2005 Cost Estimating Handbook

N A V S E A

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Synthesis - The assembling of separate or subordinate parts into a whole.

Analysis - The separation of a whole into its parts or elements.

Merriam - Webster

Webster's definitions of synthesis and analysis have opposite meanings; yet together they are descriptive of the Naval Sea Systems Command (NAVSEASYSCOM or NAVSEA) cost estimating methodology. An in-depth review of the cost estimating process reveals that a NAVSEA cost estimate indeed is an assemblage of separate, distinct, and subordinate parts. The review also reveals that each subordinate part is treated as a whole to be separated into its elements for examination, modification, and/or updating before becoming a part of a total estimate. The NAVSEA cost estimating process is both analytical and synthesizing in nature and is an effort directed toward accurately calculating the future costs of ships, submarines, and weapons systems.

The Cost Engineering and Industrial Analysis Division (SEA 017) leads the NAVSEA cost estimating community, shown in Figure A. As the technical warrant holder for cost engineering, SEA 017 is the controlling office and agency for this NAVSEA Cost Estimating Handbook (CEH) and for the NAVSEA cost estimating community.

This CEH describes the cost estimating process and supporting techniques for the cost estimators and is intended as a reference manual for all Program Office members, Business Financial Managers (BFMs), sponsors, cost estimators, and for those who, although not directly involved in cost estimating, have a need to know because of their interface roles. Where appropriate, past experiences are presented to build knowledge into the cost estimating process and to pass on corporate cost history to show how the NAVSEA cost estimating process has evolved to its current state.

This CEH is a living document and will periodically be updated. The information contained in this document is current as of its publication on 15 November 2004. The NAVSEA CEH is designed to be an electronic resource viewed in Adobe .pdf form. A downloadable version of the document in Adobe Acrobat .pdf format is available on the SEA 017 web page: http://www.navsea.navy.mil/sea017/overview.asp?txtTypeID=41. Feedback, comments, and suggested improvements are encouraged. Information requests, comments, and/or feedback on this CEH can be sent to: NAVSEA_CEH_Feedback@navsea.navy.mil.

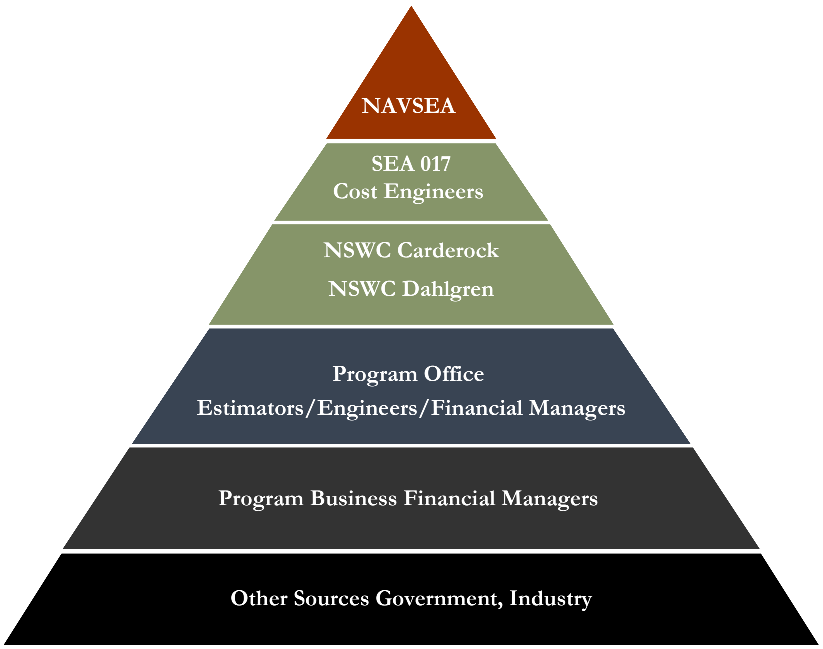

Figure A:
NAVSEA Cost Estimating Community

Acknowledgements

NAVSEA 017 gratefully acknowledges those who participated in the development of this CEH. A list of participants who were interviewed and those that provided input during the development of this CEH are listed below:

Office of the Secretary of Defense (OSD) Cost Analysis Improvement Group (CAIG)

Deputy Assistant Secretary of the Navy (DASN) Ships

DASN Integrated Warfare Systems (IWS)

DASN Littoral and Mine Warfare (LMW)

ASN Financial Management and Comptroller, Office of Budget (FMB)

Industry and Contractors

Naval Cost Analysis Division (NCAD)

Naval Shipbuilding Support Office (NAVSHIPSO)

Numerous NAVSEA Directorates & Program Managers

Numerous NAVSEA affiliated Program Executive Officers (PEOs) & Program Managers (PMs)

Naval Surface Warfare Center (NSWC) Carderock

NSWC Dahlgren

Office of the Chief of Naval Operations (OPNAV) N8

OPNAV N7

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
1333 ISAAC HULL AVE SE
WASHINGTON NAVY YARD DC 20376-0001

IN REPLY TO

7110
Ser 017/035
18 NOV 04

From: Commander, Naval Sea Systems Command

Subj: NAVSEA Cost Estimating Handbook

1. This complete revision of the NAVSEA Cost Estimating Handbook updates and expands our previous manual, providing the NAVSEA cost engineering community a useful resource in performing cost estimating. It defines a framework for the cost estimating process at NAVSEA and serves as the foundation for the development of ship, and other ship system cost estimates.

2. A key element in effective implementation of technical authority within the NAVSEA cost engineering community is to better define cost engineering processes resulting in a more consistent output and approach to developing our systems costs. This handbook is the authoritative component of current quality technical standards and processes supporting development of NAVSEA cost estimates.

3. The NAVSEA Cost Estimating Handbook provides a ready reference for staff across the command, in particular for the Program Managers and cost engineers. The handbook's framework provides a description of the methods, techniques and considerations of developing cost estimates for complex ships, ship systems, and combat weapons systems. Additionally, it provides insight into the supporting tools and processes required for development of the estimate. We welcome comments on this handbook as we strive for continuous improvement of our cost engineering tools and processes.

4. The NAVSEA cost engineering community is a major contributor in identifying the right force for our future Navy by providing accurate, timely and reliable cost information to decision makers. Through your day-to-day work in developing authoritative, independent cost products you are an active participant in helping our Navy and our nation achieve our goals.

C. S. DEEGAN
Director, Cost Engineering
and Industrial Analysis Division

P. M. BALISLE
Vice Admiral, U.S. Navy

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Section 1:

Introduction

The Department of Defense (DoD) policy on cost estimating and analysis is implemented throughout the Department of the Navy (DON) via SECNAV Instruction (SECNAVINST) 5000.2. The Navy cost estimating community, which is guided by SECNAVINST 5000.2, consists of a number of Navy offices that perform cost estimating and analyses tasks to meet various organizational, financial, and contractual requirements. This Cost Estimating Handbook (CEH) was written to communicate cost estimating processes and best practices to this larger Naval Sea (NAVSEA) cost estimating community, including all cost estimators and analysts for NAVSEA not residing in the Cost Engineering and Industrial Analysis Division (SEA 017).

Hundreds of Navy cost estimates are produced each fiscal year by the NAVSEA cost estimating community, most by SEA 017. SEA 017 is charged with the responsibility of preparing the Navy's official cost estimates for planning and programming purposes and for the annual DoD budget submittal for shipbuilding and other NAVSEA cognizant major acquisition programs. This CEH was written to describe the arena in which this Division functions and to address how the Division meets its Cost Engineering and Industrial Analysis responsibilities. Of the many cost estimating and analysis tasks performed by SEA 017, this CEH addresses economic analysis techniques and cost estimating for ships, mission modules, and combat and weapons systems.

This CEH is intended to be both instructive on these topics to NAVSEA cost engineering interns and useful as a reference for estimators in SEA 017 and estimators in the NAVSEA cost estimating community. This CEH is also intended to be helpful to Program Managers (PM), Ship Design Managers (SDM), engineers, and budget participants as it explains how cost estimates are created at NAVSEA and their specific role in cost estimating. The information included in this handbook provides NAVSEA guidance on estimating and Navy applicable data useful in the NAVSEA environment to facilitate the development of ships, mission modules, and combat and weapons systems cost estimates that are accurate, consistent, well communicated, and defensible.

PURPOSE AND OBJECTIVES

This handbook has been developed to provide useful cost estimating information for the NAVSEA cost estimating community. This includes descriptions of the cost estimating environment, details on the cost estimating process, and information on techniques that support the cost estimating process such as economic analysis and other cost estimating support applications. As part of their annual workload, NAVSEA cost estimators face daily situations where they must both recognize and avoid certain pitfalls and exercise their judgment. This handbook emphasizes these two points and presents material that has been drawn from cost estimating experience at NAVSEA. Cost estimating and analysis demands a forward-looking approach that relies in part on past acquisition and ownership cost history but with adjustments to best predict the scenario under consideration for the future program. This handbook discusses proactive and effective methods of keeping lines of communications open and estimating and assessing cost, schedule, and risks to address cost issues effectively.

This NAVSEA CEH defines and clearly communicates the standard cost estimating process used in SEA 017. The objectives of the handbook are to:

- Provide an overview of the cost estimating environment and a detailed review of the importance of cost estimating at NAVSEA.
- Describe the cost estimating process, as it should be applied to NAVSEA programs and projects.
- Communicate the generic cost estimating process used at NAVSEA, providing enough information to teach a new cost estimator, inform a non-cost estimator, or refresh the memory of an experienced cost estimator.
- Build knowledge into the cost estimating process by incorporating lessons learned, best practices, and tips throughout the document.
- Approach broad cost estimating topics through general concept discussions and generic processes and techniques that can be applied to many Navy estimating environments and provide sources for further information on cost estimating support applications and analysis techniques such as software cost estimating and escalation.
- Become a primary reference for all cost estimating needs at NAVSEA.
- Educate those outside of the cost estimating community and our customers about our business and processes.

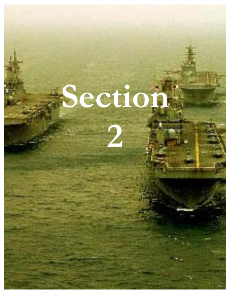
SCOPE

The scope of this CEH focuses on cost estimating and supporting techniques, not on the broader and more widely interpreted discipline of cost analysis. Areas such as budgeting, earned value, and scheduling are discussed in this CEH only in the context of how they relate to cost estimating and the responsibilities of NAVSEA 017. The scope of the cost estimation process detailed in this CEH covers any estimate, from a quick turn around estimate to a full up Life Cycle Cost Estimate (LCCE). The tasks detailed in the process are meant to provide enough information to perform the estimate along with resources for further information for readers unfamiliar with the discipline of cost estimating.

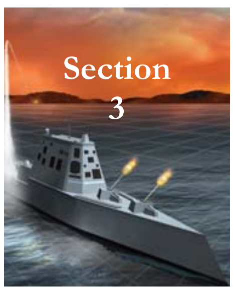
AUDIENCE (S)

The primary audience for this handbook is estimators in SEA 017, in NSWC Carderock, and in NSWC Dahlgren. This includes everyone from the newest intern to the most experienced cost estimator. The processes and guidelines in this CEH apply to all NAVSEA estimators. The secondary audience is anyone who interfaces with NAVSEA or Navy cost estimates. This larger audience of the NAVSEA Cost Estimating Community includes Business Financial Managers (BFMs) and other budget participants, PMs, and Design Managers as well as the many external NAVSEA stakeholder organizations and individuals associated with NAVSEA cost estimating.

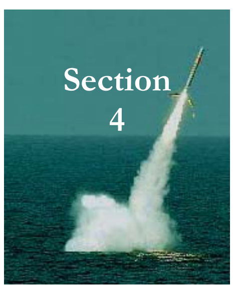
DOCUMENT ORGANIZATION



Program Decision Support Systems
Describes the related decision support systems that influence cost estimating: requirements generation, acquisition management, and Planning, Programming, Budget and Execution (PPBE).

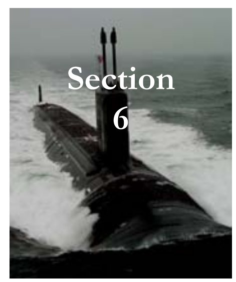


Cost Estimating at NAVSEA
Discusses the importance of cost estimating and policies and guidelines that influence NAVSEA cost estimating. An overview of the participants in NAVSEA cost estimating is given along with details on cost engineering technical warrants, cost estimating classifications, and cost estimating products.



NAVSEA Cost Estimating Process
Presents the centerpiece of the handbook, covering the three parts of the cost estimating process. Within the three parts of the overall cost estimating process, the twelve tasks are discussed in detail. This step-by-step process communicates the foundation of cost estimating at NAVSEA.

Estimating Support Applications and Techniques
Describes the applications and techniques used in the cost estimating process tasks. Topics such as cost estimating techniques, economic analysis, and other supporting applications such as learning curves are covered in one-to-three page write-ups in Section 5.



Appendices
Presents resources that are referenced in the text of the handbook that will provide useful information to the cost estimator as well as glossary, reference list, and acronym list.

Sidebars calling out definitions, references, important tips and lessons learned for the estimator are provided throughout the handbook to communicate the wisdom of experienced estimators

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Section 2:

Program Decision Support Systems

There are many management reform initiatives in place in the DoD to control costs, improve performance, and to achieve mission goals and objectives. Program managers must put their programs through performance reviews (that measure, in an objective way, whether the program is performing as anticipated based upon baseline costs, schedule, and risks) and their budget submissions must be integrated with performance-based budgeting. The cost estimator must be aware of and respond appropriately to these and the many other environmental drivers discussed throughout this handbook as they support NAVSEA PMs.

The **3** essential decision-making support systems are:

1. JCIDS: produces information for decision-makers on projected mission needs
2. Acquisition Management System: provides for a streamlined acquisition management structure and an event-driven acquisition process that links the key milestone decisions to actual accomplishments
3. PPBE system: provides the basis for making informed affordability assessments and resource allocation decisions on acquisition programs

In this Section of the CEH, the larger context of cost estimating is described. The Federal budget, appropriations, and acquisition processes are described at a high-level to demonstrate the importance of what the cost estimator does and where their deliverable (e.g., estimates) fit in the larger scheme of Naval operations.

Obtaining Congressional approval and funding is only one achievement of three major processes involved in acquiring Navy ships or combat systems for a NAVSEA program. These three essential decision-making support systems are:

- Requirements analysis as promulgated by the Joint Capabilities Integration and Development System (JCIDS),
- Acquisition management as defined in DoDI 5000.2 "Operation of the Defense Acquisition System", and
- Resource allocation as supported by the DoD Planning, Programming, Budget and Execution (PPBE) process

Effective interaction between these systems is critical for acquiring the forces necessary to meet the threats to our national security. The determination of these necessary forces begins with the President, who establishes objectives and policies to maintain national security based on the advice of the intelligence agencies [Central Intelligence Agency (CIA), Defense Intelligence Agency (DIA), etc.,] of the Executive Branch. Subsequently, SECDEF, together with the Joint Chiefs of Staff (JCS) and the Military Department Heads, establishes DoD objectives and policies and identifies through the JCIDS, the DoD force requirements necessary to maintain national security.

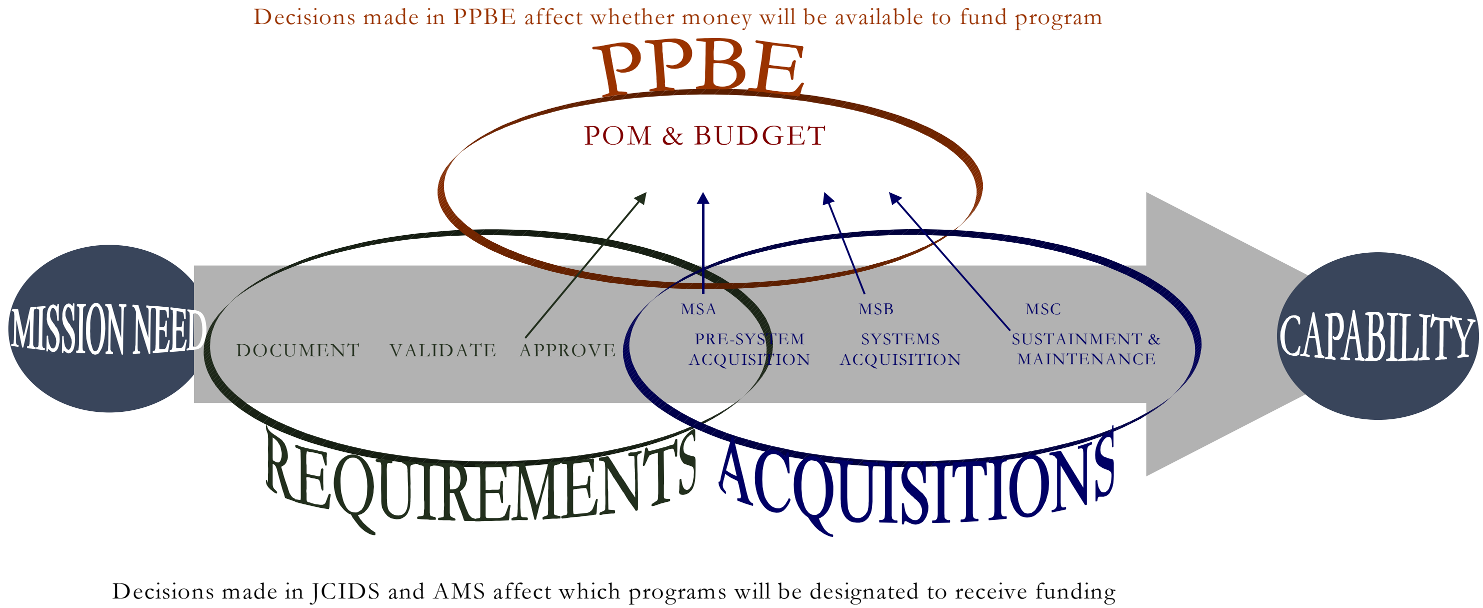


Figure 1: Fitting the Pieces Together

Figure 1 illustrates notionally how the requirements generation, acquisition management, and the PPBE systems work together.

JCIDS

The JCIDS produces information for decision-makers on projected mission needs. The needs identified are defined initially in broad operational terms in the Initial Capabilities Document (ICD) and are progressively translated into specific performance requirements in the Capabilities Development Document (CDD). These documents are then approved by the Joint Requirements Oversight Committee (JROC) and the Defense Acquisition Board (DAB), respectively.

ACQUISITION MANAGEMENT SYSTEM

The Acquisition Management System provides for a streamlined acquisition management structure and an event-driven acquisition process that links the key milestone decisions to actual accomplishments. This process provides the basis for making trade-off decisions considering affordability versus needs, and translates the needs into concepts and eventually into system designs.

DoD Directive 5000.1 and DoD Instruction (DODINST) 5000.2 establish DoD acquisition policy. Cost estimating and analysis are implemented throughout the Department via SECNAVINST 5000.2. Figure 2, taken from DoD 5000.1, illustrates the Defense Acquisition Management Framework.

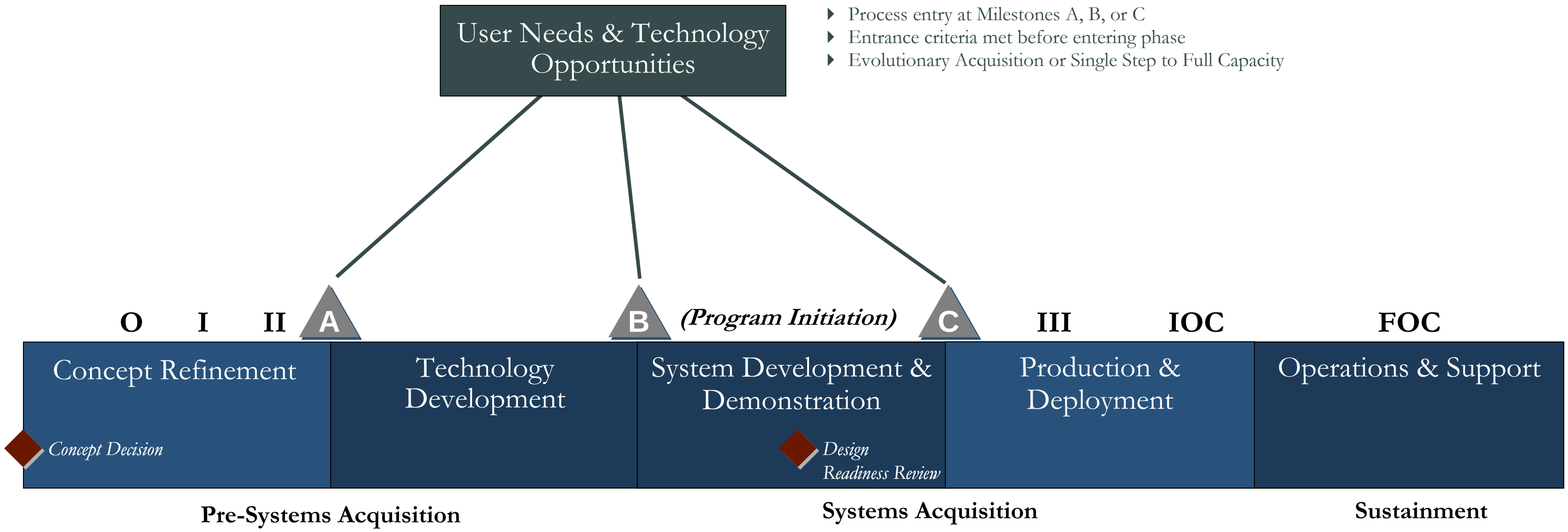


Figure 2: The DoD 5000 Defense Acquisition Management Framework

Major System Acquisition Reviews

Many NAVSEA programs are classified by the SECDEF as Major Defense Acquisition Programs (MDAPs), governed by acquisition policy set forth in DoD Directive 5000.1, including cost thresholds that determine their qualification as major programs. Both OSD and the Navy conduct key milestone reviews of MDAPs. OSD designates the Acquisition Category (ACAT) of its programs in its policy guidance document (DODINST 5000.2). These categories determine the level of milestone decision authority (MDA). For Milestones A, B and C, the Navy decision authority reviews the progress and provides authorization to proceed to the next internal Navy acquisition phase or to the OSD DAB review, as appropriate. The formal Navy review at key milestones is conducted by the Program Decision Meeting (PDM) or the SYSCOM Acquisition Review Board (ARB), as appropriate.

Table 1 describes the threshold requirements and MDA for ACAT programs.

ACAT	Threshold	MDA
ACAT I	**MDAP** must meet one of two cost thresholds: ▸ More than $365 million in Research, Development, Test and Evaluation (RDT&E) or ▸ More than $2.190 billion in procurement (both in constant Fiscal Year (FY) 00 dollars). **MDA** ▸ MDA designation as special interest	ACAT ID: USD(AT&L) ACAT IC: Assistant Secretary of the Navy, Research, Development and Acquisition, [ASN(RD&A)]
ACAT II	Fall below ACAT I dollar thresholds, but are major systems that have unique test and evaluation requirements and may have multiyear procurement requirements. ACAT II programs have dollar thresholds of more than $140 million in RDT&E or $660 million for procurement in constant FY 00 dollars. **MDA** ▸ MDA designation as special interest	Decision authority for these programs is delegated no lower than the ASN(RD&A)
ACAT III	Non-major programs that fall below the ACAT II dollar thresholds and may also have test and evaluation and multiyear procurement requirements.	ASN(RD&A)

Table 1: Description and Decision Authority for ACAT I – III Programs

DODINST 5000.2 describes the procedures for OSD Milestone Reviews and the direction of MDAPs. MDAPs classified as ACAT ID require review by the DAB, which is chaired by the USD(A,T&L). The USD(A,T&L) advises the SECDEF at key program milestones whether the program is ready to move into the next phase.

Preparation for a Cost Analysis Improvement Group (CAIG), Overarching Integrated Product Team (OIPT), and DAB reviews require significant efforts on the part of the OPNAV sponsor; the NAVSEA PM, PEO; and SEA 017. Each of these reviews is time sensitive. The OIPT sets all future review dates and the CAIG has a 180-day window within which to operate. It can be anticipated that cost will be at the forefront of the discussions, and the NAVSEA cost estimator must be prepared for in-depth reviews and to respond to data requests from the CAIG. The CAIG will develop an Independent Cost Estimate (ICE) that will be compared with the PM's estimate. The NAVSEA cost engineering team may need to respond to numerous requests for information from the CAIG during the development of the Program Life Cycle Cost Estimate (PLCCE), and the CAIG's ICE, and may even be asked to change certain assumptions. While every effort to reach consensus between the CAIG members and SEA 017 is made, sometimes this does not occur and SEA 017 and the CAIG may agree to disagree on the final estimate reconciliation.

Tips for CAIG Preparations and Milestone Support

- Many cost activities in preparation for a CAIG review vary by milestone, (e.g., program, maturity, program type).
- It is a good idea to speak with a SEA 017 team member that has recently been through a CAIG review or milestone review for lessons learned and/ or recent CAIG process changes.
- It is helpful to begin dialogue with CAIG analyst as early as possible, at least six months prior to the formal CAIG date.
- It is helpful to develop a professional rapport with the CAIG analyst.
- The Navy PLCCE should be well underway or complete before engaging with the CAIG analyst.
- A proven cost process and model is essential for PLCCE milestone reviews.
- It is a good idea to team with the CAIG analyst for data collection resources and to gain an understanding of the data and assumptions.
- A free flow of information between SEA 017 and CAIG analysts facilitates the desired result of two credible estimates that can be compared and reconciled for decision-making purposes.
- Establish inflation and dollar conversion early with the CAIG analyst. Escalation may be an issue as the CAIG may not agree with the method that SEA 017 analysts use and agreement is required.
- Be prepared for labor content/CERs to be an area that will require extra documentation and explanation.
- The analyst should be prepared to defend assumptions and to provide historical/multiple programs and engineering build up backup information.
- Generally, the CAIG uses methodologies such as analogy and parametric.
- It is important to know the historical data used in your estimate and understand all possible analogies.
- As with any estimate, the milestone estimate should be well documented and based on sound choices, using solid rationale.
- For critical/controversial portions of the estimate, it is beneficial to have a crosscheck estimate or analysis to support your primary estimate, e.g. having a (secondary) parametric estimate to support a (primary) engineering estimate.
- Understand the CAIG perspective and use CAIG logic to defend your position.
- Be prepared to agree to disagree.

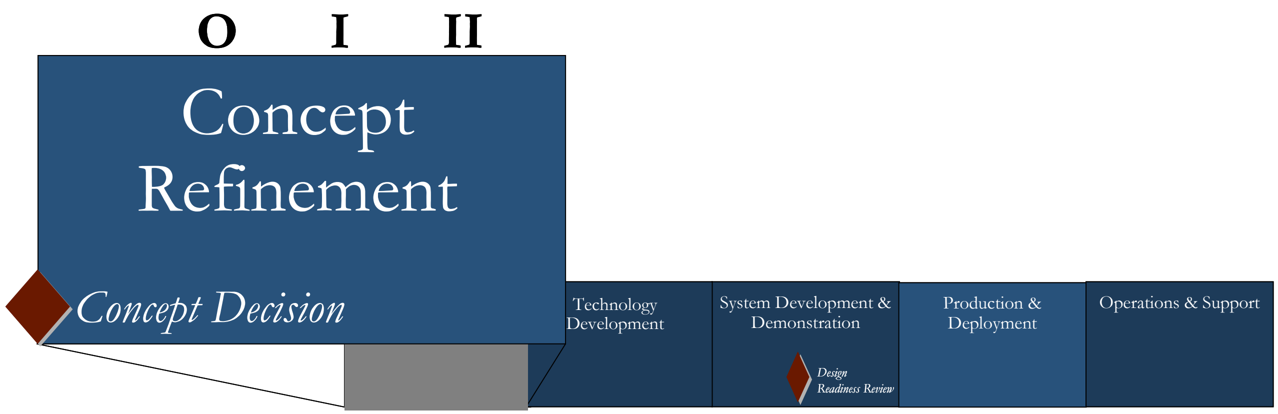


Figure 3: Concept Refinement

Concept Refinement Phase Activities

All acquisition programs are based on identified mission needs. These needs are first identified by the Unified and Specified Commands, the Military Departments, OSD, or the Chairman of the JCS and are documented in an ICD. The USD(AT&L) classifies the programs and decides whether and when to convene a DAB for review of the ICD. Approval by the DAB of an ICD marks Milestone A and the beginning of the Concept Refinement work effort (See Figure 3). According to DODINST 5000.2:

> *Concept Refinement begins with the Concept Decision. The ICD and the AoA plan shall guide Concept Refinement...To achieve the best possible system solution, emphasis shall be placed on innovation and competition…The results of the AoA shall provide the basis for the Technology Development Strategy (TDS), to be approved by the MDA at Milestone A for potential ACAT I programs.*
>
> DoDI 5000.2

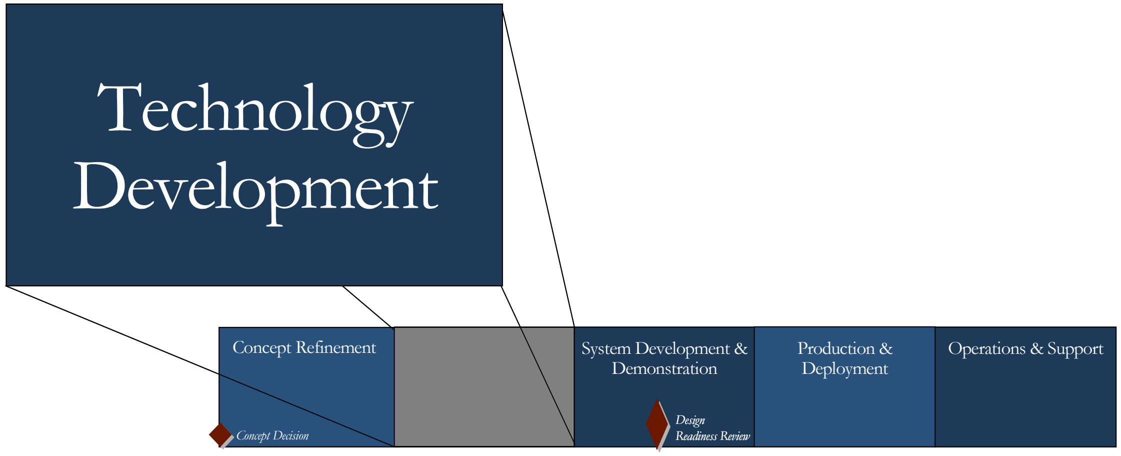


Figure 4: Technology Development

Technology Development Phase (TDP) Activities

The Milestone A decision is followed by entry into the TDP (See Figure 4). According to DODINST 5000.2:

> *Shipbuilding programs may be initiated at the beginning of Technology Development…a cost assessment shall be prepared in lieu of an independent cost estimate (ICE), and a preliminary assessment of the maturity of key technologies shall be provided… The project shall exit Technology Development when an affordable increment of militarily-useful capability has been identified, the technology for that increment has been demonstrated in a relevant environment, and a system can be developed for production within a short timeframe (normally less than five years); or when the MDA decides to terminate the effort. During Technology Development, the user shall prepare the Capability Development Document (CDD)* [formerly termed the Operational Requirements Document (ORD)] *to support program initiation, refine the integrated architecture, and clarify how the program will lead to joint warfighting capability. The CDD builds on the ICD and provides the detailed operational performance parameters necessary to design the proposed system. A Milestone B decision follows the completion of Technology Development… An affordability determination results from the process of addressing cost during the requirements process and is included in each CDD using life-cycle cost or, if available, total ownership cost.*
>
> DODINST 5000.2

The Navy prepares and presents a CDD to the DAB. An AoA must have been performed and presented to the OSD, Assistant Secretary of Defense (Program Analysis and Evaluation) [OSD(PA&E)], at a CAIG Briefing before the DAB meeting. A go-ahead decision at this point is a validation of the requirement by the DAB on the basis of early program information for the initiation of new ACAT I programs. Milestone B is usually where detailed design and construction begins. Milestone B approval is usually required before the program can award advanced development contracts. In a competitive source environment (where multiple industry firms or teams are competing for the program), each firm or team is developing an alternative with the development contract. The Navy will ultimately select the winning contractor based on the cost and performance of these alternatives. Milestone B approval initiates the System Integration work effort within the System Development and Demonstration Phase (SDDP)

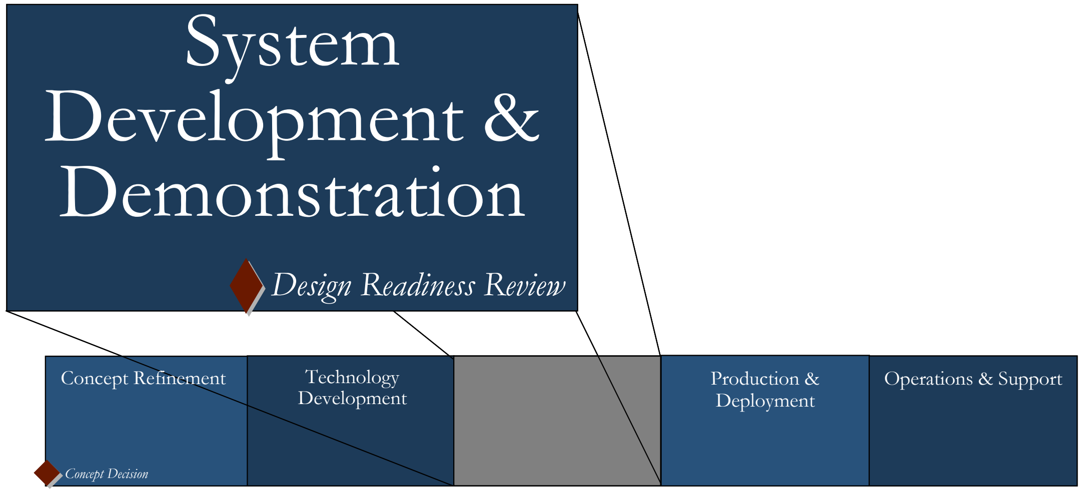


Figure 5: System Development & Demonstration

System Development and Demonstration Phase (SDDP) Activities

Requirements, test, and program documents are updated during SDDP to reflect lessons learned prior to Milestone B (See Figure 5). Before Milestone C, the MDA may require a new AoA or an update to the existing AoA to account for any factors that may have changed during the preceding phase. At this point, there is usually a preferred alternative that can be described in more detail and with more confidence in terms of cost and performance, based on data gleaned from demonstration and validation tests. The AoA analysis should first revisit the go/no-go question then identify the preferred system for implementation. Sensitivity analyses should quantify the impact of uncertainties in cost, performance, supportability, and schedule. The analysis should also explicitly identify cost ceilings and performance floors.

At this point in the acquisition process, it is usual for OIPTs to update the costs and have interaction with the CAIG. The next OSD DAB review is held at Milestone C to review ACAT ID program progress, and marks completion of SDDP. System development should be sufficiently mature that the level of risk is acceptable and both the contractor and the Navy are reasonably confident in the estimated system cost. The DAB is presented with an updated and expanded CDD that includes (1) thresholds and objectives for more detailed and refined performance capabilities, and (2) characteristics based on the results of trade-off studies and testing conducted during SDDP. A PLCCE must be presented to OSD(PA&E) at a CAIG Briefing prior to the DAB. A go-ahead decision at this DAB will permit the Navy to enter the Production and Deployment Phase (PDP), and to award a contract for detail design and construction of the system. The first work effort of this phase is formally called Production Readiness, Low Rate Initial Production (LRIP), and Initial Operational Testing and Evaluation (IOT&E).

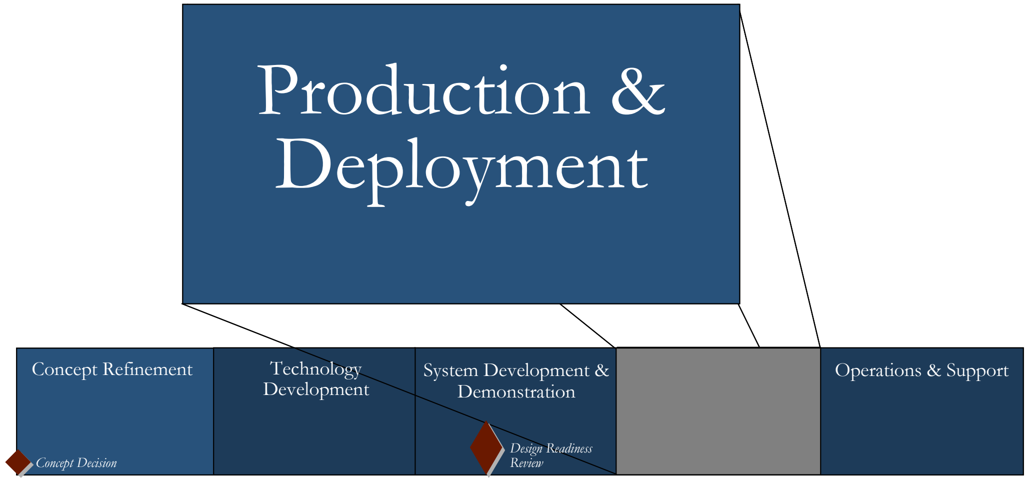


Figure 6: Production & Deployment

Production and Deployment Phase (PDP) Activities

According to DODINST 5000.2:

> *The purpose of the PDP is to achieve an operational capability that satisfies mission needs. OT&E shall determine the effectiveness and suitability of the system. The MDA shall make the decision to commit the DoD to production at Milestone C. Milestone C authorizes entry into LRIP (for ships and satellites is production of items at the minimum quantity and rate that is feasible and that preserves the mobilization production base for that system.) … An MDAP may not proceed beyond LRIP without approval of the MDA.*
>
> DODINST 5000.2

As shown in Figure 6, AoA efforts typically do not occur unless a new system or a major modification decision is made and in that case, the decision authority essentially returning the program to the Concept Refinement and TDP phases. The decision authority may require a Full-Rate Production (FRP) Decision Review prior to allowing the award of contracts to build follow-on ships. The decision authority will consider program cost and performance results (as assessed by IOT&E). A favorable decision allows the program to proceed to the FRP and Deployment work effort.

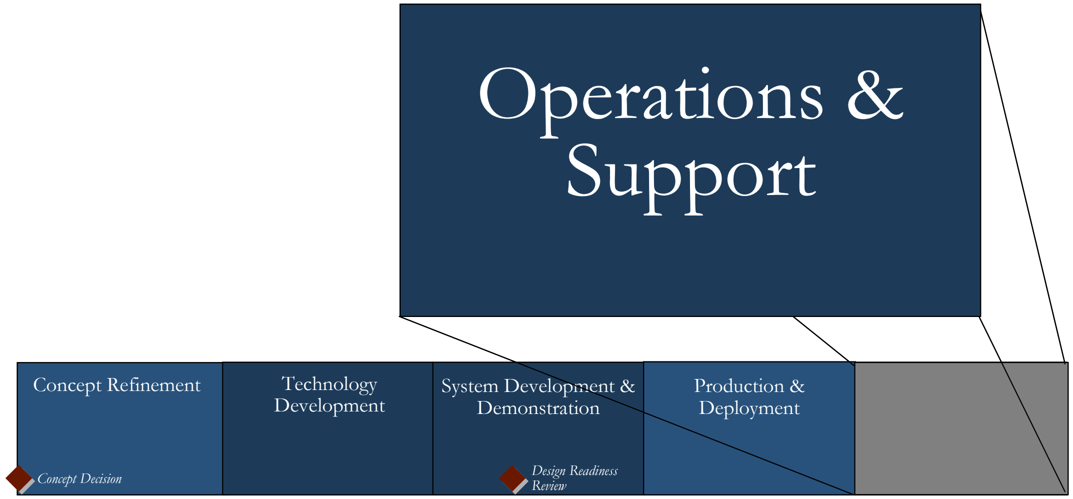


Figure 7: Operations & Support

Operations and Support (O&S) Activities

According to DODINST 5000.2:

> *The objective of this activity is the execution of a support program that meets operational support performance requirements and sustains the system in the most cost-effective manner over its total life cycle. When the system has reached the end of its useful life, it shall be disposed of in an appropriate manner.*
>
> DODINST 5000.2

Figure 7 shows the operating and support (O&S) phase. Ship life can be 30 years or more. Therefore, the O&S costs of a ship over such a long period of time makes up a significant share of the total ship life-cycle cost. As a result, the estimated O&S costs, which encompass costs associated with items such as ship manning and fuel consumption, are of great concern during the design trade-off study period.

PLANNING, PROGRAMMING, BUDGETING AND EXECUTION (PPBE)

The Federal budget process drives the operation of Federal programs and agencies. It involves multiple stakeholders, each working towards the fulfillment of the vision for Government set forth by the Executive Office of the President. The planning and analysis that constitutes the first phase of the PPBE process is the foundation for the formulation of the President's Budget. To support the Federal budgeting process effectively and to comply with the requirements for receiving Federal/program funds, continuous, accurate, and forward-focused investment planning and analysis is required. As a current year budget is being executed, the next year's budget must be formulated and planned.

PPBE Overview

PPBE is DoD's resource allocation system for making informed, affordability assessments and resource allocation decisions on acquisition programs. The PPBE system integrates force requirements with resource requirements: the natural outflow of this consolidation is the budget, and ultimately, the programs that will become part of the Operational Forces. The PPBE process examines military capabilities in a horizontal manner and relies on the Future Years Defense Plan (FYDP) to plan funding in the short term based upon long-term consequences. PPBE is a process of four interrelated and overlapping phases: planning, programming, budgeting, and execution. Figure 8 provides a notional depiction of the PPBE concurrent cycles, including the Presidents Budget (PB) and the Amended Budget Submission (ABS).

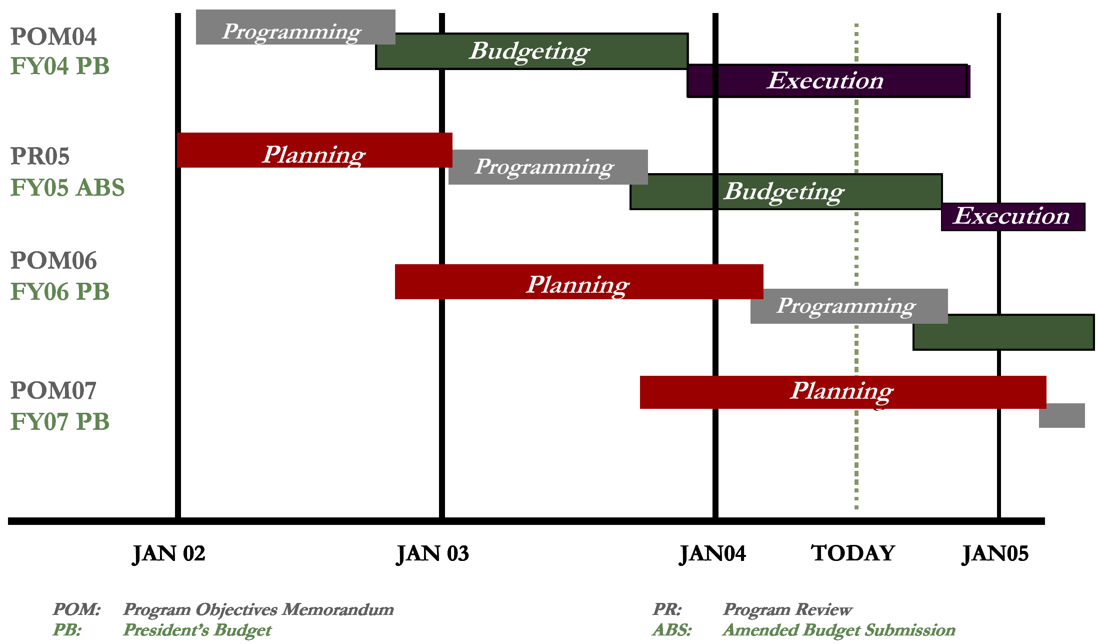


Figure 8: Notional PPBE Concurrent 'Cycles'

Implementation of Management Initiative Decision 913 (22 May 03) changed the Navy from an annual Program Objective Memorandum (POM)/Budget Estimate Submission (BES) to a biennial cycle. Now, during the on- or even years, planning guidance is updated and all DoD programs are reviewed with the Services, including the Navy submitting a POM and a BES to OSD. This change ensures that the joint perspective is captured and that near-term readiness is addressed. During the off- or odd years, few program changes are permitted and the Navy subjects its programs to Program Reviews (PRs). The final budget, called the President's Budget, is sent to Congress for approval.

Definitions

Discretionary Funds: Funds for programs like Defense and Homeland Security.

Mandatory Spending: funds for programs like Medicare, Medicaid, Social Security, Unemployment Compensation, and Food Stamps.

Total Obligational Authority: (TOA): The dollars the DON may obligate in a given period (usually a year).

Future Year Defense Plan (FYDP): Future years to which resources have been tentatively assigned.

Budget Estimate Submission (BES): Service request sent to OSD.

Program Objective Memorandum/Program Review: Phase in which requirements are matched with resources; POM in even number years, PR in odd numbered years.

SEA 017 is deeply involved during the entire year in supporting the cost estimating requirements in each PPBE phase. Because the cyclic process restarts each year, the Division can be involved in each of the phases at the same time. The PPBE process is not zero-based. Programs compete against each other for resource dollars. Table 2 presents an overview of the Division's workload timelines during the PPBE phases over a 12-month period and also depicts the type of program execution support performed by SEA 017 during the budgeting phase.

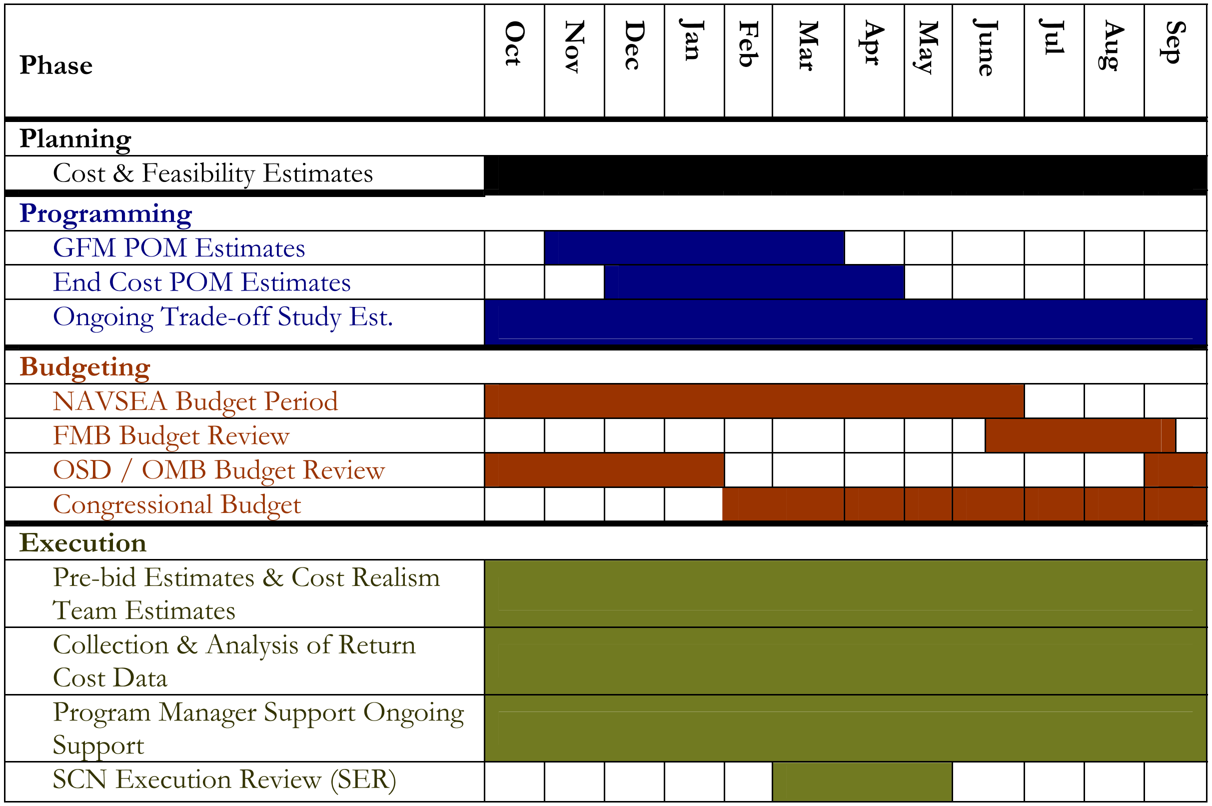


Table 2: Cost Engineering Workload Timelines

The Planning phase of the PPBE initiates every other year with a long-range investment plan and the Secretary of Defense (SECDEF)-approved Defense Planning Guidance (DPG). During this phase, the main issues are national security policy, threat assessment, and resultant force objectives. The approved DPG guides the development of a six-year Defense Program and becomes of immediate interest to the cost estimators, since a cost estimating exercise is required to respond to the document.

The Planning phase ends and the Programming phase begins with the submittal of a 6-year POM every other April. This phase of the PPBE is most significant to programs, since it is during this phase that Navy programs must be prioritized and phased so that total resource requirements are within the bounds established by the DPG. The Navy's response to the DPG is provided to the SECDEF in the Navy POM. The Navy POM encompasses the coming budget year and six out-years and requires significant efforts from a number of offices in NAVSEA. Preparation of NAVSEA and PEO input for the POM is a dedicated effort for the majority of SEA 017. SECDEF, after receiving the POM from the Secretary of the Navy (and the other Service Secretaries), and the JCS review the POM and highlight major programmatic issues for discussion by the Defense Planning and Resource Board. Program offices may prepare issue papers to address affordability of proposed new and ongoing major acquisition programs and identify potential alternatives to those programs. SECDEF decides what actions are to be taken on each issue presented, and these are recorded in a Program Decision Memorandum (PDM). This document establishes the strategic framework for the PPBE and provides guidance for each subsequent phase of the system.

Six years of programs are locked in with the issue of the SECDEF PDM (until the next update) and this becomes the FYDP. In effect, the PDM that results from the POM updates[1] the previous existing FYDP. The FYDP update initiated by the POM process signifies the end of the Programming phase of the PPBE and the start of the Budgeting phase. The POM process, the participants, and the participants' roles are discussed in detail in Section Three.

Although all six years of the FYDP receive consideration during the Budgeting phase, budgeting is most concerned with the first two years of the FYDP. The Budgeting phase consists of three distinct budget submittals as highlighted in the sidebars: System Command and PEO budget submittal to the Navy Office of Budget/Fiscal Management Division (FMB Budget), Service budget submittal to the Office of Secretary of Defense (OSD Budget), and the President's Budget submittal to the Congress (Congressional Budget).

Authorization of the Navy's annual ships, mission modules, and combat and weapons systems programs is contained in legislation passed by the Congress when both the House and the Senate have agreed to all or part of the proposed programs. The authorization bill provides the Navy with the legal power to proceed. Once authorization is received, the final phase of the PPBE, Execution begins and includes all aspects of financial, technical, programmatic, risk, and schedule management.

Congressional Budget

With final SECDEF decisions in hand, OSD updates the FYDP and assembles and submits the Defense portion of the President's Budget to OMB. OMB assembles the total budget, and the President submits it to the Congress in January. Congress will deliberate and make decisions on the Shipbuilding and Conversion, Navy (SCN) Appropriation, as well as the other appropriations that constitute the total Defense budget. COMNAVSEA, together with other Navy witnesses, provide statements and testimony to various Congressional committees on the Navy's ships building program, mission modules, and combat and weapons systems programs. These appearances before the Congressional committees are important to gaining committee confidence, support, approval, and ultimately, authorization and appropriations from the Congress.

Department of the Navy Appropriations Process

When given the legal power to proceed with the authorization bill, the Navy ships, mission modules, and combat and weapons systems programs must await Congressional appropriation of the necessary funds. The appropriation will allow the Navy to incur obligations and make payments out of the Treasury for the ships, mission modules, and combat and weapons systems program. There are a number of appropriations with which the Navy conducts its business:

- Research and Development is carried out with the Research, Development, Test, and Evaluation, Navy (RDT&EN) Appropriation. In some cases, lead ship construction work is funded through RDT&E. For example, the first ship of each Littoral Combat System (LCS) design is RDT&E funded.
- Shipbuilding procurement is carried out with Shipbuilding and Conversion, Navy (SCN)[2] Appropriation. The SCN Appropriation constitutes approximately 10 -15 % of the Navy's total annual procurement budget and includes the procurement of ships and craft to be newly constructed and major ship conversions.
- Ordnance and some ordnance weapon systems for active fleet ships are procured with the Weapon Procurement, Navy (WPN) Appropriation.
- Electronic systems and hull, mechanical, and electrical (HM&E) equipment for installation on active fleet ships are procured with the Other Procurement, Navy (OPN) Appropriation. As an example, mission packages for LCS are OPN funded while LCS is currently RDT&E funded and as a new platform, it will then move into SCN funding.
- Salaries of Navy civilian personnel including headquarters and field activities (shipyard labor associated with overhaul of active fleet ships and funding of Navy repair and maintenance activities), ship operating costs, and certain contractor support funding are all funded by the Operations and Maintenance, Navy (O&MN) Appropriation.
- Military salaries are paid with the MILPERS Appropriation.
- Facility construction and modifications are paid with the MILCON Appropriation.[3]

FULL-FUNDING POLICY

Of the various OSD funding policies that have been established for each of the appropriations, the full-funding policy for procurement appropriations such as SCN is of great significance to NAVSEA. Simply stated, this policy means that an SCN procurement item that has been authorized by Congress must be funded in total at all times or the work on it must cease. However we are starting to see other funding strategies, such as : advance procurement, incremental funding, split funding, advanced appropriation in order to balance shipbuilding and industrial base concerns. "Total" in this case is defined as "end cost," which is described in the following section.

The Defense Acquisition Guidebook

The Defense Acquisition Guidebook is a an interactive, web-based capability designed to provide the acquisition workforce and their industry partners with an instant on-line reference to best business practices as well as supporting policy, statute, and lessons learned. While the DoD acquisition policy documents (DoDD 5000.1 and DoDI 5000.2) released last year explain "what" acquisition managers are required to do, the Guidebook complements those documents by explaining "how." Defense acquisition professionals are able to use the Guidebook to review discretionary best business practices and then tailor them to the particular needs of their program.

In addition to the wealth of information virtually available through the Guidebook, acquisition workforce members are also be able to employ the Guidebook to access the Defense Acquisition University's Acquisition Knowledge Sharing System and many of DAU's other resources, including on-line courseware and communities of practice.

The Defense Acquisition Guidebook is currently available on the Internet at http://akss.dau.mil/dag. We encourage its use as you design and manage your programs.

END COST CONCEPT

The term "end cost" in SCN originated during the development of the fiscal year (FY) 1961 Shipbuilding Program. Before FY 1961, Congress provided annual appropriations for shipbuilding programs that included funds for the new budget-year programs plus additional funds identified by the Navy to complete prior-year programs. A prior-year shortfall was anticipated each year. At that time, ship cost estimates were presented to Congress priced in current-year dollars with allowance for inflation, despite the fact that shipbuilding construction periods stretched over a period of three to six years and sometimes longer. In addition, no reserves were included in the estimates to cover other unanticipated funding requirements that could arise during this lengthy period. Prior-year funding shortfalls caused ships to be canceled or delayed when Congress did not appropriate additional funds. The shortfall identified in the FY 1961 budget submittal was so large that OSD directed the Navy to revise the policy for reserves in ship cost estimates. With approval by Congress, the new policy for SCN was one of full funding of all reasonable and expected costs through the ship construction and post-delivery period. Ship cost estimates prepared under this policy were then said to be "end costed." The major cost categories of an end cost estimate are presented in detail in Section Five.

Over time, certain refinements to end costing have taken place[4]. The most significant change involves ship outfitting and post-delivery budget estimates. These categories are no longer included in the categories making up end cost at the time of budget submittal but are budgeted separately in later fiscal years when payment is actually required.

RELEVANT SCN BUDGET DOCUMENTS

The responsibility for submitting individual ship program budget documents to the SCN Appropriation Division (SEA 012) is that of the cognizant PM. SEA 017, however, plays a significant role in the preparation of a number of these documents and in estimating the data displayed on each of these documents. Therefore, usually the cost estimator reviews the final documents before the SEA 012 analyst puts the SCN budget into final form.

Each budget activity, shown on this page, is further divided into specific ship/ship class procurement items designated as P-1 line items. A cover sheet for each P-1 line item in the budget year provides end cost, prior advance procurement, present advance procurement, any adjustments and new Total Obligation Authority (TOA), which is the FY bottom-line budget dollars being requested. An explanation of the variance between the current estimate and the previous POM estimate is also provided. Each of these program documents is submitted with the FMB budget and, as appropriate, with the OSD budget submittal. The documents represent the individual programs to the reviewers outside of NAVSEA and provide the basis for the discussions held at the follow-on budget meetings. The following budget documents are submitted for each P-1 line item:

The SCN Appropriation is divided into five Budget Activities (B.A.) as follows:

- B.A.1 -- Fleet Ballistic Missile Ships
- B.A.2 -- Other Warships
- B.A.3 -- Amphibious Ships
- B.A.4 -- Mine Warfare and Patrol Ships
- B.A.5 -- Auxiliaries, Craft, and Prior-Year Program Costs

BUDGET DOCUMENTS

- P-8: This exhibit is currently not required as a budget exhibit but is still requested by Congressional Staffs on an *ad-hoc* basis. It breaks down the total P-1 cost estimate in end cost categories. For prior-year programs, provides original estimate appropriated by Congress, last OSD-approved estimate, and current estimate. For budget-year estimates, provides current estimate. Advance procurement amounts are identified by fiscal year. Provides shipbuilding locations and schedule information.
- P-8A: Breaks down the GFM portions of the total P-1 cost estimate in the categories of ordnance, electronics, HM&E, and propulsion. All P-35 equipment is identified as well as high-dollar-value, non-P-35 equipment. This information is provided for budget year (BY) ships and BY+1, BY-1, BY-2 ships. Identifies any space and weight GFM items.
- P-8B: For each P-1 line item, provides design schedule, cost estimate classification, basic construction award date, contract type, and information supporting the contract escalation estimate.
- P-10: Provides detailed information for justification of advance procurement requirements. Equipment, significant schedule dates, and funding requirements are listed.
- P-5: Similar to P-8, provides a break down of total P-1 current cost estimate in end cost categories via budget year (BY) ships, BY+1, and for most prior-year ships of the program.
- P-27: Provides the ship production schedule for each ship of the P-1 line item starting with lead ship through BY to last year of the FYDP. Information provided includes hull number, fiscal year contract award date, start of construction date, and ship delivery date.
- P-35: Major Ship Component Fact Sheet - For high-dollar-value GFM, provides FY installation plans by hull, contractor, quantities, unit cost, contract award date, and delivery date. A P-35 is prepared for equipment having a unit cost of $500,000 or more and for all radars, sonars, fire control systems, and missile systems. This exhibit is not included in the budget backup book but is available in the files of the SCN Appropriation Division.
- P-40: A budget item justification document that identifies the mission and technical characteristics of the P-1 line item program together with production status. Quantity of ships and total estimated cost is provided for BY, FYDP years, and two prior years.
- P-44: Provides quantity of ships programmed for Navy, other Services, and FMS/Other. Provides a unit cost analysis (average cost per unit) by P-22 category and reason for change (difference) for BY ships, and BY+1, BY-1, and BY-2 ships.

SCN EXECUTION REVIEW (SER)

Prior FY NAVSEA programs are at various stages of completion during the execution phase of the SCN acquisition process. For example, it is not unusual for the Navy's most complex ships to be delivered six to eight years after authorization and funding by Congress, especially when a prior FY award included multiple ships. During this lengthy period, the cognizant PMs and the NAVSEA Comptroller Directorate continually review budgets. An SER, which is a formal budget review under the direction of SEA 012, is conducted each year in the February to May time period. This review involves the collection, analysis, and evaluation of actual cost data derived from Cost Performance Reports (CPRs), estimates at completion (EACs), justification of increases and decreases, review of unobligated balances, and a reexamination of end cost estimates for unawarded ships. This latter task falls principally to SEA 017. The cognizant NAVSEA cost estimator is provided with an opportunity to revisit the estimate to reflect any cost data that may be appropriate, such as recent awards or current economic information. For example, the contract escalation line on each ongoing program is updated to reflect actual obligations and new inflation forecasts (see Section 5 for more information about inflation).

Lessons Learned

O&MN to SCN

There are occasions when ship modernizations, funded with O&MN funds, are transferred to the SCN Appropriation. The experienced SCN ship cost estimator is aware that the O&MN cost estimate is not the total estimate because ordnance, electronics, and other material planned for installation on the ship are funded in the WPN and OPN Appropriations. The O&MN, WPN and OPN estimated costs are totaled if comparisons are to be made with the SCN estimate.

Program Modification Process

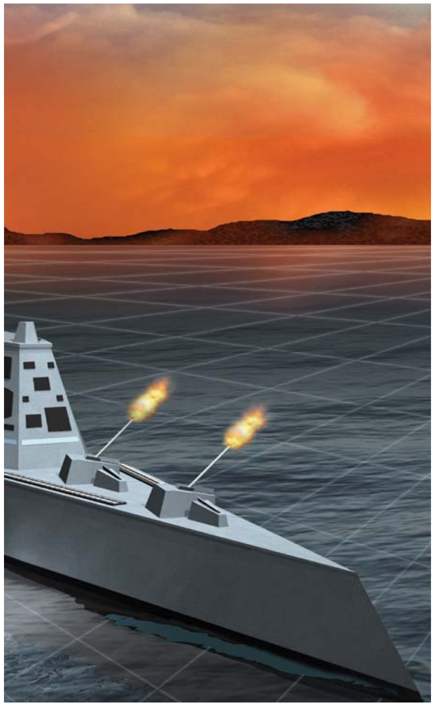
SECNAVINST 5000.2 dictates a system for controlling quantity, schedule, cost, and configuration change in previously approved programs. A program modification that does not breach the program's current approved Acquisition Program Baseline (APB) agreement may be accomplished at the discretion of the PM. However, a program modification that causes a breach of any current, approved APB threshold requires a Program Design Review (PDR) and revised APB, submitted to the CNO and SECNAV via a Request for Baseline Change. The program MDA will approve the proposed modification by approving the revised APB. A program modification, which exceeds an APB and/or has combined RDT&E and procurement costs greater than FY00 $100M for ACAT I programs or FY00 $40M for ACAT II programs, must be reported by the Program Deviation Report to the CNO and SECNAV. These procedures may be applied to any program modification, regardless of value or impact on baseline thresholds at the discretion of the MDA.

The cognizant PM generally initiates PDRs within NAVSEA. SEA 017 personnel are expected to assist PMs in developing the PDR content and to determine the cost estimate classification. The Division also provides final review and certification of the cost estimates and PDR content prior to COMNAVSEA signature. This responsibility is significant, and personnel are required to set aside sufficient time to provide each PDR with a proper and careful review. A side benefit of the PDR process is the visible, documented program cost track provided by the PDRs.

2005 Cost Estimating Handbook

Section 3:

Cost Estimating at NAVSEA



Cost estimating is a highly structured process that has evolved over a period of many years at NAVSEA into the formal framework described in this handbook (see Section 4 for a full description). Cost estimating is an essential element to effective program management and is required for realistic program planning and decision-making. Following the cost estimating process and framework presented in this handbook permits Navy managers to optimize the use of limited financial resources. Cost estimators must be proficient and aware of the financial management, performance measurement, schedule analysis, acquisition management, as well as the technical aspects of a program to support the cost estimating process effectively.

The primary function of SEA 017 is to provide cost estimating, cost engineering, and industrial analysis for NAVSEA and associated PEO Programs. The many participants, their responsibilities, and the coordination among their functions, form the cost estimating framework and environment at SEA 017. This framework including participants, NAVSEA/PEO products, cost estimating deliverables, cost estimate classifications, and estimating in the program life cycle, is described in this section.

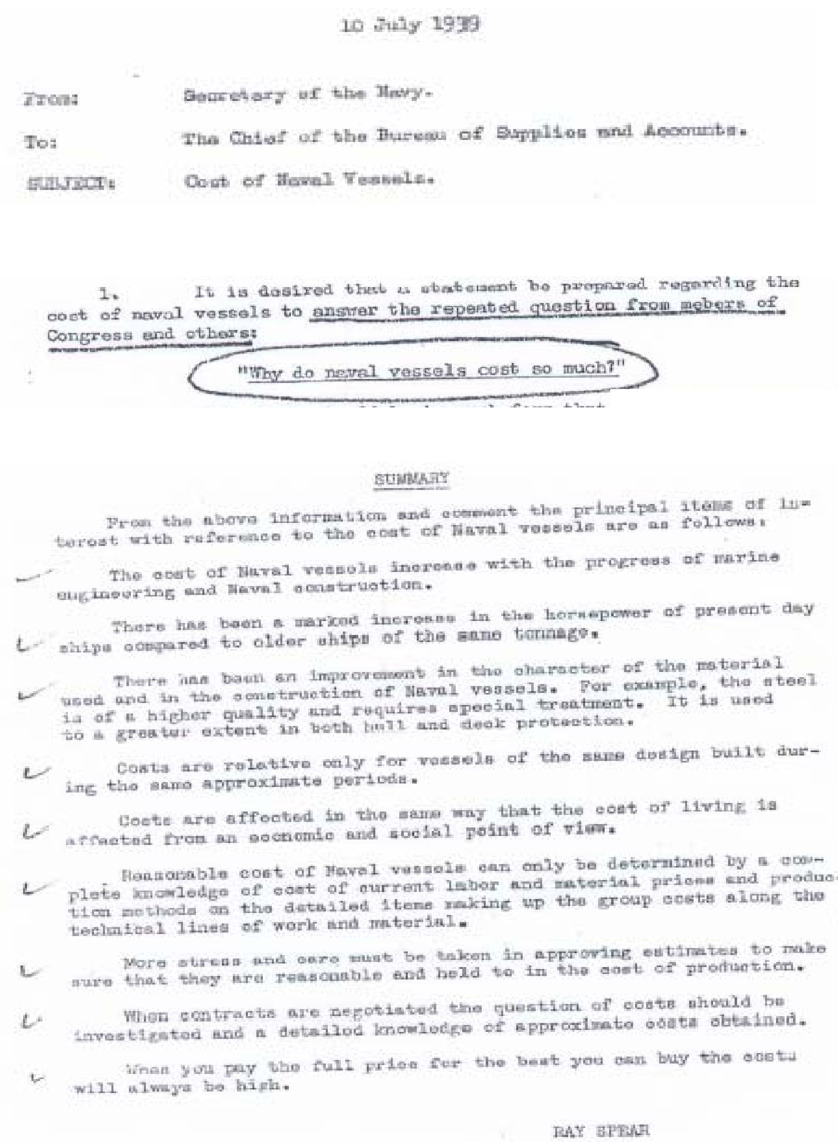
THE IMPORTANCE OF COST ESTIMATING TO NAVSEA

Improving government performance is one of the key tenets in the President's Management Agenda. In that document, the President of the United States calls for program proponents to "bear the burden of proof to demonstrate that programs they advocate actually accomplish their goals, and do so better than alternative ways of spending the same money."[5] One of the best ways to accomplish this is through the systematic process of cost estimating. Accurate cost estimating that considers risks and benefits in a quantifiable manner puts a program or project on a solid foundation, as does the consistent and continuous application of system engineering and program management. Cost estimating is extremely important to NAVSEA and associated PEOs as it is a key function in determining costs at the onset of a program, assuming proper budgets are in place, and in managing and controlling cost throughout the program's life cycle.

Attention to the issue of cost is not new, as evidenced by this 1939 inquiry from the Secretary of the Navy shown here. As the summary results in this excerpt from the requested study point out, the issues of cost growth are a timeless problem.

PARTICIPANTS AND THEIR ROLES

There are many participants in the cost estimating process at NAVSEA and associated PEO programs. From the cost estimators to the end users, each participant plays an important role. This section provides an overview of each person or group participating in the cost estimating process along with a description of their roles and responsibilities as they relate to the cost estimating process for NAVSEA and affiliated PEO programs.



10 July 1939

FROM: Secretary of the Navy.

To: The Chief of the Bureau of Supplies and Accounts.

SUBJECT: Cost of Naval Vessels.

1. It is desired that a statement be prepared regarding the cost of naval vessels to answer the repeated question from mebers of Congress and others:

"Why do naval vessels cost so much?"

SUMMARY

From the above information and comment the principal items of interest with reference to the cost of Naval vessels are as follows:

The cost of Naval vessels increase with the progress of marine engineering and Naval construction.

There has been a marked increase in the horsepower of present day ships compared to older ships of the same tonnage.

There has been an improvement in the character of the material used and in the construction of Naval vessels. For example, the steel is of a higher quality and requires special treatment. It is used to a greater extent in both hull and deck protection.

Costs are relative only for vessels of the same design built during the same approximate periods.

Costs are affected in the same way that the cost of living is affected from an economic and social point of view.

Reasonable cost of Naval vessels can only be determined by a complete knowledge of cost of current labor and material prices and production methods on the detailed items making up the group costs along the technical lines of work and material.

More stress and care must be taken in approving estimates to make sure that they are reasonable and held to in the cost of production.

When contracts are negotiated the question of costs should be investigated and a detailed knowledge of approximate costs obtained.

When you pay the full price for the best you can buy the costs will always be high.

RAY SPEAR

COMNAVSEA (SEA 00) Roles and Responsibilities

NAVSEA's responsibilities include designing and delivering ships and weapon systems to the fleet, and the maintenance, repair, modernization, and conversion of in-service ships and their weapons and combat systems. Additionally, NAVSEA and affiliated PEOs provide technical, industrial, and logistics support for naval ships, and ensures the proper design and development of the total ship, including contractor-furnished shipboard systems.

Other important NAVSEA and affiliated PEO functions include introduction of ships to the Fleet, the Navy's diving and salvage operation, explosive ordnance safety and disposal, coordination of naval ship conversion and repair for both the DoD and the Military Sealift Command, and support of ship construction for the Maritime Administration.

The ships, mission modules, and weapons systems program is presented to Congress each January as part of the President's Budget. Each year as part of its responsibilities, COMNAVSEA provides statements and testimony to various Congressional committees on the Navy's annual budgets for ships, mission modules, and weapons systems. These appearances before the Senate and House Armed Services Committees (SASC and HASC, respectively) and the Senate and House Appropriations Committees (SAC and HAC, respectively) and potentially the Congressional Seapower Committee are important to gaining committee confidence, support, approval, and ultimately, authorization and appropriations from the Congress. COMNAVSEA prepares for these appearances with a number of briefings and discussions with management personnel. In addition, a statement and briefing book is assembled for COMNAVSEA and includes (among other NAVSEA business) data on ongoing programs, together with data on current budget and future-year programs.

Comptroller/Deputy Commander (SEA 01) Roles and Responsibilities

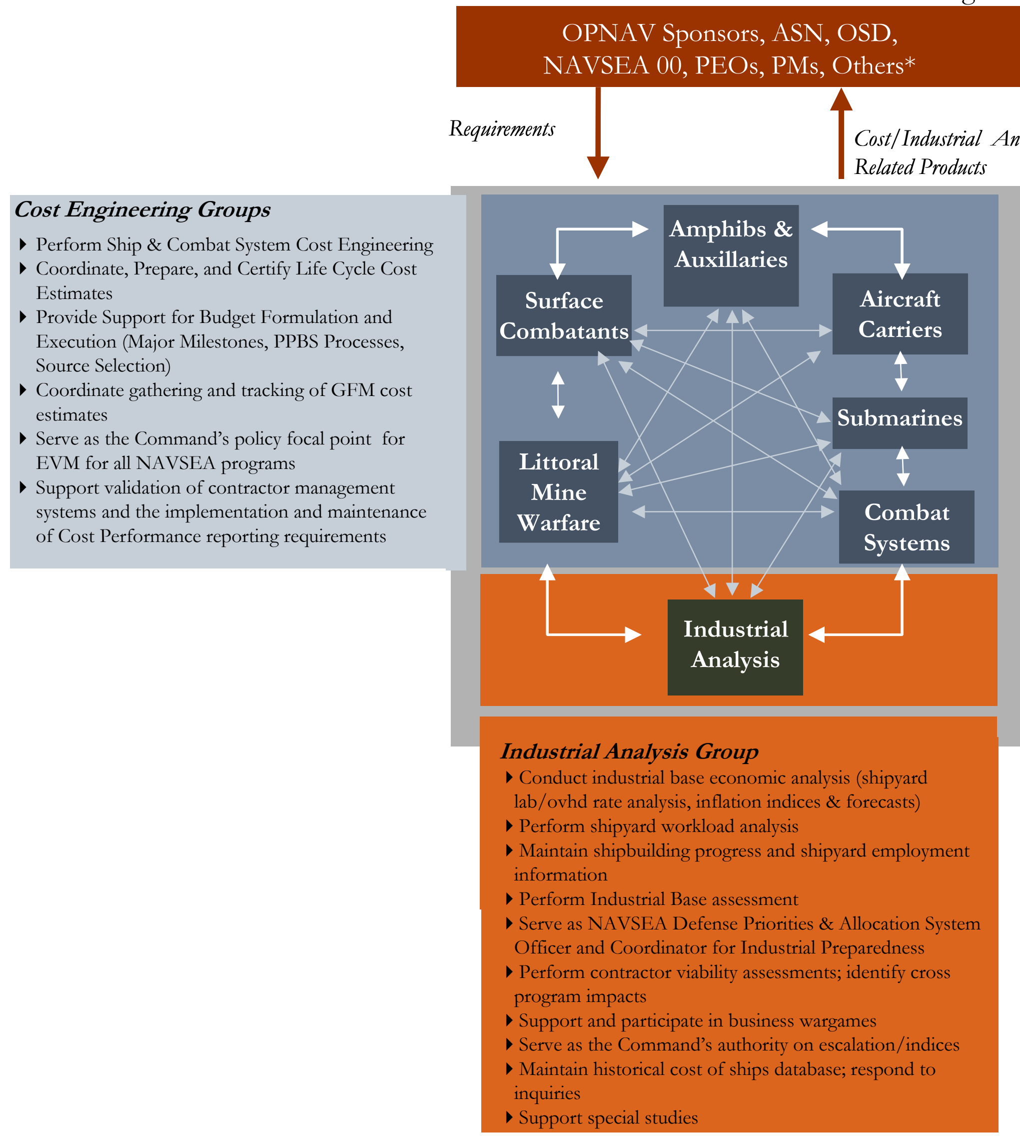
The NAVSEA Comptroller addresses the financial implications, the basis for the estimates, and the industrial feasibility of the POM. Other Comptroller roles and responsibilities include:

1. Serve as the chief financial advisor to the Commander and to the PEOs in accordance with the individual Memoranda of Understanding (MOUs).
2. Direct and coordinate overall Command comptroller functions for the entire NAVSEA claimancy including supporting PEOs in the areas of programming, budgeting, accounting, fiscal progress, statistical reporting, internal control, and cost estimating.
3. Develop and implement internal financial policies and systems for all comptroller functions.
4. Direct and coordinate formulation and submission of NAVSEA's input to the Navy PPBE and assist NAVSEA PMs in developing PPBE inputs.
5. Serve as the Navy Budget Submitting Office (BSO) and Administering Office for the SCN Appropriation.
6. Ensure compliance with appropriation controls and regulations. Establish charts of accounts for all NAVSEA programs and allocate funds to PMs in accordance with line items in the charts of accounts.
7. Serve as NAVSEA Cost Estimating Manager, focal point and advisor on all aspects of ships, ships' systems, and installed combat systems cost estimating and analysis. Serve as NAVSEA's review and certification focal point for cost estimates developed for designated weapon systems to be acquired under SCN, RDT&EN, WPN, and OPN funding. Authenticate cost estimates leaving the Command.
8. Evaluate the financial status of NAVSEA programs and recommend corrective action, as required.
9. Exercise 31 USC 1301(a) and 31 USC 1517 responsibilities for funds made available for NAVSEA programs. Approve and recommend reprogramming and recoupment actions.
10. Direct, analyze and review the execution of approved programs, including coordination and preparation of the SCN Execution Review and recommend program changes to ensure maximum utilization of available resources within the SCN Appropriation.
11. Serve as the NAVSEA representative to ASN(FM&C) and DFAS to review and prioritize enhancements and design changes to STARS and other DoD accounting systems, provide feedback to the Managers on user problems, and provide recommendations to accounting systems Managers on policy issues.
12. Act as Command focal point for NAVSEA Navy Working Capital Fund (NWCF) budgeting and financial matters, including stabilized rates for NWCF activities.
13. Provide fiscal guidance, operational oversight and coordination of the NAVSEA Quality of Life Program for shore activities.
14. Serve as NAVSEA focal point for Security Assistance Program financial management policy and program procedures.
15. Serve as a member of the NAVSEA Executive Council (NEC).

