or practice. For Navy ships, intermediate maintenance is not conducted by ship (unit) personnel and hence is not considered unit-level.

Intermediate Maintenance (External to Unit-Level)

In some cases, intermediate maintenance is performed by organizations that are not considered unit- or field-level. The term *intermediate* is used to refer to a maintenance capability that falls between the capabilities of organizational maintenance and depot maintenance. Navy Regional Maintenance Centers, Aviation Intermediate Maintenance Departments, and the Trident Refit Facility are examples of Navy intermediate maintenance organizations. Note that such organizations not only provide off-equipment component repair, but also can provide limited on-equipment overhauls and repairs for the system as a whole. In addition, there are two public shipyards, Pearl Harbor and Puget Sound, that are hybrid in character and provide both intermediate and depot maintenance.

The Air Force has only a few organizations, known as Centralized Intermediate Repair Facilities, which provide shop-type work, that are not considered unit-level.

As noted above, the Army employs a two-level maintenance concept, consisting of field-level maintenance and sustainment maintenance. Within the sustainment level, the Army conducts what is called "below depot sustainment maintenance." This type of maintenance involves component repair and is roughly equivalent to intermediate maintenance performed external to the unit level. In particular, the Army now has component repair companies that provide repairs of components for electronic systems, armament and artillery systems, automotive equipment, and other types of equipment.

Depot Maintenance

Depot maintenance is the major on-equipment repair and overhaul of weapon systems and other end items such as aircraft engines, and the off-equipment repair of system components at a maintenance depot. This requires a more industrial-type facility and a higher skill level of maintenance personnel than available at organizational and intermediate maintenance activities. Depots normally have high-cost tooling and facilities that are not found at unit- or intermediate-level maintenance facilities.

Depot maintenance is provided by a mix of government and contractor sources. These contractor sources include the weapon system original equipment manufacturer (OEM) and other contractor facilities including private shipyards. There are also some arrangements for depot maintenance known as public-private partnerships, or "P3s," where the work is shared or subcontracted between the contractor and a government entity.

Note that as described in this appendix, the term *depot maintenance* is associated with two distinct elements of the cost element structure presented in Chapter 3 of this guide: depot level reparables (DLRs) (element 3.2) and depot maintenance (element 3.4).

A DLR is a reparable item/component that is repaired at least in part at the depot level of maintenance. DLR costs are incurred largely at the unit level. Typically, when a DLR item requires maintenance, the item is removed from the system and replaced with another item from local inventory. This remove and replace action usually takes place at the unit level. When unit maintenance turns in a "failed" item/component (sometimes referred to as a "carcass"), that organization ("customer") is charged with an exchange price (sometimes called the net price). This exchange price includes the cost of direct labor and material for item repairs along with a surcharge for transportation, storage, inventory management, and other overhead. The direct material costs consist of consumables and sometimes nested reparable items. If unit maintenance does not have a "failed" item/component to return to the supply system, that organization is charged with a standard price. The standard price includes the new item/component purchase price along with a surcharge for attrition, transportation, storage, inventory management, and other overhead. Also, in cases where a failed item is turned in but the item is determined to be irreparable due to customer negligence or maliciousness, the customer is charged the difference between the exchange price and the standard price.

Also, much work associated with system hardware modifications and other modernization upgrades takes place at a maintenance depot. Although the hardware upgrades are regarded as distinct from the system depot maintenance, and are funded separately, in practice the two activities are often synchronized in planning and execution.

Extensive statutory requirements associated with depot maintenance are described in Appendix H of this guide.

Supply Chain or Materiel Management

The supply chain management function is critical to ensuring the timely delivery of reparable and consumable items. The key elements to supply chain management are:

- Cataloging and configuration management,
- Demand forecasting,
- Setting of inventory levels,
- Procurement of consumable items and materials,
- Storage,
- Processing customer requisitions,
- Sourcing of repairs, and
- Distribution.

For the Air Force and Navy, this function is conducted at the enterprise level by the Air Force Sustainment Center and the Navy Supply Systems Command, respectively. The Army has a more decentralized approach, and the supply chain management function resides at each of the commodity Life Cycle Management Commands. In addition, as explained later in this appendix, the supply chain management function for most consumable items resides at the Defense Logistics Agency (DLA).

Additional Topics

Role of the Defense Logistics Agency

For cost analysts, it is important to not only understand the basic concepts and terminology for maintenance conducted within each military department, but also to understand the role of DLA in providing essential logistics support for the armed forces. This support includes two important aspects. First, DLA is responsible for contracting, purchasing, and—where needed—storing and distributing most of the consumable items for DoD. In other cases, DLA is responsible for managing the delivery of these items from the vendors directly to the military units. DLA manages several supply centers (inventory control points) and a global network of distribution centers (warehouses). Second, DLA is responsible for the petroleum supply chain and associated transportation services and infrastructure. DLA manages the transportation and contractor support required for distribution of petroleum to military units and other customers throughout the United States, Europe, the Western Pacific, and the Middle East. In addition, DLA manages the worldwide acquisition of other fuels and propellants such as missile and rocket fuels, and satellite propellants.

Background on the Defense Working Capital Fund

Many of the military department and DLA activities for the maintenance and logistics of major weapon systems are financed through an arrangement known as the Defense Working Capital Fund (DWCF). For the most part, the DWCF is used to finance consumables, DLRs, depot maintenance, and fuel. The basic tenet of the DWCF is to create a business-like, customer-provider relationship between the military operating units and the support organizations. This arrangement is designed to establish incentives for efficiency.

For example, if depot maintenance were centrally funded by the military department headquarters, the operating units would regard such depot maintenance as a free good or service. Requiring the operating forces to pay for the support that they receive as customers provides increased assurance that the services obtained and provided are scrutinized and actually needed. In addition, the DWCF providers are expected to operate under business financial management principles. For support organizations within the fund, they are required to establish a cost accounting system that identifies costs (direct labor, material, and overhead) with the outputs of the business. This provides visibility into the cost drivers and encourages management to scrutinize costs based on financial operating results.

For cost analysts, there are two perspectives on cost data for DWCF maintenance and logistics activities. One perspective is the prices that users pay for goods and services, which normally is what is captured by the military department VAMOSC systems. A second perspective is the actual costs—for direct labor and material, as well as a surcharge for overhead—experienced by the support organizations. Data on these costs from this perspective can often be obtained from military department Enterprise Resource Planning systems and the operating budgets of the military department and DLA working capital funds.

Product Support Management and Integrated Product Support

Each major weapon system is required to have a product support strategy document that addresses all aspects of system sustainment throughout the life cycle. Each system has a product support manager (PSM) responsible for the development and implementation of this strategy. The PSM reports to the Program Manager and the two together are responsible for the execution of the product support strategy within specified budgets.

The Integrated Product Support (IPS) elements are used as a guide for the development and implementation of the product support strategy. However, the IPS elements are a management framework, and do not map directly to the CAPE O&S cost element structure. O&S cost data collection and estimation should maintain the discipline of the standard structure in order to have standardized cost estimates and analyses and consistent reporting to higher authorities and Congress. Further information on the IPS elements can be found in the *Integrated Product Support (IPS) Elements Guidebook*.

Terminology About Contractor Support

The remainder of this appendix provides additional remarks about contractor support, initially during the production and deployment phase, which later transitions into support during the operations and sustainment phase.

Interim Contractor Support (ICS) is temporary contractor support provided before a permanent support solution (organic or contractor) is established. This support consists of labor, material, and overhead for maintenance, supply management, and other support functions required to sustain the system during the early fielding of the system. The actual scope of an ICS effort varies among programs and contracts.

