U.S. Department
of Transportation

**United States
Coast Guard**

TOTAL OWNERSHIP COST GUIDING PRINCIPLES

COMDTINST M4140.1

U.S. Department of Transportation
United States Coast Guard

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Ref: (a) Office of Management and Budget, Circular A-11, Preparing and Submitting Budget Estimates of 12 July, 1999.
(b) Office of Management and Budget, Circular A-94, Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits of 29 Oct, 1992 (revised semi-annually).

1. **PURPOSE.** This Manual sets in place, for the first time, a methodology for Total Ownership Cost (TOC) data collection and calculation for the Coast Guard. This is required in order to enable the Coast Guard to more effectively and efficiently manage its capital assets and meet budget and congressional requirements. References (a) and (b) apply.

2. **ACTION.** Area and district commanders, commanders of maintenance and logistics commands, commanding officers of headquarters units, assistant commandants for directorates, special staff offices at Headquarters and all personnel associated with operational platforms, equipments, and systems shall:

   a. Use this Manual's Guiding Principles to gain an understanding of the concepts and principles behind TOC, pending implementation of a fully developed TOC process.

   b. Incorporate these Guiding Principles in the business decision-making processes where possible.

   c. Participate in, or contribute to, the TOC Implementation NWG, as requested.

3. **DIRECTIVES AFFECTED.** None.

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4. **BACKGROUND.** The Coast Guard's Strategic Plan defines the mission, vision, goals, and objectives of the service. It expresses the Coast Guard's intent to use "well thought out measures to continuously improve our performance in achieving our objectives, and to identify targets for improvement and candidates for shifting of resources." Consideration of total ownership cost is an integral part of this resource management process. To accomplish the fundamental purpose of Coast Guard logistics – to put the right capability in the right place at *the right cost* – decision-makers must be equipped with total ownership cost data to ensure that funding decisions yield the highest return on investment possible, over the life cycle of the investment. Total ownership cost methods can be applied to many types of capability - personnel, information and physical assets - and are used before and during the life of the asset. In the past, consideration of ownership costs was applied on an ad-hoc basis, drawing from a number of non-integrated data sources, and using non-standard techniques. Refinement of data collection methods and systems is a prerequisite for comprehensive TOC estimation and analysis. To this end, a number of initiatives are underway to develop and integrate systems to acquire and manage information essential for TOC analysis. This Manual addresses standardization of methods for TOC analysis and use of TOC information in decision making and resource management.

5. **SCOPE.** TOC policies and procedures described in this Manual are applicable to all platforms, systems, and equipments operated and maintained by the Coast Guard.

6. **PROCEDURES.** All Coast Guard personnel involved and associated with TOC data computation, data collection, data analysis, and involved with TOC based business decisions, shall refer to this Manual for guidance, descriptions, cost data elements, and definitions.

T. W. JOSIAH
Chief of Staff

Table of Contents

	Table of Contents	i
1.	Total Ownership Cost (TOC) and Life Cycle Costs (LCC)	1-1
1.A.	Total Ownership Cost	
1.B.	Background	1-1
1.C.	Current State	1-2
1.D.	Investment Board	1-2
1.E.	Future State	1-3
1.F.	Purpose	1-4
2.	Organizational Responsibilities	2-1
2.A.	Director of Finance & Procurement (G-CFP)	2-1
2.B.	Office of Financial Systems (G-CFS)	2-1
2.C.	Office of Plans & Evaluation (G-CPP)	2-1
2.D.	Assistant Commandant for Systems (G-S)	2-1
2.E.	Director of Information and Technology (G-CIT)	2-2
2.F.	Assistant Commandant for Acquisition (G-A)	2-2
2.G.	Assistant Commandant for Operations (G-O) and Assistant Commandant for Marine Safety and Environmental Protection (G-M)	2-2
2.H.	Assistant Commandant for Human Resources (G-W)	2-2
2.I.	Director of Human Resources Management Directorate (G-WR)	2-2
2.J.	Assistant Commandant, Area and District Commanders, Commanders of Maintenance & Logistics Commands, Commanding Officers of Headquarters Units and Integrated Support Commands	2-2
3.	Concepts, Procedures, and Methods for Analyzing Total Ownership Costs	3-1
3.A.	Introduction	3-1
3.B.	Concepts, Procedures and Methods	3-1
3.C.	Case Studies	3-13
3.D.	Learning Curves with Production-Rate Adjustments	3-31
4.	Definitions	4-1
4.A.	Definition of Total Ownership Cost	4-1
4.B.	Coast Guard Life Cycle Phases	4-1
4.B.1.	Planning	4-1
4.B.2.	Acquisition and Procurement	4-4
4.B.3.	Management and Use	4-14
4.B.4.	Modification and Overhaul	4-21
4.B.5.	Disposal (End of Economic Life)	4-32

Enclosure (1) Check-off List for Coast Guard Life Cycle Phases

CHAPTER 1 - TOTAL OWNERSHIP COST (TOC) and LIFE CYCLE COST (LCC)

A. Total Ownership Cost

Total ownership cost (TOC), alternatively referred to as the total cost of ownership, is the sum of all costs associated with the research, development, procurement, personnel, training, operation, logistical support and disposal of an individual asset. This cost includes the total supporting infrastructure that plans, manages, and executes that asset's program over its full life, as well as the cost of requirements for common support items and systems that are incurred because of introducing the particular asset into the Coast Guard. TOC excludes "non-linked" Coast Guard infrastructure costs that are not affected by the individual asset systems' development, introduction, deployment or operations. TOC is broader and more encompassing than Life Cycle Cost (LCC).

LCC is a subset of TOC. LCC are defined as direct costs associated with a program and indirect costs that can be obviously linked to a program. LCC has traditionally excluded most of the infrastructure costs needed to support a system or program. LCC estimating is performed to support acquisition, maintenance, and modification decisions. Except for program unique facilities, supporting infrastructure is not typically acquired or disposed due to the acquisition of a single system. As such, LCC normally excludes infrastructure costs as not relevant to the decision being made.

B. Background

The Coast Guard depends on the capability provided by its operational and support assets to perform its missions. Investment in new capital assets, or in replacement or modernization of existing assets, enables us to provide critical services to the nation around the clock, year after year.

For many years the Coast Guard (and the federal government in general) bought new assets solely on the basis of the lowest bid. Traditional methods of acquiring new assets on the basis of lowest bid often resulted in lower initial acquisition costs while causing significantly increased downstream, or out-year, costs in the operation and maintenance (O&M) of the asset. *The up-front cost of an acquisition may be as small as 5 to 20 percent of its lifecycle costs – and yet the lifecycle cost is determined by many of the events and much of the planning which take place during acquisition*. From the life-cycle cost perspective, *a significant part of the TOC of an asset is determined by these O&M costs* (e.g., the TOC of a 41' UTB, including crew, fuel, maintenance and overhauls, based on a 25-year service life, is twenty times the original acquisition cost). By considering tradeoffs between acquisition and downstream O&M costs, the lowest life cycle cost can serve as the basis of the decision. By applying a life cycle cost approach in evaluating projects, we hope to

better understand the longer term fiscal implications of the assets we are purchasing today. Sound business decisions concerning the purchase of new assets must consider mission effectiveness, initial acquisition cost, and an analysis of total ownership costs.

The Government Performance and Results Act of 1993 (GPRA), the Strategic Plan, and the Performance Plan require an accurate accounting of the costs of the resources associated with the public goods provided.

The GPRA requires strategic and performance planning in the Federal Government. Under this law, the Coast Guard is accountable for defining and then achieving program results with the *resources at its disposal*.

The Coast Guard's Strategic Plan establishes general goals and objectives, and strategies for achieving those goals and objectives. It also includes descriptions of the operational processes, skills and technology, and the human, capital, information, and other resources required to meet those goals and objectives.

The Coast Guard's Performance Plan, developed around the Coast Guard's five operational outcome goals of Maritime Safety, Maritime Mobility, Protection of Natural Resources, Maritime Security and National Defense, is prepared and submitted annually. A Performance Report follows this Plan, assessing the actual program results against the established performance goals.

C. Current State

The Coast Guard lacks a means of fully accounting for the TOC of various assets (or sub-components of those assets) which would enable the comparison of assets (both existing and proposed) against each other. By methodically forecasting the costs associated with each asset over the course of its acquisition, use and disposal, we can plan for the long-term funding needed to operate the assets and maintain their full capability and functionality. By assessing the costs of existing assets over time, we can make decisions about replacement, if appropriate, with more cost-effective replacements. It is important to note that this approach does not by itself comprehensively address increasing productivity. The operational effectiveness – the benefit side of the productivity ratio[1] – must also be addressed.

To make the best use of available funding, the Coast Guard must have a means of comparing the costs of various initiatives, and associated options, to ensure that each is considered thoroughly with a common level of detail and underlying assumptions.

D. Investment Board

Within this context, an Investment Board, chaired by the Director of Resources, (and including the Assistant Commandants for Human Resources; Marine Safety, Security and Environmental Protection; Operations; Systems; Acquisition; the Director of Finance and Procurement, and the Director of Information and Technology) is

[1] P=V/C; where "P" is productivity, "V" is value, and "C" is cost

chartered by the Chief of Staff to provide cross-programmatic review and prioritization of investment and divestment alternatives. The Investment Board provides recommendations to the Chief of Staff on the development of yearly Forecast Stage Budgets. This senior management review is critical to the prioritization of organizational goals and investment opportunities, and guides the formulation of the budget and the development of yearly forecast plans.

E. Future State

Competition for capital resources, will increase during the foreseeable future as the Coast Guard enters a critical period of recapitalization. The methodology the Investment Board uses to accomplish this review and prioritization will evolve over the next few years, and should provide a common basis for making investment decisions across the spectrum of initiatives. Investment decisions should consider both operational effectiveness and/or organizational benefit (e.g., improved performance, enhanced capability), as well as total ownership costs. Our ability to maintain and acquire future resources will be directly tied to our ability to demonstrate Return on Investment (ROI), sound base management, and contribution toward performance goals.

In order to make the best decisions - decisions that will maximize our ROI for all assets in all mission areas – we must have data covering cost and performance that encompass the life of the asset. The *Capital Programming Guide* (Supplement to OMB Circular A-11) addresses the use of cost-benefit analyses at key decision points in the capital programming process

> "to help decide whether the best way to reduce the performance gap is through acquiring a new capital asset, undertaking a major modification on an existing asset, or some other method,"

and stipulates that

> "…costs should be estimated over *the full life-cycle* of each alternative."

The Coast Guard Agency Capital Plan provides the following direction to asset managers: "Minimizing out-year costs and avoiding near-term costs must be a continuously pursued goal…in ongoing business planning and portfolio management efforts. Life cycle costs must be a major factor in the evaluation and selection of proposals in the acquisition process."

By applying a lifecycle cost approach in evaluating projects, the downstream fiscal implications of the assets we purchase today are better understood. Sound business decisions concerning the purchase of new assets *must* consider lifecycle costs as well as the potential improvements in mission effectiveness. In doing so, certain criteria are fundamental to the decision-making process:

1. Program objectives and functional requirements must be explained. Program objectives from the Coast Guard's annual performance plan, the performance gap which the investment is intended to fill, and the functional requirements for the asset should be identified.

2. Alternative means of meeting the program objectives must be considered. (Other than acquisition of an asset.)
3. Budget projections and financial forecasts must be considered.
4. Finally, the choice of "the best capital asset" is dependent in part upon a cost-benefit analysis, which *considers not only initial acquisition costs, but also all life-cycle costs.*

These criteria provide a means of evaluating the maximization of benefits and the minimization of costs. The emphasis of this manual is on the cost component: The collection of accurate lifecycle cost data (e.g. planning costs, manufacturing and procurement costs, management and use costs, modification and overhaul costs, and disposal costs) is an important factor in the development of any business case. Together with mission effectiveness, LCC evaluations will be used as part of the basis for business decisions that will allocate scarce resources to maximize support of our operational missions.

F. Purpose

The main purpose of this manual is to provide a foundation for the TOC data processes, procedures, and analytical criteria - possible only through diligent and planned cost accounting and data sharing. This foundation will provide the basis for the development of financial and automated systems decisions that will eventually tie all the data collection points together. The resulting data will inform business decisions that will enhance the way we support our operational missions and expend scarce resources. Our successful implementation of this manual will be evident in the availability of lifecycle cost data to future Investment Board decisions and recommendations.

A common methodology (Chapter 3) is provided, as well as Cost Data Element Definitions (Chapter 4) and recommended check lists (enclosure (1)) needed to ensure that total ownership costs are considered in as consistent a manner as possible. The framework presented is general enough to be applicable to various types of Coast Guard assets including aircraft, buildings and facilities, boats and cutters, computer hardware and software, and electronic equipment.

CHAPTER 2 - ORGANIZATIONAL RESPONSIBILITIES

A. Director of Finance and Procurement (G-CFP). G-CFP is the functional process owner of TOC. They will oversee all initiatives, changes, or modifications in partnership with the Assistant Commandant for Acquisition (G-A), the Assistant Commandant for Systems (G-S), and the Assistant Commandant for Human Resources (G-W). They will, in collaboration with each of these Directorates, be responsible for maintaining and updating this manual.

B. Office of Financial Systems (G-CFS). G-CFS will be responsible for TOC process management and standardization, and for ensuring that these guiding principles are being followed throughout the financial arena. Object class codes will be identified to track the individual cost data elements of Coast Guard capital assets.

C. Office of Plans, Policy & Evaluation (G-CPP). G-CPP will be responsible for overall enforcement, and will incorporate these guiding principles into the Coast Guard resource management process.

D. Assistant Commandant for Systems (G-S). G-S will be responsible for ensuring that all G-S Offices, and Headquarters Commands are familiar with these guiding principles and are implementing organizational policies that will ensure the appropriate support cost data elements are tracked, recorded, and reported. This is required specifically for the support areas of the Management & Use, Modification & Overhaul, and Disposal phases of the life cycle.

1. Offices of Aeronautical Engineering (G-SEA), Naval Engineering (G-SEN), Civil Engineering (G-SEC), Electronics Systems (G-SCE), and Logistics Systems (G-SLS) will:

    a. Ensure TOC cost data is considered in the development of all support plans and systems upgrades, for both new and existing platforms, systems, and equipment.

    b. Ensure that Headquarters Commands are capturing, tracking, and reporting support cost data elements for the capital assets they support.

    c. Ensure that TOC guiding principles and cost data elements are considered in all automated logistics systems. These data elements and requirements, if not already imbedded, will be included in any automated systems upgrades.

2. Office of Logistics Policy (G-SLP): They will be responsible for ensuring that the guiding principles contained in this manual are included, as appropriate, in all applicable integrated logistics support and configuration management policy manuals.

E. Director for Information and Technology (G-CIT). G-CIT will control IT architecture and will provide direction over and review of systems development and base funding management.

F. Assistant Commandant for Acquisition (G-A). They will be responsible for capturing all cost data elements associated with the Planning and Acquisition & Procurement life cycle phases for major acquisitions.

1. Chief, Acquisition Technical Support (G-A-2) will ensure that appropriate models are used during Planning, Acquisition & Procurement Life Cycle phases. These models will be selected based on each particular acquisition project requirements. The desired model is parametric based, however, non-parametric modeling may be required depending on program needs and requirements. The cost data elements tracked and collected need to be coordinated with G-CFS and the Coast Guard Finance Center to ensure that they match up with overall Coast Guard requirements.

2. Chief, Office of Contract Support (G-ACS) will develop TOC contract language that will be included in major and non-major acquisition contracts as appropriate.

G. Assistant Commandant for Operations (G-O) and Assistant Commandant for Marine Safety and Environmental Protection (G-M). TOC will be considered when planning for new operational capability requirements, modernization, or contingencies. TOC will also be considered, to the extent possible, for unexpected new operational requirements.

H. Assistant Commandant for Human Resources (G-W). G-W will be responsible for both existing systems and for new system requirement planning for capturing all cost data elements associated with recruiting costs, ascension costs, technical and professional training costs, annual pay and benefit costs and the costs of retired pay and benefit liabilities for human resources. In addition, they will provide assistance to those preparing TOC estimates for these data elements.

I. Director of Human Resources Management Directorate (G-WR). G-WR must work with all directorates during the development phase of asset procurement to ensure that the people are qualified when the Coast Guard takes delivery of new assets. G-WR is responsible for developing Standard Personnel Costs used in estimating the people side of TOC.

J. Assistant Commandants, Area and District Commanders, Commanders of Maintenance & Logistics Commands, Commanding Officers of Headquarters

Units and Integrated Support Commands. They are responsible for ensuring that their subordinate units are using the correct cost codes on all financial transactions. This is critical if the data collected and compiled at the Finance Center is to be accurate. This cost data will be considered within these organizations in all operational and support business decisions.

CHAPTER 3 - CONCEPTS, PROCEDURES, AND METHODS FOR ANALYZING TOTAL OWNERSHIP COSTS

A. Introduction.

The main body of this instruction sets forth Coast Guard policy and objectives pertaining to investment in capital assets. Analyses of total ownership costs are an integral part of the process leading to the eventual investment decisions. This chapter deals strictly with TOC analyses. The material presented here is entirely consistent with, although not drawn exclusively from, Office of Management and Budget Circular No. A-94, Revised, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, October 1992.

Three sections follow this introduction. The first addresses concepts, procedures, and methods largely in narrative form, although it does contain a few explicit analytical formulations. The second summarizes several "case studies" intended to reinforce, by example, the narrative that precedes them. The final section deals with sources of cost and cost-related data thought to be useful across a wide range of Coast Guard analyses. That section is very preliminary because many systems for tracking and reporting costs are either in their infancy or not yet in existence. As new data sources evolve, and as experience accumulates in conducting cost analyses to inform investment decisions, that section—and the overall instruction—will be revised.

B. Concepts, procedures, and methods.

Because *investment in capital assets* and *total ownership costs* are very broad topics, this document must be equally broad. The approach taken in this section is to pose a number of questions for which answers should be sought early in any TOC analysis. The chapter discusses why the questions are important and how their answers can be used to properly shape and execute the analysis. In some cases, very specific statements can be made about obtaining the answers and the form they will take. In others, that won't be possible. The reason is that no two TOC analyses are alike. The decisions they seek to support vary widely, as do the numbers and types of alternatives within each decision set. Moreover, some analyses focus on alternatives that represent only minimal departures from systems and concepts that are well understood and for which solid data are available. Others represent just the opposite. Nevertheless, regardless of where on that spectrum any particular analysis of TOC falls, the information contained in this guide should ensure that a solid analytical framework is established and that all important cost issues bearing on the ultimate decision are addressed.