NAVSEA Cost Engineering and Industrial Analysis Division (SEA 017) Roles and Responsibilities

ORGANIZATIONAL STRUCTURE

The Cost Engineering and Industrial Analysis Division is located in the Comptroller Directorate of NAVSEA and serves as advisor to COMNAVSEA, PEOs, and the NAVSEA Comptroller on the historic, current, and emerging trends in all elements of cost estimating and cost analysis. This is demonstrated by the organizational overview of SEA 017 presented in Figure 9. For many years the Division has performed as the Command's and the Navy's authority in the field of ship cost estimating. PMs are responsible for ensuring that cost estimates are available for their programs. Many work with the central Cost Engineering and Industrial Analysis Division in the preparation of the estimates while others use the Division as a means to validate their independently generated estimates. It is important to note that the SEA 017 organization works for the NAVSEA Commander (COMNAVSEA) and keeps an independent view of their work while still supporting the PEOs and PMs. In 1983, COMNAVSEA expanded the SCN authority role of the Division to cover all other NAVSEA combat and weapon systems as well as weapon acquisition programs funded by WPN, OPN, and RDT&EN. This latter role has evolved to the actual development of cost estimates for major combat and weapon systems in the ship SCN cost estimates, in addition to ordnance and ordnance systems funded by WPN.



**Others may include: DARPA, MARAD, DASNs, Coast Guard, SEA 05 (engineering), SEA 02 (contracts), FMS program/sponsors, Donation Ship program, etc.)*

Figure 9: SEA 017 Roles & Responsibilities

The current Cost Engineering and Industrial Analysis Division, and its predecessor organizations, was established primarily to prepare ICEs for PPBE purposes but Figure 10 provides an overview of the many activities where SEA 017 provides cost engineering expertise at NAVSEA. Internal customers include NAVSEA, PEOs, and PMs and external customers include ASN(RDA), OPNAV, and OSD. An important part of the SEA 017 organization is its ability to provide cost engineering decisions as the Technical Authority (TA) for Cost Engineering at NAVSEA. An overview of SEA 017 Cost Warrants is provided in the next section. Following the cost estimating process, the current SEA 017 organization prepares independent estimates for all products, including ships that will become a line item in the shipbuilding SCN budget. The advantage of SEA 017 providing ICEs is that in most cases, the estimate becomes the program office estimate and these numbers that support the budget were developed through a formal and rigorous, well-documented process. This increases the chances of program success and builds credibility in SEA 017 estimates.

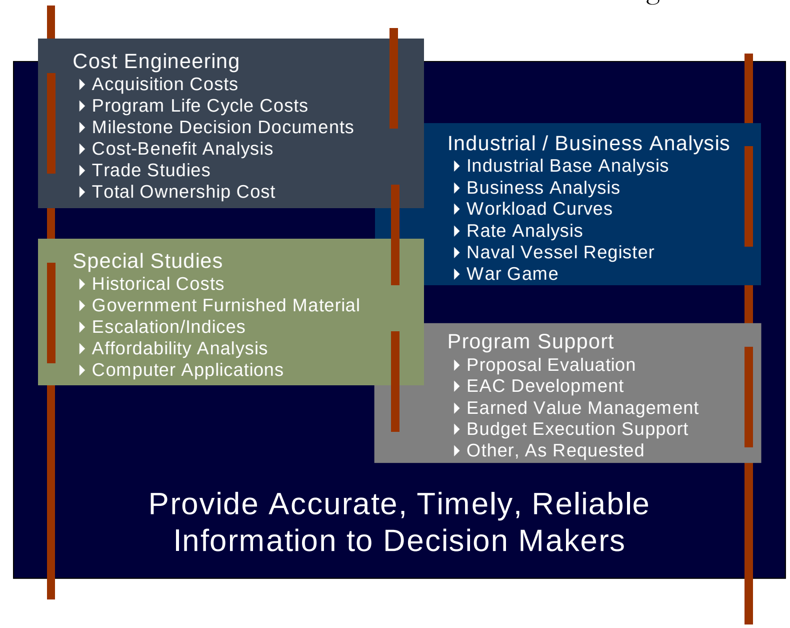


Figure 10: SEA 017 Roles and Responsibilities

A civilian Division Director, a member of the Federal Senior Executive Service (SES), manages the NAVSEA Cost Engineering and Industrial Analysis Division. There are six cost estimating groups and one analysis group in the organization. A GS –15 Group Director, manages each group.

SEA 017 Cost Warrants

Disciplined and independent cost engineering is an essential aspect of the systems engineering process and a required capability contributing to improving the efficiency and effectiveness of the Navy's platforms and operations. Technical decisions and subsequent program direction depend on a clear understanding of the cost and cost implications of various technical options. Credible cost estimates based on rigorous cost estimating standards and processes must be ensured for NAVSEA to meet assigned responsibilities.

According to the NAVSEA Instruction on Technical Authority Policy, "Technical Authority (TA) is the authority, responsibility, and accountability to establish, monitor, and approve technical products and policy in conformance to higher tier policy. Individuals warranted as TAs are entrusted and empowered to oversee cost engineering processes and make technically sound engineering decisions, and must do so with integrity and discipline. This allows decisions to be made in a timely and responsive manner, not requiring excessive review and oversight.

Technical Warrant Holders

There are six different kinds of Technical Warrant Holders:

- Technical Area Experts,
- Platform Design Managers,
- Cost Engineering Managers,
- Technical Process Owners,
- Chief Systems Engineers and
- Waterfront and Depot Chief Engineers.

Under each of these six TWHs is a pyramid structure of engineering managers and lead engineers, who are experts in their field, to provide technical authority with bedrock credibility and allow for essential independent functioning.

COMNAVSEA is the Technical Authority (TA) for ships, weapons, systems and infrastructure and warrants the Director, SEA 017 as the technical authority for cost engineering. Jointly with COMNAVSEA, SEA 017 warrants Cost Engineering Managers (CEMs) as Technical Warrant Holders (TWHs). Technical Warrant Holders are subject matter experts. Within their defined technical areas they are responsible for establishing technical standards. They are entrusted and empowered to make authoritative decisions and held accountable for the technical decisions made. NAVSEA's CEMs are recognized experts and are expected to:

- Oversee cost engineering processes and develop authoritative cost estimates; based on a defined set of programmatic and technical requirements.
- Ensure cost engineering policies, processes, standards and tools are well defined, comply with higher tier requirements and are properly applied.
- Make authoritative, independent cost engineering decisions based on program technical and schedule performance parameters.
- Ensure cost engineering processes are effectively integrated into the systems engineering process.
- Be the accepted source of expert cost related information and advice.
- Steward the Navy's cost engineering capabilities.

NAVSEA's TA policy clearly establishes TA for the TWHs in SEA 017's CEMs, to make authoritative technical decisions separate and independent from the programmatic authority of the PMs and provides for coordination and conflict resolution processes with regard to engineering decisions. Within NAVSEA, TA peers cross many boundaries and areas of the command's activities, tapping various levels of expertise in the warfare centers, shipyards and waterfront activities, as well as headquarters. There are eight TWHs in SEA 017, the seven Group Directors and one individual responsible for overall SEA 017 policy and processes.

As delegated by the Secretary of the Navy, NAVSEA is bound to execute TA to support Fleet customers with an accountable and independent process of providing responsive problem resolution and engineering support. Through TA, the TWH always retains ownership of the problem or issue that needs resolution, giving the customer a single point of entry into NAVSEA's intellectual capital. An important role of TA experts is to evaluate associated risks and assess best value to determine timely alternative solutions. The Chairman of the NAVSEA Technical Authority Board has noted, "A streamlined and clearly understood TA process results in a NAVSEA organization that is far more agile, effective and efficient in its support to the warfighter, and capable of meeting the changing needs of the Navy."

Roles and Responsibilities in the Cost Estimating Framework

SEA 017 prepares independent estimates for NAVSEA and associated PEOs products, including, weapons systems, submarines, and ships that will become a line item in the shipbuilding SCN budget and other appropriation accounts. Using the cost estimating framework and following the process within the framework for each estimate conducted for every program ensures a quality NAVSEA independent SEA 017 estimate.

Since every official NAVSEA cost estimate is to be treated as a potential budget candidate, certain basic requirements have been established for the estimator, and they include:

- Written OPNAV cost and feasibility request should be in hand for POM call estimates.
- Formal technical design inputs should be available.
- An approved acquisition strategy and product schedule should be available.
- A cognizant PM should be involved.

In the event that one or more of these requirements have not been met, the estimator must ensure that management individuals in the chain of command are made aware of where exceptions have been taken. In this way, the estimate can be treated in its proper context.

SEA 017 initiates its efforts months before the biennial POM call. Cost analysis guidance will have been prepared for the cost estimator in areas such as shipyard labor rates; shipbuilding material inflation factors; contract escalation, including fringe and energy considerations; overhead rates; and "cost of money". The cost estimators will have been updating their cost data on the basis of another year of return costs on previously awarded shipbuilding contracts and the past year's bid data on new awards. SEA 017 promulgates the POM call to the appropriate Participating Acquisition Resource Managers (PARMs), tasking them for Government Furnished Material (GFM) planned cost estimates for each ship. The POM pricing period is a busy time of the year for SEA 017, with a great deal of cost estimating and review to be accomplished in an extremely short period of time. The cost estimator must ensure that all the required inputs are in hand early so that the bulk of the available time can be spent in developing or refining estimates, and gaining the approval of the cognizant PMs. SEA 017 supports OPNAV with follow-on alternative POM pricing as required.

NAVSEA Cost Estimators Roles and Responsibilities

Cost estimators support COMNAVSEA during Congressional appearance by preparing and providing data for their cognizant programs and assembling the statement and briefing book. The cost estimator's role during Congressional deliberation is one of supporting the NAVSEA PMs and the PEOs, associated with the SCN Appropriation as they respond to Congressional staff requests for additional supporting program data.

Outside of SEA 017 there are other estimators in the NAVSEA cost estimating community that may perform estimates. These participants may be trained cost estimators that are organic to the program office or engineers providing input to the cost estimate. In many cases engineers will provide inputs to an estimate by providing engineering build up or “grass roots” estimates. BFMs may also play a role in providing inputs or developing cost estimates or responses to quick turn around “what if” drills for a program.

In addition to ICE preparation, cost estimators support the product contract award process by serving on various Source Selection Evaluation Board (SSEB) cost teams established to perform cost analysis on cost proposals, producing a Technical Analysis Review/Report (TAR), Cost Realism Evaluation, Source Selection Board Analysis, or Should-Cost Study. In these cost reviews, a government position (accept, select, modify, reject) is taken on each element of the contractors cost proposal in preparation for source selection and/or contract negotiations. Supporting the proposal evaluation process is a significant and rewarding responsibility for the cost estimator. The wealth of data, the interface with contractor personnel, and the exposure to various estimating systems all provide an invaluable learning experience for SEA 017 cost estimators. Estimator support also includes Integrated Baseline Review (IBR) participation and EAC development.

SEA 017 Focal Point Responsibilities

The Cost Engineering and Industrial Analysis Division maintains focal point responsibilities in NAVSEA for other cost-based resource management endeavors. These responsibilities include:

- Economic analyses,
- Life-cycle costs,
- Cost as an Independent Variable (CAIV)
- Design to cost, and
- Should-cost studies.

Navy investment decision making is enhanced by more depth (time, advanced process, automation) and range (program coverage) of cost engineering analysis conducted by SEA 017.

Stakeholders Roles and Responsibilities

Estimates are prepared to support Navy inputs to the PPBE process. From the time the estimate is prepared to when it becomes part of the federal budget process there are many stakeholders that participate in the process and use the cost estimate. Some of these stakeholders and some of their primary responsibilities with relation to cost estimating are discussed in this section.

Chief of Naval Operations

The Chief of Naval Operations (CNO/OPNAV) determines the needs of the Naval forces within available resources and develops program objectives that are stated in the CNO's Biennial POM. Together with pricing, NAVSEA is asked to comment on the feasibility of the POM from an industrial capability viewpoint. Usually, the design of a ship that is included in the POM for pricing will already have reached at least the feasibility stage by NAVSEA. That is, OPNAV, in earlier efforts, has stated the mission need and operational requirements and these have been developed by NAVSEA into a feasible ship design. At POM time, refinements of these earlier design studies are then priced. Of course, follow-on, repeat design ships are also included as part of the POM. The NAVSEA cost estimator works with the OPNAV sponsor offices and the SCN Manager's office to assist in refining the POM. The predominant interface is with the latter because of the overall coordination responsibilities of the SCN Manager and the SCN Manager's office to assist in refining the POM.

Sponsor Offices

Each program that the cost estimator is asked to price has a sponsor office in OPNAV. The major organizational breakdown for ships and craft is as follows:

- Submarines, submarine tenders
- Aircraft carriers
- All other surface ships and craft
- Weapon systems

From the cost estimator's point of view, one of the sponsor's significant tasks is to promulgate preliminary and a final approved CDD at the appropriate times in the pricing cycle so that a detailed technical definition can be produced by NAVSEA for design feasibility and pricing purposes. In addition, the estimator may interface with the sponsor to clarify pricing assumptions such as ship quantities and characteristics. For coordination purposes, the estimator apprises the OPNAV SCN Manager of any significant decisions resulting from such discussions.

OPNAV SCN Manager (N70)

The OPNAV SCN Manager (N70) is a key participant in the PPBE process. Daily contact with SEA 017 during POM pricing is not unusual. The SCN Manager works closely with all the OPNAV offices involved in the POM cycle.

Program Executive Offices (PEOs)

The Program Executive Offices (PEOs) and Direct Reporting PMs (DRPMs) have responsibility for management of most of the Navy's major defense acquisition programs as well as smaller programs directly associated with those efforts. The PEOs and DRPMs report to the ASN(RD&A). The PEOs are physically collocated with NAVSEA and are provided functional support by NAVSEA. NAVSEA affiliated PEOs include PEO Ships, PEO Submarines, PEO Integrated Warfare Systems (IWS), and PEO Littoral and Mine Warfare (LMW). Program offices for ship and ship system acquisitions report to the appropriate PEO based on product line.

Program Manager (PM)

PMs, are responsible for budget justification of their individual programs; SEA 017 is responsible for supporting the PM and SEA012 in meeting their budget responsibilities. These offices, and the other participants identified earlier, constitute the group engaged in the annual FMB and OSD/OMB SCN budget meetings. PMs are responsible for all management elements of their programs, including programming, budget formulation and presentation, and execution. PM responsibilities include having program cost estimates available, a function that the PM often chooses to delegate to SEA 017 in accordance with NAVSEA policy.

The PM takes steps to ensure that the proper cost estimate inputs are available or produced for the POM programs under PM cognizance. The inputs include the ship acquisition strategy; technical definition of ship design parameters; shipbuilding schedules; listing of Government Furnished Equipment (GFE)/GFM, including long-lead material items required to support the acquisition strategy; and special programmatic factors. These inputs help to build a credible, risk-adjusted cost estimate. The PM tasks the Ship Design Integration and Engineering Directorate to produce the necessary technical inputs and tasks the Industrial Operations Directorate to provide the shipbuilding schedules taking into account the total Navy shipbuilding acquisition program.

The cost estimator during this time is coordinating the estimating work on a continuing basis with the PM. When the estimator completes the estimate, it is presented to the PM for approval. Any PM concerns are resolved to the mutual satisfaction of both parties. In the very rare case when agreement cannot be reached, differences are passed to the NAVSEA Comptroller and, if necessary, to COMNAVSEA and PEO for resolution. The cost estimating support provided by SEA 017 to NAVSEA PM's is formally documented through Customer Support Agreements (CSAs). These CSAs normally cover a two-year period and describe the PMs costing requirements, SEA 017s schedule of deliverables and resources, including people and funding needed to support the agreement.

Investment Pricing Validation Teams (IPVTs)

IPVTs are formed to provide insight into the Navy's investment strategy for programs and to assist in minimizing financial churn. IPVT guidance is issued early in the calendar year, usually February, and a team is formed to review candidate Programs. This review focuses on pricing issues associated with the Program of Record (POR), defined as the President's Budget content. Programs are ranked, and based on the results of the IPVT, Navy senior decision makers are able to decide the impact of the issues and set a course of action for evaluating and addressing the issues.

NAVSEA SCN Appropriation Division (SEA 012)

SEA 012 is another key participant in the PPBE process. This Division coordinates and prepares PPBE inputs for the SCN Appropriation and presents and assists in the justification to higher authority. The Division reviews POM estimates for consistency with current policy and participates in the presentation of the POM estimates to the NAVSEA Comptroller. SEA 012 is responsible for overall direction, coordination and presentation of the SCN Budget for the Command. In addition to supporting SCN, NAVSEA also supports RDT&EN, OPN, and WPN. There are some 30-40 PARMs residing in SPAWAR, NAVAIR, NAVSEA 08, NAVSEA 05, PEO IWS, etc.

NAVSEA Warfare Systems Engineering Directorate (SEA 05)

Primarily, the cost estimator establishes lines of communication with the Ship Design Group and the Weights Division within the Warfare Systems Engineering Directorate (SEA 05). To eliminate any misunderstanding as to what is being costed, a Ship Design Study Costing Data Form (found in Appendix C may be used to provide study identification, general characteristics, weights, and key features of the design. Other forms may be used as determined by the cost analyst in concert with the ship design Integrated Product Team (IPT). Generally, the cost estimator should have the agreed form as part of the estimate final documentation and generally it is desirable to have it before proceeding with the estimate (although it is not necessary to obtain repetitive forms for identical follow ships). Many times this design study sheet can only be partially completed.

After the POM and for the months that follow, ship cost estimators continue to communicate with SEA 05 as ship designs progress from initial feasibility to final contract design. As greater in-depth technical definition becomes available, cost estimate quality will continue to improve with the ultimate goal to approach a budget quality estimate. The SDMs in SEA 05 are generally part of the Program Office IPT. The design products come via the SDM and PM to SEA 017 for costing.

NAVSEA Logistics, Maintenance & Industrial Operations Directorate (SEA 04)

The Industrial Planning Division of Industrial Operations Directorate (SEA 04) provides information such as workload and labor rates on public yards to the cost estimator. NAVSEAINST 5400.013 defines these roles and responsibilities.

Participating Manager (PARM)

PMs are the principal managers of ship programs in NAVSEA; however; they obtain assistance from other organizations in NAVSEA or NAVSEA supported PEOs and other Commands that have expertise and cognizance for many hardware and software systems installed aboard ships. These organizations, when tasked by the PM, are referred to as PARMs. The PARMs play an especially active role when their systems are to be provided to a shipbuilder as GFM/GFE/Government Furnished Information (GFI) for ship construction programs.

During the POM pricing process, the PARMs are notified of an input requirement by memorandum or letter, as appropriate, from SEA 017. The PARM is provided a detailed list of systems and equipments (Schedule A) that the PM has determined to be GFM/GFE/GFI on given ship types. Estimates are provided by the PARM for each equipment and system and provided to the PM on Form 7300/4, Equipment Unit Cost Estimate, with a copy to SEA 017. The PARM estimates may be produced by estimators within SEA 017 or by the PARM. Sometimes the cost estimator participates in an annual PARM review conducted with the ship program office to validate the completeness and quality of the PARM input as well as to ensure that the underlying assumptions are documented.

Special note is made of one participating manager, the Nuclear Propulsion Directorate (SEA 08). This Directorate is responsible for all matters pertaining to nuclear propulsion of U.S. Navy ships. The ship cost estimator, although responsible for the overall end cost estimate, does not proceed with a nuclear ship cost estimate without an input from SEA 08. The final estimate is reviewed with personnel from the cognizant PM and SEA 08. NAVSEA 08 is also a player in the ship design solution as it pertains to the overall ship propulsion, electrical power requirements, and safety.

PARMs are located in various Commands (and Command-supported offices) of the Navy. Commands and examples of cognizant systems are as shown in Table 3:

Command	Systems
NAVAIR	Catapults, arresting gear, landing aids, Identification Friend or Foe (IFF)
SPAWAR	Communications equipment, direct finders, surveillance sonars, radar, navigation
NAVMED	Medical equipment
NAVSEA and Affiliated PEOs	Radar, sonar, armament, HM&E, nuclear and conventional propulsion systems, data systems

Table 3: Command PARMs

NAVSEA Contracts Directorate (SEA 02)

SEA 02 serves as the procuring contracting office in direct support of NAVSEA PMs that entails planning, selecting, negotiating, awarding, administering, and terminating contracts for design, development, manufacture, installation, modification, and repair of ship systems, combat systems, special support equipment, and related services. The Contracts Directorate of NAVSEA provides support and advice on all contractual matters in support of the requirements and originating codes comprising NAVSEA and affiliated PEOs. The directorate is organized into four contracting divisions, an e-business operations division, and a resource and contract policy division to provide specialized support unique to the various command managers and program executive officers.

COST ESTIMATING IN THE PROJECT LIFE CYCLE

This section provides an overview of NAVSEA cost estimating activities in a representative project life cycle. This section focuses on the cost estimating activities during the life cycle, the milestone events, the types of data needed/available, and the estimating methodologies to support these estimating activities during the program life cycle. Depending on the ACAT of a program and where the program is in the DoD program life cycle, data availability and management, milestone events, and cost estimating methods may vary in the degree of difficulty. For example, early in a program life cycle, there may be very little data available to the estimator. Late in the program life cycle there may be large amounts of data available that need to be verified for consistency in program content or normalized before use in an estimate.

DoD Project Life Cycle Phases and Milestones

Table 4 outlines the typical SEA 017 involvement in different ACAT programs.

ACAT	Thresholds (Constant FY2000$)	PLCCE	ICE	Note
ID	>$365M RDT&E or >$2.19B procurement	PM	OSD CAIG	SEA 017 usually assists PM with PLCCE/Service Cost Position (SCP)
IC	>$365M RDT&E or >$2.19B procurement	PM	NCAD	SEA 017 usually assists PM with PLCCE/SCP
II	>$140M RDT&E or >$660M procurement	PM	SEA 017	SEA 017 performs ICE or Assessment of PM's Cost Estimates
III	Does not meet above Thresholds	PM	Not Req'd	
IV	Does not meet above Thresholds	PM	Not Req'd	

Table 4: SEA 017 Involvement/Cost Estimating Requirements for ACAT I – IV Programs

Figure 11 provides a representative overview of a program life cycle through the DoD Acquisition Management Framework. In Figure 11 and in Figure 12 program events during the life cycle and the cost estimating activities as well as deliverables generated within the representative timelines are highlighted. Ongoing items are noted at the bottom of the schedule.

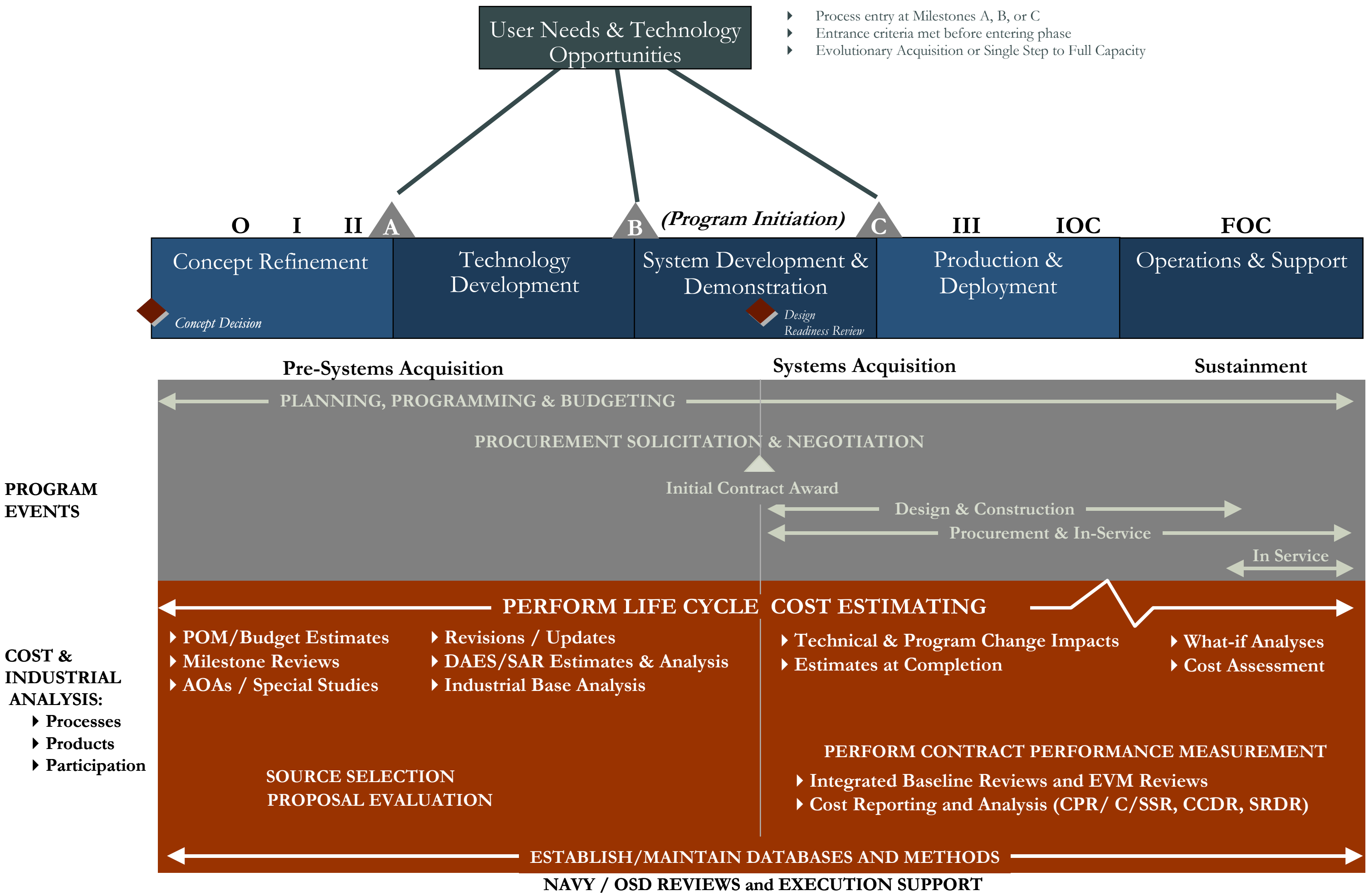


Figure 11: Cost Estimating Activities in the Program Life Cycle

A PLCCE for all ACAT I and ACAT IA programs must be prepared by the Navy program office[6] in support of the program initiation and for subsequent decision reviews. The CAIG is an organization outside the Service acquisition community chain that prepares a separate and distinct cost estimate on ACAT ID programs known as an ICE. This estimate is a statutory requirement for all Milestone and Decision Reviews after Milestone A. The ICE and the PLCCE are compared and reconciled prior to the DAB Review. Figure 12 illustrates the timeline for completion of the PLCCE and ICE prior to DAB reviews.

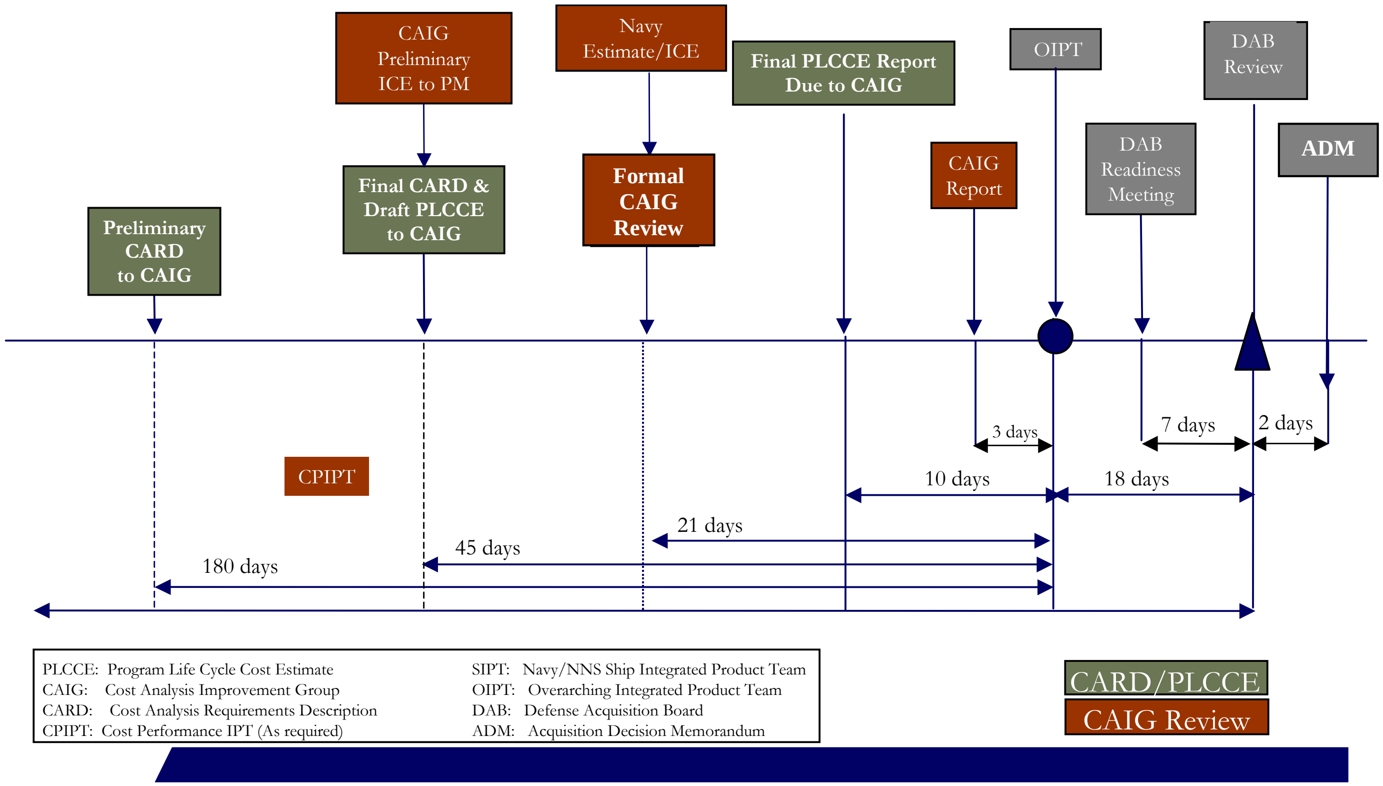


Figure 12: CAIG Milestone Review Timeline

COST ESTIMATING DELIVERABLES

In this section, an overview of the cost estimating deliverables that SEA 017 creates for Program Offices, Programs, and participants outside NAVSEA is presented. Many of these deliverables occur on a specific timeline and others occur at the request of a Program Office/PEO. SEA 017 creates three major categories of deliverables.

The first category of deliverables is **Cost Estimating and Analysis**. This category includes deliverables such as the LCCE or PLCCE. The LCCE or PLCCE is the most common deliverable created by SEA 017. The LCCE can be conducted in support of many requests including a CAIG review, an ICE, or a budget.

The second category of deliverables is **Economic Analysis**. This category includes deliverables that support special studies as well as ongoing program activities. Some economic analysis deliverables include Shipyard labor/overhead rate sheets, economic analyses, material inflation rate projections by Ship WBS (SWBS), and Business Case Analyses.

The third category of deliverables is **Industrial Base Analysis**. This category addresses activities that provide SEA 017 analysts and programs with continuously updated information on the Navy industrial base. Examples of these deliverables include Material - MATCER indices by SWBS group, the Inflation Data Sheet/Factor Program, and Industrial Base Sector Studies. A detailed listing of SEA 017 deliverables grouped by these three categories noted above can be found in Table 5. Information is provided on each deliverable including the formal title, a description of what the deliverable is, the purpose it serves, and any considerations that should be taken into account by the estimator or the customer.

Cost Estimating and Analysis			
Deliverable	**Description**	**Purpose**	**Consideration**
Life Cycle Cost Estimate (LCCE) or Program Life Cycle Cost Estimate (PLCCE))	An estimate accounting for the total cost to the government of acquisition and ownership of a system over its full life. Identification of all cost elements pertaining to the total life of a project, beginning with mission feasibility and extending through operations and support and disposal or conclusion. A PLCCE is specifically conducted for a program.	Facilitates supporting the DoD Acquisition Process, the investment decision-making process and supports budgetary decisions by providing an exhaustive and structured accounting of all costs related to a program. Becomes the project budget baseline, ensuring that costs are fully accounted for and that each project's LCC is minimized.	Logistics support by the OEM is being considered, where the government previously provided it. Iterative and on-going reviews should be conducted by the project's technical team to ensure credibility and accuracy. The final estimate goes to the CAIG.
Independent Cost Estimate (ICE)	An independent estimate conducted by an organization outside the acquisition chain, using the same detailed technical and procurement information. Other estimates to support modifications may include estimates for Conversion, Activation, Modernization and Service Life Extension.	Serves as a comparison to the PM's estimate to assist in determining the fairness and reasonableness of an estimate. Results are reconciled with the PLCCE.	ICEs in support of modifications can be challenging when determining the full scope of work to be accomplished. Unlike a new-construction weight estimate, a weight statement that reports weight added, removed or relocated is not by itself a sufficient measure of the total work to be accomplished. Select and/or modify a CER that truly reflects the complexity of working on an existing ship.
Independent Cost Assessment (ICA)	An outside evaluation of a cost estimate, taking into account both the quality and accuracy of the estimate in question, looking for specific cost and technical issues. Also, a process used to determine whether the current program estimate reflects the program of record (POR).	An ICA can be requested by a PM or an outside source to gain perspective on the quality and accuracy of an estimate.	Typically a non-advocate review of ACAT I, II and special interest non-ACAT programs conducted for ASN(RD&A). Assesses programs for technical approach, risk and acquisition strategy and to ensure program cost estimates capture all requirements. May also be used as a process to assess cost estimates prepared by activities outside of SEA 017.

Table 5: SEA 017 Deliverables

Cost Estimating and Analysis			
Deliverable	**Description**	**Purpose**	**Consideration**
Estimate at Completion (EAC)	An EAC is conducted using Earned Value data. The EAC is the actual cost of work completed to date plus the predicted costs and schedule for finishing the remaining work. It can also be the expected total cost of an activity, a group of activities, or of the project when the defined scope of work is completed.	An EAC is conducted to provide an estimated actual cost of remaining work to assist in determining the overall cost of a program.	
Participation in Source Selection	Provide industrial base, production, producibility, cost estimating and analysis and schedule expertise to source selection team.	Provide shipbuilding industrial base technical support to source selection team.	
Participation in PMS-333 Ship Donation Evaluation Boards	Provide analysis of offeror business and financial plans	Supports NAVSEA PMS-333 Inactive Ships Program Office ship donation program evaluation criteria.	Requires tasking and funding by PMS-333. Support by NAVSHIPSO.
Basis of Estimate (BOE) Reviews	Provide independent technical review and assessment of selected design and production related cost and manhour estimates.	Provide the Program Office with in-depth government assessment of selected cost estimates	

Table 5: SEA 017 Deliverables (cont.)

Economic Analysis			
Deliverable	**Description**	**Purpose**	**Consideration**
Business Case Analysis (BCA)	A BCA provides the justification for a proposed investment. It combines strategic analysis with quantitative cost/benefit/risk analysis.	A business case has three primary functions: to clarify/structure the planning and analysis required for effective decision-making, to determine the value of an investment or business initiative, and to guide on-going investment management and evaluation. A thorough business case details acquisition, implementation, and performance measurement strategies to create a foundation for detailed program/asset management plans.	
Material Inflation Rate Projections by Ship Work Breakdown Structure (SWBS)	Annual survey of approximately 500 manufacturers of systems and equipment supporting current Navy shipbuilding programs. Survey encompasses approximately 1,500 line items across 8 SWBS groups and covers current year plus 5 outyears.	Used to support SEA 017 shipbuilding cost models in aggregate and for specific ship classes.	Labor intensive effort conducted by NAVSHIPSO requiring phone contact, multiple at times, with each manufacturer to ensure effective response rates of at least 70%.
Material - BLS/Global Insight by SWBS Group	Material inflation indices by SWBS group using representative Bureau of Labor Statistics indices for historical values, and Global Insight projections	Used to inflate shipbuilding material costs or CERs from one date to another	Updated semi-annually; provided to NAVSEA cost community or others as requested
Labor - BLS Shipbuilding Projection Tables	Monthly actual/projected NAVSEA/BLS Steel Vessel Labor and Material inflation indices (as specified in CVN & LHD contracts)	Used to calculate shipbuilding contract escalation for ship contracts with compensation adjustment clauses	Updated quarterly or as requested; provided to NAVSEA PMs/others, support contractors, SUPSHIP, DCAA as requested
Inflation Data Sheet/Factor Program	Cost conversion factors for major appropriations (SCN, WPN, OPN, O&MN, RDT&EN, MILCON)	Used to convert program costs in terms of one FY to another FY (move budget dollars between years). Convert "then-year" dollars to "constant-year" dollars (or the reverse)	Updated annually; provided to NAVSEA cost community, other NAVSEA offices, support contractors
SCN Total Obligation Authority (TOA) Factor Table	Table for converting SCN budget/program $ between FY	Used to convert SCN program costs in terms of one FY to another FY - "then-year" to "then-year" conversion. Published as a quick reference for GFM estimators/analysts.	Updated annually; provided to GFM PARMS, NAVSEA GFM analysts

Table 5: SEA 017 Deliverables (cont.)

Economic Analysis (cont.)

Deliverable	Description	Purpose	Consideration
Unique Inflation Indices	Actual/projected inflation indices for specific products, services, or labor categories	Used by SEA 02 to evaluate reasonableness of labor/material inflation in contractor proposals. Used by cost community to inflate unique labor or material items (mission systems, technical support, IT support, etc.)	Provided on demand to SEA 02; NAVSEA cost community or others as requested
Shipbuilding Contract Escalation Estimate	Summary report showing shipbuilding contract escalation estimates by hull, based on requestor inputs, actual/projected expenditure curves, and actual/projected inflation indices	Used to determine the "Escalation" line item of the P-5 budget exhibit. Required for ship contracts containing compensation adjustment clauses	Provided on demand. Requestor must provide the following inputs: Contract Dates - Base, Award, Start of Construction, Delivery; Costs: Direct Labor, Indirect/Overhead, Material; and Mandays (or Manhours): Engineering, Production

Industrial Base Analysis

Deliverable	Description	Purpose	Consideration
Shipyard Workload Chart	Graphical representation of the resources necessary to design, construct, maintain, and repair ships under contract and future potential ship contracts at a single shipyard. Charts can be aggregated to regional and total level.	Used to analyze potential resource issues at a specific yard and to evaluate the resource impact caused by changes to baseline shipbuilding assumptions at a single shipyard	Provided upon request; If requesting an alternative to the current baseline, customers shall provide SEA 017 with an update of the shipbuilding assumptions (Award date, Start Date, Delivery Date, Production Manhours, Engineering Manhours) for each hull of the shipclass that is being modified. This shall be provided using the SEA 017 Workload Assumption Template
Shipyard Labor/Overhead Rate Sheets	Projected direct labor and overhead rates for the "big six" shipyards, based on FPRA data adjusted for workload assumptions	Used in SEA 017 ship cost estimates - applied to man-hour estimates to estimate shipbuilding labor costs	Provided upon request to SEA 017 cost engineers
Private Sector Government Manday Rate for Repair and Modernization	Private sector government manday rate for ship repair facilities conducting repairs or modernization work on USN ships. Includes rate for previous year as well as projections through the FYDP using either forward priced rates or escalated rates using appropriate indices. Provides rates for individual facilities, port average, and coast wide average rates.	Used in development of ship maintenance and modernization budgets, development of estimates for installation costs associated with proposed Ship Change Documents (SCDs formerly SHIPALTS). Used by SEA013 in development of modernization budget. Used by SEA04 within the MRS system to develop notional manday estimates for ship maintenance availabilities.	Provided on an annual basis to OPNAV N43, Fleet and Type Commanders, and various NAVSEA organizations to support POM/PR development of the Maintenance Capability Plan (CP)

Table 5: SEA 017 Deliverables (cont.)

Industrial Base Analysis (cont.)			
Deliverable	**Description**	**Purpose**	**Consideration**
NAVSEA Quarterly Progress Report for Shipbuilding & Conversions	Summary of major shipbuilding schedule, progress & contact data for active Navy & Security Assistance Programs. Based on information stored in the White Book database.	Used as a central source for major ship metrics by the acquisition, logistics and news media community both in and outside of government.	
Industrial Base Sector Studies	Analytical reports assessing specific manufacturers or industry sectors such as propulsion shafting, submarine batteries, etc.	Used by various NAVSEA Program Offices to evaluate diminishing sources, foreign restrictions, sole source, corporate mergers, corporate viability and other issues that may represent risk to shipbuilding programs.	Reports are provided as tasked by NAVSEA Program Offices. May require Program Office tasking and funding. Support by NAVSHIPSO.
Special Feasibility Studies	Provide feasibility review of candidate shipyards for alternatives proposed by Program Office	Used by Program Office to support Analysis of Alternatives (AOA).	May require tasking and funding by Program Office. Support by NAVSHIPSO.
Shipyard Facility Database	Database of shipyard facility information including employment, skilled trades, berths, drydocks, cranes, shop areas, water access restrictions, etc.	Provide timely data to support preparation of Industrial Base Assessment Reports and special inquiries from NAVSEA Program Offices. Annual survey required by the U.S. Merchant Marine Act of 1936 to establish adequacy of mobilization base.	Conducted in conjunction with Maritime Administration (MARAD). Industrial Shipbuilding and Repair Base (ISRB) updated accordingly. Support by NAVSHIPSO.
Supporting Industry Database	Database of critical manufacturers supporting Navy shipbuilding programs including employment, skilled trades, sales, sales distribution, product line, production rates, lead times, capacity utilization rates, etc	Provide timely data to support preparation of Industrial Base Assessment Reports and special inquiries from NAVSEA Program Offices.	Data collected via annual solicitation using form DD2737 extract "Industrial Capabilities Questionnaire." Other sources include plant visits, websites, corporate SEC filings, trade journals, etc. Support by NAVSHIPSO.
www.nvr.navy.mil, Annual Inventory of Ships and Service Craft to NAVSEA 017, Numerous Data Extracts to Navy Organizations	The NVR database contains pertinent ship and service craft data including key dates, vessel name, homeport, Fleet assignment, hull characteristics, custodian, builder, commissioning date, strike date, etc.	Annual end of year inventory used by NAVSEA for preparation of financial reports. Used by numerous Navy organizations and the general public as a source of information on the Fleet. Numerous data extract and reports, both canned and custom, are provided to Navy organizations throughout the year. Also used to prepare Certificates-In-Lieu-of-Builder's Certificate for owners who purchase excess service craft from DRMO.	NVR is required by USN Regulations Article 0406.1 and 10 USC 7304-7308. The NVR has also been designated as a "Critical Financial Feeder System" by the DoD Financial Management Improvement Plan (FMIP). Support by NAVSHIPSO.

Table 5: SEA 017 Deliverables (cont.)

LCC Estimate (LCCE)

Life Cycle Cost is the total cost to the government of a program over its full life. A cost estimate provides a projection for every life cycle cost element for every aspect of the program required to respond to the threat identified in the ICD and outlined in the CDD and Capabilities Production Document (CPD). These costs can be also grouped by the following life cycle cost category:

- Research and Development includes development and design costs for the lead system development, engineering and design, test and evaluation and other one-time costs for the system design features. It includes the nonrecurring costs for development, design, startup, prototypes, software, initial spares, live fire test and evaluation, special tooling and test equipment, facility changes, etc. This category may be funded with RDT& E, SCN, and MILCON Appropriations.
- Procurement Investment includes the total production (or low-rate production) and deployment costs of the prime system and its related support equipment and facilities. It includes, any related GFE/GFM, and initial spares and repair parts. For Navy shipbuilding programs, it also includes outfitting and post delivery costs. This category may be funded with SCN, OPN and PANMC and WPN Appropriations.
- Operation and Support includes all the direct and indirect costs incurred in using the prime system (i.e., manpower, fuel, maintenance, and support) through its entire life cycle. Manpower costs should be based on estimates for officers, enlisted personnel, civilians, and contractors, expressed in terms of the Manpower Estimate Report (MER). For Navy ships, maintenance and support is comprised of organizational & intermediate level maintenance, depot repair including the mid-life Refueling and Complex Overhaul (RCOH), modernization, and other/sustaining and support. This category may be funded by the MPN, OPN, WPN, RDT&E, O&MN, and SCN Appropriations.
- Disposal (inactivation) includes the costs of disposing (inactivating) the prime equipment after its useful life. For nuclear Navy ships, it includes the inactivation of the spent nuclear fuel, both at the mid-life RCOH and at the end of the ship's life. This category is funded with the O&MN Appropriation.

LCCEs provide an exhaustive and structured accounting of all resources necessary to identify all cost elements including project feasibility, project definition, system definition, preliminary and final design, fabrication and integration, deployment, O&S, and disposal effort. The LCC encompasses all past ("sunk"), present, and future costs. Life cycle costing enhances the decision-making process, especially during the early planning/concept formulation phase of the acquisition cycle. Design trade-off studies conducted during this period can be evaluated on a total cost basis as well as on a performance/technical basis.

A LCCE is used to support budgetary decisions, milestone reviews, and to support decision makers in investment decisions. A LCCE can also be referred to as a PLCCE if the estimate was created in support of a program. A PLCCE is developed to ensure that costs are fully accounted for. The life cycle of a program equals its total life, beginning with mission feasibility and extending through O&S and disposal. The PLCCE should be comprehensive and structured to identify all cost elements and should capture all costs necessary to design, develop, deploy, field, operate, maintain, and dispose of a system over its lifetime. As members of the product or program design team, cost estimators prepare a PLCCE by translating the technical and design parameter characteristics and schedules into cost estimates using established cost estimating methodologies. Iterative and on-going reviews are conducted with the technical team during the design process until the cost estimator and the project management team is confident that the cost estimate credibly reflects the baseline program's design requirements, technical capabilities, management structure, and operational scenarios. Then, the PLCCE becomes the basis for the program's budget baseline and the APB agreement.

Independent Cost Estimate (ICE)

Title 10 USC requires that an independent LCCE be conducted by an organization outside the acquisition chain. Further, SECNAVINST 5000.2 indicates that Naval Cost Analysis Division (NCAD) will perform an ICE for ACAT 1C programs whenever the OSD CAIG elects not to, which is almost always the case. For Automated Information Systems (AISs), DODINST 5000.2 states, "a CAIG ICE is not required." The services carry the burden for conducting AIS ICEs. SEA 017 serves as the Command focal point interfacing with NCAD in support of developing statutorily required ICEs. SEA 017 works for COMNAVSEA and affiliated PEOs programs and is also an independent estimating function for NAVSEA programs. The following list indicates other occasions when an ICE is called for:

- The CAIG will develop an ICE that will be compared with the PM's estimate. SEA 017 may need to respond to numerous requests for information from the CAIG during the development of the ICE, and usually is asked to clarify certain assumptions.
- SEA 017 prepares and submits the Government (Navy) ICE for SEA 02. The pre-bid contract ICE involves the basic construction line and, if applicable, the construction plans line. SEA 02 may also request the escalation associated with the estimate. The Contracting Officer requests the ICE to assist in determining the fairness and reasonableness of bids and proposals received in response to the Invitation For Bids (IFBs) or Request For Proposals (RFPs). In preparing the ICE, the cost estimator makes use of the same detailed technical and procurement information that is available to the shipbuilders. The baseline for the ICE may be different than that of any previous budget estimate.
- If needed, SEA 017 prepares and ICE for ACAT II Programs for ASN RDA.

An ICE may also be used as a process to assess cost estimates prepared by activities outside of SEA 017.

COST ESTIMATE CLASSIFICATIONS

Every estimate described in this section and prepared by SEA 017 follows a specific process, yet every estimate is different. There are many factors that go into preparing an estimate that may influence the estimate results. Time and data are the most critical resources when preparing an estimate. If either of these resources is missing when preparing an estimate, it could affect the estimate and prompt the estimator to make assumptions when developing the estimate. A way of standardizing the issues that affect an estimate and communicating this information to the users of the estimate is to use cost classifications.

In 1970, at a time when many shipbuilding programs were suffering from financial problems, the concept of a cost estimate classification system originated as a by-product of a review of the ship cost estimating process. This process revealed that all ship budget estimates provided to the Congress were presented on an equal basis but varied in quality. That is, some budget estimates were submitted prematurely and lacked acquisition strategy plans and adequate technical definition. The review also showed that these deficiencies were not communicated to all the participants in the budgeting process. NAVSEA Instruction 7300.014B promulgated the ship cost estimate classification system and associated quality of ship cost estimates as submitted in the PPBE under the SCN Appropriation. The acceptance of this cost estimate classification system by the Congress, OMB, OSD, Navy Secretariat, OPNAV, FMB and NAVSEA management makes its judicious use a serious responsibility for the NAVSEA cost estimator. The cost estimator also factors the cost classification of the cost estimate into the risk assessment for the estimate. The cost estimate classification system uses letters of the alphabet to designate estimate quality. Summarized in Table 6, the letter designation, its meaning, and how it is used are described in the following subsections. It is important to note that the cost estimate classification can be no higher than the level of fidelity of the technical inputs that are provided.

Class	Basic Technical Input	Use
C	Completed Preliminary Design Three Digit Weights	Current Budget Year (New Construction)
D	Scope of Work, Including Weights of Deletes & Adds SHIPALTS and Repairs	Current Budget Year (Conversion)
F	Feasibility Study One Digit Weights	POM/Outyear Planning Programming Phase
R	ROM Less Than Feasibility Study	Planning Phase
X		A directed or modified estimate - an estimate not developed through the normal NAVSEA estimating process. An estimate established external to NAVSEA

Table 6: NAVSEA Ship Cost Estimate Classification System

Class C – Budget Quality (New Construction)

The Class C estimate is the ultimate goal of the ship cost estimating process, since this classification indicates that the estimate is of budget quality. A budget-quality Class C rating is a commitment to Congress by the Navy that additional funds will not be required in the future to complete the scope of work for the POR. The only exception Congress allows on this commitment has to do with the out-year inflation rates assumed in the estimate. The costs driven by these rates can be adjusted plus or minus in future budgets on the basis of forward pricing rate agreements and approved material indices.

As stated in NAVSEAINST 7300.014B, the general attributes of a Class C budget-quality cost estimate are as follows:

- It is developed by the professional cost estimating staff of SEA 017,
- It provides high confidence that the program can be executed within the budget,
- It contains reasonable contingencies commensurate with identified uncertainties and risks, and
- It avoids unrealistic management/technical or programmatic assumptions that may foster subsequent cost overruns or contractor claims.

The approved Preliminary Design Report (PDR), including a Master Equipment List (MEL) with the Preliminary Design Weight Estimate developed to the three-digit SWBS level, should be available for each ship prior to establishing a Class C estimate. Costs for a complete GFM equipment list and any required GFI are to be incorporated in the ship cost estimate. A list of potential shipbuilders should be developed to determine appropriate labor rates, overhead rates and cost of money factors, as applicable. An industry capacity analysis should be made and realistic award dates and building periods should be established. The degree of concurrent interdependency required for contractor furnished equipment (CFE) and GFM should be evaluated to the extent possible. In addition, cost impacts resulting from special category items or government support costs should be assessed. These would include programmatic costs such as test and evaluation, shock test and instrumentation, NAVSEA in-house support, on-board spares, shore base stock spares, Supervisor of Shipbuilding requirements, computer compatibility costs, tech manuals and trainers.

Equipment allowances and their costs obtained outside of NAVSEA should be documented by official memoranda. The lead times for advanced material procurement; expected award, start of construction and delivery dates for applicable ships; inflation rates; and the adequacy of the industrial base of GFM suppliers should be known. The electronics, weapons, propulsion, etc. equipment should be sufficiently defined and developed technologically to eliminate any developmental costs. If items of uncertainty do exist, appropriate growth factors must be included and the cost estimate and the documentation fully noted. The Cost Estimating Relationships (CERs) used to calculate the cost estimate should be based on: (1) an accepted weight estimate using bid information, and (2) current weight estimate when using cost data from the contractor's latest Cost Performance Report (CPR), or (3) similar ship construction data of the prospective building yard(s) where new designs are being costed.

Risk considerations have significant influence in the determination of Class C cost estimates. If major equipments (GFE or CFE) have not met the requirements of "approved for Full Production," an additional cost allowance for an alternative fall back position may be justified for a Class C cost estimate.

If the contract is planned to include a standard compensation escalation clause, projected shipyard escalation cost calculations should be based on: (1) a PM's developed ship contract award, start of construction and delivery schedules, and (2) Global Insight (GI) projections of the appropriate labor and material indices. Additionally, if the estimate is base dated, escalation calculations should be made using the approved escalation model developed by SEA 017. If technical design, program planning or economic (cost) information is lacking credibility or, in the opinion of the cost estimator, significant information is questionable or not up-to-date, the cost estimate should be classified either Class F or R, as appropriate.

Class D – Budget Quality (Conversion)

There are uncertainties related to ship conversions, modernizations, and Ship Life Extension Programs (SLEPs) that cannot be resolved until after contract award, therefore, a Class C classification is not appropriate for these types of estimates. The uncertainties are as follows:

- Scope of repair package (determined after open and inspect),
- Quality of repair cost estimates,
- Requirements for shipyard industrial and workforce buildup and capability for sustaining manning,
- Shipyard work force limitations to perform needed labor hours of work during scheduled availability, and
- The number of ship crew available for production and support work during the conversion, modernization, or SLEP; i.e., how much of the actual work package will they accomplish?

For a conversion, modernization, or SLEP cost estimate to conform to this classification, the detailed scope of work requirements shall include: (1) the description and weights of equipments or systems to be removed, relocated, or added, and (2) a list of proposed ship alterations (SHIPALTS), GFM, and an adequately defined repair package. Additionally: (1) costs for similar SHIPALTS, ship repairs, and modernization items from comparable conversion or SLEPs should be available; or an initial shipyard cost estimate of projected repairs, SHIPALTS, and modernizations improvements should be made by the prospective building yard, and (2) the potential interface and interdependency considerations of these items should be determined as related to the existing design. An allowance should be made to recognize that the ship condition may differ considerably two years after the budget is submitted; i.e., when the ship is actually worked on. Other items that should be included are: (1) the status of the current shipyard workload and additional workload projections for the prospective conversion, modernization, or SLEP shipyard; (2) assessment by the ship cost estimator for productivity considerations; (3) realistic projection of labor rates at the shipyard; and (4) the expected use of premium pay for overtime if the schedule so requires.

Class F – Feasibility Estimate

Class F estimates are those costs prepared by using design information resulting from ship feasibility studies. The feasibility study usually produces at least one-digit SWBS ship weights and only general guidance with respect to major electronics and weapons equipment. Cost estimates that fit this classification also involve those derived by inflating to current dollars a previous cost for a similar ship and then making rough or gross adjustments for expected changes in design, program requirements, or program cost factors. Any cost estimate that is derived from a current POM/Budget year estimate by deflating or inflating to some other year by the application of a labor and material shipbuilding index will be designated Class F. The shipyard type (private or naval) and number of ships to be built in a single yard are often not known when deriving Class F cost estimates. Escalation calculations are either based on inflating the escalation cost contained in the total cost estimate used as the base (reference) estimate or by using a flat percentage of the shipyard portion of the cost estimate based on an approximation calculation. Cost estimates are sometimes designated as Class F even though the shipyard assignment is known, complete acquisition strategies are available, and an escalation run is made on the escalation model developed by SEA 017. In this instance, the major elements generally missing are the lack of a completed preliminary design and reliable economic information.

Class R – Rough Order of Magnitude (ROM)

The Class R or ROM cost estimate results when design information does not meet the standards equivalent to a ship, other platform, or weapons systems feasibility study. The design study may produce rough calculations of ship weights and the basis for the weights and other ship design parameters are not founded on sufficient technical information and analysis to support high reliability in the design. Some examples are: (1) a new design of an unconventional ship platform, (2) a ship platform that is initially designed to carry many unconventional or developmental equipments, or (3) a ship designed beyond the current state of the art. Other conditions that call for use of an R classification are as follows:

- Inflating a historical total ship cost 10 years or more, because such a time span is sufficiently long to generate a potential for changes in specifications or an outdating of electronics and combat systems and introduce questionable reliability in the economic data (its applicability),
- Projecting outyear ship costs beyond the current POM where long-range economic and ultimate ship configuration uncertainties are attendant with such projections,
- Using nation-wide or area-wide labor and overhead rates instead of yard specific rates, and
- Designing to roughly defined mission requirements.

Class X – Directed or Modified Estimate

Class X is applied to a cost estimate that is: (1) not developed by SEA 017, or through the normal estimating process, (2) provided by other Commands or agencies, or (3) directed by higher authority. Directed cost estimates are generally a total cost limitation that is established without the benefit of a fully developed design concept and related cost estimate such as a cost goal or cost target. Moreover, a directed estimate also applies to any previous cost estimate (Classes C through R) that was changed to conform to budget cuts or restrictions on a total cost that is not based on scope decisions. Cost estimates that are commonly treated as Class X are those sometimes referred to as Congressional Control Number, OPNAV Control Number or OPNAV Planning Wedge.

2005 Cost Estimating Handbook

Section 4:

NAVSEA COST ESTIMATING PROCESS

The NAVSEA cost estimating process has been designed with a viable structure and procedures that have evolved over many years and continues to evolve and keep pace with the needs of the Navy cost estimating community. The basic components of the NAVSEA cost estimating process include:

- A process that is designed to tie in with existing cost collection/accounting systems, making it practicable for actual return costs to be tracked against estimates.
- A process that is designed so that technical and cost data can be joined in CERs and then applied to estimating the cost of NAVSEA products.
- A process that accommodates costs/bids submitted in a standard format consistent with the NAVSEA cost estimating process. Actual return cost data should also be submitted in formats that are compatible with the NAVSEA cost estimating process. This continuous input of bids and actual return cost data is essential to keeping the databases and tools up-to-date for real time cost estimating needs.
- A process that has been automated to facilitate and to accommodate the estimating workload and continually enhanced to accommodate design changes.

These four basic components are also fundamental to the ship end cost estimating categories. Another critical component that makes the cost estimating process work successfully within NAVSEA is the open and continuous communications between the estimator and the designer. This communication builds understanding and consistency, which in turn helps to create a more accurate and credible estimate.

The cost estimating process is a systematic process that requires judgments and decisions to be made at each step of building an estimate. Four significant judgment points that will essentially control the final outcome of the estimate in terms of success or failure are:

- A judgment regarding the future status of the marketplace in which the system will be procured;
- A judgment regarding the selection of cost data that will be reflective of the projected marketplace;
- A judgment, especially for new designs, regarding the degree of cost estimating relationship (CER) development; and
- A judgment regarding the assessment of risk and how the risk, if not mitigated, controlled, or eliminated, can affect cost and schedule.

Carefully considering judgments at each of the program decision points and documenting decisions are fundamental in the NAVSEA cost estimating process.

Cost estimates can be conducted in a variety of situations and time frames. The most common are generally two extremes:

- Estimate for Milestone decision—labor intensive, longer cycle time (possibly one year or longer)
- Estimate for budget drill---a quick (sometimes just a single-day) turnaround.

These extremes demonstrate the need to follow a consistent cost estimating process that is defensible and produces well-documented estimates.

THE THREE PARTS OF THE COST ESTIMATING PROCESS

The cost estimating process presented in this section is intended to be generic so any estimator estimating any product at NAVSEA can follow it. At the end of this section, product specific data sheets on each of the NAVSEA mainline products that are commonly estimated by SEA 017 cost estimators are presented. These product specific data sheets are intended to provide specific information on each of the mainline products and to highlight areas in the cost estimating process where estimating a specific product may have unique requirements or considerations. Unique sources of data, methodologies, and models are some of the items highlighted for each of the products within the 12 tasks of the cost estimating process.

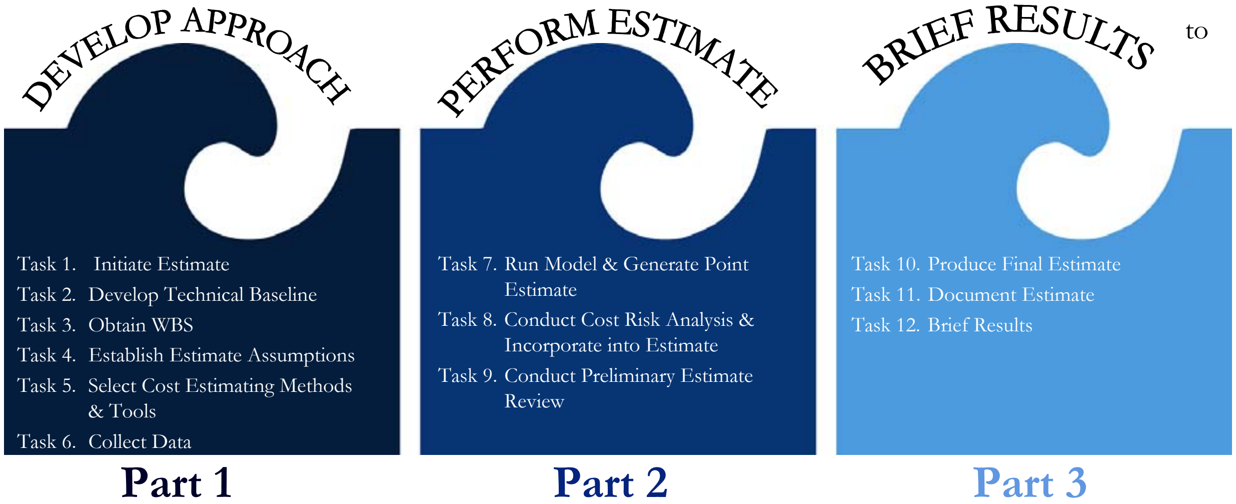


Figure 13: NAVSEA Cost Estimating Process

It is important to keep in mind that the cost estimating process presented herein is iterative. A full LCC estimate or a PLCCE would most likely run through many of the tasks more than once to make certain that the estimate contains the most accurate and up-to-date information from all sources during the cost estimating process. A quick component cost estimate or a "what if drill" will follow this same process, but may only briefly conduct each of the 12 tasks to complete the estimate.

The 12 tasks of the cost estimating process have been grouped into three parts as shown in Figure 13: Develop Approach, Perform Estimate, and Brief Estimate Results.

Part I: Develop Approach

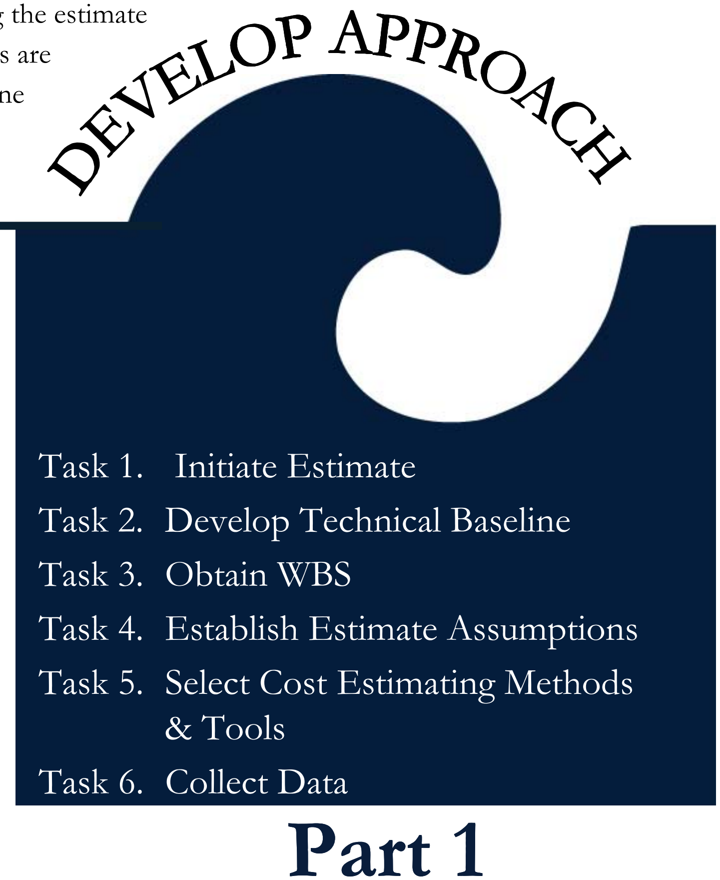
This part encompasses the first six tasks in the cost estimating process to create the foundation of the estimate and start the estimate off on the right "foot." These six tasks relate to developing an effective approach for cost estimating and include initiating the estimate, obtaining the program description, obtaining or creating the WBS, establishing the estimate assumptions, selecting methodologies and tools, and collecting data. The task activities conducted at the beginning of an estimate by NAVSEA 017, the TWHs for cost estimating, help to establish the framework from which the estimate is conducted.

Part II: Perform Estimate

The second part of the estimating process encompasses the three key tasks of performing an estimate. These tasks include running the model and generating a point estimate, conducting a risk assessment, and conducting a preliminary estimate review. Once a solid estimate approach has been developed as the output of Part 1, the estimate can pull together from many sources to result in a point estimate. The risk assessment is the second stage of generating an estimate. Without risk considerations an estimate is incomplete. Once these two results have been combined, it is important to run a "sanity check" review of the results.

Part III: Brief Estimate Results

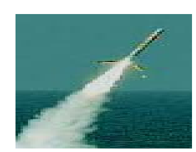
Part three of the cost estimating process includes the last three tasks in the process that involve communicating the estimate results. Once the estimate has been reviewed, the final estimate can be produced and documented. These tasks are critical to ensuring consistent communication of the estimate results to decision makers and to provide a baseline for future estimates. The final task is to brief the estimate results which is important to ensure the content and message of the estimate is delivered accurately and defendable.



Task 1: Initiate Estimate

Once a formal request for an estimate is made, there are some important steps SEA 017 takes to ensure the estimate starts on a solid foundation. First, a lead cost analyst is identified. It is the responsibility of the lead cost analyst to determine the purpose and scope of the estimate, and to understand the end result and deliverable(s) expected by the requesting customer. Once this understanding is established, a team is formed to produce the estimate with the resources commensurate to the effort. If it is a small effort, the "team" may only be one estimator. Adequate human resources include a team with the skills needed to estimate the NAVSEA product and the time available to complete the estimate. Other resources that the team needs include technical and program data, cost data, and tools to conduct the estimate.

Once the team is formed and adequate resources are in place, the team needs to understand the program or product being estimated. To gain this understanding, the cost estimating team needs to review the program's mission, objectives, and goals as well as the operating environment in which the product will operate. The team must identify what phase of the life cycle the program is in, the acquisition strategy planned or in place, and collect relevant programmatic, technical, and cost data such as any previous estimates conducted (see more about understanding the program in task 2). An assessment of the baseline program environment also identifies the mission need, risks, and system deficiencies that have prompted the need for an estimate and establishes the baseline from which the estimate can be compared. Other sources of data to help educate the estimator on the product being estimated may include the Ship Design Project Historical Book "Red Book," commercial sources, or potentially the Internet.



TASK 2: DEVELOP PROGRAM DESCRIPTION

Understanding the program is key to the development of good estimates. This means understanding the program acquisition strategy, technical definition, characteristics, design features, and technologies to be included in its design. The ideal place to start is a programmatic description of features pertinent to costing the system being developed and acquired. Such a document, known as a Cost Analysis Requirements Description (CARD) or a Program Technical Description, provides a system technical description and programmatic information to create a common baseline used by the project team to develop their estimates.

A CARD contains the most comprehensive set of data for use by the cost estimator. It defines and provides quantitative and qualitative descriptions of the program characteristics from which cost estimates will be derived. A well-constructed CARD helps reduce misunderstanding as to program content and significantly reduces time to reconcile estimates. It is important that no cost data be included in the CARD so that it can be used as the common baseline for independently developed estimates.

Estimators use CARDs to baseline life-cycle costs, including technical and programmatic risks. In lieu of an independent technical assessment, the cost estimator bears the burden of articulating potential cost growth due to changes in specification and development risk via sensitivity analyses. The CARD assists the estimator in identifying any area or issue that could have a major cost impact.

For each topic in the CARD outline, narrative information and data should be provided for the purpose of costing the program. The CARD should also include quantitative comparisons between the proposed system and any predecessor and/or analogous system for the major outline headings. An analogous system is a currently operational or pre-existing system with a mission similar to that of the proposed system. It is often the system being replaced or augmented by the new acquisition. For a program that is a major upgrade to an existing platform, the new system would be the platform as equipped with the upgrade, and the analogous system would be the platform as equipped prior to the upgrade. A completed reference systems section of the CARD is important to the cost estimator as a source of data for analogous reference ships. Program Offices are responsible for ensuring that CARDs are updated to reflect all program changes and the program cost team should be notified of all CARD updates. During the cost team's review of a CARD, it is appropriate for cost teams to query the Program Office's technical staff and provide feedback and comments during the CARD development.

Typical CARD Elements include:

- System description
- System WBS
- Detailed technical and physical description
- Subsystem descriptions, as appropriate
- Technology maturity levels of critical components
- System quality factors
- Reliability/Maintainability/Availability
- PM's assessment of program risk and risk mitigation measures
- System operational concept
- Organizational/unit structure
- Basing and deployment description (peacetime, contingency, and wartime)
- System support concept
- System logistics concept
- Hardware maintenance and support concept
- Software support concept
- System training concept
- Time-phased system quantity requirements
- System manpower requirements
- System activity rates (OPTEMPO or similar information)
- System milestone schedule
- Acquisition plan or strategy
- Draft CSDR Plan

The CARD should be as complete as possible but there will be unknowns so assumptions should be made and socialized with the Program Office to try to create an inclusive view of the program. During the earliest stages of the system's life cycle, a CARD is generally not available when the estimator has to produce the initial estimates for the program such as an AoA estimate. In these cases, the best starting place is with cognizant experts in the program office and/or the ship design supporting office. As a team-- design experts, logisticians, test and evaluation experts, financial managers, and cost estimators-- you can develop the programmatic and technical baselines required to produce the cost estimate. It is worthwhile to work with program engineers to get as much complete information as possible. Accurate and sufficient detail is critical to the usefulness of the CARD.

When appropriate, CARDs for alternatives can be prepared as excursions to the preferred alternative. The level of detail of information in a CARD will vary depending on the maturity of a program. Programs at the concept refinement and technology development stages (pre-Milestone A and Milestone A) are less defined than programs at the production and deployment and O&S phases. Ranges are common at concept refinement phase, less so at system development and demonstration phase, and rare at production and deployment phase.

TASK 3: OBTAIN WORK BREAKDOWN STRUCTURE (WBS)

The next task is to obtain a program WBS[7] to serve as the structure for the estimate. A WBS may also be called a Cost Breakdown Structure (CBS) or a Cost Element Structure (CES).