If the permanent support solution is provided by a contractor, it is known as Contractor Logistics Support (CLS). Like ICS, CLS consists of labor, material, and overhead for maintenance, supply management, and other support functions required to sustain the system. The only difference between ICS and CLS is the period of performance. If CLS is used, it begins when the ICS period has ended. DoD 7000.14-R, *Financial Management Regulation*, Volume 2A, Chapter 1, section 010208, provides guidance for funding policies for ICS and CLS. ICS is funded with procurement appropriations for the period established in the program baseline before the establishment of a permanent support solution. After that period, contractor support is regarded as CLS, and is funded with O&M appropriations. However, for some programs, the ICS and CLS may in practice overlap.

For many years, DoD policy has favored a product support strategy known as Performance-Based Logistics (PBL). PBL is synonymous with performance-based support. Current DoD policy states that program managers and product support managers will develop and implement an affordable and effective performance-based support, or PBL, package that utilizes performance metrics. PBL integrates the various product support activities with appropriate metrics and incentives, and product support requirements are described in terms of the desired results rather than in terms of how work is to be performed. The PBL strategy can apply to both CLS and organic maintenance. The PBL strategy is implemented through a formal arrangement known as a Performance-Based Arrangement (PBA). The PBA establishes a system or subsystem/component measurable level of performance in a contract, Memorandum of Agreement, Service Level Agreement, or other formal arrangement.

For programs employing CLS, DoD policy states that a performance-based contract is to be used wherever possible.

For CLS using the traditional transactional product support model, the Government purchases parts or maintenance services from the contractor. When equipment fails or is overhauled, the contractor charges the Government for repair, replacement, or overhaul on a transaction-by-transaction basis. The contractor often is not incentivized to reduce sustainment costs or improve materiel availability.

Under a PBL contracting strategy, the contractor is responsible for providing a specified level of performance, usually material availability, and is paid based on system usage or activity (operating tempo or OPTEMPO). The contract is structured to provide positive incentives for achieving improved performance fostering innovations and efficiencies, and negative incentives for achieving inferior performance. In some cases, the contractor can also be allowed to reduce sustainment costs by improving system or component reliability, and can then financially receive a fraction of the savings.

Further guidance on PBL can be found in the *Performance Based Logistics (PBL) Guidebook*.

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APPENDIX G
Product Support Cost Estimate at the Component Level of Detail

Introduction

Much of the discussion in this guide is focused on O&S cost estimates for major weapon systems. In contrast, this appendix provides an illustrative example of how to prepare an O&S cost estimate at the component or black box level of detail. In addition, cost estimates are also provided for acquisition logistics cost elements such as the procurement of initial spares, support equipment, and initial training. The acquisition logistics support cost elements are described in Appendix C of this guide.

Specifically, the estimate in this example concerns costs for an avionics or electronic subsystem that is to be installed on a host platform or vehicle. The approach is to obtain detailed data concerning component unit cost, reliability, maintainability, and other characteristics. There are also other general data such as subsystem service life, platform system quantities and operating hours, and maintenance level information. The data can then be used in various accounting equations to estimate the yearly and total costs.

This example uses the Cost Analysis Strategy Assessment (CASA) model managed by the Army Logistics and Engineering Center (LEC) in the Army Logistics Data Analysis Center of the U.S. Army Materiel Command. The CASA model is a bottom-up, accounting type tool that can be used for estimating system life-cycle costs. The model software provides extensive on-line help to the analyst, including complete descriptions of the accounting equations that are used in the model. The model also provides several features such as automated tools for sensitivity analysis or risk and uncertainty analysis. This model is available free of charge to US personnel within the public and private sectors. Further information is available at the CASA home page at www.logsa.army.mil/#/lec/casa.

Ground Rules and Assumptions

The major ground rules and assumptions for the cost analysis are shown below:

- 120 avionics subsystems are to be installed and operated on the host platforms.
- Each subsystem has a service life of 20 years.
- The host platforms are operated in 10 units, with 12 platforms in each unit. Each platform is operated at 20 hours per month.
- There are two levels of maintenance for the subsystem: (1) unit (or field) level maintenance, where each unit conducts maintenance, consisting of both organizational

maintenance and intermediate maintenance resident in the unit, and (2) depot maintenance, which supports the entire fleet with a more extensive repair capability.

- The avionics subsystem consists of three black boxes or Line Replaceable Units (LRUs). Each LRU consists of various Shop Replaceable Units (SRUs) such as electronic circuit boards.
- There will be an inventory of initial spares (LRUs and SRUs) for each platform unit, and at depot-level.
- The avionics subsystem will require new support equipment for both unit-level and depot-level maintenance.
- The avionics subsystem will require a new training course to support training for system maintenance. This training course will require a new type of training device.
- The avionics subsystem will require a new unit-level maintenance manual, and a new depot-level maintenance manual.
- The costs for maintenance man-hours for both unit-level and depot-level maintenance are based on an hourly labor rate for each level.

Detailed Component Data

Tables G-1 and G-2 show the major reliability, maintainability, and other data assumed for the subsystem components.

Table G-1. Avionics Components Input Data

Item	WBS Level ITYPE	Unit cost of a spare in $ COST	Quantity per next higher assembly QPNHA	Mean time between failures in hours MTBF	Mean time to repair (Man-hours) MTTR	Shipping weight WT
Avionics Subsystem	1	0	1	135	0	0
Black Box Type 1	2	750,000	1	385	16	160
Circuit Board Type 1A	3	100,000	3	3,000	24	10
Circuit Board Type 1B	3	150,000	3	2,000	24	10
Board Rack Type 1	3	50,000	1	10,000	32	100
Black Box Type 2	2	1,200,000	1	435	16	160
Circuit Board Type 2A	3	200,000	3	1,500	24	10
Circuit Board Type 2B	3	200,000	3	15,000	24	10
Board Rack Type 2	3	50,000	1	10,000	32	100
Black Box Type 3	2	1,000,000	1	400	16	80

Table G-2. Avionics Components Input Data (continued)

ITEM	Level Repair LRPR	Level Remove LREM	Portion of failures expected to retest okay, expressed as a decimal fraction of real failures RTOK	Matl Cost Per Repair $ MCPR	Portion of failures not repairable at the designated primary maintenance level, expressed as decimal NRTS	Portion of failures expected to be condemned expressed as a decimal fraction COND
Avionics Subsystem	0	0	0.0	0	0.0	0.000
Black Box Type 1	1	1	0.1	0	0.1	0.001
Circuit Board Type 1A	2	1	0.0	1,000	0.0	0.025
Circuit Board Type 1B	2	1	0.0	1,500	0.0	0.025
Board Rack Type 1	2	2	0.0	500	0.0	0.001
Black Box Type 2	1	1	0.1	0	0.1	0.001
Circuit Board Type 2A	2	1	0.0	2,000	0.0	0.025
Circuit Board Type 2B	2	1	0.0	2,000	0.0	0.025
Board Rack Type 2	2	2	0.0	500	0.0	0.001
Black Box Type 3	2	1	0.1	10,000	0.0	0.001

Some explanatory remarks for these data are shown below:

- The components are displayed in a work breakdown structure (WBS) hierarchy associated with levels of assembly. In this example, the avionics subsystem consists of three types of black boxes, where there is one of each black box type per subsystem. The first two types of black boxes consist of various circuit boards and a board rack.
- Each component has a unit cost that is used in the calculations of initial spares and replenishment spares.
- Each component has a specified reliability that is expressed as Mean Time Between Failures in hours. In this example, the subsystem operating hours are assumed to be the same as the operating hours of the host platform.
- A specified portion of the component failures Retest Okay, and do not result in repairs.
- Each component repair has an associated Mean Time to Repair (in manhours) and an associated Material Cost per Repair (in dollars).

- Each component has a specified maintenance concept, which consists of the level of removal and the level of repair for each component. In this example, Black Box Types 1 and 2 are primarily repaired at the unit level. However, they may require repair at the depot level a fraction of the time.
- Each component has a shipping weight that can be used in the calculations of transportation costs associated with the various maintenance activities.
- A specified portion of the failures result in component condemnations, which in turn result in the purchase of replenishment spares.