1. What decision(s) will the cost analysis inform, and what are the alternatives under consideration?

These are actually two questions that are best treated as one. Experienced cost and system analysts agree that, in order for cost information to be meaningful, it must be developed with a clear view of its intended use. Attempts to carry out cost analyses in

the abstract are simply unproductive. An example of "cost analyses in the abstract" might be, "Develop the total ownership costs of the Coast Guard's fleet of icebreakers." Such an effort would be effectively unbounded and would have no ties to any decision involving investment alternatives. The case studies presented later in the enclosure provide examples of analyses tied to Coast Guard investment decisions. In general, Coast Guard decisions requiring TOC analysis will focus on alternative ways of achieving:

- System optimization.
- Infrastructure and organizational optimization.
- Optimization of capital asset replacement cycles; and
- Optimal selection from candidates for new acquisition.

It is natural to think of the alternatives under consideration as consisting of different mixes of systems, equipments, and—on occasion—facilities. However, what generates the time-dependent streams of ownership costs that the analysis seeks to quantify are not the capital assets themselves, but rather *implementation of the courses of action* needed to adopt each of the candidate mixes. Thus, while "Fleet #1," "Fleet #2," and "Fleet #3" may be convenient labels for the alternatives, the true *decision alternatives* are the respective sets of actions required to achieve the target capabilities or outcomes. Moreover, in laying out and tracing the implications of these actions, certain types of costs frequently arise that had not been previously recognized. Examples are contract cancellation charges and activity relocation expenses. Costs such as these do not typically appear in standardized lists of life-cycle cost elements.

Summary point: <u>It is important to understand both how the cost information will be used, as well as the actions required to implement each alternative under consideration</u>.

Agency Guidance: <u>All TOC analysis will use societal perspective as the basis for determining the existence of costs and benefits. It is inappropriate to ignore a cost or a benefit from the analysis because it is not born or received by the Coast Guard.</u>

2. What categories of costs will be affected?

The literature on cost analysis makes frequent reference to the notion of *relevant* costs. Costs that are affected by—meaning those that vary with—the alternatives being considered are said to be relevant. For example, in an analysis focusing on the selection of an engine for a particular type of helicopter, fuel consumption costs of the candidate engines would be highly relevant, as would their maintenance costs. On the other hand, costs of the flight crew would probably not be relevant because, in all likelihood, the size and configuration of the crew would be the same regardless of what engine is selected. Assuming that to be the case, would it be a mistake to estimate crew costs and include them in the analysis? The answer is that it would *not* be a mistake because (1) those costs may be of interest in another context, and (2) what ultimately matters are the *differences* in costs among the alternatives. In this hypothetical example, the common crew costs would simply drop out when the cost differences are computed.

The general approach recommended for answering this question is to carefully trace through the alternatives, with special focus on the actions and activities associated with each, using the elements and definitions in enclosure 1 as a checklist. Typically, different categories of costs will be affected by the different alternatives. For example, one or more alternatives might include procurement of new assets, while another provides for extending the service life of existing assets. And as mentioned above, when the implications of the different courses of action are fully identified, one or more non-standard categories of costs may become apparent. (Again, contract cancellation costs are mentioned both as an example of a nonstandard cost and as a category that had an important impact on an actual study.)

Summary point: Only those costs that vary across the alternatives are truly relevant to the analysis, and their identification requires careful assessment of the courses of action under consideration.

Agency Guidance: All resources used and consumed by the analysis alternatives must be included within the cost analysis. Specifically, the consumption of assets must be included in the analysis as a cost. They may not be excluded from the analysis based on the rational that the funds expenditure is not within the analysis period.

Agency Guidance: Opportunity costs must be used for resources used to provide the service/product, even if the resource is not consumed. This most commonly occurs with the agency use of federally owned land.

3. How should the costs be estimated?

Entire texts are written on methods of cost estimating, and courses of one or two semesters are given on the subject. This document provides only a brief overview—a thumbnail sketch, actually—that may be useful in selecting a suitable approach for a given category of cost in a given analysis.

There are five different approaches to cost estimating, listed (with certain exceptions) in ascending order of information required for use:

- Vendor quotes
- Cost factors
- Analogy
- Parametric estimation
- Engineering build-up.

When vendor quotes are used, the estimator essentially acknowledges having little or no basis for constructing an independent estimate of a cost in question. For a wide range of commercial off-the-shelf products, this is a thoroughly satisfactory approach. Difficulties can arise, however, in the case of nonstandard products or services with which the vendor has minimal experience. Also, vendor quotes will typically not include such things as

warranties, spare parts, transportation, technical data, initial training, or fleet introduction costs. Therefore, additional estimation problems may remain.

A cost factor is a metric such as cost-per-square-foot for constructing a particular type of facility—an aircraft hangar, for instance. Using this factor, the only information needed to generate a construction cost estimate is the square footage of a proposed new hangar. Obviously, a wide range of things other than size will influence the ultimate cost of the new hangar, but this factor-based estimate might easily suffice in the initial stages of an analysis.

Estimation by analogy is only a short step away from the use of cost factors. Suppose the item of interest is the procurement cost of a new gas-turbine engine for surface-ship propulsion. Suppose further that shaft horsepower (shp) is thought to be the principal driver of this cost. Empirical data indicate that a 40,000-shp engine costs $2 million. Because the new engine will have 60,000 shp, the ratio of 60,000 to 40,000 is applied to the original $2 million cost to obtain an estimate of $3 million to procure the new engine. Note that analogy estimation requires roughly the same amount of information as needed when cost factors are used.

Parametric methods represent a logical extension of estimation by analogy. Imagine that a need exists to estimate fuel costs per flight hour for a new fixed-wing transport aircraft. Certainly, the weight of the aircraft has an influence on fuel consumption, but the same is also true of cruising speed and certain engine characteristics. In this context, aircraft weight, speed, and engine characteristics are considered "parameters," which gives rise to the term *parametric* estimation. Provided information is available on fuel consumption, weight, speed, and engine characteristics for a sufficient number of different types of transport aircraft, application of statistical methods—usually multiple regression analysis—would make it possible to develop a parametric estimating equation such as

$$Y = 127.7 + 5.62X_1 + 0.88X_2 - 148.3X_3,$$

where

Y = estimated fuel costs per flight hour
X_1 = gross take-off weight (thousands of pounds)
X_2 = average cruising speed (knots)
X_3 = an *indicator* variable equal to 1 if turbo-prop engine and 0 otherwise.

Clearly, parametric estimation requires a good deal more information (and time) than the other methods that have been discussed. However, where this approach is feasible, the resultant estimate rests on fairly solid ground in that definitive statistical statements can be made about its accuracy and about the significance of the factors on which the estimate is based.

Engineering build-up is probably the most accurate method of cost estimation, and it certainly requires the most information to implement. Very detailed designs must be

available, together with accumulated experience on material usage and costs, labor hours by type of labor, and an associated set of burden rates. The paradox about engineering-based estimation is that by the time (in the evolution of a new system) sufficient information is available to make it feasible, virtually all the important cost-related decisions will have been made. Thus, the primary value of the engineering estimate is to fine-tune an earlier estimate that played a more important decision role.

In the discussion of estimation by analogy, the example used was "the" procurement cost of a gas-turbine engine. This implies that the procurement cost for each engine is constant. In point of fact, procurement costs of virtually all platforms, weapons, and other systems manufactured for use by the U.S. Government tend to vary in a systematic way. Unit costs decrease with increases in (1) the cumulative number of units produced, and (2) annual rates of production. The first type of variation is referred to as *learning* or *progress*. As additional units are produced, workers become more proficient at their jobs, plant layout and materials handling improve, and lower-cost vendors are sought out. The second type results from the fact that, as annual production rates increase, certain fixed costs are spread over a larger number of units, which tends to decrease unit cost. These phenomena are usually analyzed and quantified by what are known as *rate-adjusted learning curves*. The appendix to this enclosure provides considerably more detail on this topic.

Summary point: <u>Costs can be estimated by many different methods. Choosing a particular method depends on the amount and type of information available to the estimator and the degree of accuracy required of the estimate</u>.

4. Do personnel costs raise any special issues?

Personnel costs—especially the costs of military personnel—do in fact raise certain special issues. First, it is no trivial matter to identify and estimate the totality of *direct* personnel costs. And second, coming to grips with the *indirect* costs of military personnel is a far more difficult matter. The reason is that indirect costs are never entirely visible.

The Coast Guard publishes updated tables of the direct costs of military and civilian personnel on a semi-annual basis. For military personnel, the cost elements are basic pay, basic allowance for quarters, variable housing allowance, basic allowance for subsistence, FICA, incentive and special pays, clothing allowance, COLA and overseas housing allowance, and reenlistment bonuses. For civilians, the elements include basic/locality pay, lump sum payments, benefits, and other forms of compensation such as hazardous duty and severance pays.

Retirement is one element that is missing altogether in the military costs and only partially provided for in the civilian costs. The reason is that it is accrued, but not funded, on a current basis. The data in table 1, taken from the Coast Guard's life-cycle cost estimate of alternatives for maintaining heavy icebreaking capabilities on the Great Lakes, include an estimate of retirement accrual costs along with all other direct costs.

Following current practice in the Department of Defense, a factor of 32 percent of basic pay is frequently used to provide for retirement accrual costs of military personnel.

As Coast Guard military personnel strength increases and decreases over time, there are cost impacts on the support infrastructure that provides training, health care, and station transfers. Those are the indirect costs of military personnel. The Coast Guard has developed a methodology for estimating these costs. Application of that methodology suggests that, in terms of very rough averages, annually recurring indirect costs represent about 15 percent of direct costs for officers and 26 percent for enlisted personnel. It is important to note that these percentages do not include some substantial one-time (nonrecurring) costs.

Table 1. Estimates of direct military and civilian personnel costs per year (in thousands of FY 1999 dollars)

Military				Civilian	
Grade/rank	Cost	Grade/rank	Cost	Grade	Cost
O-6	133.2	E-9	84.4	GS-15*	111.7
O-5	115.3	E-8	72.8	GS-14	101.2
O-4	98.9	E-7	65.0	GS-13	85.6
O-3	86.7	E-6	58.1	G2-12	74.3
O-2	70.3	E-5	50.9	GS-11	62.5
O-1	54.1	E-4	43.0	GS-10	60.6
		E-3	36.7	GS-9	52.4
W-4	93.7	E-2	32.3	GS-8*	48.4
		E-1	38.3	GS-7*	45.0

*Not included in original source; estimated independently.

Summary point: <u>Estimation of direct personnel costs requires careful treatment, and indirect military personnel costs pose further difficulties.</u>

5. What time horizon should the analysis cover?

In a few cases, the length of the relevant time horizon is clearly evident. One such case is an analysis that focuses on establishing an interim capability, or on finding an interim solution to a problem, while waiting for the availability of something more permanent. Quite often, however, there is no definitive answer to this question. Capital assets tend to have very long lives. In fact, the lives are sufficiently long as to be somewhat uncertain. Moreover, an asset's technologically useful life may be quite different—and even more uncertain—than its physical life. Add to that the uncertainty associated with future mission requirements, operating environments, and funding levels, and it becomes apparent why the length of the analytical time period may be in doubt. The general subject of uncertainty is taken up later in the enclosure, but worthy of note here is that if there is serious doubt about the relevant time horizon, the effects of varying its length

should be examined. At a minimum, the time period should be long enough to reveal the full cost consequences of adopting each alternative under consideration.

Summary point: It is seldom possible to know with certainty what period of time an analysis should cover, but the length of the time horizon is an important parameter and one that deserves careful consideration.

6. What should be done about inflation?

There is widespread agreement that the measures of cost used in TOC analyses should be adjusted for inflation. One reason is that, from the perspective of cost alone, the important difference between two competing alternatives is the *real* resource demand imposed by each. *Real* resources are the products and services that are ultimately purchased with money. Gallons of fuel, items of test equipment, rounds of ammunition, and person-years of military and civilian labor are some obvious examples. Without adjustment for inflation, monetary cost measures represent an indeterminate mix of real resource consumption and price fluctuation.

A second reason for using inflation-adjusted measures is their greater ease of interpretation. If a cost or budget estimate, applicable 10 years hence, is expressed in today's dollars, it can be readily understood and assessed. If it is expressed in the prices that are expected to prevail 10 years from now, the number has very little meaning. In fact, an analyst's first inclination would be to find a way to adjust it back to today's prices in order to make it understandable.

Dollar measures of costs that have not been adjusted for inflation are referred to variously as *then-year* dollars and *undeflated* dollars. Adjusted measures are said to be in *constant* dollars, with the unit and base year of the adjustment typically specified, as in "millions of constant FY 1999 dollars." Similarly, *nominal* costs are those that have not been adjusted for inflation, whereas *real* costs have been adjusted. *Budget year* dollars are a type of *constant* dollars where the base year is the budget year in which the money is being requested.

The adjustment process is typically carried out by use of *cost escalation indexes,* where the undeflated cost divided by the appropriate index to convert the nominal dollars into constant year dollars. Likewise, deflated costs are multiplied by the appropriate index to convert constant year dollars into budget year dollars. Table 2 provides a very simple example of that process.

Table 2. Example adjustment for inflation

Fiscal year	Costs in budget year dollars (mil)	Escalation index	Costs in constant FY 1999 dollars (mil)
1998	621.5	0.9613	646.5
1999	822.4	1.0000	822.4
2000	977.9	1.0540	927.8

Although the TOC analyses should be done in constant dollars, when the time comes to incorporate the results of those analyses into budget submissions or other financial management plans, it is necessary to convert back to budget year dollars. Continuing with the example above, if some FY 2000 cost had been estimated in constant FY 1999 dollars, that estimate would have to be multiplied by 1.0540—the hypothetical index value used here—in order to budget for the actual number of dollars required in FY 2000.

The Coast Guard is concerned with escalation indexes for four categories of costs: military pay and allowances, civilian pay, fuel, and all other purchases.

The concept behind the escalation indexes is—at least in principle—quite straightforward. Year-to-year changes in the first two categories are determined by congressional action. Changes in fuel prices—known for their volatility—are determined by the interaction of worldwide supply and demand, and have their own tracking and reporting system. For all other purchases, the index corresponding to price changes in Gross Domestic Product—the so-called *GDP implicit price deflator*—is thought to be the best single measure. In practice, however, matters are more complicated, primarily for the following reason. Coast Guard financial management is centered on *appropriation accounts* such as Research, Development, Test, and Evaluation (RDT&E); Acquisition, Construction, and Improvements (AC&I); and Operating Expenses (OE), whereas the four cost categories above constitute building blocks (with varying weights) for the appropriation accounts. Table 3 provides escalation index data for the four cost-building blocks. Access to other information of this type, including annual updates, is discussed in the section of the enclosure dealing with data sources.

Summary Point: <u>Cost measures used in TOC analyses should be in constant dollars; cost estimates included in budget submissions should be in budget year dollars</u>.

7. Should future costs be discounted to their present value?

All else being equal, it is preferable to defer a cost into the future. It then becomes possible to use, at least temporarily, the funds in question to exploit near-term opportunities. Alternative cost streams are compared analytically by *discounting* the year-by-year costs to their equivalent *present values*. Office of Management and Budget (OMB) Circular No. A-94 (Revised), October 1992, is the authoritative source on present-value analysis and discount rates for the Executive Branch of the U.S. Government. The circular's policy and procedures differ between benefit-cost studies and cost-effectiveness analyses.

Benefit-cost analysis focuses on a single (proposed) project, and seeks to determine whether that project can be justified on economic grounds. Justification requires that the stream of expected monetary benefits accruing to society at large, when discounted to its present value, exceed the discounted stream of expected costs. For such analyses, where the benefits and costs are measured in real terms, A-94 prescribes an inflation-adjusted discount rate of 7 percent. That rate is said to approximate the marginal pretax rate of

return on an average investment in the private sector. For cost-effectiveness analyses, which may constitute the most common use of TOC analysis throughout the Coast Guard, as well as for lease-purchase, internal government investment, and asset-sale analyses, A-94 prescribes a different rate for use in discounting the constant-dollar cost streams. (Cost-effectiveness analysis is defined in Appendix A of A-94 as "A systematic quantitative method for comparing the costs of alternative means of achieving the same stream of benefits or a given objective.") That rate is pegged to the real Treasury borrowing rate on marketable securities of comparable maturity to the period of analysis. OMB updates the Treasury rates annually, usually in February. Since the 1992 revision to A-94, rates on 30-year securities—a time horizon frequently used in TOC analyses—have ranged from a high of 4.9 percent to a low of 2.8 percent, with an average of 3.7 percent.

Table 3. Escalation indexes for the four primary cost categories
(Base year = FY 2000)

Fiscal year	Military pay and allow	Civilian pay	Fuel	Implicit GDP deflator
1970	0.1951	0.2098	0.4429	0.2560
1971	0.2105	0.2280	0.4630	0.2691
1972	0.2348	0.2468	0.4808	0.2820
1973	0.2560	0.2618	0.5007	0.2944
1974	0.2757	0.2851	0.5303	0.3157
1975	0.2977	0.3082	0.6102	0.3482
1976	0.3191	0.3333	0.6559	0.3733
1977	0.3404	0.3625	0.7097	0.4017
1978	0.3656	0.3916	0.7600	0.4300
1979	0.3894	0.4147	0.8786	0.4656
1980	0.4216	0.4430	1.6386	0.5070
1981	0.4732	0.4818	1.8977	0.5569
1982	0.5165	0.4944	2.1116	0.5963
1983	0.5427	0.5212	1.9029	0.6238
1984	0.5655	0.5424	1.6400	0.6479
1985	0.6072	0.5609	1.5212	0.6702
1986	0.6265	0.5731	1.3181	0.6893
1987	0.6501	0.6087	1.2102	0.7092
1988	0.6807	0.6474	1.0145	0.7339
1989	0.7095	0.6880	1.0153	0.7649
1990	0.7281	0.7217	0.9059	0.7966
1991	0.7614	0.7504	1.6958	0.8308
1992	0.7857	0.7817	1.1311	0.8552
1993	0.8184	0.8116	1.1469	0.8778
1994	0.8387	0.8322	1.3086	0.8990
1995	0.8593	0.8527	1.1463	0.9206
1996	0.8793	0.8732	1.2105	0.9387
1997	0.9051	0.8994	1.2263	0.9564
1998	0.9313	0.9246	1.4679	0.9678
1999	0.9616	0.9579	1.3387	0.9804
2000	1.0000	1.0000	1.0000	1.0000
2001	1.0357	1.0390	1.1320	1.0210
2002	1.0726	1.0795	1.1682	1.0424
2003	1.1111	1.1216	1.1881	1.0643
2004	1.1516	1.1654	1.2095	1.0867
2005	1.1938	1.2108	1.2312	1.1095

Source: *National Defense Budget Estimates for FY 2000*, Office of the Under Secretary of Defense (Comptroller), March 1999.

The standard factor used in discounting a cost that is expected to be incurred in year t is $1/(1 + r)^t$, where r is the discount rate in decimal form. This is called *end-of-year* discounting, meaning that all costs are assumed to occur in a lump sum at the end of each year. However, because costs are more likely to flow uniformly over the course of a year, a better approach—and A-94 acknowledges this—is to use *midyear* discounting. In that case, the factor becomes $1/(1 + r)^{t - 0.5}$. Table 4 illustrates midyear discounting

applied to the hypothetical constant-dollar costs from table 2. The discount rate used is the 3.7 percent average for 30-year Treasuries.