WBS - Load Items and Margins

Load items:

- Fuel
- Lube oil
- Cargo
- Fresh water
- Payloads
- Crew
- Provisions

Margins are to allow for changes in ship design. For most ship designs, the following properties are margined:

- Weight and KG
- Distributed system capacity such as electric power, chill water, network loading
- Accommodations
- Arrangeable area
- Propulsion power

The WBS is a critical project management tool used throughout the project's life cycle to structure the project, to manage acquisitions, to capture all costs, and to communicate scope among review authorities and stakeholders. It provides a structure that includes all elements of the project the cost estimate will cover. There are three activities associated with preparing or obtaining a WBS:

1. Determining if a WBS exists or working with the project to create.
2. Creating a WBS Dictionary to define the WBS elements.
3. Ensuring that the cost estimating WBS is consistent and/or standard between functions such as budgeting, weight statements, Earned Value Management (EVM), project plan, System Engineering Master Plan (SEMP), contracts, etc., to enable improved cost estimation, future data collection, and performance measurement and management.

If a WBS is not available from the program office or from a CARD, an estimator may need to create a WBS. Guidelines for creating a WBS can be found in MIL-HDBK-881. However, it is important to note that for a LCC estimate, the WBS should cover all phases of the program from Concept Definition to Operations & Support and Disposal. Using a comprehensive WBS for an LCC estimate helps to ensure all LCC costs for the program are included in the estimate. For overall contract and program reporting, the estimate's WBS should track directly to the program's Contract Status Data Reporting System.

The Expanded Ship Work Breakdown Structure (ESWBS) promulgated by NAVSEA Instruction 4790.01A encompasses, updates, and supersedes other earlier classification systems, including the Bureau of Ships Consolidated Index (BSCI), the Ship Work Breakdown Structure (SWBS), and MIL-HDBK-881. A WBS may also be created in the model the estimator chooses to use, however this will be a generic WBS and may not be properly suited for the product being estimated. Regardless of where the WBS is created, it is important that the customer requesting the estimate or the estimate reviews, understands and agrees with the WBS before the estimator continues with the estimate.

A good WBS has a strong product focus with a project life cycle orientation, and generally includes hardware, software, and supporting services. It establishes a hierarchical structure or product oriented "family tree" of elements. It is used to organize, define, and graphically display all the work items or work packages to be done to accomplish the project's objectives, including:

- Project and technical planning and scheduling;
- Cost estimation and budget formulation (in particular, costs collected in a product-based WBS can be compared to historical data collected against the same products);
- Defining the scope of statements of work and specifications for contract efforts;
- Project status reporting, including schedule, cost, workforce, technical performance, and integrated cost/schedule data [such as EVM and estimated cost at completion (EAC)]; and
- Plans such as the SEMP and other documentation products such as specifications and drawings.

The ESWBS establishes policy and issues procedures to provide a method to integrate design with logistics (including cost estimating) through standard coding of the WBS for ships, ship systems and combat systems. The combat and weapons system estimator should refer to the combat and weapons system product data sheet at the end of this section for a discussion on creating a product specific WBS. The ESWBS serves as a common language between the designer and the cost estimator and between NAVSEA and the shipbuilder and is divided into 10 major groupings:

- A general guidance and administration group concerned with operational, logistic, management and planning functions (GR 000);
- Seven functional technical groups (GR 100 to 700); and
- Two groups that deal with engineering integration and ship assembly and support services (GR 800 and 900).

The ship cost estimating Basic Construction category is directly associated with Groups 100 to 900. The technical information that flows from the designer to the cost estimator can be at the 1-digit, 2-digit or 3-digit levels of detail as shown in Table 7 and is generally provided in terms of weight in tons, square feet of material, shaft horsepower of engines, kilowatts of power, lengths of material (such as piping or cable) or other similar expressions of the technical information. The estimator draws on the available historical cost data to establish CERs that can be applied to the technical input to generate the labor manhours and material portion of the cost estimate. The historical cost data in NAVSEA consists of past and current Navy shipbuilding ESWBS bid and return cost breakdowns. This data is generally required by all Navy shipbuilding contracts.

MIL-HDBK-881 Level	Estimating Level	ESWBS Level
Level 1	Class of Ships (Ship Program)	N/A
Level 2	Ship End Cost / Post Delivery and Outfitting	N/A
N/A	End Cost Category	N/A
Level 3	Hull Structure - Group 100 Electric Plant - Group 300	1-Digit Weight Breakdown
Level 4	Hull Decks - Group 130 Lighting System - Group 330	2-Digit Weight Breakdown
Level 5	Second Deck - Group 132 Lighting Fixtures - Group 332	3-Digit Weight Breakdown

Table 7: Ship End Cost Estimating Levels

The functional technical groups of the ESWBS and their assigned numbers are presented in Table 8:

Group #	ESWBS Name	Group Description
100	Hull Structure	Includes shell plating, decks, bulkheads, framing, superstructure, pressure hulls, and foundations
200	Propulsion Plant	Includes boilers, reactors, turbines, gears, shafting, propellers, steam piping, lube oil piping, and radiation shielding
300	Electric Plant	Includes ship service power generation equipment, power cable, lighting systems, and emergency electrical power systems.
400	Command and Surveillance	Includes navigation systems, interior communications systems, fire control systems, radars, sonars, radios, teletype equipment, telephones, and command and control systems.
500	Auxiliary Systems	Includes air conditioning, ventilation, refrigeration, replenishment-at-sea systems, anchor handling, elevators, fire extinguishing systems, distilling plants, cargo piping, steering systems, and aircraft launch and recovery systems
600	Outfit and Furnishings	Includes hull fittings, painting, insulation, berthing, sanitary spaces, offices, medical spaces, ladders, storerooms, laundry, and workshops
700	Armament	Includes guns, missile launchers, ammunition handling and stowage, torpedo tubes, depth charges, mine handling and stowage, and small arms.
800	Integration/Engineering	Includes all engineering effort, both recurring and nonrecurring. Nonrecurring engineering is generally recorded on the Construction Plans category line of the end cost estimate while recurring engineering is recorded in Group 800 of the Basic Construction category.
900	Ship Assembly and Support Services	Includes staging, scaffolding, and cribbing; launching; trials; temporary utilities and services; materials handling and removal; and cleaning services

Table 8: ESWBS Names and Group Descriptions

A detailed discussion of the ESWBS can be found in Appendix F.

Tip: Revisit the GR&A Often

Keeping the assumptions for the estimate task current and accurate becomes an ongoing effort until the estimate is complete, as the GR&A serve as a record of the assumptions that need to be made during the course of the cost estimating process.

ESWBS and Cost Estimate Quality

The three-digit weight breakdown is at the core of the NAVSEA ship cost estimating process and is mandatory for a Class C budget-quality estimate. The basic construction category line of an end cost estimate developed within the guidelines of the Ship Estimate Classification System always has a weight breakdown to support the estimate (occasionally, ROM estimates may not). In those increasing number of cases in which weight may not be the best cost estimating parameter; e.g., state-of-the-art lightweight materials or combat systems for which suitable CERs have not been developed, the resourceful estimator is encouraged to seek out other parameters to enhance the cost estimate. Other estimating methods are discussed further in Task 5.

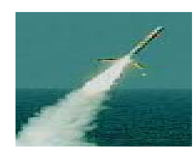
The cost categories that constitute a total end cost estimate for a ship also shows the major ESWBS groups to which the Basic Construction category work is costed. These end cost estimate categories tie in directly with the cost collection/accounting and budgetary systems of NAVSEA.

Task 4: Establish Estimate Assumptions

Establishing and documenting the Ground Rules and Assumptions (GR&A) is a critical task in any estimate and should be clearly prominent in all documentation and presentation material that the estimator prepares. A comprehensive list of the GR&A is a major element of a cost estimate. GR&A are important to define the program clearly and for estimators to be able to understand what costs are being included and excluded for the current estimate and future comparisons. By spending time developing and communicating accurate GR&A with customers, problems can be avoided that may cause an inaccurate or misleading estimate. GR&As:

- Satisfy requirements for program milestones per DODINST 5000.2
- Answer probing questions from various oversight groups
- Help to ensure the estimate is complete and professional
- Present a convincing picture to skeptical parties
- Provide useful estimating data and techniques to other cost estimators within SEA 017
- Reconstruct the estimate at a later date, perhaps years in the future when the current set of estimators are no longer available

The cost estimator works with the technical team to establish and document a set of programmatic GR&A bound the estimate's scope. Each estimate should have two sets of GR&A, global and element specific. Global GR&A apply to the entire estimate and include items such as base year dollars and total quantities. Element specific GR&A are found in the detail section for each WBS element such as unit quantities and schedules. Since it is impossible to know every technical or programmatic parameter with certainty in the design phase of a program/project, a complete set of realistic and well-documented GR&A adds to the soundness of a cost estimate. These GR&A should be developed in coordination with and agreed upon by the NAVSEA/PEO Program Manager. A final reconciliation of the GR&A with the CARD is important to ensure consistency between the SEA 017 estimate and those ICEs generated by oversight organizations using the CARD.



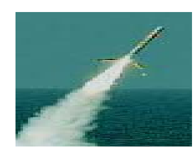
The following is a list of common GR&A that should be considered in an estimate.

- Guidance on how to interpret the estimate properly.
- What base year dollars and units the cost results are expressed in, e.g., FY04$M or FY05$K.
- Inflation indices used.
- Operations concept.
- Clarification to the limit and scope in relation to acquisition milestones.
- O&S period, maintenance concept(s) and if required, training strategy.
- Acquisition strategy, including competition, single or dual sourcing, contract type, and incentive structure.
- Production unit quantities, including assumptions regarding spares, long lead items, and make or buy decisions.
- Quantity of development units or prototype units.
- Percentages (or approach) used for computing program level wraps: i.e., fee reserves, program support, other direct costs (ODCs), etc.
- Implementation approach, such as Integration and test approach/test articles, mission assurance/safety approach, commercialization and outsourcing approach, and FMS commitments.
- Schedule information: development and production start and stop dates, Phase B Authorization to Proceed (ATP), Phase C/D ATP, Initial Operating Capability (IOC) timeframe for LCC computations, etc.
- Use of existing facilities, modifications to existing facilities, and new facility requirements.
- Management concepts, especially if cost credit is taken for change in management culture, New Ways of Doing Business (NWODB), in-house versus contract, etc.
- Commonality or design inheritance assumptions.
- Technology assumptions and new technology to be developed.
- Technology refresh cycles.
- LCC considerations: mission lifetimes, hardware replacement assumptions, hardware and software heritage, etc.
- Specific items or costs excluded from the cost estimate.

Task 5: Select Cost Estimating Method(s) and Tools

This task contains two activities: selecting the appropriate cost estimating method for the product being estimated and selecting the appropriate tool to conduct the estimate. For either activity, there may be more than one selection. An estimate may use a combination of different estimating methods for different WBS elements. These methods can be supported by different tools, which can result in multiple models or databases. The estimators' job is to select the most appropriate method and tool for each WBS element. Once each element is estimated, the estimator needs to combine all of the results into the final estimate. This is commonly done in one model, even if it is a simple spreadsheet.

Figure 14 demonstrates the project life cycle and common estimating methods used during a specific phase of a program.



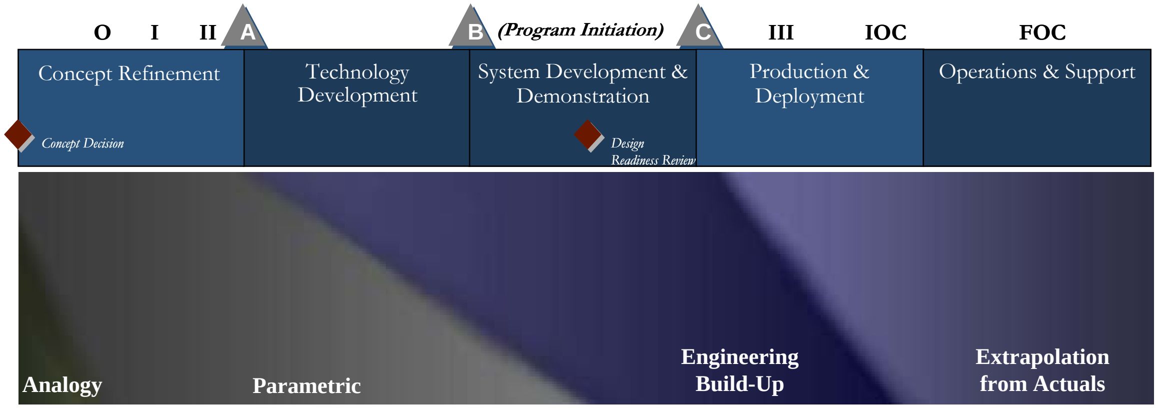


Figure 14: Common Estimating Methods by Life Cycle Phase

Methods and tool selection decisions are influenced by the level of the program definition; the purpose of the estimate; the availability of cost, technical, or economic data; the quality of the cost, technical or economic data; and time constraints. These selection decisions require knowledge and experience estimating the product. Estimating methods also become refined over time as more of the product is defined and new information becomes available. As with each task in the cost estimating process, this task is iterative and should be revisited during the estimating process.

Table 9 provides an overview of which cost estimating methods are commonly used during different phases of a program life cycle. Moving down the left column of the table is a process that can only be accomplished if the information and progress your program and the contractor(s) have made make the data available to support each of these methods. Analogy, parametric, and engineering build-up are three traditional cost estimating methods, discussed in detail in this section.

	Concept Refinement	Technology Development	System Development & Demonstration	Production & Development	Operations & Support
Analogy	●	●	◑	◑	◑
Parametric	●	●	◑	◑	●
Engineering Build-Up	◑	●	●	●	◑
Legend	○ *Not Applicable*		◑ *Sometimes Applicable*		● *Applicable*

Table 9: Cost Estimating Methodology by Program Life Cycle Phase

Analogy Cost Estimating Method

This cost estimating method is accomplished by forecasting the cost of the future based on the historical cost of a similar or analogous item. The costs of the historical item must first be normalized for both content and historical price differences. Normalizing for content entails deducting the cost of components that are not comparable to the new design and adding estimated costs of the new components. Normalizing for inflation entails converting historical cost to an appropriate base year value and applying the proper escalation indices to achieve then-year costs.

Estimating by analogy involves comparing your system and/or WBS elements to comparable current and or historical systems or WBS elements. This involves understanding the program and how it derives its history, for example, what program it is based upon. It is important to interact with program engineers to ensure the validity and credibility of candidate analog program to the future system; once comparable programs are considered, it is necessary to seek out those specific systems if possible to obtain necessary data and cost information. The estimator will need to talk to the program engineers to understand differences between the future system and the comparable analogous system(s). While complexity factors have been used to adjust analog estimates, they can often undermine credibility of the future estimate since they cannot be substantiated and are subject to human bias. (If the engineers suggest the new program is twice as complex as the analogous program X, then the new program's cost should be twice the cost of program X, excluding inflation). Such subjective adjustments negate the credibility of the estimate. For example, if the analogous system spent $10M to activate 10 sites, then it's reasonable to 'scale' or extrapolate that a future system having 11 sites should cost $11M for site activation.

Parametric Cost Estimating Method

Parametric estimating requires that a statistically valid mathematical relationship be established among the dependent variable, cost and independent variables, such as costs of other elements, and or various physical and performance characteristics of that system. This parametric Cost Estimating Relationship (CER) is then used to estimate the cost of a new system for which different physical and performance characteristics have been designed. In addition to parametric CERs, non-parametric CERs are also popular, but not recommended. Non parametric CERs are usually based on custom or 'generally accepted factors' and do not include the historical data than confirms their statistical accuracy. For example, rote use of "Installation cost = 50% of hardware item cost" without the underlying historical data to confirm it's validity, would be viewed with disdain by parametric cost estimators.

CER Consistency

The ship cost estimator must ensure that CERs are developed in a manner that is consistent with the items to be priced. For example, if a major system component within the cost group is CFM for the ship that is being priced, then the ship from which cost data are being used to develop the CER must also have had that component as CFM and not GFM. If this is not the case, a CER adjustment may be required. The estimator must also be sure that no new installation or manufacturing techniques have been introduced. Such a change could affect the CER. For ship construction contracts, more efforts are being outsourced to reduce cost. This "make versus buy" decision will require modification to historical CERs and may influence learning curve analysis.

When an item is switched from GFM to CFM, special care must be taken for the related transferring of costs. The material cost for the item as GFM must equal the CFM material cost after groups 800 & 900 percentages, profit, facilities cost of money, change orders, and escalation have been added onto the line item. This is a policy decision to eliminate questions of whether or not to purchase an item as GFM or CFM on a cost basis.

NAVSEA ship cost estimating is often based on parametric cost techniques. The level of technical definition that is usually available, plus the level of available historical cost data, lends itself to supporting the parametric approach.

CER Development

Cost estimators must determine a logical estimating relationship by hypothesizing what the CER should be. The estimator must structure the forecasting model and formulate the hypothesis to be tested. The work may take several forms depending upon forecasting needs. It involves discussions with engineers to identify potential cost drivers and scrutiny of the technical and cost proposals. Only with an understanding of ship and ship systems can an analyst attempt to hypothesize a forecasting model necessary to develop a CER. The process and movement between data availability and model form will take place until there is a model form that is supported by available cost and technical information.

Regression Analysis

Once the database is developed and a hypothesis determined, the estimator is ready to mathematically model the CER. While this analysis can be linear or curvilinear, we will initially consider one simple model -- the least squares best fit (LSBF). A number of commercial statistical software packages are available to generate the LSBF equation. Once established, the database and the hypothesis testing complete the modeling activity and the equations are then relatively easy to derive.

The purpose of regression analysis is to improve the ability to predict the next "real world" occurrence of our dependent variable. Regression analysis may be defined as the mathematical nature of the association between two variables. The association is determined in the form of a mathematical equation. Such an equation provides the ability to predict one variable on the basis of the knowledge of the other variable. The variable whose value is to be predicted is called the **dependent variable**. The variable about which knowledge is available or can be obtained is called the **independent variable**. In other words, the dependent variable is dependent upon the value of independent variable(s).

$$y = a + bx$$

where

$y =$ (represents) the calculated value of y - the dependent variable

$x =$ the independent variable

$b =$ the slope of the line, the change in y divided by the corresponding change in x

a and b are constants for any value of x and y

The relationships between variables may be linear or curvilinear. By linear, we mean that the functional relationship can be described graphically (on a common X-Y coordinate system) by a straight line and mathematically by the common form:

Weight is the most consistent physical property that the designer is able to provide to the ship cost estimator. Therefore, the most common parametric form employed in ship cost estimating uses weight as the technical parameter. The general form of the CER for material costs is then:

For this form, the "a" term above equals 0, where the regression line passes through the origin.

$$C = K * W$$

where

C = estimated cost of item

K = cost per unit of material weight (e.g., cost per ton)

W = weight of item in appropriate units

Similarly, the CER form for labor hours is:

$$MH = K * W$$

where

MH = estimated labor manhours

K = number of labor manhours per unit of weight

W = weight of item in appropriate units

The values of K may also be calculated by simply dividing MH or C by the weight. This is a "quick and dirty" CER that can describe a particular data set.

Other technical parameters, when available, are used if better estimating results are anticipated. For example, for propulsion or energy generating systems, both weight and unit rating could be used. The material-cost CER then might have a multiplicative form, such as the following:

The term $\left(R/R_S \right)^{Kr}$ represents an adjustment factor to the CER on the basis of weight to account for the rating difference between the current and standard unit. In this form, if $R = R_S$, the CER reduces to $C = K_m * W$.

$$C = \left(R/R_S \right)^{Kr} * \left(K_m * W \right)$$

where

Kr = cost factor based on unit power rating

R = power rating (e.g., horsepower) of unit under consideration

R_S = power rating of "standard" unit

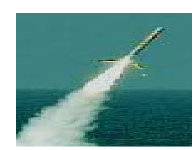
K_m = cost per unit of weight

W = weight of unit

A more in-depth discussion of regression analysis is presented in Section 5.

Parametric cost estimating method steps include:

1. Review available acquisition documentation: This task requires that the estimator communicate with the cognizant PM to review and evaluate acquisition and programmatic documentation relative to sole source, open or restricted competition, as well as the anticipated type of contract and predicted construction schedule.
2. Determine the Level of Available Technical Data: This activity primarily involves communications between the cost estimator and the ship designer to determine what technical parameters can be made available for the new design. The technical parameters ultimately selected by the cost estimator for the new design must also be available for the existing item(s) selected from the available historical cost data in Step 3.
   While weight is the most commonly used technical parameter and has been shown in practice to provide good estimates, the cost estimator is encouraged to explore other available parameters to be used with or in lieu of weight.
   Frequently, technical considerations will provide clues as to the applicability of a "standard" parameter. This is particularly true if new materials are being introduced to replace standard material. Thus, if the standard CER is $K * W$, but the new item has a combination of standard (e.g., steel) and new (e.g., composite) material, then a CER still based on weight might have the form $C = (K_S * W_S) + (K_N * W_N)$, where the subscripts $_S$ and $_N$ refer to standard and new, respectively.
3. Considerations of Other Factors: There are other factors to be considered when selecting data, including shipyard environment (workload, facilities and productivity changes), differences in procurement quantity and contract type and, of course, economic factors such as inflation. Unique program events are other factors that occur can during the construction of a particular vessel such as labor strikes, hurricanes, or technical problems that require significant rework. All these other factors that could bias the data or require normalization before a baseline CER can be identified, and the differences between the past and current procurement resolved. Once these factors are identified and understood, a second screening may be undertaken.
4. Analyze Data for Initial Cost Quantification: This task involves data analysis procedures to develop appropriate CERs with the data and information assembled in Steps 1 through 3. Typically, for a simple CER form such as $MH = K_m * W$, the data are used to obtain the K_m or manhours per unit of weight parameter. If several sets of data are available, an average might be calculated, perhaps with the *K* value for each data set being weighted by its relevance to the estimating task at hand. More sophisticated statistical techniques such as regression analysis may also be applied. The latter is especially useful when the CER involves more than one technical parameter.
5. Apply Escalation Factors as Appropriate: Following Step 4 will yield a baseline CER. If necessary and if not done in a prior step, these baseline values must be normalized to account for differences that may exist between the historical data and the current procurement as discussed in Step 3. Normalization of material costs to account for inflation is almost always required. Historical material CERs must be normalized for any inflation between the original CER reference date and the reference date for the current estimate. This reference date may be the "base date" (for a base dated estimate) or the "material midpoint date" (for a forward priced estimate). Material CERs are adjusted using the appropriate SEA 017 material inflation index, or actual program/contract data if available. SEA 017 publishes two different material inflation indices. The first reflects material inflation indices by SWBS group, based on Global Insight projections for applicable Bureau of Labor Statistics material categories. The second material inflation index is based on the annual shipbuilding material vendor survey conducted by the NAVSEA Shipbuilding Support Office (NAVSHIPSO). The choice of material index should be determined on an individual program basis. For additional information, see "Inflation/Escalation" in Section 5.



The material CERs should be updated when new material inflation indices are published - normally each year during the development of the POM/PR budgets. If necessary, the estimator should use the old material indices to bring the CERs back to their historical reference date (for an awarded contract). The new material indices are then applied to bring the CERs back up to the desired reference date (projected contract). This is done so that there is not a mix of indices in forecasting the outyears.

Engineering Build Up Cost Estimating Method

The **engineering build up** cost estimating method depends on a well-defined description of a proposed system, including detailed bills of material. The detailed material data are priced in the marketplace while labor costs (manhours) are estimated by applying the anticipated shipyard labor standards against the detailed bills of material. When conducting an engineering build-up cost estimate, be sure that a complete description is issued to avoid inadvertently overlooking or omitting parts of the estimate.

The engineering build up method allows the estimator to estimate at a comparatively detailed level and then summarize the WBS elements in a building-block approach. Engineering build up can also enhance major equipment estimates with quotes from vendors. Using the parametric estimating method does not take into account specific contractor accounting/processes/labor spread and level, so these items are generally estimated using an engineering build up method. This method should be built from contractor's proposed labor, hardware, and software requirements. An effective way to cross check an engineering build-up estimate is to use updated CERs from pre-Source Selection estimates. This method involves working closely with project engineers to assess and quantify technical inputs and risks (schedule, programmatic, and cost). A danger of using the engineering build up method is that the estimate can be precise, but wrong. By estimating what the engineers, or the contractor "knows," it is easy to underestimate the costs that are unknown.

Task 6: Collect Data

Data collection includes many facets and is done continuously throughout the development of a cost estimate. Many types of data need to be collected, including technical, programmatic, cost and risk data. Once collected, the data needs to be normalized. Once the estimate is complete, data needs to be protected and stored for future use. This section outlines the steps in the data collection task. The four major areas of data normalization are cost accounting, inflation, learning, and quantity adjustments. The adjustments must be correctly made to provide a data set that is sufficient for analysis. These techniques are discussed in detail in Section 5.

Data Sources

Although there are many sources of data, the predominant sources of data are the private shipbuilders who build the Navy's ships. It has taken years to develop an understanding with the shipbuilders and to earn their trust regarding the use of this proprietary and business-sensitive data by the Navy. The trust is built on the premise that data are strictly used for contracting purposes in the ship-award process, for management purposes during construction, and for NAVSEA cost estimating/analysis purposes to prepare budget estimates for future Navy shipbuilding programs. This trust has been maintained by NAVSEA with tenacity and is responsible for the continual flow and depth of data received.

Cost estimating needs to have a continuous influx of current and relevant cost data to remain credible. The cost data should be managed by estimating professionals who understand the basis on which prior data were prepared, submitted, and collected; who can determine whether the data have value in future projections; and who can make the data a part of the corporate history. The NAVSEA Cost Engineering and Industrial Analysis Division has the most complete file of Navy ship cost data in existence, and it is continually supplemented with vendor quotes, contract data, and actual return cost data for each new Navy procurement. Division personnel are knowledgeable of program acquisition plans, contracting processes, and marketplace conditions, all of which have meaning in the bid and return cost data collected. This knowledge provides the basis of credibility for using, modifying, or rejecting the bid and return cost data in projections of future ship costs.
The three traditional cost estimating method discussed earlier require specific types of data. There exists a "back and forth" movement between the method and the data to find the balance between data sources and resulting uncertainty. The goal is to develop the estimate with the smallest uncertainty that can reasonably be achieved with the data available.

Data Examples

Mission Requirements

- Weight, Speed, Endurance, Payload, Survivability, Technology, Mission Systems, Hardware/Software, Commonality, Manufacturing techniques, Specifications and standards, Identification of Analogous System/Program

Programmatic

- Acquisition Strategy, (Competition/Sole Source, Contract Type), Quantity (Quantity & Profiles), Schedules

Economic

- Industrial base Considerations, (Shipyards, Suppliers/Vendors), Inflation & Expenditure Rates, Indices (BLS Actual Indices, OSD/OMB Projections), Economic Price Adjustment Clauses

Types and Sources of Data

There are three main types of data: cost, schedule, and technical.

Cost data includes labor dollars (with supporting labor hours and direct and burden rates), material and overhead dollars, profit, and where applicable, cost of money (COM), an element of facilities cost of capital. Facilities Capital Cost of Money (FCCM) is discussed further in Section 5.

Schedule data provides the time sequence and duration for the events over the portion of the life cycle required. Milestone dates in shipbuilding include lead time schedules, construction start and duration, delivery dates, outfitting, testing, fleet introduction, and operating schedules and profiles. In conjunction with the physical schedule requirements and initial operational capability (IOC) dates, there is another set of schedules related to the budget and review cycles. All these factors must be considered in developing an estimate.
Technical data defines the ship or equipment being costed based upon the physical and performance attributes. In the case of ships, the most frequently used parameters include overall length, maximum beam, light ship displacement, margin, shaft horsepower, accommodations, and armament. Installed equipment such as radar and sonar possess their own parameters characteristics. When collecting technical data, care must be taken to relate the types of technologies and production methodologies used. These change over time and will require adjustments when developing estimating relationships.

Given that all cost estimating methods are data-driven, it is critical that the estimator know the best data sources. Presented in Table 10 are nine basic data sources. If at all possible, use primary sources of data. Primary data is obtained from the original source and is considered the best in quality, and ultimately the most useful. Secondary data is derived, not obtained directly from a primary data source. Since it was derived (actually changed) from the original data, it may be of lower overall quality and usefulness. It is important to understand how the data was changed before determining if it will be useful. In many cases this is actual data that has been sanitized, so the resulting derived data becomes an estimate from the actuals. As a general rule, it is always better to use actuals rather than estimates as data sources.

NINE POTENTIAL SOURCES OF DATA		
	Data Source	Source Type (Primary or Secondary)
1.	Basic Accounting Records	Primary
2.	Cost Reports	Either (Primary or Secondary)
3.	Historical Databases	Either
4.	Functional Specialist	Either
5.	Other Organizations	Either
6.	Technical Databases	Either
7.	Other Information Systems	Either
8.	Contracts or Contractor Estimates	Secondary
9.	Cost Proposals	Secondary

Table 10: Nine Potential Sources of Data

Examples of generic data sources include historical data from CPRs, CSDRs, weight reports, HCOST, and Forward Pricing Rates, Business Plans, etc. In the O&S area, common data sources include COMET, VAMOSC, and OARS.

For data sources that are specific to a product, see the product templates at the end of this section.

Other Government Agencies and Offices

Other Government agencies and offices, such as the Maritime Administration, U.S. Coast Guard, U.S. Army, and Military Sealift Command in cooperation with the Navy, are involved with ship and small craft construction. It is not unusual to have normalized cost data interchanged or compared. Additionally, a number of government agencies and industry trade associations publish cost data and other shipbuilding industry data that are useful in ship cost estimating.

Weapons systems estimators should pay special attention to one additional component of the Defense Department, the Defense Contracts Management Agency (DCMA). This agency has on-site representatives at most major defense contractor facilities, including private shipyards. Although a great deal of the cost data reviewed by DCAA are considered proprietary and therefore not available for NAVSEA cost estimating purposes, there is much local shipyard knowledge and useful ship cost information to be realized from the resident DCAA auditors. In addition, it is common to have DCAA auditors as members of NAVSEA teams assembled to review elements of shipbuilder proposals, especially in areas of labor and overhead rates, COM, and supervision manhour percentages. Weapons systems estimators can leverage DCAA just as ship estimators can leverage Supervisor of Shipbuilding, Conversion and Repair (SUPSHIP) to monitor shipyard performance.

Where SUPSHIP provides contract management, a close relationship between SEA 017 and the Supervisor and staff exists. SUPSHIP plays a major roll, through memoranda of agreements, and delegated contract administration functions, in the planning, implementation, analysis, and reporting of cost data related to ship and weapon system construction and integration. The unique perspective of the SUPSHIP staff in areas such as production, adds to the value of the cost data reported by the shipbuilder under the EVM and contract reporting requirements. Such analysis and support from SUPSHIP is not only necessary for proper monitoring and reporting of the contract under administration, but it is also important in continuously populating cost databases, subject to proprietary restrictions, that may be used by SEA 017 in the estimation process.

Cost estimators, are encouraged to establish and nurture contacts with the activities discussed here so that a continuous flow of current cost-related information can be maintained.

Data Examples

There are a number of shipbuilder actions or conditions that can cause cost data to become dated. Some obvious ones are as follows:

- Recent addition of modern facilities and application of new construction techniques
- Upward or downward changes in shipyard productivity
- Changes in shipyard accounting procedures, e.g., indirect to direct charging, and in make/buy decisions
- Actual performance reflected in return costs disprove bid or proposal cost data
- Shipyard shuts down to any further Navy construction; accumulated data are of limited value for future projections

The cost estimator can usually make necessary adjustments to historical data to offset these shipbuilder actions and, in this way, to keep accumulated data current. One further note of caution -- shipbuilders, in negotiated contracts, are not required to revise the submitted detailed data to reflect final negotiated position. Therefore, the estimator has to consider this factor when developing CERs with the detailed data.

Data Quality

The cost estimator must consider the limitations of cost data before the data can be used confidently to project future costs. Historical cost data accumulated by SEA 017 has two predominant limitations: (1) the data collected represents discrete sets of contracting and marketplace circumstances that must be known if the data are to have future value; and (2) current cost data become dated. The first limitation is routinely handled by the professional estimating staff with established cost data collection procedures that record these circumstances as part of the corporate history. The experienced analyst, through data adjustment and collecting new data can, also accommodate the second limitation. The contract form (FFP, FPI, CPAF) to be used in a future procurement may differ from that of the cost data selected to be projected. This is not to say that there cannot be a mix in contract form in selecting cost data; however, the estimator should be aware of the conditions so that an informed data selection decision can be made.

Data Applicability and Reliability

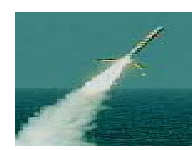
The estimator must assess the reliability and applicability of the data in order to adequately perform a cost estimate. Throughout the life of a particular ship class or weapon system, significant changes occur which may create wide variations of designs on similar platforms. The scope of these configuration changes must be analyzed. Furthermore, the estimator must be aware of any bias inherent to the data. Bids, CPRs, and other data may have management bias factors included in them that cause the data to deviate from actual data. Hence, it is essential for the estimator to be fully knowledgeable of the data that is used.

To a great extent, SEA 017 can deal with the data limitations discussed in this section due to the following:

(1) The continuous in-flow of current data
(2) Thorough knowledge of the circumstances surrounding the data collected. The new data provide a means for comparison to seek out evolving trends and also provide a means to quantify those trends. Background knowledge of the data allows the estimator/analyst, with confidence, to use the data directly, to modify it so it becomes useful, or simply to reject it
(3) Contact and discussion with the provider

Data Documentation, Storage, and Archiving

The NAVSEA Cost Engineering and Industrial Analysis Division is the repository of the most complete file of Navy ship cost data in existence. This large amount of historical data remains viable because it is continually supplemented with each new Navy procurement's actual return costs and with each vendor quote or shipbuilder contract. Although there are many sources of data, the predominant sources of data are the private shipbuilders who build Navy ships. It has taken years to develop an understanding with the shipbuilders and to earn their trust regarding the use of this proprietary and business-sensitive data by the Navy. This trust is built on the premise that data are strictly used for contracting purposes in the ship-award process, for management purposes during construction, and for NAVSEA cost estimating/analysis purposes to prepare budget estimates for future Navy shipbuilding programs. This trust has been maintained by NAVSEA with tenacity and is responsible for the continual flow and depth of data received.



All data collection activities must be documented as to source, work/product content, timeframe, units, and an assessment of accuracy and reliability. Comprehensive documentation during the data collection phase will greatly improve the quality, and reduce subsequent work of the development and documentation of the estimate.

Formats for data collection should serve two purposes. First, the format should provide for full documentation and capture of information to support analysis and documentation, and secondly, the format should permit easy transcription of information from other forms containing cost data. The NAVSEA 4280/2, Unit Price Analysis – Basic Construction form is an example.

The next three tasks of the cost estimating process relate to performing the estimate.

PERFORM ESTIMATE

Task 7. Run Model & Generate Point Estimate

Task 8. Conduct Cost Risk Analysis & Incorporate into Estimate

Task 9. Conduct Preliminary Estimate Review

Part 2

TASK 7: RUN MODEL AND GENERATE POINT ESTIMATE

The following are the six steps associated with this task:

1. Populate Model According to Estimate Assumptions

   When the model has been constructed or modified from a previous version to accomplish the estimating task at hand, it needs to be populated in terms of the estimating assumptions and independent variable inputs. The WBS elements that are the lowest level to be estimated are addressed on an element-by-element process. When a value is a throughput, it is entered from the cost estimating worksheet or other source document. In the case of costs, they should be entered in the base year as defined in the GR&A.

   When an equation is the CER, the values of the independent variables must be entered in the manner the model was developed. The variable values can be included in an equation, or accessed from a supporting database or table of values. When factored costs such as Program Management or Systems Engineering are based on hardware elements or prime mission equipment, the factors must be entered in the WBS element equation.

   When all variables, factors, and throughputs have been entered, the model is run to develop the initial estimate.

2. <u>Time Phase Estimate</u>

   Time phasing occurs as the model is run the first time, but it may also be done in a two-step process whereby the total element costs are time phased in accordance with the assumptions for appropriations and phase schedules. Time phasing an estimate is the act of spreading the estimate dollars based on program requirements by each fiscal year of the program. Often a model is developed that permits the modification of phase and major milestone dates linked to WBS elements, permitting sensitivity analysis and "what-if" drills to be rapidly and efficiently conducted.

   The time phasing is based on the inflation indices prescribed in the GR&A. This can be done using many techniques, including beta curves, historical spreads, engineering judgment, and budget constraints. Normally the indices promulgated by NAVSEA, based on OSD guidance are used. NAVSEA is unique in that base dates for construction are established as a month and year, and therefore indices must be developed that reflect monthly values. Also the terms "inflation" and "escalation" are different and specific. Inflation means a rise or fall in the general price level of labor and material, while escalation is used in the calculation of payments to the shipbuilder under the "escalation" clause of the contract reflecting payment based on inflation over the construction period.

3. <u>Run Populated Model to Generate Point Estimate</u>

   When all the inputs, factors, and variable have been entered, the model is exercised and the results of the point estimate are reviewed. Once again, this is not a serial process, and "running a model" really means viewing the entire process and inputs and assumptions are entered, and seeing that the results move as anticipated. This particular fact cannot be emphasized too strongly; the estimator must always be aware of what should be happening in a general sense, and checking to see that it does. For example, a positively correlated weight based CER should increase in results with increased independent variable values.

4. <u>Validate Estimate</u>

   When the model has been exercised to the point that it should be stable and reflecting the scope of the GR&A properly, costs of an item that is unchanging in constant dollars should indicate increasing then-year cost (unless there is negative inflation), and so on. The first review looks for obvious problems, and the more detailed the model, the more effort is required to validate the results.

5. <u>Perform Sensitivity Analysis</u>

   Sensitivity analysis is normally run to assess the impact of varying independent variable values, changes in schedules, or changes in quantities. Sensitivity analysis is not risk analysis, where the results are quantified in a resulting cost and then included in the total estimate. Sensitivity analysis is used as a "what-if" tool to determine impacts of changes to find the right variable to include in the estimate. The distinction must be kept in mind to avoid treating the effects of changing possible ranges of input variable values as uncertainty. Each sensitivity analysis should be documented and may be included as supporting data for a WBS element or for the overall estimate. A sensitivity analysis can be used to develop cost ranges and risk reserves, and to determine how the different ranges affect the different point estimates.

6. <u>Re-Run model if Necessary</u>

   In practice, models are exercised over and over to accommodate the realities of a program and to accommodate changes as a program proceeds through the normal acquisition process. As more data becomes available, risks become events or are mitigated and program requirements change, estimates need to be updated. Models are also re-run to reflect the current execution plan and program of record.

TASK 8: CONDUCT COST RISK ANALYSIS AND INCORPORATE INTO ESTIMATE

In discussing risk and uncertainty in the context of cost estimating, it is necessary to identify the difference between the two. According to the Defense Acquisition Acronyms and Terms, Eleventh Edition, September 2003, Defense Acquisition University Press:

> **"Risk:** A measure of the inability to achieve program objectives within defined cost and schedule constraints. Risk is associated with all aspects of the program, e.g., threat, technology, design processes, or Work Breakdown Structure (WBS) elements. It has two components, the probability of failing to achieve a particular outcome, and the consequences of failing to achieve that outcome."
>
> **"Uncertainty:** A condition, event, outcome, or circumstance of which the extent, value, or consequence is not predictable. State of knowledge about outcomes in a decision, which are such that it is not possible to assign probabilities in advance. Some techniques for coping with this problem are *a fortiori* analysis (making use of conclusions inferred from another reasoned conclusion or recognized fact), contingency analysis, and sensitivity analysis."

What is a Confidence Interval?

Simply speaking, confidence intervals are a useful way to consider margin of error, a statistic often used in voter polls to indicate the range within which a value is likely to be correct (e.g., 30% of the voters favor a particular candidate with a margin of error of ± 3.5%).

The primary distinction is that **risk** is associated with a probability**,** and **uncertainty** is not.

A Cost/Risk Analysis begins with determining the level of risk associated with identified program sub-systems. The Risk Management Guide for DoD Acquisition, June 2003, Defense Acquisition University, defines risk as "…a measure of the potential inability to achieve overall program objectives within defined cost, schedule, and technical constraints…"

Measurement areas are typically the probability (likelihood) and severity (impact) of an event occurring. Risk analysis provides an examination of risk areas to determine options and the probable impacts affecting cost, technical performance, and schedule for each event.

Risk management is a continuous process used to assess and mitigate events that may adversely impact a program while serving as a basis for identifying alternatives to achieve cost, schedule, and performance goals. Risk management also provides risk information for acquisition decisions and supports monitoring of the health of the program as it proceeds. As a result, PMs can more effectively allocate resources by better understanding program risks.[8]

Risk Process

Risk management planning should be used continuously throughout the Program Acquisition Life Cycle. Starting with identification, risks can be categorized as affecting performance, schedule, or cost. Risks are then analyzed utilizing several methods, including probability and severity of occurrence, sensitivity analysis, and cost/schedule/performance impact analysis. Based on the outcome of the risk analysis, a handling method, or a mitigation strategy is assigned to each risk. Risks are then monitored and controlled while being reduced to an acceptable level through mitigation plans. A risk matrix is generally used to depict where risks lie in a program, giving the PM immediate insight into where the most critical risks are. The risk process enables continuous and robust risk management and is illustrated in Figure 15:

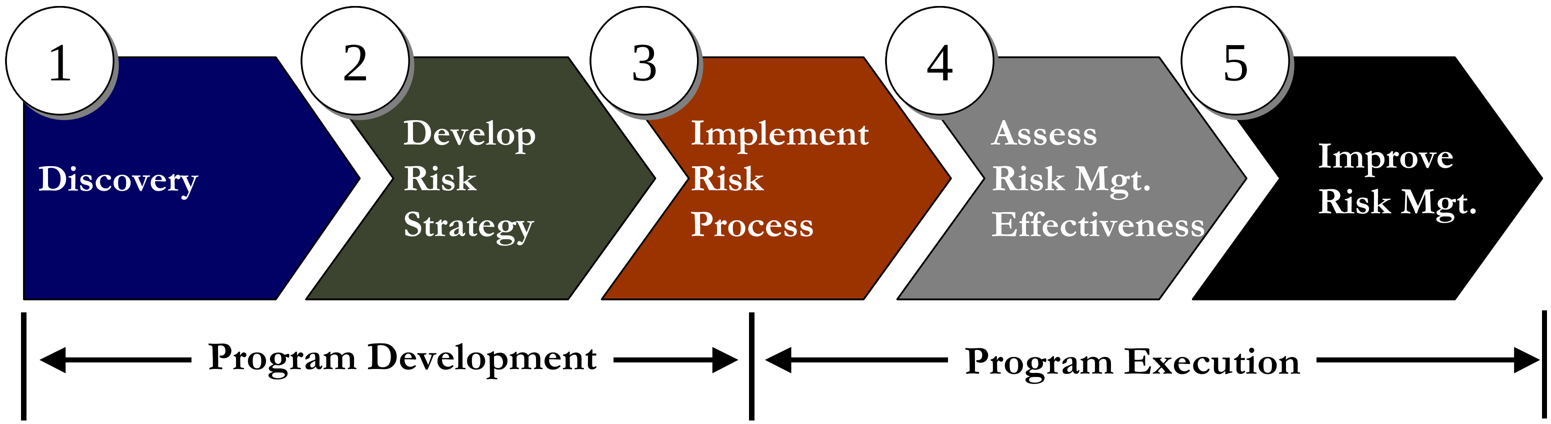


Figure 15: Risk Management Process

1. The *Discovery* phase focuses on documenting several aspects of the program, from life cycle stage, program baseline, requirements, and client risk sensitivity. This analysis sets the basis for virtually all of the risk management and analysis that follows.
2. *Develop Risk Strategy* provides guidance for cultivating the risk management practice. It identifies the process and methodology for identifying risks for the program.
3. Implement the Risk Process is the core analytical element of risk management. It is in this phase where risk descriptions are captured and risk scores are calculated. In addition, risks are mapped to WBS elements, which is the basis for allocating cost and schedule impacts throughout the program.
4. *Assess Risk Management Effectiveness* involves the development of risk handling plans and subsequent review of program risk mitigation activities.
5. *Improve Risk Management* is the final stage of total risk review for the purposes of improving any of the previous activities described earlier.

Upon deriving risk scores and the program risk profile from the above process, cost/risk analysis can be performed.

Cost/Risk Analysis

By the very nature of forecasting into the future, there exists a certain amount of risk and uncertainty with an LCC estimate. Yet, every effort is made to ensure the accuracy of the estimates. As long as the risk is identified, it can be managed and controlled. To account for the uncertainty and the lack of precision in each of the assumptions, input variable distributions (minimum, most likely, maximum) can be estimated for key cost elements. Once the LCC model is fully developed for each alternative with the input variable distributions, the model can then be subjected to a Monte Carlo simulation to assess potential variability of the estimate.

Two of the most complex issues associated with simulation of the point estimate to develop a range of numbers, are the assessment of the variable distribution, and the degree of correlation between cost elements. It is not reasonable to assume that all elements are independent, nor that all elements are related. There are methods available from utilizing curve-fitting programs to learning the distribution of behavior of historical elements, to using expert judgment to estimate the degree of interdependence between elements.

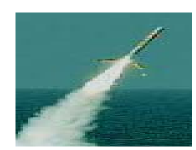
Within NAVSEA 017, there are two primary software programs available for developing cost risk profiles. The first is Crystal Ball ®, mathematical software product (a Microsoft Excel ® Add-in), and RI$K, the risk-analysis module of the ACEIT (Automated Cost Estimating Integrated Tools) suite, which has been developed and enhanced for the Air Force (ESC/FMC). These tools possess strengths that lend them to a particular estimating situation. If the estimating model is ACEIT based, such as the Aircraft Carrier Ship Construction Model, then RI$K is appropriate because it is integrated with the product. MS Excel ® based models are likely to use Crystal Ball ®, since it is an add-in to the spreadsheet.

A Monte Carlo simulation calculates numerous scenarios of a model by repeatedly picking random values from the input variable distributions for each "uncertain" variable and calculating the results. Typically, a simulation will consist of 2,500 to 10,000 iterations. The results of Monte Carlo simulations are risk-adjusted estimates and corresponding statistical estimate distributions. The estimate distributions provide the decision-maker with a range of possible outcomes and bounds, with a minimum and maximum value. (The input variable distributions and cost estimate range is provided with each alternative analysis.) Conducting a risk analysis develops a reserve range and determines the risk adjusted point estimate for probability of occurrence.

Commercial Risk Software

A particular difference between the two risk packages is that Crystal Ball utilizes Spearman (rank) correlations, and RI$K uses the Pearson definition. Mathematically, there is a difference in the results that has been the subject of research. A study titled, "*Cost Risk Model Assessment Report*" developed for the Air Force (ESC/GAX), examines this issue, among others and explains the significances. In addition, Crystal Ball® may use either Latin Hypercube or Monte Carlo statistical sampling, while RI$K applies Latin Hypercube.

A presentation titled, **"***Comparing Crystal Ball® With ACEIT***."** Proceedings of the 2004 Crystal Ball User Conference, addresses the issue of mathematical consistency and states, "This paper serves to demonstrate that if care is taken, they (Crystal Ball® and ACEIT) almost always will produce the same answers. It is important that the analyst be aware of the community views of these two products, but more important that whatever risk methodology or models are used, that they are correctly applied and interpreted.



COTS tools are available to help model risk. These tools are mostly compatible with the MS Office suite of software applications and generally use Monte Carlo simulations to derive percentages of baseline costs based on the uncertainties in cost methodology, technical feasibility, and schedule. Once parameters are entered for these components of risk, the models will derive a recommended "contingency" value. This value, when added to the baseline estimate, theoretically reflects an equal chance (50%) of the actual system LCC overrunning and under running the point estimate.

"What-if" analyses are useful because help decision makers:

- Identify the project's cost drivers.
- Estimate the probability of achieving the point estimate.
- Establish reserves.
- Provide a cost range.

In conducting risk and uncertainty analysis with respect to cost risk, it is advisable to develop two estimates, baseline and risk-adjusted.

The baseline estimate should be based upon technical inputs (independent variable input values) from the CARD and other programmatic documents. Next the distributions for the CERs and cost factors are established. A Monte Carlo simulation is then conducted and the results are considered the Baseline Estimate. This estimate evaluates the most-likely cost, adjusted for the uncertainties in the estimating relationships.

The second estimate includes the quantification of both risk and uncertainty, such as the estimated variation in baseline technical and performance parameters (and cost) of an advanced propulsion system. A second simulation is conducted utilizing distributions for the risk items as well as for CER uncertainty. Triangular distributions are usually assumed, unless historical data has permitted the fitting of another form. The results of the second simulation may be considered a Risk-Adjusted Estimate. The difference between the means of the baseline estimate and the risk-adjusted estimate is cost risk.

These results should also be evaluated against the program funding profile to assess the probability of achieving success against approved funds.

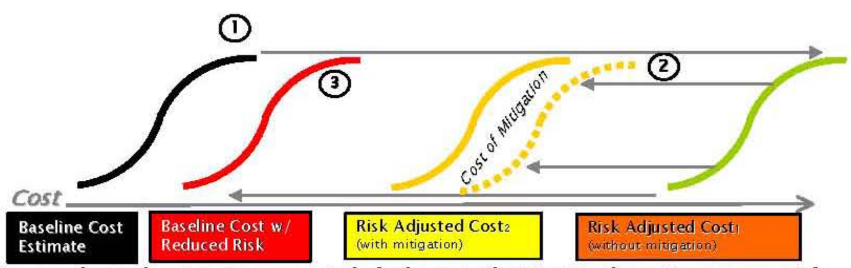
Cost Risk Reference Sheet

Types of Risk

Risk Type	*Definition*
Cost Risk	Uncertainty resulting from the use of a particular cost estimating methodology. A "risk-adjusted" estimate can be created wherein the distribution of likely values for key parameters can be incorporated via Monte Carlo simulations to provide a "range" of likely cost versus a single "point estimate" with no comment on its likelihood of occurrence.
Technical Performance Risk	Uncertainty in the system performance or "benefits," associated with programmatic, system, or process requirements, planning, design, implementation or operations to achieve performance objectives within specified constraints. Technical performance risk can be reflected in increased costs (to fix the technical problem) and lower overall system benefits.
Project Schedule and Programmatic Risk	Uncertainty in the project completion or fielding schedule, and the subsequent impact on costs and level of benefits. A stretched-out schedule may increase costs due to extended level-of-effort funding requirements, and result in delivery of systems too late to have the desired effect (reduced benefits).
Integration Complexity Risk	Includes risks associated with the number of data dependencies, the number of actual interfaces between modules, and the technical issues regarding programming and application solutions.
Market Risk	Includes risks associated with the stability of vendors and their software and related tools and services within the market. Market risk may increase or decrease depending on such factors as the number of vendors or products within the market, the degree to which specific products are tested and implemented in a production environment similar to the intended use of the system under consideration, and implementation.

"S" Curves

S Curves present an analysis of cost avoidance and cost mitigation:



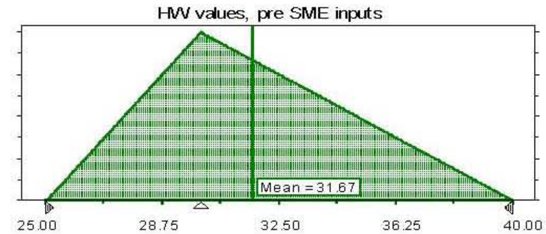
True analysis of cost savings must include the cost of mitigating the entire program risk set

Selecting a Distribution

A key factor in developing cost risk profiles from point estimates is the selection of the probability distribution to be used in the simulation, normally Monte Carlo. The most commonly used distributions are:

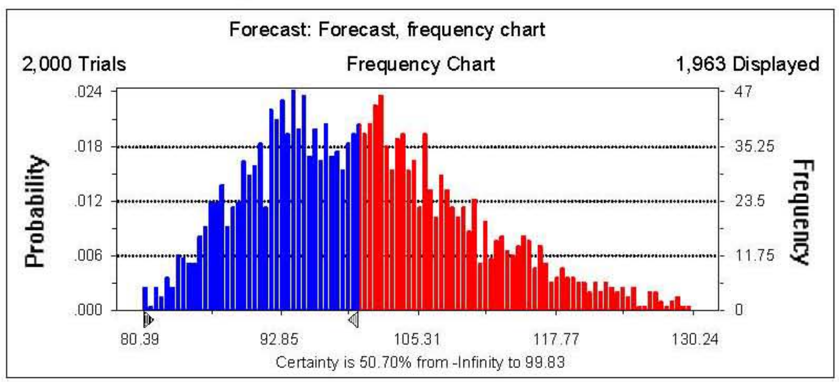
Triangular - least, most likely, and high values
Normal - natural phenomenon (e.g. inflation)
Lognormal - values are positively skewed, but cannot be negative (e.g. pay scales)
Uniform - all values in range are equally likely
Custom - represents unique situations

Estimates of 'Most Likely' cost, as well as Min and Max drive initial risk adjustment calculations:



Crystal Ball Output (Cumulative Probability Distribution)

When an estimate is developed, all lowest level elements are summed through the WBS, where the total represents the point estimate (mapping risks to the program WBS serves as the basis for allocating cost and schedule impacts throughout the program). This estimate does not reflect the risk and uncertainty involved. One way to display this uncertainty is to use a software program like Crystal Ball® to portray the uncertainty interval as well as risk impacts:



Task 9: Conduct Preliminary Estimate Review

Thorough reviews help to ensure successful completion of the estimates. Possible sources of reviews include: the Program Offices, supporting NAVSEA and NAVAIR activities, Naval Reactors, other business codes within NAVSEA, as well as other SEA 017 estimators (i.e., peer reviews). There are three steps associated with this task.

1. <u>Cross Check Estimate</u>

   As part of the review of the estimate, WBS elements should be evaluated in terms of other cost estimating methods, or "cross checks." It is generally not possible to develop two estimating methodologies for each element, but as an element meets the following two criteria, more effort should be expended on developing a second estimate. The two criteria are "percent of total estimated cost" and "uncertainty of the estimate." As an element becomes a larger percentage of the total **and** contains more risk and/or uncertainty, then secondary methods and data must be found. An alternate method might be to look at the historical percentage of the element in other programs, compared to calculation by CER. If both methods are reasonable and logical, confidence in the primary method increases.

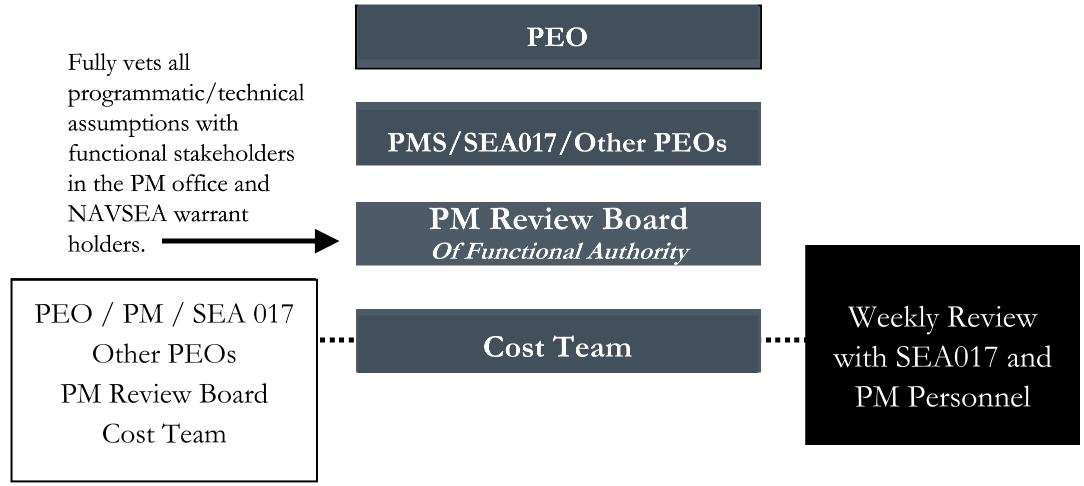


Figure 16: Sample Estimate Review Process

2. <u>Estimate Reviews</u>

   In general there are three levels of review for an estimate. These are Peer reviews, Leadership reviews, and Program reviews. Peer reviews are used as a continuous in process set of checks to make sure the estimate is progressing. Periodic leadership reviews address the larger questions concerning reasonableness, risk, robustness, and accuracy. Program reviews are the most formal set of preliminary reviews, established to emulate the review of the final product. Program reviews are less in number that Leadership reviews, and normally remain at a higher level. As with all aspects of the cost estimating process, reviews are part of the feedback process. Given a program's time limitations, the number of revisits is a function of the completeness and quality of the in-process activities.

Estimate Review Example

Figure 16 illustrates a recent example of an estimate review. As shown in Figure 16, there are various reviews that take place with the 017 cost team:

- Cost reviews within our cost team
- Reviews with the Advisory Board which focus on getting data for the effort and advice from the group on how particular issues should be handled with the CAIG and other reviews
- Reviews with the PM Review Board where the estimates, assumptions, and other details are shown to provide information and to get feedback
- Reviews with leadership
- Ultimately, a review with the CAIG

3. Estimate Reconciliation

Estimates may be reconciled with either prior estimates, or with estimates developed by other activities, depending on the situation and degree of independence required. Often there are situations where the requirement is for a "single best estimate" using the skills of multiple estimating groups.

The reconciliation process begins with a thorough understanding of what is being estimated, and with an agreement on the GR&A. Areas of disagreement form the basis for the documentation for the reconciliation report. Reconciliation does not mean that there is a single answer, as with a single best estimate, but that differences in results have been explained in a numerical sense and the assumptions that the differences are based upon are communicated and understood.

BRIEF RESULTS

Task 10. Produce Final Estimate

Task 11. Document Estimate

Task 12. Brief Results

Part 3

Task 10: Produce Final Estimate

To produce the final estimate, it is important to check and recheck formulas and data entry to ensure accuracy and to document each input and formula for the detailed estimate documentation. This is also the appropriate time to incorporate and reconcile review comments provided. If a previous estimate was conducted a cross track should be prepared comparing the two estimates, showing the deltas and documenting the reasons for the deltas. Once each of these items have been addressed after the final risk adjusted estimate is complete, the final estimate can be produced and is ready for documentation.

Task 11: Document Estimate

Thorough documentation is essential for a valid and defensible cost estimate. Cost presentation documentation provides a concise, focused illustration of key points that should direct the reader's attention to the cost drivers and cost results. Cost estimate documentation requirements have been established to set a standard to be adhered to by the cost estimating and analysis offices of the various Systems Commands. The requirements specify that the following elements be addressed:

- Date of estimate
- Category of estimate
- Preparing organization
- Purpose of estimate
- Description of system
- GR&A and constraints
- Data sources
- Estimating methodology
- Estimates (dollars)
- Uncertainty and risk

Although detailed narratives are not required, the professional cost estimator is expected to provide sufficient documentation that other experienced personnel could review and proceed from that point. The estimating task is not considered complete until all the required documentation is in place. Group Directors/TWHs provide their personnel with specific documentation requirements and unique formats appropriate for each group. Three aspects of documenting an estimate are described below.

1. Generate Final Report

   The final report should be the culmination of the in-process estimating process and review cycle. The parts of the documentation and descriptions should be available at the final run of the model for inclusion in the final report. The specific format will depend on the final use of the product, what the Acquisition category is, what further reviews will be taking place, and so forth.

2. Documentation

   The documentation format needs to be focused on content, rather than structure except where specific formats are required. The recent Naval Cost Analysis Division Instruction 4451.1A of 3 February 2004 provides excellent guidance with respect to documenting NCAD cost estimates. The guidance also fulfills SECNAV requirements. A general rule is that estimate should be able to be replicated by some one not involved in the original estimate.

3. Estimate Storage

   Resulting cost estimates and associated final reports need to be archived for historical and administrative purposes. The electronic storage of the estimates and documentation will greatly facilitate the recovery and review capability of estimating personnel. Care should be exercised that data is stored where it can be easily found and retrieved. Too many times data is stored electronically or hard copies are scanned into electronic files and lost forever if the original analyst is no longer working the program.

   Proper storage and classification by product line and deliverable category, will enhance the ability of estimators to access the estimate as a data source for future work. SEA 017 has a common storage location on the "I Drive." The current high level hierarchy of the "I Drive" contains information in the following electronic file structure for each program:

Program Name

- Budget 9000.1a
- Contracts
- EVM 9000.1c
- Industrial Base 9000.1a
- Inquiries 9000.1a
- Integrated Product Teams 9000.1a
- Milestone 9000.1a
- Other (add other MAJOR categories as needed) 9000.1a
- SCA 9000.1a
- Special Studies 9000.1a
- TOC 9000.1a

Under this file structure, SEA 017 can house information that crosses programs or involves multiple groups, for all cost or study items that 017 delivers. Along with this structure, each SEA 017 group can house their own work in progress and studies for their own platforms. This "I" drive file hierarchy allows SEA 017 to store deliverables properly containing data and final reports to ensure "good" documentation, and storage for future use.

Task 12: Brief Results

There are two steps associated with Task 12.

1. Standard Briefing Recommendations

   The cost estimator should prepare briefing material with all supporting documentation to be used to present the estimate. As with the cost estimate documentation, while it may not be realistic to standardize the content and format of the cost analysis briefing charts across all NAVSEA products for all estimate types, it is recommended that existing NAVSEA templates be used to maintain as much consistency internally as possible, as this facilitates understanding during the management review process and promotes completeness and quality of the cost estimating and analysis documentation.

   Thorough documentation is essential for a valid and defensible cost estimate. Cost presentation documentation provides a concise, focused illustration of key points that should direct the reader's attention to the cost drivers and cost results.

   Cost estimates are used as baseline rationale to develop budget submissions for Presidential and Congressional approval. A program that uses a valid cost estimate greatly improves the defensibility of a budget request. This is due to the fact that with a detailed cost estimate, there is little room for hiding money by asking for too much money. Similarly, a detailed cost estimate will show impacts to the program if allocated too little money. Quality, risk, and sensitivity analyses along with thorough documentation and a consistent briefing format are all important factors when defending an estimate.

Update Estimate Often

The capability to produce ship cost budget estimates in a timely manner requires ship cost estimators to rely upon preliminary program information and assumptions. After the FMB, OSD and Congressional budgets are prepared and submitted, it is imperative that estimators allot adequate time in the post-budget period to monitor the budget programs to determine if the preliminary information and assumptions continue to form a proper basis for the budget estimate. Developments that may take place during this period can be of a technical nature, such as a growth in ship tons, or of a programmatic nature, such as a construction schedule change or the addition of a more demanding ILS specification. By frequent monitoring of the program, the ship cost estimator will detect any major cost/budget problems that may be developing. In this way, corrective management actions, as necessary, can be taken in a timely manner before bids or proposals are received from industry.

Despite the unique differences in NAVSEA products, it is important to have some consistency in the presentation of an estimate. The presentation must include the programmatic and cost related program particulars and displays of the costs, workload curves and industrial base considerations, and budget implications. Once again, each product group has a different set of presentation requirements, but where there exist common displays (budget, top level WBS, etc.,) they should be used. To help ensure consistency, a recommended list of items that should be included in a briefing follows:

- Title page (date, name of office or person receiving brief)
- Outline (top level)
- Purpose (why are you there? what was the question? what are you attempting to show?)
- Estimating GR&A (acquisition strategy, buy profile, construction yard, schedule, contracting, learning curve, profit & anything else that may be peculiar to this estimate)
- Methodology/Estimating Process (techniques or process you actually went through, data sources etc; show methodology for cost drivers, high value items)
- Cost & Cost Summary/Results (cost numbers, show comparison to budget or controls, show deltas, or if an update show differences from last brief)
- Risks (cost drivers, outside influences, any type of contingencies included, tie to technical risk)
- Concerns/Challenges (issues that the brief receiver should know about)
- Conclusions/Recommendations (if decisional give available options w/suggested option, if informational perhaps provide a recommendation for future)

Note: If LCC brief you need a separate section on each phase, R&D, Procurement, O&S & Disposal

2. <u>Communicating Estimate Results</u>

Once documented, the estimate can remain viable if the documentation is kept current. In addition, the accumulated documentation can be used for tracking changes to the estimate over time.

Each product group within NAVSEA 017 has a set of unique requirements associated with their particular product. Communicating the results of an estimate conducted for a patrol craft to be built in a small Gulf Coast shipyard differs from the briefing material associated with the next generation aircraft carrier.

Mainline Product Overviews

Aircraft Carriers

AIRCRAFT CARRIERS PRODUCT OVERVIEW

Aircraft Carriers are the largest ships in the Navy. Most of the current in-service ships are NIMITZ class carriers, whose design features include:

- Two nuclear reactors
- Four shafts
- 1,092 feet long with four steam catapults
- ~ 90,000 tons displacement (full load)
- Speed of over 30 knots (35 miles per hour)
- Carry 85 aircraft
- Accommodations for 5,000 ship and air wing crew

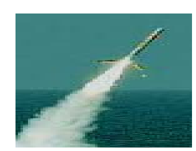
All NIMITZ Class aircraft carriers have been built by Northrop Grumman Newport News (NGNN), and have an end cost[9] of approximately $5 billion each (FY01$). Other carriers in the Navy inventory include the USS ENTERPRISE (nuclear powered with eight reactors) and JOHN F. KENNEDY (non-nuclear powered).

The **Carrier Role:** Aircraft Carriers provide a wide range of possible responses for the National Command Authority. Their mission is:

- To provide a credible, sustainable, independent forward presence and conventional deterrence in peacetime,
- To operate as the cornerstone of joint/allied maritime expeditionary forces in times of crisis, and
- To operate and support aircraft attacks on enemies, protect friendly forces and engage in sustained independent operations in war.

RELATED AIRCRAFT CARRIER COST ESTIMATING DELIVERABLES

Cost estimating deliverables include the traditional budget estimates for use in the PPBE, EAC for DAES and SAR reporting; AoAs and PLCCE documents in support of program milestones or decision points; TOC estimates in support of program execution requirements, and various other economic analyses, cost-benefit analyses, what-if drills, and special studies performed on an as needed basis for Navy decision-makers or congressional inquiry (GAO, CBO, legislative staffers, etc.). These deliverables are generally similar to the deliverables provided by other ship cost estimating groups.



APPLYING THE COST ESTIMATING TASKS

This section will guide the estimator to product specific and unique sources of data, techniques, or other differences when estimating a specific NAVSEA product. Each unique item for Aircraft Carrier is categorized by cost estimating process task. Use this product data sheet, alongside the cost estimating process described earlier in this section to provide a comprehensive view of cost estimating Aircraft Carriers.

Task 1: Initiate Estimate

New Construction Aircraft Carriers are classified as ACAT I whereas, In-Service carriers are categorized as ACAT 1C. Therefore, new construction carriers fall under the scrutiny of OSD. New construction aircraft carrier estimates are generally initiated by the Program Sponsor office of OPNAV and include the need for an AoA and milestone reviews. Most other estimate requests for New Construction or In-Service carriers come to SEA 017 via the Aircraft Carrier Program Offices. These estimates may include the PPBE estimates, Congressional SAR and DAES reports, and other specialized "what if" scenarios.

Task 2: Obtain Program Description

Understanding the program is key to the development of good estimates. This means that one must understand the program's acquisition strategy, technical definition, characteristics, design features, and technologies to be included in its design. The ideal place to start is the program's CARD. If a CARD is unavailable (e.g., during the earliest stages of the system's life cycle), the best starting place would be with the cognizant experts in the program office and the ship design supporting office. The cost estimator should work with design experts, logisticians, test and evaluation experts, financial managers, and cost estimators to develop the programmatic and technical baselines required to produce the cost estimate.

An important difference between the Aircraft Carrier and most other programs is that the Aircraft Carriers (along with submarines) are nuclear powered. The nuclear industry is a low production, highly regulated industry with a unique relationship with the Federal government. In almost all situations, SEA 08 will supply cost estimates for any nuclear related system. SEA 017 cost estimators must keep the SEA 08 staff informed of any situation that might impact the nuclear systems.

Task 3: Obtain Work Breakdown Structure

The following is a sample WBS for an aircraft carrier (new construction) used to present the cost estimate for management and review.

Cost Breakdown Structure	APPN
Development & Design Cost	
Propulsion / Electric Plant (PP/EP)	
RDT&E Funded PP/EP	
Engineering & Design	RDT&E
Design Agent & Component Dev.	RDT&E
SCN Funded Detail Design (Plans)	
Engineering & Design	SCN
Design Agent & Component Dev.	SCN
Platform Design Dev.	
RDT&E Funded	
Engineering & Design	RDT&E
Technology Dev.	RDT&E
Test & Evaluation	RDT&E
Program Support	RDT&E
SCN Funded Engineering & Design	SCN
Facilities	
Public Shipyards, Navy Bases and Sites	MILCON
Private Shipyard	SCN (included in Construction Overhead)
Construction	**SCN**
Shipbuilder	SCN
Propulsion (RP GFE)	SCN
Electronics (GFE)	SCN
Ordnance (GFE)	SCN
Hull, Maintenance, and Electrical (GFE)	SCN
Other (Program Support, & Misc)	SCN
Operation and Support Cost	
Inactivation	O&MN / SCN

Task 4: Establish Estimate Assumptions

Documenting the assumptions used in Aircraft Carrier cost estimates is similar to documenting assumptions used in other ship and weapons cost estimates. In all cases, documenting GR&A must be thorough, accurate, and complete. Proper documentation enables us to:

- Ensure the estimate is complete and professional,
- Satisfy requirements for program milestones per DOD 5000.2,
- Present a convincing picture to skeptical parties,
- Answer probing questions from various oversight groups, and
- Reconstruct the estimate at a later date, perhaps years in the future when a new estimating team is in place.

Task 5: Select Cost Estimating Methods and Tools

The cost estimating methods and tools employed by Aircraft Carrier cost estimators are similar to those used in other ship estimating groups. Exceptions to this are:

- For future carriers, a combination of earned value historical data and weight-based CERs are used to derive the production man-hours and material estimates; estimate are forward priced to the phasing of the work and then broken down into the base-dated and escalation components. Make or buy differences, accounting differences, and workload scenarios are taken into account. Shipyard labor rates are analyzed for carrier specific differences from the yard-wide rates of the Forward Price Rate (FPR) set. Throughput costs are input for items determined off-line from the model, e.g., known costs for components, etc.
- Up-front engineering and design estimates are crosschecked against shipbuilder estimates and a SEA 017 parametric model based on ship complexity analysis.
- SEA 08 provides the Reactor Plant GFE and the Nuclear Engineering and Design effort for the ship and for propulsion and electric plant component development. Non-nuclear GFE estimates are validated via an annual PARM review as a joint Program Office and SEA 017 effort.

O&S costs are estimated using the Aircraft Carrier O&S model developed jointly by a SEA 017-led team consisting of members from NGNN and subcontractors, PERA CV, Navy Activities, and NCAD. OPNAVNOTE 4700 is considered a benchmark for the industrial effort for the ship's maintenance cycle. Disposal costs are based on the ship's inactivation costs estimated by analogy to other ships along with nuclear defueling and storage costs supplied by SEA 08.

Task 6: Collect Data

Data for Aircraft Carrier estimates derive from the same data sets as available to other SEA 017 groups plus carrier cost reports, shipbuilder estimates, reports, rates, workload forecasts, workforce demographics, inflation projections, and the like. Examples include historical data from CPRs, CSDRs, weight reports, HCOST, and Forward Pricing Rates, NGNN Business Plan, etc. In the O&S area, common data sources include COMET, VAMOSC, and OARS. Unique carrier data is used to determine ship's crew workload distribution by ESWBS as well as the SMD and MER.

Task 7: Run Model and Generate Point Estimate

This step is not unique for Aircraft Carrier cost estimates except to the extent that models are unique, e.g., Parametric Design and Engineering Model, TOC Model, ROI analyses, etc.

Cost Drivers for Aircraft Carriers

- Length overall (LOA)
- Beam
- Displacements
- Draft
- Nuclear Plant Designation
- Shaft Horsepower
- Catapult Configuration
- Number of screws
- Accommodations

Task 8: Conduct Cost Risk Analysis and Incorporate into Estimate

Cost risk analysis for carrier construction consists of sensitivity analyses conducted for a range of possible outcomes as discussed between the program office, ship design participants, the shipbuilder, and SEA 08. Parameters considered in the sensitivity analyses include: schedule, design maturity, historical cost data, EVM history for the shipbuilder, technology insertion off-ramps, industrial scenario, etc.

Labor and overhead rates are subject to the fluctuations caused by shipyard workload projections, and the size of a carrier work force can greatly influence costs.

Task 9: Conduct Preliminary Estimate Review

Review of the estimate is similar for Aircraft Carrier estimates as for other SEA017 cost estimates with differences mainly in the Sponsor or Stakeholders involved, e.g., NALG and NAVAIR. Thorough reviews help to ensure successful completion of the estimates. Possible sources of reviews include: the Program Offices, supporting NAVSEA and NAVAIR activities, SEA 08, other business codes within NAVSEA, as well as other SEA 017 estimators (i.e., peer reviews)

Task 10: Produce Final Estimate

Production of the final Aircraft Carrier estimate is done in the same manner as other ship and weapon systems estimates. Exceptions are that SEA 08 must review the product before it is delivered and reviews by unique PARMs may be required, e.g., NAVAIR.

Task 11: Document Estimate

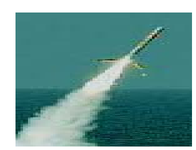
Documenting Aircraft Carrier cost estimates is similar to other ship and weapons estimates. In all cases, documentation must be thorough, accurate, and complete. Proper documentation enables us to:

- Ensure DOD 5000 requirements are met,
- Ensure professionalism and completeness of the deliverable(s),
- Provide an audit trail for future reference as well as establish historical database or library,
- Present a convincing picture to skeptical parties,
- Enhance preparedness to answer probing questions from various oversight groups, and
- Provide useful estimating data and techniques, including lessons learned to other cost estimators within SEA 017

Task 12: Brief Results

Production of the final Aircraft Carrier estimate is done in a similar manner as other ship and weapon systems estimates. One exception is that SEA 08 must be involved as well as any unique PARMs (e.g., NAVAIR) before the estimate is delivered outside of the Program Offices or SEA 017.

> Aircraft Carriers are unique in their size, small numbers, and extensive construction labor requirements.
>
> Aircraft Carriers tend to be derivative designs from previous classes, and the length of time from initiation of a new or repeat design to construction requires a careful and thorough methodology to incorporate emerging technologies.