Other Input Data

There is also additional input data associated with the estimates for acquisition logistics and O&S costs. Examples are shown for support equipment, initial spares, technical data, and training.

Support Equipment

In this example, the avionics subsystem requires two items of support equipment: Unit-Level Test Equipment, and Depot-Level Test Equipment. Table G-3 provides the input data associated with support equipment procurement and maintenance.

Table G-3. Support Equipment Input Data

Unit-Level Test Equipment	Data
Unit Cost for Support Equipment ($)	500,000
Annual Maintenance Factor (%)	0.025
Hours Required for SE	
Black Box Type 1	8
Black Box Type 2	8
Depot-Level Test Equipment	**Data**
Unit Cost for Support Equipment ($)	3,000,000
Annual Maintenance Factor (%)	0.025
Hours Required for SE	
Black Box Type 1	8
Circuit Board Type 1A	12
Circuit Board Type 1B	12
Board Rack Type 1	16
Black Box Type 2	8
Circuit Board Type 2A	12
Circuit Board Type 2B	12
Board Rack Type 2	16
Black Box Type 3	8

The model calculates the required quantities of the support equipment to be procured based on the anticipated maintenance workload. There is also consideration of the availability of the support equipment. In this example, it is assumed that the unit-level maintenance has two shifts per day, and that the unit-level test equipment is available 343 hours per month. The depot-level maintenance is assumed to have one shift per day, and that the depot-level test equipment is available 171 hours per month. It is also assumed that the maximum utilization of the support equipment is a utilization rate of 90%. For support equipment maintenance costs, the model uses an "Annual Maintenance Factor." This factor represents the annual maintenance cost of each support equipment item expressed as a fraction of the support equipment item unit cost.

Initial Spares

In this example, the avionics subsystem requires procurement of initial spares for both unit-level and depot-level maintenance. For unit level, it is assumed that initial spares are procured for the three black box types and the various circuit boards. For depot level, it is assumed that initial spares are procured for the three black box types, the circuit boards, and the board racks. Note that the model calculates the required quantities of initial spares to be procured based on the anticipated maintenance workload and a required confidence level for spares availability. The calculations also consider the average turnaround time for spares for both unit-level and depot-level maintenance. The turnaround time is the amount of time from when a

spare is taken out of the inventory until it is replaced by another (either by repair of the failed item or the shipping of a replacement item from another maintenance level). In this example, the average unit-level turnaround time was assumed to be 0.25 months for the three black box types and the circuit boards. The average depot-level turnaround time was assumed to be 0.50 months for the circuit boards, and 1.00 months for the other hardware items.

Technical Data

In this example, the avionics subsystem requires two items of technical data: a Unit-Level Maintenance Manual, and a Depot-Level Maintenance Manual. Table G-4 displays the input data associated with the procurement and maintenance of technical data.

Table G-4. Technical Data Input Data

Unit-Level Maintenance Manual	Data
Year Cost Incurred	2020
Total Number of Pages	100
Cost per Page to Develop ($)	5,000
Cost per Page to Publish ($)	0.6
Total Number of Copies	20
Annual Number of Revised Pages	5
Revision Cost per Page ($)	5,000
Depot-Level Maintenance Manual	**Data**
Year Cost Incurred	2020
Total Number of Pages	300
Cost per Page to Develop ($)	7,500
Cost per Page to Publish ($)	0.6
Total Number of Copies	5
Annual Number of Revised Pages	15
Revision Cost per Page	7,500

Training and Training Devices

In this example, the avionics subsystem will require a new training course to support training for system maintenance. This training course will require a new type of training device. Table G-5 provides the input data associated with initial training, recurring training and the training devices.

Table G-5. Training and Training Devices Input Data

Initial Training	Data
Per Diem ($/day)	150
Round Trip Cost ($)	1,500
System Maintainer Course	
Year	2020
Class Hours	24
Development Cost per Class Hour	50,000
Trainee Labor Rate ($/hour)	45
Number of Trainees	30
Number of Days	3
Number of Instructors	3
Instructor Labor Rate ($/hour)	75
Recurring Training	**Data**
Unit-Level	
Recurring Training Hours	24
Development Cost per Class Hour	50,000
Annual Turnover Rate	0.33
Training Devices	**Data**
Repair Trainer Unit	
Year Cost Incurred	2020
Quantity of Devices	15
Init Cost for Device ($)	200,000

Model Output

Acquisition Logistics Costs

Table G-6 shows the estimated acquisition logistics costs for the avionics subsystem.

Table G-6. Total Acquisition Logistics Costs

FY 2020 Dollars in Thousands	Total
Initial Support Equipment	12,100
Initial Spares	51,150
Initial Tech Data	2,754
Initial Training	1,307
Training Devices	3,000
Total	**70,311**

O&S Costs

Table G-7 shows the estimated O&S costs for the avionics subsystem.

Table G-7. Total O&S Costs

FY 2020 Dollars in Thousands	Unit Level	Depot Level	Total
Repair Labor	1,536,622	4,621,407	6,158,029
Support Equipment Maintenance	2,032,292	2,531,250	4,563,542
Recurring Training	1,257,945	-	1,257,945
Repair Parts and Material	-	14,054,148	14,054,148
Consumables	-	1,405,415	1,405,415
Condemnation Spares	2,236,611	9,716,861	11,953,472
Technical Data Revisions	493,750	2,221,875	2,715,625
Total	**7,792,217**	**35,403,940**	**43,196,157**

Other Considerations

This example was limited in scope for demonstration purposes, and did not address other costs that might be appropriate for a specific application. The CASA model has equations that could be used for other costs not illustrated in this example. Examples that could be added include costs for facilities modifications and maintenance, item management, contractor services, engineering changes, software maintenance, transportation, and warranties. The model also permits a more sophisticated approach for hardware reliability that allows the use of reliability growth models.

The model also provides an extensive menu of a wide range of output reports not shown in this appendix. There are options for reports on annual costs in constant, then-year, and discounted dollars. In addition, more detailed reports provide visibility into the costs of the distinct LRUs and SRUs, support equipment utilization, and maintenance workload at each location. There are also input data reports that the analyst can use for study data verification. The model also provides the analyst with a wide variety of sensitivity analysis reports concerning the

major input data. The model also provides features that enable the development of an S-curve risk model for the cost estimate.

Equations

The remainder of this appendix provides a simplified review of the accounting equations used for the elements of annual O&S cost for this example. Equations are provided for repair labor, support equipment maintenance, recurring training, repair parts and material, condemnation spares, and technical data revisions. Note that the equations are different for each level of maintenance.

Repair Labor

Unit Level

$$\sum_{i} \frac{(NS)(OH)(QPNHA_i)((1 - COND_i)(MTTR_i)(UMLR)}{MTBF_i}$$

Depot Level

$$\sum_{i} \frac{(NS)(OH)(QPNHA_i)((1 - COND_i)(NRTS_i)(MTTR_i)(DMLR)}{MTBF_i} +$$

$$\sum_{i,j} \frac{(NS)(OH)(QPNHA_i)(QPNHA_{ij})((1 - COND_{ij})(MTTR_{ij})(DMLR)}{MTBF_{ij}}$$

Support Equipment Maintenance

Unit Level

$$\sum_{k} (QSEU_k)(NU)(UCSEU_k)(AMFU_k)$$

Depot Level

$$\sum_{l} (QSED_l)(UCSED_l)(AMFD_l)$$

Recurring Training

Unit Level

$$\frac{(NU)(UMAXMMH)(UTOR)(UTRHRS)(UMLR)}{160}$$

Depot Level

$$\frac{(DMAXMMH)(DTOR)(DTRHRS)(DMLR)}{160}$$

Repair Parts and Material

Unit Level

$$\sum_{i} \frac{(NS)(OH)(QPNHA_i)((1-COND_i)(1-NRTS_i)(MCPR_i))}{MTBF_i}$$

Depot Level

$$\sum_{i} \frac{(NS)(OH)(QPNHA_i)((1-COND_i)(NRTS_i)(MCPR_i)}{MTBF_i} +$$

$$\sum_{i,j} \frac{(NS)(OH)(QPNHA_i)(QPNHA_{ij})((1-COND_{ij})(MCPR_{ij})}{MTBF_{ij}}$$