Table 4. Example midyear discounting (r = 3.7 percent)

Fiscal year	Costs in constant FY 1999 dollars (mil)	Discount factors	Discounted costs in constant FY 1999 dollars (mil)
1998	646.5	0.9820	634.9
1999	822.4	0.9470	778.8
2000	927.8	0.9132	847.2

Although the benefits associated with certain Coast Guard operations can occasionally be measured in monetary terms, the decision to acquire and sustain the capability to conduct those operations is generally not based on the outcome of a benefit-cost analysis. Instead, the supporting analysis seeks to choose from alternative ways of providing that capability. Accordingly, A-94 discounting procedures based on Treasury rates constitute the norm for Coast Guard use.

Summary point: Constant-dollar cost streams in TOC analyses should be discounted to their present values, using discount rates prescribed annually by OMB Circular No. A-94 for cost-effectiveness analyses.

8. How will risk and uncertainty be treated?

This discussion begins with a note on semantics. There are different schools of thought as to the distinction, if any, between *risk* and *uncertainty*. One view, which can be traced far back in the academic and professional literature, holds that risk can be characterized in probabilistic terms, whereas uncertainty cannot. A second interpretation is that risk has to do with the occurrence of an undesired outcome, whereas uncertainty is more neutral or symmetric. (There is *risk* in driving at very high speeds, but whether a car will be available is *uncertain*.) Still another view is that, for analytical purposes, the two are the same. For convenience more than anything else, the discussion that follows adopts the third position, but certainly there is merit in the first two.

The only costs pertinent to investment decisions are those that will occur in the future. Because the future is inherently uncertain, so, too, are estimates of future costs. This is an important and fundamental concept. The important practical considerations are (1) the *degree* of uncertainty in any particular estimate, and (2) the relative importance of the estimate with respect to total cost. Where cost estimates pertain to existing assets and are based on several years of experience with those assets, the degree of uncertainty should be minimal. Where the assets do not yet exist, or have not existed long enough for any data to be accumulated, the uncertainty will be greater. If one or more estimates are thought to be highly uncertain, but if they pertain to cost elements that represent only a small fraction of total costs, the validity of the analysis is not seriously threatened. If the

elements in question represent a substantial portion of total costs, the analysis must deal explicitly with the uncertainty.

Uncertainty can be dealt with in two ways. The first is by sensitivity analysis. Rather than using a single estimate that is thought to be uncertain, multiple values are used, and the effect of changes in the estimate on preference among alternatives is assessed. (OMB Circular No. A-94 encourages this, and also encourages use of sensitivity analysis with respect to discount rates in present-value analysis.) TOC analyses frequently attempt to bound the uncertainty by using optimistic, pessimistic, and most likely estimates.

The second approach makes use of probability analysis. The objective is to characterize uncertainty (either in individual estimates or in total costs) by use of a particular type of probability distribution with specified parameter values. Often the distribution and parameter values are generated by Monte Carlo simulation. The probability approach makes it possible to speak in terms of the *expected* costs of each alternative—in the sense of mathematical expectation. It also becomes possible to make statements regarding statistical confidence in the results, such as, "Alternative 2 is thought to be less costly than Alternative 1 with statistical confidence of 80 percent." Another such statement might be, "There is 90-percent confidence that the total costs of Alternative 2 will not exceed $900 million (in constant FY 1999 dollars)."

There seems to be a natural tendency to defer risk and uncertainty considerations until an analysis is nearly complete, and to then "tack it on" at the end. This is not good practice. For one thing, there will very likely be insufficient time and resources remaining to deal adequately with these matters. In addition, certain insights and interim results that would have informed the uncertainty analysis may not have been retained. The best practice is to begin addressing the uncertainty issue at the same time that the relevant cost categories are being identified and an estimation strategy is being formulated.

Summary point: <u>Estimates of future costs are inherently uncertain. In cases where a high degree of uncertainty surrounds a substantial fraction of total cost, its consequences should be examined by sensitivity analysis or probabilistic modeling</u>.

9. What are the documentation requirements?

A major theme running through this document is that no two TOC analyses are alike, and therefore no template can be provided for structuring and carrying out an analysis. The same applies to documenting the work. However, a few general observations and suggestions can be offered.

The primary objective of the documentation is to ensure that the reader/user (1) understands what was done—and what was not done, in some instances—and (2) can fairly assess the results. The reference to "what was not done" has in mind situations in which certain alternatives or certain analytical approaches were considered for inclusion but were ultimately left out. The reason(s) for the exclusion might constitute important information. A good test of whether a sufficient basis has been provided for

understanding the work is that of "reproducibility." This is a test in principle only because frequently it is impractical to include in the documentation all input data needed to generate the results being reported. The pertinent question is whether a reader/user, if provided with all requisite inputs (as well as sufficient time and computing resources), could then reproduce the results. In applying this test, it often becomes apparent that certain assumptions were made—perhaps implicitly—that impact the results. Those assumptions need to be spelled out.

Enabling a reader/user to "fairly assess the results" requires what might be characterized as *full disclosure*. If the persons conducting the analysis were required to make certain assumptions with which they are not comfortable, this should be noted. And although all analyses will embody some degree of uncertainty, it clearly plays a larger role in some than in others. In general, this has to do with the subject matter being examined and the quality of the available data, not with the capabilities of the study team. Acknowledging and dealing explicitly with uncertainty—in the ways discussed above—is typically a sign of good work. So, too, is documentation tailored to the needs and backgrounds of its target audience.

Summary point: <u>Documentation of TOC analyses should permit, at least in principle, the results to be reproduced, and should also provide the basis for a thorough understanding and fair assessment of those results</u>.

C. Case studies.

As indicated at the outset of this enclosure, the following case studies are intended to reinforce, by example, the preceding discussion of concepts, procedures, and methods associated with the analysis of total ownership costs. Although the cases do not represent actual studies, they are intended to be sufficiently realistic to provide a Coast Guard context for the analytical issues being demonstrated. And although they do not cover all functional areas, they are diverse enough to suggest how a very wide spectrum of TOC analyses might be structured and carried out.

1. Case 1: Analysis of engines for medium-range surveillance aircraft

a. Background and assumptions

The Coast Guard (CG) has a fleet of 50 medium-range surveillance aircraft that have been in service for about 20 years. The airframes have estimated remaining service lives of about 30 years. The engines can also last that long, if properly maintained and serviced. Currently, the CG crew does the operational-level (O-level) and the intermediate level (I-level) maintenance, while the engine manufacturer performs the major overhauls. However, the costs to maintain and repair the engines have been steadily increasing. The maintenance records show that these costs (as well as the costs of fuel consumption) have been increasing by about one percent (in real terms) every year for the last six years. The reliability engineers and the maintenance personnel predict that the trend will continue for the rest of the service life of the engine. The CG has decided to examine alternatives to the status quo. Two

alternatives have emerged as being the most promising. Both involve purchasing the same new engines (TFE-800s) and retrofitting them to the airplanes. However, one alternative (Alt 1) proposes performing all levels of maintenance in-house, whereas the other (Alt 2) recommends the CG to do only O-level maintenance and buy contractor warranties to cover the I-level and depot-level (D-level) maintenance throughout the service life of the engine.

Annual O-level and I-level maintenance costs for each current engine are $100 thousand and $200 thousand, respectively. The new engine should cost only half as much to maintain at each level. Costs of contractor overhauls are $1.2 million each, and are performed about once every five years (the annualized overhaul costs are $240 thousand per engine). The CG's D-level maintenance of the new engine would cost half as much. Under Alt 2, the engine contractor has been providing a warranty to other customers at $300 thousand per engine per year. The CG facilities engineers have estimated that the current I-level infrastructure costs to support the current engine are $5 million per year. They project that it would also cost about $5 million annually to support the D-level infrastructure for the new engine (if the CG decides to perform that maintenance). The new engine may be purchased under a two-year contract at $2 million each, in lots of 25 engines per year. There would be nonrecurring engineering efforts to review, design, and test the retrofitting of the new engine into the CG airplane—at an estimated cost of $15 million. The retrofit itself is expected to cost $500 thousand if performed during a regularly scheduled overhaul. On average, 20 percent of the engines go through overhaul each year. The average annual fuel cost for an aircraft using the current engine is $100 thousand. The new engine would be more efficient, and the fuel cost is expected to decrease by 10 percent. All costs presented here are in constant FY 1999 dollars. If approved, the reengine project would start in the year 2001 with the initiation of the engineering efforts. The retrofits would be completed by the year 2007. The period of analysis is from the beginning of the project to 20 years of operation of the last retrofitted engines (i.e., from 2001 to 2026).

b. Issues and analysis

In comparing the alternatives, all cost elements affected by each of the alternatives are considered. They include not only the operations and maintenance (O&M) costs and the investment costs, but also the infrastructure support costs and the warranty costs. The cost streams are constructed from the major assumptions presented above and some miscellaneous cost breakdowns shown in the attached worksheet. The cash flows are then discounted. All cash flows are assumed to occur uniformly over each year, and the mid-year discounting was done to the beginning of 2001, the first year of the reengine project. This is a case of internal government investments to decrease Federal costs over time, therefore the appropriate discount rate is the Treasury rate. The real interest rate on a 20-year Treasury Note is 2.7 percent and 2.9 percent for a 30-year note (from OMB Circular No. A-94, February 1999 update). For this analysis (of the 26-year span), the interpolated rate of 2.82 percent is used.

c. Results

For both Alt 1 and Alt 2, the downstream cost savings are large enough to offset the initial investments to buy and retrofit new engines for the surveillance aircraft. Although the contractor warranty cost is greater than the sum of the I- and D-level maintenance costs, the reductions in the infrastructure support costs make Alt 2 more cost-effective than Alt 1. The cash flow computations (both discounted and undiscounted) for each of the alternatives are shown on the following page.

Aircraft engine replacement

All costs in millions of 1999$	status quo	Alt 1	Alt 2	
O&M				
quantity	50	50	50	number of engines
O-level maint	0.10	0.05	0.05	$ per engine per year
I-level maint	0.20	0.10		$ per engine per year
Depot-level maint		0.12		$ per engine per year (average over 5 years)
Contractor overhaul	0.24			$ per engine per year (average over 5 years)
Warranty (I- and D-level)			0.30	$ per engine per year
Fuel	0.10	0.09	0.09	$ per engine per year
Sum	0.64	0.36	0.44	$ per engine per year
Total O&M	32	18	22	$ per year (in steady state--after complete retrofit*)
Annual O&M % increase	1%	0%	0%	percentage increase per year

(* for Alt 1 and Alt 2, they would initially incur the O&M costs of the status quo, then as new engines are retrofitted into the airframe, those units would begin to incur the O&M costs of the respective alternatives--older engines would still incur the old O&M costs, until they are all replaced.)

Infrastructure support				
I-level support	5	5		$ per year
D-level support		5		$ per year
Sum	5	10	0	$ per year
Investment				
Non-recurring				
non-recurring (first year)	0	10	10	$ per year
non-recurring (second year)	0	5	5	$ per year
Recurring				
quantity	0	50	50	number of replacement engines
unit purchase cost	n/a	2.00	2.00	$ per unit
1st year purchase cost	0	50	50	$ per year (purchase 50% in 1st year)
2nd year purchase cost	0	50	50	$ per year (purchase 50% in 2nd year)
unit retrofit cost	n/a	0.50	0.50	$ per unit
1st year retrofit cost	0	5	5	$ per unit (retrofit 20% in 1st year)
2nd year retrofit cost	0	5	5	$ per unit (retrofit 20% in 2nd year)
3rd year retrofit cost	0	5	5	$ per unit (retrofit 20% in 3rd year)
4th year retrofit cost	0	5	5	$ per unit (retrofit 20% in 4th year)
5th year retrofit cost	0	5	5	$ per unit (retrofit 20% in 5th year)
Discount rate	2.82%			

	Undiscounted				Discounted		
Fiscal year	status quo	Alt 1	Alt 2		status quo	Alt 1	Alt 2
2001	38	48	48	non-rec + O&M	37	47	47
2002	38	93	93	non-rec + 50% purchase + O&M	36	89	89
2003	38	93	93	50% purchase + 20% retrofit + O&M	36	87	87
2004	39	46	41	20% retrofit + O&M (incl. Warranty)	35	41	37
2005	39	43	39	"	34	38	35
2006	39	32	28	"	34	28	24
2007	40	36	35	"	33	30	29
2008	40	28	22	O&M	32	23	18
2009	40	28	22	"	32	22	17
2010	41	28	22	"	31	21	17
2011	41	28	22	"	31	21	16
2012	41	28	22	"	30	20	16
2013	42	28	22	"	30	20	16
2014	42	28	22	"	29	19	15
2015	43	28	22	"	28	19	15
2016	43	28	22	"	28	18	14
2017	43	28	22	"	27	18	14
2018	44	28	22	"	27	17	14
2019	44	28	22	"	26	17	13
2020	44	28	22	"	26	16	13
2021	45	28	22	"	25	16	12
2022	45	28	22	"	25	15	12
2023	46	28	22	"	24	15	12
2024	46	28	22	"	24	15	11
2025	46	28	22	"	23	14	11
2026	47	28	22	"	23	14	11
Sum	1094	923	795		768	700	615

2. Case 2: Decision to lease or buy new facilities

a. Background and assumptions.

The Coast Guard currently leases a facility in Washington, D.C., that serves as an office building for 500 of its acquisition and logistics personnel. The lease on the building expires in the year 2003. The CG has three options: (1) extend the lease on the current building, (2) build and own a facility nearby, and (3) move to Portsmouth, Virginia. There are CG-owned facilities in Portsmouth that, due to recent reductions in forces, have excess capacity sufficient to provide working space for the additional 500 people.

The period of analysis is from years 2003 to 2022. The cost of the land and the new building is estimated by the CG facility managers to be $30 million in 2003 dollars. The residual value of the new facility is estimated to be $10 million (in 2003 dollars) at the end of the 20-year period. This figure represents the projected market value of the facility at that time, less the costs of refurbishment and sale. The lease, if renewed, will be $2 million for the first year, then adjusted for inflation after that. The lease includes utilities and maintenance costs. The CG will have an option to continue the lease for up to 20 years. The move from Washington, D.C., to Portsmouth will involve all moving costs for personnel willing to relocate. (A survey shows that 30 percent would choose not to relocate.) The average moving allowance is estimated to be $40 thousand in 1999 dollars. In addition, there will be substantial costs to move the office furniture, and to administer the move in the first two years. The personnel who choose not to move will have to be replaced by hiring and training new people. The cost of hiring a new employee is estimated to be $25 thousand in 1999 dollars. The cost of training a new employ is estimated to be $20 thousand spread over two years.

b. Issues and analysis

In comparing the alternatives, all cost elements affected by each of the alternatives are considered. They include: the cost of the new building; the facility operations, maintenance, and management costs; the rent; and the costs associated with moving people and hiring and training new employees to replace those who choose not to move. The cost streams are estimated from the major assumptions presented above and some miscellaneous categories of costs shown in the worksheet. The cash flows are then discounted. All cash flows are assumed to occur uniformly over the year, and the mid-year discounting was done to the beginning of 2003, the first year of the new lease. This is a case of internal government investments (to lease or purchase) to decrease Federal costs over time, therefore the appropriate discount rate is the Treasury rate. As noted in case 1, the real interest rate on a 20-year Treasury Note is currently 2.7 percent.

c. Results

Although the initial outlays are large for both the new-construction and the moving options, the savings in the outyears make those options more cost-effective than the leasing option. The moving alternative may seem like an attractive option considering the vacancies available in the government-owned facilities in Portsmouth. However, the considerable costs associated with moving people and hiring and training new employees make this option as expensive as building a new facility nearby. The cash flow computations (both discounted and undiscounted) for each of the alternatives are shown on the next page. Note that on an undiscounted basis, the purchase option is clearly preferable, but when the cost streams are discounted, that option becomes slightly inferior to the move alternative. However, the difference is so small that the ultimate decision would probably not turn on these computation.

Lease or purchase of facilities

All dollars in thousands

Lease	2000	per year including O&M (in 2003$)		
Purchase				
Cost of new bldg	30000	FFP contract (in 2003$)		
Value(after 20 yr)	10000	residual value (in 2003$)		
facility O&M	300	per year (in 1999$)	333.8	per year (in 2003$)
Facility mgmt	40	per year (in 1999$)	44.5	per year (in 2003$)
Move				
number of people	500	all essential, fully occupied		
% not moving	30%	based on survey		
personnel move+TDY	40	one time cost (in 1999$)	44.5	one time cost (in 2003$)
Office moving	1000	"	1112.5	"
hiring cost	25	per person (in 1999$)	27.8	per person (in 2003$)
train cost (Yr 1)	10	"	11.1	"
train cost (Yr 2)	10	"	11.1	"
Admin cost (Yr 1)	40	per year (in 1999$)	44.5	per year (in 2003$)
Admin cost (Yr 2)	10	"	11.1	"
facility O&M	300	"	333.8	"
Facility mgmt	20	"	22.3	"

Inflation rate	O&M
1999 to 2003	1.1125

Discount rate 2.70%

	Undiscounted (2003$)			Discounted (2003$)		
Year	Lease	Purchase	Move	Lease	Purchase	Move
2003	2000	30378	22929	1974	29976	22625
2004	2000	378	2036	1922	363	1956
2005	2000	378	356	1871	354	333
2006	2000	378	356	1822	345	324
2007	2000	378	356	1774	336	316
2008	2000	378	356	1727	327	307
2009	2000	378	356	1682	318	299
2010	2000	378	356	1638	310	292
2011	2000	378	356	1595	302	284
2012	2000	378	356	1553	294	276
2013	2000	378	356	1512	286	269
2014	2000	378	356	1472	278	262
2015	2000	378	356	1434	271	255
2016	2000	378	356	1396	264	248
2017	2000	378	356	1359	257	242
2018	2000	378	356	1323	250	236

	2019	2000	378	356	1289	244	229
	2020	2000	378	356	1255	237	223
	2021	2000	378	356	1222	231	217
	2022	2000	-9622	356	1190	-5723	212
Sum		40000	27565	31373	31008	29519	29407

3. Case 3: Service-life extension versus time charter of a vessel

a. Background and assumptions.

A single-purpose Coast Guard ship, which has been in service for more than 50 years, needs a major overhaul to extend its service life. The CG can continue to operate the vessel in the same manner as it has been operated (at about the same annual operating cost) after completion of the service-life extension program (SLEP), which is projected to occur in 2007. There is, however, a viable alternative. The CG can hire a private contractor to perform the same mission. Under this time charter option, the contractor will provide the vessel and its crew, and bear the costs of operating and maintaining the ship. The CG will assign two of its personnel to oversee the operation at an annual cost of $120 thousand.