Mainline Product Overviews

Aircraft Carriers Overhaul

AIRCRAFT CARRIER OVERHAUL PRODUCT OVERVIEW

An important milestone in a carrier's 50-year life cycle is the Refueling and Complex Overhaul (RCOH) that occurs at midlife. At this 25 year mark, an aircraft carrier undergoes a three year maintenance period to refuel its nuclear reactors, upgrade and modernize combat and communication systems, and overhaul the ship's hull, mechanical and electrical (HM&E) systems. Upon redelivery, the carrier will be ready for another 25 years of service. NGNN is the only shipyard that performs RCOHs.

RELATED COST ESTIMATING DELIVERABLES

Cost estimating deliverables include the traditional budget estimates for use in the PPBE, AoA, and PLCCE documents in support of program milestones or decision points; TOC estimates in support of program execution requirements, and various other economic analyses, cost-benefit analyses, what-if drills, and special studies performed on an as needed basis for Navy decision-makers or congressional inquiry (GAO, Congressional Budget Office (CBO), legislative staffers, etc). These deliverables are generally similar to the deliverables provided by other ship cost estimating groups.

APPLYING THE COST ESTIMATING TASKS

This section will guide the estimator to product specific and unique sources of data, techniques, or other differences when estimating a specific NAVSEA product. Each unique item for Aircraft Carrier Overhaul is categorized by cost estimating process task. Use this product data sheet, alongside the cost estimating process described earlier in this section to provide a comprehensive view of cost estimating Aircraft Carrier Overhauls.

Task 1: Initiate Estimate

In-Service carriers are categorized as ACAT 1C, and therefore do not fall under the scrutiny of OSD. Most estimate requests for RCOHs come to SEA 017 via the Aircraft Carrier Program Offices. These estimates may include the PPBE estimates, Congressional SAR and DAES reports, and other specialized "what if" scenarios.

Task 2: Obtain Program Description

Understanding the program is key to the development of good estimates. With the RCOH estimates, this task is especially important and difficult. Preceding the three years that the ship is in the yard, there is a four-year planning period. O&S records are thoroughly reviewed, and many ship systems are "opened and inspected" to determine condition and need for overhaul. The best starting place for obtaining the program description would be with the cognizant experts in the program office and the ship design supporting office. The cost estimator should work with design experts, logisticians, test and evaluation experts, financial managers, and cost estimators to develop the programmatic and technical baselines required to produce the cost estimate.

An important difference between the Aircraft Carrier and most other programs is that the Aircraft Carriers (along with submarines) are nuclear powered. The nuclear industry is a low production, highly regulated industry with a unique relationship with the Federal government. In almost all situations, Naval Nuclear Reactors (SEA 08) will supply cost estimates for any nuclear related system. SEA 017 cost estimators must keep the SEA 08 staff informed of any situation that might impact the nuclear systems.

Task 3: Obtain Work Breakdown Structure

The following WBS, abstracted from VAMOSC, is typical for an RCOH estimate.

3 Maintenance & Modernization - Depot

3 Maintenance - Scheduled - Depot

- **3.1.1 Maintenance - Scheduled - Depot - Regular Overhaul (ROH)**
  - **3.1.1.1 Maintenance - Scheduled - Depot - ROH - Public Shipyards**
    - 3.1.1.1.1 Maintenance - Scheduled - Depot - ROH - Public Shipyards - Overhead
    - 3.1.1.1.2 Maintenance - Scheduled - Depot - ROH - Public Shipyards - Labor
    - 3.1.1.1.3 Maintenance - Scheduled - Depot - ROH - Public Shipyards - Material
  - **3.1.1.2 Maintenance - Scheduled - Depot - ROH - Private Shipyards**
  - **3.1.1.3 Maintenance - Scheduled - Depot - ROH - Ship Repair Facility (SRF)**
    - 3.1.1.3.1 Maintenance - Scheduled - Depot - ROH - SRF - Overhead
    - 3.1.1.3.2 Maintenance - Scheduled - Depot - ROH - SRF - Labor
    - 3.1.1.3.3 Maintenance - Scheduled - Depot - ROH - SRF - material
- **3.1.2 Maintenance - Scheduled - Depot - Selected Restricted Availability (SRA)**
  - **3.1.2.1 Maintenance - Scheduled - Depot - SRA - Public Shipyards**
    - 3.1.2.1.1 Maintenance - Scheduled - Depot - SRA - Public Shipyards - Overhead
    - 3.1.2.1.2 Maintenance - Scheduled - Depot - SRA - Public Shipyards - Labor
    - 3.1.2.1.3 Maintenance - Scheduled - Depot - SRA - Public Shipyards - Material
  - **3.1.2.2 Maintenance - Scheduled - Depot - SRA - Private Shipyards**
  - **3.1.2.3 Maintenance - Scheduled - Depot - SRA - Ship Repair facility (SRF)**
    - 3.1.2.3.1 Maintenance - Scheduled - Depot - SRA - SRF - Overhead
    - 3.1.2.3.2 Maintenance - Scheduled - Depot - SRA - SRF - Labor
    - 3.1.2.3.3 Maintenance - Scheduled - Depot - SRA - SRF - Material
- **3.1.3 Maintenance - Scheduled - Depot - Other**

3 Fleet Modernization

- **3.3.1 Fleet Modernization - Public Shipyards**
  - **3.3.1.1 Fleet Modernization - Public Shipyards - Overhead**
  - **3.3.1.2 Fleet Modernization - Public Shipyards - Labor**
  - **3.3.1.3 Fleet Modernization - Public Shipyards - Material**
- **3.3.2 Fleet Modernization - Private Shipyards**
- **3.3.3 Fleet Modernization - Ship Repair Facility (SRF)**
  - **3.3.3.1 Fleet Modernization - SRF - Overhead**
  - **3.3.3.2 Fleet Modernization - SRF - Labor**
  - **3.3.3.3 Fleet Modernization - SRF - Material**
- **3.3.4 Centrally Provided Material**
  - **3.3.4.1 Centrally Provided Material - FMPMIS**
- **3.3.5 Other - FM**
  - **3.3.5.1 Other - FM - NAVSEA**
  - **3.3.5.2 Other - FM - Program Office**
- **3.3.6 Outfitting and Spares**

Task 4: Establish Estimate Assumptions

Documenting the assumptions used in RCOH cost estimates is similar to documenting assumptions used in cost estimates for other ship and weapons estimates. Proper documentation of GR&A enables us to:

- Ensure the estimate is complete and professional,
- Present a convincing picture to skeptical parties,
- Answer probing questions from various oversight groups, and
- Reconstruct the estimate at a later date, perhaps years in the future when a new estimating team is in place.

Task 5: Select Cost Estimating Methods & Tools

The methodology and tools employed by RCOH cost estimators are similar to those used in other ship estimating groups. Exceptions to this are:

- Up-front engineering and design estimates are cross-checked against shipbuilder estimates and a SEA 017 parametric model based on ship complexity analysis.
- Reactor Plant GFE and the Nuclear Engineering and Design effort for the ship and for propulsion and electric plant component development are provided by SEA 08.
- Non-nuclear GFE estimates are validated via an annual PARM review as a joint Program Office and SEA 017 effort.
- In-Service carriers are estimated using an approach similar to that for new construction. However, weights are generally not used as a parameter of the estimate.
- O&S costs are estimated using the Aircraft Carrier O&S model developed jointly by a SEA 017-led team consisting of members from NGNN and subcontractors, PERA CV, Navy Activities, and NCAD. OPNAVNOTE 4700 is considered as a benchmark for the industrial effort for the ship's maintenance cycle. Disposal costs are based on the ship's inactivation costs estimated by analogy to other ships along with nuclear defueling and storage costs supplied by SEA 08.

Task 6: Collect Data

Data for RCOH estimates derive from the same data sets as available to other SEA 017 groups plus carrier cost reports, shipbuilder estimates, reports, rates, workload forecasts, workforce demographics, inflation projections and the like. Examples include historical data from CPRs, weight reports, HCOST, and Forward Pricing Rates, NGNN Business Plan, etc. In the O&S area, common data sources include COMET, VAMOSC, and OARS. Unique carrier data, the Ship's Manning Document (SMD) and Manpower Estimate Report (MER) are used to determine ship's crew workload distribution by ESWBS.

Cost Drivers
for Aircraft Carriers Overhauls

- Length overall (LOA)
- Beam
- Displacements
- Draft
- Nuclear Plant Designation
- Shaft Horsepower
- Catapult Configuration
- Number of screws
- Accommodations

Task 7: Run Model and Generate Point Estimate

This step is not unique for RCOH cost estimates except to the extent that models are unique, e.g., Parametric Design and Engineering Model, TOC Model, ROI analyses, etc.

Task 8: Conduct Cost Risk Analysis and Incorporate into Estimate

Cost risk analysis for carrier construction consists of sensitivity analyses conducted for a range of possible outcomes as discussed between the program office, ship design participants, the shipbuilder, and SEA 08. Parameters considered in the sensitivity analyses include: schedule, design maturity, historical cost data, EVM history for the Shipbuilder, technology insertion off-ramps, industrial scenario, etc.

Other areas of risk include labor and overhead rate fluctuations caused by shipyard workload projections; given the size of a carrier's work force, these fluctuations can produce large effects on costs.

Task 9: Conduct Preliminary Estimate Review

Review of the estimate is similar for Aircraft Carrier estimates as for other SEA017 cost estimates with differences mainly in the Sponsor or Stakeholders involved, e.g., Navy Aviation Leadership Group (NALG) and NAVAIR. Thorough reviews help to ensure successful completion of the estimates. Possible sources of reviews include: the Program Offices, supporting NAVSEA and NAVAIR activities, Naval Reactors, other business codes within NAVSEA, as well as other SEA 017 estimators (i.e., peer reviews).

Task 10: Produce Final Estimate

Production of the final RCOH estimate is done in the same manner as other ship and weapon systems estimates. Exceptions are that SEA 08 must review the product before it is delivered and reviews by unique PARMs may be required, e.g., NAVAIR.

Task 11: Document Estimate

Documenting RCOH cost estimates is similar to documenting assumptions used in cost estimates for other ship and weapons estimates. In all cases, documentation must be thorough, accurate, and complete. Proper documentation enables us to:

- Ensure professionalism and completeness of the product,
- Provide an audit trail for future reference as well as establish historical database or library,
- Enhance preparedness to answer probing questions from various oversight groups, and
- Provide useful estimating data and techniques, including lessons learned to other cost estimators within SEA 017.

Task 12: Brief Results

Carrier estimates are presented in a manner similar to estimate presentations for other NAVSEA product areas. Estimate presentations may vary in structure and depth depending on the target audience. As is the case with submarine cost estimates, RCOH estimates also need to be presented to SEA 08.

Mainline Product Overviews

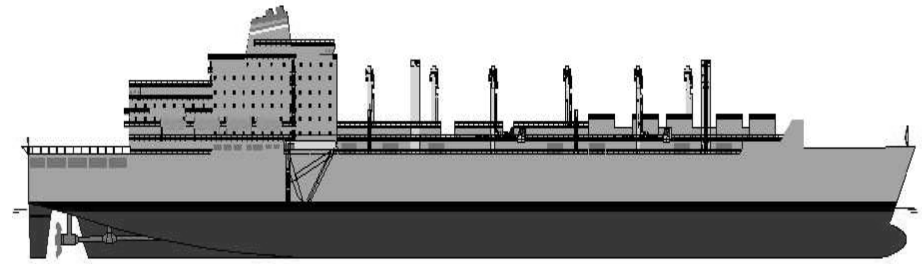
Amphibious & Auxiliary Ships

PRODUCT OVERVIEW

Amphibious and Auxiliary Ships make up the majority of the ships of the US Navy. Amphibious Ships are designed to deliver Marines and weapons directly ashore, either by smaller craft or by beaching their landing ramps on the shore. Auxiliary ships come in a number of designs, but in general, they are similar to commercial ships and carry logistics and replacement materials for the Fleet, like fuel, ammunition, supplies, etc.

Cost estimates for Amphibious and Auxiliary Ships include the subsystems such as combat and weapons systems, machinery systems, auxiliary systems, communications, cargo handling, equipment loading and sometimes, aviation facilities. Combat and weapons systems can be provided to the ship as GFE or as CFE depending on the acquisition strategy.

The diagram below shows a sample Auxiliary Ship with each of the types of systems that an estimator may be asked to estimate.



Dimensions Communications Machinery Systems Underway Replenishment
Performance Aviation Facilities Auxiliary Systems Cargo Capacity

The Amphibious and Auxiliary Role

The role of the Amphibious and Auxiliary Ships (L and A ships) is to provide critical delivery of personnel and equipment in support of the fleet and directed operations. The provisioning mission of these ships literally permits the functioning of the rest of the fleet. Cost drivers for Amphibious and Auxiliary Ships are combat and weapon systems, propulsion systems and survivability. Auxiliary Ships can be built to military standards, whose costs are driven by the amount of cargo, aircraft and troops it can hold. Auxiliary Ships can also be built to commercial standards and can be military manned or commercial manned. For Amphibious and Auxiliaries ships, combat systems costs, including integration, are derived from the SEA017 combat systems division or from GFE estimates from the program office.

RELATED COST ESTIMATING DELIVERABLES

Cost estimating deliverables include the traditional budget estimates for use in the PPBE, AOA and PLCCE documents in support of program milestones or decision points; TOC estimates in support of program execution requirements, and various other economic analyses, cost-benefit analyses, what-if drills, and special studies performed on an as needed basis for Navy decision-makers or congressional inquiry (GAO, CBO, legislative staffers, etc.). These deliverables are generally similar to the deliverables provided by other ship cost estimating groups.

APPLYING THE COST ESTIMATING TASKS

This section will guide the estimator to product specific and unique sources of data, techniques, or other differences when estimating a specific NAVSEA product. Each unique item for Amphibious and Auxiliary Ships is categorized by cost estimating process task. Use this product data sheet, alongside the cost estimating process described earlier in this section to provide a comprehensive view of cost estimating Amphibious and Auxiliary Ships.

Task 1: Initiate Estimate

When the estimator is collecting data to understand the program, they should understand that of the four main private shipyards currently available to build non-nuclear surface ships, two (Ingalls and Avondale) are part of the NGSS Business Unit, and two (NASSCO and Bath Iron Works) are part of the General Dynamics Corporation. Historically, Northrop Grumman Ship Systems and General Dynamics/Bath Iron Works have built surface combatants, while NASSCO and Avondale have built Amphibious and Auxiliaries Ships. With new non-nuclear surface ship acquisition initiatives like Joint Venture and WestPac Express, the cost estimator would need to go to shipyards or sources that had actually built these vessels.

Task 2: Obtain Product Description

Understanding the program is key to the development of good estimates. This means that one must understand the program acquisition strategy, technical definition, characteristics, design features, and technologies to be included in its design. The ideal place to start is the program's CARD. If a CARD is unavailable (e.g., during the earliest stages of the system's life cycle), the best starting place would be with the cognizant experts in the program office and the ship design supporting office. The cost estimator should work with design experts, logisticians, test and evaluation experts, financial managers, and cost estimators to develop the programmatic and technical baselines required to produce the cost estimate.

Task 3: Obtain Work Breakdown Structure

The WBS for the shipbuilder portion of Amphibious and Auxiliary Ships is traditionally the ESWBS as described as part of the basic cost estimating process. The P-5 or P-8 Budget Exhibit is usually the standard rollup structure for end cost, the Basic Construction Cost is the primary category for shipbuilder costs, with the other categories being Plans and Change Orders, as well as Escalation for base-dated estimates. Consult the Weapons Systems template for more details on the non-shipbuilder categories.

It is also important to note that shipyards structure their cost by contract line item numbers (CLIN), whereas the Navy uses SWBS. The shipyard attempts to map CLIN data into SWBS, however; the cost estimator should carefully examine this cost allocation as this mapping can be a source of major cost data differences between shipyards.

Task 4: Establish Estimate Assumptions

Amphibious and Auxiliary Ships are built to military or commercial standards with designs to enhance survivability in hostile environments. Estimating these ships, a cost engineer may find some unique challenges in terms of technical and programmatic aspects of these ships. These unique features are as follows:

- Amphibious and auxiliary ships are generally less dense, i.e., less equipment are packed per square foot for less weight than other surface ships. This creates different labor hours for installations. Finding a CER from a ship class with similar features is important. Key features to look for are aviation facilities and well decks, as well as amount of vehicle and cargo spaces.
- Amphibious and auxiliary ships also contain simpler structure with more flat, thicker plate steel. These features also allow for lower labor hours for construction in hull structure SWBS groups than seen on surface combatants.
- Many of the systems or subsystems are associated with cargo handling and equipment movement.
- Ship integration is a major cost driver for all surface ships. Ship wide area networks, total ship computing environment, and the total ship systems testing, cost of testing facility and the mobile test team should be carefully considered.
- Many systems are evolutionary, using open architecture and plug and play components that are subject to spiral development. Continuous systems upgrades require sizable recurring engineering effort on follow-on ships.
- For new technology, it must be determined if it is funded with R&D dollars or SCN dollars. In general, Amphibious and Auxiliary Ship classes have significantly less developmental items (R&D funded) than Surface Combatants or nuclear ships.
- Amphibious Ships are typically not as complex as Surface Combatants, but they are still built to robust military standards because they operate in hostile environments and carry high value cargo.
- Auxiliary ships are normally built to less stringent commercial (i.e., ABS and USCG) standards because they either operate in a non-hostile environment or are under the protective umbrella of the battle group.
- The Navy typically does not buy as many Auxiliary and/or Amphibious Ships as they do Surface Combatants, so serial production is harder to come by. The spacing between hull construction starts (every 3-4 years) does not allow for rapid or consistent learning. This makes determining learning curves and production labor more difficult.

Task 5: Select Cost Estimating Methods and Tools

As is the case with any cost estimate, various cost estimating methods can be appropriate for different cost elements in an estimate. SEA 017 has resident performance and/or weight-based models to help estimate the cost of Amphibious and Auxiliary Ships. In some cases special relationships have been developed for estimating the costs of these types of ships.

When preparing to run a shipbuilder cost model, the estimator needs to obtain labor and overhead rates from the Industrial Base Group, which will require inputs from the estimator, and time to incorporate the rates before results are obtained to complete the estimate. For some of the newer smaller Auxiliary Ships, the possibility that these ships may be built in other than one of the traditional "big-six" shipyards exists. This means that SEA 017 may not have as detailed of information on the labor and overhead rates as it does for the larger shipyards with which the Navy has traditionally worked.

Utilization of earned value historical data and weight-based CERs from Amphibious and Auxiliary Ships are used to derive the production man-hours and material estimates. Estimates are forward priced to the phasing of the work and then broken down into the base-dated and escalation components. Make or buy differences, accounting differences and workload scenarios are taken into account. Throughput costs are input for items determined off-line from the model, e.g., known costs for components, etc. Existing performance and/or weight-based models are selected as available. In some cases special relationships have been developed for estimating these types of ships.

Task 6: Collect data

There is no real difference in this task from estimating other products. When the estimator is collecting data they should understand that of the four main private shipyards currently available to build Amphibious and Auxiliary Ships, two (Ingalls and Avondale) are part of the NGSS Business Unit, and two (NASSCO and Bath Iron Works) are part of the General Dynamics Corporation. Historically, Northrop Grumman Ship Systems (NGSS) and General Dynamics/Bath Iron Works have built Surface Combatants, while NASSCO and Avondale have built Auxiliaries and Amphibious ships.

Data from a number of different ship classes may be used to develop estimates. In particular, when estimating the cost of a specific component (e.g., main propulsion, cargo handling gear), several platforms may be similar and therefore appropriate as cost analogies. The estimator may need to collect information relating to the differences between the current ship and the baseline ships from which the CERs were created. Shipbuilders and industry studies can be the source of such information.

When developing CERs and establishing estimating ranges, care must be taken to either utilize data specific to the shipyard or to normalize data from other shipyards to make the comparison accurate. If the possibility exists for the ship to be constructed in multiple shipyards, the estimator should be careful when applying yard-specific data as the basis of one's estimate.

Task 7: Run Model and Generate Point Estimates

The model execution and estimate development is generally the same as other products. Specific models have been developed to address acquisition of Amphibious and Auxiliary Ships in a commercial standards environment. Other models address O&S and finally life cycle cost.

Task 8: Conduct Cost Risk Analysis and Incorporate into Estimate

In many cases, specific risk analyses may be required prior to ship contract award. Some options that may be included to minimize risks may include development of technology off-ramps or Engineering Development Models (EDMs). Estimators may need to research the technical risks in the program and ensure that a technical risk analysis effort is being conducted. Unique risk areas for Amphibious and Auxiliary Ships arise from the fact that their acquisitions are normally evolutionary and rely on off-the-shelf products.

Tasks 9: Conduct Preliminary Estimate Review

Review of the estimate is similar for Amphibious and Auxiliary Ships estimates as for other SEA 017 cost estimates with differences mainly in the Sponsor or Stakeholders involved. Thorough reviews help to ensure successful completion of the estimates. Possible sources of reviews include: the Program Offices, other business codes within NAVSEA, as well as other SEA 017 estimators (i.e., peer reviews).

Task 10: Produce Final Estimate

Production of the final Amphibious and Auxiliary Ships estimate is done in the same manner as other ship and weapon systems estimates. As Navy platforms become candidates for use by other services, such as the Military Sealift Command, there may be changes to the structure and presentations to respond to additional requirements.

Task 11: Document Estimate

Documenting Amphibious and Auxiliary Ship cost estimates is similar to documenting assumptions used in cost estimates for other SEA 017 estimates. In all cases, documentation must be thorough, accurate, and complete. Proper documentation enables us to:

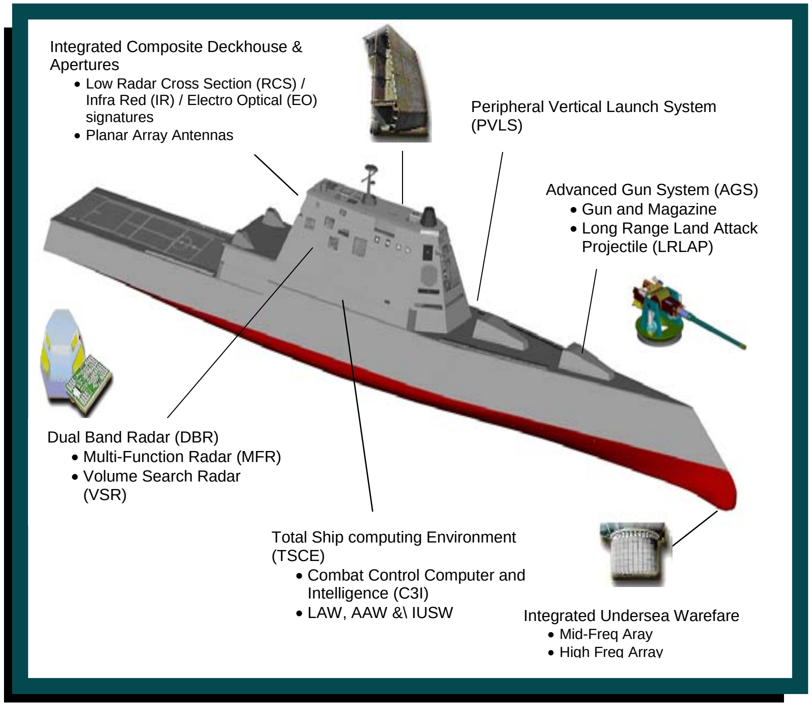
- Ensure DOD 5000 requirements are met,
- Ensure professionalism and completeness of the product,
- Provide an audit trail for future reference as well as establish historical database or library,
- Present a convincing picture to skeptical parties,
- Enhance preparedness to answer probing questions from various oversight groups, and
- Provide useful estimating data and techniques to other cost estimators within SEA 017.

Task 12: Brief Results

Presentation of Amphibious and Auxiliary Ship estimates is similar to estimate presentations for other NAVSEA product areas. As is the case with final estimate production (Task 10), estimate presentations may vary in structure and depth depending on the target audience (e.g., briefings for other services).

Mainline Product Overviews

Combat and Weapons Systems



COMBAT AND WEAPON SYSTEMS PRODUCT OVERVIEW

Combat and Weapons Systems include Radars, Sonars, Combat Systems, Fire Control, Weapons Control, Electronic Warfare, Mine-Hunting, Torpedoes, Missiles and Missile Launch Systems. The cost of these systems is included as part of the total ship cost estimate. However, combat and Weapon Systems are often their own ACAT program and therefore their cost estimates are also reported separately. Combat and Weapon Systems can be provided to the ship as GFE or as CFE depending on the acquisition strategy. For example, DD(X) Combat and Weapons Systems are mostly CFE while DDG systems are GFE. Some mission combat systems are stand-alone modules (e.g., LCS). Stand-alone modules are brought onto the ship for a specific mission and are not permanently installed into the ship.

Combat and Weapon Systems can be procured for both forward-fit (new ships) and back-fit (ships already in the fleet). This has implications for the cost estimator, as he/she must be cognizant of the type of appropriation (color of money) used. Systems procured for forward-fit are normally procured with the Ship Construction and Conversion, Navy (SCN) appropriation and back-fit systems are procured with Other Procurement, Navy (OPN) funds, although exceptions to this occur[10]. Installation costs are also a consideration. Installation costs for forward-fit usually are included as part of the ship's end cost but may be installed in a post delivery availability. However, installation costs must be included in the Combat and Weapon Systems for back-fit systems in estimates of OPN(or WPN) requirements. If the system is installed outside the SCN window, OPN must be used to procure the system.

Combat and Weapons systems are becoming more software intensive, thus a major element of Weapons and Combat Systems cost estimating is software cost estimating (see Section 5 for Software Cost Estimating methodologies).

Combat and Weapons Systems often have shorter procurement and manufacturing times than the ship. Therefore, to meet the planned installation schedule of the system the commencement of the procurement and manufacture of the system is often one to four years after the start of construction of the ship. This has an impact on the escalation factors that are applied to the combat or weapons system.

The illustrations on this page show an exploded diagram of the Standard Missile with the major sections identified and the Surface Ship Defense System (SSDS). The SSDS is a combat system for several classes of surface combatants including LSD, LPD, LHD, and CVN68 Class ships.

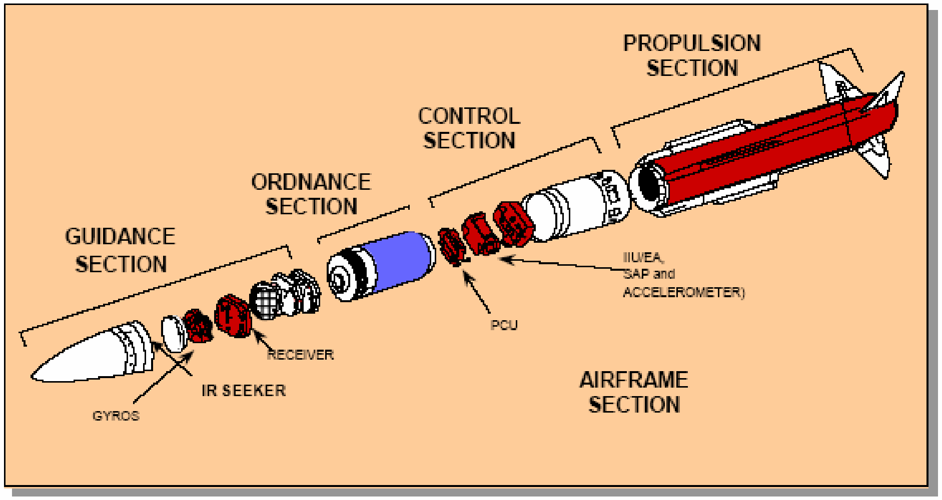
See _Janes_ for descriptions of various Combat and Weapon Systems.

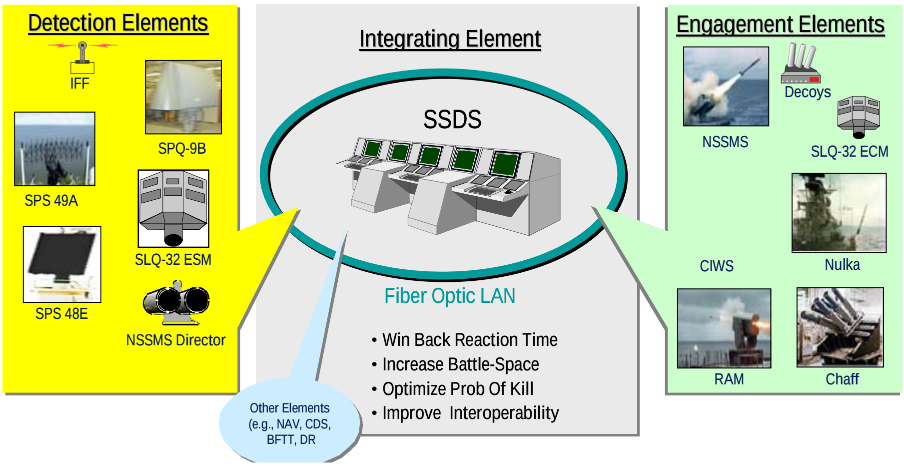
COMBAT AND WEAPONS SYSTEMS COST ESTIMATING DELIVERABLES

Most Combat and Weapon System estimates are traditional LCC or PLCCEs. Often, Combat and Weapons systems procurement estimates for a ship are allocated to the Electronics or Ordnance portions of the ship P5 Exhibit. As mentioned previously, the Combat and Weapon System may be identified as GFE on the ship. If so, a 7300 Form is used to accumulate the system's hardware and other costs required to support the system's procurement. The 7300 Form is provided to the ship cost estimator. Combat and Weapon System cost estimates for back-fit to a ship are programmed into the Navy's Fleet Modernization Program (FMP) database.

APPLYING THE COST ESTIMATING TASKS

This section will guide the estimator to product specific and unique sources of data, techniques, or other differences when estimating a specific NAVSEA product. Each unique item for Combat and Weapons Systems is categorized by cost estimating process task. Use this product data sheet, alongside the cost estimating process described earlier in this section to provide a comprehensive view of cost estimating Combat and Weapons System.





Task 1: Initiate Estimate

Since Combat and Weapon Systems cost estimates are part of the ship cost estimates but often their own ACAT program as well, the combat and weapons cost estimator may be tasked for cost estimates by his/her ship cost estimator counterparts as well as the combat and weapons system program office. As with all estimates, expectations must be established with the customer as well as with NAVSEA 017 leadership.

Task 2: Obtain Program Description

Usually, the PM provides a description of the Combat and Weapon System. However, often a good description is not available, and the SEA 017 cost estimator must work with the PM and the technical community to define the system. Other sources of technical descriptions for a product may include: interviews with the engineers, the preliminary or final CARD, technical baseline documents, contractor-supplied information, and software development plans.

Task 3: Obtain Work Breakdown Structure

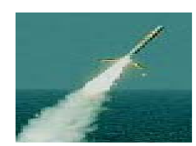
Like the program description, the WBS structure is often not available when an estimate is requested. The cost estimator will often need to work with the program office and the technical community to help develop the WBS. When the Combat and Weapon System is also GFE on a ship, an additional cost breakdown structure, a 7300 Form is completed. See Appendix F for the 7300 Form and definition of the cost elements. A PARM manages each GFE system. The 7300 Form is provided to the ship cost estimator after approval by the TWH and the PARM.

The WBS provided in this section is a sample for a Combat and Weapon System. While it is generic in nature for weapons and combat systems, it includes the major categories of cost the analyst must include. It will require tailoring (adding additional depth) for the specific system.

Also, some cost estimates may not require a full LCC estimate and may focus on only development or production or O&S costs.

Be aware that O&S costs can vary greatly. Radars are operating at some level all the time, while a single torpedo may only be fired during an exercise once every two years or so.

WBS #	Title / Description	WBS #	Title / Description
1.0	Combat or Weapons System	1.2.1.3	Integration, Test & Eval.
1.1	**Development**	1.2.1.4	Integrated Logistics Support
1.1.1	Contractor	1.2.1.5	Data
1.1.1.1	Prime Mission Equipment	1.2.1.6	Support Equipment
1.1.1.2	PM/SE	1.2.1.7	Facilities
1.1.1.3	Integration, Test & Eval.	1.2.1.8	Initial Spares
1.1.1.4	Integrated Logistics Support	1.2.2	Government
1.1.1.5	Data	1.2.2.1	Prime Mission Equipment
1.1.1.6	Support Equipment	1.2.2.2	PM/SE
1.1.1.7	Facilities	1.2.2.3	Integration, Test & Eval.
1.1.1.8	Initial Spares	1.2.2.4	Integrated Logistics Support
1.1.2	Government	1.2.2.5	Data
1.1.2.1	Prime Mission Equipment	1.2.2.6	Support Equipment
1.1.2.2	PM/SE	1.2.2.7	Facilities
1.1.2.3	Integration, Test & Eval.	1.2.2.8	Initial Spares
1.1.2.4	Integrated Logistics Support	1.3	**Operations & Support**
1.1.2.5	Data	1.3.1	Mission Personnel
1.1.2.6	Support Equipment	1.3.2	Unit Operations
1.1.2.7	Facilities	1.3.3	Maintenance
1.1.2.8	Initial Spares	1.3.4	Sustaining Support
1.2	**Production**	1.3.5	Continuing System Improvements
1.2.1	Contractor	1.3.6	Indirect Support
1.2.1.1	Prime Mission Equipment		
1.2.1.2	PM/SE		



Task 4: Establish Estimate Assumptions

Many assumptions for the Combat and Weapon Systems are common and developed jointly with the ship cost estimators. These include economic assumptions such as the year dollars to base the estimate, accounting decisions (what costs are accounted for where), and budgeting policies. The acquisition strategy may be different since combat and weapons systems are often procured under separate contracts. The procurement profile may be the same for the ship and the weapons and combat systems, though it may be different due to additional combat and weapons systems may be procured for other ship classes. Also, the length of time required to build a ship (4-9 years) is usually much longer than required for a Combat and Weapon System (2-3 years). Therefore, the Combat and Weapon System may not need to be procured until several years after the ship is procured. In addition, due to the length of the ship construction, there may need to be a Technology Refresh to update the Combat and Weapon System prior to the Ship IOC to replace obsolete parts.

Task 5: Select Cost Estimating Methods and Tools

Combat and Weapon System estimating methods and tools are generally the same as other methods and tools used for other product estimates at NAVSEA. Generally analogies are used for both primary and cross check estimates. Software estimating is an important part of the combat and weapons system estimate. More information on software estimating is provided in Section 5.

Task 6: Collect Data

In addition to Task 2 information, common sources of data for a combat and weapon system include:

- Contractors via various cost reports: CPRs, C/SSRs, CCDRs, FCHRs, and SRDRs.
- Contractor basis of estimates (BOEs) from their LCC estimates and cost proposals.

One difference between combat and weapons systems and other products is that many other products do not use C/SSRs or SRDRs in contractor reporting.

For Combat and Weapon Systems, SEA 017 collects and archives data in the Electronics Database (EDB). Increasingly, missile, torpedo, and software data is also being collected and included in internal databases.

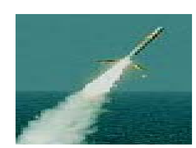
Task 7: Run Model and Generate Point Estimate

Combat and Weapon Systems cost estimators generally use procedures similar to ship estimators to generate a point estimate. The one area that is sometimes unique is software cost estimating. Because Combat and Weapon Systems are generally software intensive, it is not unusual for a software estimate to be conducted in a separate model and then combined with the overall product estimate.

Another unique aspect of estimating a Combat and Weapon System is that it may be estimated as a subsystem to another platform. If this is the case, the estimate may be part of a larger estimate, which may affect how a model is selected and the point estimate is generated.

Task 8: Conduct Cost Risk Analysis and Incorporate into Estimate

Risk analysis is similar for ships and Combat and Weapon Systems. What is different are the specific risks. If the program has developed a Risk Management Plan, risks from that process should be analyzed and included. These can include schedules, vendor stability, and test failures. For hardware, these risks can include: yield rates on radar MMICs and sonar transducers, cost improvement and rate curve factors; For software, modified and reused software factors, productivity factors, labor rates, software (SLOC) growth are typical sources of risk.



Task 9: Conduct Preliminary Estimate Review

Review of the estimate is similar for Combat and Weapons Systems estimates as for other SEA017 cost estimates with differences mainly in the Sponsor or Stakeholders involved. Thorough reviews help to ensure successful completion of the estimates. Possible sources of review include: the ship, combat system, and weapon system Program Offices, other business codes within NAVSEA, as well as other SEA 017 estimators (i.e., peer reviews).

Task 10: Produce Final Estimate

Production of the final Combat and Weapons Systems estimate is done in a manner similar to other SEA 017 estimates. The final format of a combat or weapon system estimate may vary depending on who furnishes the system (GFE/CFE), whether it is for inclusion in a ship cost estimate or not, and whether it is for a forward fit or back fit.

Task 11: Document Estimate

Documenting Combat and Weapons System cost estimates is similar to documenting assumptions used in cost estimates for other ship and weapons estimates. In all cases, documentation must be thorough, accurate, and complete. Proper documentation enables us to:

- Ensure DOD 5000 requirements are met,
- Ensure professionalism and completeness of the product,
- Provide an audit trail for future reference as well as establish historical database or library,
- Present a convincing picture to skeptical parties,
- Enhance preparedness to answer probing questions from various oversight groups, and
- Provide useful estimating data and techniques to other cost estimators within SEA 017.

Task 12: Brief Results

This step is not unique for Combat and Weapons System cost estimates. The only variance is based on differences in the target audiences.

Mainline Product Overviews

Submarines

SUBMARINE PRODUCT OVERVIEW

The core of the U.S. Navy's nuclear deterrent capability is its fleet of Ohio-class submarines that carry Trident II nuclear missiles, which can strike targets at a range of 4,600 miles. Ohio-class submarines remain on patrol at sea at all times, and they are nearly undetectable by sonar and other types of sensors. The U.S. Navy also has over 50 attack submarines. These powerful, quiet submarines can sink enemy submarines and ships with torpedoes, lay mines off enemy ports, monitor enemy ships and coastal activities, deploy and support special operations units, and launch cruise missile strikes against land targets.

Estimating life cycle costs of submarines is in many respects similar to surface ship estimation. The major discriminating factors are nuclear propulsion and the need for stealth (detection avoidance quieting technologies).

U.S. Submarine Force Role

The primary roles and missions for the U.S. submarine force are:

- Surveillance and Intelligence: Submarines carry complex sensor packages in order to routinely conduct intelligence, surveillance, and reconnaissance (ISR) missions. In the future, submarines may also use Autonomous Undersea Vehicles to conduct ISR operations in areas where it may be unsafe for a submarine to venture.
- Special Operations: Submarines provide covert delivery of commandos, reconnaissance teams, and agents on high-risk missions.
- Precision Strike: Submarines operate as part of an integrated strike force, conducting long-range, precision strike with conventional warheads (Tomahawk Land-Attack Missiles) against shore targets.
- Battle Group Operations: Attack submarines are integrated into Navy battle group operations. Usually each battle group has two attack submarines that participate with the battle group in all pre-deployment operational training and exercises.
- Sea Denial: Submarines use torpedoes, missiles, and mines to stop enemy surface ships and submarines from using the seas.

SUBMARINE SYSTEMS COST ESTIMATING DELIVERABLES

As is the case for most NAVSEA platforms, most cost estimating products for submarines are traditional LCC estimates or what-if drills conducted by varying key parameters such as the purchase quantity or schedule. Development of these estimates follows the traditional 12-step cost estimating process described earlier in this Section. The following section highlights considerations specific to submarine cost estimation.

APPLYING THE COST ESTIMATING TASKS

This section will guide the estimator to product specific and unique sources of data, techniques, or other differences when estimating cost for Submarine systems. Each unique item for Submarines is categorized by cost estimating process task. Use this product data sheet, alongside the cost estimating process described earlier in this section to provide a comprehensive view of cost estimating Submarine systems.

Task 1: Initiate Estimate

Submarine estimates for major program milestone are initiated by OSD and the PM's direction. Many cost drills are requested by PM and PEO staff, OPNAV. New designs are may be obtained from SEA 05 staff.

Task 2: Obtain Program Description

Understanding the program is key to development of good estimates. The ideal place to start is the program's CARD. Since estimators often have to develop their estimates before a formal CARD is in place, alternative strategies may be needed to gather the necessary information. When a CARD is unavailable, the most comprehensive starting place should be the program office and/or Engineering Directorate (SEA 05). The estimator should work with program office staff (including engineers and logisticians) to develop programmatic and technical baselines for the program.

Programmatic baseline information such as the POA&M and procurement profiles can be found in program office overview presentations as well as the program's acquisition strategy.

Technical baseline information can be gathered by working with staff within the program office, the shipyards, and the contractor design community. Submarines have important unique technical considerations that drive costs. The following areas must be kept in mind when developing a submarine cost estimate:

1. Nuclear implications – redundancy; specialized steel, valves, and testing
2. Quieting technologies to aid detection avoidance (e.g., special hull treatments)
3. Tight design tolerances due to space constraints
4. Teaming arrangements or dual awards to maintain the industrial base
    a. Teaming can make programs cost more depending on the scenario. If two shipyards team to make different sections of each submarine produced and one of them also integrates the sections prior to delivery then there can be additional costs for transportation, testing, and inefficient sequencing.
    b. Differences in each shipyard's labor and overhead rates can also affect the cost estimate.

The nuclear industry is a low production, highly regulated industry with a unique relationship with the federal government. In almost all situations, SEA 08 will supply cost estimates for any nuclear related system. SEA 017 cost estimators must keep the SEA 08 staff informed of any situation that might impact the nuclear systems.

Task 3: Obtain Work Breakdown Structure (WBS)

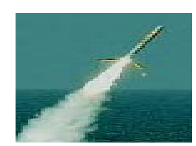
The following are examples of submarine program WBSs for design and procurement. While they are not standard, they are a good starting place when developing your program's WBS. Please note that these structures do not address the O&S cost elements. As is the case with the other NAVSEA product cost estimates, submarine cost estimates follow OSD CAIG guidance for O&S estimates.

The first example is for a new construction submarine program.

PLANS	ELECTRONICS (cont.)
Supship Groton	CWITT
96c2100 perf incentive	NPES SE&I
IPPD 96 (Detail Design)	MISC Electronics
96c2100 overrun	**HM&E**
ILS Support	MPC
Support Taskings	Propulsor
Acquisition Management	Steam & Electric Plant Equip
EB/NNS Design Build	VLS PSE
SUPSHIP	T&E
BASIC CONSTRUCTION	HM&E Installation & Testing
Contract P-Mod	CSA MK2
SHT	SUPSHIP responsible materials
KAPL D-TO-I	**PROPULSION EQUIP**
96c2100 construction overrun *	
Technology Obsolescence	**OTHER**
BASIC: CHANGE ORDERS	ILS SUPPORT
Definitized (Contract)	Support Taskings
Undefinitized (Contract)	Commissioning & Berthing
Technology Insertion	Curricula Development
ELECTRONICS	Outfitting & Post Delivery
Sonar, Combat Control & Arch	
ESM	
Photonics Mast	
UMMs	
SRWS	
System Level Activities	
AN/BPS-16	
Navigation	
AN/UQY-70	
ECS	

The next example is for a submarine conversion program.

RDT&E	SCN (cont.)
Design Studies	**Conversion Manufacturing**
GFE Design	Conversion Material
Sys Eng & Prog Mgt	EB Manufacturing Labor
Attack Weapons System Design	**Conversion Installation**
AWS Concept Exploration and Risk Reduction	**Other GFE Procurement**
MAC	**Overhaul and Associated Costs**
ETS/Integration SE&I	ERO
Facilities/Logistics/Crew Cert	NUC ALTS
T&E/LFT&E	NON-NUC ALTS
Other RDT&E	Reactor Cores
Hydro/Submerged Op Envelope	
Marginal Utility Analysis	**Outfitting & Post Delivery**
System Safety	**OPN**
Ship Control	**REACTOR CORES**
Ship Detail Design	
Attack Weapons System	
AWCS Development & Procurement	
MAC Procurement	
Trainers	
Facilities/Logistics/Crew Cert SE&I	
Sys Eng and Prog Mgt	
T&E	
Conversion Manufacturing	
Conversion Material	
EB Manufacturing Labor	
Conversion Installation	
Other GFE Procurement	
Overhaul and Associated Costs	



Task 4: Establish Estimate Assumptions

Documenting assumptions enables the reader to understand what a cost estimate represents. Apart from traditional ground rules and assumptions, submarine estimates should also document assumptions like the following if they apply:

1. Public Yard rates from SEA 04,
2. Hull-specific rates developed by SEA 017's Industrial Base Group based on the private yard's latest approved FPRA,
3. Teaming arrangement with more than a shipyard, and
4. The nuclear component is estimated as a throughput from SEA 08.

Task 5: Select Cost Estimating Methods & Tools

Submarine estimates are developed using similar methods and tools as the other product estimates at NAVSEA. Most CERs used in developing submarine estimates are not weight based; instead they are based on the most useful parameter available. For example, the surface area of a special hull treatment may be the independent parameter used in estimating the procurement cost of the hull treatment.

Like other ship system estimates, submarine estimates take "make or buy" differences, accounting differences and workload scenarios into account. Shipyard labor rates used in these estimates are specifically developed to account for submarine specific differences from the yard wide rates of an FPRA rate set. The nuclear component of submarines is unlike anything on other ships. SEA 08 provides estimates for Reactor Plant GFE, Nuclear Engineering and Design effort, and development of the Electric Plant component.

Task 6: Collect Data

Submarine estimates are generally developed using similar data sets as the other product estimates at NAVSEA. Specifically, submarine estimates utilize historical data formally collected from contractors as well as previous milestone documentation, program briefs to the CAIG, and weight reports.

Task 7: Run Model and Generate Point Estimate

This step is not unique for submarine cost estimates. Please refer to the corresponding task write up in the basic cost estimating process description provided earlier in this section.

Task 8: Conduct Cost Risk Analysis and Incorporate into Estimate

As is the case with cost-risk analysis in general, the estimator must identify drivers that affect the submarine cost estimate. For submarine programs drivers to consider have been listed in the Cost Drivers for Submarines sidebar.

Cost Drivers for Submarines

- Length overall (LOA)
- Beam
- Displacements
- Draft
- Propulsion Type
- Shaft Horsepower
- Weapons configuration
- Integration method (2 yards)
- Quieting
- Speed
- Depth
- Acquisition Strategy (one vs. two shipyards)
- SUBSAFE Certification
- Shock Testing
- Environmental nuclear disposal
- Exotic welding materials
- Special hull treatments

Task 9: Conduct Preliminary Estimate Review

Submarine estimate review follows the same process as that for other NAVSEA product estimates. Depending on the purpose of the estimate and its audience the estimate may be reviewed by the analyst (for routine drills), the team leader, the group director, or by the SEA 017 Director for estimates leaving NAVSEA such as a CAIG estimate. Since the nuclear component of the estimate is developed by SEA 08 and is used as a throughput in the SEA 017 estimate, SEA 08 also has review authority in submarine estimates. The estimator also has at his disposal the Submarine Performance Based Cost Model (PBCM) a performance based tool originally developed at NSWC Carderock, that can assess rough submarine costs based on varying characteristics and provide insight into cost drivers and where "knees" in cost curves occur. This tool is always good to utilize as a double check of a detailed estimate.

Task 10: Produce Final Estimate

Production of the final submarine estimate is done in the same manner as other ship and weapon systems estimates. An exception is that SEA 08 must review the product before it is delivered any further.

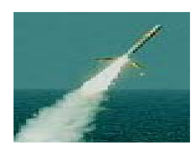
Task 11: Document Estimate

Documenting submarine cost estimates is similar to documenting assumptions used in cost estimates for other ship and weapons estimates. In all cases, documentation must be thorough, accurate, and complete. Proper documentation enables us to:

- Ensure DOD 5000 requirements are met,
- Ensure professionalism and completeness of the product,
- Provide an audit trail for future reference as well as establish historical database or library,
- Present a convincing picture to skeptical parties,
- Enhance preparedness to answer probing questions from various oversight groups, and
- Provide useful estimating data and techniques to other cost estimators within SEA 017.

Task 12: Brief Results

Submarine estimates are presented in a manner similar to estimate presentations for other NAVSEA product areas. Estimate presentations may vary in structure and depth depending on the target audience. As is the case with preliminary estimate review (Task 9), the estimate may also need to be presented to SEA 08.



Mainline Product Overviews

Surface Combatants

SURFACE COMBATANTS PRODUCT OVERVIEW

Non-nuclear naval vessels are categorized into Surface Combatants, Amphibious and Auxiliary ships, and Boats and Craft. Non-nuclear surface combatants perform most Navy missions including land attack, anti-surface ship strike, anti-submarine warfare and anti-aircraft warfare. Many new construction shipyards have the ability to produce theses vessels. Surface Combatants include Frigates, Destroyers, Cruisers, and Littoral Combat Support (LCS) ships. Whereas the primary mission of other combatants like Destroyers, Cruisers, and LCS ships is to provide firepower to the theater battle and land attacks, Frigates are used to provide escorts to supply ships and possess primarily self-defense capabilities.

Cost estimates for non-nuclear surface ships include the subsystems such as combat and weapons systems, machinery systems, auxiliary systems, communications, and sometimes, aviation facilities. Combat and Weapons Systems can be provided to the ship as GFE or as CFE, depending on the acquisition strategy.

The Surface Combatant Role

Surface combatants provide a wide range of capabilities to support the security goals of the Nation. These roles include surface combat operations, force protection, surface strike utilizing missiles, protection of sea lines of communications, and other actions and missions as directed. Non-nuclear surface ships are built to military standards. Cost drivers are combat and weapon systems, propulsion systems and survivability.

SURFACE COMBATANT COST ESTIMATING DELIVERABLES

Cost estimating deliverables include the traditional budget estimates for use in the PPBE, AoAs, and PLCCE documents in support of program milestones or decision points; TOC estimates in support of program execution requirements, and various other economic analyses, cost-benefit analyses, what-if drills, and special studies performed on an as needed basis for Navy decision-makers or congressional inquiry (GAO, CBO, legislative staffers, etc). These deliverables are generally similar to the deliverables provided by other ship cost estimating groups. With the recent movement towards the use of mission modules on combatant platforms, the issue of module integration, both within the mission module itself, and on to the combatant platform, has taken on a more important role in the estimating process.

APPLYING THE COST ESTIMATING TASKS

This section will guide the estimator to product specific and unique sources of data, techniques, or other differences when estimating a Surface Combatant. Each unique item for Surface Combatants is categorized by cost estimating process task. Use this product data sheet, alongside the cost estimating process described earlier in this section to provide a comprehensive view of cost estimating Surface Combatants.

Task 1: Initiate Estimate

Multiple ship builders may be involved; historically, Ingalls Shipbuilding and Bath Iron Works have built Surface Combatants. With new non-nuclear surface ship acquisition initiatives like Joint Venture and WestPac Express, the estimator may need to go to shipyards or sources that have actually built these vessels. As is the case with most SEA 017 deliverables, Surface Combatant ship cost estimates are initiated by the PM or OSD. Cost drills are often requested by PM and PEO staff, and OPNAV.

Task 2: Obtain Product Description

Understanding the program is key to the development of good estimates. This means that one must understand the program acquisition strategy, technical definition, characteristics, design features, and technologies to be included in its design. The ideal place to start is the program's CARD. If a CARD is unavailable (e.g., during the earliest stages of the system's life cycle), the best starting place would be with the cognizant experts in the program office and the ship design supporting office. The cost estimator should work with design experts, logisticians, test and evaluation experts, financial managers, and cost estimators to develop the programmatic and technical baselines required to produce the cost estimate.

An estimator should always document any key pieces of programmatic and technical understanding that form the basis of their estimate. The description of Task 4 provides examples of assumptions that can form the basis of a surface combatant ship cost estimate.

Task 3: Obtain Work Breakdown Structure

The WBS for the shipbuilder portion of Non-Nuclear Surface Combatants is traditionally the ESWBS, as described as part of the basic cost estimating process. The P-5 or P-8 Budget Exhibit is usually the standard rollup structure for end cost, the Basic Construction Cost is the primary category for shipbuilder costs, with the other categories being Plans and Change Orders, as well as Escalation for base-dated estimates. Consult the Weapons Systems template for more details on the non-shipbuilder categories.

Task 4: Establish Estimate Assumptions

In general, the Surface Combatants are complex ships and are built to very robust, shock-hardened or military standards to enhance survivability in hostile environments. Estimating these ships, a cost engineer may find some unique challenges in terms of technical and programmatic aspects of these ships that require critical assumptions. Some unique features are as follows:

- The Surface Combatants are generally very compact or dense, i.e., more equipment are packed per square foot or pound than other surface ships. This creates higher labor hours for installations.
- Many of the systems or sub-systems are developmental and have state-of-the-art technologies that may or may not be analogous to the existing systems in the Navy inventory.
- Surface Combatants use significant systems automation to keep the ship's crew size down in order to reduce life cycle cost. However, the skill levels of the crew are generally higher for operating sophisticated weaponries, which leads to higher personnel cost for life cycle costing.

- Use of exotic materials such as composites for the deckhouse or other structures, high strength steel (HY 80/100) for deck plate, or titanium structures for engine exhaust/stack that are more expensive for installation in addition to the increased material costs.
- Low Radar Cross Section (RCS) is very important for surface combatants for avoiding enemy fire. Sometimes ships are fitted with special non-RCS tiles, shapes and concealed appendages to reduce ship's signature. These features may lead to higher cost. Usually, separate studies are performed by design teams to help determine which features may be included on a particular ship concept. Many times cost analysts will participate on these studies to gather information and data from the technologists to help with performing a cost estimate of the feature.
- Ship Integration is a major cost driver for surface combatants. Ship wide area networks, total ship computing environment, the total ship systems testing, cost of testing facility and the mobile test team should be carefully considered.
- Many systems are evolutionary, which use open architecture, plug and play components that are subject to spiral development. Continuous systems upgrades require sizable recurring engineering effort on follow-on ships.
- Surface Combatant production quantities are higher than most other NAVSEA products. These higher quantities generally require production at more than one shipyard. A dual yard procurement requires lead and follow yard services costs. It is important to understand the assumed procurement profile. Usually the profile is dynamic. Document the assumed profile and quantities of ships built in each yard and in which years. A good cost estimating model will be sensitive to these frequent changes and will allow the estimator to be flexible and make changes in profiles quickly. It is also important to understand the underlying procurement situation from the base CERs, and to make adjustments if necessary.
- For new technology you must determine if it is funded with R&D or SCN Appropriations.

Task 5: Select Cost Estimating Methods and Tools

As is the case with any cost estimate, various methods can be appropriate for different cost elements in an estimate. SEA 017 has resident performance and/or weight-based models to help estimate the cost of surface combatant ships. In some cases special relationships have been developed for estimating the costs of these types of ships.

Typically historical earned value management data and weight-based CERs are used to derive the production man-hours and material estimates for surface combatant ships. Make or buy differences, accounting differences and workload scenarios are taken into account while developing these estimates. The estimates are forward priced to the phasing of the work and then broken down into the base-dated and escalation components.

Task 6: Collect Data

There is no real difference in this task from estimating other products. When the estimator is collecting data they should understand that of the four main private shipyards currently available to build non-nuclear surface ships, two (Ingalls and Avondale) are part of the NGSS Business Unit, and two (NASSCO and Bath Iron Works) are part of the General Dynamics Corporation. Historically, NGSS and General Dynamics/Bath Iron Works have built surface combatants, while NASSCO and Avondale have built auxiliaries and amphibious ships. With new non-nuclear surface ship acquisition initiatives like Joint Venture and WestPac Express, the cost estimator may need to go to the shipyards or sources that have actually built these vessels.

Data from a number of different ship classes may be used to develop estimates. In particular, when estimating the cost of a specific component (e.g., main propulsion, cargo handling gear), several platforms may be similar and therefore appropriate as cost analogies. The estimator may need to collect information relating to the differences between the current ship and the baseline ships from which the CERs were created. Shipbuilders and industry studies can be the source of such information.

When developing CERs and establishing estimating ranges, care must be taken to either utilize data specific to the shipyard or to normalize data from other shipyards to make the comparison accurate. If the possibility exists for the ship to be constructed in multiple shipyards, the estimator should be careful when applying yard-specific data as the basis of one's estimate.

Task 7: Run Model and Generate Point Estimates

Surface Combatant cost estimate model execution and development is generally the same as that for other products. Specific models have been developed to address acquisition, O&S, and life cycle cost of surface combatants. Other specialized models have been developed and may be useful when conducting AoA analyses and tradeoffs between different propulsion alternatives and hull materials.

Task 8: Conduct Cost Risk Analysis and Incorporate into Estimate

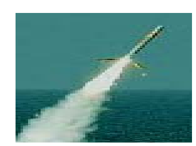
In many cases, specific risk analyses may be required prior to ship contract award. Some options that may be included to minimize risks may include development of technology off-ramps or EDMs. Estimators may need to research the technical risks in the program and ensure that a technical risk analysis effort is being conducted. Unique risk areas for surface combatant ships arise from the fact that their acquisitions are normally evolutionary – typically new capabilities are fielded in different flights of ships.

Tasks 9: Conduct Preliminary Estimate Review

Review of the estimate is similar for Surface Combatant estimates as for other SEA017 cost estimates with differences mainly in the Sponsor or Stakeholders involved. Thorough reviews help to ensure successful completion of the estimates. Possible sources of reviews include: the Program Offices, other business codes within NAVSEA, as well as other SEA 017 estimators (i.e. peer reviews).

Tasks 10: Produce Final Estimate

This step is not unique for Surface Combatant ship cost estimates. Please refer to the corresponding task write-up in the basic cost estimating process, described earlier in this section.



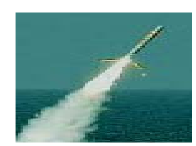
Tasks 11: Document Estimate

Documenting surface combatant ship cost estimates is similar to documenting assumptions used in cost estimates for other SEA 017 estimates. In all cases, documentation must be thorough, accurate, and complete. Proper documentation enables us to:

- Ensure DOD 5000 requirements are met,
- Ensure professionalism and completeness of the product,
- Provide an audit trail for future reference as well as establish historical database or library,
- Present a convincing picture to skeptical parties,
- Enhance preparedness to answer probing questions from various oversight groups, and
- Provide useful estimating data and techniques to other cost estimators within SEA 017.

Tasks 12: Brief Results

Surface Combatant ship estimates are presented in a manner similar to estimate presentations for other NAVSEA product areas. Estimate presentations may vary in structure and depth depending on the target audience.



2005 Cost Estimating Handbook

Section 5:

Cost Estimating Support Applications

This section contains information on the many processes and applications that support cost estimating at NAVSEA. From explaining Total Ownership Cost or procurement categories to providing details on how to conduct a software estimate or a regression analysis, many details referenced in Section 4 are clarified here in Section 5.

INDUSTRIAL BASE CONSIDERATIONS

The cost history of each NAVSEA shipbuilding program includes a myriad of factors that have contributed, or are contributing, to actual final costs. All the factors that can influence final costs are not always present in each program; however, there are a few that appear in every case. Two of the more significant factors are: (1) inflation and (2) the status of the shipbuilding marketplace, which is the subject of this section.

The term "shipbuilding marketplace" refers to the private shipbuilders in the United States who are qualified to bid on and build ships for the U.S. Navy. What has happened, is happening, and may happen in each of these shipyards and in the shipbuilding industry as a whole can directly influence the cost of Navy ships and, therefore, must be a consideration for the ship cost estimator at the time return and bid cost data are reviewed and when budget estimates are prepared. The purpose of this section is to provide the cost estimator with some insight on what to look for in past and ongoing ship procurements and to point out how the present and future status of the shipbuilding marketplace must be factored into the thought process as each ship cost estimate is prepared.

The Shipbuilding Marketplace-the Past 40 Years

Ship cost estimating in NAVSEA during the past four decades has been directly influenced by events in the shipbuilding marketplace. The events are of a business nature and center around the availability of, or lack of, workload.

A great demand for Navy shipbuilding work existed in the 1960s. Although there was some commercial work available, it was not enough to fill the needs of the shipyards existing at that time. Competition for all Navy shipbuilding work was very keen, and awards were made for considerably less than what was estimated and budgeted by the Navy. This took place despite the fact that new, complex ship specifications (e.g., dynamic shock, quieting) were introduced at the time. The contract form for these awards was FFP (with escalation), which did not provide the shipyards with much flexibility. Eventually, many of the shipbuilders found themselves in financial difficulty and submitted claims to the Navy for compensation adjustments.

Contrary to the 1960s, the shipbuilders in the 1970s experienced an overflow of work and Navy shipbuilding had to compete with an extensive commercial shipbuilding program. Costs of Navy ships increased during a time of lower productivity brought about by a lack of required skill levels in the marketplace because of competing demands for skilled labor by other industries and the heavy shipbuilding programs. In addition, labor and material inflation in the United States staggered the shipbuilding industry due to the nature of the contract escalation compensation clauses. The low productivity and high rate of inflation brought about financial problems that once again caused shipbuilders to submit compensation adjustment claims to the Navy, despite the fact that most contract forms were FPI. Navy shipbuilding budgets proved to be inadequate, additional funding was required from Congress, and some Navy shipbuilding programs were cancelled or deferred.

The problems of the shipbuilding marketplace seemed to subside during the five- or six-year period, 1979 to 1983; however, this relatively calm period for the shipbuilders did not last. In 1981 the Government eliminated the Maritime Administration's construction differential subsidy program and, as a result, commercial new-construction shipbuilding essentially dissipated in the United States. Shipbuilders in the 1980s were in "dire straights" and some shipyards were forced to shut down completely or to limit the scope of their operations. The Navy shipbuilding and maintenance programs were not large enough to support the total industry. As a result, competition was extremely keen as shipbuilders bid to stay in business (with the exception of sole-source programs/shipyards, such as nuclear aircraft carriers at Newport News Shipbuilding). Award prices in this period of competitive procurement were once again very attractive to the Navy and, coupled with low inflation rates, generally resulted in awards below budget. Most contract awarded during this period were FPI.

The Post Cold War period brought a dramatic reduction to the Navy's budget and correspondingly to the Navy's shipbuilding procurement quantities. Consequently, the U.S. shipbuilding industrial base became smaller and more consolidated, with two large defense contractors each owning three of the remaining six Navy new construction shipbuilders. Teaming, allocation and sharing of shipbuilding workload, along with multi-year and block buys became more commonplace, as the Navy and Congress attempted to stabilize the industrial base and distribute the workload among the submarine, surface combatant, and amphibious shipbuilders.

Despite budget reductions, the nation's war on terrorism demonstrated the need for the Navy to rapidly surge its existing forces, rapidly respond to changing maintenance/repair requirements, and adapt its design/build capabilities to counter changing threats. As the dominant player in the nation's shipbuilding industry, U.S. Navy decisions have a direct impact on the viability and future capability of the shipbuilding industrial base. Officials in the DoD and the Navy are developing acquisition strategies that attempt to strike a balance between industrial base support and an emerging set of warfighting requirements. In the shipbuilding sector, Navy leaders and senior industry executives work closely to develop complementary approaches for meeting requirements and supporting a narrowing industrial base.

Factors Affecting the Shipbuilding Marketplace

The phrase, status of the shipbuilding marketplace, refers to both tangible and intangible factors that can influence the initial award price and, ultimately, the final costs of Navy ships. The factors may all be interrelated and are surely encompassed within expressions of shipbuilder survivability and profitability. A number of the more significant factors are reviewed in the following subsections.

Workload

The current workload, including backlog, and the prospects of future work are continuing concerns of shipbuilders and the Navy. A steady, stable workload is a prerequisite to maintaining or improving the efficiency of a shipyard and to lower costs. Conversely, an erratic workload with its start-ups and slow-downs results in lost efficiency and higher costs. A shipbuilder facing a future drop-off in workload may be competitive in bidding for work that can fill a potential harmful workload gap, while a shipbuilder who is overloaded with work may not show the same interest. Major shipbuilders are dependent on Navy ship and non-Navy construction orders for their business. At times when attractive commercial work is readily available, shipbuilders will pursue it first; and, as a consequence, Navy shipbuilding may ultimately experience higher costs and possibly later ship deliveries. Conversely, when commercial work is not available, Navy shipbuilding may experience lower than usual costs and earlier ship deliveries.

The issue of workload is evident in nearly every bid received, every award made and, ultimately, in all final recorded costs. During the lengthy ship construction periods, workload issues may change for the worse or for the better and the effects of the change will be reflected in the final actual costs. As the impact of workload on costs becomes self-evident, the cost estimator more fully understands that selection of appropriate CERs is the most difficult step in the cost estimating process.

SEA 017 is responsible for analyzing shipbuilding industrial base impacts for each of the six major private, new construction shipyards. The Industrial Planning and Analysis Group analyzes historical, on-going construction, and company forecasted data and along with Navy shipbuilding new construction and repair projections, in order to forecast the profile's impact to the shipyard's production and non-production workforce. Forecasts are usually not performed at the trade level, but illustrate a more top-level, visual impact of potential Navy decisions. The forecasts developed by the group are referred to as "Workload Curves" and are used by senior Navy decision makers throughout the programming and budgeting process.

PRODUCTIVITY

Productivity is a term used to describe relationships between resources applied (inputs) and the products produced (output). It can be given meaning and used as a measure of production when expressed as a ratio of output per unit of input over a period of time. Changes in factors that affect shipbuilding productivity (i.e., getting worse, getting better) are usually limited to situations in individual shipyards. However, there was a period of time in the early 1970s when productivity in most of the shipyards conducting business with the Navy turned dramatically downward. Although this trend was soon reversed, accumulated cost data for ships awarded before 1972 require adjustment before comparisons can be made with later cost data.

Productivity issues in shipyards during stable workload periods will probably not be of a significant nature. Productivity can be a problem, however, for the shipbuilder who is in a massive hiring mode but cannot find adequate numbers of skilled workers in the marketplace. In this case, personnel with lower skills will be hired, extensive training will take place, overall shipyard skill level will be diluted, productivity may drop, and costs will rise. Conversely, an active shipyard that has not been successful in obtaining new orders will lay off less senior and most likely, less skilled, workers first, thereby "increasing" overall shipyard skill level. This would lead one to believe that productivity would take an upward turn, but this may not be the case. When there is no future work in sight, there is a tendency to prolong existing work; in effect, productivity does not improve and, actually, may drop off. For this reason, the cost estimator should consider adding an end of program factor on the last ship or the last two ships of the program buy. Historical cost increases or "toe-ups" at the end of program buys can be obtained from the SEA 017 Business Operations Team.

Individual shipyard productivity is one additional factor of the shipbuilding marketplace that the ship cost estimator keeps abreast of and, as required, properly reflects in future ship cost estimates.

TECHNOLOGY/FACILITIES IMPROVEMENTS

The impact on ship costs brought about by shipbuilding technology breakthroughs and shipyard facility improvements have been subtle and not expressly evident in return cost data. Although there have been significant advances in the shipbuilding processes, shipbuilding remains a hands-on, labor-intensive industry. Pre-outfitting, modular and zone construction, selective use of robotics, lean initiatives and other improvements and innovations are contributing to shorter construction periods and are expected to eventually result in reduced manhours, thereby contributing to reduced costs. Use of the Integrated Product and Process Development (IPPD) and advanced computer aided design have changed the way Navy ships are developed and designed. The cost estimator should be aware of the design and manufacturing technology changes taking place in shipyards, and should actively attempt to correlate return costs with these changes, and to appropriately reflect these in future estimates.

<u>OPERATING INCOME LOSS AND PROFITABILITY</u>

The shipbuilding industry in the 1980s saw a decreasing commercial marketplace and a Navy with initiatives to use fixed price contracts and competition for awarding all ships on "lowest cost to the government" basis. The results of such practices had shipbuilders bidding on contracts using excessively low prices to survive. Ship actuals from certain classes of that era show that the shipbuilders were bidding for survival and clearly intended to break even or minimize losses using the contract shareline clause for overruns. This phenomena of operating break-even or at a controlled loss is sometimes referred to as "Operating Income Loss"; and, despite its use, many shipyards nationwide closed their doors in unrecoverable debt as a result.

In the 1990s, the surviving shipbuilders developed their niche in the marketplace and found themselves in many cases in limited competition scenarios with a minimal allocation being almost guaranteed. The hours bid were more achievable and included a noticeable increase in the profit rate percentage. Cash flow and profitability are important aspects of running a successful business and are increasingly important to the shipbuilders in this era of low production.

Recurring/Non Recurring Costs

As defined by the Defense Acquisition University (DAU), non-recurring costs are costs that are not proportional to the number of units produced. They are a one-time cost that will occur on a periodic basis for the same organization. Non-recurring costs include preliminary design effort, design engineering, and all partially completed reporting elements manufactured for tests. Non-recurring costs also include training of Service instructor personnel.

When developing a WBS it is important to distinguish between recurring and non-recurring costs and ensure that they are properly accounted for in the WBS. When normalizing data, data should be grouped into these categories or into fixed vs. variable categories. Having costs grouped in these categories can help analysts account for anomalies like production quantity differences and time-phased cost differences.

If a total cost is referred to without the benefit of insight into recurring or non recurring distribution, it can be misleading. For example, the extremely expensive non-recurring R&D costs are often reported in the media on a per unit basis, as if they were variable costs. Spreading these costs over the relatively small number of actual units results in a very large per unit cost. On the other hand, if the costs are communicated as recurring and non-recurring, the cost per unit tends to be much more understandable.

TOTAL OWNERSHIP COST/LIFE CYCLE COST

Total Ownership Cost (TOC), while often equated with Life Cycle Cost (LCC), actually has two definitions per the USD(AT &L) memo dated 13 Nov 1998. One definition applies to the DoD as a whole, and the other applies to Defense Systems.

DoD TOC, sometimes called "Big TOC," is the sum of all financial resources necessary to organize, equip, train, sustain, and operate military forces sufficient to meet national goals in compliance with all laws, all policies applicable to DoD, all standards in effect for readiness, safety, and quality of life, and all other official measures of performance for DoD and its Components. DoD TOC is comprised of costs to research, develop, acquire, own, operate, and dispose of weapon and support systems, other equipment and real property, the costs to recruit, train, retain, separate and otherwise support military and civilian personnel, and all other costs of business operations of the DoD.

Defense Systems TOC is defined as LCC. LCC (per DoD 5000.4M) includes not only acquisition program direct costs, but also the indirect costs attributable to the acquisition program (i.e., costs that would not occur if the program did not exist). For example, indirect costs would include the infrastructure that plans, manages, and executes a program over its full life and common support items and systems.

A TOC estimate provides a comprehensive view of costs, by combining performance, cost, and organizational dynamics to answer a number of important questions (e.g., what are the direct costs, indirect costs, cost drivers? etc.) Determining the TOC can be used to:

- Assess the possible return on investment (ROI) of new initiatives or proposed changes in hardware, software, services, etc.
- Benchmark NAVSEA costs and service levels against comparable enterprises to highlight areas of excellence and/or improvement
- Formulate efficient business case justifications when examining competitive sourcing options.

The TOC concept is designed to help an organization measure the whole cost of owning and operating assets by providing a consistent framework from which analysis and comparisons can be made to an organization's resource allocation. TOC considers key cost components:

- RDT&E, Procurement, O&S, Disposal
- Hardware and Software
- Operations Labor
- Administrative Support Labor
- Non-budgetary (e.g., indirect, or "soft" costs such as downtime and peer support)

Figure 17 presents a typical example of the TOC depicted for a ship class, demonstrating that the decisions made early in the development of a system drive and lock in costs early on. With the majority of system costs occurring in the O&S phase, smart decisions upfront can influence and reduce the ownership costs significantly. It is possible that spending more upfront development dollars or a little more in acquisition could reduce the manning or maintenance component of the O&S costs, which in most ship types are the main O&S cost drivers. This effect is shown in graphically in Figure 18, which is taken from the SEA05 Ship Design Manager's Manual. IPTs are helping this process by getting a team together early in a system concept. By including industrial representatives and logistics support personnel early, a PM can begin to influence the design for a potential reduction in costs.