Condemnation Spares

Unit Level

$$\sum_{i} \frac{(NS)(OH)(QPNHA_i)((COND_i)(UC_i)}{MTBF_i}$$

Depot Level

$$\sum_{i,j} \frac{(NS)(OH)(QPNHA_i)(QPNHA_{ij})((COND_{ij})(UC_{ij})}{MTBF_{ij}}$$

Technical Data Revisions

Unit Level

$(UQTYRPG)(UCSTRPG)$

Depot Level

$(DQTYRPG)(DCSTRPG)$

Model Inputs

NS = Number of systems

OH = Operating hours per system

NU = Number of units

$UMLR$ = Unit-level maintenance labor rate (dollars per hour)

$DMLR$ = Depot-level maintenance labor rate (dollars per hour)

For LRUs:

$QPNHA_i$ = Quantity per next higher assembly for the ith item

$COND_i$ = Decimal fraction of failures that result in condemnation for the ith item

$MTTR_i$ = Mean time to repair for the ith item

$MTBF_i$ = Mean time between failure for the ith item

$NRTS_i$ = Decimal fraction of failures that are Not Repairable This Station for the ith item

$MCPR_i$ = Material cost per repair for the ith item

UC_i = Unit cost (for spares) for the ith item

For SRUs:

$QPNHA_{ij}$ = Quantity per next higher assembly for the jth item of the ith LRU

$COND_{ij}$ = Decimal fraction of failures that result in condemnation for the jth item of the ith LRU

$MTTR_{ij}$ = Mean time to repair for the jth item of the ith LRU

$MTBF_{ij}$ = Mean time between failure for the jth item of the ith LRU

$NRTS_{ij}$ = Decimal fraction of failures that are Not Repairable This Station for the jth item of the ith LRU

$MCPR_{ij}$ = Material cost per repair for the jth item of the ith LRU

UC_{ij} = Unit cost (for spares) for the jth item of the ith LRU

For support equipment:

$QSEU_k$ = Quantity per unit of the kth item of unit-level support equipment

$UCSEU_k$ = Unit cost of the kth item of unit-level support equipment

$AMFU_k$ = Annual maintenance cost (as a decimal fraction of unit cost) of the kth item of unit-level support equipment

$QSED_l$ = Quantity of the lth item of depot-level support equipment

$UCSEDU_l$ = Unit cost of the lth item of depot-level support equipment

$AMFD_l$ = Annual maintenance cost (as a decimal fraction of unit cost) of the lth item of depot-level support equipment

For recurring training:

UTOR = Annual turnover rate of unit-level maintenance personnel

UTRHRS = Number of hours required to train new unit-level maintenance personnel

DTOR = Annual turnover rate of depot-level maintenance personnel

DTRHRS = Number of hours required to train new depot-level maintenance personnel

For technical data revisions:

UQTYRPG = Number of pages of technical documentation that will be revised each year at the unit level

UCSTRPG = Average cost per page to develop technical document revisions at the unit level

DQTYRPG = Number of pages of technical documentation that will be revised each year at the depot level

DCSTRPG = Average cost per page to develop technical document revisions at the depot level

Model Intermediate Calculations

UMAXMMH = Unit-level maintenance man-hours per month per location

DMAXMMH = Depot-level maintenance man-hours per month

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APPENDIX H
Relevant Statutory Requirements

Introduction

Over the last decade, the Congress has established extensive and demanding statutory requirements pertaining to operating and support (O&S) cost estimation, as well as sustainment or product support management, for major Department of Defense (DoD) weapon systems. This appendix is intended to summarize these requirements. This appendix also provides discussion and references relevant to the current DoD implementation of these statutory requirements.

Relevant Statutory Requirements in Title 10, United States Code

Section 2334, Independent Cost Estimation and Analysis

Section 2334 establishes numerous responsibilities and authorities for the Director of Cost Assessment and Program Evaluation (DCAPE) pertaining to cost estimation and cost analysis for the acquisition programs of DoD. In particular, this section requires the Director to issue guidance relating to full consideration of life-cycle management and sustainability costs in Major Defense Acquisition Programs (MDAPs) and major subprograms. In addition, this section also provides responsibilities and authorities concerning cost data collection. This section was most recently revised in the National Defense Authorization Act (NDAA) for FY 2018.

Further explanation of the policies and procedures that address the DoD implementation of this section are provided in DoD Instruction (DoDI) 5000.73, *Cost Analysis Guidance and Procedures*. Some of the topics addressed in this instruction include Independent Cost Estimates (ICEs) and other cost analyses, Component Cost Positions (CCPs), Full Funding Certification Memoranda, and requirements for cost data collection and reporting. Cost Assessment and Program Evaluation (CAPE)'s perspective on the best practices for cost estimation in general is provided in the *DoD Cost Estimating Guide*. Additional discussion specific to O&S cost estimation and weapon system sustainment are provided in this guide.

Section 2366a, Major Defense Acquisition Programs: Determination Required Before Milestone A Approval

Section 2366a states that an MDAP may not receive Milestone A approval until the Milestone Decision Authority (MDA) determines in writing that the program meets several

specific criteria. One of the criteria that must be met is that planning for sustainment has been addressed and that a determination of applicability of core logistics (i.e., depot-level maintenance and repair) capabilities requirements has been made. Another one of the criteria that must be met is that a cost estimate for the program has been submitted, with the concurrence of DCAPE, and that the level of resources required to develop, procure, and sustain the program is sufficient for successful program execution.

Additionally, within 15 days of granting Milestone A approval, the MDA is required to submit the program cost and schedule estimates, as well as the ICE, to the congressional defense committees. This section was most recently revised in the NDAA for FY 2019.

Section 2366b, Major Defense Acquisition Programs: Determination Required Before Milestone B Approval

Section 2366b states that an MDAP may not receive Milestone B approval until the MDA determines in writing that the program meets several specific criteria. One of the criteria that must be met is that life-cycle sustainment planning, including corrosion prevention and mitigation planning, has identified and evaluated relevant sustainment costs throughout development, production, operation, sustainment, and disposal of the program, and any alternatives, and that such costs are reasonable and have been accurately estimated. Another one of the criteria that must be met is that reasonable cost and schedule estimates have been developed to execute—with the concurrence of the Director, CAPE (DCAPE)—the product development and production plan under the program.

Additionally, within 15 days of granting Milestone B approval, the MDA is required to submit the program cost and schedule estimates, as well as the ICE, to the congressional defense committees. This section was most recently revised in the NDAA for FY 2019.

Section 2366c, Major Defense Acquisition Programs: Submissions to Congress on Milestone C

Section 2366c requires that the MDA provide the congressional defense committees a brief summary report not later than 15 days after granting Milestone C approval for an MDAP. This report includes the estimated cost and schedule for the program established by the military department concerned, including (1) the dollar values estimated for the program acquisition unit cost, average procurement unit cost, and total life-cycle cost, and (2) the planned dates for initial operational test and evaluation (IOT&E) and initial operational capability (IOC). This report also includes the ICE for the program and any independent estimated schedule for the program, including (1) the dollar values estimated for the program acquisition unit cost, average procurement unit cost, and total life-cycle cost, and (2) the planned dates for IOT&E and IOC. This section was most recently revised in the NDAA for FY 2018.

Section 2337, Life-Cycle Management and Product Support

Section 2337 requires DoD to issue and maintain comprehensive guidance on life-cycle management and the development and implementation of product support strategies for major weapon systems. Specifically, each major weapon system shall have a product support manager responsible for the development and implementation of the weapon system product support strategy. This section was most recently revised in the NDAA for FY 2014.