A shipyard that performs overhauls and SLEPs for CG and Navy ships has quoted a SLEP cost of $120 million in today's dollars (1999$). The yard is willing to do the work under a firm-fixed-price contract. CG contracting personnel find that price to be consistent with past contracts. A SLEP of a similar type of ship takes five years to complete, with a typical expenditure profile of 10 percent, 20 percent, 30 percent, 30 percent, and 10 percent. After the SLEP, the vessel would last another 30 years, but would require further work at mid-life—called an *availability*—at an estimated cost of $20 million. At the end of the extended service life, the ship will be disposed of at a cost of $1 million. The historical annual operating costs for the ship have fluctuated with the fuel and parts prices; however, in constant 1999 dollars, it has been a relatively constant $8 million, of which $3 million is personnel costs (direct costs only). A single contractor, whose vessels and capabilities are well known to and respected by the CG, has proposed to provide the service under the time charter. The contractor proposes a 5-year lease at $20 million per year. The CG contracting officers feel that the bid amount is excessive. They believe the final negotiated contract would range from $14 to $20 million, with a most likely value of $17 million—the chances of the actual amount being greater or less than that are about the same. All costs presented here are in constant 1999 dollars.

b. Issues and analysis

In comparing the two alternatives, all cost elements affected by each of the alternatives are considered. They are aggregated by the following categories: Acquisition, Construction and Improvement (AC&I), Operating Expense (OE), and Other (for mid-life availability and disposal). The lease cost falls into the OE category. The cost streams are based on assumptions presented above. The cash

flows are then discounted. All cash flows are assumed to occur uniformly over the year, and the discounting was done to the beginning of 2001, the first year of the acquisition program management. This is an equal-effectiveness, variable-cost analysis for which the current A-94 discount rate, applicable to time periods of 30 years or longer, is 2.9 percent.

In pricing the time charter option, one possibility is to use the most likely value of $17 million stated above. However, because there is a 50-percent likelihood that the actual negotiated price will exceed $17 million, a more conservative estimate might be preferable. Here the choice is $19 million, believing that to represent roughly an 80th percentile value, although comparing the sensitivity of the outcome to the two values would definitely be useful.

The time charter option would delegate most of the CG's function for that mission to a private contractor. Although this should have an impact on the portions of the CG infrastructure that have directly or indirectly supported the mission, the magnitude of the effect may not be significant because the case deals with a single vessel. However, the treatment of personnel costs, which reflect direct costs only, should be reexamined. As indicated in the earlier discussion of personnel costs, the CG has developed a methodology for estimating indirect costs. This case study incorporates the factors derived from that methodology. Because of the inherent uncertainty associated with indirect costs, this is another area that invites sensitivity analysis.

c. Results

The base-case results here—80th percentile cost estimate for the time charter, rough-average indirect personnel cost factors for the SLEP option, and a 2.9 percent discount rate—show the SLEP option to be preferred. However, that outcome is sensitive to how each of the three items just mentioned was treated. If this were an actual analysis, those issues should be explored exhaustively in the final documentation.

4. Case 4: Replacing a radar within a ship's navigational system

a. Background and assumptions.

A radar within the navigational system used in all Coast Guard ships has a very high failure rate. Reliability engineers have estimated that the radar has a mean time between failure (MTBF) of 500 hours, and that every failure costs $5,000 to repair. On average, a ship steams 4,000 hours per year. Engineers are proposing to replace the troublesome radar with one that has a lower failure rate (higher MTBF).

There are three options: (1) develop and procure a radar system that suits the CG need (call this the *CG system*), (2) share with the Navy in the planned development and procurement of a new radar system to replace one that is similar to, but more

sophisticated than, the Coast Guard's system (call this the *USN system*), and (3) buy a commercial off-the-shelf (COTS) radar.

The COTS radar is known to have an MTBF of 6,000 hours. Its unit cost is $195 thousand. Each of the new-development radar system (CG or USN) has a projected MTBF of 4,000 hours. (The current USN radar also has an MTBF of 500 hours and costs $5,000 to repair. For simplicity, Navy ships are also assumed to steam 4,000 hours per year.) The expected development cost of the *CG system* is $1.3 million, and the expected unit-one procurement cost is $500 thousand. Development and unit-one procurement costs for the *USN system* are expected to be twice as high because of its greater sophistication—a feature not needed by the Coast Guard. Similar systems have experienced a 90-percent learning curve with a 90-percent production-rate slope. The CG would like to replace all 450 of the troublesome systems over a 5-year period, following a one-year development. The Navy has 2,250 such systems, and their acquisition schedule is the same as that of the CG. Under the sharing arrangement with the USN, the CG would pay a proportional share (based on quantities) of the development and procurement costs.

The period of analysis is 9 years from the start of development. All systems are expected to have the same life spans of greater than the 9-year period. However, the electronic system is anticipated to be technically obsolete at the end of 9 years. Therefore, analysis of systems beyond that time horizon is not relevant. Further, the systems are believed to have little or no residual value at the end of the 9-year period. Because all of the new systems will be very similar in configuration to the older ones, their installation will not involve modification of the navigational system or the ship. In addition, the similarities of the old and the new radars, both in function and in configuration, imply little or no impact on training or the supply infrastructure. All costs quoted above are in constant 1999 dollars.

SLEP versus Time Charter			
	SLEP	Charter	
AC&I			
Acquisition PM	5	2	1999$ per year (from 2001 to 2006)
Construction cost			
Year 2002 cost	12	0	1999$
Year 2003 cost	24	0	"
Year 2004 cost	36	0	"
Year 2005 cost	36	0	"
Year 2006 cost	12	0	"
O&E			
AFC-01/12	**3.0**	**0.1**	1999$ per year
(indirect factor*)	**25%**	**15%**	
* assume 10% officers and 90% enlisted on a SLEP'ed ship and just officers to oversee the Chartered ship			
AFC-30 (excl fuel)	0.7	0.0	1999$ per year
AFC-30 (Fuel)	0.3	0.0	"
AFC-42	0.1	0.0	"
AFC-43	0.1	0.0	"
AFC-45	1.0	0.0	"
AFC-56	0.2	0.0	"
Sum	5.4	0.1	"
Sum2	**6.2**	**0.1**	
Lease (Most likely and median)	0	17	1999$ per year
Lease (80-percentile)	0	**19**	"
Mid-life avail	20	0	one-time cost in 1999$
Disposal	1	0	"
Discount rate	2.9%		

	SLEP					Time Charter				
	AC&I	OE	ML-Disp	Total	Discounted	AC&I	OE	ML-Disp	Total	Discounted
2001	5.0			5.0	4.9	2.0			2.0	2.0
2002	17.0			17.0	16.3	2.0			2.0	1.9
2003	29.0			29.0	27.0	2.0			2.0	1.9
2004	41.0			41.0	37.1	2.0			2.0	1.8
2005	41.0			41.0	36.1	2.0			2.0	1.8
2006	17.0			17.0	14.5	2.0			2.0	1.7
2007		6.2		6.2	5.1		19.1		19.1	15.9
2008		6.2		6.2	5.0		19.1		19.1	15.4
2009		6.2		6.2	4.8		19.1		19.1	15.0
2010		6.2		6.2	4.7		19.1		19.1	14.6
2011		6.2		6.2	4.6		19.1		19.1	14.2
2012		6.2		6.2	4.4		19.1		19.1	13.8

2013		6.2		6.2	4.3		19.1		19.1	13.4
2014		6.2		6.2	4.2		19.1		19.1	13.0
2015		6.2		6.2	4.1		19.1		19.1	12.6
2016		6.2		6.2	3.9		19.1		19.1	12.3
2017		6.2		6.2	3.8		19.1		19.1	11.9
2018		6.2		6.2	3.7		19.1		19.1	11.6
2019		6.2		6.2	3.6		19.1		19.1	11.3
2020		6.2		6.2	3.5		19.1		19.1	10.9
2021		6.2		6.2	3.4		19.1		19.1	10.6
2022		6.2	20.0	26.2	14.1		19.1		19.1	10.3
2023		6.2		6.2	3.2		19.1		19.1	10.0
2024		6.2		6.2	3.1		19.1		19.1	9.8
2025		6.2		6.2	3.1		19.1		19.1	9.5
2026		6.2		6.2	3.0		19.1		19.1	9.2
2027		6.2		6.2	2.9		19.1		19.1	9.0
2028		6.2		6.2	2.8		19.1		19.1	8.7
2029		6.2		6.2	2.7		19.1		19.1	8.5
2030		6.2		6.2	2.6		19.1		19.1	8.2
2031		6.2		6.2	2.6		19.1		19.1	8.0
2032		6.2		6.2	2.5		19.1		19.1	7.8
2033		6.2		6.2	2.4		19.1		19.1	7.5
2034		6.2		6.2	2.4		19.1		19.1	7.3
2035		6.2		6.2	2.3		19.1		19.1	7.1
2036		6.2	1.0	7.2	2.6		19.1		19.1	6.9
	150.0	184.5	21.0	355.5	251.4	12.0	573.5	0.0	585.5	335.4

Summary of results (1999$)		
	Undiscounted net savings	NPV
CG acquisition of CG system	32,248,145	24,368,049
CG acquisition of COTS part	2,450,000	-2,163,431
USN acquisition of USN system	105,721,288	71,924,292
CG share of USN+CG	24,705,222	17,614,019
USN share of USN+CG	123,526,112	88,070,094
USN savings from CG participation	17,804,824	16,145,802

CG acquisition of CG component		CG acquisition of COTS part	USN acquisition of USN component
R&D expenditure	1,300,000	-	2,600,000
rate adjusted T-1	500,000	195,000	1,000,000
learning curve slope	90%	100%	0.9
production rate slope	90%	100%	0.9
Repair cost per unit	5,000	5,000	5,000
MTBF in hours (old)	500	500	500
MTBF in hours (new)	4,000	6,000	4,000
Steaming hours / year	4,000	4,000	4,000
Discount rate	2.7%		

	Lot qty	Lot cost	Savings	Net	NPV	Lot qty	Lot cost	Savings	Net	NPV	Lot qty	Lot cost	Savings	Net	NPV
2002		1300000		-1300000	-1282798		0		0	0		2600000		-2600000	-2565595
2003	30	6303201	1050000	-5253201	-5047407	30	5850000	1100000	-4750000	-4563919	150	38642922	5250000	-33392922	-32084757
2004	60	8640767	3150000	-5490767	-5136968	60	11700000	3300000	-8400000	-7858745	300	52973793	15750000	-37223793	-34825272
2005	120	13531211	7350000	-6181211	-5630890	120	23400000	7700000	-15700000	-14302208	600	82955553	36750000	-46205553	-42091811

2006	120	12374694	11550000	-824694	-731519	120	23400000	12100000	-11300000	-10023317	600	75865312	57750000	-18115312	-16068629
2007	120	11701982	15750000	4048018	3496270	120	23400000	16500000	-6900000	-5959525	600	71741132	78750000	7008868	6053554
2008			15750000	15750000	13245632			16500000	16500000	13876376			78750000	78750000	66228158
2009			15750000	15750000	12897402			16500000	16500000	13511564			78750000	78750000	64487009
2010			15750000	15750000	12558327			16500000	16500000	13156343			78750000	78750000	62791635
Sum	450	53851855	86100000	32248145	24368049	450	87750000	90200000	2450000	-2163431	2250	324778712	430500000	105721288	71924292

b= -0.152003093
r= -0.152003093

	Cum qty	Lot MP*	Unit $
	30	10	210107
	90	60	144013
	210	150	112760
	330	270	103122
	450	390	97517
Avg			119671

b= 0.00
r= 0.00

Cum qty	Lot MP	Unit $
30	10	195000
90	60	195000
210	150	195000
330	270	195000
450	390	195000
		195000

b= -0.15200309
r= -0.15200309

Cum qty	Lot MP	Unit $
150	50	257619
450	300	176579
1050	750	138259
1650	1350	126442
2250	1950	119569
		144346

b. Issues and analysis

In comparing the different alternatives, all cost elements affected by each of those alternatives are considered. They include the development costs (except for the COTS case), the procurement costs, and the maintenance costs (savings). The cost streams are built from the assumptions presented above. All cash flows are assumed to occur uniformly over the year, and the mid-year discounting was set to the beginning of 2002, the first year of the replacement project. This is a case of internal investment to decrease government costs over time, with the appropriate discount rate being the real interest rate of 2.7 percent currently paid on Treasury Notes of 5- to 10-year maturities.

Although the *USN system* may initially appear to be too expensive to consider, the analysis shows that the learning and production-rate effects make the unit cost of the *USN system* competitive with the *CG system*. The average cost for the 450 CG systems is $120 thousand, whereas the average cost for the 2,700 (450 for the CG, 2,250 for the USN) Navy systems is $136 thousand. The cash flow computations (both discounted and undiscounted) for each of the alternatives and their summaries are shown in the following pages.

c. Results

Strictly from the Coast Guard's perspective, the *CG system* alternative results in the highest positive net present value (NPV), as well as the highest undiscounted net savings (savings less costs). (NPV is the algebraic difference between the discounted stream of savings and the discounted stream of costs.) The COTS option, with the highest MTBF among the alternatives, produces the most savings in maintenance dollars. However, its procurement cost is also the highest, resulting in the lowest net savings and NPV. The *USN system* option does not generate as much net savings or NPV as the *CG system* alternative. However, a reasonable argument can be made that the preferred alternative should be chosen on the basis of costs and savings to the Federal Government as a whole, not just to the Coast Guard. When the USN savings from the CG participation in the development and procurement of the same system are included, the total net savings (both discounted and undiscounted) from this option are substantially larger than those of the *CG system* option.

USN/CG acquisition of USN component	
	Total
R&D expenditure	2600000
rate adjusted T-1	1000000
learning curve slope	0.9
production rate slope	0.9
Repair cost per unit	5000
MTBF in hours (old)	500
MTBF in hours (new)	4000
Steaming hours / year	4000
Discount rate	2.7%

	CG qty	USN qty	Total qty	Lot cost	CG cost	USN cost	CG savings	USN savings	CG net	CG NPV	USN net	USN NPV
2002				2600000	433333	2166667			-433333	-427599	-2166667	-2137996
2003	30	150	180	43871210	7311868	36559342	1050000	5250000	-6261868	-6016560	-31309342	-30082801
2004	60	300	360	60141011	10023502	50117509	3150000	15750000	-6873502	-6430607	-34367509	-32153033
2005	120	600	720	94179226	15696538	78482688	7350000	36750000	-8346538	-7603434	-41732688	-38017172
2006	120	600	720	86129695	14354949	71774746	11550000	57750000	-2804949	-2488044	-14024746	-12440218
2007	120	600	720	81447524	13574587	67872936	15750000	78750000	2175413	1878902	10877064	9394512
2008							15750000	78750000	15750000	13245632	78750000	66228158
2009							15750000	78750000	15750000	12897402	78750000	64487009
2010							15750000	78750000	15750000	12558327	78750000	62791635
Sum	450	2250	2700	368368666	61394778	306973888	86100000	430500000	24705222	17614019	123526112	88070094

b= -0.15200309
r= -0.15200309

Cum qty	Lot MP	Unit $	Total savings
180	60	243729	6300000
540	360	167058	18900000
1260	900	130804	44100000
1980	1620	119625	69300000
2700	2340	113122	94500000
		136433	

4. Data sources

a. Escalation indexes

Escalation index data in table 3 were taken from *National Defense Budget Estimates for FY 2000*, Office of the Under Secretary of Defense (Comptroller), March 1999—known popularly as the "Green Book." That publication is updated and released annually. The OSD Comptroller disseminates indexes for the four cost-building blocks to each of the military departments. Those organizations, in turn, construct indexes for their respective appropriation accounts (Operation and Maintenance, Army; Aircraft Procurement, Navy; Military Personnel, Marine Corps; etc.) Consequently, the same basic escalation information is available from Internet web sites maintained by various agencies within each department. For the Navy, that agency is the Naval Center for Cost Analysis, with web site **http://www.ncca.navy.mil.** Another feature of that particular site, which may be of interest to the Coast Guard, is that it provides comprehensive information of the Navy's system for estimating indirect manning costs. That system is known as COMET (Cost of Manpower Estimating Tools).

b. Discounting policy and discount rates

As noted earlier, the authoritative source for discounting policy and discount rates is Office of Management and Budget (OMB) Circular No. A-94, *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs*, (Revised), October 1992. The discount rates generally change from year to year with changes in economic conditions and the inflation outlook. Annual updates to A-94 are usually released in February. Contact **http://www.whitehouse.gov/OMB/circulars/a094/a094.htm1.**

c. Direct and indirect personnel costs

Twice a year (in November and February) the Coast Guard updates its Standard Personnel Cost (SPC) tables. Those tables can be obtained through the Coast Guard's Intranet at **http://cgweb.comdt.uscg.mil/G-CFP/finance/spc/spcmenu.htm.** Descriptions of the methodology for estimating indirect costs, together with current estimates of those costs, can be obtained from Human Resources, Financial Management Division (G-WRP).

d. Coast Guard Legacy Asset Baseline - 2002

The Coast Guard's Deepwater Project Office (G-ADW) has assembled a comprehensive documentation of cost and cost-related data for most legacy assets associated with Deepwater (*Legacy Asset Baseline – 2002*). The procurement, alteration, operations, maintenance, and training cost data in that database constitute a rich source of information on in-being assets, and those data can also serve to facilitate cost estimation by factors, analogy, and parametric methods as described

earlier in this enclosure. The documentation may be downloaded from **http://www.uscg.mil/deepwater/documents/documents5.htm.**

e. Coast Guard budget estimates

Each year, the Coast Guard submits, through the Department of Transportation, its budget request to Congress. That document contains data that cover a three-year period: the past year, the current year, and the budget year. Cost and performance data appear in both summary and detailed form. Like the documentation of legacy assets, the budget data constitute a valuable source on in-being assets and current operations, and are also relevant to estimation of out-year costs. Coast Guard budget data are available on line at **http://cgweb.comdt.uscg.mil/g-crc/CBU/cbu.htm**. Information that parallels the budget data can be obtained from the Coast Guard's Executive Information System at **http://10.36.23.14/eis62a/eismenu.htm**.

f. Special studies

A wide range of special studies that pertain to costs of ownership has been carried out either within the Coast Guard or by supporting organizations. (The personnel cost data in table 1 were drawn from one of those studies.) Rather than attempt to cite each one here, the respective functional-area specialists are the best sources of timely and complete information on relevant analytical work. There is, however, one study that cuts across functional areas and contains a considerable amount of cost and cost-related information: *Interim Report on IACG Work for the Coast Guard's Deepwater Project*, CNA Research Memorandum 99-112, September 1999. That document may be obtained by contacting the CNA Document Control and Distribution Section at 703/824-2943.