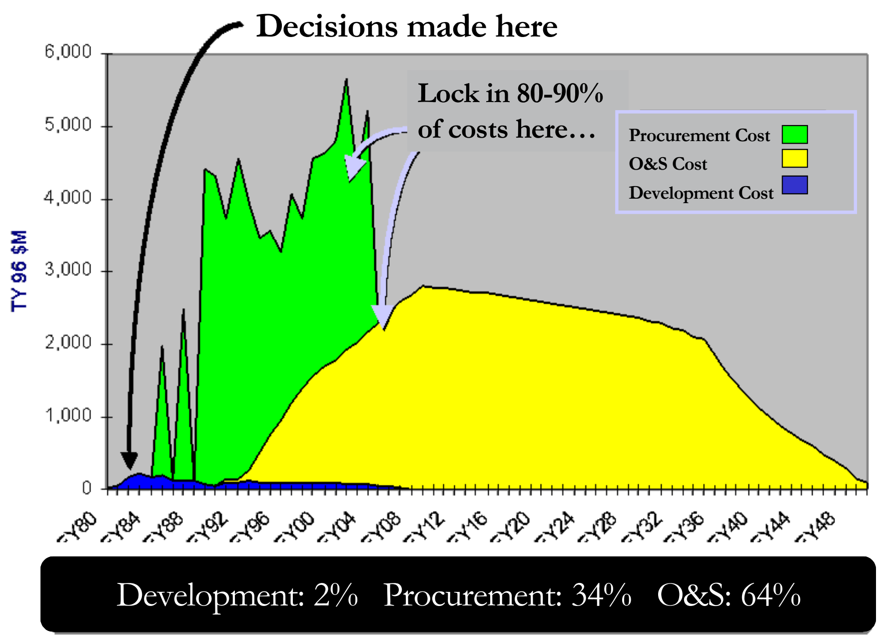


Figure 17: TOC Example

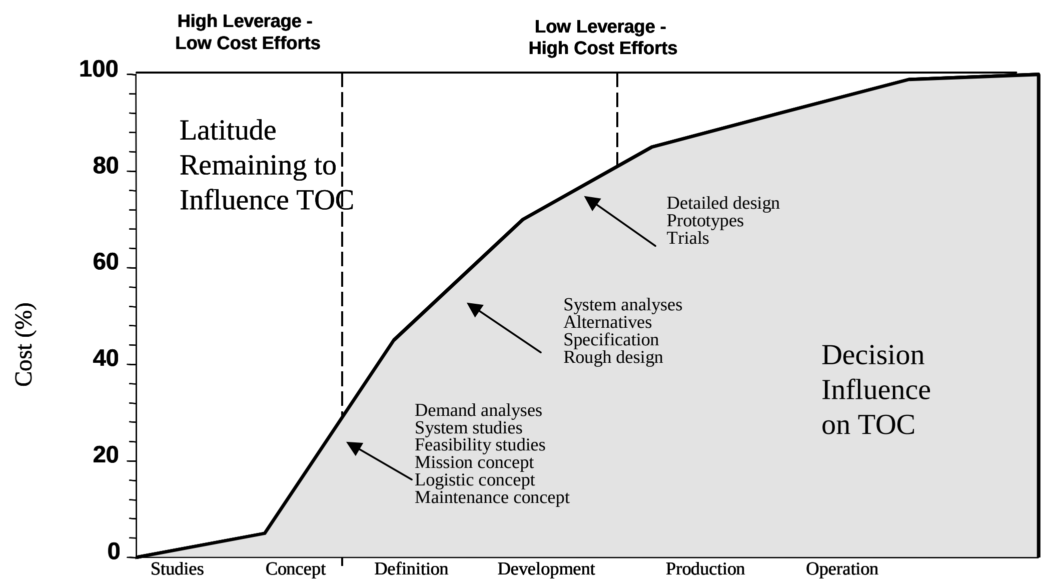


Figure 18: TOC Influence Curve

As the design proceeds and ship requirements and resulting characteristics become better defined, much of the ultimate TOC is determined. Ship design has a major impact on most TOC components including manning, fuel, maintenance, and disposal cost. Figure 19 shows the components of TOC.

In Appendix G, VAMOSC, OSCAM, and COMET are profiled as tools and databases that are available to cost estimators for the estimation of LCC and TOCs. (Note: these tools are used for O&S cost portion of LCC only, not the entire LCCE)

Figure 19: Components of Total Ownership Cost

ESTIMATING PROCUREMENT (P-5 EXHIBIT) COSTS

This section of the handbook addresses estimating procurement costs. It is organized according to the major categories delineated on the Procurement Budget Exhibit 5, or P-5 (see Appendix C for this form). The major categories of the P-5 Exhibit are:

- Basic Construction,
- Construction Plans,
- Change Orders,
- GFM, including Electronics, Propulsion, HM&E,
- Other Cost,
- Ordnance, and
- Escalation.

Each of these categories is discussed in the following subsections. The summation of these categories is referred to as the ship end cost and represents the total cost of constructing and integrating the ship and shipboard components.

Basic Construction Category

Basic Construction is the main segment of the shipbuilder portion of the ship end cost. Basic Construction includes all allowable shipbuilder direct labor, indirect labor (overhead), and material costs required to construct the ship, plus an amount for cost of money and profit. There are two primary techniques that can be used to develop the Basic Construction estimate - "base dating" or "forward pricing." A description of these concepts is provided in the following section. Other pertinent details regarding the Basic Construction estimate including development and application of labor and overhead rates, cost of money, and profit are detailed in this section.

Base Dating and Forward Pricing

Prior to the mid-1990s, virtually all ship construction estimates were "base dated," or estimated in terms of a specific month and year (base date). This base date is normally approximately eleven months before the planned contract award date to ensure that shipbuilders are able to include known costs in their bids, rather than individual forecasts of future inflation. The base-dated estimate reflects labor rates and material costs as of that particular date. The additional cost for inflation over the long period of ship construction, termed "escalation," is estimated and identified as a separate line item on the P-5 budget exhibit. In order to develop a base-dated estimate, the estimator adjusts prior-year cost data to reflect price levels appropriate to the base date (i.e., an inflation adjustment). After the estimate has been prepared to the base date, the estimator adds an appropriate amount for escalation, reflecting the inflation anticipated from the base date through the ship construction period, taking into account the time phasing of labor and material costs.

The current preferred method is to "forward price" ship construction estimates. The forward-priced estimate reflects the total anticipated cost to construct the ship, including the projected labor and material inflation that will occur during the construction period. In this method, the cost associated with inflation is not separately identified. To develop a forward-priced estimate, the estimator obtains forward-priced labor and overhead rates for a given ship from the SEA 017 Industrial Planning and Analysis Group. These rates represent the average rate at the selected shipyard(s) over the years of ship construction. Another method for calculating forward-priced labor/overhead costs is to inflate historical costs using the midpoint method described in the next paragraph. However, the estimator should only use the midpoint method when ship-specific labor/overhead rates are not available, because labor costs inflated using the midpoint method are not as accurate as the SEA 017 forward-priced rates. Material costs may be forward-priced by either the midpoint method or by applying annual inflation rates to time-phased material costs.

The "midpoint" method allows the estimator to develop a forward-priced cost estimate quickly by deriving labor and material midpoints to account for inflation over the construction period. In this method, historical or actual cost data is inflated to the labor or material midpoint date for a future ship. The estimator must first determine the base or reference dates for the historical labor or material costs to be inflated. Additional inputs required are the future ship's planned Contract Award date, Start of Construction date and Delivery date.

Fixed/Variable Costs

Fixed costs are costs that do not change as the production rate changes or vary with the volume of business, quantity or services performed. Some examples of fixed costs are rent for facilities, property taxes, insurance, depreciation, security, and minimum water and utility fees.

Variable costs are costs that change as the production rate changes, as the production quantity changes or as performance of services changes. Some examples of variable costs are electricity consumed and overtime pay.

Differentiating between fixed vs. variable cost helps explain cost per unit anomalies resulting from large fluctuations in production quantities from one year to another. It is important for an estimator to be aware of fixed and variable costs when grouping data into categories for normalization for accuracy. This type of data is referred to as multivariate data which contains more than one variable, such as costs to operate a factory as a function of both fixed (overhead infrastructure and personnel) and multiple variable (material and direct labor) costs. Production Rate or Learning Curves also take into account fixed and variable costs to account for their effects on a production rate change. For example, fixed costs of production spread over fewer units, increasing the per-unit cost.

The estimator calculates the midpoint date (month and year) for both labor and material using the following equations and the known dates:

$$\text{LABOR MIDPOINT} = S/C + 0.56\,(DEL - S/C)$$
$$\text{MATERIAL MIDPOINT} = AWD + 0.44\,[(DEL - 3) - AWD]$$

Where:

AWD = Contract Award Date
DEL = Ship's Delivery Date
S/C = Start of Construction Date

Then the estimator adjusts the labor rates and material costs from the base or reference dates to the corresponding midpoints using the applicable inflation index.

LABOR RATES AND OVERHEAD

Private shipyards have wage rates that correspond to their labor types that can be aggregated into their major labor pools. Projections of these labor rates, along with overhead, facilities cost of capital, and other rates are normally contained within the company's Forward Pricing Rate Proposal (FPRP). The FPRP is developed by the company, audited by Defense Contracts Audit Agency (DCAA), and negotiated between the company and SUPSHIP, ultimately resulting in a Forward Pricing Rate Agreement (FPRA) signed by both parties. While these FPRAs are designed to provide pre-negotiated rates for change order activity, they can provide a reasonable forecast of projected rates based on the company's projected volume of work.

SEA 017 analysts analyze the FPRAs and provide labor rates to the ship estimators based on the proposed schedule and the outlay of manhours for the specific ship class over time. Estimators will need to provide the ship type, and proposed award date, start fabrication date, and delivery date. In turn, the SEA 017 Industrial Planning and Analysis Group provides a production labor rate and a non-production labor rate for use in the shipbuilding estimate. These direct labor rates include an overtime premium based on the company's current and projected use of overtime.

With the completion of the estimating of direct manhours and direct labor dollars, the estimator now turns to calculating the overhead dollars of the Basic Construction category. Each shipyard, together with its <u>direct</u> labor and material costs, also has <u>indirect</u> costs or overhead. In government contract accounting, overhead includes all costs incurred to build the ship <u>except</u>: (1) wages for the workers (laborers and engineers) who spend their time with only that single ship and directly charge to that ship, and (2) the material charges for the ship which include actual material as well as subcontracted labor.

Overhead includes everything that you can see at the yard except the direct laborers and the ship, i.e., the land, buildings, tools, derricks, vehicles, and furniture. It also includes all consumable supplies, e.g., fuel, paper, and pencils; depreciation costs associated with building and capital equipment; most leases and purchased services, e.g., telephones, gas and electricity, insurance, leases for buildings, vehicles and equipment; and all business, property, state income, and social security taxes. It also includes all labor related expenses not associated directly with the construction of the ship. For example:

- Vacation and sick leave pay and pay received while attending training/safety/"quality circle" classes for <u>ALL</u> employees
- Non-wage benefits for <u>ALL</u> employees, e.g., health insurance, retirement, and tuition assistance
- Wages for employees whose efforts are not directly associated with construction of a single ship, such as:
    - Executives, accountants, secretaries, clerks, and employees in finance and personnel
    - Plant support and maintenance (plumbers, carpenters, electricians, security guards, and food service)
    - Welding schools (instructors and students) and other technical training
    - Bid and estimate preparation and cost analysis
    - Material procurement and storage
    - Program management
    - Research and development
    - Plant supervision (including some first line foremen and <u>all</u> supervisors above the first line level).

Important Factors to Consider

1. <u>First Line of Supervision</u>
   Charging of manhours associated with first-line supervisors can vary from shipyard to shipyard. In some cases, these manhours are directly charged to the work being performed (or estimated) and appear in the manhours column of return or bid cost data. In other cases, they are indirectly charged and are reflected in the overhead dollars column. To ensure proper and consistent use of the cost data, ship cost estimators must consider how the first line of supervision is being charged when making shipyard manhour and overhead comparisons and when developing CERs for estimating purposes. Specific information on shipyard charging of first line supervision is available at cognizant DCAA and SUPSHIP offices.
2. <u>Bid Labor and Overhead Rates</u>
   The bid labor and overhead rates that are routinely used and discussed in NAVSEA 017 have unique meaning in NAVSEA ship cost estimating and contractor ship bid processes. Aside from profit and cost of money, the UPA 4280/2 format used in these processes requires all other ship costs to be shown in the dollar columns for labor, overhead, or material. This means that labor costs such as estimated premium time and overtime are folded in with the direct labor costs and are reflected in a higher labor rate. Therefore, this overall projected labor rate can only be compared with a similar bid rate and cannot be directly compared with the shipyard first-class machinists labor rate or a quoted actual shipyard-wide labor rate. Similarly, the bid overhead rate can only be compared with other similar bid overhead rates. Overhead rates should be analyzed with their related workload curves (produced by SEA 017) for a better understanding of the workload impact on the rate structure. The ship cost estimator must be careful in communicating bid labor and overhead rates outside the Cost Engineering and Industrial Analysis Division offices to ensure that erroneous comparisons are avoided.
3. <u>Information Technology (IT) Costs</u>
   For years, IT expenses were performed in-house and were captured as a combination of direct and indirect charges. Recently, many of the shipbuilders have outsourced this function and these costs are now included as a material charge. To ensure proper and consistent use of the cost data, ship cost estimators should account for this change when developing their estimates. Additionally, estimators should consult with SEA 017 Industrial Planning and Analysis Group, as per seat IT rates are available to assist in the development of this estimate.

The overhead costs at a shipyard are calculated according to Cost Accounting Standards (CAS) and are audited by DCAA. Company's normally express their overhead pools as a percentage of a corresponding direct labor pool and/or a material base pool and will develop these rates by calendar year. General and Administrative (G&A) expenses are then added and are usually expressed as a percentage of labor, overhead, and material costs. Together, the indirect costs associated with labor, material, and the G&A are considered "overhead costs" and need to be included in the shipbuilding estimate.

At the time of bid, the company will forecast the outlay of their manhours and material costs across the build period and labor/overhead pools, and will apply the appropriate rates to determine the bid cost. Depending upon the contract type, during execution of the contract the company may capture the actual manhours, labor, and material costs as they are incurred, and will bill overhead costs based on the agreement in effect between SUPSHIP and the company. Eventually, a final closeout of the contract will be performed between SUPSHIP and the company, and the accounts will be adjusted according to the terms and conditions of the contract.

SEA 017 projects the overhead rates used in developing overhead dollars for NAVSEA ship cost estimates. SEA 017 has designed a computer model to project overhead rates at the major shipbuilding yards. This model is based on actual cost summaries of the shipyard overhead accounts. To project annual overhead rates, the model requires a complete profile of the workload at the yard. This includes both Navy work and commercial work anticipated during the period of construction. Based on historical data, the model computes regression equations that best fit the historical data. The key assumption is that overhead varies inversely with workload. The initial output of the model is separate production and non-production overhead rates by year. The second phase is to compute the aggregate overhead rate for each ship in the yard. This is done by computing an average rate weighted by the proportion of manhours that the ship represents of the appropriate (production or non-production) manhours in the yard for every year of construction.

Cost estimators are encouraged to communicate with SEA 017 personnel so as to fully understand the basis of the analyses and projections underlying the overhead rates provided to them. After the proper overhead rate for the estimate is available, the estimator applies the percentage rates against the appropriate labor base to produce the estimated overhead dollars for basic construction.

Facilities Capital Cost of Money (COM)

The Cost of Money (COM) is an element of the Cost of Facilities Capital. In 1976, the Deputy Secretary of Defense directed that a study (Profit '76) be conducted on the profitability of defense work. The supposition at that time was that defense contractors did not invest in facilities at the same level as contractors involved in commercial enterprises and that this might be attributable to defense procurement policies regarding unallowable costs (such as interest) and/or low level of profit. As a result of the findings of the Profit '76 study, two changes in defense procurement policy were made and promulgated in September 1976.

The first change specifies that the cost of providing capital for facility investments is an allowable expense on contracts priced and awarded on the basis of cost analysis. In this case, cost analysis is defined as the review and evaluation of: (1) individual cost elements and proposed profit of a contractor's cost or pricing data, and (2) the judgmental factors that were applied by the contractor to produce the proposed price. In those cases in which cost analysis is not a factor, e.g., firm fixed price (lowest qualified bidder wins award), COM is not applicable. The second change in defense procurement policy provides that the level of facility investment be recognized by contracting officers in reaching negotiated profit objectives under the weighted guidelines method.

CAS 414 and 417 provide specifics on the computation of COM. In simple terms, the standards specify how defense contractors can treat the value of their facilities dedicated to defense work as capital invested in the marketplace. The rate of return is an interest rate set semiannually by the Secretary of the Treasury (as specified in Public Law 92-41). COM becomes a part of the contractor's estimated total price. In accordance with the CAS for each year, the contractor multiplies his allowable net book value of assets by the imputed interest rate and then divides this number by the allocation base to determine the appropriate COM rates. SEA 017 simplifies these calculations and provides an appropriate COM rate to the ship cost estimator for use in his/her Basic Construction estimate.

PROFIT

The final element to consider before completing the Basic Construction estimate is profit. Estimated profit dollars are calculated by applying an appropriate percentage against all shipbuilder basic construction cost dollars except COM dollars (not allowed by Federal regulation). The appropriate percentage to be applied during the budget process requires careful consideration of the shipbuilding market structure (i.e., extent of competition -- full, limited or none) and the type of contract contemplated (which defines the shipbuilder's risk). The estimator should consult with the PM and contracting officer to determine the appropriate profit rate to be included. The estimator has the benefit of past actions and also receives management guidance to ensure that profit dollars included in the Basic Construction category allow for significant future negotiations between the Navy and potential shipbuilders.

Construction Plans Category

The Construction Plans category is the second major shipbuilding segment of the cost estimate. This category includes the nonrecurring costs related to detailed construction plans and other associated engineering tasks for lead ships. Planning yard, lead yard, and follow yard costs for ship classes may also be accounted for in this category or in the Basic Construction category.

The Basic Construction estimate is completed prior to the Construction Plans estimate. Knowing the extent of Basic Construction is useful in developing the estimate of the construction plans line and in establishing the magnitude of the scope of effort involved in the new design.

Estimating construction plans line is not as structured as estimating Basic Construction. One reason is that the specific engineering work to be performed will not be identified until detailed specifications have been written, well after the estimates must be completed. In addition, it is difficult to quantify manhour and material requirements for engineering tasks simply by reading work specifications. The estimator will need to develop CERs from past new designs. The bid and return costs for previous new design engineering efforts are sufficiently detailed in manhours and material at the task level to allow comparison estimates to be made. CERs based on design parameters -- such as displacement; length, beam, and draft; and numbers of major weapon systems can be utilized. Another useful CER that is employed extensively in early planning estimates is developed by reviewing the historical data to determine what percentage the Construction Plan costs were of the Basic Construction line on previous new designs. Percentages developed in this manner from previous similar designs are adjusted by judgment factors, such as ship complexity, before being applied against the new estimated Basic Construction line. Estimates developed by this methodology have proven to be very reasonable for Class F estimates.

Estimating the Construction Plans category tests the ingenuity and judgment of the estimator. Historical data enables the estimator to use several approaches to develop the estimate and then to choose the most consistent result. In the later budgeting phase, additional technical information (e.g., an estimate of the number of detailed drawings involved) may become available. With such additional information, the estimator can continue to refine the estimate up until the time the estimate is submitted into the budget. The estimator needs to understand the design tools for both the historical data as well as the new programs.

Change Order Category

No complex methodology is required to estimate the Change Order category. This category is simply an allowance of dollars to fund necessary changes after the shipbuilding contract is awarded. The allowance of dollars for the category is derived by a simple percentage of the Basic Construction price. For many years, 12% and 8% were applied for lead and follow ships, respectively. These percentages were based on a number of reviews of historical ship cost-return data, which supported the overall percentages. Starting with the 1984 FY SCN budget, NAVSEA, in the interest of further economy, established new guidelines for programmatic factors. In the past percentages for the Change Order category, 10% and 5% for lead and follow ships, respectively were used. Based on new construction methods and designs, FMB has required a reduction of Change Order percentage allowance to numbers on the order of 3-5%.

Estimators should note that the change order allowance is considered to be fully inflated. In other words, the PM is expected to manage change orders over the life of the shipbuilding contract within the total dollars of the Change Order category.

Government Furnished Material (GFM)

A thorough understanding of GFM costs plays a critical role in ensuring accurate program cost estimates and executable, affordable programs. GFM has been a significant contributor to program end cost in the past. More recent ship classes are tending to acquire more equipment as CFE versus GFE. The Navy provides GFM (hardware and software) to shipbuilders for installation aboard ships as part of shipbuilding construction contracts. The Navy customarily provides certain GFM for combatants, submarines, and complex ships and does so selectively for less complex ships. Also, the government furnishes equipment for purposes of standardization, safety, security, cost savings, risk mitigation, and convenience. The process by which GFM cost estimates are developed is described later in this Section.

SEA 017 developed a web-based database to streamline GFM cost submission and analysis process across the Command, especially where equipment is planned for installation across multiple platforms. This database uses the limited GFM cost estimating and management resources in the Program Offices as well as in SEA 017 more efficiently. The GFM database is a tool that provides a historical track of GFM costs electronically. PARMS submit their GFM equipment cost estimates into the system using the 7300/4 form on-line template. The system is available for authorized users that include PMs, PARMs, BFMs, and cost engineers only. Registration for access is via your web browser at https://GFM.NAVSEA.NAVY.MIL.

GFM is categorized into the following major groups:

- **Electronics** - includes production components, training support equipment, sonars, towed arrays, combat systems, external communications, satellite navigation and communication equipment, integrated command and control (C2) communication equipment, integrated C2 systems, computers and displays, test and engineering services, and repair parts associated with installation.
- **Ordnance/Air** - includes fire and missile control systems, search radars, missile launching systems, gun systems, training support equipment, test and integration services and other ordnance equipment. In addition, this category includes any air related GFM, e.g., arresting gear engines, landing aids and selected catapult components.
- **HM&E** - includes items such as interior communications, inertial navigation systems, deep submergence systems, periscopes, small boats, inflatable life boats, special vehicles, environmental protection equipment, training support equipment, repair parts associated with installation of HM&E equipment, propulsion equipment (non-nuclear), electric generator and motor equipment, and all medical equipment provided by the Bureau of Medicine and Surgery (BUMED).
- **Propulsion** - includes turbines, gears, and nuclear propulsion reactors and associated equipment.

Cost estimates are prepared for each of these categories and are included as part of the total ship end cost estimate. The SEA 017 cost analyst, although responsible for the overall end cost estimate, generally receives the associated GFM estimates from the cognizant program office. GFM 7300/4 equipment estimates are normally captured in an annual data call.

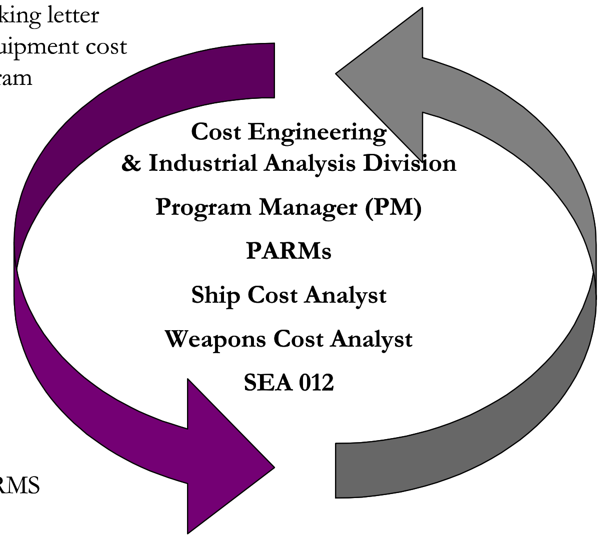
GFM COST ESTIMATING PROCESS

The GFM cost estimating process requires action, inputs, and outputs from a number of organizations before the estimate is finalized. In the case of POM and budget estimates, the organizational roles are essentially the same as those organizations described in Section 3, with a few significant differences. A basic difference is that GFM detail cost estimating, at the present time, is a shared responsibility of the PARMs, the SEA 017 cost analyst, and the cognizant weapons system estimator.

Figure 20 illustrates the specific input/output actions that make up the GFM cost estimating process.

INPUT PHASE

1. Prepare and promulgate tasking letter
2. PARMs prepare 7300/4 equipment cost
3. 7300/4s submitted to program
4. Analyst rolls up GFM
5. Analyst prepares budget submission (P-5s, P-8As, P-35s) and should:
   - Perform reasonability assessment
   - Review PARM cost estimates with program offices
6. PARM validation reviews:
   - Program Office and SEA 017 meet with PARMS to discuss estimate
   - Determine any non-recurring cost increases for modified equipment or new equipment
   - Vendor, industrial base and customer base impacts increasing cost of GFM over previous equipment



OUTPUT PHASE

1. Cost analyst assists BFM in preparing budget exhibits
2. Cost analyst reviews budget exhibits
3. PM reviews P-5s, P-8s, prepares P-35s
4. PM forwards budget exhibits to SEA 012
5. Program Office prepares and submits POM letter to OPNAV

Figure 20: Typical GFM Cost Estimate Flow Diagram

SEA 017 or the Program Office usually initiates the GFM cost estimating process for the POM ship cost estimates. These estimates are requested in the Form of 7300s in Then Year Dollars dated in the full funding year of the ship.

Input Phase

PARMs submit 7300s to the Program Office, who in turn submit data to the SEA 017 analyst/NAVSEA on-line 7300 cost tracking system. The SEA 017 analyst is responsible for the following:

- Organizing and categorizing the estimates by budget exhibit categories: Electronics, Ordnance, HM&E, and Other.
- Ensuring the data is organized using the PARETO principal by system cost (ordered from largest to smallest cost driver in each respective budget category).

The SEA 017 analyst also performs a reasonability assessment on the estimates:

- Compares to similar systems on historical ships for a sanity check. A red flag is raised if PARM estimate over 10% higher than historical costs (inflating historical costs to the full funding ship year).
- GFE cost trends are reviewed.

After the aforementioned SEA 017 analyst and/or many of the Program Office meet to share reasonability assessment results, a questionnaire is sent back to the respective PARM on unexplained costs or cost differences prior to the validation review. These questions are expected to be answered during these reviews, and can include questions such as:

1. If estimates are much higher than historical costs, why is this so?
2. Are there non-recurring costs associated because of vendor-base or workload changes?
3. What is the Basis of the Estimate (BOE), such as metrics or historical costs for its derivation?
4. What are the pricing risks?

The PARM validation/Ship Project Directive (SPD) reviews are conducted to reconcile between the historical costs and PARMS estimates. Following completion of these reviews, the validated 7300s are then returned back to the PARMS for revisions/updates.

OUTPUT PHASE

The approved 7300s from the Program Office take into account many different considerations. For major weapon systems, the 7300s are subjected to selected validation reviews. Specific areas assessed are diverse and may include some or all of the following:

1. Comparison with prior 7300/4 estimates
2. Correctness of learning and rate curves used based on prior contractor experience
3. Past procurement trends
4. Variance and trend analysis from CPRs
5. CSDR analysis results
6. Effects of competition
7. Assessment of program management reserves
8. Analysis of the first unit cost (T_1)
9. Relationships between recurring and non-recurring cost elements
10. Relationship between hardware and support cost elements
11. Contract target and ceiling (including not-to exceed (NTE)) costs
12. Validation of proper inflation rates
13. What contract is associated with this item?
14. Will the item be provided from a sole source competitive contract?
15. What type of contract; that is, cost plus, fixed, etc.?
16. What is the ACAT?
17. What has changed from your previous submission?
18. What are the risks associated with your program? High, medium, low risk? What is the probability of occurrence?
19. Is this effort a rework, modification, or COTS item?
20. Any changes or modifications to the system being incorporated? Has the PM agreed to these changes?
21. What is the potential effect of risks?
22. Who is the prime contractor or sub contractor?
23. What portion of work is the PARM responsible? Shipyard?
24. How will being partially funded affect this item?
25. When was the item first procured?
26. What cost changes have occurred on previous and current units?
27. Is the item in development?
28. Is the item in production?
29. What is the item baseline specified for each ship type and class?
30. Does the 7300 estimate correspond with the baseline, or are there additional upgrades included in the estimate?
31. Give an explanation for the BOE.
32. Where is the documentation to support this estimate?
33. What other programs use this item?
34. What are the major cost drivers associated with this item?
35. What actual cost data do you have?
36. If this effort is software driven: what is SLOC, ESLOC, Reuse, modified, code count?
37. Could another item do the same function as this item?
38. How was the 7300 generated?
39. If you are not reporting the GFM items in the GFM Database, where are you reporting these items?
40. How confident are you in the 7300 estimates?
41. What are the main risks to the 7300 estimates?
42. Who are the key personnel involved in estimating this item?

The PARMs/PMs are required to submit P-5s, P8-As, and P-35s budget exhibits to the SEA 012 for each of their programs. The 7300s provide all the information required to complete the P-8A exhibit. SPDs are the tasking agreements between the PMs and PARMs and provide procurement direction and dollars for acquisition of GFM to be provided to shipbuilding by the Government.

The SEA 012 receives the P-8As from each of the PARMs/PMs and reviews the cost information for consistency with previous SCN budget inputs and with similar procurements in other appropriations (OPN/WPN). Last, SEA 012 prepares P-35 budget exhibits from the information provided.

GFM Cost Estimate Breakdown

The GFE items are broken down into seven major cost elements. Each of the elements, as appropriate, is estimated by the cognizant PARM or the cognizant cost estimating branch at a detailed level and then summarized on Form 7300/4. A discussion of each of the cost estimate basic elements is presented in the following subsections.

The GFE items are broken down into these seven major cost elements:

1. **Major Hardware**—are the primary components that make it possible for the GFM system/equipment to meet mission requirements. This hardware may include units manufactured by: (1) the GFM contractor, (2) their major subcontractors, (3) Navy "standards" procured by another PARM from another contractor; and may include components provided by the government to the GFM vendor. For example, a gun barrel manufactured in a government plant could be provided to a GFM vendor who manufactures and assembles guns.

   For a major weapon system, major hardware often represents the content of the hardware CLIN and therefore may include contractor's internal project management, systems engineering, integrated logistics support (ILS), data, and testing requirements.
2. **Ancillary Equipment**—is equipment required to logistically support the major hardware and includes such items as special purpose test equipment, special tools, gauges, and jigs. Also included are installation fixtures and any unique shipping equipment such as reusable containers as well as maintenance assist modules (MAMs) that are used for fault localization.
3. **Technical Data/Documentation**— this element includes the cost of revising and documenting the complete data package associated with installation, integration, O&S of the hardware or system. Included are such items as technical manuals, drawings, provisioning technical documentation, planned maintenance systems, system manuals and operator's handbooks. In most cases, the technical data and documentation requirements are specified by the government on the Contract Data Requirements List (CDRL), DD Form 1423. However, the cost of developing some of the above items may be RDT&E funded, in which case these items should not be included on the 7300.
4. **Spares**— this element includes the cost of all the spare parts required to ensure the operational readiness of an equipment or system. Included are installation and checkout spares, depot, and initial stock spares required to support the system until the normal Navy Supply system assumes support.
5. **Systems Engineering—** this element includes the cost of engineering support required to ensure successful integration of the components constituting a major hardware item. This effort precedes and is separate from the overall systems test and evaluation.
6. **Technical Engineering Services**— this element includes the cost of contractor or vendor and government field engineering services required to support installation of the systems on the ship at the shipyard.

Other—this element includes a number of sub-elements that may be applied on an individual program basis. The sub-element efforts include the following:

- **Development** - not RDT&E, but costs related to changes required to adapt equipments to specific ship classes.
- **Production Start-Up** - nonrecurring costs directly associated with production, including production special tooling and special test equipment.
- **Training** - procurement cost of O&S training equipment required to train pre-commissioning crews.
- **Software and Programming and Computer Program Support** - cost to update and improve software and programming associated with the operation of the equipment system.
- **System Test and Evaluation** - cost of test plans, procedures, testing, and integration; may include factory-based test site and testing aboard ships.
- **Changes** - cost of design engineering changes before production and engineering change proposals during production; includes cost of field changes made to production systems.
- **Management Services** - cost of management efforts such as integrated logistics support, configuration management, quality assurance (including reliability, maintainability, and availability programs), and technical data maintenance.
- **Contractor Support Services (CSS)** - cost for services of a "white collar" professional and nonprofessional nature consisting of both administrative and technical support. CSS are in seven categories as follows: (1) individual experts and consultants; (2) studies, analyses, and evaluations; (3) management support services; (4) engineering and technical services; (5) contract systems engineering; (6) information technology; and (7) federally funded research and development centers.

The PARM or cognizant SEA 017 group estimates the cost of each of these elements and summarizes the results on Form 7300/4. The cost estimates are presented in the appropriate benchmark fiscal year.

GFM Cost Estimating Considerations

In many GFM procurements, the system will go through several development phases funded by the RDT&E Appropriation. The production SCN cost estimates in this situation are based on cost data gathered during the development phase. This is probably the most difficult estimate to assess because of the great amount of engineering judgment required on the part of the cost estimator to understand the transition from RDT&E costs to SCN production costs. In addition, the estimator considers all the factors mentioned above concerning market conditions, learning, etc. An estimate of this nature requires continual attention so that the most recent and firmer data can be reflected in the estimate before final budgets must be submitted. This is especially true when the system is under concurrent development and limited production.

A GFM estimate may be required for an item that has been out of production for a period of time. In this case, the estimator has to consider: (1) production start-up costs such as retooling; (2) finding and rehiring skilled workers; (3) learning curve implications; and (4) inflation, if historical return cost data are used to develop the estimate.

On occasion, a new GFM system is procured with SCN funds when there is no need for an RDT&E funded development phase. In this case, the ships analyst develops CERs from past similar procurements. These relationships may include time units and technical parameters such as manhours per printed circuit board, manhours per unit of weight, or manhours per foot of cable. In any case, the following cost elements are estimated: direct manhours and labor costs, material costs, overhead, other direct costs, cost of money, general and administrative costs, and profit. There are many occasions when the PARM interfaces with industrial producers who may be interested in developing and producing the GFM system. The cost estimate input from potential contractors provides a valuable source of data for the GFM estimator.

Non-recurring costs should be placed on the lead ship of the class and on the first ship of each fiscal year as appropriate. There are competitive situations where non-recurring costs may apply to the first system that each contractor is providing in each fiscal year. Some systems will show non-recurring costs on the last system of the fiscal year because upgrades are introduced at that time.

GFM ROLE FOR THE SEA 017 COST ANALYST

The overall responsibility for the total end cost estimate lies with the SEA 017 cost analyst. Although the number of GFM systems may make it impossible in the available time period to evaluate each system, analysis of high-value systems by the SEA 017 cost analyst should be conducted as a minimum. These reviews take on special significance at the point in time when the estimate must be upgraded to Class C. The upgrading to budget quality by the SEA 017 cost analyst should only be accomplished if the GFM review has taken place. If the SEA 017 cost analyst is not confident of some GFM cost element affecting ship end cost, then resolution of this issue is recommended before upgrading the estimate. The GFM role, then, is a significant one for the SEA 017 cost analyst and it cannot be overstated. The SEA 017 cost analyst must make GFM reviews a part of standard procedures to develop ship end cost estimates.

Other Cost Category

Various categories of an end cost estimate can be conveniently summarized into three segments. Two of these segments are the Shipbuilder Portion, and GFM. This section presents the third and final segment, "All Other," a convenient catch-all of miscellaneous but important categories of an end cost estimate. The categories that are included in the "All Other" segment are as follows:

- **Test and Instrumentation (T&I)** -- Although each ship will bear some T&I costs, the majority of the T&I costs for a class of ships are charged to the lead ship. These costs include government-responsible testing and instrumentation incident to routine or special trials leading to qualifying a ship for active service.

  T&I costs are estimated using analogy or comparison. NAVSEA historical cost data is replete with actual costs experienced in the T&I category for nearly every ship constructed by the Navy. The ship cost estimator selects appropriate lead or follow-ship cost data from the files for a number of comparative ships. A contact with the cognizant PARM/PM can reveal information about those ships such as number of trials and special tests that may have been conducted. A plus and minus process can be used to adjust the past requirements to the current requirements. The costs must be inflated to the proper time period, remembering that most of the T&I effort is conducted during the period before ship delivery and final acceptance by the Navy. If this technique is accomplished for a number of past construction efforts, the estimator, based on engineering judgment, selects the most reasonable estimate.

In many cases, the PARM/PM provides a T&I estimate. When this is the case, the estimator reviews the estimate with the PARM/PM and, when satisfied that the PM methodology has produced good results, includes the T&I estimate as part of the end cost.

- **Stock Shore-Based Spares** - The stock spares funded in this category are back-up spares for stock ashore or aboard tender/repair ships. Stock spares funded by SCN are limited to first-of-its-kind installations on the lead ship. In other cases, shore-based spares are funded in the OPN or WPN Appropriation. Specific policy is outlined in NAVSEA Instruction 4400.03A.

  The PARM/PM is responsible for identifying the equipment to be procured as stock spares, and the estimator is responsible for obtaining prices for the list of equipment. In most cases, the estimator will already have priced the equipment in estimating Basic Construction or HM&E GFE. If this is not the case, the estimator can obtain assistance by seeking a marine vendor input from SEA 017.

- **Other Support -** There are a number of programmatic efforts funded by the PM with funds set aside in the Other Support category. Some of the efforts that are visible in most end cost estimates are as follows:
  - Planned Maintenance Subsystem (PMS): Installed aboard ship. Identifies the servicing and maintenance requirements of major ship systems or subsystems.
  - SUPSHIPS Material or Services: The Navy has O&MN-funded SUPSHIPS offices at major private shipbuilding yards to provide on-site Navy management and contracting services. Specific tasks requested by PMs for SCN shipbuilding programs are funded in this category. In addition, other similar Navy Support Activities may be tasked and funded by the Other Support category.
  - Contractor Support Services: Separately contracted for services required by the PM to fulfill program management responsibilities.
  - Travel: Travel by Naval Activities (personnel) in direct support of shipbuilding. Excludes travel costs of NAVSEA Headquarters and those activities that are mission-funded, such as SUPSHIPS, which are funded with operating funds.
  - Commissioning Ceremony: Costs directly related to the Commissioning Ceremony (over and above shipbuilder costs included in basic construction) are funded in this category.

These tasks and other similar tasks constitute the efforts in the Other Support category. The PM is in the best position to provide cost estimates for each of these efforts to the ship cost estimator. The estimator assists the PM by reviewing historical cost data and making comparison studies similar to that described for the T&I category above.

For many years, under the end cost concept, an additional category to those listed above was included in the "All Other" segment and labeled Future Characteristics Change (FCC) Reserve. This reserve was intended to fund CNO-approved changes in ship characteristics after the ship was budgeted and during the construction period. The changes were usually brought about because of state-of-the-art improvements in equipments or systems that became available during this time. In FY 1984, the House Appropriations Committee deleted the FCC Reserve and stated that in the future the Navy should request funds for FCC changes in a cost-growth budget line item.

The elements of work estimated and funded in these categories are programmatic in nature, and they enable the PM to manage and execute the shipbuilding programs properly. As such, the PM is required to provide inputs to the ship cost estimator to ensure that program's requirements in these categories are fully funded.

Escalation Category

The final segment of shipbuilder cost is Shipbuilding Contract Escalation, or simply "escalation." This category is applicable only if the Basic Construction estimate was developed as a base-dated estimate, or if the shipbuilding contract is planned to include a separate "Compensation Adjustment" or "escalation" clause. Escalation represents the cost to be paid to the shipbuilder for the effects of inflation over the long ship construction period. The section on "Contractual Considerations," provides additional information on shipbuilding contract inflation clauses and estimating escalation costs.

IN-SERVICE ESTIMATING

Once a ship is in-service, the focus is not necessarily on estimating costs, but rather on capturing cost data for future estimates of similar products, and on estimating the future operating costs of the product. This may include significant costs such as those for modernization. Knowledge of O&S costs and key O&S cost drivers is important during the design phase of the product. Design tradeoffs can be made to help reduce O&S costs over the total lifecycle of the product. This section covers the various types of in-service estimates and associated estimating methodologies.

O&S Estimating

A ship's expected service life is typically 30 years or more. Therefore, one can anticipate that the O&S costs of a ship over such a long period make up a significant share of the total ship life cycle cost. As a result, the estimated O&S costs, which encompass costs associated with items such as ship manning, fuel consumption, maintenance, repair and modernization, are of great concern during the design trade off study period. The primary source of historical data to support the development of operating and support costs is the Visibility and Management of Operating and Support Costs (VAMOSC) data base outputs.

Alterations (SHIPMAIN)

Maintenance has always been a highly complex, critical and expensive component of a ships operation, and therefore important in the estimation of life cycle costs. Maintenance in the broader sense for a ship in service includes not only preventive and corrective maintenance (i.e., repair), but also includes the installation of alterations (i.e., configuration changes). A recent initiative to improve, streamline and reduce the overall cost of maintenance, while maintaining effectiveness is Ship Maintenance (SHIPMAIN).

The Commander Naval Surface Forces (COMNAVSURFOR) has issued guidance on the SHIPMAIN process that:

> "Management of surface ship maintenance processes and procedures has been the subject of considerable review. Budgetary constraints, improvements in both work processes and in maintenance automated information systems, and the continuing need to streamline and re-engineer our approach to maintenance in order to maximize resource efficiency have driven multiple studies… This re-engineering process has not ended. Future, metrics driven changes will continue to improve the efficiency of the maintenance process while contributing to improvements in ship material readiness and availability for operations (Ao)."

SHIPMAIN is designed to:

- Create a common planning process for surface ship maintenance and modernization,
- Increase the efficiency of the process without compromising its effectiveness,
- Install a disciplined management process with objective measurements,
- Institutionalize the process and a continuous improvement method, and
- Address current maintenance and modernization challenges.

The SEA 017 cost engineer may encounter requirements to develop or review estimates associated with development, production, or installation of ship changes (alterations). These estimates present unique challenges in that they are estimates for specific hardware or ship systems and the costs associated with development, production, integration and installation of these products on ships already in service. The scope of these changes may range from minor component changes to extensive major system modifications or installation.

Modifications to Existing Ships

In addition to building new construction ships, the Navy may decide to modify an existing ship. The cost engineer may be required to develop cost estimates for a major ship modification to include:

- A **conversion** consists of that work necessary for ship repair and for incorporation of military and technical improvements, which significantly change the mission or type classification of a ship.
- An **activation** is taking a preserved ship in the Inactive Reserve Fleet and removing dehumidification equipment, reassembling machinery, lighting off all systems, and making the ship ready for sea.
- **Modernization** consists of that work necessary for ship repair and for installation of updated military and technical improvements without significantly changing the mission type classification of a ship.
- **Extended Life:** A Service Life Extension Program (SLEP) consists of that work necessary to significantly extend the useful life of a ship beyond that expected of the new construction design considering normal maintenance, repair and overhaul. The hull and all systems are restored to a level adequate to support mission requirements of the ship during its extended life. Improvements to military characteristics by alterations made in conjunction with such restoration may also be included.

The challenging part of estimating these programs is determining the full scope of work to be accomplished. Unlike a new construction weight estimate, for a ship modification, a new weight statement will be provided that reports weight added, removed, or relocated. This weight information by itself, will likely not be sufficient to estimate the total scope of work to be accomplished. Often, other equipment may need to be moved, and access provided to enable equipment installation. This effort does not show up on a weight report, as the other equipment or incidental material is returned to its original state, during the completion of the modification.

The estimating approach used in developing modification estimates is different than the approach used in developing cost estimates for new construction. Selection and/or modification of CERs that truly reflects the complexity of working on an existing ship may also be challenging, as return cost data of this nature is not readily available. Identification of the installation activity will be critical in ensuring the proper labor/overhead rates are applied. Major ship modification programs may be planned for execution in a public sector Naval Shipyard or in a private shipyard. The public sector Naval Shipyards currently are: Portsmouth Naval Shipyard, Norfolk Naval Shipyard, Puget Sound Naval Shipyard, and Pearl Harbor Naval Shipyard. These shipyards use a "stabilized manday rate" which are unique to U.S. Naval shipyards and provide an all-inclusive rate for an 8 hour manday. The Navy Working Capital Fund Division (SEA015) in the NAVSEA Comptroller Directorate can provide these rates as well as additional information on these rates. If the program will be executed in private sector shipyard, the Government Manday Rate for private sector ship overhaul and repair would be a possible source for labor/overhead rate data. SEA 017 publishes the Government Manday Rate report on an annual basis.

OTHER RELATED PROCESSES

This section provides information on other analysis processes that are related to the cost estimating process but are not the primary functions of the cost engineer. Many of these disciplines such as schedule analysis and EVM have analysts dedicated in the programs to conduct the primary reporting. Generally it is the cost estimators responsibility to work with these analysts and data to find items relevant to the cost estimate. Many times analysis from a project schedule can effect the phasing of an estimate, EVM data can provide a source of actual data to use in the estimate, and a CAIV analysis can help the cost estimator work with the project engineers to make early trades off decisions in a project's life.

This section is meant to be a reference for each topic, not a complete text on the topic. It is written from the perspective of the cost estimator and what the estimator should know when conducting an estimate.

Software Estimation

Software development cost and schedule estimation is a critical and challenging task that requires knowledge and understanding of the complexities inherent to any given software project. Industry surveys demonstrate that the average software project cost overrun in 2002 was 43%, while the average schedule overrun in the same year reached 82%.[11] While these numbers are not solely attributable to poor project estimation, the lack of consistent estimation methodologies based on quantitative analysis is a strong contributing factor. Growth in software Equivalent Source Lines of Code (ESLOC) size, either through bad initial assessment of effort required or requirements creep are major causes of software cost growth.

No single standard approach to software estimation exists. Although many methodologies can be applied to generate software estimates, they are categorized into two general groups: manual and parametric. Both types are appropriate in different situations, and each has advantages and disadvantages. Ideally, multiple methods can be applied to produce more than one estimate for a development project. This strategy attacks the problem from two different perspectives, and where differences arise, further analysis and reconciliation can often result in more robust estimates. The various models used for estimating the cost of software in NAVSEA programs are: COCOMOII, SASET, SEER, Price-S and function point models. Other models that are used, along with descriptions can be found in Appendix G. In the following sections, the current NAVSEA software cost estimating process is described and then brief summaries of software cost estimating methods are provided.

NAVSEA SOFTWARE ESTIMATING PROCESS

SEA 017's usual software cost estimating process is to use a commercial model such as COCOMOII or SASET and an ESLOC Productivity methodology. The ESLOC Productivity methodology is described below.

- Acquire estimated Source Lines of Code (SLOC), by language, to be developed from the software developer or the technical community in terms of New, Modified, and Reused.
- Convert SLOC to New ESLOC. SEA 017's conversion factors are based on Developing Software to Government Standards by William H. Roetzheim, Prentice Hall, 1991. To convert SLOC to ESLOC, multiply the quantity of new SLOC by 1.00, modified SLOC by 0.73 and reused SLOC by 0.24.
- Apply an appropriate ESLOC Growth factor. (NCCA Software Development Study (1998) and the Defense Science Board Task Force Report (2000)).
- Develop Productivity rates (ESLOC/manday) to be applied to the ESLOC to determine mandays. Productivity rates vary by the type of code (language) being produced. Productivity rates for the specific contractor are desirable.
- Develop manday labor rates ($/manday) to be applied to the mandays. Labor rates can be derived from the CCDR DD1921-1 form, proposals, FRPAs, etc.
- Apply proper contractor loadings (overhead, G&A, COM, and fee). Loadings for the specific contractor are desirable.
- Run uncertainty Monte Carlo simulation on "soft areas." Soft areas include SLOC to ESLOC conversion factors, SLOC growth factor, productivity rates, Manday rates, and loadings.
- Incorporate software estimate with risk into the overall LCC model estimate.

MANUAL ESTIMATION

Manual software estimation applies simple calculations to derive effort, cost, and schedule. This includes analogy, engineering buildup, or CERs. Analogy compares the project at hand to "comparable" projects. The estimate then may be adjusted to account for any obvious differences (e.g., estimated size or complexity). Engineering buildup leverages expertise of people who have experience in software development. These experts apply their best judgment to estimate the duration and effort required to complete the project. The analysis may be broken down into work packages, modules, or activities to drive to greater granularity and accuracy. CERs, or "rules of thumb," use simple factors such as productivity metrics, percentages, or multipliers that are easily applied to size, staffing, or other estimate data to derive cost, effort, and schedule.

The main advantages of manual estimation are the ability to produce an estimate quickly and the simplicity with which one can be completed. While these methods are practiced widely, they are most appropriate for estimates very early in the project life cycle, with very small development efforts, or for non-critical, unimportant projects. The results of simple manual methods are also useful as cross-check estimates. However, for mission critical applications, larger development efforts, and contracted software development projects, manual estimation methods have proven inadequate to produce consistently accurate results.[12] Manual methods simply cannot account for the wide range of complex factors that affect the outcome of software development projects.

Parametric Estimation

Parametric, or tool-driven, software estimation provides more thorough and reliable estimates than manual methods. Parametric tools are based on data collected from hundreds or thousands of actual projects. This data is used to develop algorithms that become the "engines" of the models. Inputs provided by tool users drive the resulting cost, schedule, and effort estimates produced by the model. These inputs range the models from personnel capabilities and experience and development methodology and tools to the amount of code reuse, programming language, and labor rates. Some tools also require the expected productivity factors as an input to the model. Others utilize the other input parameters to calculate the appropriate productivity factor. Most parametric tools provide default settings for these input parameters, which means that a reasonable estimate can be derived from a minimal amount of information. Additionally, parametric tools provide flexibility by accepting multiple sizing metrics, so estimators can apply any number of sizing methodologies. Parametric software estimation models produce even better results when calibrated to specific development teams using actual project data. Another significant benefit of automated tools is the ability to perform sensitivity and risk analysis for a project estimate. Estimators can manipulate various inputs to gauge the overall sensitivity to parameter assumptions and then assess the overall project risk based on the certainty of those inputs.

The primary drawback to using parametric software estimation models is the need for users to be trained and experienced in application of the tool and interpretation of the results. While some of these models are very easy to manipulate, it is important to understand the *appropriate* inputs given the particular project, as well as to be able to explain the resulting cost and schedule estimates. Simply using a tool does not enhance the validity of the estimate—using a tool correctly in the context of the specific project does increase the likelihood of a more accurate estimate. Many commercial software estimation tools are available on the market for a wide range of costs. This list includes COCOMO, SLIM, KnowledgePlan, Price-S, CostXpert, Costar, and SEER-SEM. Another drawback of the software parametric models is the difficulty in getting information that may or may not exist for specific inputs. Often the estimator does not know who the contractor will be, so using model default values may not be any better than the industry averages used in the CER model.

Sizing Methods

Software sizing is the process of determining how big the application being developed will be.[13] Not only is it often difficult to generate a size estimate for an application that has not yet been developed, but the software process also often experiences requirements growth and scope creep that can significantly impact software size and the resulting cost and schedule estimates. Projects that do not track and control this trend typically have difficulty dealing with budget and schedule constraints.

Despite the difficulty, however, estimating software size is the most critical aspect of software estimation methodologies (except for engineering buildup) and is typically the most significant driver of cost and schedule for a software project. There are two primary sizing methods: source lines of code (SLOC) and function point analysis.

SLOC

Counting or estimating SLOC is the oldest and most widely used software sizing method. This metric looks at the volume of code required to develop the software. SLOC estimation is accomplished through analogy, engineering expertise, or automated code counters. There are several reasons for the popularity of SLOC as a measure of software size. First, it is fairly easy to reach a number, either by physically counting code or through an automated code counter. Second, there is usually plenty of historical data available in the form of legacy applications. Finally, most estimating tools accept SLOC as a sizing input for estimating purposes. SLOC sizing is particularly appropriate for estimating projects that have been preceded by other projects that are extremely similar in nature (e.g. same language, same developers, same application type). This helps to ensure that the past experience is relevant to the future development effort being estimated. When using SLOC, estimators also have to be aware of reuse assumptions, consider code growth assumptions, and ensure the SLOC estimates are specific to the identified coding language.

While SLOC is the most common sizing method, it does present some difficulties as a common metric because there is no standard to define what should be counted as a line of code and what should not. Typically estimators consider either physical implementation or logical statements when counting SLOC. In some programming languages, physical lines and logical statements are nearly the same, but in others, significant differences in size estimates can result. Because each line is terminated by the enter key, the physical SLOC metric is very simple to count and lends itself to automated counting tools.[14] Logical statements may encompass several physical lines and typically include executable statements, declarations, and compiler directives. SLOC counts based only on logical statements typically ignore programmer comments. Organizations, however, may come up with their own definition of what constitutes a line of code. This lack of a consistent standard makes it especially important to understand the organization's SLOC definition early in the estimating process. [15] Other criticisms of SLOC include the lack of reliable cross-language translation factors, the fact that the volume of SLOC produced by different individual coders to produce the same functionality can vary significantly, and the irrelevancy of SLOC as a size measure in many of today's development environments (Graphical User Interface (GUI), object-oriented, etc.).

FUNCTION POINTS

The other primary technique for estimating software size is function point analysis. Function points were established in the late 1970s as an alternative to SLOC. Only recently have they gained more attention and use, and in 2003 the International Standards Organization (ISO) published function points as a software sizing standard (ISO/IEC 20926:2003). Function points measure software size based on the functionality requested by and provided to the end user[16], and they measure logical size (as opposed to a physical size components). Functions are categorized as data or transactions. Data functions represent logical groupings of the data that end users need to do their jobs. Transactional functions are the processes and actions that end users utilize to manipulate and manage that data in the course of doing their jobs. This typically includes inputs (add, change, and delete), outputs (reports), and inquiries (searches or retrievals).

One of the key benefits of using function points as the sizing method is that counting standards are established and maintained for the technique. The International Function Point Users Group (IFPUG)[17] manages, regulates, and issues updates to these standards through the IFPUG *Counting Practices Manual*, which make function points fully traceable. Many resources can avail themselves to function point analysis at various stages in the development life cycle, including user or estimator interviews, requirements and design documents, data dictionaries and data models, use cases and user guides, and even screen captures or the actual software. Because it is linked directly to system requirements and functionality, FPA puts size analysis into terms that a user can understand. The size estimates (and resulting cost and schedule estimates) can be updated based on quantifiable analysis throughout the project life cycle as requirements change. Function points are particularly useful in many of today's development environments that might use the unified modeling language (UML), commercial-off-the-shelf components, or object-oriented approaches to software development and implementation.

Function point analysis does present some potential drawbacks. Accurate counting requires in-depth knowledge of standards, experience, and usually the function point certification from IFPUG. To date, no true automated function point counting tool exists, so it is largely a manual process. Also, some function point variations exist (Mark II, COSMIC, use case points) that are not standardized and can produce different results. Additionally, function points have not traditionally been used to estimate the size of algorithmic-intensive systems, real-time systems, tactical systems, or embedded software. However, the function point approach to software sizing is starting to be seen more frequently in these types of technologies, as the application of function point counting rules come to be understood in the context of these environments.

Cost Performance Trade Studies

Traditional design trade studies, such as Cost as an Independent Variable (CAIV) and Design To Cost (DTC) methodologies are both intended to identify cost reduction opportunities in mission architectures and system designs. CAIV focuses on performance trades for an overall system, where DTC only focuses on cost targets. These methodologies generally focus on a few design alternatives, with cost serving as either a design target or input to design alternative analysis. CAIV moves beyond these one-dimensional approaches to integrate cost, performance and utility, and system requirements in an ambitious approach for defining a system or architecture "best-value" design. A "best value" design is, by definition, the point on the cost/utility curve where an additional dollar of investment either doesn't increase or reduces the value to the system user. An example of this dynamic might be striving to achieve a performance goal, the final 5% that drives 50% of the cost.

<u>CAIV</u>

A CAIV analysis is a systematic, interdisciplinary examination of the several factors affecting system design: system design variables (i.e., weight, bandwidth), key performance parameters, system utility assessments, and various aspects of system cost. Executing a CAIV analysis involves the definition and coordination of these factors into a comprehensive study plan that compares design, performance and cost into some common unit of measurement. Normalizing these factors can be achieved with the following framework::

1. Identify Study Scope: Determine the trade space to be analyzed and the cost, design and performance objectives desired.
2. Determine CAIV Variables/Metrics: Select design variables, performance metrics, utility assumptions and cost approach.
3. Assess Variable Relationships: Design variable vs. Performance, Utility vs. Performance, Cost vs. Design Variables.
4. Plot Relationship Curves: Graphically depict variable relationships.
5. Derive Cost/Utility Function: Determine the dollar value of utility and the point of diminishing investment returns.

The detail or depth of the definition of the design approaches will depend on the resources available and should remain consistent throughout the trade study. The success of CAIV relies on this consistency as well as to the general acknowledgment of some critical analysis tenets:

- ***To trade you must be able to show the cost of each alternative***. Some alternatives can be challenging to cost and, more importantly, costs do not change if CERs do not include the parameter being changed.
- ***To trade you must know the dollar value of utility***. This involves important assumptions regarding the change in utility with each additional increment of performance. These can be hard to agree upon. Documentation is essential.
- ***To trade cost and performance the two must be compared in some common measurement unit***. This is most often connected through the utility assumptions.
- ***A trade should involve some measure of risk***. Risk can either be assessed in relative terms among design alternatives or factored into the metrics and design variables used in the analysis. Risk-adjusted cost methodologies can be used to trade risks and dollars.
- ***CAIV is iterative and relies on total program commitment***. PMs must have the proper motivation to take the inevitable risks associated with the innovation necessary to identify a best value solution that may, in some respects, vary from their initial point designs.

The method used to estimate costs for a CAIV analysis, and the data available to support it, are an important contributor to the effort's success. Critical to this effort is the ability of the cost estimating team to determine the cost associated with changes in the design variables selected for the analysis. Generally, point estimates for design alternatives are often determined using established methods of cost analysis: analogous program, engineering build-up, CERs, etc. Cost estimators should be prepared to provide these point estimates to the government for review and consideration.

These alternative estimates serve an important guide for deriving design variable/cost relationships. From here, it is possible, with the assistance of system design engineers, to relate changing costs between variables and derive the mathematical relationship (factoral, polynomial, etc.,) that exists between them. Once this relationship is established, the cost/design variable curve can be established. This should be duplicated for each design variable used in the analysis. The cost estimator integrates this cost/design variable with a similar performance metric/design variable curve generated by the system engineering team. Reducing the common design variable factor it is possible to determine the cost to performance relationship, or the performance estimating relationship (PER). This relationship defines the incremental change in cost with each addition of increased system performance.

<u>DTC</u>

DTC is a management concept that demands that cost be considered as a key design parameter during all phases of the acquisition process. DTC goals, in constant dollars, are established early to become part of the design trade-off process that examines other parameters such as schedule, performance, and operational capability. DTC goals can be set in each phase of the acquisition process and tracked until DTC parameters have been met. The DTC goal can be in the form of average unit sailaway cost targets. Shipbuilders and GFM vendors can be provided with DTC contracting incentives to motivate them during the production phase.

Occasionally, SECNAV or CNO may establish cost "caps" for certain programs. Although these cost ceilings in budget-year dollars are not considered to be formal DTC goals, many of the DTC procedures discussed above are applied.

Programs that have established DTC goals consume a significant share of the estimator's time. In addition to costing out a great deal more elements and studies, the estimator may have to consider unique construction techniques and materials proposed to reduce cost. The estimator is required to be innovative in CER selection and in estimating at a detailed bottoms-up engineering level.

Policy statements and procedures for DTC are provided in DoD Defense Acquisition Guidebook and in the Joint (Services) Design-to-Cost Guide (NAVMAT P5242).

Foreign Military Sales (FMS)

Selling of ships, ship systems, and combat and weapon systems to allies and friendly nations is accomplished by the U.S. Security Assistance Program and the FMS Program. The hardware procured by foreign nations is either the same or similar to hardware being procured by the U.S. Navy. These costs can be considered in two parts: (1) costs similar to bottom-line SCN costs, and (2) additional U.S. administrative costs and add-ons required to be paid by the buyer. It is the responsibility of the PM to determine these latter costs, which include elements such as USN support personnel, training, training equipment, spares, and missile and ammunition load. In addition, these nations share in a pro-rata of system non-recurring costs that have been previously paid for by the U.S. Navy. Cost estimators analyzing GFM costs assist the PM in assembling these pro-rata costs.

SEA 017 is responsible for developing or certifying the SCN-type costs referred to above. These costs are developed in the same manner and with similar procedures as described in this document for SCN estimates.

FMS cases are usually developed in two steps: Price and Availability (P&A) and Letter of Offer and Acceptance (LOA). The P&A estimate is a preliminary estimate usually developed for discussion purposes. The LOA estimate can, be the basis for an agreement between the United States and the foreign nation; and although it is considered to be a budget quality estimate, the foreign nation is responsible for all final costs.

Using Project Schedules in Cost Estimates

Project schedules play an important role in the development of any project, both for delivery of a product or service and understanding impact to cost. When a project is completed early, there may be cost savings associated with using fewer resources, unless resources were fully used in a more compressed time period. More often, schedules impact cost when projects are late, and more resources are consumed. For example, imagine a project that is scheduled to be completed in one year. Now assume that the project is actually completed in one year and three months. If the original schedule was used to estimate costs, then there are three months of cost unaccounted for in the original estimate. Even if no additional project materials were necessary, there would still be three months of labor, facilities, utilities, etc., which were not included in the estimate. The difference between Schedules and PERT's is their primary function. For example the primary function of a schedule is to plan and control programs, while a PERT is used to identify and resolve scheduling conflicts. Schedule analysis helps to answer the questions of how long will the project be delayed, and what those delays will cost the project.

Cost estimating personnel give FMS cases high priority and attention in accordance with NAVSEA Command policy.

PERT is the most common of various methods used to analyze schedules. Today, another variation of this method, the Critical Path Method (CPM) or critical path analysis (CPA) is also used. Figure 21 presents a sample PERT chart, showing the critical path and network of activities needed to complete a project, the order in which the activities need to be completed and the dependencies between them.

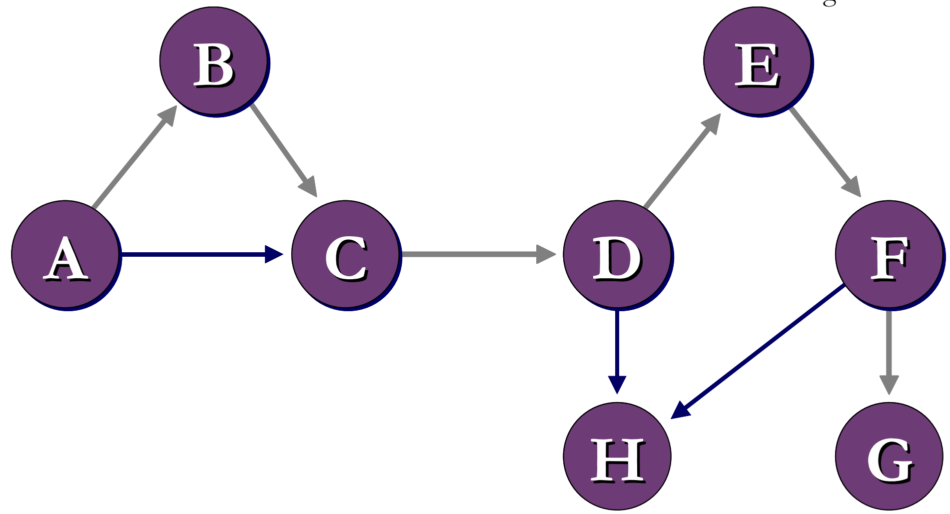


Figure 21: The Critical Path with a 12-Day Estimated Duration

The diagram consists of a number of circles, representing events within the development life cycle, such as the start or completion of an activity, and lines, which represent the activities themselves. Each task is additionally labeled by its time duration. The primary benefit is the identification of the critical path. The critical path is the path for which the total time for the activities on the path is greater than any other path through the network (delay in any task on the critical path leads to a delay in the project). Therefore, any delay in the critical path will lead to increased cost of the project, unless other measures are undertaken to prevent it. One example of this would be wait time. If a task is delayed due to wait time, such as waiting for approval of a change or for an additional part, additional cost can be avoided if resources can be diverted to, and billed to, another project during the wait. Unfortunately, this is not always feasible, and total project cost increases.

There are a wide variety of available methods to calculate estimated schedule slips ranging from PERT, to GANTT, to variance analysis using start, end, or duration variances. There are also a variety of tools available to conduct scheduling activities, such as: MS Project, Artemis, Open Plan, Primavera, Timeline, Project Scheduler II, and Project Workbench. The method used will be dependent upon the type of project, the data available, and the resources available to devote to schedule analysis. Often, the most efficient method is the PERT diagram, used to identify the critical path, which is then supplemented by the technical expertise of an independent authority regarding probable future schedule slips based on prior schedule performance and current project phase. Earlier phases of the project will likely encounter more schedule slips than later phases.

Once the schedule analysis has been completed, an amount must be assigned to any schedule delays for cost estimating or assessment purposes. Once again there are several methodologies for estimating, based on available data, resources, and project knowledge. One of these methods is calculating an average burn rate for the project. A simplistic approach would be to divide the total cost of the project by the number of weeks the project has been open, to arrive at an average weekly burn rate. This rate can then be multiplied by the number of weeks of schedule delay identified as likely, to derive an estimate of the total cost of the schedule delay. A more detailed estimate of the burn rate may be calculated by identifying the resources impacted by schedule delay (only labor, or labor and facilities) and calculating the burn rate based only on the cost of those resources impacted. Lastly, the most important factor in schedule analysis is clarity on the methodology used to calculate both the schedule outcomes, and the approach used to estimate the increased resource requirements for those outcomes. If clearly documented assumptions and methodologies are communicated, estimates may be more easily reusable, transferable, and understood by all relevant stakeholders.

In estimating ship construction cost, schedule is a key parameter in determining time value of money or inflation, direct labor, and overhead rates. Normally a ship construction schedule is provided by the PM's office to the assigned estimator. The schedule information comes in the form of Contract Award Date, Start of Construction Date, Laying Keel Date, and Ship Delivery Date. The program office establishes these dates based on the Initial Operation Capability (IOC) requirement provided by the force structure planners to mitigate specific threats or lift shortfall. Although schedule comes as a programmatic input a good estimator always examines whether the construction time i.e., the months between the start of construction or fabrication date and the delivery date is achievable based on the estimated production hours. It has been demonstrated that any significant risk to schedule translates to cost risks. The estimator also checks whether the time between the award date and the start of construction date is adequate to complete majority of the detail design and planning required for starting fabrication. An estimator must keep in mind that inadequate design information to construction floor causes re-work resulting in higher labor hours.

Schedule is also important in determining Long Lead Time Material (LLTM) costs. Some of the major weapon systems and ship systems, such as Dual Band Radar (DBR) or Permanent Magnet Motor (PMM) for electric drive propulsion systems require procurement or development early to meet the ship construction schedule. An estimator should consider appropriate fiscal year for procuring LLTM items and phasing plan if required.

Schedule also plays a key input in determining contractor's direct and indirect or overhead rates. The industrial planning and analysis group in SEA 017 uses the schedule to develop workload curves for all work in the construction yard. Use of incorrect schedule would result in incorrect rates. A ship estimator must coordinate the schedule information between program office and SEA 017 industrial planning and analysis group and clearly understand the time phasing of labor hours to defend the estimate and the rate used.

Earned Value Management (EVM)

EVM is a recognized management tool that ties cost, schedule, and technical performance together. Using fairly standard analysis techniques, actual performance data from a project can be used to estimate the final cost of the project, an EAC. For example, the analyst(s) relates the technical content to the time-phased, resource-loaded budget baseline. The analysts may also look at programmatic and technical risks, threats, liens, and deferred technical content with associated budget impacts. The analyst reviews all of these elements in terms of performance to date as well as the assumptions made by the program for its future performance.

Earned Value Management (EVM)

A management technique that relates resource planning to schedules and to technical cost and schedule requirements. All work is planned, budgeted, and scheduled in time-phased increments constituting a cost and schedule measurement baseline.

Earned Value Management System (EVMS)

A management system and related sub-systems implemented to establish a relationship between cost, schedule, and technical aspects of a project, measure progress, accumulate actual costs, analyze deviations from plans, forecast completion of events, and incorporate changes in a timely manner.

Sensitivity Analyses

It is recommended that a sensitivity analysis be performed to identify the major cost drivers (i.e., those variables whose changes create the greatest changes in cost.) Conducting a sensitivity analysis also ensures that all potential improvements and costs have been captured. Sensitivity is determining how the different ranges of estimates affect the point estimates. For decision- makers, a range estimate with an understanding of the certainty of how likely it is to occur within that range is generally more useful than a point estimate. Due to the nature of the NAVSEA design and development process, there will always be uncertainty about the values of some, if not many, of the technical parameters during the definition phase of a project. Likewise, many of the assumptions made at the beginning of a project's definition phase will turn out not to be accurate. Therefore, once the point estimate is developed, it is often desirable to determine how sensitive the total cost estimate is to changes in the input data.

Sensitivity Analysis

A technique used to discover how sensitive the results from economic and financial models are to changes in the input values of the variables used to calculate the results.

A high degree of sensitivity is a warning to interpret the results of the model with care and circumspection, especially because many of the input variables themselves will have been estimated and therefore be subject to error. Use of econometric models must not obscure awareness of their limitations and possible pitfalls, especially when they are being used for forecasting

While sensitivity analyses can occur at any stage of an estimate, it generally makes sense to derive an unconstrained solution that meets all mission objectives initially, then begin to "back off" that solution in the interests of saving money. Care must be taken, however, not to impact the material solution to such an extent that the benefits derived from that solution are significantly altered through introduction of the changes.

If an estimator is using the parametric cost estimating method, the model's input parameters can be easily changed. A sensitivity analysis in the model can show how changes to certain parameters impact the cost of a program by changing the variables and recording how cost changes with respect to that parameter.

Sensitivity analysis is also used when conducting an Economic Analysis (EA). If an EA is to have any real credibility, initial recommendations must undergo sensitivity analysis. Much of an EA is based on assumptions and constraints, so it is important to consider the impact of varying those assumptions and constraints on the ranking process. Once a proper sensitivity analysis has been conducted, a final set of recommendations can be prepared and presented for the decision-maker's use.

Regardless of why a sensitivity analysis is performed, it is important to document all assumptions and results. Only one number may be recorded as "the estimate," however supporting data can assist engineers in making technical trade offs and PMs in making key acquisition and program management decisions.

Regression Analysis

Regression Analysis is a quantitative technique used to establish a line-of-best-fit through a set of data to establish a relationship between one or more independent variable and a dependent variable. That line is then used with a projected value of the independent variable(s) to estimate a value for the dependent variable. Regression analysis is a statistical tool designed to use an existing data set to forecast future values. It does this by finding "best fits" of mathematical functions to the existing data set, where "best fit" has a specific and unambiguous statistical meaning. Terms like "best fit" and "least squares" are often used in describing regression analysis because a regression function minimizes, in a well-defined mathematical sense, the difference between the actual data set and the forecast values.

Regression Analysis

Regression analysis calculates best fits to historical data, and, through the use of powerful techniques, tests the strength and direction of the statistical relationships. Regression does NOT establish causality any more than correlation analysis does.

Regression analysis underpins the parametric approach to cost estimating by CERs derived from historical data to project the future cost of a project. A CER is a mathematical equation that describes the relationship between cost and one or more variables that are thought to "drive" costs. A CER is the result of a regression analysis, which describes how the values of cost (the independent variable) are related to ("driven") by the values of one or more "independent" variables. A CER is an example of a parametric estimating technique, since the parametric estimating method relies on the value of one or more input variables, or parameters, to estimate the value of another variable, namely cost. For example, a study of existing shipboard radar systems may yield a CER relating equipment unit cost to the weight of the system, and radiated power. This CER could then be used to predict radar unit cost for a new system whose weight and radiated power can be estimated.

To perform the regression analysis for a CER, the first step is to determine the relationship between the dependent and independent variables. Then, the data is fit using techniques such as:

- Linear regression: involves transforming the dependent and independent variables into linear forms
- Nonlinear regression: for data that is not intrinsically linear

The dependent variable is called that because it responds to changes in the independent variable. For a CER, the dependent variable will always be cost and the independent variable will be the cost driver. The cost driver should always be chosen because there is correlation between it and cost and because there are sound principles for the relationship being investigated. For example, the assumption may be made that the complexity of a piece of computer software drives the cost of a software development project. The dependent variable is the Y variable and the independent the X variable.

The point of regression analysis is to "fit" a line to the data that will result in an equation, which describes that line, expressed by $y = a + bx$. In this case, we assume a positive correlation, one that indicates that as complexity increases, so does cost. It is very rare that a CER will be developed around a negative correlation, i.e., as the independent variable increases in quantity, cost decreases. Whether the independent variable is complexity or weight or something else, there is typically a positive correlation to cost. One estimates the parameters of a model. The usual technique is called least squares. A linear regression model is one in which the dependent and independent variables can be transformed into a linear form. A non-linear regression model is one for which there is no such transformation. More formally, a non-linear regression model is one for which the first-order conditions for least-squares estimation of the parameters are non-linear functions of the parameters.

With the addition of possible explanatory variables (see Table 11), a more precise and robust regression equation can be obtained. Since more than one independent variable is likely to have an effect on the dependent variable, one can calculate multivariate regression:

Regression Coefficient	Meaning
ß$_1$	Impact of a one-unit increase in X_1 on the dependent variable Y, holding constant all the other included independent variables (X_2 and X_3)
ß$_2$	Impact of a one-unit increase in X_2on Y, holding X_1 and X_3 constant
ß$_3$	Impact a one-unit increase in X_3 on Y. holding X_1 and X_2 constant

Table 11: Explanatory Variable for Regression Equations

The usual method of regression coefficient estimation is using a computer program capable of calculating estimated coefficients with a technique called Ordinary Least Squares (OLS). Table 12 provides a reference guide to help evaluate regression results.

Symbol	Check Point	Reference	Decision
X_1	Data Observations	Check for errors, especially outliers in the data.	Correct any errors. If the quality of the data is poor, may want to avoid regression analysis or use just OLS.
ß^	Estimated Coefficient	Compare signs and magnitudes to expected values.	If they are unexpected, reexamine the model if appropriate or assess other statistics.
e_1	Residual	Check for transcription errors.	Take appropriate corrective action.
R^2	Coefficient of Determination	Measures the degree of overall fit of the model to the data.	A guide to overall fit.
$\check{R}^2$	R^2 adjusted for degrees of freedom	Same as R^2. Also attempts to show the contribution of an additional explanatory variable.	One indication that an explanatory variable is irrelevant is if the $\check{R}^2$ fails when it is added.
TSS	Total Sum of Squares	$TSS = \Sigma(Y_1 avg\ Y)^2$	Used to compute R^2 and $\check{R}^2$.
RSS	Residual Sum of Squares	$RSS = \Sigma(Y_1 - \hat{Y}_1)^2$	Used to compute R^2 and $\check{R}^2$.

Table 12: Reference Guide for Interpreting Regression Results

As illustrated in Figure 22, developing a CER begins by defining a hypothesis for the relationship between the two items that the estimator is trying to test. Once the hypothesis is clearly defined, the estimator collects data to support this relationship test. As mentioned in Section 4, the Cost Estimating Process Data Collection Task, this data must be evaluated for relevance and accuracy and normalized for consistencies and inflation. Once the estimator has identified relationships and prepared the data, a statistical analysis can be performed through regression analysis. Just as the cost estimating process is iterative, so too, is the regression analysis process. Once the regression has been run, the relationships need to be tested again to see if the hypothesis can be proved or disproved. This process can be repeated until the estimator finds a good fit for the data with a reliable CER. Once the estimator finds a satisfactory relationship, the CER can be selected. Once the CER has been selected, the data and methodology should be documented for future use.