Further explanation of the policies and procedures that address the DoD implementation of this section are provided in DoDI 5000.85, Appendix 3D ("Product Support"). Additional discussion specific to weapon system sustainment and O&S cost management are provided in the following:

- Chapter 4 ("Life Cycle Sustainment") of the *Defense Acquisition Guidebook,*
- *Performance Based Logistics Guidebook,*
- *Product Support Manager Guidebook,* and
- *Operating and Support Cost Management Guidebook.*

Section 2337a, Assessment, Management, and Control of Operating and Support Costs

Section 2337a requires DoD to issue and maintain guidance on a wide range of actions to be taken to assess, manage and control DoD costs for the operation and support of major weapon systems. This section was added by the NDAA for FY 2012, and codified into statute by the NDAA for FY 2018. Note that this section requires that the guidance for this section be issued in conjunction with the guidance for the requirements of Section 2337, Life-Cycle Management, described earlier.

Specifically, Section 2337a requires DoD guidance to address the following elements:

- Establish policies and procedures for the collection, organization, maintenance, and availability of standardized data on O&S costs for major weapon systems.
- Establish standard requirements for the collection and reporting of O&S costs for major weapon systems by contractors performing weapon system sustainment functions in an appropriate format, and develop contract clauses to ensure that contractors comply with such requirements.
- Include reliability metrics for major weapon systems and requirements on the use of metrics as triggers—
  - to conduct further investigation and analysis into drivers of the metrics, and
  - to develop strategies for improving reliability, availability, and maintainability of such systems at an affordable cost.

Further explanation of the policies and procedures that address the DoD implementation of the first two elements is provided in Chapter 6 of this guide. Further explanation of the policies and procedures that address the DoD implementation of the third element are provided in DoDI 5000.85, Appendix 3D ("Product Support"). Additional discussion is provided in Chapter 4 ("Life Cycle Sustainment") of the *Defense Acquisition Guidebook*. Note that this particular element (reliability metrics) has been expanded by more recent legislation (Section 2443, Sustainment Factors in Weapon System Design) described later in this appendix.

In addition, the DCAPE is responsible for developing and maintaining a database on O&S cost estimates, supporting documentation, and actual O&S costs for major weapon systems. The implementation of this element is described in Chapter 6 of this guide, which described the military department Visibility and Management of Operating and Support Costs (VAMOSC) systems, and the EVAMOSC initiative. In addition, CAPE now collects independent cost estimates, CCPs, and various related cost estimation and acquisition documents and briefings and stores them in the Cost Assessment Data Enterprise (CADE) library.

Each military department is responsible for the following elements:

- Retain each estimate of O&S costs that is developed at any time during the life cycle of a major weapon system, together with the supporting documentation used to develop the estimate.
- Update estimates of O&S costs periodically throughout the life cycle of a major weapon system, to determine whether preliminary information and assumptions remain relevant and accurate, and identify and record reasons for variances.
- Collect and retain data from operational and developmental testing and evaluation on the reliability and maintainability of major weapon systems, and use such data to inform system design decisions, provide insight into sustainment costs, and inform estimates of O&S costs for such systems.
- Ensure that sustainment factors are fully considered at key life-cycle management decision points and that appropriate measures are taken to reduce O&S costs by influencing system design early in development, developing sound sustainment strategies, and addressing key drivers of costs.
- Conduct an Independent Logistics Assessment (ILA)[13] of each major weapon system prior to key acquisition decision points (including milestone decisions) to

[13] An ILA is an analysis of a program's supportability planning and execution conducted by a team of impartial subject matter experts. An ILA assesses the program's product support strategy, as well as how this strategy is resulting in the effective operation of the system at an affordable cost. ILAs are described in the *Logistics Assessment Guidebook*.

identify features that are likely to drive future O&S costs, and effective strategies for managing such costs.

- Conduct periodic reviews of O&S costs of major weapon systems after such systems achieve IOC to identify and address factors resulting in growth in O&S costs and adapt support strategies to reduce such costs.

Estimates of O&S costs are updated at each program milestone review, and also may be updated each year for inclusion in the annual program Selected Acquisition Report (SAR). The format for SAR reporting is described in Chapter 5 of this guide.

The tracking of reliability and maintainability data from test and evaluation is described in Appendix E of this guide. These data can be used to inform design trades and cost estimates in one of two ways, depending on the maturity of the program. One way would be to use parametric cost estimating relationships that estimate maintenance costs as a function of reliability and other independent variables, as discussed in Chapter 7 of this guide. Another way would be to use a bottom-up accounting model for O&S costs that considers reliability and maintainability factors as model inputs, as discussed in Appendix G of this guide.

Discussion about the consideration of sustainment factors in the influence of system design at all key management decision points is provided in DoDI 5000.85, Appendix 3D ("Product Support"). Additional discussion is provided in Chapter 4 ("Life Cycle Sustainment") of the *Defense Acquisition Guidebook*.

Section 2379f, Major Weapon System Defined

In Section 2379f, the term *major weapon system* means a weapon system acquired pursuant to an MDAP. The term major weapon system is used throughout this guide.

Section 2437, Development of Major Defense Acquisition Programs: Sustainment of System to be Replaced

Section 2437 states that whenever a new MDAP begins development, the defense acquisition authority responsible for that program shall develop a plan (to be known as a "sustainment plan") for the existing system that the system under development is intended to replace. This section was added by the NDAA for FY 2005.

Guidance on the replaced system sustainment plan is provided in DoDI 5000.85, Appendix 3D ("Product Support").

Section 2441, Sustainment Reviews

Section 2441 requires that the Secretary of each military department shall conduct a sustainment review of each major weapon system not later than five years after declaration

of IOC of an MDAP and throughout the life cycle of the weapon system to assess the product support strategy, performance, and O&S costs of the weapon system. For any review after the first one, the Secretary concerned shall use availability and reliability thresholds and cost estimates as the basis for the circumstances that prompt such a review. This section was added by the NDAA for FY 2017.

Each sustainment review is required to include the following elements:

- An independent cost estimate for the remainder of the life cycle of the program.
- A comparison of actual costs to the amount of funds budgeted and appropriated in the previous five years, and if funding shortfalls exist, an explanation of the implications on equipment availability.
- A comparison between the assumed and achieved system reliabilities.
- An analysis of the most cost-effective source of repairs and maintenance.
- An evaluation of the cost of consumables and depot level reparables.
- An evaluation of the costs of information technology, networks, computer hardware, and software maintenance and upgrades.
- As applicable, an assessment of the actual fuel efficiencies compared to the projected fuel efficiencies as demonstrated in tests and operations.
- As applicable, a comparison of actual manpower requirements to previous estimates.
- An analysis of whether accurate and complete data are being reported in the cost systems of the military department concerned, and if deficiencies exist, a plan to update the data and ensure accurate and complete data are submitted in the future.

Guidance on sustainment reviews is provided in DoDI 5000.85, Appendix 3D ("Product Support"). Suggested analytic methods that can support sustainment reviews are provided in Appendix E of this guide.

Section 2443, Sustainment Factors in Weapon System Design

Section 2443 states that DoD shall ensure that the defense acquisition system gives ample emphasis to sustainment factors, particularly those factors that are affected principally by the design of a weapon system, in the development of a weapon system. DoD also shall ensure that reliability and maintainability are included in the performance attributes of the key performance parameter on sustainment during the development of capabilities requirements. In addition, DoD shall ensure that sustainment factors, including reliability and maintainability, are given ample emphasis in the process for source selection

of a contract for engineering and manufacturing development of a weapon system. This section was added by the NDAA for FY 2018.