D. Learning Curves with Production-Rate Adjustments

The basic notion is that learning curves come in families. There is a curve corresponding to each annual production rate. The higher the rate, the lower the curve. The reasoning behind this is that over the course of a procurement program, there are certain (typically indirect) costs of production that are fixed for the most part. Examples are managerial compensation, license fees, property taxes, hazard insurance, building security, and depreciation. The more units produced in any accounting period, the smaller the indirect cost burden carried by each. (In practice, annual procurement quantities are treated as a proxy for production rates. That is a simplification but not a serious distortion.) All of this is depicted in figure 1 below.

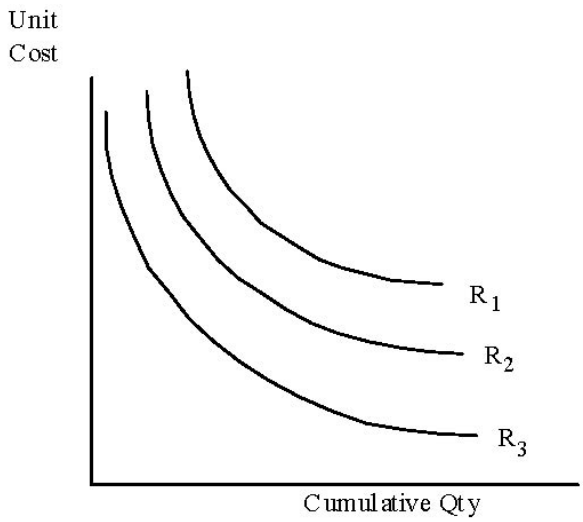

Figure 1.

What figure 1 shows is a three-variable relationship in two dimensions. The functional form taken for the equation is

$$C = \alpha Q^{\beta} R^{\lambda},$$

where C is the cost of the Qth unit, and R is the procurement rate for the year in which that unit falls. The parameter α is the so-called *theoretical unit-one* cost.[1] (With Q and R equal to 1, C is equal to α.) The remaining parameters, β and λ, are each less than zero and reflect the magnitude of the learning and rate effects, respectively. They can be converted readily to the familiar "percentage slope" measures, as explained below.

The arithmetic of learning curves

The slope of a learning curve is typically referred to in percentage terms, with the percentage related to a *doubling* of quantity. For example, an 80-percent curve means that—all else held constant—unit 2 will cost 80 percent as much as unit 1, unit 4 will cost 80 percent as much as unit 2, etc. The value of β associated with an 80-percent curve is given by the following calculation:

$$\beta = log(0.80)/log(2) = -0.32.$$

Similarly, if it is know, for example, that $\beta = -0.25$, the associated slope can be calculated from

$$\text{Slope} = 2^{-0.25} \times 100 = 84 \text{ percent.}$$

[1] The value of α will be different in a rate-adjusted learning curve than in a traditional curve where no provision is made for production-rate effects.

Note that the closer β is to zero, the flatter the learning curve. Note also that the same interpretation and same calculations apply to the production-rate parameter.

Statistical estimation of learning curves

In estimating the parameters of rate-adjusted learning curves from data on procurement programs, analysts make use of the fact that the underlying equation is linear in the logarithms of the variables, i.e.,

$$C^* = \alpha^* + \beta Q^* + \lambda R^*,$$

where the asterisks denote logs. Therefore, if data are available on *C*, *Q*, and *R*, one can—at least in principle—quantify the function by performing a multiple regression of the log of *C* on the log of *Q* and the log of *R*. There are, however, certain nuances associated with this process. Interested readers may want to consult the professional literature.[2]

There is an additional dimension of estimation, depicted in figure 2, that warrants mention. That figure attempts to tell the following story. Annual procurement rates tend to be small at the outset of a program, with corresponding costs falling on a relatively high learning curve. Then, as rates increase, costs drop to lower and lower curves. However, if one takes only the quantity and cost data and constructs a learning curve without considering production-rate effects, the result will be something that looks like the dashed curve. It will not match any of the curves in the family, and in fact will be steeper than the true curves. In other words, the estimate of β will be biased downward. (The technical term for this is *specification bias*. The effects of the omitted variable, *R* in this case, are being picked up by the included variable, *Q*.) This further underscores the importance of incorporating rate adjustments in traditional learning curves.

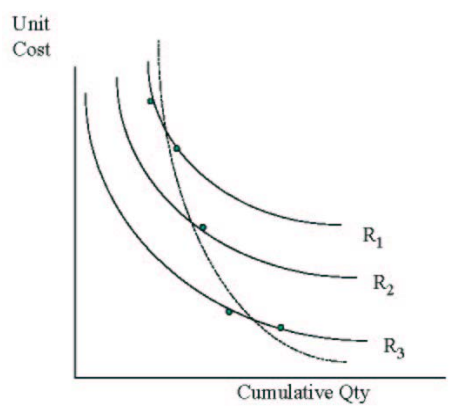

Figure 2

[2] See, for example, H. Eskew, "Tutorial on Log-Linear Regression," *National Estimator*, Spring 1994. A more comprehensive discussion is found in D. Lee, *The Cost Analyst's Handbook*, McLean, VA: Logistics Management Institute, 1997.

CHAPTER 4 - DEFINITIONS

A. Definition of Total Ownership Cost.

1. Total ownership cost (TOC), alternatively referred to as the total cost of ownership, is the sum of all costs associated with the research, development, procurement, personnel, training, operation, logistical support and disposal of an individual asset. This cost includes the total supporting infrastructure that plans, manages, and executes that asset's program over its full life, as well as the cost of requirements for common support items and systems that are incurred because of introducing the particular asset into the Coast Guard. TOC excludes "non-linked" Coast Guard infrastructure costs that are not affected by the individual asset systems' development, introduction, deployment or operations. TOC is broader and more encompassing than Life Cycle Cost (LCC).

2. LCC is a subset of TOC. LCC are defined as direct costs associated with a program and indirect costs that can be obviously linked to a program. LCC has traditionally excluded most of the infrastructure costs needed to support a system or program. LCC estimating is performed to support acquisition, maintenance, and modification decisions. Except for program unique facilities, supporting infrastructure is not typically acquired or disposed due to the acquisition of a single system. As such, LCC normally excludes infrastructure costs as not relevant to the decision being made.

B. Coast Guard Life Cycle Phases: The TOC of a particular Coast Guard asset is spread across each of the following five life cycle phases: planning, acquisition and procurement, management and use, modification and overhaul, and disposal. These components of the life cycle phases are described below:

1. **Planning**. Infrastructure for planning and researching asset/project; feasibility studies; concept exploration; initial planning; market analysis; product research; engineering design; design documentation; systems requirements documentation; other planning costs.

   a. **Technology Base Building**. RDT&E Technology Base Building involves technology scans, forecasts or assessments to produce a base of agency knowledge to support applied R&D efforts 5-15 years hence.

      (1) **Contract Costs**. Includes acquisition and contract administration services for procurement of property, equipment, services, and supplies. May also include leasing of equipment.

      (2) **Small Purchase Costs**. Includes cost for incidentals that can be covered under the rules governing small purchases.

      (3) **Travel Costs**. Includes all associated costs to cover official travel expenses.

(4) **Project Personnel Costs**. All CG Personnel Costs directly attributed to the project.

b. **Research**. RDT&E Research is systematic study and experimentation directed toward increasing knowledge and understanding of scientific or engineering phenomena/principles as they relate to solving Coast Guard problems.

(1) **Contract Costs**. Includes acquisition and contract administration services for procurement of property, equipment, services, and supplies. May also include leasing of equipment.

(2) **Small Purchase Costs**. Includes cost for incidentals that can be covered under the rules governing small purchases.

(3) **Travel Costs**. Includes all associated costs to cover official travel expenses.

(4) **Project Personnel Costs**. All CG Personnel Costs directly attributed to the project.

c. **Exploratory Development**. RDT&E Exploratory Development is the systematic use of knowledge of scientific or engineering phenomenon/principles in the initial stages of producing or adapting technology new to an intended Coast Guard application, and is performed to establish some confidence that the proposed technology cann address the desired mission requirement. The distinguishing characteristic is the goal of evaluating and demonstrating feasibility and practicality of the technology in meeting the mission requirement.

(1) **Contract Costs**. Includes acquisition and contract administration services for procurement of property, equipment, services, and supplies. May also include leasing of equipment.

(2) **Small Purchase Costs**. Includes cost for incidentals that can be covered under the rules governing small purchases.

(3) **Travel Costs**. Includes all associated costs to cover official travel expenses.

(4) **Project Personnel Costs**. All CG Personnel Costs directly attributed to the project.

d. **Advanced Development**. RDT&E Advanced Development is the stage of RDT&E that begins once the feasibility and practicality have been sufficiently established to warrant further development for experimental use within and actual or simulated operational environment.

(1) **Contract Costs**. Includes acquisition and contract administration services for procurement of property, equipment, services, and supplies. May also include leasing of equipment.

(2) **Small Purchase Costs**. Includes cost for incidentals that can be covered under the rules governing small purchases.

(3) **Travel Costs**. Includes all associated costs to cover official travel expenses.

(4) **Project Personnel Costs**. All CG Personnel Costs directly attributed to the project.

e. **R&D Program Management and Support Costs**. These costs provide the support structure required to execute the entire Coast Guard R&D Program.

(1) **Program Management Costs**.

(a) **Administrative Costs**. Includes all overhead costs associated with, or attributable to this project.

(b) **Personnel Costs**. These personnel cost will be based on the CG's Standardized Personnel Costs.

(2) **Research and Development Center Management and Administrative Costs**.

(a) **Building Lease**. Any facilities that have to be leased specifically for this project.

(b) **Computer Systems, Maintenance, and Support**. Costs of specialized Information Technology systems required for this project.

(c) **Technical Libraries and Communications**. Costs of research that is required above that already available through normal sources.

(d) **Graphics Support**. Specialized graphics required as part of the project.

(e) **Travel and Training**. Includes all associated costs to cover official travel expenses related directly to training requirements. Training required to meet the specific needs of the study.

(f) **All Other Administrative Costs**. This category is for any other costs associated with the project, that are not included under the other terms and definitions.

(g) **Personnel Costs**. These personnel cost will be based on the CG's Standardized Personnel Costs.

2. **Acquisition and Procurement**. Execution of acquisition/procurement; asset cost; development, testing and evaluation costs; quality control; initial outfitting of parts and spares; delivery, installation and/or fielding costs; demolition of existing asset; site work; exterior utilities; construction; construction contingencies; non-recurring "start-up" costs (including initial specialized training, manuals/documentation, and travel); other acquisition and procurement costs.

   a. **Unique System Equipment**. All technical and functional activities associated with the design, development, and production of equipment, parts, materials, and software required to assemble the level 3 equipment (hardware/software) elements into a level 2 mission equipment (hardware/ software) as a whole and not directly part of any other individual level 3 element. All systems engineering/program management and system test and evaluation, which are associated with the overall system, are excluded from this element.

NOTE: When an unique system equipment element is utilized at lower levels of the contract work breakdown structure, it will be summarized into the next higher level equipment (hardware/software) work breakdown structure element and should never be summarized directly into a level 3 integration, assembly, test, and checkout element.

(1) **Production Engineering**. The development of engineering layouts, determination of overall design characteristics, and determination of requirements of design review.

(2) **Production Facility Investment**. Productability engineering planning (PEP), and manufacturing process capability, including the process design development and demonstration effort to achieve compatibility with engineering requirements and the ability to produce economically and consistent quality inspection activities related to receiving, factory and vendor liaison, design maintenance efforts, quality planning and control tooling (initial production facilities, factory support equipment) including planning, design, and fabrication.

(3) **Production Material Inventory**. The initial raw materials inventory required to produce level 3 equipment elements.

(4) **Prime Equipment Unit Production**. The joining or mating, and final assembly of raw materials to form a complete level 3 equipment unit, when the effort is performed at the manufacturing facility, and the set up, conduct, and review of testing assembled components or subsystems prior to assembly into a level 2 mission equipment.

(5) **Prime Equipment PHS&T**. All packaging, handling, storage, and transportation of level 3 equipment units prior to assembly into a level 2 mission equipment.

(6) **ADP & Information System Investment**. The hardware, software, related furniture and other equipment required to produce level 3 equipment units and the associated documentation, manuals, training materials and services required to support level 3 equipment units including installation and integration into level 2 mission equipment.

b. **Systems Engineering/Program Management**. All technical and management efforts of directing and controlling a totally integrated engineering effort of a system or program (design engineering, specialty engineering, production engineering, and integrated test planning) and the business and administrative planning, organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall program objectives which are not associated with specific hardware elements and are not included in systems engineering.

(1) **Project Management**. All CG Personnel Costs directly attributable to the project.

(2) **Concept Exploration**. Efforts to transform an operational need or statement of deficiency into a description of system requirements and a preferred system configuration.

(3) **Requirements/Capabilities Validation**. System definition, overall system design, design integrity analysis, system optimization, system/cost effectiveness analysis, and intra-system and inter-system compatibility assurance, etc.; the integration and balancing of reliability, maintainability, producibility, safety, human health, environmental protection, and survivability; security requirements, configuration management and configuration control; quality assurance program, value engineering, preparation of equipment and component performance specifications, design of test and demonstration plans; determination of software development or software test facility/ environment requirements.

(4) **Configuration Management**. The technical planning and control effort for planning, monitoring, measuring, evaluating, directing, and re-planning the management of the technical program.

(5) **Logistics Management**. Integrated Logistics Support Planning, including planning and management of all the functions of logistics. Examples are: maintenance support planning and support facilities planning; other support requirements determination; support equipment; supply support; packaging, handling, storage, and transportation; provisioning requirements determination and planning; training system requirements determination; computer resource determination; organizational, intermediate, and depot maintenance determination management; and data management. Other logistics management functions encompass the support evaluation and supportability assurance required to produce an affordable and supportable system.

(6) **Risk Management**. Reliability engineering—the engineering process and series of tasks required to examine the probability of a device or system performing its mission adequately for the period of time intended under the operating conditions expected to be encountered.

Maintainability engineering—the engineering process and series of tasks required to measure the ability of an item or system to be retained in or restored to a specified condition of readiness, skill levels, etc., using prescribed procedures and resources at specific levels of maintenance and repair.

Human factors engineering—the engineering process and the series of tasks required to define, as a comprehensive technical and engineering effort, the integration of doctrine, manpower, and personnel integration, materiel development, operational effectiveness, human characteristics, skill capabilities, training, manning implication, and other related elements into a comprehensive effort.

Supportability analyses—an integral part of the systems engineering process beginning at program initiation and continuing throughout program development. Supportability analyses form the basis for related design requirements included in the system specification and for subsequent decisions concerning how to most cost effectively support the system over its entire life cycle. Programs allow contractors the maximum flexibility in proposing the most appropriate supportability analyses.

(7) **Contract Management**. All contract and subcontract support element management functions, i.e. cost, schedule, performance measurement management, warranty administration, data management, vendor liaison, etc.

(8) **Environmental Planning, Studies & Documentation**. National Environmental Policy Act process and related studies and documentation.

(9) **Financial Management**.

c. **System Test and Evaluation**. The use of prototype, production, or specifically fabricated hardware/ software to obtain or validate engineering data on the performance of the system during the development phase of the project. It includes detailed planning, conduct, support, data reduction and reports from such testing, and all hardware/software items which are consumed or planned to be consumed in the conduct of such testing; all effort associated with the design and production of models, specimens, fixtures, and instrumentation in support of the system level test program. It excludes all formal and informal testing up through the subsystem level which can be associated with the hardware/software element and acceptance testing.

(1) **Development Test and Evaluation**. This effort is planned, conducted and monitored by the Coast Guard. It includes test and evaluation conducted to demonstrate that the engineering design and development process is complete, the

design risks have been minimized, the system will meet specifications, to estimate the system's utility when introduced, to determine whether the engineering design is supportable (practical, maintainable, safe, etc.) for operational use, to provide test data with which to examine and evaluate trade-offs against specification requirements, life cycle cost, and schedule, and to perform the logistics testing efforts to evaluate the achievement of supportability goals, the adequacy of the support package for the system, (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, and personnel skills and training requirements, etc.). Includes all contractor in-house effort and all models (programs, where applicable), tests and associated simulations such as wind tunnel, static, drop, and fatigue; integration ground tests; test bed aircraft and associated support; qualification test and evaluation, development flight test, test instrumentation, environmental tests, ballistics, radiological, range and accuracy demonstrations, test facility operations, test equipment (including its support equipment), chase and calibrated pacer aircraft and support thereto, and logistics testing

- (for aircraft) avionics integration test composed of the following:

  ⇒ test bench/laboratory, including design, acquisition, and installation of basic computers and test equipments which will provide an ability to simulate in the laboratory the operational environment of the avionics system/subsystem.

  ⇒ air vehicle equipment, consisting of the avionics and/or other air vehicle subsystem modules which are required by the bench/lab or flying test bed in order to provide a compatible airframe avionics system/subsystem for evaluation purposes.

  ⇒ flying test bed, including requirements analysis, design of modifications, lease or purchase of test bed aircraft, modification of aircraft, installation of avionics equipment and instrumentation, and checkout of an existing aircraft used essentially as a flying avionics laboratory.

  ⇒ avionics test program, consisting of the effort required to develop test plans/procedures, conduct tests, and analyze hardware and software test results to verify the avionics equipments' operational capability and compatibility as an integrated air vehicle subsystem.

  ⇒ software, referring to the effort required to design, code, de-bug, and document software programs necessary to direct the avionics integration test.

  ⇒ (for engines) engine military qualification tests and engine preliminary flight rating tests.

⇒ (for ships) model basin, hydrostatic, fatigue, shock, special sea tests and trials, etc., including the Ship Work Breakdown Structure (SWBS), Trials Agenda Preparation, Data Collection & Analysis; Dock and Sea Trials ; and Hull Vibration Survey elements

(2) **Operational Test and Evaluation**. The test and evaluation conducted to assess the prospective system's utility, operational effectiveness, operational suitability, logistics supportability (including compatibility, inter-operability, reliability, maintainability, logistic requirements, etc.), cost of ownership, and need for any modifications. Includes initial operational test and evaluation conducted during the development of a system such tests as system demonstration, flight tests, sea trials, mobility demonstrations, on-orbit tests, spin demonstration, stability tests, qualification operational test and evaluation , etc., and support thereto, required to prove the operational capability of the deliverable system; contractor support (e.g., technical assistance, maintenance, labor, material, etc.) consumed during this phase of testing; logistics testing efforts to evaluate the achievement of supportability goals and the adequacy of the support for the system (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, personnel skills and training requirements, and software support facility/environment elements)

(3) **Mock-ups**. The design engineering and production of system or subsystem mock-ups which have special contractual or engineering significance, or which are not required solely for the conduct of one of the above elements of testing.