All CERs should be validated, well documented, and explained. If they are improperly applied, the result could be a serious estimating error. Excel or other commercially available modeling tools are most often used for these calculations. It is important to recognize that there are weaknesses in using CERs for cost estimates. For example, improperly documented CERs are difficult for others to understand. There can also be credibility issues with data, including adjustments, use in equations, and the interpretations of statistical findings. Collecting and validating data can be time consuming and expensive. Once CERs are used, they must continue to be tested for relevancy and for credibility outside the relevant data range. Regardless of these weaknesses, CERs can be excellent predictive tools that can answer "what if" estimating questions without reliance on expert opinion—provided the independent variables used in the expression remain within the range of data upon which the CER is based.

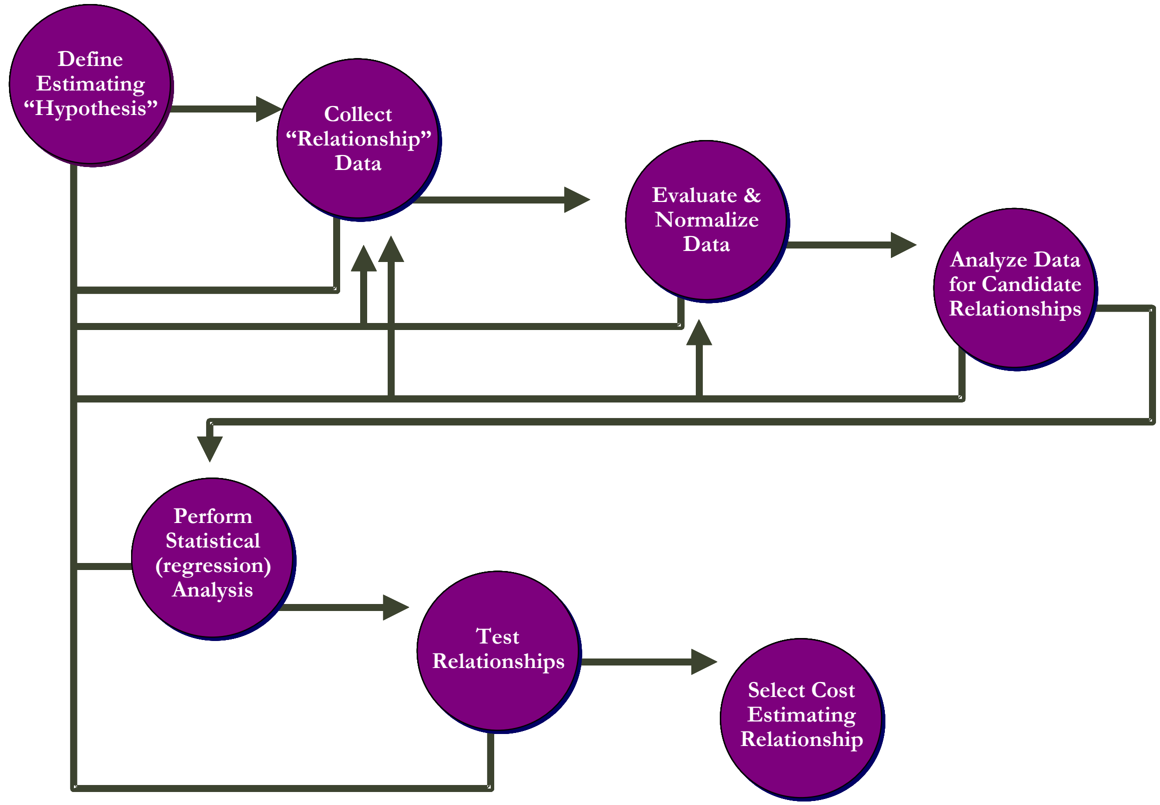


Figure 22: CER Methodology

For further information on regression analysis, see:

- State University, Long Beach (Regression) http://www.csulb.edu/~msaintg/ppa696/696regs.htm#REGRESSION
- London School of Economics and Political Science (Regression) http://econ.lse.ac.uk/ie/iecourse/notes/Sep01C2.pdf
- University of Exeter (Regression) http://www.exeter.ac.uk/~SEGLea/psy2005/simpreg.html http://www.exeter.ac.uk/~SEGLea/psy2005/basicmlt.html
- University of Hawaii (Regression) http://www.soest.hawaii.edu/wessel/courses/gg313/DA_book/node74.html o University of Southern California (Regression) http://www-rcf.usc.edu/~moonr/econ419/econ414_2.pdf
- University of Sussex (Regression) http://www.cogs.susx.ac.uk/users/andyf/teaching/pg/regression1/sld001.htm

Learning Curves

Many industries, including shipbuilding, experience a learning or improvement process when multiple units are constructed in an orderly, phased sequence. Learning curve information is needed to calculate the Theoretical First Unit or T1 production hours and this data is used by SEA 017 to calculate the rate impacts.

Historical data validates that learning takes place and provides the basis for what is referred to as learning curve theory. As it pertains to shipbuilding, the theory states that each time the total quantity of ships built doubles, the manhours, material or basic construction cost of the ships is reduced by a constant percentage of the previous manhours, material, or basic construction cost. The complement of this constant percentage of reduction is sometimes referred to as the "slope," which can be expressed in two ways. If the fourth ship's manhours, for example, were 90% of the second ship's manhours and if the eighth ship's manhours were 90% of the fourth ship's manhours, then the slope would be expressed as a 90% unit learning curve. On the other hand, if the average manhours of all eight ships were 90% of the average manhours of the first four ships, then the slope would be expressed as a 90% cumulative average learning curve. Similarly, weapon systems, missiles, torpedoes, and other hardware may also exhibit learning. These may be expressed individually, or in lots using cumulative average theory. In any case, the application can be expressed as a mathematical function to a power and this function is linear on logarithmic scales.

Calculating Learning Curves

Cumulative Average Curve
(T.P. Wright, traditional approach)

Calculates average unit value of production lot

$Y = AX^b$

Y = Cum average unit value of the Xth unit

A = Theoretical first unit value (T1)

X = Unit number

b = Log(slope)/Log(2)

Unit Curve (J.R. Crawford/Boeing Approach)

Calculates unit value of specific point on curve

$Y = AX^b$

Y = Unit Value of the Xth unit

A = Theoretical first unit value (T1)

X = Unit Number

b = Log(slope)/Log(2)

Midpoint Value

Point on the curve where the unit value represents the simple average of all units in the lot

$$MPV = \left[\frac{(X_e - X_b + 1) * (1 + b)}{(X_e + 0.5)^{1+b} - (X_b - 0.5)^{1+b}} \right]^{-1/b}$$

MPV = True lot midpoint value
X_e = End point (last unit in the lot)
X_b = Beginning point (first unit in lot)
b = Log(slope)/Log(2)

Entire courses and books are devoted to learning curve theory, including sections on learning curve shifts and rotations, as well as the impacts resulting from new scope additions, production gaps, and so forth. The estimator should be aware that when multiple units, be it ships or other commodities, are awarded under a single contract, learning benefits and reduced costs are anticipated. If repeat units are awarded to the manufacturer on an appropriate periodic basis, learning benefits and reduced costs are also anticipated. The cost estimator should be knowledgeable of the acquisition plan when preparing estimates and must exercise judgment to determine whether learning curve theory applies. If it does, appropriate consideration must be given to selection and application of proper learning rates for both manhours and material dollars. In most cases, SEA 017 applies rate effects to material costs to account for learning. Lead ships or first lots will likely carry the burden of nonrecurring costs. These costs are not a factor in learning curve theory, which deals with reduction of recurring costs. The estimator must adjust for the nonrecurring costs before applying learning rates. Estimators have a choice to either work with unit or cumulative average curves. As long as the historical data are interpreted correctly and as long as the selected curve is defined and applied properly, the selection of unit or cumulative average learning curve theory is left to the discretion of the estimator.

For more information on learning curves please see the following websites:

- http://www.computerworld.com/cwi/story/0,1199,NAV47-68-85-1942_STO61762,00.html
- http://www.sc.doe.gov/sc-80/sc-82/430-1/430-1-chp21.pdf
- http://ioe.engin.umich.edu/ioe463/learning.pdf
- http://www.jsc.nasa.gov/bu2/learn.html

Rate Curves/Effect

The standard production quantity can change over time with the addition (or removal) of facilities. The Rate Effect is the result of spreading of fixed costs over a larger base or higher quantity. With more mature, high-volume products, there may not be a cost improvement curve but only a rate effect.

Rate curves deal with the effects of various production events on learning. Learning curve theories predict a general decrease in costs with each unit produced and do not take into consideration the rate of production. Sometimes but not always, production rates and unit costs are inversely related, for example, when production rates decrease, personnel and material expenses increase and when production rates increase, personnel expenses decrease. Recently there has been research suggesting that production rates and unit costs are often positively related.

When production rates decrease, personnel and material expenses increase because there is a smaller quantity of units being produced over a fixed amount of time. As a result of the decrease, workers must be laid off or the company must retain a standing army in anticipation of the production rate increasing again. Compounding the situation, fixed production costs must also be spread across the decreased number of units being produced. The decreased production rate also impacts the ordering of materials for the product. This results in the manufacturer paying higher prices for parts as they are unable to take advantage of quantity discounts. If the manufacturer already made purchases the material costs per unit may remain the same, however; now there may be a storage cost to keep the extra parts in inventory. All of these factors may increase the price of each unit produced and the customer has to bear the price increase.

When production rates increase, personnel expenses generally decrease with the increase in workforce as the overhead costs can be spread across more units and personnel. Material costs also decrease in this situation as the manufacturer can take advantage of quantity discounts and minimize storage for parts.

Learning Curve Slope Rules of Thumb

- Shipbuilding 85- 93%
- Electronics manufacturing 90-95%
- Repetitive electrical operations 75-85%
- Raw materials 93-96%
- Labor 92%
- Complex machine tools 75-85%
- Machining or punch press 90-95%
- Repetitive welding operations 90%
- Purchased parts 85-88%

Approximation/Arithmetic Mean Approach:

Shortcut to calculating the midpoint
For the first lot::

- If the lot size < 10
  MPV = lot size / 2 + (# of prior units)
- If the lot size > 10
  MPV = lot size / 3 + (# of prior units)
- For subsequent lots:
  MPV = lot size / 2 + (# of prior units)

Rate Theory attempts to capture these production rate/curve events in a model. The RAND Corporation first proposed Rate Theory in 1974, attempting to combine production rate into the Unit Learning Curve (ULC) model. Two key variables are added to the ULC equation: R, the annualized rate of production, which varies depending on the unit and the period of time over which it is built, and c, the regression coefficient for R in the log-linear equation, just as b is the regression coefficient for X, and it is derived in a similar manner.

Rate Theory can be used to analyze budget impacts, such as the effects of budget reductions and translating the impact to a per unit cost impact. One problem with this use of Rate Theory is that the results are rarely found to be statistically significant and this method is not often favored by cost estimating oversight organizations.

The Rate Theory modified learning equation:

$$Y = aX^{b}R^{c}$$

Y	=	Cost of the Xth unit
a	=	Theoretical First Unit Cost (T1)
X	=	Sequential unit number of unit being calculated
b	=	ln Learning Curve Slope (LCS)/ln(2), a constant reflecting the rate of cost decrease from unit to unit
R	=	Annual Production Rate
c	=	Regression coefficient for R

Inflation/Escalation

The term "inflation" as used in cost estimating means a rise (or drop) in the general price level of labor and material. Consideration of the impact of inflation on shipbuilding costs is an important part of the cost estimating process. Prior-year ship cost data, almost without exception, must be adjusted by a proper inflation factor if it is to be used in current-year or out-year budget estimates. Cost estimates prepared for some future budget year will always include: (1) the forecasted inflation between the current year and the future year, and (2) the forecasted inflation (escalation) over the construction period of the particular ship. Inflation measures the change in prices from one period to another, and is usually expressed as a percent. Escalation represents the cost for the time-phased impact of inflation over the ship construction period, and is usually expressed as a dollar value.

Realistic Inflation in Ship Estimates

To adjust costs for inflation, the estimator must apply an appropriate inflation index or inflation rate. This section describes sources of realistic shipbuilding inflation and their application to ship cost estimates.

Each year in the December/January timeframe, OSD publishes updated inflation projections for defense procurement. These OSD indices are based upon OMB's forecast of the Gross Domestic Product Implicit Price Deflator, which measures general inflation for all goods and services produced and sold in the U.S. economy. The DON Budget Guidance manual states that the use of approved OSD/OMB price escalation indices to estimate future increases due to inflation is mandatory *except in those cases where other specific information is available*. Historically, actual shipbuilding inflation has generally been higher than the generic OSD indices, and this trend is expected to continue in the future. In the past, use of OSD projections for direct and indirect labor, material, and other separately identified costs in some shipbuilding programs has led to under-budgeting for inflation.

In recognition of the unique inflationary pressures affecting the shipbuilding industry, ASN(RD&A) issued a memorandum in February 2004 directing that *all ship program estimates should reflect realistic shipbuilding-specific inflation* when available, rather than the generic OSD/OMB inflation projections. SEA 017 subsequently instituted a policy to forward price ship estimates using realistic inflation. Realistic inflation data is available from a number of sources:

- Global Insight, Inc., a world leader in econometric forecasting and a major source for general inflation information. Global Insight was created in 2002 to combine two leading economic and financial forecasting companies - DRI (formerly Data Resources Inc.) and WEFA (formerly Wharton Econometric Forecasting Associates). Global Insight develops inflation forecasts for hundreds of Bureau of Labor Statistics (BLS) material commodities and labor categories. This information is used to support the cost estimating process, as well as proposal evaluation, source selection, and contract execution. The SEA 017 Industrial Planning and Analysis Group maintains a subscription to Global Insight data services and can assist in developing special inflation indices tailored to a specific program or product line.
- Global Insight also produces an industry-wide inflation forecast for shipbuilding and repairing labor. In cases where FPRA or yard-specific data is not available, this forecast may be used to inflate shipbuilding labor costs from one date to another.

- Shipbuilder FPRAs are the main sources for realistic shipbuilding labor inflation. Each shipbuilder's FPRA reflects future labor and overhead cost projections, including assumptions concerning union negotiations, skill mix changes, fringe benefit changes (recently greatly affected by rising health care and pension costs), changes in the overhead allocation base, and other cost trends. The Industrial Planning and Analysis Group incorporates FPRA data into their labor/overhead rate models to develop forward-priced rates based on specific ship schedules and manhours. These rates are then provided to SEA 017 estimators for inclusion in ship estimates.
- Shipbuilding material inflation information is also available from various sources. Actual program or contract-specific material inflation may be used if available. Another source for inflation information is the annual shipbuilding material vendor survey conducted by NAVSHIPSO. Each year, NAVSHIPSO sends out a survey to vendors supplying material or equipment products applicable to the various SWBS groups, requesting actual historical and anticipated price inflation. NAVSHIPSO then compiles and analyzes this data for each SWBS group to produce the Material Cost Estimating Relationship (MATCER) inflation indices. In addition to the annual survey, NAVSHIPSO has also conducted special material analyses specifically for aircraft carriers (CVN) and submarines (SSN).
- SEA 017 develops material inflation indices by SWBS group based on Global Insight projections. These indices include actual and projected inflation rates for BLS material categories applicable to each SWBS group.

The choice of the material index should be determined on an individual program basis. Factors to consider include historical data trends for the same or similar programs, or whether the material includes specialized/unique categories or applications, such as nuclear or submarine-specific components. The NAVSHIPSO MATCER indices include inflation for a number of shipbuilding-unique components. Global Insight projections reflect selected general industrial material categories that are applicable to the types of material used in shipbuilding, but are not themselves shipbuilding-specific.

In accordance with ASN(RD&A) direction, ship cost estimates and budgets should always reflect the best available information regarding shipbuilding inflation. For long-term projections, inflation rates should reflect a continuation of the rate trend established by best available information. As stated in the DON Budget Guidance Manual, in cases where specific inflation information is not available (such as overall Government Furnished Material costs) the general OSD inflation rates for defense procurement may be used.

CONTRACTUAL CONSIDERATIONS

In the current ship acquisition environment, PMs may tailor their shipbuilding contracts to account for unique inflation experience for a particular ship platform or shipbuilder. Shipbuilding contracts, particularly Fixed-Price Incentive (FPI) contracts, may include special clauses that detail how the shipbuilder will be compensated for the effects of inflation over the long ship construction period. There are two different types of standard clauses that are typically used: "Compensation Adjustment" or "Economic Price Adjustment." The purpose of both types of clauses is to protect the shipbuilder from unforeseen inflation beyond his control during contract execution. Regardless of the planned contracting method, ship cost estimates are now typically forward-priced.

The "Compensation Adjustment" clause is also known as an "escalation" clause. With this type of clause, the contract cost is specified in base-dated dollars, or "Target Cost." The clause specifies how the shipbuilder will be reimbursed for labor and material inflation that occurs in the shipbuilding industry over the performance period of the contract. This additional compensation for inflation is termed "escalation." The base date and special shipbuilding indices specified in the contract are utilized for measuring the amount of inflation and calculating the escalation cost. Additional details on estimating contract escalation costs are discussed in Appendix B.

The "Economic Price Adjustment" clause is used when the contract cost is forward-priced. The clause identifies projected inflation over the life of the contract, along with upper and lower threshold limits, or "tolerance bands." As long as the actual inflation (as measured by the indices specified in the contract) stays within the predetermined threshold limits, there is no adjustment to the contract cost. If actual inflation is higher than the upper limit originally projected at the time of contract award, the contract cost is adjusted upward. Conversely, if actual inflation is below the lower limit originally projected, the contract price is adjusted downward. The specifics of these calculations are detailed in the clause. Figure 23 illustrates the application of the clause for direct labor costs. In this example, actual labor inflation (green line) over the life of the contract is within the blue "tolerance bands" determined at the onset of the contract, so no adjustment to the contract direct labor cost is necessary.

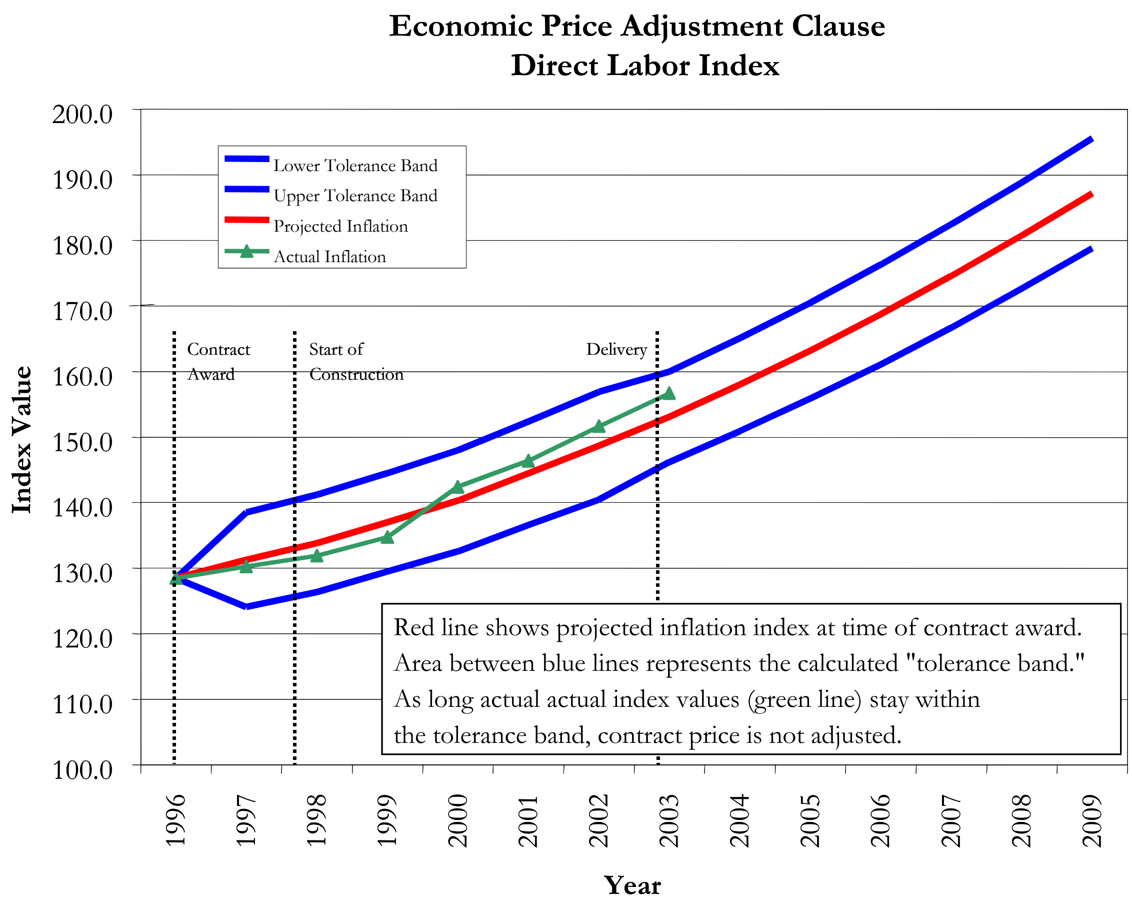


Figure 23: Applying the Economic Price Adjustment Clause

Contracts and Share Lines

The type of shipbuilding contract at time of award is not in and of itself a factor directly driven by the status of the shipbuilding marketplace. It is only later during construction that the type of contract becomes an influence on the way a shipbuilder manages the contract, and this can become a factor in return costs. In a ship procurement, the type of contract used is set by the Navy to suit the circumstances of the particular procurement, primarily the degree of risk, and therefore which party assumes the greater burden. When a shipbuilder undertakes significant risks, the Navy contract will be selected and structured to share that risk with the shipbuilder. When circumstances dictate that there is little risk to the shipbuilder, the contract form selected will place a greater burden on the shipbuilder. A discussion of the more prevalent types of contracts used by the Navy in shipbuilding programs is presented in the following section.

<u>Firm Fixed Price</u>

A firm fixed-price (FFP) contract entails a fixed dollar amount established at time of award and payable to the shipbuilder for meeting the total stated contract requirements. A FFP contract is suitable for low-risk, short-term construction contracts, e.g., repeat buys of boats and craft. Any anticipated inflation during the short period of the contract would have to be considered in the fixed price. There is also a modified form of the FFP-type contract and that is an FFP contract with escalation. For low-risk, long-term (two years or more) contracts, the Navy will include an escalation clause in the contract. The shipbuilder in this way is provided with protection against inflation during the extended contract period.

The most significant aspect of the FFP-type contract to the shipbuilder is that the bid price includes a good approximation of estimated costs. A lesser amount could become a serious problem if unanticipated events during construction cause the shipbuilder's costs to rise. Shipbuilders will give priority attention to work contracted for under a FFP contract, especially if other work in the shipyard has been contracted for with contract terms that are more flexible.

The ship cost estimator approaches the FFP-type estimate with the primary emphasis on establishing a fair and reasonable estimated price. CER selection is made from cost data accumulated from prior FFP awards. The estimator communicates with cognizant PMs and the NAVSEA Contracts Directorate, as required, to monitor contract performance on prior FFP awards and to determine if shipbuilder bid data submitted in support of those awards are consistent with actual shipbuilder experience.

Fixed Price Incentive (FPI)

Most major Navy ship programs are contracted for with FPI-type contracts. The FPI-type contract is similar in some respects to the FFP (with escalation)-type contract form. A significant difference or added feature is the expressed Navy intent to share the cost risks and benefits of the contract along stated share lines. Inherent within the FPI-type contract is the premise that a reasonable target cost can be established and that there is a reasonable opportunity for the competent shipbuilder to be able to perform for less than that cost. A target cost, target profit, ceiling price and under-target and over-target sharing formulas are established as part of the negotiations. If shipbuilder final costs (in base date dollars) fall below target, the shipbuilder and the Navy share those savings along some predetermined percentage share line. Share ratios that result in the share line are written as "75/25" for example, which means the Government assumes 75% of the cost risk and the contractor assumes 25%. If events force costs upward past target, the shipbuilder and the Navy share those additional costs along the same or similar share line. It is not unusual for the over-target and under-target share lines to be different based on risk ranges. In this latter case, the Navy share ends when total costs reach a predetermined ceiling price. At this point, the financial commitment of the Navy is complete and the shipbuilder remains totally responsible for any additional costs. This is called the "Point of Total Assumption (PTA)".

Shipbuilders readily accept an FPI arrangement because profit status over a long range of costs is made clear at the time of contract award. This knowledge provides the shipbuilder with a degree of flexibility on the use of available resources across various contracts that may be working in the shipyard at the same time.

The ship cost estimator handles the FPI-type estimate similarly to the FFP. That is, the estimator makes his best estimate of fair and reasonable target cost using CERs developed from prior FPI cost data. FPI return costs are reviewed with cognizant PMs and contracts personnel to determine whether the data are suitable to be used in future FPI-type estimates.

Cost Plus Contracts

There are occasions when the status of a particular shipbuilding program requires that a cost-type contract arrangement be used. Such a case could be a lead ship with an innovative hull form, new propulsion machinery design, or, perhaps, a first-of-a-kind combat system. In situations such as this, the contract form generally used is Cost Plus Award Fee (CPAF). The established cost targets in a CPAF contract include anticipated inflation. The successful shipbuilder is provided with a fee at time of award. The Navy pays all allowable costs from this point on. The shipbuilder can be awarded additional profits, up to a predetermined maximum percentage, if contract performance warrants such profits. In addition to CPAF, cost contracts could be in the form of cost plus fixed fee (CPFF) or cost plus incentive fee (CPIF).

The cost-type contract provides the shipbuilder with maximum cost risk protection and, perhaps, the most flexibility on resource utilization; however, a cost-type arrangement tends to produce higher costs per unit than a fixed-price arrangement. This may be attributed to a number of factors such as uncertainties associated with new plans, specifications, and requirements, or to shipyard management practices. Bid data and return cost data accumulated from cost-type contracts must be reviewed carefully for traces of these factors before the data are used for CER development. The estimator's objective for a cost-type arrangement in a competitive procurement continues to be to estimate a fair and reasonable target cost.

Source Selection Techniques

Source selections for most shipbuilding contracts are done on the basis of "best value to the Government." Best Value is the expected outcome of an acquisition that, in the Government's estimation, provides the greatest overall benefit in response to the requirement. In different types of acquisitions, the relative importance of cost or price may vary. For example, in acquisitions where the requirement is clearly definable and the risk of unsuccessful contract performance is minimal, cost or price may play a dominant role in source selection. The less definitive the requirement, the more development work required, or the greater the performance risk, the more technical or past performance considerations may play a dominant role in source selection. Specific weighting and evaluation criteria are specified in Section M of the RFP.

The PM's Source Selection Plan is the key document that describes, in detail, the entire source selection process. It lists the members of the source selection organization, the evaluation factors (listed in relative order of importance), methods for rating proposals, a description of the evaluation process (including a description of how cost will be evaluated), and other administrative details (e.g., plans for obtaining secured facilities and for obtaining from all participants their financial disclosure statements.)

The plan will describe the cost or price analysis that will be done for the source selection. The FAR defines *"price analysis"* as the process of examining and evaluating a proposed price without evaluating its separate cost elements; the FAR defines "*cost analysis*" as the review and evaluation of the separate cost elements and profit in an offeror's proposal (including cost or pricing data or information other than cost or pricing data), and the application of judgment to determine how well the proposed costs represent what the cost of the contract should be, assuming reasonable economy and efficiency.

Tip: Source Selection

There is no magic formula for making the cost/technical trade off.

A price premium must be justified, regardless of the superiority of the rating.

It is important to follow the evaluation criteria/process outlined in the RFP and source selection plan. In the event of a protest by the unsuccessful Offeror(s), it is imperative that the evaluation process be followed and documentation support the decision made in a complete fashion.

The typical source selection organizational structure is:

- **Source Selection Authority (SSA**) – the government official in charge of the selection
- **Source Selection Advisory Council (SSAC**)- a group of functional experts appointed by the SSA to advise the SSA
- **Source Selection Evaluation Board (SSEB)-** the team appointed by the SSAC for evaluating technical and other non-price factors. The SSEB is not allowed to review any of the proposed cost information; they cannot use cost data in their evaluations.
- **Performance Risk Assessment Group (PRAG)-** a panel appointed by SSAC to assess performance risk
- **Cost/Price Analysis Team or Cost Assessment Board -** a team selected to evaluate the proposed costs or prices of the proposals. Typically, the Contracting Officer or his/her representative heads the team. Usually, the Cost/Price Analysis Team reports directly to the SSAC in order to ensure that offerors' proposed costs/prices have not been considered by the SSEB in their technical evaluations. The Cost/Price Analysis Team can obtain technical assistance and data from the SSEB; the SSEB is not allowed to obtain any cost information from the Cost/Price Analysis Team. Often it is possible for SSEB members to review proposed labor hours, without being given any rates, or other cost information. The duties and responsibilities of the Cost/Price Analysis Team are:
  - Ensure that the RFP requests the necessary cost/price data needed to meaningfully evaluate proposals.
  - Ensure that offerors' cost proposals and cost data is safeguarded and kept separate from the technical data.
  - Evaluate the proposed cost or prices in accordance with the RFP and SSP guidelines, which may include contact with the DCAA, or others, necessary to verify proposed rates or cost history.
  - Prepare a Cost/Price Report that documents the reasonableness or realism of proposed price and cost, and the basis of any determinations or adjustments made to proposed prices and costs.
  - Provide such briefings and consultations concerning the evaluation as may be required by the SSA or SSAC.
  - Participate in debriefing of unsuccessful offerors' as requested by the PCO.

Cost or price must be an evaluation factor in all acquisitions; however, the evaluation will vary depending on the specific circumstances of each acquisition. For fixed price contracts, comparison of the proposed prices usually satisfies the requirement to perform a price analysis, and a cost analysis need not be performed. Cost or price analysis shall be conducted in accordance with FAR 15.305 http://www.arnet.gov/far/(a)(1).

For flexibly priced contracts (e.g., fixed price incentive, cost-reimbursement), evaluations may include a "*cost realism analysis*" for certain purposes in accordance with FAR 15.404 http://www.arnet.gov/far/. In the case of fixed price incentive ship acquisitions, cost realism analyses are almost always done. For cost reimbursement contracts, evaluation shall include a cost realism analysis to determine what the Government should realistically expect to pay for the proposed effort (FAR 15.305(a)(1) http://www.arnet.gov/far/).

The FAR defines a "cost realism analysis" as the process of independently reviewing and evaluating specific elements of each offeror's proposed cost estimate to determine whether the estimated proposed cost elements are realistic for the work to be performed; reflect a clear understanding of the requirements; and are consistent with the unique methods of performance and materials described in the offeror's technical proposal.

A cost realism analysis shall be performed on cost-reimbursement contracts to determine the probable cost of performance for each offeror.

- The probable cost may differ from the proposed cost and should reflect the Government's best estimate of the cost of any contract that is most likely to result from the offeror's proposal. The probable cost shall be used for purposes of evaluating and determining the best value.
- The probable cost is determined by adjusting each offeror's proposed cost, and fee when appropriate, to reflect any additions or reductions in cost elements to realistic levels based on the results of the cost realism analysis.

A cost realism analysis may also be used on competitive FPI contracts. Results of the analysis may be used in performance risk assessments and responsibility determinations. However, *proposals shall be evaluated using the criteria in the solicitation, and the offered prices shall not be adjusted as a result of the analysis.*

Another key point about cost realism analyses is that they usually include an audit of the rates. In the audit, DCAA determines whether proposed labor and overhead rates, as well as other pricing elements, are reasonable, allocable, and consistent with acceptable accounting and estimating systems.

Cost/Technical Tradeoffs

For selected solicitations (FAR 15.101-1 http://www.arnet.gov/far/) where award may be made to other than the lowest cost technically acceptable offeror, making a cost/technical tradeoff is appropriate. Ratings are merely guides for decision making. The SSA is responsible for independently determining whether non-cost advantages are worth the cost/price that might be associated with a higher rated proposal. The decisive element is not the difference in ratings, but the SSA's rational judgment of the significance of that difference, based on an integrated comparative assessment of proposals (FAR 15.308 http://www.arnet.gov/far/).

To determine which proposal provides the best value, the SSA must analyze the differences between competing proposals. This analysis must be based on the facts and circumstances of each acquisition and must be consistent with the solicitation. This analysis ensures a disciplined and documented process for an integrated comparison of proposals and a rational basis for the SSA's ultimate decision.

The cost/technical tradeoff and the source selection decision, which must be consistent with the solicitation, require that the SSA exercise reasonable business judgment in selecting the offeror for contract award. The information considered should include an analysis of the following:

- The proposals' total evaluated price(s) or cost(s).
- The significance of the differences in the non-cost ratings as indicated by each proposal's strengths, weaknesses, risks, and deficiencies. The strengths, weaknesses, risks, and deficiencies for each factor must be considered in light of the relative importance of each factor stated in the solicitation.
- Whether any perceived benefits are worth the associated price premium (if any) and why.

It is essential to document cost/technical tradeoff judgments with detailed narrative explaining the relevant facts and supporting rationale (FAR 15.101 http://www.arnet.gov/far/-1and 15.308 http://www.arnet.gov/far/). Mere statements of conclusion based on ratings or scores alone are not acceptable. The cost/technical tradeoff documentation must explicitly justify a price premium regardless of the superiority of the selected proposal's technical or non-cost rating. This justification is required even when the solicitation indicates that non-cost factors are more important than cost/price. The justification must clearly state what benefits or advantages the Government is getting for the added cost/price and why it is in the Government's interest to expend the additional funds.

Where it is determined that the non-cost benefits offered by the higher priced, technically superior offeror are not worth the price premium, an explicit justification is also necessary. In this case, the documentation must clearly show why it is reasonable in light of the significance of the differences to pay less money for a proposal of lesser technical merit.

The Sole Source proposal evaluation process is less structured than the competitive source selection process. The NAVSEA Contracts Directorate (SEA 02) typically requires that the PM appoint a Technical Team (which often includes SEA 017 representatives) to ensure that the offeror is proposing to the full needs and requirements of the Government as defined in the solicitation. Concurrently the Contracting Officer requests that DCAA perform an independent review of proposal labor hours and rates, subcontractor information, material costs, and overhead. The Technical Team reports its results to the Contracting Officer in its "Technical Assessment Report" (TAR) and DCAA reports its results to the Contracting Officer via an Audit Report. With that information in hand, the Contracting Officer then negotiates the contract.

SHIP CONTRACT AWARD PROCESS

The ship contract award process initiates the ship acquisition execution phase. After Congress authorizes and funds the fiscal year shipbuilding program, SEA 02, together with the cognizant PM, takes the necessary steps to advise the shipbuilding industry of the Navy's procurement intentions. Contract documents in the form of Invitation For Bids (IFBs) or Request For Proposals (RFPs) are prepared and released, and technical information is made available to those shipbuilders who are interested in the procurement. Before receipt and opening of bids and proposals, the Shipbuilding Contracts Division usually requests SEA 017 prepare and submit the Government (Navy) Independent Cost Estimate (ICE). At this time, the pre-bid contract ICE involves the basic construction line and, if applicable, the construction plans line. The Shipbuilding Contracts Division may also request the escalation associated with the estimate. The Contracting Officer requests the ICE to assist in determining the fairness and reasonableness of bids and proposals received in response to the IFB/RFP. In preparing the ICE, the estimator makes use of the same detailed technical and procurement information that is available to the shipbuilders. The baseline for the ICE may be different than that of any previous budget estimate. The estimating procedures are essentially the same as described in earlier sections; however, a much more refined estimate can be prepared that will consider the currently available detailed technical information, any unique procurement issues, and the current state of the shipbuilding marketplace.

In addition to ICE preparation, ship cost estimators support the ship contract award process by serving on various cost teams of the SSEB established to perform cost analysis of shipbuilder proposals. This analysis effort may be a TAR usually on labor or material, Cost Realism Evaluation, Source Selection Board Analysis, or Should-Cost Study. In these cost reviews, a government position (accept, select, modify, reject) is taken on each element of the shipbuilder's cost proposal in preparation for source selection and/or contract negotiations.

Best Value Selection

Best Value Selection (BVS) is a process most commonly used in proposal evaluation for competitive contracting. BVS seeks to select an offer based on the best combination of price and qualitative merit of the offeror's submission, through trades between cost and the other evaluation factors. The ultimate goal is to give the Government a contract result that brings the best value for the contract dollars spent. Making a BVS can result in a reduction of the administrative burden on the offerors and the Government.

BVS takes advantage of the lower complexity of mid-range procurements and predefines the value characteristics that will serve as discriminators among offers submitted. This allows Government agencies to place emphasis on past performance that demonstrates value to the Government rather than solely selecting an offeror on the lowest price. In turn, this may also provide the contractors more flexibility in proposing and in presenting options for cost and performance trade offs.

One area where the Navy has adopted BVS techniques is employing a standardized approach to screen potential offerors. One specific system in use by NAVSUP is the RED/YELLOW/GREEN computerized vendor identification system. The technique uses a traffic light approach to select vendors by screening potential offerors against a Navy quality assurance database. Before a buyer awards a contract, the system advises the color of the offeror and provides award instructions.

BVS can yield cost and time savings, and there are pitfalls to avoid. For more information on BVS, see Executive Order 12931, issued on 13 October 94 (http://www.acqnet.gov/Library/OFPP/PolicyDocs/Exec_Order_12931.html). Additional information on Best Value can be found at: http://www.abm.rda.hq.navy.mil/navyaos/acquisition_topics/contracting_/best_value

Independent Cost Assessment (ICA)

ICA teams rely on SEA 017 for basic coordination and support, and in the past have been lead by a cost analyst. ICAs are conducted on ACAT I programs requested by ASN(RDA) and on ACAT II programs. After examining the cost estimate, the teams produce their results in a report that is delivered to the PEO as well as an Independent Review Panel (IRP). This procedure is illustrated in Figure 24.

NAVSEA has developed a reliable procedure for performing ICAs, divided into four basic steps of relatively equal duration, described in the next section and shown in Figure 25.

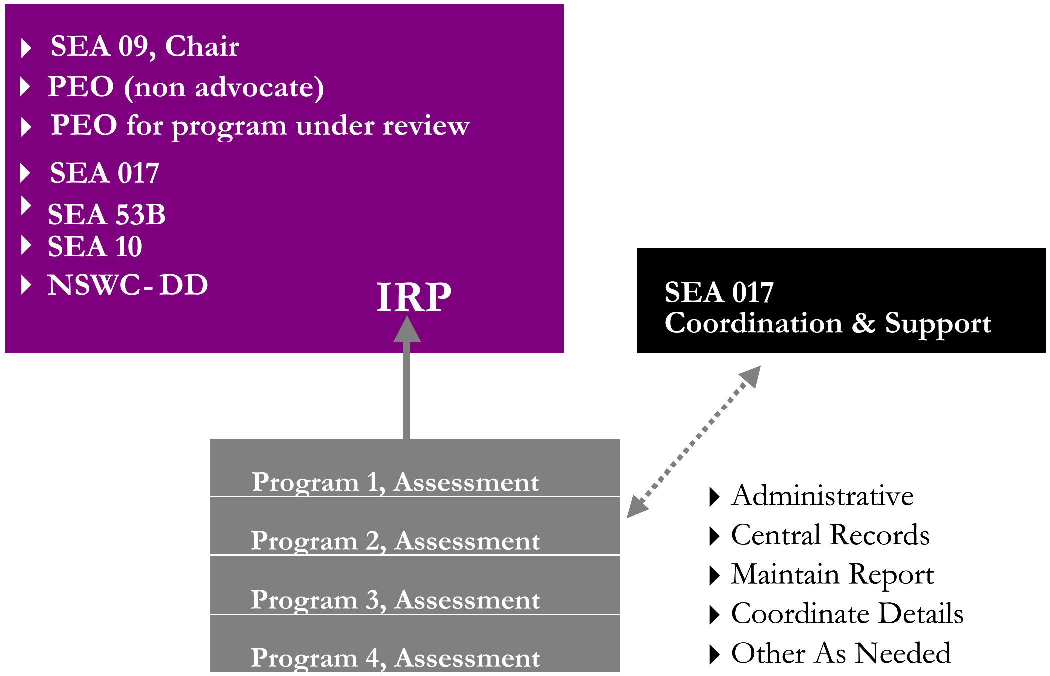


Figure 24: NAVSEA Formal Independent Cost Assessment Process

STEP 1: PM PREPARATION

There are many steps taken before an ICA can actually be performed. Two weeks prior to an assessment, the PM should gather the most recent documentation on the project, which may include elements like the SAR (ACAT I), DAES (ACAT I), CARD, budget exhibits and issue papers, Test and Evaluation Master Plan (TEMP), CDD, acquisition strategy, cost estimate (PLCCE or other), technical documentation, contracts or contract summaries. In addition, the PM is asked to complete an ICA questionnaire provided in Appendix C. SEA 017 will then conduct a coordination review to make sure everything is in place and ready for the ICA to begin.

Process for one program.

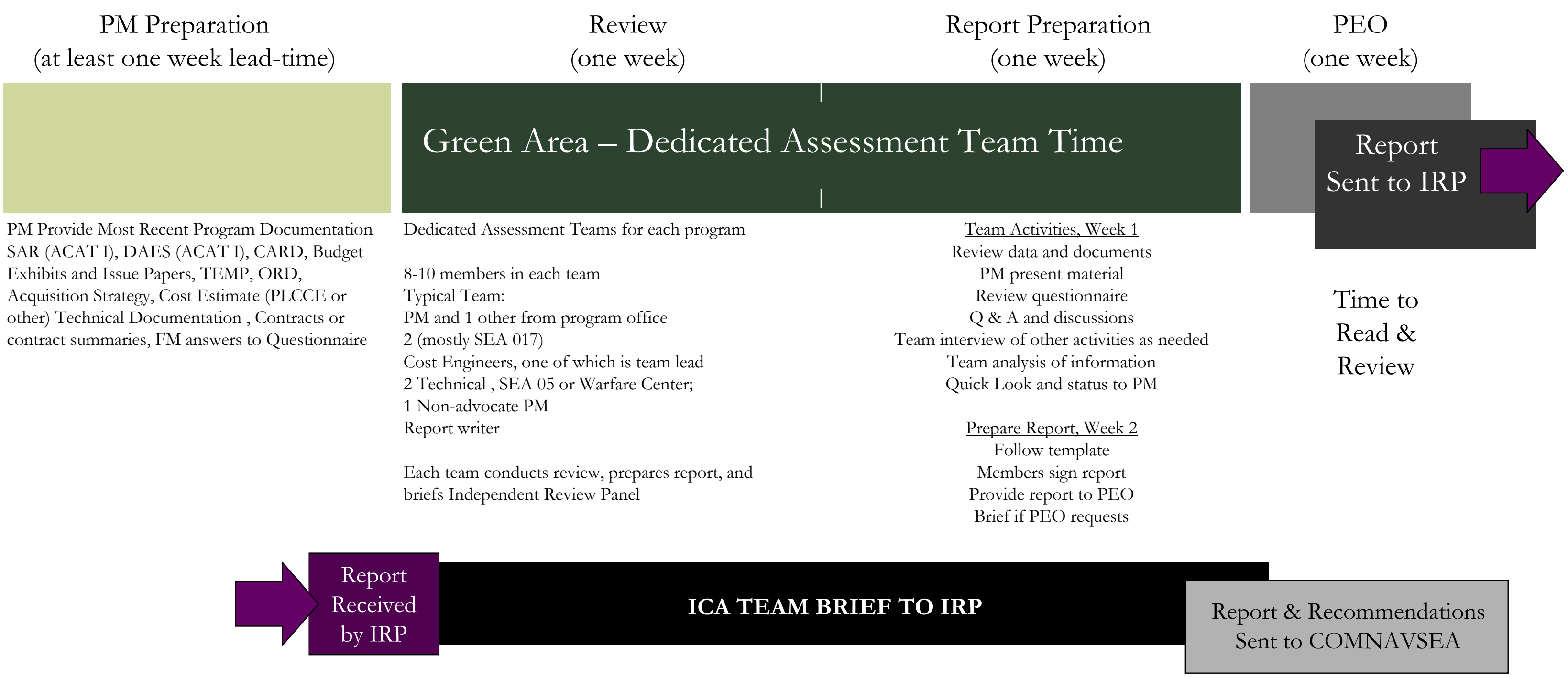


Figure 25: New ICA Process Summary

STEP 2: ASSESSMENT TEAM REVIEW

The independent assessment team performs the next two steps, which comprise the core of the formal ICA. Typical teams are made up of eight to ten members, including the PM and another member of the program office, two SEA 017 cost engineers (one of which is the team lead), two technical experts from SEA 05 or the Warfare Center, one non-advocate PM, and one report writer.

Before beginning their assessment, an ICA team must first gain a basic understanding of the program and its technical requirements. To do so, the ICA team typically reads and reviews the most recent documentation provided by the PM. NAVSEA has divided this one-week process of material review into days: typically, the first two and a half days are an overall examination of the documents, starting with a two to three hour presentation of the material by the PM. During this time, the ICA team will also review the questionnaire, broadly discuss their observations, and conduct a Q&A session to fully understand the scope of the problem at hand and the cost estimating techniques used. The rest of day three and day four are a team analysis of the information and day five is one final quick look and status report to the PM.

Step 3: Report Preparation

The following week, the ICA team formulates their conclusions and findings. In this section, the team will address any cost problems they found in Research, Development, Test & Evaluation (RDT&E), SCN, as well as technical risks with the project as a whole. From these results, the team will write a report to be given to the PEO and then subsequently sent to the IRP. The report follows a basic template and as a rule of thumb, should not exceed five-pages. Once completed, all members must sign the report, provide it to the PEO for review and brief the PEO if requested.

Step 4: PEO Review

After the report has been made, the PEO typically takes one week to read and review the assessment before sending it to the Independent Review Panel (IRP).

The IRP will be briefed by the ICA team and will review the report and then send the report with recommendations on to COMNAVSEA.

Once an initial ICA has been completed, later reviews follow a similar, although slightly modified process captured in Figure 26.

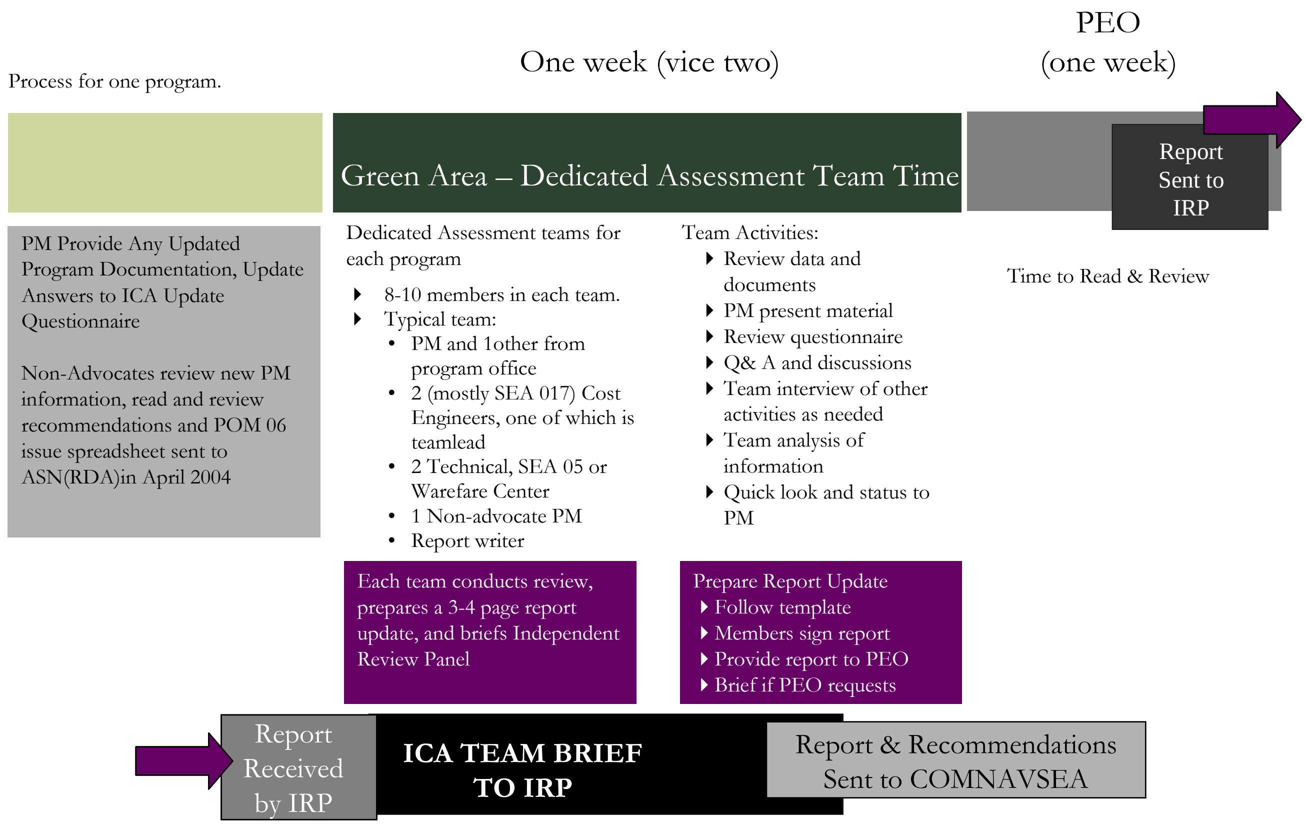


Figure 26: ICA Update Process Summary

ECONOMIC ANALYSIS TECHNIQUES

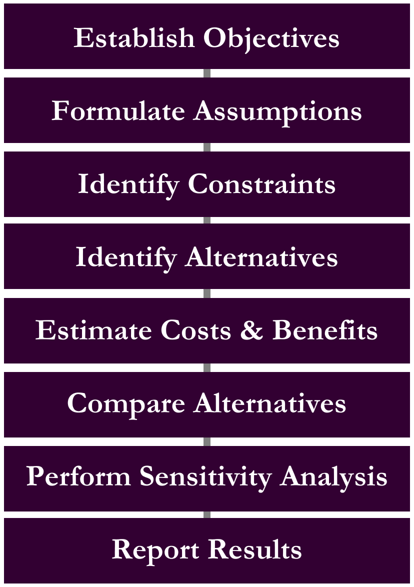


Figure 27:
Economic Analysis Process

DoD's formal Economic Analysis (EA) program was established to provide a systematic approach to decision-making, especially in cases of problems of choice. DoD Instruction 7041.3 promulgated this program and requires that an EA be conducted for proposed programs that involve a choice or trade-off between two or more options. An EA, as defined by this guidance document, is a systematic approach to the problem of choosing how to employ scarce resources and an investigation of the full implications of achieving a given objective in the most efficient and effective manner. Cost is the bottom line of any EA, while performance considerations such as technical, operational, and schedule can be key variables and assumptions of the analysis.

EAs facilitate the decision-making process by providing a strong analytical framework for evaluating alternatives, identifying costs and issues, highlighting implications of individual alternatives, identifying variables that drive results, assessing risks, uncertainties, and sensitivities of assumptions and costs, and suggesting recommendations. Since EAs focus on the present point in time and forward, they traditionally do not include sunk costs. Figure 27 illustrates the steps that comprise the EA process.

Ongoing programs should be assessed periodically for their cost-effectiveness. These assessments entail a comparison of actual performance with the approved program/project. To do this, an update to the program's EA is often required. The update must reflect the current status of the program and consider actual costs and benefits experienced to date. Actual data used in program evaluation will also form a sound basis for updated estimates of future costs and benefits.

Business Case Analysis

A business case must adhere to OMB Circulars A-11, *Preparing and Submitting Budget Estimates*, A-130 *Management of Federal Information Resources*, and Clinger Cohen, and also follows Circulars A-94[18], *Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs* (http://www.whitehouse.gov/omb/circulars/a094/a094.html), and Circular A-76[19], *Performance of Commercial Activities* (http://www.whitehouse.gov/omb/circulars/a076/a076s.html). OMB A-76 identifies burden rates of Federal employees.

OMB Circular A-11, Part III (http://www.whitehouse.gov/omb/circulars/a11/2001_A-11.pdf) provides the framework to guide Federal Agencies through the process of formulating a BCA and ultimately the budget submission. Major capital investments proposed for funding must:

- Support the core mission;
- Support work redesign to cut costs, improve efficiency, and use of off-the-shelf technology;
- Be supported by a cost benefit analysis based on both qualitative and quantitative measures;
- Integrate work processes and information flows with technology to achieve the strategic goals;
- Incorporate clear measures to measure not only a project's success but also its compliance with a security plan; and
- Be acquired through a strategy that allocates the risk between the Government and contractor, and provides for the effective use of competition.
- Present results and recommendations.

A BCA enables decision-makers to base investment decisions on facts while discovering the potential risks and rewards of the specific project. A BCA is an EA that supports investment decisions involving what to buy, how much to spend, what returns to expect, and when to implement. A BCA presents the expected cash flow consequences of competing alternatives over time and includes the assumptions for quantifying benefits and costs.

A BCA has three primary functions: to clarify/structure the planning and analysis required for effective decision-making, to determine the value of an investment or business initiative, and to guide on-going investment management and evaluation. A thorough BCA details acquisition, implementation, and performance measurement strategies to create a foundation for detailed program/asset management plans. A business case is important because it documents the decision-making process used to evaluate the merits of investments for the organization and serves as the basis for management plans of those investments.

The BCA overview presented in Figure 28 and the methodology depicted in Figure 29 are based on industry best practices and lessons learned. This highly flexible methodology is designed to address specific NAVSEA needs and issues and can be tailored to suit any product line. The methodology revolves around the performance of a rigorous and structured alternatives analysis in which a baseline and then various selected alternatives are assessed against a single decision framework built upon three data points: cost, benefits, and risk. An understanding of these three data points and their relationships to one another makes it possible to define and compare a series of alternatives to a baseline, and to approximate which will provide the Navy with the most advantageous mix of benefits, cost, and risk.

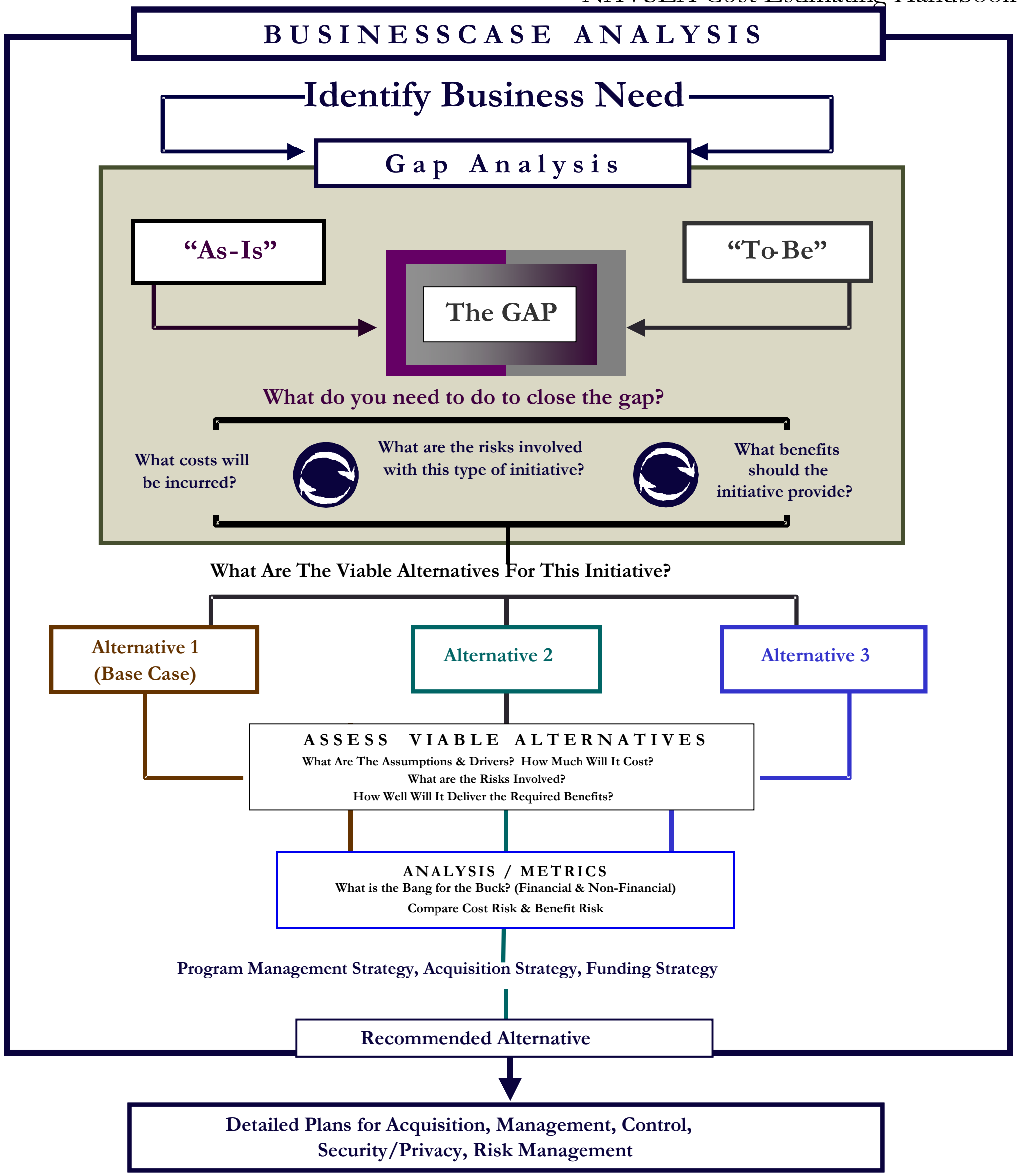


Figure 28: BCA Overview

This methodology consists of three main steps as described below.

STEP 1: DEVELOP THE DECISION FRAMEWORK

A decision framework creates a roadmap for defining and analyzing alternatives. The decision framework enables the definition and analysis of the baseline and alternatives to reflect the priorities and imperatives of relevant stakeholders and customers in a quantifiable and structured manner. There are four tasks associated with the development of the framework, discussed in the following paragraphs.

- Define the Benefit Factors – Benefit Factors guide the identification of the benefits of the initiative under consideration and are designed to capture the full range of financial and non-financial benefits that should be considered when making an investment decision.
- Define the Benefit Measures–Benefit Measures are identified in each of the Benefit Factors to define and score the desired or required performance.
- Prioritize the Benefit Factors and Benefit Measures–Weight the Benefit Factors and Measures to reflect the priorities of NAVSEA, the Navy, and other stakeholders.
- Weight the Benefit Factors–By establishing the relative importance of the factors and assigning each a weight, a NAVSEA leadership group is able to ensure that when the benefit score is aggregated, the sum will reflect the groups' overarching priorities.
- Weight the Benefit Measures–Determining the relative importance of each Benefit Measure against the others, from the viewpoint of the affected customer or stakeholder group, provides deeper insight into the purpose of the initiative and areas in which attention should be focused. The weighting of the measures is also reflected in the calculation of the overall benefit score.

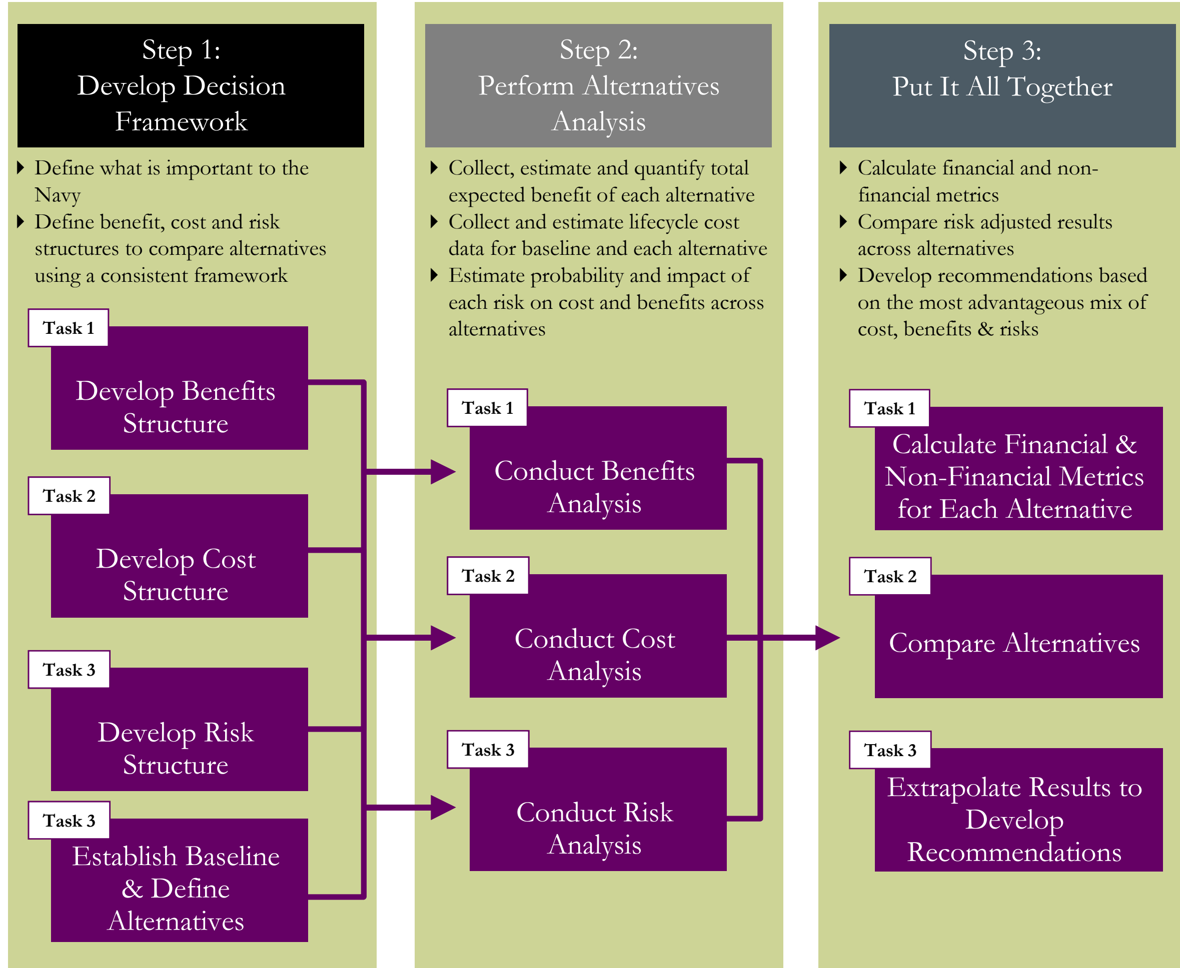


Figure 29: BCA Industry Best Practice Methodology

The actual determination of the weights is normally accomplished at working sessions facilitated with the use of Expert Choice©, an analytical hierarchy process tool. During the working sessions, participants are asked to vote on a series of pairwise comparisons, to determine the relative importance of the Benefit Factors or Benefit Measures within each factor.

Next, a standardized CES is created for use in collecting cost data for the baseline and all the alternatives.

Then, a risk assessment structure is developed. The purpose of the risk assessment structure is to guide the identification and analysis of risk. There are two components of the risk structure-- the risk inventory and the risk tolerance boundary. The risk inventory is based on a set of risk factor categories derived from Government and private-sector risk analysis best practices, and tailored to address the specific NAVSEA risk environment. Identification of risks in each of these categories helps to ensure that all possible risks are considered. The risk tolerance is established by gathering insight from senior management's tolerance for risk based on its experience, knowledge, and vision. Such insights approximate the point at which the risk is too great to warrant an investment. Senior management insights are translated into high, medium, and low definitions of risk.

The final step in developing the Decision Framework is to establish the baseline and to develop the alternatives to be examined. Key to this task are the steps taken to ensure that all parties involved in the development of the BCA understand and agree with the way in which the alternatives are defined and the rationale behind each assumption.

Step 2: Perform the Alternatives Analysis

The alternatives analysis is at the core of any BCA and it is focused on the assessment and comparison of the benefits, costs, and risks associated with the baseline and the considered alternatives. Following the approach, each factor is assessed against the decision framework developed in Step 1. To approximate how well the alternatives and the baseline would perform against the targets established in the decision framework, the following efforts should be conducted:

- Collect Data–The estimation of benefits captures how well each alternative and the baseline will perform against the benefit measures defined in the benefit structure.

The Metric & The Normalized Scale

ILLUSTRATIVE

Value	10	20	[illegible]	[illegible]	50	60	70	80	90	100
Average # hours from receipt of customer feedback message to response	48.	[illegible]	.33	38.00	34.67	31.33	28.00	24.67	21.33	18.00

Projected Range of Performance

	Low	Med.	High
Average # hours from receipt of customer feedback message to response	38	24	18

Projected Value Translated on to Normalized Scale

Value	10	20	30	40	50	60	70	80	90	100
Average # hours from receipt of customer feedback message to response	48.00	44.67	41.33	38.00 40	34.67	31.33	28.00	24.67 82	21.33	18.00 100

Low = 38.00 → 40; Med. = 24.00 → 82; High = 18.00 → 100

Figure 30: Normalizing the Benefit Score

- Normalize Benefit Scores–A normalized scale is defined so each benefit measure can be consistently compared. Once the benefits have been estimated, they are translated onto the normalized scale as shown in Figure 30.

- Calculate Benefit Score–A benefit score is calculated for the baseline and each alternative by doing the following:
  - Calculating a normalized score for each Benefit Factor by aggregating the normalized scores assessed for each Benefit Measure according to the predetermined weights.
  - Calculating the benefit score for the baseline and each alternative by aggregating the normalized score for each Benefit Factor according to the predetermined weights.
- Assess Uncertainty–A low, medium, and high score is assessed for the performance of each alternative against each Benefit Measure. By examining the breadth of the range selected to estimate benefits, it is easy to see which are the most uncertain; the larger the range, the greater the uncertainty. Uncertainty analyses are conducted using a method known as Monte Carlo simulations. Conducted automatically when using software such as Crystal Ball, a Monte Carlo simulation calculates numerous scenarios of a model by repeatedly picking random values from the value ranges for each "uncertain" model input (e.g., estimated costs, value projections, cost drivers) and calculating the results. Typically, a simulation will consist of 2,500 to 10,000 iterations. The output of the Monte Carlo simulation will show a range of possible results and mark the mean, or expected value-- the point at which there is an equal chance that the actual value or cost will be higher or lower.
- Conduct Sensitivity Analysis–The sensitivity analysis identifies the inputs that have the greatest impact on the final benefit projection.

To approximate the cost of the baseline and each of the alternatives, the CES developed in Step 1 is populated and the cost estimated.

Using the risk inventory developed in Step 1, the next step is to determine the:

- Probability of a Risk Occurring, and
- The impact of the Risk.

Therefore, the first step in the risk analysis process is to assign a value of low, medium, or high to the CES of the decision framework and the benefit structure of the decision framework to rate the probability and impact (see Figure 31).

ILLUSTRATIVE

ALTERNATIVE A - COST RISK ANALYSIS

Risk	Probability	Cost Impacted	Impact
Risk #1	Med	1.0 System Planning & Development	Low
		2.0 System Acquisition & Imp.	High
		3.0 System Maintenance & Operations	Med
Risk #2	High	1.0 System Planning & Development	Med
		2.0 System Acquisition & Imp.	Med
		3.0 System Maintenance & Operations	Low

ALTERNATIVE A - BENEFIT RISK ANALYSIS

Risk	Probability	Benefit Impacted	Impact
Risk #1	Med	Total Cost Savings to Investment	Low
		Total Cost Avoidance to Investment	Low
Risk #2	High	Total Cost Savings to Investment	Low
		Total Cost Avoidance to Investment	Low
Risk #3	Med	Accessibility of Voice services to Users	High
		User Trust in External access	High
		Confidence in Critical Features	High
		Reduction of Identity misuse	High
		Regulatory Compliance	High
		Total Cost to Savings Investment	High
		Total Cost Avoidance to Investment	High

The probability of a specific risk occurring remains constant through out the analysis of a specific alternative, regardless of where it impacts the benefit or cost of a particular alternative

The impact of a single risk factor may differ in magnitude at each point where it interacts with cost and benefit

Figure 31: Assessing CES Risk Values

The low, medium, and high scores assessed for probability and impact are next translated into percentages, by way of a risk scale (See Figure 32).

The effect of each risk on expected cost and benefits is determined by multiplying the risk impact estimate by the risk probability estimates. The product of impact and probability results in the percent increase in cost or decrease in the benefit score. Separate benefit and cost risk scores are calculated for the baseline and each of the alternatives. The benefit risk score is calculated by determining the percentage of performance slippage between the expected benefit score and the risk-adjusted benefit score (see Table 13.) In like manner, the cost risk score is calculated by determining the percentage of cost increase between the expected cost and the risk-adjusted expected cost (see also Table 13).

ILLUSTRATIVE

Risk	Probability	Cost Impact	Benefit Impact
High	50%	25%	-25%
Medium	20%	15%	-15%
Low	25%	5%	-5%

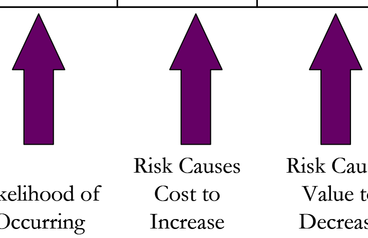


Figure 32: Risk Scale

Alternative X	Expected Cost Before Risk	Risk Adjusted Cost	Cost Risk Score
Benefits	$900	$990	10%

Table 13: Illustrative Benefit Risk Score and Illustrative Cost Risk Score

STEP 3. PULL IT ALL TOGETHER

The purpose of this step is to compile the analysis performed in Step 2 and calculate financial and non-financial metrics, compare the alternatives and the baseline, as well as to identify which among them will provide the DON with the most advantageous mix of cost, benefits, and risk. A comparison of the benefits, risks, and costs associated with the baseline and each alternative is conducted through the calculation of ROI and NPV metrics.

Because a single set of benefits and a normalized scale were used to approximate the benefits associated with each alternative, it is possible to compare benefit scores with the investment costs to provide decision makers with an idea of the level of benefit they will receive for the money invested (See Figure 33). Comparing the benefit per investment score of several alternatives provides the opportunity to understand the trade-offs that would be made when one alternative is selected over the others. The decision maker must decide whether the trade-off in value is worth the savings in investment.

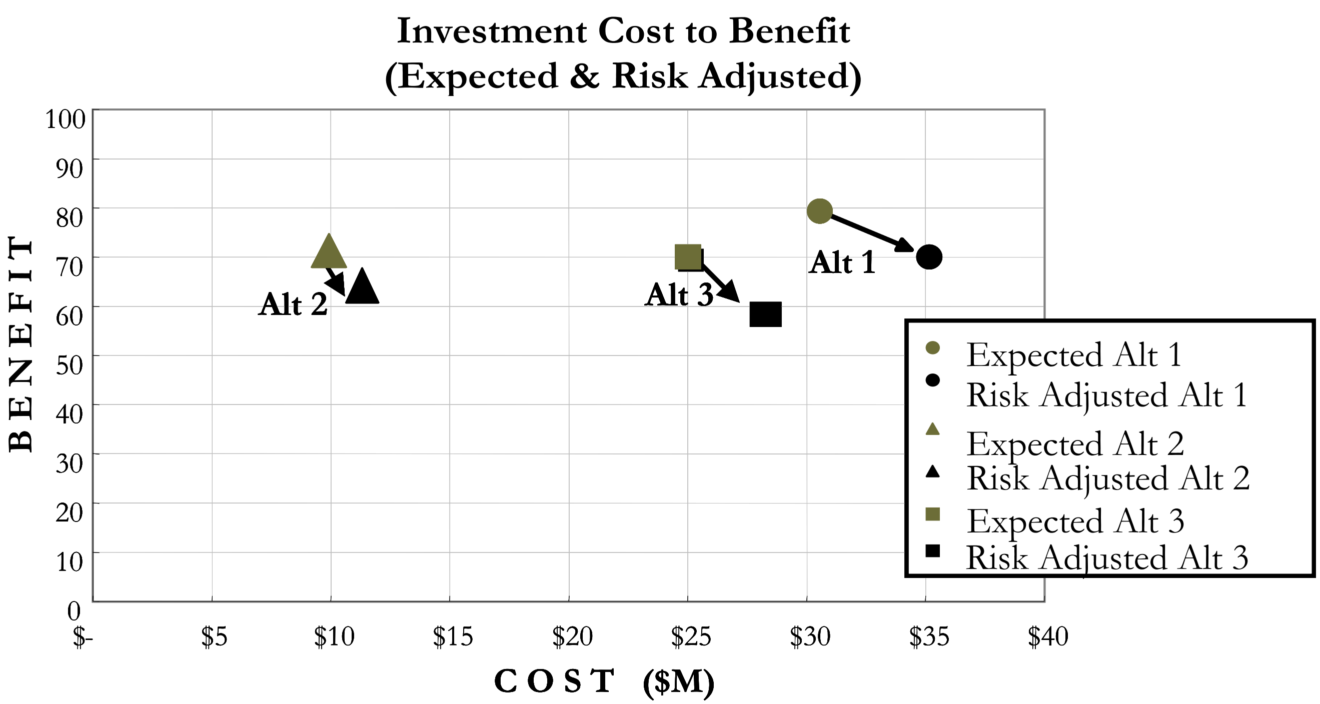


Figure 33: Illustrative Risk Adjusted Cost and Benefit Chart

Cost Benefit Analysis

As shown in Figure 34, a Cost Benefit Analysis (CBA) is an EA called for in OMB Circular A-94, where the cost and benefits of each alternative are compared to determine the ROI for the program/project. A CBA balances two equally important components: the LCC estimate for each alternative and the estimated benefits of each alternatives. The LCC typically focuses on the investment requirements, O&S cost, as well as disposal cost for each alternative. The benefits analysis focuses on the benefits realized from the investment.

A CBA is part of a BCA and is conducted to estimate:

- The full cost of an initiative over its life cycle (from initial planning through implementation to on-going O&S);
- The benefits or performance improvements that the initiative will achieve; and
- The impact of risk on both the cost and performance of the initiative.