Guidance on this requirement is provided in Annex D ("Sustainment KPP Guide") to Appendix G ("Development of Performance Attributes") of the *Joint Capabilities Integration and Development System (JCIDS) Manual*, and in DoDI 5000.85, Appendix 3D ("Product Support"). The *JCIDS Manual* establishes that the capabilities needs documents for all MDAPs will include a Sustainment Key Performance Parameter (KPP). This is intended to ensure that the requirements and acquisition communities consider sustainment, including reliability and maintainability, as a requirement in the development of the program design. The Sustainment KPP is supported by several elements:

- Requirements for Materiel Availability and Operational Availability.
- A supporting Key System Attribute (KSA) or Additional Performance Attribute (APA) for Reliability.
- A supporting KSA or APA for Maintainability.
- A supporting KSA or APA for O&S costs.

This KPP is mandatory for a program's Capability Development Document and is included in the Acquisition Program Baseline. Beginning at Milestone B, the parameters of the KPP are subject to reporting and tracking as the program proceeds through the acquisition phases.

The JCIDS Manual states that the O&S costs included with the Sustainment KPP should conform to the cost element structure provided in this guide.

The developers of the sustainment KPP requirements are expected to conduct up-front trade studies and other analyses to determine sustainment requirements that are balanced with program acquisition cost and what is achievable based on technology maturity. The process for conducting these trade studies is described in the *Reliability, Availability, Maintainability, and Cost* (*RAM-C) Manual*. A RAM-C Report documents the rationale behind the development of the sustainment metric requirements, including reliability metrics, along with underlying assumptions and supporting analyses. The *RAM-C Manual* also provides guidance to the acquisition community to ensure that the sustainment requirements can be measured and tested throughout the program life cycle.

Regarding the requirement concerning the source selection process, DoDI 5000.85, Appendix 3D "(Product Support") requires that solicitations to be used in weapon system procurements include criteria for sustainment factors principally affected by design and development, and that those criteria receive ample emphasis in source selection.

Section 2448a, Program Cost, Fielding, and Performance Goals in Planning for Major Defense Acquisition Programs

Section 2448a requires the MDA to establish program cost and fielding targets for an MDAP before Milestone A, B, or C approval. The program cost targets are the procurement unit cost and sustainment cost. The program fielding target is the date for IOC. This section was added by the NDAA for FY 2017.

Guidance on this requirement is provided in DoDI 5000.85, Appendix 3C ("Additional Program Management Considerations"). In this guidance, the term *sustainment cost* is treated as synonymous with *operating and support cost*.

Section 2460, Definition of Depot-Level Maintenance and Repair

Section 2460 defines the term *depot-level maintenance and repair* as material maintenance or repair requiring the overhaul, upgrading, or rebuilding of parts, assemblies, or subassemblies, and the testing and reclamation of equipment as necessary, regardless of the source of funds for the maintenance or the location at which the maintenance or repair is performed. The term includes (1) all aspects of software maintenance classified by DoD as depot-level maintenance and repair, and (2) interim contractor support or contractor logistics support, to the extent that such support is for the performance of services described in the preceding sentence. This section was last modified by the NDAA for FY 2013.

Section 2464, Core Logistics Capabilities

Section 2464 establishes the policy that it is essential for DoD to maintain a core logistics capability that is Government-owned and Government-operated to ensure a ready source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, and other emergency requirements. DoD is required to identify this core logistics capability, and the peacetime workload required to maintain this capability, that is necessary to maintain and repair the weapon systems and other military equipment (including mission-essential weapon systems or materiel not later than four years after achieving IOC) necessary to support the Department's strategic and contingency plans. DoD is required to submit a biennial report on whether or not it has the required core capability in military depots to support fielded systems. This section was last modified by the NDAA for FY 2019.

The process to define the numerical magnitude of the workload to maintain core logistics capabilities is documented in DoDI 4151.20, *Depot Maintenance Core Capabilities Determination Process*.

Section 2466, Limitations on the Performance of Depot-Level Maintenance of Materiel

Section 2466 states that not more than 50 percent of the funds made available in a fiscal year to a military department or defense agency for depot-level maintenance and repair workload may be used to contract for the performance by non-Federal Government personnel of such workload for the military department or the defense agency. This restriction is applied to each military department or defense agency as a whole, and is not applied to individual systems or commodity types. Any such funds that are not used for such a contract shall be used for the performance of depot-level maintenance and repair workload by employees of DoD. DoD is required to submit an annual report identifying, for each of the armed forces and each defense agency, the percentage of the funds that was expended during the preceding fiscal year, and are projected to be expended during the current fiscal year and the ensuing fiscal year, for performance of depot-level maintenance and repair workloads by the public and private sectors. This section was last modified by the NDAA for FY 2010.

Section 2474, Centers of Industrial and Technical Excellence: Designation, Public-Private Partnerships

Section 2474 states that the Secretary of each military department shall designate each depot-level activity in that department as a Center of Industrial and Technical Excellence (CITE) in one or more specific technical competencies required for the core capability required to be identified by Section 2464 described earlier. Work for depot maintenance performed at an organic depot designated as a CITE, related to the technical competencies of the CITE, by a contractor pursuant to a public-private partnership is not counted for purposes of applying the 50/50 percentage limitation on contractor workload established by Section 2466 described earlier. The three basic types of public-private partnerships are:

- Workshare: An arrangement where workload at the CITE is shared between the contractor and the organic activity.
- Direct Sale: An arrangement where workload at the CITE is handled through a contractual relationship between the contractor and organic activity for the purchase of depot maintenance services.
- Lease: An arrangement where a contractor may have access to facilities and equipment located at an organic depot designated as a CITE through a lease.

This section was last modified by the NDAA for FY 2019.

Other Relevant Statutory Requirements

Section 804, Middle Tier of Acquisition for Rapid Prototyping and Rapid Fielding

Section 804 of the NDAA for FY 2016 establishes a "middle tier" of acquisition programs that are intended to be completed within five years. These programs would fall between "rapid acquisitions" that are generally completed within six months to two years, and "traditional" acquisition programs that last much longer than five years. Middle tier acquisition provides for two acquisition pathways: (1) rapid prototyping (prototypes with innovative technologies), and (2) rapid fielding (new or upgraded systems with minimal development). Programs in this middle tier are to follow streamlined procedures, and are to be exempt from the traditional requirements and acquisition processes. DoD guidance for middle tier acquisition must establish a process for transitioning successful prototypes to new or existing programs for production and fielding under the rapid fielding pathway or the traditional acquisition process.

This guidance was provided in DoDI 5000.80, *Operation of the Middle Tier of Acquisition (MTA)*. As stated in this instruction, program managers and product support managers are to develop and implement sustainment programs addressing product support elements to deliver affordable readiness. For the rapid fielding programs, the DoD Components are to develop a process for considering life-cycle costs, address issues of logistics support and training, and identify and exploit opportunities to reduce total ownership costs. This process will result in a tailored life-cycle sustainment plan. DoDI 5000.80 also states that the DCAPE establishes policies and prescribes procedures for the collection of cost data and cost estimates for MTA programs, as appropriate.

CAPE has established new procedures for cost estimates for MTA programs in the most recent revision to DoDI 5000.73, *Cost Analysis Guidance and Procedures*. Procedures for MTA cost estimates were briefly mentioned in Chapter 5 of this guide and additional details including timelines are provided in DoDI 5000.73.

Section 809, Advisory Panel on Streamlining and Codifying Acquisition Regulations

Section 809 of the NDAA for FY 2016 called for the Secretary of Defense to establish an independent advisory panel on streamlining acquisition regulations. A Defense Technical Information Center website (discover.dtic.mil/section-809-panel/) provides the various reports and recommendations made by the panel from August 2016 to its conclusion in July 2019. Recommendation 41 of the panel calls for DoD to establish a sustainment program baseline, implement key enablers of sustainment, elevate sustainment to equal standing with development and procurement, and improve the defense materiel enterprise focus on weapon system readiness.