(4) **Test and Evaluation Support**. The support elements necessary to operate and maintain, during test and evaluation, systems and subsystems which are not consumed during the testing phase and are not allocated to a specific phase of testing. Includes repairable spares, repair of reparables, repair parts, warehousing and distribution of spares and repair parts, test and support equipment, test bed vehicles, drones, surveillance aircraft, tracking vessels, contractor technical support, etc. Excludes operational and maintenance personnel, consumables, special fixtures, special instrumentation, etc., which are utilized and/or consumed in a single element of testing and which should be included under that element of testing

(5) **Test Facilities**. The special test facilities required for performance of the various developmental tests necessary to prove the design and reliability of the system or subsystem. Includes test tank test fixtures, propulsion test fixtures, white rooms, test chambers, etc. Excludes brick and mortar-type facilities identified as industrial facilities.

d. **Training**. Deliverable training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will learn to operate and maintain the system with maximum efficiency. Includes all effort associated with the design, development, and production of deliverable training equipment as well as the

execution of training services. Excludes overall planning, management, and task analysis function inherent in the WBS element Systems Engineering/Program Management

(1) **Equipment**. Distinctive deliverable end items of training equipment, assigned by either a contractor or military service, required to meet specific training objectives. Includes operational trainers, maintenance trainers, and other items such as cutaways, mock-ups, and models.

(2) **Services**. Deliverable services, accessories, and aids necessary to accomplish the objectives of training. Includes training course materials; contractor-conducted training (in-plant and service training); and the materials and curriculum required to design, execute, and produce a contractor developed training program; materiel, courses, and associated documentation (primarily the computer software, courses and training aids). Excludes deliverable training data associated with the WBS element Support Data.

(3) **Facilities**. The special construction necessary to accomplish training objectives. Includes modification or rehabilitation of existing facilities used to accomplish training objectives. Excludes installed equipment used to acquaint the trainee with the system or establish trainee proficiency and the brick and mortar-type facilities identified as industrial facilities.

e. **Data**. The deliverable data required to be listed on a Contract Data Requirements List. Includes only such effort that can be reduced or avoided if the data item is eliminated; (government-peculiar data) acquiring, writing, assembling, reproducing, packaging and shipping the data; transforming into government format, reproducing and shipping data identical to that used by the contractor but in a different format.

(1) **Technical Publications**. Technical data, providing instructions for installation, operation, maintenance, training, and support, formatted into a technical manual. Data may be presented in any form (regardless of the form or method of recording). Technical orders that meet the criteria of this definition may also be classified as technical manuals. Includes operation and maintenance instructions, parts lists or parts breakdown, and related technical information or procedures exclusive of administrative procedures; (for ships) Ship Work Breakdown Structure (SWBS), Technical Manuals and Other Data elements.

(2) **Engineering Data**. Recorded scientific or technical information (regardless of the form or method of recording) including computer software documentation. Engineering data defines and documents an engineering design or product configuration (sufficient to allow duplication of the original items) and is used to support production, engineering and logistics activities. Includes all final plans, procedures, reports, and documentation pertaining to systems, subsystems, computer and computer resource programs, component engineering, operational testing, human factors, reliability, availability, and maintainability, and other engineering analysis, etc.; Technical data package (reprocurement package) which

includes all engineering drawings, associated lists, process descriptions, and other documents defining physical geometry, material composition, and performance procedures; (for ships) Ship Work Breakdown Structure (SWBS), Design Support, Ship's Selected Records; Design Support, Services, Reproduction; and Engineering Drawings and Specifications elements. Excludes computer software or financial, administrative, cost or pricing, or management data or other information incidental to contract administration.

(3) **Management Data**. The data items necessary for configuration management, cost, schedule, contractual data management, program management, etc., required by the government in accordance with functional categories selected from the Systems Acquisition Manual. Includes project management plans, integrated support plans, Earned Value Management reports, contractor cost reports, cost performance reports, contract funds status reports, schedules, milestones, networks, etc.

(4) **Support Data**. The data items designed to document support planning in accordance with functional categories selected from DoD 5010.12-L. Includes supply; general maintenance plans and reports; training data; transportation, handling, storage, and packaging information; facilities data; data to support the provisioning process and all other support data; and software supportability planning and software support transition planning documents.

(5) **Data Depository**. The facility designated to act as custodian to maintain a master engineering specification and establish a drawing depository service for government approved documents that are the property of the U.S. Government. As custodian for the government, the depository, authorized by approved change orders, maintains these master documents at the latest approved revision level. This facility is a distinct entity. Includes all drafting and clerical effort necessary to maintain documents. Excludes all similar effort for facility's specification and drawing control system, in support of its engineering and production activities.

NOTE: When documentation is called for on a given item of data retained in the depository, the charges (if charged as direct) will be to the appropriate data element.

f. **Peculiar Support Equipment**. The design, development, and production of those deliverable items and associated software required to support and maintain the system or portions of the system while the system is not directly engaged in the performance of its mission, and which are not common support equipment (See 1.7 below). Includes vehicles, equipment, tools, etc., used to fuel, service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain mission equipment; any production of duplicate or modified factory test or tooling equipment delivered to the government for use in maintaining the system. (Factory test and tooling equipment initially used by the contractor in the production process but subsequently delivered to the government will be included as cost of the item

produced.) ; any additional equipment or software required to maintain or modify the software portions of the system. Excludes overall planning, management and task analysis functions inherent in the work breakdown structure element, Systems Engineering/Program Management; common support equipment, presently in the DoD inventory or commercially available, bought by the using command, not by the acquiring command.

(1) **Test and Measurement Equipment**. The peculiar or unique testing and measurement equipment which allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening or quality assurance effort at an organizational, intermediate, or depot level of equipment support. Includes test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, taps, and related software, firmware and support hardware (power supply equipment, etc.) used at all levels of maintenance; packages which enable line or shop replaceable units, printed circuit boards, or similar items to be diagnosed using automatic test equipment.

(2) **Support and Handling Equipment**. The deliverable tools and handling equipment used for support of the mission system. Includes ground support equipment, vehicular support equipment, powered support equipment, nonpowered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware and software)

g. **Common Support Equipment**. The items required to support and maintain the system or portions of the system while not directly engaged in the performance of its mission, and which are presently in the DoD inventory for support of other systems. Includes acquisition of additional quantities of this equipment needed to support the item and all efforts required to assure the availability of this equipment to support the item.

(1) **Test and Measurement Equipment**. The common testing and measurement equipment which allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening or quality assurance effort at an organizational, intermediate, or depot level of equipment support. Includes test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, taps, and related software, firmware and support hardware (power supply equipment, etc.) used at all levels of maintenance; packages which enable line or shop replaceable units, printed circuit boards, or similar items to be diagnosed using automatic test equipment.

(2) **Support and Handling Equipment**. The deliverable tools and handling equipment used for support of the mission system. Includes ground support equipment, vehicular support equipment, powered support equipment,

nonpowered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware/software).

h. **Operational/Site Activation**. The real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and launch prime mission equipment at the organizational and intermediate level. Includes conversion of site, ship, or vehicle; system assembly, checkout, and installation (of mission and support equipment) into site facility or ship to achieve operational status; and contractor support in relation to operational/site activation.

(1) **System Assembly, Installation, and Checkout on Site**. The materials and services involved in the assembly of mission equipment at the site. Includes installation of mission and support equipment in the operations or support facilities and complete system checkout or shakedown to ensure operational status. (Where appropriate, specify by site, ship or vehicle.)

(2) **Contractor Technical Support**. The materials and services provided by the contractor related to activation. Includes repair of reparables, standby services, final turnover, etc.

(3) **Site Construction**. Real estate, site planning and preparation, construction, and other special-purpose facilities necessary to achieve system operational status. Includes construction of utilities, roads, and interconnecting cabling.

(4) **Site/Ship/Vehicle Conversion**. The materials and services required to convert existing sites, ships, or vehicles to accommodate the mission equipment and selected support equipment directly related to the specific system. Includes operations, support, and other special purpose (e.g., launch) facilities conversion necessary to achieve system operational status. (Where appropriate, specify by site, ship or vehicle.)

i. **Industrial Facilities**. The construction, conversion, or expansion of industrial facilities for production, inventory, and contractor depot maintenance required when that service is for the specific system. Includes equipment acquisition or dernization, where applicable; maintenance of these facilities or equipment; industrial facilities for hazardous waste management to satisfy environmental standards.

(1) **Construction/Conversion/Expansion**. The real estate and preparation of system peculiar industrial facilities for production, inventory, depot maintenance, and other related activities.

(2) **Equipment Acquisition or Modernization**. The production equipment acquisition, modernization, or transferal of equipment for the particular system. (Pertains to government owned and leased equipment under facilities contract.)

(3) **Maintenance (Industrial Facilities)**. The maintenance, preservation, and repair of industrial facilities and equipment.

j. **Initial Spares and Repair Parts**. The deliverable spare components, assemblies and subassemblies used for initial replacement purposes in the materiel system equipment end item. Includes repairable spares and repair parts required as initial stocks to support and maintain newly fielded systems or subsystems during the initial phase of service, including pipeline reserve quantities, at all levels of maintenance and support. Excludes development test spares and spares provided specifically for use during installation, assembly, and checkout on site. Lower level WBS breakouts should be by subsystem.

3. **Management and Use**. Operations costs; hardware and software maintenance; data maintenance; intermediate maintenance - spare parts, supplies and logistics; depot level maintenance; environmental and hazardous material storage and handling; contract leasing and contractor support; support personnel and other support costs and infrastructure incurred as a result of introduction of asset/project; other management and use costs.

a. **Personnel**. This broad category of personnel costs includes active duty officers, warrant officers, enlisted personnel, government civilian employees and reservists. Standard salary and support tables are used.

(1) **Standard Personnel Costs – Active Duty Military**. Military personnel costs are obtained by multiplying the number of officers, warrant officers and enlisted personnel, by rank, by the appropriate Standard Personnel Costs (SPC). This includes pay and standard allowances, Social Security/Medicare, reenlistment bonuses, severance pay, separation allowance, uniform clothing allowance, as well as recurring PCS (AFC-20), recurring support costs (AFC-30), recurring training (AFC-56), recurring health (AFC-57), etc. If the grade structure is not available, an average SPC rate for officers, warrant officers and enlisted personnel should be used. Only full year costs should be included, not partial years. If adding billets, full non-recurring and recurring cost for AFC-20 and AFC-30 should be used, in accordance with the SPC Tables. For out-of-cycle PCS, the average transfer costs (recurring and non-recurring) should be used for the year with which the PCS takes place.

(a) **Military Pay and Allowances**. All Military compensation including base pay, housing entitlements, subsistence, special pays, Social Security/Medicare, bonuses and special retention pays, severance pay, accrued leave, uniform issue and clothing allowances.

(b) **Military PCS**. The cost of moving military members from on duty station to the next duty station. This includes normally scheduled moves as well as moves required to take place outside the normal cycle. These costs include the cost of shipping household goods, transporting vehicles, and per-diem for members in transition.

(c) **Military OE Support Costs**. Administrative support costs of maintaining records and infrastructure in support of the military workforce

(d) **Military Training**. The cost of providing required training to members in support of Coast Guard missions. This includes transporting members to and from training, providing training materials, equipment, and training facilities.

(e) **Military Medical Costs**. The cost of providing adequate medical coverage to military members and there families.

(f) **Travel/Temporary Duty**. This category includes special costs of official travel and temporary duty required for support of the objective of the proposal.

(2) **Standard Personnel Costs – Salaried Civilians**. Costs for salaried personnel are obtained by multiplying the number of FTE, by grade, by the Standard Personnel Cost (SPC). This rate includes salaries, overhead, benefits, overtime, awards, retirement, group life insurance, health benefits, unemployment compensation, and Social Security/Medicare. If the grade structure is not available, an average SPC rate should be used.

(a) **Salaried Civilian Pay and Allowances**. All Salaried Civilian compensation including base pay, medical benefits, retirement benefits, special pays, Social Security/Medicare, bonuses and special retention pays, severance pay, moving costs, and accrued leave.

(b) **Salaried Civilian OE Support Costs**. Administrative support costs of maintaining records and infrastructure in support of the civilian workforce.

(c) **Salaried Civilian Training**. The cost of providing required training to members in support of Coast Guard members, This includes transporting members to and from training, providing training materials, equipment, and training facilities.

(d) **Travel/Temporary Duty**. Includes special official travel and temporary duty costs incurred in the implementation of the proposed project

(3) **Standard Personnel Costs – Wage Grade Civilians**. Costs for wage grade personnel are obtained by multiplying the number of FTE, by grade, by the Standard Personnel Cost (SPC). This rate includes salaries, overhead, benefits, overtime, awards, retirement, group life insurance, health benefits, unemployment compensation, and Social Security/ Medicare. If the grade structure is not available, an average SPC rate should be used.

(a) **Hourly Civilian Pay and Allowances**. All Hourly Civilian compensation including base pay, medical benefits, retirement benefits, special pays, Social Security/Medicare, bonuses and special retention pays, severance pay, moving costs, and accrued leave.

(b) **Hourly Civilian Training**. Special civilian training for hourly personnel required for the project which would not have normally been incurred.

(c) **Travel/Temporary Duty**. Includes special travel and temporary duty necessary to support the objective of the project.

(d) **Civilian Separation Pay**. Costs of involuntary separation of a civilian as a result of cutbacks or reorganizations (only applies to salaried employees). Calculations should be made using full average transfer costs.

b. **Operations and Maintenance**. This category includes all types of operational activities. Associated costs of facilities are frequently determined parametrically in terms of dollar per miles, dollar per flight hour, dollars per day, etc. The factors must be examined carefully to make sure the proper components are included. Dollars per flying hour may include fuel, the crew, maintenance, support personnel, etc.

(1) **Operational Activities Operating Costs**. The cost to operate Coast Guard platforms, systems, and equipment.

(a) **Cutter Operating Costs**. Includes costs identified with the operation of the marine vessel while underway and performing their mission. Costs may also include allocated training time and maintenance costs.

1. **Cutter Operating Consumables**. Includes the normal items which will not be reusable, and will be consumed in the normal course of operations.

(b) **Boat Operating Costs**. Includes costs identified with the operation of the small boat while underway and performing their mission. Costs may also include allocated training time and maintenance costs.

2. **Boat Operating Consumables**. Includes the normal items which will not be reusable, and will be consumed in the normal cost of operations.

(c) **Aircraft Operating Costs**. Includes costs directly associated with the flight operations of aircraft (fixed and rotary wing) related to the project. In case standard dollars/flight hour rates are used, consumable and maintenance costs may already be included. In that case, those latter costs should not be added separately in order to preclude double-counting.

1. **Aircraft Operating Consumables**. Includes the normal items below a dollar expense threshold which will not be reusable, and will be consumed in the normal course of operations.

(d) **Fixed Operational Activity Operating Costs**. Includes cost of operations directly related to fixed operational activities (e.g., navigation sites, communication stations)

1. **Consumables**. Includes the normal items below a dollar expense threshold which will not be reusable, and will be consumed in the normal cost of operations.

(e) **Other Operational Activity Operating Costs**. Costs associated with a non-standard, temporary operational operations.

(f) **Support Activity Operations and Maintenance**. Cost required to support and maintain support activities.

(g) **Area/District Offices**. Includes costs associated with proposed project as they relate to area or district offices.

(h) **Other Support Activity Operating Costs**. Costs associated with non-standard temporary support operations.

(2) **Shore Support Services**. Includes all costs for the support provided by the shore establishment in support of Coast Guard operations. Specifically, it includes all administrative support, housing, maintenance, safety and related costs.

(a) **Building and Real Property Maintenance**.

1. **Unit Operating and Maintenance Costs**. Includes costs associated with recurring unit AFC-30 maintenance

2. **Electronics Maintenance and Repair**. Includes costs associated with recurring AFC-42 maintenance

3. **Major Maintenance and Repair**. Includes costs associated with recurring AFC-43 maintenance

(b) **Administrative Support**. Includes all types of administrative, rather than mission, support that is performed in support of the Coast Guard mission as it relates to the project.

1. **Administrative Services**. Includes records management, personnel locator, document control and handling, forms and publication, copying, and maintenance of official publications, and mail service not provided by the post office

.

2. **Administrative Office Space**. Includes the office space required to perform the administrative function, generally expressed in terms of square feet required.

3. **Finance and Accounting**. Includes expense, reimbursement, working fund, payroll and leave accounting, financial reporting, and the development of accounting systems.

4. **Office Equipment & Repair**. Includes the normal repair and purchase of office equipment.

5. **Civilian Personnel Services**. Includes the staffing and operation of employment, placement, classification, employee management, labor relations, employee development, equal opportunity services for civilians and local nationals, based on the number of personnel serviced.

6. **Military Personnel Services**. Includes passport, forces stamp, social security, and other personnel affair services, testing, casualty reporting, noncombatant evacuations, relocations, and transition assistance for military personnel, based on the number of personnel serviced.

7. **Communications**. Includes base communications facilities, telephone equipment and services and may include leasing of communications and special communications electronics equipment services.

8. **Audiovisual Services**. Includes still photography, graphics, presentation services, films, microfilms, micrographic services, and other visual media information services.

9. **Public Information Services**. Includes press relations, press releases, information to the public on the facility and operations, and advice to the command on the role of public affairs.

10. **Purchasing/Contracting**. Includes acquisition and contract administration services for procurement of property, equipment, services and supplies. May also include leasing of equipment.

(c) **Military Personnel Support**.

1. **Legal Assistance**. Includes the provision of advice and services on all legal matters pertaining to legal assistance, military justice, initial claims, processing, property utilization, award and execution of procurement contracts, and personnel matters such as conflicts of interest, standards of conduct, and grievance hearings/reviews, based on the number of individuals to be serviced.

2. **Health Services**. Includes furnishing of outpatient testing, treatment, rehabilitation, and associated professional services and medical support; may also include environmental health inspections and veterinary services.

(d) **Security**.

1. **Fire Protection**. Includes fire fighting, protection, and prevention programs

2. **Police Services**. Includes guards, security protection, maintenance of law and order, and crime prevention measures

3. **Safety Services**. Includes operation of safety programs, educational support, and promotional efforts

(e) **Housing and Real Property Maintenance**. Costs which are incurred as a change from the status quo. These are recurring, day-to-day operation maintenance costs associated with shore facilities, as outlined below

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1. **Family Housing/Bachelor Quarters**. The basic planning guidance for family housing derives from OMB Circular A-18 (Rev) and is further detailed in the Housing and Civil Engineering Manual. This also includes guidance on unaccompanied personnel housing.

2. **Disposal**. Includes collection and disposal of trash and waste materials, operation of incinerators and other equipment intended for transportation, disposal or destruction of waster materials.

3. **Food**. Includes provisioning, preparation and serving of food to authorized and transient personnel.

4. **Utilities**. Includes the provision for procurement, production and distribution of utilities, heating and air conditioning, as well as energy conservation programs.

5. **Laundry and Dry-cleaning**. Includes cleaning, storage and delivery.

6. **Real Property Maintenance and Repair Minor Construction**. Includes maintenance and repair of real property, installed equipment, miscellaneous structures, roads, grounds, railroads, and surfaced areas plus entomological and pest control services.