The outcomes of a CBA provide the means by which alternatives to solving a business problem or meeting a business need may be compared. A CBA is not a one-time activity but should be updated regularly to refine and compare estimates with actual data.

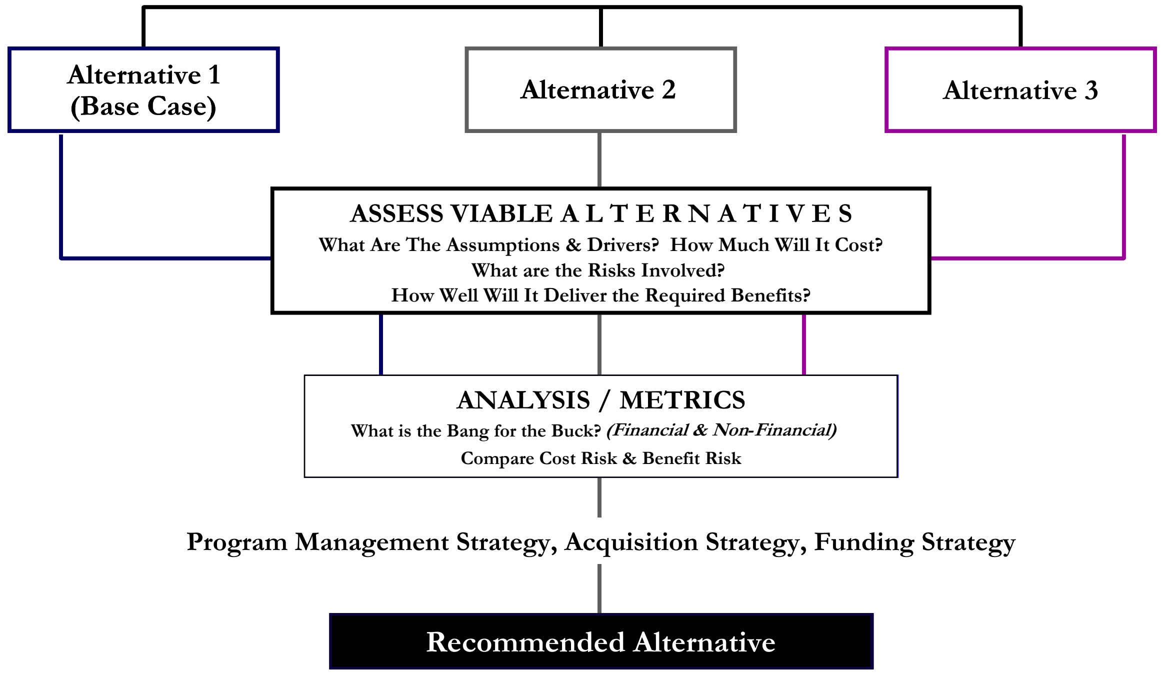


Figure 34: CBA Methodology

An integral part of the cost estimate is an independent assessment of the benefits associated with the investment. Benefits derived from an investment, along with the cost, provide a true picture of the impact of the investment. Determining the benefits associated with a program/project is vital to the PM, who has to justify the cost by showing how it helps to meet the project's mission, objectives, and goals. Ultimately, the benefits analysis, along with the cost estimate, are used together to identify how to measure the attainment of the goals and objectives to "score" each alternative on the extent to which it satisfies those goals and objectives.

Net Present Value, Discounting, and Opportunity Costs

This section provides an overview of three commonly used calculations and techniques used to support an economic analysis.

NET PRESENT VALUE (NPV)

NPV is defined as the value today of future benefits or costs. In other words, $0.91 is called the present value or the value today of an investment that yields $1.00 one year from today at a rate of return of 10%. When government expenditures occur over time, it is necessary to convert them into dollars of present value. This is especially important when comparing the costs and benefits of alternatives because the time pattern of expenditures generally differs among alternatives. Two projects could have the same absolute total costs but because the pattern of expenditures differs over time their present value would not be the same.

The present value is calculated with respect to a certain decision date. Only benefits/costs that are incurred after the decision date need be included in the analysis. Costs/benefits prior to the decision date are considered "sunk" costs and have no impact on the decision.

NPV is a project's net contribution to wealth and is the difference between the discounted present value of benefits and the discounted present value of costs. The NPV indicator provides a measurement of the net value of an investment in today's dollars. OMB Circular A-94 establishes net present value as the standard criterion for deciding whether a government program can be justified on economic principles.

NPV is a predictor of profitability, determining when the investment will generate sufficient cash flows to repay the invested capital and provide the required rate of return on that capital. Because all cash flows are discounted back to the present time, the NPV compares the difference between the present value of the benefits and costs and takes into account the opportunity costs of both cash flows. Therefore, a positive NPV is a good financial indicator. In the most general terms (consistent with OMB Circular A-94), NPV is defined as the difference between the present value of benefits and the present value of costs. All costs and benefits are adjusted to "present value" by using discount factors to account for the time value of money. Mathematically, NPV is calculated by subtracting the Present Value (Annual Cost) from the Present Value of Annual Benefits. These benefits must be quantified in cost or financial terms in order to be included in the equation. For most government generated cost estimates, discount rates provided in OMB Circular A-94 are used to discount all cash flows as shown:

[PV(Operational Project Cost Savings) + PV (Mission Cost Savings)] - PV (Initial Investment) = NPV

<u>DISCOUNTING</u>

The process of converting future dollars to present dollars or value is called discounting. The present value of a stream of expenditures is determined by multiplying each year's expected annual benefit or cost by its appropriate discount factor, and then summing the results over all the years of the period of the alternative being considered. Inflation is generally excluded from the present value analysis. However, when comparing alternatives, OMB prescribes that the analysis be done in terms of constant dollars. This then requires the use of an appropriate deflator to convert current dollars to constant dollars that are then discounted to arrive at a present value expressed in terms of constant dollars. In constructing the stream of costs, price changes should be included. The application of OMB's discount rate to convert future outlays to a present value is referred to as discounting.

<u>OPPORTUNITY COST</u>

When expenditures are diverted from the private sector to the public sector, there is an opportunity cost associated with their use. An opportunity cost is the cost of doing one thing rather than another. In this case, the opportunity cost associated with government expenditures is the rate of return that the money could have earned had it remained available for investment in the private sector. The treatment of costs and benefits over time is further complicated by the fact that a dollar today is not the same as a dollar tomorrow. This is generally referred to as the <u>time value of money.</u> In the private market place, this value is generally reflected by the interest rate. For example, at a 10% yearly interest rate, $0.91 would be needed today to yield $1.00 one year from today.

Return on Investment

ROI is the net benefit expressed as a percentage of the investment amount:

$$ROI = NPV/PV\ Investment$$

Using this formula to calculate ROI shows the incremental gain from an investment, divided by the cost of the investment. In this sense, an investment that costs $1,000 and pays back $1,500 after a defined period of time has a 50% ROI. ROI metrics are critical in decision-making as they ensure senior managers and decision-makers that the investments they authorize will contribute to making the DoD more cost-efficient. It is important to note, however, that cost-efficiency is only one data point in the decision-making process. No matter how cost efficient an investment appears to be, if it fails to improve the effectiveness of the Navy or the DoD, it is unlikely to show any benefit at all. For this reason, ROI should be used as an indicator, along with other performance and risk indicators for a comprehensive view of program value.

Payback Period and Break-Even Analysis

The payback period is the time required for the cumulative value of savings to be equal to the cumulative value of investment. The payback period helps to answer the question "how long will it take to make back the money spent on the investment?" The payback period measures the time (i.e., years, months) needed to recover the initial investment and break even.

One of the main benefits of the payback period indicator is that it identifies projects that generate benefits occurring *early* in the life cycle. Because out-year benefits are often less certain than benefits that occur early in the life cycle, the payback period is valuable as a ranking indicator when deciding between two investments. Decision-makers must then decide if the payback period is appropriate considering the Department's other investment opportunities.

Computing the amount of time it takes for a project to pay for itself (or return its initial investment) is another commonly used criterion for selecting among alternative courses of action in an investment analysis.

In the simplest of cases, the benefits (or returns) begin predictably at the completion of the investment phase and occur in an equal amount each time period. However, for large projects that take years to complete, benefits begin accruing prior to completion of the investment phase and do not occur in equal annual amounts. In both simple and complex situations, the Payback Period in years, x, can be found using the following formula (where t = time periods in years):

$$\text{PV(Initial Investment)} = \sum_{t=1}^{t=x} \text{PV(Operational Savings + Mission Savings)}$$

Number of Years Required for Cumulative Present Value Financial Benefits to equal the Cumulative Present Value of the Investment = Payback Period

2005 Cost Estimating Handbook

Appendix A

Cost Engineering & Industrial Analysis Division (SEA 017) Charter

1. Serve as the Command's, Command-supported PEOs', and the Navy's authority in the broad professional field of ship and ship related combat system and weapons cost engineering and industrial analysis.
2. Serve as advisor to the Commander, the Comptroller, and the Deputy Commander for Corporate Operations on the historic, current and emerging trends in all elements of ship cost engineering and industrial analysis.
3. Assist in the Command decision process for planning, budgeting and ultimate acquisition of combatant, amphibious, and auxiliary ships and Navy designed commercial ships.
4. Provide cost engineering support as necessary in support of the DAB review process including AoA studies.
5. Participate in contract source selection process and associated proposal evaluations; perform cost analyses in support of ship design tradeoffs and construction process changes.
6. Serve as the Command's focal point for Earned Value Management (EVM). Act as the subject matter expert for the implementation and utilization of EVM.
7. Ensure that Earned Value Management Information Systems are adequate to provide visibility of program progress and performance measurement from established baselines, including early identification of problems.
8. Serve as coordinator for cost research projects for the Command.
9. Provide executive level control and direction of all ships, equipment, material and weapons cost engineering, cost data analysis, evaluation reviews, audits and related programs. Integrate the cost engineering and industrial analysis process with the ship production function, and provide assessments and justifications for the adequacy and quality of the program cost estimation to the NAVSEA and Command-supported PEO ARB, Navy Program Decision Meeting (NPDM), the DAB, and (OIPTs).
10. Conduct economic analyses of ship combat system, weapons and equipment acquisition to include analysis and forecasting of labor, industrial and technical trends as they impact the overall process. Provide cost and economic analysis in support of industrial base assessment.
11. Provide leadership within the NAVSEA industrial analysis community (SEA 017, NSWC) to enhance the capability to assess the impact that notional acquisition scenarios may have upon the viability of the shipbuilding and combat system industrial base.
12. Support the life cycle management concept through life cycle costing of NAVSEA acquisitions and maintain liaison with the Deputy Commanders and Director of Research and Technology to ensure a life cycle perspective in the costing process. Serve as the Command's focal point for implementation of policies, processes and procedures aimed at reducing the TOC for all major and non-major acquisition programs (ships, combat systems and weapons) and integration of TOC into program planning and execution. Serve as the Command's focal point for implementing CAIV principles.
13. Review and certify cost estimates for all major acquisition programs (ships, combat systems and weapons) funded by the RDT&EN, SCN, WPN, and OPN appropriations under the cognizance of COMNAVSEA and Command-supported PEOs. Support, including acting as the Chair, program office Integrated or Engineering Product Teams (I/EPTs) where cost control or the development of product cost estimates are the principle focus.
14. Provide leadership with regard to diagnosis and analysis of cost drivers for major acquisition programs, with particular regard to identification of key performance indicators and programmatic interdependencies.

15. Ensure the professional development of the cost engineering personnel of the Command in all aspects of the cost engineering discipline. Serve as the PM of the Cost Engineering Intern Program.
16. Act as the focal point for the implementation of the Cost and Software Data Reporting (CSDR) requirements of the DoD for the Command and Command-supported PEOs.
17. Prepare independent cost Estimates-At-Completion (EACs) for Major Acquisition Programs reporting under the Defense Acquisition Executive Summary (DAES) process.
18. Provide cost engineering analysis in support of the decision making process in the determination of acquisition strategies (dual source, sole source, multi-year procurement, etc.) for the Command, Command-supported PEOs, and the Navy Secretariat. This responsibility entails the provision of cost engineering and analysis to enable the assessment of industrial base implications.
19. Act as the Command focal point for interface with the Naval Center for Cost Analysis (NCCA) in support of the development of the statutorily required ICEs.
20. Provide cost analysis and estimates in support of Foreign Military Sales (FMS), Foreign Military Assistance Programs, and Information Exchange with other nations.
21. Provide cost analysis and estimates to other government agencies as required (e.g., National Oceanic and Atmospheric Administration (NOAA), Coast Guard, Maritime Administration (MARAD), Strategic Operations Command (SOCOM), etc.).

For the latest information on SEA 017, go to: http://www.navsea.navy.mil/sea017/overview.asp?txtTypeID=41

Appendix B

Contract Escalation Reserve Category

An introduction to the terms inflation and contract escalation and their application in the ship cost estimating and ship contracting processes was provided in section five. This appendix further discusses the term contract escalation, including its role, how it is paid, and how it is estimated.

THE ROLE OF CONTRACT ESCALATION

The Contract Escalation Reserve category can be a major element of the end cost estimate and a significant part of the shipbuilder portion. The dollar amounts reserved in this category are intended to cover increasing shipbuilding labor and material costs attributed to inflation during ship construction. Average Navy ship construction periods from award to delivery can stretch from two to seven years or more for the largest ships. As most follow-on shipbuilding contracts are of a fixed-price nature rather than of a cost type, adjustment clauses may be included to compensate shipbuilders for inflationary costs over the long construction periods. This compensation is over and above the original fixed-price agreement, which is priced to a base date, as discussed in Section 5. By including compensation adjustment clauses in the contract, shipbuilders and the Navy can avoid contingency pricing in the target price because of the uncertainty of future inflation. Although the magnitude of future inflation and the estimated amount of recovery may not always initially be agreed upon, differences are always resolved through negotiation during the contracting process and the resolution can sometimes affect the negotiated Target Price. In any case, the dollars that ultimately compensate the shipbuilder for inflation costs are set aside in the Contract Escalation Reserve category.

HOW CONTRACT ESCALATION IS PAID

Inflation in Navy shipbuilding contracts is measured by labor and material indices produced monthly for the Navy by the U.S. Department of Labor, Bureau of Labor Statistics (BLS). The labor index (Base: May 1987 = 100.00) measures monthly changes in straight-time (no premium time or overtime included) average hourly earnings including lump sum payments, as reported to BLS by major shipbuilders across the United States. The material index (Base: 1982 monthly average = 100.00) measures monthly changes in a composite of three subgroups of the Producer Price Index. The subgroup codes and the weightings are as follows:

Code 101	Iron and Steel	45%
Code 114	General Purpose Machinery	40%
Code 117	Electrical Machinery	15%
		100%

Shipbuilder costs subject to monthly compensation adjustment as measured by the BLS indices are as follows:

Direct Material Cost:	BLS Material Index
Direct Labor Cost:	BLS Labor Index
**Overhead Cost:	BLS Labor Index

** Overhead Cost subject to escalation is exclusive of depreciation and taxes since escalation payments on these elements are not permitted by federal regulation. In addition, selected employee benefits and energy costs in certain contracts are excluded from this calculation because these costs are provided by separate compensation calculations based on actual shipbuilder experience.

A procedure for calculating a typical monthly labor inflation payment is provided in the following example:

October 2001 actual labor cost = $1,000,000

October 2001 BLS labor index value = 146.5

Contract base date (Jan 2000) labor index value = 140.1

$$\text{Escalation Payment} = CI - CI \times \frac{(BLS_B)}{(BLS_C)}$$

where

CI = actual cost incurred

BLS_B = index value for contract base date

BLS_C = index value for month under consideration

$$\text{Escalation Payment} = CI - CI \times \frac{(BLS_B)}{(BLS_C)}$$

$$\text{Escalation Payment} = \$1,000,000 - \$1,000,000 \times \frac{140.1}{146.5}$$

$$= \$1,000,000 - \$956,314$$

$$= \$43,686$$

Similar calculations are performed for all the cost elements eligible for escalation payments. In the true sense, as the example shows, the actual costs are de-escalated back to contract base costs. Escalation payments stop at the "post delivery" date specified in the contract, typically eight months after actual ship delivery. By this date, all incurred shipbuilder costs have been accumulated. However, escalation payments stop earlier if the sum of the de-escalated actual incurred costs exceeds the specified contract ceiling price.

Note that it is possible to have a negative answer; i.e., the index value for the month under consideration could conceivably be a smaller value than the index value for the contract base date, such as April 2000. For example:

$$\text{Escalation Payment} = \$1{,}000{,}000 - \$1{,}000{,}000 \text{ X } \frac{140.1}{139.9}$$

$$= \$1{,}000{,}000 - \$1{,}001{,}430$$

$$= -\$1{,}430$$

In this unusual case, the shipbuilder is experiencing less cost, as measured by the shipbuilding index, than what was agreed to in the base dated contract price; therefore, the contract price would be ultimately adjusted for this negative period.

Although Navy inflation-compensation-adjustment clauses are not precise in every respect and shipbuilders occasionally voice objections over the BLS shipbuilding indices, historically (current clauses were put into effect in 1975) it can be shown that the clauses and the National BLS indices have served the purpose they were intended for -- to reimburse shipbuilders for incurred inflation costs beyond their control.

HOW CONTRACT ESCALATION IS ESTIMATED

The Industrial Planning and Analysis Group uses the SEA 01 escalation model to prepare escalation estimates. Because the majority of ship estimates are now forward priced, the escalation model has the capability to run "backwards" from a forward-priced estimate to determine the contract escalation portion of that forward-priced cost.

The following inputs are required:

- Estimate base date
- Award date
- Start of construction date
- Delivery date
- Production mandays
- Engineering mandays
- Target direct labor costs (including Cost of Money if applicable)
- Target overhead costs
- Target direct material costs

In addition to the required inputs above, there are also a number of assumptions to be made. First, they include the assumed inflation rate. The projected inflation rate is based on the Global Insight forecasts applicable to the labor and material indices. The second assumption concerns labor and material expenditure curves. On the basis of historical data, general shipbuilding expenditure curves have been developed for production labor, engineering labor and direct material costs. The Labor and Material Expenditure Curves are depicted in Figure 35. For ships under contract where actual costs are available, the expenditure curve reflects the actual costs expended to date, then spreads the remaining projected costs over the period of construction.

The computer program accepts the inputs and produces an estimate of contract escalation. The program not only produces escalation estimates for future ships, but can also calculate estimates for ongoing programs reflecting actual monthly costs incurred by the shipbuilder. The program can provide PMs with essential escalation information and dollar requirements as inflation forecasts change, as actual rates become known, and as actual expenditures are tracked against projected costs.

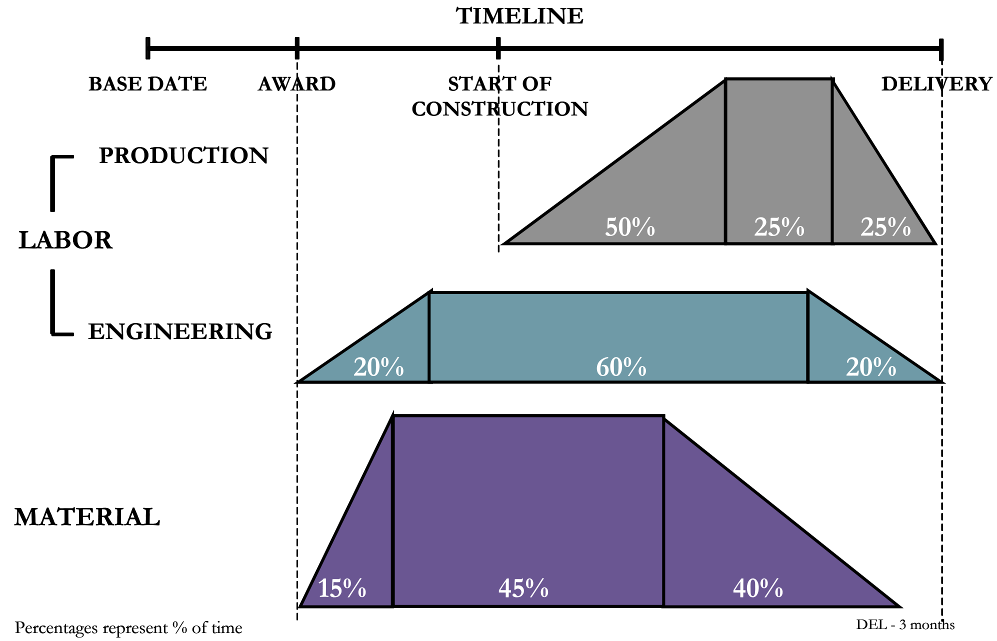


Figure 35: Expenditure Curves

Appendix C

Cost Forms

ICA summary used for all programs evaluated in the ICA process

NAVSEA
NAVAL SEA SYSTEMS COMMAND

Results - ________ Program

	ACAT	Last MS	Prime Kr	ICE	PY Bill	Kr Type	SCN, FYDP	RDT&E, FYDP	Approved ORD	Approved ASR	Approved TEMP
Program name	XX	X		Y, CAIG & 017	Y or N	CPIF/CPFF, FPIF follow	$XX.XB	$X.XB	Y or N	Y or N	Y or N

Cost Issues
RDT&E:
(1)
(2)

SCN:
(1)
(2)
(3)
(4)
(5)

Post-ICA:
(1)
(2)

Technical risks:
(1)
(2)

Previous ICA Issues and Resolution:
(1)
(2)

ACAT II Independent Cost Estimate/Assessment (ICE/ICA) Questionnaire

1. Program Name:	**6a. Last Milestone:** **6b. Last Milestone Date:**
2. Program Manager: **3. Program Executive Office:**	**6c. Next Milestone:** **6d. Next Milestone Date:**
4. Program Office:	**7. Resource Sponsor:**
5. Acquisition Category:	

8. Program Description (no field required)

Please attach existing, unclassified program documentation that best provides overview of:

- **Technical Requirements (A)**
- **System Description (B)**
- **Schedule (ie. Program Master Schedule or Equivalent) (C)**
- **Acquisition Strategy (D)**
- **Major Contracts Awarded or to be Awarded (E)**
- **Narrative History of the Program (Rescoping, Rebaselining, Schedule Changes, etc.) (F)**

9. Prime & Major Contractor(s). Identify subsidiaries and locations. Include all contractors that will earn more than 10 percent of the acquisition costs.

10. Performance (no field required)
Please attach latest CPR or CSSR analysis for the Major Contracts of Attachment E (G).

11. Cost Estimate (R&D and Procurement) (no field required)

11a. Who Performed the Estimate?

11b. Date of Estimate:

11c. Does this estimate capture all anticipated costs? No If "No," respond to field 11d.

11d. What costs are not captured by the estimate?

Please Attach Cost Estimate and Backup Documentation (H). If Assessment Team already has, or has generated latest cost estimate, so indicate, and do not submit this documentation.

12. Current Program Funding (no field required)

Please identify and request Latest Budget Exhibits (R&D and Procurement) from SEA 01 Comptroller Analysts (I). They will provide exhibits to the Independent Assessment Team. Please provide existing Issue Papers that remain relevant for PR-05 (J).

13. Major Program Interfaces and Integration:
Are all interface and integration requirements fully funded in accordance with scheduled needs? Provide narrative describing unbudgeted, or under-budgeted interface and integration requirements including, if available, an estimate of additional funds needed by fiscal year. The narrative should identify specific systems involved and also address any cross program interdependencies in which schedule slippage, ongoing technical changes, or funding issues in the other program will have cost impact to this program.

Provide a narrative description of anticipated new interfaces and integration needs that are expected to be approved in the near-term-i.e., in time to affect PR 05. Do they have a significant potential budgetary impact? If available, please provide an estimate of additional funding requirements.

14. Other Issues:
Please identify any additional significant cost issues associated with the program: Budget Shortfalls (Prior years and PR 05) Schedule Technical Development Contractor Performance Acquisition strategy and Procurement Profile Other

Certificate of Non-Disclosure and Statement of Financial Interest and Non-Disclosure Agreement

CERTIFICATE OF NON-DISCLOSURE AND STATEMENT OF FINANCIAL INTEREST

I understand my obligation not to divulge information received in confidence from or proprietary to the competing teams in connection with their proposals, trade secrets, inventions, discoveries, and reports of a financial, technical and scientific nature, regardless of the physical medium in which this information is received by me.

I further understand my responsibility not to disclose the methods or procedures being used to evaluate the competing teams' proposals or contract deliverables. I will not reveal the evaluation criteria, ratings or rankings used by this Source Selection Organization in the evaluation process unless authorized to do so by the Agreements Officer.

To the best of my knowledge, neither I nor any member of my immediate family has a substantial direct or indirect interest in any of the firms submitting proposals for the XXXX Program which conflict, or appear to conflict with my responsibilities in the evaluation and source selection process, or with my responsibilities with respect to XXX contract performance, except as noted below. In the event that I later acquire or become aware of such an interest, I agree to disqualify myself and report this fact to the AO and to abide by any instructions, which he may give me in this matter.

____

Signature

____

Activity

____

Date

Agreement Regarding Access To Proprietary Data

The performance of work on the xxxxx Project for SEA 017/PEO xxxx may require the contractor to have access to business sensitive data provided by other companies and/or the U.S. Government, which the companies and the U.S. Government consider to be proprietary. In such event, the contractor shall agree to use the proprietary information only to perform this contract and also the contractor shall agree not to disclose or make any other use of this business sensitive data so long as the data remains proprietary. The contractor shall make no copies of said data prior to its return.

Further, the contractor shall agree to include the special provision of the preceding paragraph in all subcontracts so as to require all subcontractors to adhere to the same restrictions regarding access to and use of business sensitive data provided by any other companies or the U.S. Government in the performance of their contract with the contractor.

I have read the preceding paragraphs and fully understand their contents.

____

Signature/Date

Ship Design Study Costing Data Form

1. STUDY IDENTIFICATION

Ship Study Name/No. Date
New Design Repeat Mod/Rpt Conv
Brief Description
Prepared By (Name/Code/Phone)

2. GENERAL CHARACTERISTICS:

Hull Form (Mono, Acv, Swath, Etc.)
Length, Waterline (Ft)
Length, Overall (Ft)
Beam Or Dia, Max @ Waterline (Ft)
Breadth, Extreme (Ft)
Depth, Hull @ Amidships (Ft)
Draft, To Keel @ Amidships (Ft)
Draft, Navigational (Ft)
Military/Commercial Specs For: Hull
Other

3. WEIGHTS:

SWBS GROUP SIMILAR SHIP	WEIGHT (L.T.)
1. Structure	
2. Propulsion	
3. Electric Plant	
4. Command and Control*	
5. Auxiliary Machinery	
6. Outfit & Furnishings	
7. Armament	
Sum 1-7	
Des. & Const. Margins	
Light Ship	
Future Growth Margin	
Loads	
Full Load	

4. KEY FEATURES: **

4.1 Structure:

Materials breakdown by weight
(MS, HY-80, Al, kevlar, etc.)
* Includes long tons of water in sonar dome.
**Fill in only the required data for the specific type of ship being reported.
Keep this form unclassified if possible.

4.2 Propulsion Machinery:

Type of Propulsion
No. of screws/total SHP
No. and rating of main units
(boilers, gas turbs, diesels)
Steam conditions or unit designation
Propeller dia/type/RPM

4.3 Electric Plant:

Ship service generator no./size
Generator unit type/designation
Emergency generator no./size
Generator unit/type/designation

4.4 Command And Control:

(GFE Equipment List: see Attachment A)
Unusual Features (Flag facilities; TFCC, etc.)

4.5 Auxiliary Machinery:

(GFE Equipment List: see Attachment A)
Unusual GFE equipments (thrusters, elevators, winches, etc.)

4.6 Outfit And Furnishings:

Accommodations:

Ship-Navy	Off	CPO	Other EM
Ship-MSC	Off	CPO	Other EM
Troops	Off	CPO	Other EM
Air Wing	Off	CPO	Other EM
Flag	Off	CPO	Other EM

Total Accommodations:
Habitability Standards

4.7 Armament:

GFE Equipment List: See Attachment A

4.8 Load Items:

Unusual items (special cargo, vans, coal, etc.) that could affect cost

4.9 Protection: (Note: this information is usually classified)

Shock (Y/N)
Blast (psi overpressure)
Torpedo SPS (Y/N)
Cruise Missile Prot. System (long tons)
Ice Strengthening (Y/N)

5. ATTACHMENTS: (supplied where applicable/available - indicate yes/no)

A. List of Major Government Furnished Equipment (GFE)*

B. List of Risk/Developmental Items

C. List of Space and Weight Items (with SWBS weights)

D. List of New or Unusual Features (SSES; etc.)

E. List of 3-Digit Weight Changes (+/-), plus list of Major Equipment Removals and Additions**

F. Sketch of Ship

* Required for all studies

** Required for all conversion/major modernization studies

NAVSEA 4280 Unit Price Analysis

UNIT PRICE ANALYSIS - BASIC CONSTRUCTION

OMB APPROVAL NO. 45-R271

BIDDER	VESSEL	INVITATION NO.
ADDRESS		NO. OF VESSELS COVERED BY THIS UNIT PRICE ANALYSIS

ITEM			DIRECT LABOR		DIRECT MATERIAL 1/	OVERHEAD	TOTAL
			HOURS	DOLLAR			
A.	ESTIMATED COST						
	100	HULL STRUCTURE					
	200	PROPULSION PLANT					
	300	ELECTRIC PLANT					
	400	COMMAND AND SURVEILLANCE					
	500	AUXILIARY SYSTEMS					
	600	OUTFIT AND FURNISHINGS					
	700	ARMAMENT					
	800	INTEGRATION / ENGINEERING					
	900	SHIP ASSEMBLY & SUPPORT SERVICES					
B.	SUB-TOTAL - COST						
C.	PROPOSED PROFIT (OF LINE B)						$0.00
D.	GRAND TOTAL - UNIT PRICE						

1/ DIRECT MATERIAL BREAKDOWN			
A	DIRECT (Stores)		
B	PURCHASED PARTS		
C	SUBCONTRACTS (Major)		
	1		
	2		
	3		
	4		
		TOTAL	

This is to certify that the information herein is based upon or compiled from the books and records of this company and is accurate to the best of my knowledge and belief.

NAME OF FIRM	
ADDRESS	
BY (*Name*)	TITLE
SIGNATURE	DATE

NAVSEA 4280/2 (5-97)

* See definitions on reverse

DEFINITIONS

100 HULL STRUCTURE:

Shell plating or planking; Longitudinal and transverse framing; inner bottom plating; Platforms and flats below lowermost continuous deck; Fourth deck; Third deck; Second deck; Main deck or hanger deck; Forecastle deck (including platforms, flats, and decks between main and gallery deck); Gallery deck; Flight deck, landing platforms and special purpose decks above weather deck (Includes catapult troughs); Superstructures; Foundations for main propelling machinery; Foundations for auxiliaries and other equipment; Structural bulkheads; Trunks and enclosures; Structural sponsons; Armor; Aircraft fuel saddle tank structure; Structural castings, forgings, and equivalent weldments; Sea chests; Ballast and buoyancy units; Doors and closures, special purpose; Doors, hatches, manholes, and scuttles, non-ballistic; Doors, hatches, manholes, and scuttles, ballistic; Masts and king posts; Compartment testing.

200 PROPULSION PLANT:

Boilers and energy converters; Propulsion units; Main condensers and air ejectors; Shafting, bearings, and propellers; Combustion air supply system; Uptakes and smoke pipes; Propulsion control equipment; Main steam system; Feedwater and condensate systems; Circulating and cooling water system; Fuel oil service system; Lube oil system.

300 ELECTRIC PLANT:

Electric power generation; Power distribution switchboards; Power distribution system (cable); Lighting system distribution and fixtures.

400 COMMAND & SURVEILLANCE:

Navigational systems and equipment; Interior communication systems; Armament control systems; Counter-measures and ships' protective systems (except electronic); Electronic systems including electronic countermeasures.

500 AUXILIARY SYSTEMS:

Heating system; Ventilation system; Air-conditioning system; Refrigerating spaces, plant and equipment; Gas, HEAF, cargo piping, oxygen-nitrogen, aviation lube oil systems; Plumbing installations; Firemain, flushing, and sprinkler systems; Drainage, trimming, heeling, and ballast systems; Fresh water system; Scuppers and deck drains; Fuel and diesel oil filling, venting, stowage, and transfer systems; Tank heating systems; Compressed-air systems; Auxiliary steam, exhaust steam, and steam drains; Buoyancy control system (flooding and venting- submarines); Miscellaneous piping systems; Distilling plant; Steering gear system; Rudder; Winches, capstans, cranes, and anchor handling system; Elevators, moving stairways, and cargo handling equipment; Operating gear for retractable elevating units; Aircraft elevators; Aircraft arresting gear barriers and barricades; Catapults and jet blast deflectors.

600 OUTFIT AND FURNISHINGS:

Hull fittings; Boats, boat stowage and handling; Rigging and canvas; Ladders and gratings; Nonstructural bulkheads and nonstructural doors; Paintings; Deck covering; Hull insulation; Storerooms, stowages, and lockers; Equipment for utility spaces; Equipment for workshops; Equipment for galley, pantry, scullery, and commissary outfit; Furnishings for living spaces; Furnishings for office spaces, electronic, and radar; Furnishings for medical and dental spaces.

700 ARMAMENT:

Guns, mounts, and launching devices; Ammunition handling systems; Ammunition stowage; Special weapon stowage and handling.

800 INTEGRATION/ENGINEERING:

Design and engineering services.

900 SHIP ASSEMBLY & SUPPORT SERVICES:

Staging, scaffolding, and cribbing; Launching; Trials and docking; Temporary utilities and services; Material handling and removal; Cleaning ship services.

NAVSEA 4280/2 (5-97) (BACK)

UNIT PRICE ANALYSIS -- SUMMARY

(By Ship's Work Breakdown Structure)

OMB APPROVAL NO. 45-R271

GROUP 1 HULL STRUCTURE		TOTAL MAN-HOURS	MATERIAL DOLLARS
100	HULL STRUCTURE, GENERAL		
110	SHELL AND SUPPORTING STRUCTURE		
111	Shell Plating, Surf. Ship and Submarine Press. Hull		
112	Shell Plating, Submarine Non-Pressure Hull		
113	Inner Bottom		
114	Shell Appendages		
115	Stanchions		
116	Longit. Framing, Surf. Ship and Submarine Press. Hull		
117	Transv. Framing, Surf. Ship and Submarine Press. Hull		
118	Longit. and Transv. Submarine Non-Press. Hull Framing		
120	HULL STRUCTURAL BULKHEADS		
121	Longitudinal Structural Bulkheads		
122	Transverse Structural Bulkheads		
123	Trunks and Enclosures		
124	Bulkheads in Torpedo Protection System		
125	Submarine Hard Tanks		
126	Submarine Soft Tanks		
130	HULL DECKS		
131	Main Deck		
132	2nd Deck		
133	3rd Deck		
134	4th Deck		
135	5th Deck and Decks Below		
136	01 Hull Deck (Forecastle and Poop Decks)		
137	02 Hull Deck		
138	03 Hull Deck		
139	04 Hull Deck and Hull Decks Above		
140	HULL PLATFORMS AND FLATS		
141	1st Platform		
142	2nd Platform		
143	3rd Platform		
144	4th Platform		
145	5th Platform		
149	Flats		
150	DECK HOUSE STRUCTURE		
151	Deckhouse Structure to First Level		
152	1st Deckhouse Level		
153	2nd Deckhouse Level		
154	3rd Deckhouse Level		
155	4th Deckhouse Level		
156	5th Deckhouse Level		

NAVSEA 4280/2A (5-97) Page 1 of 12

GROUP 1 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
157	6th Deckhouse Level		
158	7th Deckhouse Level		
159	8th Deckhouse Level		
160	SPECIAL STRUCTURES		
161	Structural Castings, Forgings, and Equiv. Weldments		
162	Stacks and Macks (Combined Stack and Mast)		
163	Sea Chests		
164	Ballistic Plating		
165	Sonar Domes		
166	Sponsons		
167	Hull Structural Closures		
168	Deckhouse Structural Closures		
169	Special Purpose Closures and Structures		
170	MASTS, KINGPOSTS, AND SERVICE PLATFORMS		
171	Masts, Towers, Tetrapods		
172	Kingposts and Support Frames		
179	Service Platforms		
180	FOUNDATIONS		
181	Hull Structure Foundations		
182	Propulsion Plant Foundations		
183	Electric Plant Foundations		
184	Command and Surveillance Foundations		
185	Auxiliary Systems Foundations		
186	Outfit and Furnishings Foundations		
187	Armament Foundations		
190	SPECIAL PURPOSE SYSTEMS		
191	Ballast, Fixed or Fluid, and Buoyancy Units		
192	Compartment Testing		
195	Erection of Sub Sections (Progress Report Only)		
198	Free Flooding Liquids		
199	Hull Repair Parts and Special Tools		
	TOTAL		
GROUP 2 PROPULSION PLANT			
200	PROPULSION PLANT, GENERAL		
210	ENERGY GENERATING SYSTEM (NUCLEAR)		
211	(Reserved)		
212	Nuclear Steam Generator		
213	Reactors		
214	Reactor Coolant System		

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GROUP 2 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
215	Reactor Coolant Service Systems		
216	Reactor Plant Auxiliary Systems		
217	Nuclear Power Control and Instrumentation		
218	Radiation Shielding (Primary)		
219	Radiation Shielding (Secondary)		
220	ENERGY GENERATING SYSTEM (NON-NUCLEAR)		
221	Propulsion Boilers		
222	Gas Generators		
223	Main Propulsion Batteries		
224	Main Propulsion Fuel Cells		
230	PROPULSION UNITS		
231	Propulsion Steam Turbines		
232	Propulsion Steam Engines		
233	Propulsion Internal Combustion Engines		
234	Propulsion Gas Turbines		
235	Electric Propulsion		
236	Self-Contained Propulsion Systems		
237	Auxiliary Propulsion Devices		
238	Secondary Propulsion (Submarines)		
239	Emergency Propulsion (Submarines)		
240	TRANSMISSION AND PROPULSOR SYSTEMS		
241	Propulsion Reduction Gears		
242	Propulsion Clutches and Couplings		
243	Propulsion Shafting		
244	Propulsion Shaft Bearings		
245	Propulsors		
246	Propulsors Shrouds and Ducts		
247	Water Jet Propulsors		
250	PROPULSION SUPPORT SYS. (EXCEPT FUEL AND LUBE OIL)		
251	Combustion Air System		
252	Propulsion Control System		
253	Main Steam Piping System		
254	Condensers and Air Ejectors		
255	Feed and Condensate System		
256	Circulating and Cooling Sea Water System		
259	Uptakes (Inner Casting)		
260	PROPULSION SUPPORT SYSTEMS (FUEL AND LUBE OIL)		
261	Fuel Service System		
262	Main Propulsion Lube Oil System		
263	Shaft Lube Oil System (Submarines)		
264	Lube Oil Fill, Transfer, and Purification		

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GROUP 2 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
290	SPECIAL PURPOSE SYSTEMS		
298	Propulsion Plant Operating Fluids		
299	Propulsion Plant Repair Parts and Special Tools		
	TOTAL		
GROUP 3 ELECTRIC PLANT			
300	ELECTRIC PLANT, GENERAL		
310	ELECTRIC POWER GENERATION		
311	Ship Service Power Generation		
312	Emergency Generators		
313	Batteries and Service Facilities		
314	Power Conversion Equipment		
320	POWER DISTRIBUTION SYSTEMS		
321	Ship Service Power Cable		
322	Emergency Power Cable System		
323	Casualty Power Cable System		
324	Switchgear and panels		
330	LIGHTING SYSTEM		
331	Lighting Distribution		
332	Lighting Fixtures		
340	POWER GENERATION SUPPORT SYSTEMS		
341	SSTG Lube Oil		
342	Diesel Support Systems		
343	Turbine Support Systems		
390	SPECIAL PURPOSE SYSTEMS		
398	Electric Plant Operating Fluids		
399	Electric Plant Repair Parts and Special Tools		
	TOTAL		
GROUP 4 COMMAND AND SURVEILLANCE			
400	COMMAND AND SURVEILLANCE, GENERAL		
410	COMMAND AND CONTROL SYSTEMS		
411	Data Display Group		
412	Data Processing Group		
413	Digital Data Switchboards		
414	Interface Equipment		

NAVSEA 4280/2A (5-97) Page 4 of 12

GROUP 4 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
415	Digital Data Communications		
416	Command and Control Testing		
417	Command and Control Analog Switchboards		
420	NAVIGATION SYSTEMS		
421	Non-Electrical/Electronic Navigation Aids		
422	Electrical Navigation Aids (Incl Navig. Lights)		
423	Electronic Navigation Systems, Radio		
424	Electronic Navigation Systems, Acoustical		
425	Periscopes		
426	Electrical Navigation Systems		
427	Inertial Navigation Systems		
430	INTERIOR COMMUNICATIONS		
431	Switchboards for I.C. Systems		
432	Telephone Systems		
433	Announcing Systems		
434	Entertainment and Training Systems		
435	Voice Tubes and Message Passing Systems		
436	Alarm, Safety, and Warning Systems		
437	Indicating, Order, and Metering Systems		
438	Integrated Control Systems		
439	Recording and Television Systems		
440	EXTERIOR COMMUNICATIONS		
441	Radio Systems		
442	Underwater Systems		
443	Visual and Audible Systems		
444	Telemetry Systems		
445	TTY and Facsimile Systems		
446	Security Equipment		
450	SURVEILLANCE SYSTEMS (SURFACE)		
451	Surface Search Radar		
452	Air Search Radar (2D)		
453	Air Search Radar (3D)		
454	Aircraft Control Approach Radar		
455	Identification Systems (IFF)		
459	Space Vehicle Electronic Tracking		
460	SURVEILLANCE SYSTEMS (UNDERWATER)		
461	Active Sonar		
462	Passive Sonar		
463	Active/Passive (Multiple Mode) Sonar		
464	Classification Sonar		
465	Bathythermograph		

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GROUP 4 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
470	COUNTERMEASURES		
471	Active ECM (Incl Combination Active/Passive)		
472	Passive ECM		
473	Torpedo Decoys		
474	Decoys (Other)		
475	Degaussing		
476	Mine Countermeasures		
480	FIRE CONTROL SYSTEMS		
481	Gun Fire Control Systems		
482	Fire Control Systems (Non-Sonar Data Base)		
483	Fire Control Systems (Sonar Data Base)		
489	Fire Control Systems Switchboards		
490	SPECIAL PURPOSE SYSTEMS		
491	Electronic Test, Checkout, and Monitoring Equipment		
492	Flight Control and Instrument Landing Systems		
493	Non Combat Data Processing Systems		
494	Meteorological Systems		
495	Integrated Operational Intelligence Systems		
498	Command and Surveillance Operating Fluids		
499	Command and Surv. Repair Parts and Special Tools		
	TOTAL		
GROUP 5 AUXILIARY SYSTEMS			
500	AUXILIARY SYSTEMS, GENERAL		
510	CLIMATE CONTROL		
511	Compartment Heating System		
512	Ventilation System		
513	Machinery Space Ventilation System		
514	Air Conditioning System		
515	Air Revitalization Systems (Submarines)		
516	Refrigeration System		
517	Auxiliary Boilers and Other Heat Sources		
520	SEA WATER SYSTEMS		
521	Firemain and Flushing (Sea Water) System		
522	Sprinkler System		
523	Washdown System		
524	Auxiliary Sea Water System		
526	Scuppers and Deck Drains		
527	Firemain Actuated Services - Other		
528	Plumbing Drainage		
529	Drainage and Ballasting System		

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GROUP 5 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
530	FRESH WATER SYSTEMS		
531	Distilling Plant		
532	Cooling Water		
533	Potable Water		
534	Aux. Steam and Drains Within Machinery Box		
535	Aux. Steam and Drains Outside Machinery Box		
536	Auxillary Fresh Water Cooling		
540	FUELS AND LUBRICANTS, HANDLING AND STORAGE		
541	Ship Fuel and Fuel Compensating System		
542	Aviation and General Purpose Fuels		
543	Aviation and General Purpose Lubricating Oil		
544	Liquid Cargo		
545	Tank Heating		
550	AIR, GAS, AND MISC. FLUID SYSTEMS		
551	Compressed Air Systems		
552	Compressed Gases		
553	O_2 N_2 System		
554	LP Blow		
555	Fire Extinguishing Systems		
556	Hydraulic Fluid System		
557	Liquid Gases, Cargo		
558	Special Piping Systems		
560	SHIP CONTROL SYSTEMS		
561	Steering and Diving Control Systems		
562	Rudder		
563	Buoyancy and Hovering (Submarines)		
564	Trim System (Submarines)		
565	Trim and Heel (Roll Stabilization)		
566	Diving Planes and Stabilizing Fins		
567	Lift Systems		
568	Maneuvering Systems		
570	UNDERWAY REPLENISHMENT SYSTEMS		
571	Replenishment-At-Sea		
572	Ship Stores and Personnel and Equip. Handling		
573	Cargo Handling		
580	MECHANICAL HANDLING SYSTEM		
581	Anchor Handling and Stowage Systems		
582	Mooring and Towing Systems		
583	Boat Handling and Stowage Systems		
584	Mechanically Operated Door, Gate, Ramp, Turntable Sys.		
585	Elevating and Retracting Gear		

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GROUP 5 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
586	Aircraft Recovery Support Systems		
587	Aircraft Launch Support Systems		
588	Aircraft Handling, Servicing and Stowage		
589	Miscellaneous Mechanical Handling Systems		
590	SPECIAL PURPOSE SYSTEMS		
591	Scientific and Ocean Engineering Systems		
592	Swimmer and Diver Support and Protection Systems		
593	Environmental Pollution Control Systems		
594	Submarine Rescue, Salvage, and Survival Systems		
595	Towing, Launching and Handling for Underwater Sys.		
596	Handling Sys. for Diver and Submersible Vehicles		
597	Salvage Support Systems		
598	Auxiliary Systems Operating Fluids		
599	Auxiliary Systems Repair Parts and Tools		
	TOTAL		
GROUP 6 OUTFIT AND FURNISHINGS			
600	OUTFIT AND FURNISHINGS, GENERAL		
610	SHIP FITTINGS		
611	Hull Fittings		
612	Rails, Stanchions, and Lifelines		
613	Rigging and Canvas		
620	HULL COMPARTMENTATION		
621	Non-Structural Bulkheads		
622	Floor Plates and Gratings		
623	Ladders		
624	Non-Structural Closures		
625	Airports, Fixed Portlights, and Windows		
630	PRESERVATIVES AND COVERINGS		
631	Painting		
632	Zinc Coating		
633	Cathodic Protection		
634	Deck Covering		
635	Hull Insulation		
636	Hull Damping		
637	Sheathing		
638	Refrigerated Spaces		
639	Radiation Shielding		
640	LIVING SPACES		
641	Officer Berthing and Messing Spaces		

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GROUP 6 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
642	Noncommissioned Officer Berthing and Messing Spaces		
643	Enlisted Personnel Berthing and Messing Spaces		
644	Sanitary Spaces and Fixtures		
645	Leisure and Community Spaces		
650	SERVICE SPACES		
651	Commissary Spaces		
652	Medical Spaces		
653	Dental Spaces		
654	Utility Spaces		
655	Laundry Spaces		
656	Trash Disposal Spaces		
660	WORKING SPACES		
661	Offices		
662	Machinery Control Centers Furnishings		
663	Electronics Control Centers Furnishings		
664	Damage Control Stations		
665	Workshops, Labs, Test Areas (Incl Portable Tools, Equip)		
670	STOWAGE SPACES		
671	Lockers and Special Stowage		
672	Storerooms and Issue Rooms		
673	Cargo Stowage		
690	SPECIAL PURPOSE SYSTEMS		
698	Outfit and Furnishings Operating Fluids		
699	Outfit and Furnish. Repair Parts and Special Tools		
	TOTAL		
GROUP 7 ARMAMENT			
700	ARMAMENT, GENERAL		
710	GUNS AND AMMUNITION		
711	Guns		
712	Ammunition Handling		
713	Ammunition Stowage		
720	MISSILES AND ROCKETS		
721	Launching Devices (Missiles and Rockets)		
722	Missile, Rocket, and Guidance Capsule Handling Sys.		
723	Missile and Rocket Stowage		
724	Missile Hydraulics		

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GROUP 7 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
725	Missile Gas		
726	Missile Compensating		
727	Missile Environmental Monitoring and Launcher Contr.		
728	Misssile Heating. Cooling. Temperature Control		
730	MINES		
731	Mine Launching Devices		
732	Mine Handling		
733	Mine Stowage		
740	DEPTH CHARGES		
741	Depth Charge Launching Devices		
742	Depth Charge Handling		
743	Depth Charge Stowage		
750	TORPEDOES		
751	Torpedo Tubes		
752	Torpedo Handling		
753	Torpedo Stowage		
754	Submarine Torpedo Ejection		
760	SMALL ARMS AND PYROTECHNICS		
761	Small Arms and Pyrotechnic Launching Devices		
762	Small Arms and Pyrotechnic Handling		
763	Small Arms and Pyrotechnic Stowage		
770	CARGO MUNITIONS		
772	Cargo Munitions Handling		
773	Cargo Munitions Stowage		
780	AIRCRAFT RELATED WEAPONS		
782	Aircraft Related Weapons Handling		
783	Aircraft Related Weapons Stowage		
790	SPECIAL PURPOSE SYSTEMS		
792	Special Weapons Handling		
793	Special Weapons Stowage		
797	Misc. Ordnance Spaces		
798	Armament Operating Fluids		
799	Armament Repair Parts and Special Tools		
	TOTAL		

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GROUP 8 INTEGRATION/ENGINEERING (SHIPBUILDER RESPONSE)		TOTAL MAN-HOURS	MATERIAL DOLLARS
800	INTEGRATION/ENGINEERING (SHIPBUILDER RESPONSE)		
801	Shipbuilders Information Drawings		
802	Contract Drawings		
803	Standard Drawings		
804	Type Drawings		
806	Study Drawings		
810	Production Engineering		
811	Configuration Management		
812	Change Proposals, Scoping and Shipchecking		
813	Planning and Production Control		
820	Special Drawings for Nuclear Propulsion Systems		
830	Design Support		
831	Construction Drawings		
832	Specifications		
833	Weight Engineering		
834	Computer Programs		
835	Engineering Calculations		
836	Models and Mockups		
837	Photographs		
838	Design/Engineering Liaison		
839	Lofting		
840	Quality Assurance		
841	Tests and Inspection, Criteria, and Prodcedures		
842	Trials Agenda Preparation, Data Collection and Anal.		
843	Inclining Experiment and Trim Dive		
844	Combat Systems Checkout Criteria, and Procedures		
845	Certification Standards		
850	Integrated Logistic Support Engineering		
851	Maintenance		
852	Support and Test Equipment		
853	Supply Support		
854	Transportation		
855	Engineering Drawings and Specifications		
856	Technical Manuals and Other Data		
857	Facilities		
858	Personnel and Training		
859	Training Equipment		
890	Special Purpose Items		
891	Safety		
892	Human Factors		
893	Standardization		
894	Value Engineering		
895	Reliability and Maintainability		
896	Data Management		
897	Project Management		
	TOTAL		
GROUP 9 SHIP ASSEMBLY AND SUPPORT SERVICES			
900	SHIP ASSEMBLY AND SUPPORT SERVICES		
901	901 Thru 979 Reserved for Ident. of Assemblies		
980	Contractual and Production Support Service		
981	Insurance		
982	Trials		

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GROUP 6 (Continued)		TOTAL MAN-HOURS	MATERIAL DOLLARS
983	Delivery		
984	Open and Inspect (Conversions Only)		
985	Fire and Flooding Protection		
986	Tests and Inspections		
987	Weighing and Recording		
988	Contract Data Requirements (Administration)		
989	Fitting-Out		
990	Construction Support		
991	Staging, Scaffolding, and Cribbing		
992	Temporary Utilities and Services		
993	Material Handling and Removal		
994	Cleaning Services		
995	Molds and Templates, Jigs, Fixtures, and Spec. Tools		
996	Launching		
997	Drydocking		
	TOTAL		
	GRAND TOTAL		

NAVSEA 7300/4s Equipment Unit Cost Estimate

Instructions for filling out this form follow immediately.

EQUIPMENT UNIT COST ESTIMATE (In Thousands of Dollars)

FY $	SHIP CLASS	EST. CAT	SHAPM (SIG. DATE):	PREP BY: (CODE)	DATE	
			PARM (SIG. DATE):	SIGNATURE:		
PROD LEAD TIME MOS.	CONTRACTOR	CONTRACT NO.	CONTRACT TYPE	AWARD DATE MO. YR.	APPROP.	BUY (UNITS)
				D2**NAVY SUPPLY SUPPORT DATE:		
SYSTEMS PER SHIP:						

	ITEM	FY__ SPD	FY__ CONTRACT AWARD	LEAD SYSTEM COST	FOLLOW SYSTEM COST		ITEM	FY__ SPD	FY__ CONTRACT AWARD	LEAD SYSTEM COST	FOLLOW SYSTEM COST
A.	MAJOR HARDWARE	0	0	0	0	E.	SYSTEMS ENGINEERING				
1	HARDWARE	0	0	0	0	F.	TECH ENGNR'G SERVICES	0	0	0	0
a	*					1	CONTRACT FIELD SERVICES				
b	*					2	GOVT. FIELD SERVICES				
c	*						OTHER COSTS	0	0	0	0
d	*					G.	DEVEL. COSTS (NOT RDT&E)				
e	*					H.	PRODUCTION START-UP				
f	*					J.	TRAINING				
2	WARRANTY					K1.	SOFTWARE & PROGRAMMING				
3	BATTLE SPARE/ TRAINER					K2.	COMPUTER PROG SUPPORT				
4	GOVT. PROVIDED COMPONENTS					L.	SYSTEM TEST & EVALUATION				
	*					M.	DESIGN ENGNR'G CHANGES				
	*					N1.	ORDALTS/FIELD CHANGES				
B	ANCILLARY EQUIPMENT	0	0	0	0	N2.	ORDALTS/FLD CH SUPPORT SERV				
1	TEST EQUIPMENT					P.	ENG/ILS/CONFIG MGMT SUP SERV				
2	SHPNG & INSTALL FIXTURES					Q	SHIPBOARD CERTIFICATION				
C	TECH DATA DOCUMENTATION					R.	QA & RMA				
D	SPARES	0	0	0	0	S.	MAINTENANCE OF TECH DATA				
1	INSTALLATIONS & CHKOUT SPARES						*				
2	INIT'L SPARES SUP SUPPORT						*				
3	SHYD I&C KIT						SYSTEM TOTALS	0	0	0	0

* RESERVED FOR ADDED COST ELEMENTS

This form, the NAVSEA 7300/4 Equipment Unit Cost Estimate provides the total system cost when purchased under SCN funding.

Cost Element Definitions

A. Major Hardware: The total cost of the principal components of the system, i.e., the primary unit which makes it possible for the total system to meet mission requirements. This is the sum of A-1 through A-4.

A-1 Hardware: The cost of equipment delivered as a part of the production system by the prime contractor (Major equipment and their respective costs will be listed as sub-elements a. through f.).

A-2 Warranty: The cost which allows the government additional time after acceptance in which to assert a right to correction of the deficiencies or defects, re-performance, and equitable adjustments in the contract price or other remedies.

A-3 Battle Spare/Trainer: The cost of procuring spare equipment as insurance backup for first-of-a-kind shipboard equipment. Trainers are funded under the lead ship or first production buy of ships provided tat the equipment or device duplicates a shipboard item that is the first of a kind and the equipment or device is required to train precommissioning crews.

A-4 Government Provided Components: The cost includes all individual equipment provided as GFM to the prime contractor, i.e., computers, display consoles, etc., (Major equipment and respective costs will be listed as sub-elements a. through e.).

B. Ancillary Equipment: The total cost of those equipment required to provide logistic support to the major hardware. This is the sum of B-1 (Test Equipment) and B-2 (Shipping and Installation Fixtures).

B-1 Test Equipment: Special test equipment for use on this particular system that is not a part of Item A (Major Hardware) and not general purpose test equipment for shipboard allowance.

B-2 Shipping and Installation Fixtures: Any unique requirements for system transport, including reusable containers. Frequently, a special design container is developed for this purpose. Also includes installation fixtures, special tools, gauges, jigs, etc.

C. Technical Data/Documentation: The total cost of the data and documentation associated with the system to provide for installation, integration, operation and maintenance. It includes the entire data package, such as technical manuals, Category E drawings, provisioning technical documentation, Planned Maintenance System (PMS) including Maintenance/Repair Cards (MRCs), a system manual and operator's handbook. It also includes all Contract Data Requirements List Items (DD Form1423)

D. Spares: The total cost of all the spare parts needed to prove out the operational readiness of the system and to stock an initial allowance of authorized spares. This is the sum of D-1 Installation and Checkout Spares, D-2 Initial Spares/Supply Support, and D-3 Shipyard Installation and Checkout Kit. The actual or predicted Navy support date will be indicated for the Initial Spares/Supply support in the block noted ** at the top of the form. Subsequent to the actual or predicted Navy support date, it is the responsibility of the cognizant PROGRAM MANAGER to make provisions for this item under outfitting costs.

D-1 Installation & Checkout (I&C) Spares: Spares to support the installation and checkout of the hardware system through system acceptance. Spares not used are retained in I&C spares stock by the shipbuilder until all anticipated installations are complete. Any spares still not used go into ship supply support.

Appendix D

Procurement Budget Exhibits

This section provides selected commonly used budget forms. The following link provides a source document of all procurement budget exhibits and cost forms:

http://www.dod.mil/comptroller/fmr/02b/02barch/Chapter04c.pdf

SUMMARY OF EXHIBIT REQUIREMENTS

Exhibit Appropriation

P-1 Procurement Program All

P-1C Procurement Program - Comparison Report All

P-1M Procurement Program- Modification Summary Aircraft/Missiles

P-1R Procurement Program-Reserve Components All, except SCN

P-3a Individual Modification Program All, except SCN

P-5 Cost Analysis All

P-5a Procurement History and Planning All, except SCN

P-5b Analysis of Cost Estimates-Basic/Escalation SCN

P-8a Analysis of Ship Cost Estimates - Major Equipment SCN

P-10 Advance Procurement Analysis All, as applicable

P-17 Layaway and/or Distribution All, as applicable

P-18 Initial and Replenishment Spares Requirements All, except SCN

P-20 Requirements Study All, as applicable

P-21 Production Schedule All

P-21a Production Schedule, All Types PAA

P-22 Ammunition Inventory Ammunition Accounts

P-23 Time Phased Requirements Schedule All, as applicable

P-23a Installations Data All, as applicable

P-25 Production Support & Industrial Facilities Cost Analysis All, as applicable

P-26 Maintenance of Inactive Facilities PAA & as applicable

P-27 SCN Ship Production Schedule SCN

P-29 SCN Outfitting Costs SCN

P-29a SCN Outfitting Costs-Comparison SCN

P-30 SCN Post Delivery Costs SCN

P-30a SCN Post Delivery Costs-Comparison SCN

P-32 Procurement Purchases from DWCF All

P-35 Major Ship Component Fact Sheet SCN

P-36 Depot Level Ship Maintenance Schedule OPN

P-40 Budget Item Justification Sheet All

P-40a Budget Item Justification for Aggregated Items All

P-45 Summary of Reimbursables All, as applicable

MYP-1 Multiyear Procurement Criteria All, as applicable

MYP-2 Total Program Funding Plan All, as applicable

MYP-3 Contract Funding Plan All, as applicable

MYP-4 Present Value Analysis All, as applicable

Exhibit P-5 Budget Estimate

UNCLASSIFIED
CLASSIFICATION

P-5 EXHIBIT
FY20__ [PRESIDENT'S, FMB, or OSD/OMB] BUDGET E

APPROPRIATION: SHIPBUILDING AND CONVERSION, NAVY

PROGRAM COST BREAKDOWN (EXHIBIT P-5)

BUDGET ACTIVITY: P-1 ITEM NOMENCLATURE: SUBHEAD:

	FY 20__		FY 20__		FY 20__	
ELEMENT OF COST	QTY	TOT COST	QTY	TOT COST		TOT COST
PLAN COSTS	0	0	0	0	0	0
BASIC CONSTRUCTION/CONVERSION		0		0		0
CHANGE ORDERS		0		0		0
ELECTRONICS		0		0		0
PROPULSION		0		0		0
HM&E		0		0		0
OTHER COST		0		0		0
ORDNANCE		0		0		0
ESCALATION		0		0		0
TOTAL SHIP ESTIMATE		0		0		0
LESS: ADVANCE PROCUREMENT FY 20XX		0		0		
LESS: ADVANCE PROCUREMENT FY 20XX		0		0		0
NET P-1 LINE ITEM (REQUIREMENT)	0	0	0	0	0	0

Exhibit P10 Advance Procurement Requirements Analysis

Exhibit P-10, Advance Procurement Requirements Analysis (Page 1 - Funding)	Date:
Appropriation (Treasury) Code/CC/BA/BSA/Item Control Number	P-1 Line Item Nomenclature

Weapon System	First System (BY1) Award and Completion Date	Interval between Systems

($ in Millions)

	PLT	When Rqd	Prior Years	PY-1	PY	CY	BY1	BY2	BY2+1	BY2+2	BY2+3	BY2+4	To Complete	Total
End Item Qty														
CFE														
Engines														
GFE														
GFE														
GFE														
EOQ														
Design														
Term Liab														
Other*														
Total AP														

Description:

*Specifically identify other items for all pages of this exhibit.

P-1 Shopping List Item No 20-3 of 10

Exhibit P-10, Advance Procurement Requirements Analysis
(Exhibit P-10, page 1 of 8)

Exhibit P-35 Major Ship Component Fact Sheet

Exhibit P-35, Major Ship Component Fact Sheet
(TOA, $ in Millions)

Ship Type - (SSN-21) Equipment Item - (AN/BSY-2 Combat System) PARM Code - (NAVSEA PMS XXX)

Description/Characteristics/Purpose:

Current Funding	FY 20PY		FY 20CY		FY 20BY1		FY 20BY2	
Major Hardware	Hull	Total FY	Hull	Total FY	Hull	Total FY	Hull	Total FY
Hardware								
Warranty								
Battle Spare/Trainer								
GFE								
Ancillary Equipment								
Test Equipment								
Shipping and Installation Fix								
Technical Data and Documentation								
Spares								
Installation & Checkout								
Installation & Sup Spt								
System Engineering								
Technical Engineering Services								
Contract Field Services								
Govt Field Services								
Other Costs (List separately)								
Other Costs								

Contract Data (major hardware)	Prime Contractor	Contract Award Date (indicate if estimated)	Contract Type	New/Option	Contract Qty	Contract Hardware Unit Cost
PY						
CY						
BY1						
BY2						

Delivery Data	Earliest Ship Delivery Date	Months Required before Delivery	Production Leadtime	Required Award Date
PY				
CY				
BY1				
BY2				

V. Competition/Second-Source Initiatives:

P-1 Shopping List - Item No 30-9 of 30-9

Exhibit P-35, Major Ship Component Fact Sheet
(Exhibit P-35, page 1 of 2)

Exhibit P-40 Budget Item Justification

Exhibit P-40, Budget Item Justification							Date					
Appropriation (Treasury) Code/CC/BA/BSA/Item Control Number							P-1 Line Item Nomenclature					
Program Element for Code B Items:				Other Related Program Elements								
	ID Code	Prior Years	PY FY 1998	CY FY 1999	BY1 FY 2000	BY2 FY 2001	BY2+1 FY 2002	BY2+2 FY 2003	BY2+3 FY 2004	BY2+4 FY 2005	To Complete	Total
Proc Qty												
Gross Cost												
Less PY Adv Proc												
Plus CY Adv Proc												
Net Proc (=P-1)												
Initial Spares												
Total Proc Cost												
Flyaway U/C												
Wpn Sys Proc U/C												
Description (Use continuation pages, as necessary)												

P-1 Shopping List - Item No 17-1 of 17-5

Exhibit P-40, Budget Item Justification

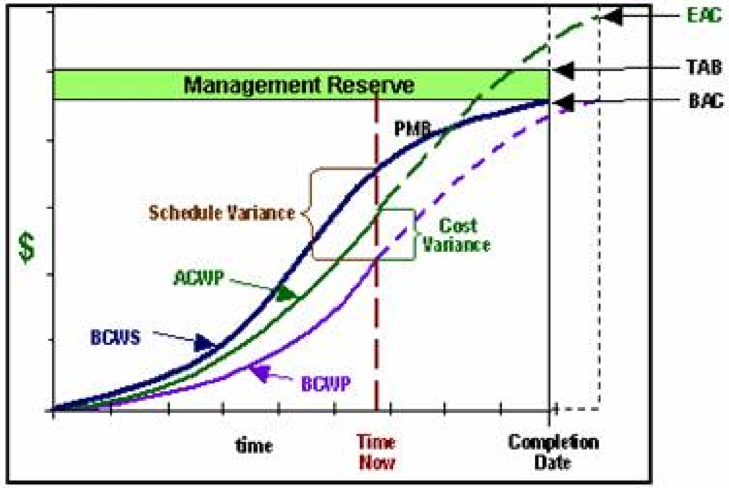
(Exhibit P-40, page 1 of 4)

Appendix E

Defense Systems Management College EVMS GOLD CARD

Earned Value Management 'Gold Card'

Defense Acquisition University



VARIANCES Favorable is Positive, Unfavorable is Negative

Cost Variance	CV	= BCWP – ACWP CV % = (CV / BCWP) * 100
Schedule Variance	SV	= BCWP – BCWS SV % = (SV / BCWS) * 100
Variance at Completion	VAC	= BAC – EAC

PERFORMANCE INDICES Favorable is > 1.0, Unfavorable is < 1.0

Cost Efficiency	CPI	= BCWP / ACWP
Schedule Efficiency	SPI	= BCWP / BCWS

OVERALL STATUS

% Schedule = ($BCWS_{CUM}$ / BAC) * 100

% Complete = ($BCWP_{CUM}$ / BAC) * 100

% Spent = ($ACWP_{CUM}$ / BAC) * 100

ESTIMATE AT COMPLETION *

EAC = Actuals to Date + [(Remaining Work) / (Efficiency Factor)]

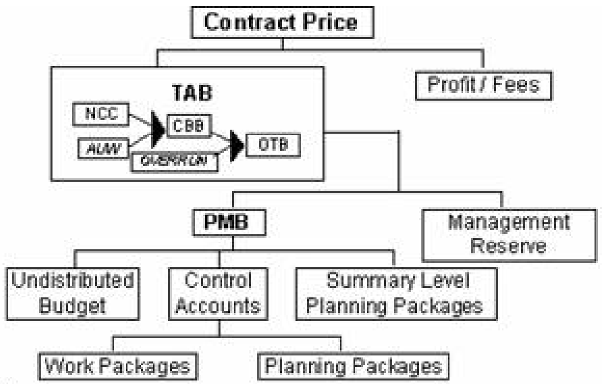
EAC_{CPI} = $ACWP_{CUM}$ + [(BAC – $BCWP_{CUM}$) / CPI_{CUM}] = BAC / CPI_{CUM}

$EAC_{Composite}$ = $ACWP_{CUM}$ + [(BAC – $BCWP_{CUM}$) / (CPI_{CUM} * SPI_{CUM})]

TO COMPLETE PERFORMANCE INDEX (TCPI) *

$TCPI_{EAC}$ = Work Remaining / Cost Remaining = (BAC – $BCWP_{CUM}$) / (EAC – $ACWP_{CUM}$)

* To Determine Either TCPI or EAC; You May Replace BAC with TAB



TERMINOLOGY

NCC	Negotiated Contract Cost	Contract price less profit / fee(s)
AUW	Authorized Unpriced Work	Work contractually approved, but not yet negotiated / definitized
CBB	Contract Budget Base	Sum of NCC and AUW
OTB	Over Target Baseline	Sum of CBB and recognized overrun
TAB	Total Allocated Budget	Sum of all budgets for work on contract = NCC, CBB, or OTB
BAC	Budget At Completion	Total budget for total contract thru any given level
PMB	Performance Measurement Baseline	Contract time-phased budget plan
MR	Management Reserve	Budget withheld by Ktr PM for unknowns / risk management
UB	Undistributed Budget	Broadly defined activities not yet distributed to CAs
CA	Control Account	Lowest CWBS element assigned to a single focal point to plan & control scope / schedule / budget
WP	Work Package	Near-term, detail-planned activities within a CA
PP	Planning Package	Far-term CA activities not yet defined into WPs
BCWS	Budgeted Cost for Work Scheduled	Value of work planned to be accomplished = PLANNED VALUE
BCWP	Budgeted Cost for Work Performed	Value of work accomplished = EARNED VALUE
ACWP	Actual Cost of Work Performed	Cost of work accomplished = ACTUAL COST
EAC	Estimate At Completion	Estimate of total cost for total contract thru any given level; may be generated by Ktr, PMO, DCMA, etc. = $EAC_{Ktr/PM\ or\ DCMA}$
LRE	Latest Revised Estimate	Ktr's EAC or EAC_{Ktr}
SLPP	Summary Level Planning Package	Far-term activities not yet defined into CAs
TCPI	To Complete Performance Index	Efficiency needed from 'time now' to achieve an EAC

EVM POLICY: **EVMS = DFARS 252.234-7000; 252.234-7001; & C/SSR = DFARS 252.242-7005; 252.242-7006; ANSI/EIA-748-A Jan 2002 / Mar 2003; DoDI 5000.2, Table E3.T2; & Defense Acquisition Guidebook**

MANAGEMENT REQUIREMENTS: **Select pair of Contract Clauses based on cost, risk, criticality:**

- **EVMS EIA-748** Management System Validated as Consistent with EIA-748 Standard at detailed level
  - Non-FFP contracts / agreements for R&D > $73M; & Proc or O&M > $315M (CY00$)
- **Cost/Schedule Status Report (C/SSR)** Management System not required to meet EIA-748 Standard;
  - Non-FFP contracts / agreements > $6.3M (CY00$) & > 12 months duration
- **Integrated Baseline Review (IBR)** Mandatory for both EVMS & C/SSR within 6 months of Contract Award

REPORT REQUIREMENTS: **Tailor Data Requirements via CDRL, Select One:**

- **Cost Performance Report = DI-MGMT-81466** = Formats 1-5 (WBS, Organization, Baseline, Staffing, & Explanations)
  - CPR is Mandatory for EVMS EIA-748 contracts & optional for C/SSR contracts
- **Cost/Schedule Status Report = DI-MGMT-81467** = 2 Formats (WBS & Explanations) **or 'Tailored' CPR**

EVM Home Page = http://acc.dau.mil/evm
http://www.dcma.mil = "One Book"
DAU POC: (703) 805-2891 (DSN 655)
eMail Address: EVM@dau.mil
Revised Feb 2004

Defense Systems Management College EVMS Gold Card

E

Appendix F

ESWBS

NAVSEA SHIP END COST ESTIMATE CATEGORIES AND THE SHIP WORK BREAKDOWN STRUCTURE

The major cost estimating categories of a total end cost are presented, and the tie-in with the existing budgeting/accounting systems is discussed. In addition, the primary means of communication between the designer and the estimator and between NAVSEA and the shipbuilder, for example Expanded Ship Work Breakdown Structure (ESWBS), is presented with special emphasis on the significance of ESWBS for estimating the basic construction line.

The NAVSEA ship cost estimating system has evolved over many years and was designed with viable structure and procedures. The system continues to evolve and keep pace with the needs of the Navy cost estimating community as the Division responsibilities grow.

The basic components that constitute the foundation of the NAVSEA cost estimating system are as follows:

- The system was designed to tie in with existing cost collection/accounting systems making it practicable for actual return costs to be tracked against estimates.
- The system was designed so that technical data and cost data could be joined in cost estimating relationships (CERs) and then applied to estimating the cost of new ship designs as descriptive technical data become available.
- Shipbuilders are required to submit estimated costs/bids in a standard format consistent with the NAVSEA cost estimating system. In addition, most successful shipbuilders provide actual return cost data in formats that are compatible with the NAVSEA cost estimating system. This continuous input of bids and actual return cost data is essential to keep the system up to date for real time cost estimating needs.
- The system has been computerized and computer programs are continually being redesigned to enhance the cost estimating process and to facilitate and accommodate the estimating workload. The system is flexible and can accommodate these design changes.

These four basic elements that underlie the NAVSEA ship cost estimating system are also fundamental to the ship end cost estimating categories. The material in this appendix focuses on the end cost categories of a ship estimate and on the ship work breakdown structure that provides a means of communication between the estimator and the designer.

SHIP END COST ESTIMATE CATEGORIES

The cost categories that constitute a total end cost estimate for a ship are shown in Figure 36.

Figure 36 also shows the major ESWBS groups to which the Basic Construction category work is costed. These end cost estimate categories tie in directly with the cost collection/accounting and budgetary systems of NAVSEA. The tie in is made through the Major Category Codes (MCC) that apply to all costs under the NAVSEA administered subheads of the SCN Appropriation. The estimator must be familiar with the MCC categories because of their use in the estimating and budgeting process and because they provide the means for obtaining return cost data through the Standard Accounting Reporting System (STARS). A brief description of the work included in the end cost estimating categories and the related MCC numbering is provided in the following subsections.