The Department has not implemented this recommendation at the time of the publication of this guide. However, as noted earlier in this appendix, Section 2337a already requires the military departments to update estimates of O&S costs periodically throughout the life cycle of a major weapon system. In addition, the program SAR reporting provides a comparison between the current O&S cost estimate and the SAR baseline objective and threshold values for total O&S costs.

Section 832, Implementation of Recommendations of the Independent Study on Consideration of Sustainment in Weapon Systems Life Cycle

Section 832 of the NDAA for FY 2019 requires the Secretary of Defense to commence implementation of each recommendation of an independent assessment conducted by the MITRE Corporation (of the extent to which sustainment matters are considered in decisions related to requirements, acquisition, cost estimating, programming and budgeting, and research and development for MDAPs). The specific MITRE recommendations pertaining to O&S cost data systems for the Department, which are now being addressed by the EVAMOSC initiative, are described in Chapter 6 of this guide.

Section 879, Briefing on Funding of Product Support Strategies

Section 879 of the National Defense Authorization Act for FY 2019 requires the Secretary of Defense to provide an annotated briefing to the congressional defense committees regarding the funding for product support strategies for major weapon systems for each of the fiscal years 2020, 2021, and 2022. The briefing shall include for each major weapon system:

- A current estimate of the total funding required for the product support strategy for specific costs of the weapon system over its expected life cycle.
- A current estimate of the funding required for the product support strategy per year over the Future Years Defense Program (FYDP) for the specific product support costs of the weapon system.
- A summary of the funding requested for the product support strategy in the FYDP per year specifically for the weapon system.
- A summary of the amounts expended to support costs specific to the weapon system as described in the product support strategy of the weapon system during the prior fiscal year.
- A summary of the improvements made to data collection and analysis capabilities of DoD, including in the military services, to improve the analysis and cost estimation of life-cycle costs, improve the analysis and identification of cost drivers, reduce life-cycle cost variance, identify common and shared costs for

multiple weapon systems, and isolate the life-cycle costs attributable to specific individual weapon systems.

APPENDIX I
Rates for Military and Civilian Manpower

Some cost estimates use manpower estimates obtained from unit manning documents or tables of organization and equipment. In such cases, it is necessary to apply manpower rates to the unit manning documents.

Manpower costs for active officers and enlisted personnel include the elements of the DoD Standard Composite Rates for military personnel, which include the following items: basic pay, retired pay accrual, Medicare-Eligible Retiree Health Care (MERHC) accrual, basic allowance for housing, basic allowance for subsistence/subsistence-in-kind, incentive and special pays, Permanent Change of Station (PCS) expense, and miscellaneous expenses such as the employer's contribution to social security (FICA) and uniform/clothing allowances. Each year, the OSD Comptroller issues the military personnel composite standard pay rates for each military service to be used in cost estimates. These rates can be found at the OSD Comptroller public website http://comptroller.defense.gov/Financial-Management/Reports (Tab K).

Manpower costs for officers and enlisted personnel in the reserve components (National Guard and Reserve) include basic pay, retired pay accrual, MERHC accrual, basic allowance for housing, subsistence, and miscellaneous expenses. PCS costs are included for full-time members. Reserve manpower costs vary among different pay categories of reserve personnel. Cost estimates of reserve personnel should separately identify the number of personnel using the following categories:

- Full-time – Active/Guard/Reserve (AGR) members
- Drill Personnel (Pay Group A) – drilling members of a Selected Reserve Unit

The cost of drill personnel depends on the extent of their annual drill time. The average annual drill time should be used and documented in developing a cost estimate. Some military departments also have reserve military technicians, federal civilian employees who also serve in a dual status as military reservists, who receive both civilian and drill pay.

Rates for reserve personnel for each pay category can be derived from the military personnel budget justification material submitted by the National Guard and Reserve of each military service. In these budget justification materials, the funding for reserve personnel can be found in a table known as the Summary of Entitlements by Subactivity, and the end-strength can be found in a table known as the Summary of Personnel.

The Naval VAMOSC system obtains actual Active and Reserve military manpower costs for pay and allowances from Defense Finance and Accounting Service pay files that are provided by the Defense Manpower Data Center. Additionally, PCS costs are obtained from the Bureau of Navy Personnel, FICA and retired pay accrual are calculated as percentages of basic pay, and MERHC accrual is the annual published per capita actuarial allocation amount.

The costs of government civilian manpower consist of the elements of the DoD Composite Standard Rates for civilian employees, which are the following: regular salaries and wages, additional variable payments (for overtime, holiday pay, night differentials, and awards), cost-of-living allowances, and the government contribution to employee benefits: insurance, retirement, Social Security contributions, and certain relocation expenses that are regarded as benefits.

A version of the OP-8 budget exhibit ("Total Civilian Personnel Costs") for DoD as a whole can be found in the DoD Operations and Maintenance (O&M) budget overview. Rates are provided for the Senior Executive Schedule, General Schedule, Wage System, and other categories of US DoD employees. The exhibit also provides rates for foreign national direct and indirect hires. Additionally, each military department prepares its own version of an OP-8 display for each appropriation with civilian personnel costs.

APPENDIX J
References

Directives, Instructions, Manuals and Regulations

(a) DoD Directive 5105.84, *Director of Cost Assessment and Program Evaluation (DCAPE)*, May 11, 2012

(b) DoD Instruction 5000.73, *Cost Analysis Guidance and Procedures*, March 13, 2020

(c) DoD 5000.04-M-1, *Cost and Software Data Reporting (CSDR) Manual*, November 4, 2011

(d) DoD Directive 5000.01, *The Defense Acquisition System*, May 12, 2003, as amended

(e) DoD Instruction 5000.02, *Operation of the Adaptive Acquisition Framework*, January 23, 2020

(f) DoD Instruction 5000.85, *Major Capability Acquisition*, August 6, 2020

(g) DoD Instruction 5000.80, *Operation of the Middle Tier of Acquisition (MTA)*, December 30, 2019

(h) MIL-STD-881D, *Work Breakdown Structures for Defense Materiel Items*, April 9, 2018

(i) CJCS Manual, *Joint Capabilities Integration and Development System (JCIDS) Manual*, August 31, 2018

(j) Department of Defense *Reliability, Availability, Maintainability, and Cost Rationale Report Manua*l, June 1, 2009

(k) DoD 7000.14-R, *DoD Financial Management Regulation*, May 2019

(l) DoD Instruction 4151.20*, DoD Maintenance Core Capabilities Determination Process*, May 4, 2018, as amended

Guides and Other Publications

(m) *DoD Cost Estimating Guide*, publication pending

(n) *Inflation and Escalation Best Practices for Cost Analysis*, April 2016

(o) *Inflation and Escalation Best Practices for Cost Analysis: Analyst Handbook*, January 2017

(p) *Joint Agency Cost Estimating Relationship (CER) Development Handbook*, February 9, 2018

(q) *Joint Agency Cost Schedule Risk and Uncertainty Handbook,* March 12, 2014

(r) *Defense Acquisition Guidebook*

(s) *Operating and Support Cost Management Guidebook,* February 2016

(t) *Product Support Manager Guidebook,* December 2019

(u) *Integrated Product Support (IPS) Elements Guidebook,* July 31, 2019

(v) *Performance Based Logistics Guidebook,* April 2016

(w) *DoD Product Support Business Case Analysis Guidebook,* March 2014

(x) *Logistics Assessment Guidebook,* July 2011

(y) *Reliability, Availability, Maintainability, and Cost (RAM-C) Rationale Report Outline Guidance,* February 28, 2017