(f) **Community Support**. Includes the costs to support the whole Coast Guard community of the shore establishment. It is costed as a function of the total population served, including dependents.

1. **Religious Services/Chaplain**. Includes pastoral ministries, worship services, religious rites, visits, counseling and religious education.

2. **Community Support**. Includes child development and care programs, youth services, family support center activities, hobby shops and craft centers.

3. **Social Actions**. Includes costs of social action activities not included elsewhere (e.g., counseling, support programs, and similar activities necessary for assigned personnel and/or their dependents.

4. **Education and Training**. Includes instruction, counseling and testing

(g) **General Shore Base Support**. Includes costs generally supporting the base. It is costed as a function of the workload involved.

1. **Storage,Warehousing and Stevedoring**. Includes the cost of handling cargo from the point of delivery to the warehouse, preparation and movement to storage, and the cost of storage. Also includes the cost of stevedoring operations at the pier to support maritime transportation efforts.

2. **Commercial Transportation; Terminal Operations**. Includes bus service operated for or by the government, on or to/from the shore establishment, as well as the movement of cargo. Also includes the cost of maintaining a fixed shore establishment terminal for transportation by land, sea or air.

3. **Logistic Air Support**. Includes transport of cargo for air movement only

4. **Expendable and General Supplies**. Includes the cost of consumables or disposables used by all organizations of the shore establishment.

5. **Disaster Preparedness**. Includes the cost of preparing plans, conducting tests, and procuring and distributing emergency equipment necessary for disaster preparedness.

6. **Official Vehicles; Vehicular Equipment & Components**. Includes the cost of operating and maintaining all official vehicles on the base. Also includes the cost of equipment and components required for base support, communications, and maintenance.

7. **Petroleum Oil Lubricants**. Includes the cost of consumable petroleum products for the operation of vehicles, equipment and utilities, which are not included in costs elsewhere.

(h) **Leases/Rents**. Costs of leases and rents required, either temporarily or permanently, for the project life cycle

1. **Equipment Leases/Rents**. Includes computers or other equipment that for a variety of reasons may be more prudently leased/rented than purchased.

2. **Property or Building Lease/Rents**. Includes temporary buildings for storage, training, offices, or housing under government or ISSA contracts.

(i) **Contract Services**. Contracting services necessary for the execution of the project, any time during the life cycle of the project. It may include ISSA with host units or tenant units of joint-use facilities.

1. **Contract Services - Operating Support**. Contract services for operating support (exclusive of buildings) necessary during the lifetime of the project.

2. **Contract Services - Professional Services**. Contract services for professional support of any kind during the life cycle of the project.

(j) **Other Support Facility Operations and Maintenance**. Other operational costs for shore operations not included elsewhere which are required for the project.

(k) **Utilities**. Electric power, water, sewer and communications.

(3) **Other System Considerations**.

(a) **Information Systems Operating Costs**.

1. **Hardware Maintenance and Modification**. Includes recurring hardware maintenance costs and the cost of periodic (but minor) hardware modifications.

2. **Software Maintenance and Modification**. Includes recurring software maintenance costs and the cost of periodic software modifications.

3. **Consumables**. Includes the recurring cost of all consumables related to ADP usage, such as paper, disks, tapes, etc.

(b) **Permanent Deployment/Redeployment**. Includes all cost specifically related to deploying or re-deploying units, including their dependents (e.g., consolidation of stations).

(c) **Transportation**. Costs for all operational transportation requirements.

1. **Transport Mission Facilities**. Includes costs which are related to movement of mission facilities and equipment.

2. **Transport Mission Support Equipment**. Includes costs associated with the movement of mission support equipment.

3. **Personnel Transportation (including dependents)**. Includes costs associated with the movement of personnel to the new location.

4. **Household Goods and POV Transportation**. Includes all costs related to the movement of personnel household goods and POV to the new location. AFC-20 standard costs should be used for this purpose.

5. **Temporary Living Expenses**. Includes all costs related to accommodations and housing for authorized personnel during in-transit status and while locating quarters at a new station.

(d) **Exchange, Morale, Welfare & Recreation**. Included here are only costs that are not funded directly by the U.S. Government, frequently referred to as non-appropriated funds.

1. **Coast Guard Exchange System**. Includes costs and construction of exchange services which will be funded and required by the project to support assigned and eligible personnel.

2. **Morale Welfare and Recreation**. Includes the proposed costs of theaters, parks, recreation, centers, gyms, fitness centers, athletic fields, and related services to support assigned and eligible personnel.

(e) **Environmental**. The recurring costs of complying with environmental compliance standards associated with cutters, boats, aircraft, shore facilities and MWR facilties.

1. **Environmental Conservation**. Includes studies to identify whether or not environmental measures operate as designed.

2. **Pollution Prevention**. Includes engineering and design efforts to ensure that the system operates in a manner that minimizes the generation of pollution.

3. **Environmental Compliance**. Includes costs associated with determining if the system is meeting environmental standards.

4. Modification and Overhaul. Major modifications and overhauls including rehabilitation, improvements, upgrades, modernization initiatives, productivity enhancements and increases to useful life of asset/project; other modification and overhaul costs.

a. **Acquisition Project**.

(1) **Unique System Equipment**. All technical and functional activities associated with the design, development, and production of equipment, parts, materials, and software required to assemble the level 3 equipment (hardware/software) elements into a level 2 mission equipment (hardware/ software) as a whole and not directly part of any other individual level 3 element. All systems engineering/program management and system test and evaluation, which are associated with the overall system, are excluded from this element.

NOTE: When an unique system equipment element is utilized at lower levels of the contract work breakdown structure, it will be summarized into the next higher level equipment (hardware/software) work breakdown structure element and should never be summarized directly into a level 3 integration, assembly, test, and checkout element.

(a) **Production Engineering**. The development of engineering layouts, determination of overall design characteristics, and determination of requirements of design review.

(b) **Production Facility Investment**. Producibility engineering planning (PEP), and manufacturing process capability, including the process design development and demonstration effort to achieve compatibility with engineering requirements and the ability to produce economically and consistent quality inspection activities related to receiving, factory and vendor liaison, design maintenance efforts, quality planning and control tooling (initial production facilities, factory support equipment) including planning, design, and fabrication.

(c) **Production Material Inventory**. The initial raw materials inventory required to produce level 3 equipment elements.

(d) **Prime Equipment Unit Production**. The joining or mating, and final assembly of raw materials to form a complete level 3 equipment unit, when the effort is performed at the manufacturing facility, and the set up, conduct, and review of testing assembled components or subsystems prior to assembly into a level 2 mission equipment.

(e) **Prime Equipment PHS&T**. All packaging, handling, storage, and transportation of level 3 equipment units prior to assembly into a level 2 mission equipment.

(f) **ADP & Information System Investment**. The hardware, software, related furniture and other equipment required to produce level 3 equipment units and the associated documentation, manuals, training materials and services

required to support level 3 equipment units including installation and integration into level 2 mission equipment.

(2) **Systems Engineering/Program Management**. All technical and management efforts of directing and controlling a totally integrated engineering effort of a system or program (design engineering, specialty engineering, production engineering, and integrated test planning) and the business and administrative planning, organizing, directing, coordinating, controlling, and approval actions designated to accomplish overall program objectives which are not associated with specific hardware elements and are not included in systems engineering.

(a) **Project Management**. All CG Personnel Costs directly attributable to the project.

(b) **Concept Exploration**. Efforts to transform an operational need or statement of deficiency into a description of system requirements and a preferred system configuration.

(c) **Requirements/Capabilities Validation**. System definition, overall system design, design integrity analysis, system optimization, system/cost effectiveness analysis, and intra-system and inter-system compatibility assurance, etc.; the integration and balancing of reliability, maintainability, producibility, safety, human health, environmental protection, and survivability; security requirements, configuration management and configuration control; quality assurance program, value engineering, preparation of equipment and component performance specifications, design of test and demonstration plans; determination of software development or software test facility/ environment requirements.

(d) **Configuration Management**. The technical planning and control effort for planning, monitoring, measuring, evaluating, directing, and re-planning the management of the technical program.

(e) **Logistics Management**. Integrated Logistics Support Planning, including planning and management of all the functions of logistics. Examples are: maintenance support planning and support facilities planning; other support requirements determination; support equipment; supply support; packaging, handling, storage, and transportation; provisioning requirements determination and planning; training system requirements determination; computer resource determination; organizational, intermediate, and depot maintenance determination management; and data management. Other logistics management functions encompass the support evaluation and supportability assurance required to produce an affordable and supportable system.

(f) **Risk Management**. Reliability engineering—the engineering process and series of tasks required to examine the probability of a device or system

performing its mission adequately for the period of time intended under the operating conditions expected to be encountered.

Maintainability engineering—the engineering process and series of tasks required to measure the ability of an item or system to be retained in or restored to a specified condition of readiness, skill levels, etc., using prescribed procedures and resources at specific levels of maintenance and repair.

Human factors engineering—the engineering process and the series of tasks required to define, as a comprehensive technical and engineering effort, the integration of doctrine, manpower, and personnel integration, materiel development, operational effectiveness, human characteristics, skill capabilities, training, manning implication, and other related elements into a comprehensive effort.

Supportability analyses—an integral part of the systems engineering process beginning at program initiation and continuing throughout program development. Supportability analyses form the basis for related design requirements included in the system specification and for subsequent decisions concerning how to most cost effectively support the system over its entire life cycle. Programs allow contractors the maximum flexibility in proposing the most appropriate supportability analyses.

(g) **Contract Management**. All contract and subcontract support element management functions, i.e. cost, schedule, performance measurement management, warranty administration, data management, vendor liaison, etc.

(h) **Environmental Planning, Studies & Documentation**. National Environmental Policy Act process and related studies and documentation.

(3) **System Test and Evaluation**. The use of prototype, production, or specifically fabricated hardware/ software to obtain or validate engineering data on the performance of the system during the development phase of the project. It includes detailed planning, conduct, support, data reduction and reports from such testing, and all hardware/software items which are consumed or planned to be consumed in the conduct of such testing; all effort associated with the design and production of models, specimens, fixtures, and instrumentation in support of the system level test program. It excludes all formal and informal testing up through the subsystem level which can be associated with the hardware/software element and acceptance testing.

(a) **Development Test and Evaluation**. This effort is planned, conducted and monitored by the Coast Guard. It includes test and evaluation conducted to demonstrate that the engineering design and development process is complete, the design risks have been minimized, the system will meet specifications, to estimate the system's utility when introduced, to determine whether the

engineering design is supportable (practical, maintainable, safe, etc.) for operational use, to provide test data with which to examine and evaluate trade-offs against specification requirements, life cycle cost, and schedule, and to perform the logistics testing efforts to evaluate the achievement of supportability goals, the adequacy of the support package for the system, (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, and personnel skills and training requirements, etc.). Includes all contractor in-house effort and all models (programs, where applicable), tests and associated simulations such as wind tunnel, static, drop, and fatigue; integration ground tests; test bed aircraft and associated support; qualification test and evaluation, development flight test, test instrumentation, environmental tests, ballistics, radiological, range and accuracy demonstrations, test facility operations, test equipment (including its support equipment), chase and calibrated pacer aircraft and support thereto, and logistics testing

- (for aircraft) avionics integration test composed of the following:

  ⇒ test bench/laboratory, including design, acquisition, and installation of basic computers and test equipments which will provide an ability to simulate in the laboratory the operational environment of the avionics system/subsystem.

  ⇒ air vehicle equipment, consisting of the avionics and/or other air vehicle subsystem modules which are required by the bench/lab or flying test bed in order to provide a compatible airframe avionics system/subsystem for evaluation purposes

  ⇒ flying test bed, including requirements analysis, design of modifications, lease or purchase of test bed aircraft, modification of aircraft, installation of avionics equipment and instrumentation, and checkout of an existing aircraft used essentially as a flying avionics laboratory

  ⇒ avionics test program, consisting of the effort required to develop test plans/procedures, conduct tests, and analyze hardware and software test results to verify the avionics equipments' operational capability and compatibility as an integrated air vehicle subsystem.

  ⇒ software, referring to the effort required to design, code, de-bug, and document software programs necessary to direct the avionics integration test

  ⇒ (for engines) engine military qualification tests and engine preliminary flight rating tests

⇒ (for ships) model basin, hydrostatic, fatigue, shock, special sea tests and trials, etc., including the Ship Work Breakdown Structure (SWBS), Trials Agenda Preparation, Data Collection & Analysis; Dock and Sea Trials ; and Hull Vibration Survey elements

(b) **Operational Test and Evaluation**. The test and evaluation conducted to assess the prospective system's utility, operational effectiveness, operational suitability, logistics supportability (including compatibility, inter-operability, reliability, maintainability, logistic requirements, etc.), cost of ownership, and need for any modifications. Includes initial operational test and evaluation conducted during the development of a system such tests as system demonstration, flight tests, sea trials, mobility demonstrations, on-orbit tests, spin demonstration, stability tests, qualification operational test and evaluation , etc., and support thereto, required to prove the operational capability of the deliverable system; contractor support (e.g., technical assistance, maintenance, labor, material, etc.) consumed during this phase of testing; logistics testing efforts to evaluate the achievement of supportability goals and the adequacy of the support for the system (e.g., deliverable maintenance tools, test equipment, technical publications, maintenance instructions, personnel skills and training requirements, and software support facility/environment elements).

(c) **Mock-ups**. The design engineering and production of system or subsystem mock-ups which have special contractual or engineering significance, or which are not required solely for the conduct of one of the above elements of testing.

(d) **Test and Evaluation Support**. The support elements necessary to operate and maintain, during test and evaluation, systems and subsystems which are not consumed during the testing phase and are not allocated to a specific phase of testing. Includes repairable spares, repair of reparables, repair parts, warehousing and distribution of spares and repair parts, test and support equipment, test bed vehicles, drones, surveillance aircraft, tracking vessels, contractor technical support, etc. Excludes operational and maintenance personnel, consumables, special fixtures, special instrumentation, etc., which are utilized and/or consumed in a single element of testing and which should be included under that element of testing

(e) **Test Facilities**. The special test facilities required for performance of the various developmental tests necessary to prove the design and reliability of the system or subsystem. Includes test tank test fixtures, propulsion test fixtures, white rooms, test chambers, etc. Excludes brick and mortar-type facilities identified as industrial facilities

(4) **Training**. Deliverable training services, devices, accessories, aids, equipment, and parts used to facilitate instruction through which personnel will learn to operate and maintain the system with maximum efficiency. Includes all effort associated with the design, development, and production of deliverable training equipment as well as the execution of training services. Excludes overall planning, management, and task analysis function inherent in the WBS element Systems Engineering/Program Management

(a) **Equipment**. Distinctive deliverable end items of training equipment, assigned by either a contractor or military service, required to meet specific training objectives. Includes operational trainers, maintenance trainers, and other items such as cutaways, mock-ups, and models.

(b) **Services**. Deliverable services, accessories, and aids necessary to accomplish the objectives of training. Includes training course materials; contractor-conducted training (in-plant and service training); and the materials and curriculum required to design, execute, and produce a contractor developed training program; materiel, courses, and associated documentation (primarily the computer software, courses and training aids). Excludes deliverable training data associated with the WBS element Support Data.

(c) **Facilities**. The special construction necessary to accomplish training objectives. Includes modification or rehabilitation of existing facilities used to accomplish training objectives. Excludes installed equipment used to acquaint the trainee with the system or establish trainee proficiency and the brick and mortar-type facilities identified as industrial facilities.

(5) **Data**. The deliverable data required to be listed on a Contract Data Requirements List. Includes only such effort that can be reduced or avoided if the data item is eliminated; (government-peculiar data) acquiring, writing, assembling, reproducing, packaging and shipping the data; transforming into government format, reproducing and shipping data identical to that used by the contractor but in a different format.

(a) **Technical Publications**. Technical data, providing instructions for installation, operation, maintenance, training, and support, formatted into a technical manual. Data may be presented in any form (regardless of the form or method of recording). Technical orders that meet the criteria of this definition may also be classified as technical manuals. Includes operation and maintenance instructions, parts lists or parts breakdown, and related technical information or procedures exclusive of administrative procedures; (for ships) Ship Work Breakdown Structure (SWBS), Technical Manuals and Other Data elements.

(b) **Engineering Data**. Recorded scientific or technical information (regardless of the form or method of recording) including computer software documentation. Engineering data defines and documents an engineering

design or product configuration (sufficient to allow duplication of the original items) and is used to support production, engineering and logistics activities. Includes all final plans, procedures, reports, and documentation pertaining to systems, subsystems, computer and computer resource programs, component engineering, operational testing, human factors, reliability, availability, and maintainability, and other engineering analysis, etc.; Technical data package (reprocurement package) which includes all engineering drawings, associated lists, process descriptions, and other documents defining physical geometry, material composition, and performance procedures; (for ships) Ship Work Breakdown Structure (SWBS), Design Support, Ship's Selected Records; Design Support, Services, Reproduction; and Engineering Drawings and Specifications elements. Excludes computer software or financial, administrative, cost or pricing, or management data or other information incidental to contract administration.

(c) **Management Data**. The data items necessary for configuration management, cost, schedule, contractual data management, program management, etc., required by the government in accordance with functional categories selected from the Systems Acquisition Manual. Includes project management plans, integrated support plans, Earned Value Management reports, contractor cost reports, cost performance reports, contract funds status reports, schedules, milestones, networks, etc.

(d) **Support Data**. The data items designed to document support planning in accordance with functional categories selected from DoD 5010.12-L. Includes supply; general maintenance plans and reports; training data; transportation, handling, storage, and packaging information; facilities data; data to support the provisioning process and all other support data; and software supportability planning and software support transition planning documents.

e) **Data Depository**. The facility designated to act as custodian to maintain a master engineering specification and establish a drawing depository service for government approved documents that are the property of the U.S. Government. As custodian for the government, the depository, authorized by approved change orders, maintains these master documents at the latest approved revision level. This facility is a distinct entity. Includes all drafting and clerical effort necessary to maintain documents. Excludes all similar effort for facility's specification and drawing control system, in support of its engineering and production activities.

(6) **Peculiar Support Equipment**. The design, development, and production of those deliverable items and associated software required to support and maintain the system or portions of the system while the system is not directly engaged in the performance of its mission, and which are not common support equipment (See 1.7 below). Includes vehicles, equipment, tools, etc., used to fuel, service, transport, hoist, repair, overhaul, assemble, disassemble, test, inspect, or otherwise maintain mission equipment; any production of duplicate or modified

factory test or tooling equipment delivered to the government for use in maintaining the system. (Factory test and tooling equipment initially used by the contractor in the production process but subsequently delivered to the government will be included as cost of the item produced.) ; any additional equipment or software required to maintain or modify the software portions of the system. Excludes overall planning, management and task analysis functions inherent in the work breakdown structure element, Systems Engineering/Program Management; common support equipment, presently in the DoD inventory or commercially available, bought by the using command, not by the acquiring command.

(a) **Test and Measurement Equipment**. The peculiar or unique testing and measurement equipment which allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening or quality assurance effort at an organizational, intermediate, or depot level of equipment support. Includes test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, taps, and related software, firmware and support hardware (power supply equipment, etc.) used at all levels of maintenance; packages which enable line or shop replaceable units, printed circuit boards, or similar items to be diagnosed using automatic test equipment

NOTE: When documentation is called for on a given item of data retained in the depository, the charges (if charged as direct) will be to the appropriate data element.

(b) **Support and Handling Equipment**. The deliverable tools and handling equipment used for support of the mission system. Includes ground support equipment, vehicular support equipment, powered support equipment, nonpowered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware and software).

(7) **Common Support Equipment**. The items required to support and maintain the system or portions of the system while not directly engaged in the performance of its mission, and which are presently in the DoD inventory for support of other systems. Includes acquisition of additional quantities of this equipment needed to support the item and all efforts required to assure the availability of this equipment to support the item.

(a) **Test and Measurement Equipment**. The common testing and measurement equipment which allows an operator or maintenance function to evaluate operational conditions of a system or equipment by performing specific diagnostics, screening or quality assurance effort at an organizational,

intermediate, or depot level of equipment support. Includes test measurement and diagnostic equipment, precision measuring equipment, automatic test equipment, manual test equipment, automatic test systems, test program sets, appropriate interconnect devices, automated load modules, taps, and related software, firmware and support hardware (power supply equipment, etc.) used at all levels of maintenance; packages which enable line or shop replaceable units, printed circuit boards, or similar items to be diagnosed using automatic test equipment.

(b) **Support and Handling Equipment**. The deliverable tools and handling equipment used for support of the mission system. Includes ground support equipment, vehicular support equipment, powered support equipment, nonpowered support equipment, munitions material handling equipment, materiel handling equipment, and software support equipment (hardware/software).

(8) **Operational/Site Activation**. The real estate, construction, conversion, utilities, and equipment to provide all facilities required to house, service, and launch prime mission equipment at the organizational and intermediate level. Includes conversion of site, ship, or vehicle; system assembly, checkout, and installation (of mission and support equipment) into site facility or ship to achieve operational status; and contractor support in relation to operational/site activation.

(a) **System Assembly, Installation, and Checkout on Site**. The materials and services involved in the assembly of mission equipment at the site. Includes installation of mission and support equipment in the operations or support facilities and complete system checkout or shakedown to ensure operational status. (Where appropriate, specify by site, ship or vehicle.)

(b) **Contractor Technical Support**. The materials and services provided by the contractor related to activation. Includes repair of reparables, standby services, final turnover, etc.

(c) **Site Construction**. Real estate, site planning and preparation, construction, and other special-purpose facilities necessary to achieve system operational status. Includes construction of utilities, roads, and interconnecting cabling.

(d) **Site/Ship/Vehicle Conversion**. The materials and services required to convert existing sites, ships, or vehicles to accommodate the mission equipment and selected support equipment directly related to the specific system. Includes operations, support, and other special purpose (e.g., launch) facilities conversion necessary to achieve system operational status. (Where appropriate, specify by site, ship or vehicle.)

(9) **Industrial Facilities**. The construction, conversion, or expansion of industrial facilities for production, inventory, and contractor depot maintenance required

when that service is for the specific system. Includes equipment acquisition or dernization, where applicable; maintenance of these facilities or equipment; industrial facilities for hazardous waste management to satisfy environmental standards

(a) **Construction/Conversion/Expansion**. The real estate and preparation of system peculiar industrial facilities for production, inventory, depot maintenance, and other related activities.

(b) **Equipment Acquisition or Modernization**. The production equipment acquisition, modernization, or transferal of equipment for the particular system. (Pertains to government owned and leased equipment under facilities contract.).

(c) **Maintenance (Industrial Facilities)**. The maintenance, preservation, and repair of industrial facilities and equipment.

(10) **Initial Spares and Repair Parts**. The deliverable spare components, assemblies and subassemblies used for initial replacement purposes in the materiel system equipment end item. Includes repairable spares and repair parts required as initial stocks to support and maintain newly fielded systems or subsystems during the initial phase of service, including pipeline reserve quantities, at all levels of maintenance and support. Excludes development test spares and spares provided specifically for use during installation, assembly, and checkout on site. Lower level WBS breakouts should be by subsystem.

5. **Disposal (End of Economic Life)**. Residual value; disposal costs. (This includes all disposal cost for all platforms, systems, equipments, and facilities, which are being life cycle cost/total ownership cost tracked.)

a. **Disposal of Facilities (End of Economic Life)**. This includes all costs associated with the condemnation and disposal of facilities.

(1) **Condemnation of Facility**. Condemnation cost associated with the disposal of the end item, or platform. This includes the cost of the efforts and studies required in the development of a retirement plan. Retirement plans normally provide for all aspects of the disposal process.

(2) **Condemnation of Support Equipment**. Condemnation costs associated with unique support equipment.

(3) **Condemnation of Training Devices**. Condemnation costs associated with unique Training aids and devises.

(4) **Condemnation of PHS&T Equipment**. Condemnation costs associated with unique Packaging, Handling, Storage & Transportation.

b. **Disposal of Platforms, Equipments, and Systems**. This includes all cost associated with the actual disposal process of platforms, systems, and equipments. This also includes the disposal of all associated materials unique to those platforms, systems, and equipments.

(1) **Disposal of End Items**. Disposal cost associated with the disposal of the end item (platform, system, or equipment). This includes the cost of the efforts and studies required in the development of a retirement plan. Retirement plans normally provide for all aspects of the disposal process.

(2) **Disposal of Unit Stocks**. Disposal cost associated with unique spares held in unit level stores.

(3) **Disposal of Shop Stocks**. Disposal cost associated with unique spares held at the intermediate and depot level maintenance activities.

(4) **Disposal of ICP Stocks**. Disposal cost associated with unique reparable and consumable spares held at the Inventory Control Points.

(5) **Disposal of Support Equipment**. Disposal cost associated with unique support equipment, at the organizational, intermediate, and depot levels

(6) **Disposal of Training Devices**. Disposal cost associated with unique training aids and devices held throughout the infrastructure.

(7) **Disposal of PHS&T Equipment**. Disposal cost associated with unique Packaging, Handling, Storage, &Transportation equipment.

(8) **Disposal of Fuel & Consumable Items**. Disposal cost associated with all petroleum products, any other consumable materials that must be removed prior to disposal, and not included in any other category.

c. **End of Life Environmental Restoration**. These are the cost associated with ensuring environmental compliance, cleanup, and removal during the disposal/retirement phase.

d. **Environmental Conservation**. First, evaluate the item being retired for environmental compliance, and second, what are the impacts to other similar items.

(1) **Environmental Cleanup**. This includes all costs associated with the clean up of all environmental contaminants and pollutants contained within and on the item. These cleanups include those on a specific platform, equipment, systems, and facility.

(2) **Environmental Compliance**. This includes all cost associated with ensuring all environmental issues or in compliance will Federal and State Regulations.

e. **Other Disposal Costs**. This includes any other unplanned costs not addressed in the other categories.

(1) **GSA Caretaker Costs**. These are the cost associated when an item is passed to GSA for final disposal. This will include both major platforms and facilities.

(a) **Lay-up Costs**. These are the cost associated placing an item into a caretaker status. This can include some form of "moth-balling" to preserve an item for future use, or transfer to another Federal agency or foreign government.

(b) **PHS&T**. This element includes all cost associated with Packaging, Handling, Storage, & Transportation of an item and its components during the disposal phase.

(2) **Demilitarization Costs**. These are the cost associated with demilitarizing an item prior to disposal and retirement.

f. **Residual Asset Value (end of Economic Life)**. This category documents that value of the platform, System, or equipment in the case it is sold, or to be used as a trade-in.

Check-off List for Coast Guard Life Cycle Phases: Planning

Coast Guard Life Cycle Phases: The TOC of a particular Coast Guard asset is spread across each of the following five life cycle phases: planning, acquisition and procurement, management and use, modification and overhaul, and disposal.

_____ **Planning**

_____ **Technology Base Building**

_____ **Research**

_____ **Exploratory Development**

_____ **Advanced Development**

_____ **R&D Program Management and Support Costs**

Check Off List for Coast Guard Life Cycle Phase: Acquisition and Procurement

Coast Guard Life Cycle Phases: The TOC of a particular Coast Guard asset is spread across each of the following five life cycle phases: planning, acquisition and procurement, management and use, modification and overhaul, and disposal.

_____ **Acquisition and Procurement**
_____ **Unique System Equipment**
_____ **Production Engineering**
_____ **Production Facility Investment**
_____ **Production Material Inventory**.
_____ **Prime Equipment Unit Production**
_____ **Prime Equipment PHS&T**
_____ **ADP & Information System Investment**
_____ **Systems Engineering/Program Management**
_____ **Project Management**
_____ **Concept Exploration**
_____ **Requirements/Capabilities Validation**
_____ **Configuration Management**
_____ **Logistics Management**
_____ **Risk Management**
_____ **Contract Management**
_____ **Environmental Planning, Studies & Documentation**
_____ **Financial Management**
_____ **System Test and Evaluation**
_____ **Development Test and Evaluation**
_____ **Operational Test & Evaluation**
_____ **Mock-ups**
_____ **Test & Evaluation Support**
_____ **Test Facilities**
_____ **Training**
_____ **Equipment**
_____ **Services**
_____ **Facilities**
_____ **Data**
_____ **Technical Publications**
_____ **Engineering Data**
_____ **Management Data**
_____ **Support Data**
_____ **Data Depository**
_____ **Peculiar Support Equipment**
_____ **Test & Measurement Equipment**
_____ **Support & Handling Equipment**
_____ **Common Support Equipment**

_____ **Test & Measurement Equipment**
_____ **Support & Handling Equipment**
_____ **Operational/Site Activation**
_____ **System Assembly, Installation & Checkout on Site**
_____ **Contractor Technical Support**
_____ **Site Construction**
_____ **Site/Ship/Vehicle Conversion**
_____ **Industrial Facilities**
_____ **Construction/Conversion/Expansion**
_____ **Equipment Acquisition/Modernization**
_____ **Maintenance (Industrial Facilities)**
_____ **Initial Spares & Repair Parts**

Check Off List for Life Cycle Phases: Management and Use

Coast Guard Life Cycle Phases*:* The TOC of a particular Coast Guard asset is spread across each of the following five life cycle phases: planning, acquisition and procurement, management and use, modification and overhaul, and disposal.

_____ **Personnel**
_____ **Standard Personnel Costs – Active Duty Military**
_____ **Military Pay and Allowances**
_____ **Military PCS**
_____ **Military OE Support Costs**
_____ **Military Training**
_____ **Military Medical Costs**
_____ **Travel/Temporary Duty**
_____ **Standard Personnel Costs – Salaried Civilians**
_____ **Salaried Civilian Pay and Allowances**
_____ **Salaried Civilian OE Support Costs**
_____ **Salaried Civilian Training**
_____ **Travel/Temporary Duty**
_____ **Standard Personnel Costs – Wage Grade Civilians**
_____ **Hourly Civilian Pay and Allowances**
_____ **Hourly Civilian Training**
_____ **Travel/Temporary Duty**
_____ **Civilian Separation Pay**
_____ **Operations & Maintenance**
_____ **Operational Activities Operating Costs**
_____ **Cutter Operating Costs**
_____ **Cutter Operating Consumables**
_____ **Boat Operating Costs**
_____ **Boat Operating Consumable**
_____ **Aircraft Operating Costs**
_____ **Aircraft Operating Consumables**
_____ **Fixed Operational Activity Operating Costs**
_____ **Consumables**
_____ **Other Operational Activity Operating Costs**
_____ **Support Activity Operations and Maintenance**
_____ **Area/District Offices**
_____ **Other Support Activity Operating Costs**
_____ **Shore Support Services**
_____ **Building and Real Property Maintenance**
_____ **Unit Operating and Maintenance Costs**
_____ **Electronics Maintenance and Repair**
_____ **Major Maintenance and Repair**
_____ **Administrative Support**

_____ **Administrative Services**
_____ **Administrative Office Space**
_____ **Finance and Accounting**
_____ **Office Equipment & Repair**
_____ **Civilian Personnel Services**
_____ **Military Personnel Services**
_____ **Communications**
_____ **Audiovisual Services**
_____ **Public Information Services**
_____ **Purchasing/Contracting**
_____ **Military Personnel Support**
_____ **Legal Assistance**
_____ **Health Services**
_____ **Security**
_____ **Fire Protection**
_____ **Police Services**
_____ **Safety Services**
_____ **Housing and Real Property Maintenance**
_____ **Family Housing/Bachelor Quarters**
_____ **Disposal**
_____ **Food**
_____ **Utilities**
_____ **Laundry and Dry Cleaning**
_____ **Real Property Maintenance & Repair Minor Construction**
_____ **Community Support**
_____ **Religious Services/Chaplain**
_____ **Community Support**
_____ **Social Actions**
_____ **Education and Training**
_____ **General Shore Base Support**
_____ **Storage and Warehousing; Stevedoring**
_____ **Commercial Transportation; Terminal Operations**
_____ **Logistic Air Support**
_____ **Expendable and General Supplies**
_____ **Disaster Preparedness**
_____ **Official Vehicles; Vehicular Equipment & Components**
_____ **Petroleum Oil Lubricants**
_____ **Leases/Rents**
_____ **Equipment Leases/Rents**
_____ **Property or Building Lease/Rents**
_____ **Contract Services**
_____ **Contract Services -Operating Support**
_____ **Contract Services - Professional Services**
_____ **Other Support Facility Operations and Maintenance**
_____ **Utilities**
_____ **Other System Considerations**

_____ **Information Systems Operating Costs**
_____ **Hardware Maintenance and Modification**
_____ **Software Maintenance and Modification**
_____ **Consumables (paper, discs, tapes, etc.)**
_____ **Permanent Deployment/Redeployment**
_____ **Transportation**
_____ **Transport Mission Facilities**
_____ **Transport Mission Support Equipment**
_____ **Personnel Transportation (including dependents)**
_____ **Household Goods and POV Transportation**
_____ **Temporary Living Expenses**
_____ **Exchange Morale Welfare & Recreation**
_____ **Coast Guard Exchange System**
_____ **Morale Welfare and Recreation**
_____ **Environmental**
_____ **Environmental Conservation**
_____ **Pollution Prevention**
_____ **Environmental Compliance**

Check-off List for Coast Guard Life Cycle Phases: Modification & Overhaul

Coast Guard Life Cycle Phases: The TOC of a particular Coast Guard asset is spread across each of the following five life cycle phases: Planning, Acquisition and Procurement, Management and Use, Modification and Overhaul, and Disposal.

_____ **Unique System Equipment**
_____ **Production Engineering**
_____ **Production Facility Investment**
_____ **Production Material Inventory**
_____ **Prime Equipment Unit Production**
_____ **Prime Equipment PHS&T**
_____ **ADP & Information System Investment**
_____ **Hardware Procurement**
_____ **Software**
_____ **Related Furniture & Other Equipment**
_____ **Installation**
_____ **Documentation and Manuals**
_____ **Training Materials and Services**
_____ **Integration**
_____ **Systems Engineering/Program Management**
_____ **Project Management**
_____ **Coast Guard Personnel Costs**
_____ **Concept Exploration**
_____ **Market Survey**
_____ **Proposal Development**
_____ **Analysis of Alternatives**
_____ **Requirements/Capabilities Validation**
_____ **Configuration Management**
_____ **Logistics Management**
_____ **Risk Management**
_____ **Contract Management**
_____ **Environmental Planning, Studies & Documentation**
_____ **Financial Management**
_____ **System Test and Evaluation**
_____ **Development Test and Evaluation**
_____ **Brass Board Development Costs**
_____ **First Article Production Costs**
_____ **Operational Test and Evaluation**
_____ **Test Facility Design**
_____ **Test Facility Construction/Modification**
_____ **Real Estate Acquisition for Test Facilities**

_____ **Mock-ups**
_____ **Test and Evaluation Support**
_____ **Test Facilities**
_____ **Shock Qualifications**
_____ **Endurance Qualifications**
_____ **Operational Trails (Preliminary Evaluation)**
_____ **Training**
_____ **Equipment**
_____ **Services**
_____ **Facilities**
_____ **Data**
_____ **Technical Publications**
_____ **Engineering Data**
_____ **Management Data**
_____ **Support Data**
_____ **Data Depository**
_____ **Peculiar Support Equipment**
_____ **Test and Measurement Equipment**
_____ **Support and Handling Equipment**
_____ **Common Support Equipment**
_____ **Test and Measurement Equipment**
_____ **Support and Handling Equipment**
_____ **Operational/Site Activation**
_____ **System Assembly, Installation, and Checkout on Site**
_____ **Contractor Technical Support**
_____ **Site Acquisition/Disposal**
_____ **Real Property Purchase/Lease**
_____ **Real Property Sale**
_____ **Site Construction**
_____ **Design and Construction Management**
_____ **Demolition**
_____ **Site Work**
_____ **Exterior Utilities**
_____ **Waterfront/Marine Construction**
_____ **Building Construction**
_____ **Furnishings/Equipment**
_____ **Electronics/Communications**
_____ **Construction Contingencies**
_____ **Other Consumable Construction Costs**
_____ **Site/Ship/Vehicle Conversion**
_____ **Industrial Facilities**
_____ **Construction/Conversion/Expansion**
_____ **Equipment Acquisition or Modernization**
_____ **Maintenance (Industrial Facilities)**
_____ **Initial Spares and Repair Parts**

Check Off List for Coast Guard Life Cycle Phase: Disposal

Coast Guard Life Cycle Phases*:* The TOC of a particular Coast Guard asset is spread across each of the following five life cycle phases: planning, acquisition and procurement, management and use, modification and overhaul, and disposal.

_____ **Disposal of Facilities (End of Economic Life)**
_____ **Condemnation of Facility**
_____ **Condemnation of Support Equipment**
_____ **Condemnation of Training Devices**
_____ **Condemnation of PHS&T Equipment**
_____ **Disposal of Platforms, Equipment, and Systems**
_____ **Disposal of End Items**
_____ **Disposal of Unit Stocks**
_____ **Disposal of Shop Stocks**
_____ **Disposal of ICP Stocks**
_____ **Disposal of Support Equipment**
_____ **Disposal of Training Devices**
_____ **Disposal of PHS&T Equipment**
_____ **Disposal of Fuel & Consumable Items**
_____ **End of Life Environmental Restoration**
_____ **Environmental Conservation**
_____ **Environmental Cleanup**
_____ **Environmental Compliance**
_____ **Other Project Costs**
_____ **GSA "Caretaker Costs"**
_____ **Lay-up Costs**
_____ **PHS&T**
_____ **Demilitarization Costs**
_____ **Residual Asset Value (End of Economic Life)**