Abbreviations

AC	Aircraft
ACEIT	Automated Cost Estimating Integrated Tools
ADM	Acquisition Decision Memorandum
AFTOC	Air Force Total Ownership Cost
AGR	Active/Guard/Reserve
AoA	Analysis of Alternatives
APB	Acquisition Program Baseline
APA	Additional Performance Attribute
CADE	Cost Assessment Data Enterprise
CAPE	Cost Assessment and Program Evaluation
CARD	Cost Analysis Requirements Description
CASA	Cost Analysis Strategy Assessment
CCP	Component Cost Position
CDD	Capability Development Document
CER	Cost Estimating Relationship
CITE	Center of Industrial and Technical Excellence
CLS	Contractor Logistics Support
CSDR	Cost and Software Data Reporting
CVT	Consolidated VAMOSC Tool
CY	Constant-Year
DAES	Defense Acquisition Executive Summary
DCAPE	Director of Cost Assessment and Program Evaluation
DeCA	Defense Commissary Agency
DLA	Defense Logistics Agency

DLR	Depot Level Reparable
DoD	Department of Defense
DoDEA	DoD Education Activity
DoDI	DoD Instruction
DOT&E	Director of Operational Test and Evaluation
DWCF	Defense Working Capital Fund
EMD	Engineering and Manufacturing Development
EVAMOSC	Enterprise VAMOSC
FH	Flying Hour
FICA	Social Security (Federal Insurance Contributions Act)
FSR	Field Service Representative
FWG	Functional Working Group
FY	Fiscal Year
FYDP	Future Years Defense Program
GDP	Gross Domestic Product
IAVM	Information Assurance Vulnerability Management
ICE	Independent Cost Estimate
ICS	Interim Contractor Support
ILA	Independent Logistics Assessment
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IPS	Integrated Product Support
IT	Information Technology
JCIDS	Joint Capabilities Integration and Development System
KPP	Key Performance Parameter
KSA	Key System Attribute
LCN	Logistics Control Number

LEC	Logistics and Engineering Center
LRIP	Low-Rate Initial Production
LRU	Line Replaceable Unit
MDA	Milestone Decision Authority
MDAP	Major Defense Acquisition Program
MERHC	Medicare-Eligible Retiree Health Care
MTA	Middle Tier of Acquisition
MTBF	Mean Time Between Failures
MTBM	Mean Time Between Maintenance
MTBR	Mean Time Between Removals
MTTR	Mean Time to Repair
NDAA	National Defense Authorization Act
NIIN	National Item Identification Number
NSN	National Stock Number
O&M	Operations and Maintenance
O&S	Operating and Support
OEM	Original Equipment Manufacturer
OMB	Office of Management and Budget
OPTEMPO	Operating Tempo
OSD	Office of the Secretary of Defense
OSMIS	Operating and Support Management Information System
P3	Public-Private Partnership
PBA	Performance-Based Arrangement
PBL	Performance-Based Logistics
PCS	Permanent Change of Station
PE	Program Element
R&M	Reliability and Maintainability

RAM	Reliability, Availability, and Maintainability
RAM-C	Reliability, Availability, Maintainability and Cost
RCOH	Refueling and Complex Overhaul
RDT&E	Research, Development, Test and Evaluation
REMIS	Reliability and Maintainability Information System
RMF	Risk Management Framework
SAG	Sub-Activity Group
SAR	Selected Acquisition Report
SCN	Shipbuilding and Conversion
SIL	Software Integration Laboratory
SLOC	Source Lines of Code
SMD	Ship Manning Document
SRDR	Software Resources Data Reporting
SRU	Shop Replaceable Unit
TDY	Temporary Duty
TY	Then-Year
US	United States
U.S.C.	United States Code
USMC	US Marine Corps
VAMOSC	Visibility and Management of Operating and Support Costs
WBS	Work Breakdown Structure
WUC	Work Unit Code

Glossary

Availability. A measure of the degree to which a system is in an operable state and can be committed at the start of a mission when the mission is called for at an unknown (random) point in time.

Contractor logistics support. Contracted weapon system sustainment consisting of multiple maintenance and support functions that occurs over the life of a weapon system.

Depot maintenance. Action performed for the major overhaul or complete rebuild of end items, and the repair of secondary items. Depot maintenance requires extensive industrial facilities, specialized tools and equipment, and uniquely experienced and trained personnel that are not available at other levels of maintenance.

End item. The final production product when assembled or completed, and ready for issue or deployment.

Independent logistics assessment. A comprehensive review of a program's supportability conducted by a team of impartial subject matter experts.

Interim contractor support. Temporary contractor support required to sustain a system during its initial fielding before the period where a permanent support solution (organic, contractor, and hybrid) is established.

Integrated product support. A management framework consisting of twelve elements (e.g., sustaining engineering, supply support, etc.) that guides the develop and implementation of a program product support strategy.

Intermediate maintenance. The maintenance and repair of items that cannot be provided by the organizational level of maintenance and that does not need to go to the depot level of maintenance for major work.

Logistics reliability. The measure of the ability of an item to operate without placing a demand on the logistics support structure for repair or adjustment.

Line replaceable unit. An item removed and replaced at the organizational level of maintenance to restore an end item to an operationally ready condition. Also called weapon replacement assembly.

Maintainability. The ability of an item to be retained in, or restored to, a specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.

Maintenance. An action necessary to retain or restore an item to a specified condition.

Manpower estimate. An estimate of the most effective mix of DoD manpower and contract support for an acquisition program. Includes the number of personnel required to operate, maintain, support, and train for the system fielded by an acquisition program upon full operational deployment.

Materiel availability. The measure of the percentage of the total inventory of a system operationally capable, based on materiel condition, of performing an assigned mission. This can be expressed mathematically as the number of operationally available end items/total population. The total system population includes all operational systems necessary to support the operational context of the Capability Development Document including operational systems for training, systems for attrition reserve and prepositioning, and systems temporarily in a non-operational materiel condition, such as planned depot maintenance.

Mean time between failure. A measure of reliability for an item that represents the average time between inherent failures during normal operation.

Mean time between maintenance. A measure of reliability for an item that represents the average time between all maintenance actions, both corrective and preventative.

Mean time to repair. The total elapsed time (clock hours) for corrective maintenance for an item divided by the total number of corrective maintenance actions during a given period.

Mission reliability. A measure of the ability of a system or item to perform its required function for the duration of a specified mission profile, defined as the probability that the system or item will not fail to complete the mission (without reference to battle damage).

Operating metric. A measure of system usage. Common operating metrics are flying hours (aircraft), steaming hours (ships and submarines), and driving miles (vehicles).

Operational availability. A measure of the percentage of time that a system is operationally capable of performing an assigned mission and can be expressed as (uptime/(uptime + downtime)).

Organizational maintenance. The maintenance and repair of a system performed by the unit or activity that employs the system. This maintenance includes inspections, servicing, handling, and removal and replacement of parts.

Performance-based arrangement. A formal arrangement such as a contract or Memorandum of Agreement for implementing a performance-based logistics strategy.

Performance-based logistics. A strategy for weapon system sustainment that is based on specified performance outcomes as defined by performance metric(s) for a system. Applicable to contracts with industry and inter-governmental agreements.

Product support. The package of support functions required to field and maintain the readiness and operational capability of a major weapon system, subsystems, and components.

Product support business case analysis. An economic analysis that the program manager or product support manager uses to decide among alternative product support strategies.

Product support manager. The individual responsible for managing the package of product support functions.

Product support strategy. The primary document that describes the business and technical approach to plan, acquire, and implement the product support package.

Reliability. A measure of the probability that a system or item will perform without failure over a specific interval, under specified conditions, without reference to battle damage. Measures include mission reliability and logistics reliability.

Secondary item. Any item, including assemblies, subassemblies, and parts, that is not classified as an end item.

Shop replaceable unit. An item removed and replaced at the intermediate level of maintenance. Also called shop replaceable assembly.

Supply chain management. The integration of procurement, supply, maintenance, and transportation functions with the physical, financial, information, and communications networks to satisfy force materiel requirements.

Unit of usage. A measure of system usage or operating tempo (OPTEMPO). Common units of usage are flying hours (aircraft), steaming hours (ships and submarines), and driving miles (vehicles). Synonymous with usage metric.

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