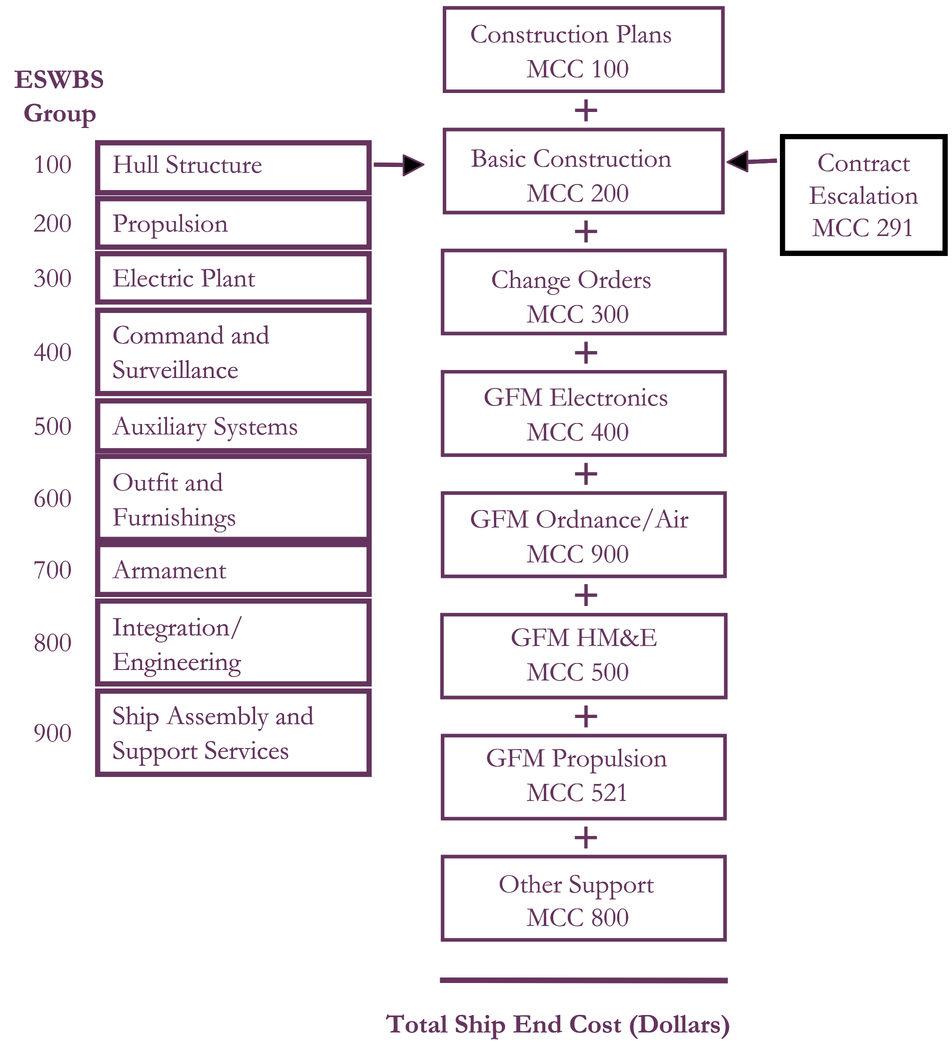


Figure 36: Total Ship End Cost

Construction Plans

On the basis of contract drawings and specifications prepared by NAVSEA, the successful shipbuilder or its design agent develops detailed construction plans, and the costs of this effort are charged to this category. Also included in this cost category are related engineering calculations, computer programs, contractor-responsible technical manuals, damage control books, ship's selected records and models and mock-ups. The lead ship will normally carry the cost burden for this category since the majority of these costs are considered to be nonrecurring. Follow ships may have costs in this category because a lead yard or planning yard has been assigned to keep the engineering development current for follow ships. The estimator must be careful not to duplicate costs included in this category with the engineering costs included in the Basic Construction category.

The MCC number assigned to this category is 111. The MCC index also includes a 113 category for construction plan change orders. The latter category could be active or inactive depending on whether the construction plans are developed by a design agent under a contract separate from the shipbuilding contract. In the case where the shipbuilder is developing the construction plans, any change orders usually will be charged to the basic construction change order category unless the PM can justify charging change orders by some other method.

Basic Construction

The Basic Construction category is the heart of the NAVSEA ship cost estimating process and requires the greatest portion of the ship estimator's time and attention. Basic Construction is defined as the original contract award price for ship construction (or modification/conversion as appropriate). This production category includes all allowable labor, overhead and material costs plus an amount for cost of money and profit. In addition to shipbuilder furnished material, the award price includes the cost for installing all GFM as specified by the contract plans and specifications.

For estimating purposes, the Basic Construction category is tied to the ESWBS, which is an integral part of the basic construction estimating methodology.

The MCC number assigned to the Basic Construction category is 211. There are other related categories in the 200 series of the MCC index that the estimator should review since on occasion there may be use for one or more of the categories. However, MCC 211 will be the predominant 200 series category for construction estimates.

Contract Escalation Reserve

Shipbuilding contracts are generally costed to a given base date (month and year). Such contracts usually include an escalation clause to reimburse the shipbuilder for inflation occurring in the shipbuilding industry over the performance period of the contract measured from the base date. The dollar requirement that is estimated is contained in the Contract Escalation category. The MCC number assigned to the Contract Escalation category is 953.

Change Orders

Historical records show that the Navy often needs to make changes to a shipbuilding contract after it is in place. Typical reasons for changes are indicated in the FAR "changes" clauses and some of these are as follows:

- To include state-of-the-art improvements that come about during the lengthy construction periods of a ship,
- To correct deficiencies discovered in contract drawings or GFI, which are the responsibility of the government.
- To correct differences between contract drawings and ship specifications,
- To incorporate safety items that emerge during construction,
- To incorporate improvements that are generated by the operational forces afloat, and approved for implementation,
- To have the shipbuilder repair or modify GFM,
- To change the contract ship delivery point, the contract date of delivery, or the method of shipment or packing.

The Navy has a number of ways of changing a shipbuilding contract. An item such as the last item listed above would probably be accomplished by amending the contract which would be accounted for by a series 200 MCC. All of the other items above, which are of a technical nature, would be accomplished by a change order. There are between 3,000 to 8,000 change orders issued each fiscal year. These in the past have been budgeted at a level of ten percent (10%) of the basic construction cost for lead ships and five percent (5%) of the basic construction cost for follow ships.

There are two kinds of change orders: Headquarters Modification Requests (HMRs) and Field Modification Requests (FMRs). HMRs are initiated by NAVSEA, and FMRs are initiated by the on-site Navy Supervisor of Shipbuilding Office. HMRs represent approximately 20 percent of the volume with a relatively high unit cost. These change orders are relatively complex involving specification revisions and a rigorous review process which is overseen by the PMs. FMRs represent approximately 80 percent of the volume with relatively low unit cost. These change orders are usually "fact of life" changes, such as correcting defective GFE, and require SUPSHIP technical reviews and cost estimates. HMRs and FMRs are authorized through supplemental agreements to the shipbuilding contract, and the costs are accumulated in the Change Order category.

The MCC number assigned to HMRs is 311, and FMRs are assigned 312. Although actual costs are collected in each category, the estimator does not have to differentiate between the two in making the estimate. Rather, since the greatest cost historically has been associated with HMRs (SUPSHIP offices have a set dollar limit on FMRs), MCC 311 is used in the estimate.

Government Furnished Material

From an acquisition/contractual point of view, it would probably be desirable for the Navy to have the shipbuilder be responsible for all material to be installed aboard ship. The Navy, however, finds that the better situation for its complex and sophisticated ships is to furnish the shipbuilder with certain items, both hardware and software, as government furnished material (GFM). There are four categories for the various kinds of GFM included in an end cost estimate listed below A discussion of what each category includes is presented in the following subsections.

1. Electronics

The Electronics items, both hardware and software, included in this category are electronics production components, training support equipment, test and engineering services, and repair parts associated with installation. The Electronics category consists of about a dozen MCC numbers in the 400 series. For estimate presentation purposes, the electronic hardware and software costs in each of the various MCC numbers can be summarized into MCC 400.

2. Ordnance/Air

The Ordnance/Air items, both hardware and software, included in this category are fire and missile control systems, search and aircraft control radars, missile launching systems, gun systems, training support equipment, test and integration services and other ordnance equipment. In addition, this category includes any air-related GFM; e.g., arresting gear engines, landing aids and selected catapult components. The Ordnance/Air category consists of nearly a dozen MCC numbers in the 900 series. For estimate presentation purposes, all ordnance and air hardware and software costs in each of the various MCC numbers can be summarized into MCC 900.

3. Hull, Mechanical, Electrical (HM&E)

The HM&E items, both hardware and software, included in this category are HM&E equipment, HM&E deep submergence systems, small boats, special vehicles, environmental protection equipment, training support equipment, HM&E engineering services, repair parts associated with installation of HM&E equipment, and all medical equipments provided by the Bureau of Medicine and Surgery (BUMED). The HM&E category is the GFM category which most frequently can shift from GFM to CFE or vice versa in shipbuilding contracts. Although each of the items above has its own MCC number assigned in the 500 series, for estimate presentation purposes they are generally summarized by MCC 525.

4. Propulsion

Propulsion is a category of HM&E. In most cases, the propulsion components for conventionally powered ships will be shipbuilder-responsible, contractor furnished material (CFM) and the Propulsion category is not used. However, the Propulsion category is always used in the case of nuclear-powered ships, since nuclear reactors and cores always are provided to shipbuilders as GFM. When propulsion GFM is involved, this category can include propulsion items such as nuclear reactors, cores, turbines, gears and other selected propulsion items. The MCC number assigned to the Propulsion category is MCC 521.

Test and Instrumentation

The Test and Instrumentation category includes the cost of testing and instrumentation incident to routine or special trials leading to qualifying a ship for active service. The costs included in this category are for government-responsible work and are separate from the shipbuilder-responsible efforts included in the design (Plans) and construction contract (Basic Construction). Although the majority of the test and instrumentation charges will be on the lead ship of the class, each ship will usually bear some costs. The MCC number assigned to the Test and Instrumentation category is MCC 541.

Stock Shore-Based Spares

The Stock Spares category includes procurement of HM&E equipment for stock ashore or aboard tenders/repair ships and is usually limited to first-of-its-kind installations on the lead ship. There are exceptions, but these require unique justification and approval. Some examples of stock spares purchased in the past are propellers, anchor chain, anchors, turbine generators, diesel engines, gas turbine engines and selected shafting. The MCC number assigned to the Stock Spares category is MCC 533.

Other Support

The Other Support category is a catch-all summary of a number of work elements required by PMs to meet their support responsibilities. This category includes Planned Maintenance Subsystems (PMS), equipment transportation costs, travel in support of ship acquisition, contract engineering services, commissioning ceremonies, in-house engineering services SUPSHIP material, PM, test and evaluation, shock test special equipment, technical manuals, and special services. The work elements of the Other Support category are all in the 800 series of the MCC index with the exception of SUPSHIP material (561). For estimating purposes, the items can all be summarized into MCC 800.

Program Manager Reserve

The last category of an end cost estimate is the PM Reserve (also called PM's Growth Reserve) category. This category provides a source of funds to the Project Manager for unforeseen future problems or required activity. For many years, this contingency fund was allowed under the end cost concept and was calculated by a simple percentage of the GFM estimates. A much more logical system was introduced and approved with the POM development for 1986. However, beginning with the FY 88 Budget, the Program Manger Reserve has not been an allowable line item of a ship cost estimate. The MCC number assigned to the PM Reserve category is 951.

Additional Non-End Cost Categories

There are two additional SCN categories that come into play during the execution phase: Navy-responsible outfitting (allowance list items) such as onboard spares, repair parts, and tools) and post-delivery work (corrections of government-responsible deficiencies). These two categories of cost are budgeted for in later fiscal years (after ship award) as required and, together with all the end cost categories, constitute the total SCN requirement.

EXPANDED WORK BREAKDOWN STRUCTURE FOR BASIC CONSTRUCTION

Estimating the Basic Construction portion of an end cost estimate can be accomplished at various levels of detail. The greater the detail, the greater the confidence the estimator will have in the estimate. MIL-HDBK-881, dated 2 January 1998, provides standard levels of detail for Military Services procurements. For Navy ships, these levels are presented in Table 14, which is known as the Expanded Ship Work Breakdown Structure (ESWBS). ESWBS is the framework by which the technical data and cost data are joined to produce a ship cost estimate and is particularly relevant to the estimation of the Basic Construction category of the ship end cost. The ESWBS Groups are discussed in more detail in the following subsections.

MIL-STD-881 Level	Estimating Level	ESWBS Level
Level 1	Class of Ships (Ship Program)	N/A
Level 2	Ship End Cost	N/A
N/A	End Cost Category	N/A
Level 3	Hull Structure - Group 100 Electric Plant - Group 300	1-Digit Weight Breakdown
Level 4	Hull Decks - Group 130 Lighting System - Group 330	2-Digit Weight Breakdown
Level 5	Second Deck - Group 132 Lighting Fixtures - Group 332	3-Digit Weight Breakdown

Table 14: Ship End Cost Estimating Levels

Expanded Ship Work Breakdown Structure

The Expanded Ship Work Breakdown Structure (ESWBS), promulgated by NAVSEA Instruction 4790.01A, establishes policy and issues procedures to provide a method to integrate design with logistics (including cost estimating) through standard coding of the work breakdown structure for ships, ship systems and combat systems. ESWBS encompasses and updates and supersedes other earlier classification systems, including the Bureau of Ships Consolidated Index (BSCI) and the Ship Work Breakdown Structure (SWBS).

ESWBS serves as a common language that provides the essential means of communication between the designer and the cost estimator and between NAVSEA and the shipbuilder.

The ESWBS system descriptions are divided into 10 major groupings: (1) a general guidance and administration group concerned with operational, logistic, management and planning functions (GR 000); (2) seven functional technical groups (GR 100 to 700); and (3) two groups that deal with engineering integration and ship assembly and support services (GR 800 and 900). The ship cost estimating Basic Construction category is directly associated with Groups 100 to 900. The technical information that flows from the designer to the cost estimator can be at the 1-digit, 2-digit or 3-digit levels of detail. The technical information is provided in terms of weight in tons, square feet of material, shaft horsepower of engines, kilowatts of power, lengths of material (such as piping or cable) or other similar expressions of the technical information. The estimator draws on the available historical cost data to establish Cost Estimating Relationships (CERs) that can be applied to the technical input to generate the labor manhours and material portion of the cost estimate. The historical cost data in NAVSEA consists of past and current Navy shipbuilding ESWBS bid and return cost breakdowns. These data are generally required by all Navy shipbuilding contracts.

Expanded Ship Work Breakdown Structure Groups 100-700

The seven functional technical groups of the ESWBS and their assigned numbers are:

Number	Group		Number	Group
100	Hull Structure		500	Auxiliary Systems
200	Propulsion Plant		600	Outfit and Furnishings
300	Electric Plant		700	Armament
400	Command and Surveillance			

Table 15: Seven Functional Technical Groups of the ESWBS and their Assigned Numbers

From a technical perspective, the seven groups together encompass the whole ship less load items and margins. Specific items that constitute each group are provided in the ESWBS. The following examples are provided as a means of introduction:

- GR 100, Hull Structure: Includes shell plating, decks, bulkheads, framing, superstructure, pressure hulls, and foundations.
- GR 200, Propulsion Plant: Includes boilers, reactors, turbines, gears, shafting, propellers, steam piping, lube oil piping, and radiation shielding.
- GR 300, Electric Plant: Includes ship service power generation equipment, power cable, lighting systems, and emergency electrical power systems.
- GR 400, Command and Surveillance: Includes navigation systems, interior communications systems, fire control systems, radars, sonars, radios, teletype equipment, telephones, and command and control systems.
- GR 500, Auxiliary Systems: Includes air conditioning, ventilation, refrigeration, replenishment-at-sea systems, anchor handling, elevators, fire extinguishing systems, distilling plants, cargo piping, steering systems, and aircraft launch and recovery systems.
- GR 600, Outfit and Furnishings: Includes hull fittings, painting, insulation, berthing, sanitary spaces, offices, medical spaces, ladders, storerooms, laundry, and workshops.
- GR 700, Armament: Includes guns, missile launchers, ammunition handling and stowage, torpedo tubes, depth charges, mine handling and stowage, and small arms.

ESWBS Groups 800 and 900

ESWBS Groups 800 and 900 deal with engineering and construction support. They are not required to physically describe the technical aspects of the ship as do Groups 100 through 700. Examples of the items included in these groups are as follows:

- GR 800, Integration/Engineering: Includes all engineering effort, both recurring and nonrecurring. Nonrecurring engineering is generally recorded on the Construction Plans category line of the end cost estimate while recurring engineering is recorded in Group 800 of the Basic Construction category.
- GR 900, Ship Assembly and Support Services: Includes staging, scaffolding, and cribbing; launching; trials; temporary utilities and services; materials handling and removal; and cleaning services.

SWBS and Cost Estimate Quality

The three-digit weight breakdown is at the core of the NAVSEA ship cost estimating process and is mandatory for a Class C budget-quality estimate. The basic construction category line of an end cost estimate developed within the guidelines of the Ship Estimate Classification System always has a weight breakdown to support the estimate (occasionally, ROM estimates may not). In those increasing number of cases in which weight may not be the best cost estimating parameter; e.g., state-of-the-art lightweight materials or combat systems for which suitable CERs have not been developed, the resourceful estimator will (and is encouraged to) seek out other parameters to enhance the cost estimate.

Appendix G

Cost Tools (Models/Databases)

Tool Name	Web Address/POC	Abstract
Aircraft Carrier Life Cycle Cost Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool used for estimating Acquisition (recurring and non-recurring), Manpower, Maintenance and Disposal/Demilitarization costs.
Aircraft Carrier Forward Pricing/Base Date Conversion Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool for forward pricing and base cost calculations.
Automated Cost Estimating-Integrated Tools (ACE-IT)	http://www.aceit.com/	Integrated suite of cost estimating and analysis tools to support nearly all aspects of life cycle cost estimating and cost analysis, including the development and application of cost estimating approaches and rationales, trade analyses, cost proposal development and evaluation, risk and uncertainty analysis, cost estimating relationship (CER) development and application, and documentation.
Artemis	http://www.aisc.com/	Multi-user, multi-platform enterprise application for managing time, resources, schedules and costs in support of earned value.
@RISK® (by Palisade)	http://www.palisade.com/html/risk.html	Risk Analysis and Simulation add-in for Microsoft Excel® or Lotus® 1-2-3. @RISK uses Monte Carlo simulation that allows taking all possible outcomes into account. Replace uncertain values in the spreadsheet with @RISK functions, which represent a range of possible values. Select bottom-line cells, like Total Profits, as outputs, and start a simulation. @RISK recalculates the spreadsheet, each time selecting random numbers from the @RISK functions entered. The result is distributions of possible outcomes and the probabilities of getting those results. The results illustrate what could happen in a given situation, but also how likely it is that it will happen.
Best Fit (by Palisade)	http://www.palisade.com/html/bestfit.asp	Windows program which finds the distribution that best fits your data.
BREAK	http://www.protech-ie.com/break.htm	Windows tool kit for evaluating the cost penalties associated with discontinuities in manufacturing. These so-called "production breaks" are a classic estimating problem, and this program is a classic and user-friendly solution.
CG Modernization Independent Cost Estimating Tool	NAVSEA Program Specific Tool	Internal NAVSEA Excel based took used to generate Independent Cost Estimates for CG Modernization Program.

Tool Name	Web Address/POC	Abstract
Checkpoint	http://www.spr.com/	Software estimating tool that provides data points for sizing, estimating, managing and controlling software projects.
COBRA (by Welcom)	http://www.welcom.com/content.cfm?node=24	System for managing project costs, measuring earned value, and analyzing budgets, actuals, and forecasts. Cobra helps project, program, and cost managers to comply with rigorous government standards and integrates fully with leading scheduling tools.
COOLSoft	http://www.wwk.com/coolsoft.html	Quantitative Tool for Software Development Cost Estimation. Allows Attributes to be entered to describe the development effort by hardware, personnel and software, utilizing a hybrid approach of intermediate and detailed versions of the Constructive Cost Model (COCOMO). This allows for the reuse of existing code, development of new code, the purchase and integration of third party code, and hardware integration. The output is then displayed as man-months of programming effort, calendar schedule, support costs and hardware costs.
Constructive Cost Model (COCOMO)	http://sunset.usc.edu/research/COCOMOII/index.html	A parametric software cost estimating suite with three standard modes of software development: Organic, Semi-Detached, and Embedded.
CoCoPro	http://www.iconixsw.com/Spec_Sheets/CoCoPro.html	Estimates resources needed to complete a software development project. The program uses exponential functions and attributes to calculate development costs.
Cost Analysis Strategy Assessment (CASA)	http://www.logsa.army.mil/alc/casa	LCC decision tool by Army Logistics Support Activity for identifying cost drivers, options and impacts
Costar	http://www.softstarsystems.com/	Software estimation tool based on the Constructive Cost Model (COCOMO) used to produce estimates of a project's duration, staffing levels, effort, and cost. Costar lets you make trade-offs and experiment with "what-if" analyses to arrive at the optimal project plan.
COSTIMATOR	http://www.costimator.com/	A single executable Desktop Cost Estimating Application, which is MDI (Multi-Document-Interface).
Cost of Manpower Estimating Tool (COMET)	http://www.ncca.navy.mil/services/comet/about2.htm	COMET provides users with Navy manpower cost estimates of active, reserve and civilian components to provide the analyst with a tool to make decisions about manpower or hardware tradeoff comparisons. COMET costs are customizable, allowing you to include only those costs pertinent to your cost analysis. COMET costs are comprehensive, including both the direct costs (MPN) of manning billets and the variable indirect costs (MPN and OMN) associated with acquiring, training, locating and supporting those personnel. COMET costs are granular, varying across skills, pay grade and geographic location (civilians). COMET incorporates parameters from NCAD's Cost of a Sailor (COAS) studies.

Tool Name	Web Address/POC	Abstract
Cost Xpert	http://www.costxpert.com/	A software cost estimation tool that is calibrated to reflect industry standards, generates cost and schedule estimates, automatically generates a work breakdown structure (WBS) and can estimate COTS packaged implementations.
Crystal Ball®	http://www.decisioneering.com/crystal_ball/index.html	Software that employs an analytical technique, called Monte Carlo Simulation to provide the capability to conduct risk and uncertainty analyses within the construct of Excel
CURV1	http://www.protech-ie.com/curv-v2.pdf	Learning curve application package in Windows which offers several choices and tools, including Regression, Calculator, and Curve Tutor "drop-down" menus. Fits curves easily, makes future estimates from curve information on file, solves for any curve variable, and allows access to a complete curve Glossary of Terms.
DDG 51 Cost Estimating Tool	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool used to generate cost estimates for DDG 51 Shipbuilding Program with and emphasis on basic construction cost.
DD(X) Ship Cost Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool used to generate DD(X) ship construction cost estimates.
DD(X) Mission System Cost Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool used for DD(X) mission system cost estimates.
DeccaPro	http://www.deccansystems.com/	Activity based cost (ABC) estimating software to build cost models and price products.
Decision by Life Cycle Cost	http://www.ald.co.il/products/dlcc.html	Total Cost of Ownership and Life Cycle Cost analysis tool that is used to evaluate and compare alternative design approaches and strategies, identifies cost effective improvements, assesses project's budget and economic viability and is used in Long term financial planning.
Decision Tools (by Palisade)	http://www.palisade.com/html/decision_analysis_software.html	Suite of software for analyzing decisions and risk, which allows for Risk Analysis, distribution fitting, What-if Analysis, distribution viewing, decision trees and influence diagrams to be added directly to Microsoft Excel.
Dekker Ltd.	http://www.dtrakker.com/index.asp	Tools for scheduling and earned value.
Escalation Program Suite for Shipbuilding Contract Escalation	NAVSEA Tool	'This program suite is used to calculate escalation cost estimates for shipbuilding contracts containing compensation adjustment clauses (ships under contract as well as future ships). It supports the SEA 01 mission to develop shipbuilding contract escalation cost estimates, and to track actual shipbuilder contract escalation costs over the long construction period. It uses actual/projected expenditure profiles and inflation indices to calculate escalation estimates by month for direct labor, overhead, and material costs. The program is regarded as the standard NAVSEA Tool for developing escalation estimates.

Tool Name	Web Address/POC	Abstract
ESTI-MATE	http://www.sparusa.com/esti-mat.htm	Project estimate software for construction and repair/modernization project estimates that supports modular construction and out-sourced subcontracting pricing options. It organizes costs by work breakdown structures and can be cross related to construction zones and product modules.
Eviews	http://www.eviews.com/	Statistical software used for statistical analysis, time series estimation and forecasting, cross-section or panel data analysis, large scale model simulation, presentation graphics, and simple data management.
Evolver (by Palisade)	http://www.palisade.com/html/evolver.asp	An optimization add-in for Microsoft Excel® that uses innovative genetic algorithm (GA) technology to quickly solve complex optimization problems in finance, distribution, scheduling, resource allocation, manufacturing, budgeting, engineering, and more.
Expert Choice	http://www.expertchoice.com/	Enterprise Portfolio Analysis and Collaborative Decision Support software and services used for a variety of tasks, like IT portfolio management, new product development, strategic planning to vendor selection.
HCost	NAVSEA Tool	The "Historical Cost of Ships" database program contains initial acquisition/major conversion costs and technical data for Navy ships and craft from 1900 to present day. For ships built after 1952, it also contains SCN end cost data broken out by P-5 budget category. The database provides a central data source containing budget and actual cost data on delivered ships and craft, and is used to respond to questions from higher echelon Navy/DoD on cost of historical ships.
LCS Mission Package Estimating Tool (Under Development)	NAVSEA Tool	Internal NAVSEA Excel based tool under development to support consolidation of costs by Mission Package and Platform for LCS program.
LHA(R) UPA Cost Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool to develop cost estimates to support LHAR Flight 0 Feasibility Design.
Logical Decisions	http://www.logicaldecisions.com/	Software package for Windows used to evaluate choices by considering many variables at once.
Mainstay (Proposal Pricing)	http://www.mainstay.com/	Proposal pricing tool, used for preparation, analysis, and presentation of proposals, as well as for the analysis and evaluation of proposals by government agencies themselves.
Mantix Systems	http://www.mantix.com/default.asp	Tools for earned value management.
Microframe Technology	http://www.microframe.com/products/mpm.html	Tools for earned value and proposal management
MicroFusion	http://www.intgconcepts.com/Prod.htm	Integrated Management Concepts project control product for pricing, estimating, what-ifs, proposals, EV analysis and reporting.
Micro Planning International	http://www.decisivetools.com.au/	An Australian company with strong scheduling and EV tools for multiple platforms.

Tool Name	Web Address/POC	Abstract
Minitab	http://www.minitab.com/	Statistical software package for improvement projects that assists in Statistical Process Control, Design of Experiments, and also has features like StatGuide and ReportPad.
MPF(F) UPA Cost Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool to develop cost estimates to support MPF(F) program.
NAVSEA Workload History and Forecasting System (WHFS)	NAVSEA Tool	An Oracle application used to project shipyard workload/employment levels given ship schedule dates, manhours, and other ship/shipyard parameters.
Naval Vessel Register	http://www.nvr.navy.mil/	Contains information on ships and service crafts that comprise the official inventory of the US Navy from the time of vessel authorization through its life cycle and disposal.
Operating and Support Cost Analysis Model (OSCAM)	http://www.oscamtools.com/	US/UK program to assess the O&S costs of high cost capital assets and their component systems. Using System Dynamics, OSCAM represents the business processes that drive costs and their relationship to management policies in order to assess the impact of alternative maintenance strategies and operating policies on the cost and availability of these assets.
Overhead Rate Model	NAVSEA Tool	An internal developed application that calculates direct labor, overhead and FCCM rates for ships. Tool requires workload/employment data and company specific parameters as input.
PrecisionTree (by Palisade)	http://www.palisade.com/html/ptree.asp	Decision Analysis Add-In for Microsoft Excel® which builds decision trees and influence diagrams directly in your spreadsheet, providing a graphical representation of cost and benefits to help decision-makers.
PRICE H/HL/M	http://www.pricesystems.com/	A suite of hardware parametric cost estimating models that accurately estimate development, production, and operations and support costs. The suite allows for generating estimates at any WBS level, which includes integration and test cost calculations. The models operate in Microsoft Windows and interface with Microsoft Excel, Project, and other office tools. Monte Carlo risk simulations capability is available with the suite.
PRICE S	http://www.pricesystems.com/	A suite of software sizing, development cost, and schedule, along with associated software operations and support cost models. The models operate in Microsoft Windows and interface with Microsoft Excel, Project, and other office tools. Monte Carlo risk simulations capability is available with the suite.
Primavera Software	http://www.primavera.com/solutions/index.html	Tools for scheduling, earned value, cost control and risk analysis.
Primavera Expedition Professional	http://www.primavera.com/solutions/ec_expedition.html	Tools for Contract management, Document control, Field administration, Issues management, Change management and Cost control.
Primavera Prime Contract	http://www.primavera.com/solutions/ec_primecontract.html	On-line project collaboration application for any engineering and construction business process from pre-project planning to facility start-up.

Tool Name	Web Address/POC	Abstract
Primavera IT Project Office	http://www.primavera.com/solutions/po.html	Tools to help the IT project office stay in alignment with overall business objectives by delivering specific functionality by role across the entire project team.
Primavera Project Planner	http://www.primavera.com/solutions/ec_p3.html	Project management software
Risk Service & Technology	http://www.risktrak.com/	Network based tool for integrated management of cost, schedule and technical risk.
SEER-DFM	http://www.galorath.com/tools_manuf.shtm	A software tool used to evaluate product and manufacturing costs, improves productivity and quality, and speeds products to market. (Design for Manufacturability)
SEER-H	http://www.galorath.com/tools_h.shtm	A development and production estimation and management tool that predicts, measures, and analyzes resources, materials and schedules for an array of products and complex systems. It presents a view of the operational and maintenance costs of a product throughout its life cycle. (Hardware Estimation and Life Cycle Cost Analysis)
SEER-IC	http://www.galorath.com/tools_ic.shtm	A complement to SEER-H, helps estimate custom integrated circuit development and production costs, generate specifications, and evaluate potential yields. (Custom Integrated Circuit Development)
SEER-SEM	http://www.galorath.com/tools_sem.shtm	A development and program management tool that predicts, measures, and analyzes costs, schedules, risks, and reliability for software projects. (Software Estimation Model)
SEER-SSM	http://www.galorath.com/tools_ssm.shtm	A software-sizing tool that creates realistic and highly reliable estimates of a project's scope. (Software Sizing Model)
Ship Parametric Engineering & Design Model	NAVSEA Tool	This model estimates total ship design and engineering man-hours (recurring and non-recurring) using Ship Complexity as a metric, vice number of drawings (heretofore, some estimates had relied on drawing counts as a metric for prediction).
Shipbuilding Material CER (MATCER)	NAVSEA Tool	Excel-based tool containing inflation indices for SWBS groups 100-900, based on the results of the annual NAVSEA Shipbuilding Support Office (NAVSHIPSO) shipbuilding material vendor survey. The tool automatically calculates factors to inflate shipbuilding material costs/CERs from one date to another.
Ship Information Database (SID)	NAVSEA Tool	Internal SEA 017 database system containing historical information related to ships and shipbuilding, including budget data, contract information, shipbuilding progress/schedules, and shipyard employment data. The system includes query/report capability.
Software Life Cycle Model (SLIM)	http://www.qsm.com/products.html	Tools to support decision making at each stage of the software lifecycle: estimating tracking, and benchmarking and metrics analysis.

Tool Name	Web Address/POC	Abstract
Software Development Resources	http://www.construx.com/resources/	Software used to predict project outcomes. Surveyor provides tools and standards for automated size measurements of projects. Software Engineering Resources pages provide links to free industry resources.
SPSS	http://www.spss.com/products/	Suite of software including Statistics applications, data mining applications, business intelligence applications and predictive analytic applications.
SSGN Cost Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool to develop cost estimates for Ohio Class submarine conversions.
Success4	http://www.uscost.net/CostEngineering/successdown.htm	Cost estimator designed specifically for the Navy. It includes Navy Templates, Reports, Macros, and a Readme file that includes direct links to often accessed pages on the NAVFAC and U.S.COST web sites.
SureTrack Project Manager	http://www.primavera.com/products/sure.html	Project management software
Tabular Format (TF!)	http://www.ascginc.com/products/tf.php	Integrated suite of software tools designed for life cycle procurement.
T-AOE(X) UPA Cost Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool to develop cost estimates to support T-AOE(X) pre-AOA baseline cost estimate.
VAMOSC	Registered users may access VAMOSC data via two websites: www.navyvamosc.com and www.usmcvamosc.com.	The Navy Visibility and Management of Operating and Support Costs (VAMOSC) management information system collects and reports US Navy and US Marine Corps historical weapon system operating and support (O&S) costs. VAMOSC provides the direct O&S costs of weapon systems, some linked indirect costs (e.g., ship depot overhead), and related non-cost information such as flying hour metrics, steaming hours, age of aircraft, etc. VAMOSC has recently added the Personnel database which contains all Active Duty Navy and USMC personnel costs and attribute data. Pre-built queries are available as well as the ability to create custom queries. No special software needs to be installed on a user's desktop; only an Internet browser is required.
Virginia Class Cost Model	NAVSEA Program Specific Tool	Internal NAVSEA Excel based tool to develop cost estimates for Virginia Class submarine with emphasis on basic construction cost.
Welcom Software Technology	http://www.welcom.com/	Tools for scheduling and earned value.
"White Book" (NAVSEA Quarterly Progress Report)	NAVSEA Tool	The NAVSEA Quarterly Progress Report Database, or "Whitebook," is an MS Access database that tracks the progress of construction and conversion of ships in the United States for the U.S. Navy and the Security Assistance Program, including schedules dates, contract information, percent complete, etc. The information for current shipbuilding contracts is updated on a quarterly basis and is used to generate NAVSEA 250-574, "NAVSEA Quarterly Progress Report for Shipbuilding and Conversion." The database also contains historical shipbuilding contract information from the 1950s to present day.
wInsight	http://cs-solutions.com/Products	Tools for earned value data analysis, incorporating risk analysis and schedules from popular scheduling tools such as MS Project, Open Plan Professional/Desktop, and SureTrak/P3.

Software Model Considerations for NAVSEA Network

In selecting new software application models to support cost estimating functions, two key factors must be considered:

1) Is the software application currently approved for use by the Navy?
2) Has the software been officially tested and certified for use in the Navy/Marine Corps Intranet (NMCI) environment?

Further detailed in this Section is the process to get Navy software approved for use on the NAVSEA network and the process for NMCI testing and certification.

NAVY SOFTWARE APPROVAL PROCESS

In 2001, the Navy began a department-wide effort to identify, review, and **reduce by 95%** the number of legacy applications used by all Navy activities. This effort to eliminate obsolete, redundant, and nonstandard applications was initiated as part of the Navy's preparations to transition to the NMCI IT services contract. A legacy application is defined as any government-developed computer application or Commercial Off-The-Shelf (COTS) software that is not part of the NMCI standard software suite.

In order to catalog and effectively manage all Navy legacy applications, the Navy established the DON Applications and Database Management System (DADMS) as the centralized, authoritative data source containing information on all applications, databases, and web sites used on Navy networks. Applications within DADMS are categorized into 24 functional areas, such as Financial Management, Logistics, and Acquisition. Each functional area has a designated Navy Functional Area Manager (FAM) who is responsible for reviewing, evaluating, and approving/disapproving applications within that functional area. One of the goals of the FAM process is to rationalize systems and reduce duplicity where economically prudent while maintaining required functionality. The rationalization process is still ongoing, but will eventually result in a selected portfolio of approved applications for each functional category. Additional information on DADMS and the FAM process can be found at the following link: https://www.dadms.navy.mil.

Before deciding on a new software application model, the user must first determine if the software application has already been identified and approved/disapproved for use on Navy networks. The Industrial Planning and Analysis Group maintains access to DADMS and can determine the approval status of a particular application. If an application has already been approved for use, the user can proceed to the next step to determine if the application has been tested and certified for use on NMCI. If the application has been disapproved in DADMS for duplicate functionality, there should be an alternative, approved application identified that the user can then evaluate. If a software application is not already in DADMS, it must be added as a new record. All requests for new additions must be approved by the cognizant NAVSEA FAM, and then by the Vice Commander of NAVSEA. Because of the emphasis on reducing the number of applications, approval to add a new application would be granted only if there is sufficient justification that no other existing approved application provides the required mission essential functionality. The list of currently approved software cost models is provided above.

NMCI TESTING & CERTIFICATION

Once the Navy has approved an application for use, it must be tested and certified for use on the Navy/Marine Corps Intranet (NMCI). Before an application can be loaded on any NMCI computer, it must undergo rigorous testing procedures to ensure that it does not violate any NMCI technical, functional, or security rules. If an application has been approved in DADMS, it may already have been certified for use under NMCI. Contact the directorate NMCI point of contact for additional information. If the application is not NMCI certified, it will need to be submitted to the SPAWAR pre-certification lab in San Diego, CA, to begin the testing process. For additional information on the NMCI testing process, see the legacy application section under the following link: http://www.nmci-isf.com/transition.htm#Transition.

Once an application has been tested and certified for use on NMCI, the directorate Activity Customer Technical Representative (ACTR) must submit an NMCI Move/Add/Change request to have the software loaded on a user's NMCI seat. Contact the directorate NMCI point of contact for additional information.

Appendix H

Cost Estimating References

Presented below is a list of references used in compiling the handbook as well as those commonly used by NAVSEA cost estimators in the course of their daily work.

DOD DIRECTIVES, INSTRUCTIONS, AND MIL-STDS

DoD Directive 5000.1, The Defense Acquisition System, May 12, 2003 http://dod5000.dau.mil/

DODINST 5000.2, Operation of the Defense Acquisition System, May 12, 2003 http://www.acq.osd.mil/ or http://www.ncca.navy.mil/resources/dod5000-2-new.pdf

DoD 5000.4, Cost Analysis Improvement Group (CAIG), 24 November 1992 (including Change 1, 16 November 1994) http://www.dtic.mil/whs/directives/corres/pdf/d50004wch1_112492/d50004p.pdf

DoD Directive 5000.4-M, Cost Analysis Guidance and Procedures, 11 Dec 1992 http://www.ncca.navy.mil/resources/dod5000-4-M.pdf

DoD Instruction 7041.3, Economic Analysis for Decisionmaking, 7 Nov 1995 http://www.dtic.mil/whs/directives/corres/html/70413.htm

MIL-HDBK-881 Department of Defense Handbook Work Breakdown Structure 2 January 1998 http://www.acq.osd.mil/pm/newpolicy/wbs/mil_hdbk_881/mil_hdbk_881.htm

Department of Defense, Operating and Support Cost-Estimating Guide, Office of the Secretary of Defense Cost Analysis Improvement Group, Washington, DC 20301, May 1992 http://www.ncca.navy.mil/resources/caig_os_guide.pdf

DoD Acquisition Guidebook http://akss.dau.mil/dag

NAVY INSTRUCTIONS AND OTHER PUBLICATIONS

SECNAVINST 5000.2, Implementation of Mandatory Procedures for Major and Non-Major Defense Acquisition Programs and Major and Non-Major Information Technology Acquisition Programs, 6 Dec 1996 (download at http://neds.nebt.daps.mil/5000.htm) or http://www.ncca.navy.mil/resources/secnavinst5000-2b.pdf

SECNAV Instruction 5420.188E, Acquisition Category (ACAT) Program Decision Process, 11 Dec 1997 (download at http://neds.nebt.daps.mil/Directives/5420188e.pdf

OPNAVINST 5513.1E, "Department of the Navy Security Classification Guides," 16 Oct1995 http://www.fas.org/irp/doddir/navy/opnavinst/

Department of the Navy (DON) PBL Guidance Document, 27 Jan 2003 http://acc.dau.mil/simplify/ev_en.php

NAVSEA Instruction 4790.1A, Expanded Ship Work Breakdown Structure (ESWBS) for Ships, Ship Systems, and Combat Systems, 13 Feb 1985 http://www.navsea.navy.mil/Instructions.asp

NAVSEA Instruction 5400.1E, Organization Manual for Naval Sea Systems Command Headquarters, 14 Apr 2000 http://www.navsea.navy.mil/Instructions.asp

NAVSEA Instruction 7000.4F, Earned Value Management, 31 Oct 1997 http://www.navsea.navy.mil/Instructions.asp

NAVSEA Instruction 7000.xx, draft, NAVSEA Cost Analysis Improvement Group (CAIG)

NAVSEA Instruction 7000.013, Cost and Schedule Control in Naval Shipyards, 3 Dec 1984 http://www.navsea.navy.mil/Instructions.asp

NAVSEA Instruction 7300.

014B, Classification of Cost Estimates for Ships, 16 May 1996 http://www.navsea.navy.mil/Instructions.asp

NAVSEA Instruction 4295.01C, Control of Contractor Cost Data, 13 Sept 1996 http://www.navsea.navy.mil/Instructions.asp

NAVSEANOTE 5400-010904, "NAVSEA Warranted Technical Authorities" http://www.dcfp.navy.mil/library/dcpubs/5400-010904.pdf

NAVSEANOTE 5400-041304, "Cost Engineering and Technical Authority Policy"

US Navy Visibility and Management of Operating and Support Costs (VAMOSC) http://www.navyvamosc.com/

NAVSEAINST 5400.013 defines rolls and responsibilities for NAVSEA Logistics, Maintenance & Industrial Operations

Department of Navy Center for Cost Analysis Policy Manual, http://www.ncca.navy.mil/resources/ncca_policy_manual.pdf

Department of Navy Center for Cost Analysis Strategic Business Plan, http://www.ncca.navy.mil/resources/ncca_strategic_business_plan.pdf

Department of Navy Center for Cost Analysis Instruction 4451-1A Guide for the Documentation of Independent Cost Estimates (ICEs), http://www.ncca.navy.mil/resources/029-03_NCADINST_4451-1A.pdf

Department of Navy Center for Cost Analysis Non-Disclosure Agreement, http://www.ncca.navy.mil/resources/NCAD_NDA_2-1.doc

Department of Navy Inflation Indices http://www.ncca.navy.mil/costidx.htm http://www.navsea.navy.mil/sea017/

Navy Inflation Calculator, http://www.ncca.navy.mil/services/inflation.cfm

Navy Open Architectural Retrieval System (OARS), http://www.oars.navsea.navy.mil/index.htm

Platform Estimates, http://www.ncca.navy.mil/services/platform_estimates.cfm

Software Estimates, http://www.ncca.navy.mil/services/software_estimates.cfm

AIS/C4ISR Estimates, http://www.ncca.navy.mil/services/c4isr_estimates.cfm

Special Projects, http://www.ncca.navy.mil/services/special_projects.cfm

Ship Design Project Historical Book "Red Book"

OTHER GOVERNMENT POLICIES AND CIRCULARS

Clinger-Cohen Act of 1996, http://www.don-imit.navy.mil/cca/

OSD, Cost Analysis Improvement Group (CAIG) Operating and Support Cost Estimating Guide, May 1992 http://www.dtic.mil/pae/

The President's Management Agenda http://www.whitehouse.gov/omb/budintegration/pma_index.html

Office of Management and Budget (OMB) Circular No. A-11 Preparing and Submitting Budget Estimates, http://www.whitehouse.gov/omb/circulars/a11/2001_A-11.pdf

Office of Management and Budget (OMB) Circular No. A-76 Performance of Commercial Activities http://www.whitehouse.gov/omb/circulars/a076/a076.html

Office of Management and Budget (OMB) Circular No. A-76 Performance of Commercial Activities Revised Supplemental Handbook http://www.whitehouse.gov/omb/circulars/a076/a076s.html

Office of Management and Budget (OMB) Circular No. A-94 Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, http://www.whitehouse.gov/omb/circulars/a094/a094.html

Office of Management and Budget (OMB) Circular A-109, Major Systems Acquisition, 5 Apr 1976 http://akss.dau.mil/docs/OMB%20Circular%20A-109.doc

Office of Management and Budget (OMB) Budget Materials FY2005, http://www.defenselink.mil/comptroller/defbudget/fy2005/index.html

GAO Defense Acquisition: Historical Insights Into Navy Ship Leasing, April 21, 1999 http://www.gao.gov/archive/1999/ns99141t.pdf

The Office of Federal Procurement Policy Act Amendment of 1988 (PL 100-679: 41 U.S.C. 423, Section 27) http://akss.dau.mil/docs/OMB%20Circular%20A-109.doc

Business Case Model for the DoD Logistics Community, A guide to Business Case Development, DUSD (L) Logistics Reinvention Office, 30 Sep 1999 http://www.acq.osd.mil/log

Cost Account Standards (CAS) 414 and 417 http://www.acq.osd.mil/dpap/contractpricing/vol3chap10.htm

OTHER SOURCE MATERIAL

Jane's http://jni.janes.com/

Navy Independent Cost Estimating brief, presented to PMCS, 13 April 2004, Director, Naval Cost Analysis Division (NCAD) Office of the Assistant Secretary of the Navy, Financial Management and Comptroller (OASN FMB-6)

Parametric Cost Estimating Handbook, http://www.ispa-cost.org/PEIWeb/newbook.htm

National Aeronautics and Space Administration (NASA) Cost Estimating Handbook (CEH) http://www.ceh.nasa.gov

COST ESTIMATING FORMS

Cost Performance Report (CPR) http://akss.dau.mil/dag/Guidebook/IG_c11.3.2.2.asp

Cost and Software Data Reporting (CSDR)
http://dcarc.pae.osd.mil/ccdr_formstools.htm

Defense Acquisition Executive Summary (DAES)
http://akss.dau.mil/dag/Guidebook/IG_c10.9.4.asp

Selected Acquisition Report (SAR)
http://akss.dau.mil/dag/GuideBook/IG_c10.9.2.asp

NAVSEAINST 4295.2B Conflict of Interest, Non-Disclosure of Information Certification
www.navsea.navy.mil/download.asp?iDataID=8578

NAVSEAINST 4200.019 Service Contract Restrictions and Safeguards
www.navsea.navy.mil/download.asp?iDataID=9186

NAVMAT P5242 Joint (Services) Design-to-Cost Guide

ASN(RD&A) Shipbuilding Specific Inflation Memorandum, February 2004

FAR 15.101-1 The Tradeoff (Best Value) Process
http://www.ntsc.navy.mil/Resources/Library/Acqguide/tradeoff.htm

TRAINING RESOURCES

Naval Cost Analysis Division (NCAD) Cost Analysis 101,
http://www.ncca.navy.mil/about/101.cfm

Navy VAMOSC Training Video,
http://www.navyvamosc.com/

Society of Cost Estimating and Analysis (SCEA),
http://www.sceaonline.net/

COST ESTIMATING TOOLS AND MODELS

Note that restrictions against using some of these tools do exist due to NMCI restrictions.

@Risk http://www.palisade.com/html/risk.html

Decision Tools Suite
http://www.palisade.com/html/decisiontools_suite.html

BestFit http://www.palisade.com/html/bestfit.html

Precision Tree
http://www.palisade.com/html/ptree.html

Evolver
http://www.palisade.com/html/evolver.html

ACEIT, http://www.aceit.com/

Best Estimate, http://www.best-estimate.com/

BREAK, http://www.protech-ie.com/break.htm

Building Systems Design SoftLink,
http://www.bsdsoftlink.com/

Cobra
http://www.welcom.com/content.cfm?node=24

Constructive Cost Model (COCOMO) II
http://sunset.usc.edu/research/COCOMOII/

COCOPRO
http://www.iconixsw.com/Spec_Sheets/CoCoPro.html

COMET
http://www.ncca.navy.mil/services/comet/index-frame.htm

COOLSoft http://www.wwk.com/coolsoft.html

Cost of Manpower Estimating Tool (COMET),
http://www.ncca.navy.mil/services/comet/index-frame.htm

Costar, http://www.softstarsystems.com/

COSMIC,
http://www.openchannelfoundation.org/cosmic/

Cost Analysis Strategy Assessment (CASA),
http://www.logsa.army.mil/alc/casa/

Cost Xpert, http://www.costxpert.com/

COSTIMATOR, http://www.costimator.com/

CostTrack, http://www.ontrackengineering.com/

Crystal Ball,
http://www.decisioneering.com/crystal_ball/index.

html

CURV1, http://www.protech-ie.com/curv-v2.pdf

Data and Analysis Center for Software (DACS), http://www.dacs.dtic.mil/databases/url/key.hts?keycode=4:1&islowerlevel=1

DeccaPro, http://www.deccansystems.com/

Decision by Life Cycle Cost, http://www.ald.co.il/products/dlcc.html

Decision Tools, http://www.palisade.com/html/decision_analysis_software.html

European Space Agency Cost Modeling Software (ECOM), http://www.estec.esa.nl/eawww/ecom/ecom.htm

European Space Agency Costing Software (ECOS), http://www.estec.esa.nl/eawww/ecos/ecos.htm

Eviews, http://www.eviews.com/

Expert Choice, http://www.expertchoice.com/

Federation of American Scientists: http://www.fas.org/main/home.jsp

Links to Software Development Resources, http://www.construx.com/reslink.htm

Logical Decisions, http://www.logicaldecisions.com/

Mainstay (Proposal Pricing), http://www.mainstay.com/

Minitab, http://www.minitab.com/

Naval Vessel Register: http://www.nvr.navy.mil/

Operating and Support Cost Analysis Model (OSCAM), http://www.oscamtools.com/

PRICE Estimating Suite, http://www.pricesystems.com/

Primavera Systems, Inc. http://www.primavera.com/

Primavera Enterprise Suite http://www.primavera.com/products/enterprise.html

Primavera Expedition Suite http://www.primavera.com/products/expedition.html

- Primavera TeamPlay Suite http://www.primavera.com/products/teamplay.html
- Prime Contract http://www.primavera.com/products/primecontract.html
- Primavera Project Planner http://www.primavera.com/products/p3.html

SureTrack Project Manager, http://www.primavera.com/products/sure.html

REVIC, http://www.jsc.nasa.gov/bu2/PCEHHTML/pceh.htm

SEER http://www.galorath.com/

- SEER-DFM http://www.galorath.com/tools_manuf.shtm
- SEER-H http://www.galorath.com/tools_h.shtm
- SEER-IC http://www.galorath.com/tools_ic.shtm
- SEER-SEM http://www.galorath.com/tools_sem.shtm
- SEER-SSM http://www.galorath.com/tools_ssm.shtm

SPSS, http://www.spss.com/products/

Success4, http://www.uscost.net/CostEngineering/successdown.htm

Tabular Format (TF!) site, http://www.ascginc.com/products/tf.php

HELPFUL WEB RESOURCES

Naval Sea Systems Command (NAVSEA) Cost Engineering and Industrial Analysis http://www.navsea.navy.mil/sea017/index.html

http://www.fas.org/irp/doddir/navy/opnavinst/

Argonne National Laboratory, Cost Estimating and Analysis, http://www.dis.anl.gov/disweb/cecea

Best Value Selection http://www.abm.rda.hq.navy.mil/navyaos/acquisition_topics/contracting_/best_value

Carnegie Mellon Software Engineering Institute, http://www.sei.cmu.edu/sei-home.html

Center for Naval Analysis, http://www.cna.org/

Cost Estimating Guidance and Directives, http://www.ncca.navy.mil/resources/guidance.cfm

Cost Estimating Tools, http://www.ncca.navy.mil/services/costtools.cfm

Cost Estimating Library, http://www.ncca.navy.mil/resources/library.cfm

Cost Estimating Research, http://www.ncca.navy.mil/resources/summaries.cfm

Contract Pricing Reference Guides, http://www.acq.osd.mil/dp/cpf/pgv1_0/

Cost Analysis Requirements Description (CARD) References, DoD5000.4M http://www.dtic.mil/whs/directives/corres/html/50004m.htm

DoD primer (Powerpoint presentation) and CARDs (38 slides) http://www.ra.pae.osd.mil/adodcas/docs/card.pdf

Department of Defense Acquisition Deskbook, http://akss.dau.mil/jsp/default.jsp

Department of Defense Dictionary, http://www.dtic.mil/doctrine/jel/doddict/

Department of Defense Earned Value, http://www.acq.osd.mil/pm/

Department of Defense Primer on Cost Analysis Requirements Description (CARD), http://acc.dau.mil/simplify/ev.php?ID=21696_201&ID2=DO_TOPIC

Department of Energy Office of Science Article on Learning Curves, http://www.sc.doe.gov/sc-80/sc-82/430-1/430-1-chp21.pdf

Department of Energy (DOE) Environmental Management (EM) Applied Cost Engineering (ACE) Team, http://web.em.doe.gov/aceteam/

Department of Finance and Accounting Services (DFAS), Civilian Pay Tables, http://www.dfas.mil/money/civpay

Department of the Treasury, http://www.ustreas.gov/

e-Government, http://egov.gov/

Earned Value Bibliography, http://www.suu.edu/faculty/christensend/ev-bib.html

Earned Value Homepage, Office of Secretary of Defense (OSD), http://www.acq.osd.mil/pm,

Formal Rick Assessment of System Cost Estimates (FRISK), http://www.acq.osd.mil/io/se/risk_management/tools_and_products.htm

Federal Acquisition Regulation (FAR), http://www.arnet.gov/far/

General Accounting Office (GAO), http://www.gao.gov/

Jane's Consultancy http://www.janes.com/

MAAP site, http://www.tfdg.com/Products/MAAP/

Naval Sea Systems Command (NAVSEA) Cost Engineering and Industrial Analysis http://www.navsea.navy.mil/sea017/index.html

Office of Management and Budget (OMB), http://www.whitehouse.gov/omb/

Office of Personnel Management Salary Tables, http://www.opm.gov/oca/payrates/

Office of the Secretary of Defense Inflation Guidance FY2005, http://www.ncca.navy.mil/services/OSD_FY05_Inflation_Guidance.pdf

Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, www.acq.osd.mil/

Project Management Glossary, http://www.maxwideman.com/pmglossary/index.htm

Software Size Measurement: A Framework for Counting Source Statements (by Robert E. Park), http://www.sei.cmu.edu/pub/documents/92.reports/pdf/tr20.92.pdf

United States Government Standard General Ledger (USSGL), http://www.fms.treas.gov/ussgl/index.html

World Wide Web Acronym and Abbreviation Server, http://www.ucc.ie/

PROFESSIONAL SOCIETIES

American National Standards Institute (ANSI), http://www.ansi.org/

American Society of Professional Estimators (ASPE), http://www.aspenational.com/

Association for the Advancement of Computing in Education, http://www.aace.org/

The Association for the Advancement of Cost Engineering through Total Cost Management (AACE) International, http://www.aacei.org/

Association of Cost Engineers (ACostE), http://www.acoste.org.uk/

Center for International Project and Program Management (CIPPM), http://www.iol.ie/~mattewar/CIPPM/

Institute for Operations Research and the Management Sciences, http://www.informs.org/

International Cost Engineering Council (ICEC), http://www.icoste.org/

International Function Point Users Group (IFPUG), www.ifpug.org

International Project Management Association (IPMA), http://www.ipma.ch/

International Society of Parametric Analysts (ISPA), http://www.ispa-cost.org/

Military Operations Research Society (MORS), http://www.mors.org/

National Contract Management Association (NCMA), http://www.ncmahq.org/

Project Management Institute (PMI), http://www.pmi.org/

Society of Cost Estimating and Analysis (SCEA), http://www.sceaonline.net/

Society for Risk Analysis (SRA), http://www.sra.org/

Appendix I

Glossary

Acquisition Strategy: The method utilized to design, develop, and display a system through its life cycle. It articulates the broad concepts and objectives, which direct and control the overall development, production, and deployment of a materiel system. It is the framework for planning, directing, contracting for, and managing a program. It provides a master schedule for research, development, test, production, fielding, modification, postproduction management, and other activities essential for program success.

Analogous System Estimate: With this technique, a currently fielded system (comparable system) similar in design and/or operation of the proposed system is identified. The cost of the proposed system is developed by taking the fielded system's data and adjusting it to account for any differences. Analogous estimates are also called *Comparative* or *Extrapolated* estimates.

Analysis: The separation of a whole into its parts or elements.

Analysis of Alternatives (AoA): Broadly examines multiple elements of project or program alternatives including technical risk and maturity, and costs. AoAs are intended to illuminate the risk, uncertainty, and the relative advantages and disadvantages of the alternatives being considered; show the sensitivity of each alternative to possible changes in key assumptions; and aid decision-makers in judging whether or not any of the proposed alternatives offer sufficient operational and/or economic benefit to be worth the cost.

Analytic Hierarchy Process (AHP): Structures problems into a hierarchical structure in order to reduce complexity. AHP is a feature of Expert Choice.

Assumption: A supposition on the current situation, or a presupposition on the future course of events, either or both assumed to be true in the absence of positive proof. Assumptions are necessary in the process of planning, scheduling, estimating, and budgeting.

Base Year (BY): A term used to define a year that is: (1) the economic base for dollar amounts in a proposal estimate, (2) the base for rate calculation or projection, or (3) the starting point for the application of inflation factors.

Benefit to Cost Ratio (BCR): The benefit cost ratio measures the discounted amount of benefits that the project generates for each dollar of cost. Fundamentally, the computation of the benefit/cost ratio is done within the construct of the following formula: Benefits/Cost.

Best Value Selection: Best Value is a process used in competitive, negotiated contracting to select the most advantageous offer by evaluating and comparing factors in addition to cost or price. It allows offerors flexibility in selection of their best proposal strategy through tradeoffs that may be made between the cost and non-cost evaluation factors. It should result in an award that will give the Government the greatest or best value for its money. It is the preferred source selection methodology, having been given renewed vigor since Executive Order 12931 was issued on 13 October 94. The Executive Order directs executive agencies to "place more emphasis on past performance and promote best value rather than simply low cost in selecting sources for supplies and services".

Best Value has become a centerpiece of acquisition reform policy. It is inextricably linked with sweeping changes in our specification/standards reform and use of Past Performance Information. Collectively, these AR elements allow the offeror great flexibility in proposing and assessing the value of cost/technical tradeoffs. The overall intent is to stimulate innovative thinking and techniques, obtain technology breakthroughs, and reduce life-cycle costs.

Beta Curve: Technique used for spreading parametrically derived cost estimates. It is used for R & D type contracts whereby costs build up slowly during the initial phases, and then escalates as the midpoint of the contract approaches. It is commonly known as the normal distribution curve.

Bottom up Estimate: An estimate derived by summing detailed cost estimates of individual work breakdown structure elements and then summed to provide a total cost estimate for the program.

Break-Even Analysis: Analysis used to uncover the point when the cumulative value of savings is equal to the cumulative value of investment.

Budget Estimate Submission (BES): Service request sent to OSD.

Budget Year Dollars (BY$): Sometimes referred to as future dollars, costs in budget-year dollars reflect the purchasing power of the dollar in the year the cost is incurred.

Business Case Analysis (BCA): Economic Analysis type that documents the review of an entire functional process or sub-process, such as the use of alternative launch vehicles, etc. It requires a risk assessment of each alternative solution, requesting a high and low estimate for each cost element and subsequent probability distribution of expected costs.

Commercial-Off-The-Shelf (COTS): Commercial items (hardware or software) that require no unique government modifications or maintenance over its life cycle to meet the needs of the procuring agency.

Competitive Sourcing Analysis Studies (A-76 Studies): Competitive sourcing is an economic analysis conducted to determine the most cost effective method of obtaining services that are available in the commercial market. Agency missions may be accomplished through commercial facilities and resources, Government facilities and resources or mixes thereof, depending upon the product, service, type of mission and the equipment required. The prevailing regulations for the Competitive Sourcing studies are the OMB Circular No. A-76 Revised Supplemental Handbook, Performance of Commercial Activities, revised 1999.

Compounding: Process of going from today's values, or present values (PVs), to future values (FVs).

Constant (Base) Year Dollars: This term is always associated with a base year and reflects the dollar "purchasing power" for that year. An estimate is in constant dollars when prior-year costs are adjusted to reflect the level of prices of the base year, and future costs are estimated without inflation. A cost estimate is expressed in "constant dollars" when the effect of changes in the purchasing power of the dollar (inflation) has been removed as if all the work is done in a single year.

Constructive Cost Model (COCOMO): A parametric software cost estimating tool developed and described by Dr. Barry Boehm in his book Software Engineering Economics.

Contract Cost Analysis: Contract cost analysis is the traditional method for analyzing a contractor's proposal. It is the analysis of the separate cost elements and profit of (1) an offeror's cost and pricing data and (2) the judgmental factors applied in projecting from the data to the estimated costs. The analyst does this to form an opinion on the degree to which the proposed costs represent what the contract should cost.

Contract Funds Status Report (CFSR): A report normally required on cost or incentive type contracts to inform the buyer of funds used and status of remaining funds.

Contract Line Item Number (CLIN): Items listed in a contract and priced individually. Some may be options.

Contract Work Breakdown Structure (CWBS): A breakout or subdivision of a project which subdivides the project into all its major hardware, software, and service elements, integrates the customer and contractor effort, provides a framework for the planning, control, and reporting. A WBS applied within a contract.

Cost and Software Data Report (CSDR): A U.S. Department of Defense report developed to provide contract cost and related data in a standard format.

Contractor Estimate: Title 10 United States Code Section 2306a requires prospective prime contractors and their subcontractors to submit certified cost or pricing data in support of their proposals. They must submit cost data in the SF 1411 format, which requires the contractor to separate the proposal and supporting data into the following groups: Purchased parts, Subcontracted items, Raw material, Engineering labor, Engineering overhead, Manufacturing labor, Manufacturing overhead, Other general and administrative (G&A), and Profit.

Cost Analysis Improvement Group (CAIG): The OSD's Cost Analysis Improvement Group (CAIG) provides an independent cost estimate for ACAT 1D programs. The CAIG's independent cost estimates provide useful cost information to DoD decision-makers. The CAIG estimates are intended primarily as internal working documents to ensure that senior officials receive the most candid and complete information about weapons acquisition programs.

Cost Benefit Analysis (CBA): An analytic technique that compares the costs and benefits of investments, programs, or policy actions in order to determine which alternative or alternatives maximize net profits. Net benefits of an alternative are determined by subtracting the present value of costs from the present value of benefits. CBA is comprised of 8 steps: analysis of the current environment, perform gap analysis, identify alternatives, estimate costs, perform sensitivity analysis, characterize and value benefits, determine net value of each alternative, and perform risk analysis.

Cost Driver: Those components of the systems or input variables that will have a significant effect on the final cost.

Cost Element Structure (CES): The framework used to cost a program or project that includes every unit of costs to perform a task or to acquire an item.

Cost Estimate: The estimation of a project's costs, time-phased by fiscal year, based on the description of a project or system's technical, programmatic, and operational parameters. A cost estimate may also include related analyses such as cost-risk analyses, cost-benefit analyses, schedule analyses, and trade studies.

Cost Estimating Relationship (CER): A mathematical relationship that defines cost as a function of one or more parameters such as performance, operating characteristics, physical characteristics, etc.

Cost Estimation: The process of analyzing each cost element, the buildup, integration and test of these elements, and the operation of the system over some specified life cycle (including disposal of the asset), with respect to the cost associated with the total effort.

Cost Overruns: The amount by which actual costs exceed the baseline or approved costs. Cost overruns can also refer to the amount by which a contractor exceeds or expects to exceed the estimated costs, and/or the final limitations (the ceiling) of a contract.

Cost Performance/Schedule Trade Study: Systemic, interdisciplinary examination of the factors affecting the cost of a system to find methods for meeting system requirements at an acceptable cost. This is achieved by analyzing numerous system concepts to find ways to attain necessary performance while balancing essential requirements that must be satisfied for the system to be successful. The objective of the cost-performance trades is not to minimize the cost of the system, but to achieve a specified level of cost reduction established by the target costing system.

Cost Risk: Risk due to economic factors, rate uncertainties, cost estimating errors, and statistical uncertainty inherent in the estimate.

Cost/Schedule Control System Criteria (C/SCSC): A planning and control reporting system devised by the Department of Defense for its contractors to use, intended to foster greater uniformity as well as early insight into impending schedule or budget overruns.

Cost/Schedule Status Report (C/SSR): The low-end cost and schedule report generally imposed on smaller value contracts, not warranting full C/SCSC.

Cost and Software Data Report (CSDR): Primary means that DoD uses to collect data on costs incurred by contractors and software development effort in performing DoD programs. Cost and Software Data Reports (CSDRs) provide standardized cost information across program types including recurring/non-recurring work split by Work Breakdown Structure element. Software Data Resources Report (SRDR) provides software information across program types including size, effort, schedule and other descriptive development data.

Cost Spreading Model: Takes the point-estimate derived from a parametric cost model and spreads it over the project's schedule, resulting in the project's annual phasing requirements.

Decision Tree: A graphic representation of the sequence of a specific activity or operation.

Delphi: A process where a consensus view is reached by consultation with experts. Often used as an estimating technique.

Descriptive Statistics: Descriptive statistics provide basic information on the nature of a particular variable or set of variables. In general, descriptive statistics can be classified into three groups, those that measure 1) central tendency or location of a set of numbers (i.e., mode, median, mean, etc.), 2) variability or dispersion (i.e., range, variance, standard deviation, etc.), and 3) the shape of the distribution (i.e., moments, skewness, kurtosis, etc.).

Direct Costs: Direct costs are costs that are obviously and physically related to a project at the time they are incurred and are subject to influence of the project manager. Examples of direct costs include contractor-supplied hardware and project labor, whether provided by civil service or contractor employees.

Discount Factor: The discount factor translates projected cash flows into present value terms using specified discount factors. Discount factors can be reflected in real or nominal terms.

Discounted Cash Flow (DCF): A cash flow summary that has been adjusted to reflect the time value of money.

Discounting: Technique for converting forecasted amounts to economically comparable amounts at a common point or points in time, considering the time value of money.

Earned Value Management (EVM): A management technique that relates resource planning to schedules and to technical cost and schedule requirements. All work is planned, budgeted, and scheduled in time-phased increments constituting a cost and schedule measurement baseline.

Earned Value Management System (EVMS): A management system and related sub-systems implemented to establish a relationship between cost, schedule, and technical aspects of a project, measure progress, accumulate actual costs, analyze deviations from plans, forecast completion of events, and incorporate changes in a timely manner.

Economic Analysis (EA): Systematically identifies the costs and benefits of each suitable future course of action. An EA specifies the objectives and assumptions, addresses appropriate alternative courses of action, includes cost of the alternatives, and describes benefits and/or effectiveness of each alternative.

e-Government: The Office of Electronic Government in the General Services Administration was formerly named the Office of Electronic Commerce. E-Government is about using technology to enhance access to and delivery of information and services to citizens, business partners, employees, agencies, and government entities.

Estimate at Completion (EAC): Actual cost of work completed to date plus the predicted costs and schedule for finishing the remaining work. It can also be the expected total cost of an activity, a group of activities, or of the project when the defined scope of work is completed.

Expanded Ship Work Breakdown Structure ESWBS): a five digit functional classification system. For weight reporting purposes, only the first three digits of this system apply. The fourth and fifth single digit classification levels are used to incorporate the functions that support maintenance and repair needs. Ship structures and machinery are divided into functional groups by the ESWBS as described in *Expanded Ship Work Breakdown Structure (ESWBS) for All Ships and Ship/Combat Systems, Volumes 1 and 2 (NAVSEA S9040-AA-IDX-010/SWBS 5D and S9040-AA-IDX-020/SWBS 5D).* The ESWBS is a comprehensive framework that is used through the ship life cycle to organize and correlate elements for cost, weight, specifications, system function and effectiveness, design, production, and maintenance studies.

Numbering systems for ship's drawings and related documents, general and contract specifications, ship's weight groups, and the NAVSEA Technical Manual (NSTM) are based on the ESWBS.

Expert Choice: Advanced decision support application that uses Analytic Hierarchy Process (AHP) and Analytic Network Process (ANP) to help quantify qualitative decisions.

Fiscal Year: The Department of Defense accounting year (1 Oct – 30 Sep).

Fixed Price Rate Agreement (FPRA): As defined in FAR 15.801, an FPRA is a written agreement negotiated between a contractor and the government to make certain rates and factors available during a specified period for use in pricing contracts or contract modifications.

FPRP: If the contractor meets the criteria in FAR 42.1701 a FPRP should be requested. When parts of the forward pricing rates are negotiated or supported by another office, such as corporate allocations, G&A rates performed at another contractor site, offsite rates, this information is needed to ensure that all efforts are coordinated in order to support negotiation of a forward pricing rate agreement, and that appropriate requests for support are issued timely.

Function Point Analysis (FPA): A standard methodology for measuring software development and maintenance using function points. Function points is a standardized metric that describes a unit of work product suitable for quantifying software that is based on the end-user's point of view. FPA can be used to determine SLOC for software cost estimating purposes.

Functional Economic Analysis (FEA): Economic Analysis type that documents the review of an entire functional process or sub-process, such as the use of alternative launch vehicles, etc. It requires a risk assessment of each alternative solution, requesting a high and low estimate for each cost element and subsequent probability distribution of expected costs.

Future Value (FV): Value a specified number of years in the future, after the interest earned has been added to the account.

Future Years Defense Program (FYDP): Future years to which resources have been tentatively assigned.

General and Administrative (G&A) Cost: G&A costs are costs that cannot be related or traced to a specific project, but benefit all activities. Such costs are allocated to a project based on a reasonable, consistent basis. Examples of G&A costs include costs associated with financial management, procurement, security, and legal activities.

Government-Off-The-Shelf (GOTS): GOTS are pre-packaged software or (less commonly) hardware purchase alternatives. The technical staff of the government agency for which it is created typically develops them. It is sometimes developed by an external entity, but with funding and specification from the agency. Because agencies can directly control all aspects of GOTS products, these are generally preferred for government purposes.

Grassroots Cost Estimating: This costing methodology approach involves the computation of the cost of a WBS element by estimating the labor requirements (in terms of man-hours or man-years, for example) and the materials costs for the specific WBS line item. It is also referred to as "bottoms-up," or engineering build-up estimating.

Ground Rules and Assumptions (GR&A): Ground rules and assumptions are external circumstances or events that are believed likely to happen. Ground rules and assumptions are based on the operation, maintenance and support of the system. Ground rules and assumptions generally include: the O&M period, base year of dollars, type of dollars, inflation indices, costs to be included or excluded, guidance on how to interpret the estimate properly, and clarification to the limit and scope in relation to acquisition milestones.

Independent Cost Estimate (ICE): A life cycle cost estimate developed outside normal channels that generally includes representation from cost analysis, procurement, production management, engineering and project management.

Indirect Costs: Costs, which, because of their incurrence for common or joint objectives, are not readily subject to treatment as direct costs.

Inflation: An increase in the volume of money and credit relative to available goods and services resulting in a continuing rise in the general price level.

Interest: The service charge for the use of money or capital, paid at agreed to intervals by the user, and commonly expressed as an annual percentage of principal.

Internal Rate of Return (IRR): The Internal Rate of Return (IRR) is another ROI metric used to measure an investment. The IRR is defined as the rate at which a bond's future cash flows, discounted back to today, equal its price. It is also defined as discount rate at which the NPV equals zero. IRR can be estimated using the formula:

IRR = NPV = PV Benefits - PV Costs = 0.

Learning Curve: Learning curves, sometimes referred to as *improvement curves* or *progress functions*, are based on the concept that resources required to produce each additional unit decline as the total number of units produced increases. The term learning curve is used when an individual is involved and the terms progress function or an improvement curve is used when all the components of an organization are involved. The learning curve concept is used primarily for uninterrupted manufacturing and assembly tasks, which are highly repetitive and labor intensive.

Lease: A lease is a long-term agreement between a user (lessee) and the owner of an asset (lessor) where periodic payments are made by the lessee in exchange for most of the benefits of ownership.

Lease vs. Buy Decision: The Lease vs. Buy decision has three steps: estimate the cash flows associated with borrowing and buying the asset, estimate the cash flows associated with leasing and asset, and compare the two financing methods to determine which has the lower cost. The decision rule for the acquisition of an asset is: buy the asset if the equivalent annual cost of ownership and operation is less than the best lease rate that can be acquired from an outsider.

Level of Effort (LOE): Effort of a general or supportive nature which does not produce definite end products or results, i.e., contract for man-hours.

Life Cycle Cost (LCC): The total cost for all phases of a project or system including design, development, production, operations, and disposal.

Linear Regression: A statistical technique used to illustrate how a linear relationship between two variables (namely X and Y) can be quantified using appropriate data. It is also referred to as *Simple Regression*.

Manual Software Estimation: Manual software estimation typically utilizes a simple, straightforward methodology to derive effort, cost, and schedule. This includes analogy, engineering buildup, or cost estimating relationship (CER) factors.

Monte Carlo Simulation: Calculates numerous scenarios of a model by repeatedly picking random values from the input variable distributions for each "uncertain" variable and calculating the results.

Net Present Value (NPV): Project's net contribution to wealth; Present Value minus Initial Investment.

Nominal Discount Rate: Rate of return used to calculate the present value for costs/benefits that are expressed in nominal dollars.

Non-Developmental Item (NDI): Non-Developmental Items (NDI) are items, other than real property, that are customarily used for Non-Government purposes.

Normalize: Method to render constant or to adjust dollar values for known differences.

Operations and Support Costs (O&S): Those operating expenditures incurred in the normal course of business to operate, maintain, support and update the system.

Parametric Cost Estimate: An estimating methodology using statistical relationships between historical costs and other project variables such as system physical or performance characteristics, contractor output measures, or manpower loading, etc. Also referred to as *"top down"* estimating.

Parametric Estimation: Involves the development and utilization of cost estimating relationships between historical costs and program, physical, and performance characteristics. The analysis uses tools, or models, that relate hardware elements, complexity, and risks of failure to expected costs – a parametric analysis.

Payback Period: The payback period is the time required for the cumulative value of savings to be equal to the cumulative value of investment. The payback period measures the number of years needed to recover the investment or break even. The accept-reject criterion for this financial indicator is the ability of the program to equal or better the organization's required payback period.

Point Estimate: An estimate with a single point result, rather than a probabilistic estimate with a cost range. Or take a sample and then calculate the sample mean, sample variance, etc.

Present Value: Reflects in today's terms the value of future cash flows adjusted for the cost of capital - the time value of money. Present value is calculated from the time series of constant dollars estimates, using the real discount rate as specified by OMB policy.

President's Budget: The final budget request sent to Congress usually in late January or early February.

President's Management Agenda (PMA): The PMA identifies government-wide and program initiatives.

Productivity Paradox: The productivity paradox is a phenomenon where the programming language that seems to have the best productivity metrics (e.g. effort per SLOC), actually results in the highest total cost because the language is less efficient than other, more modern programming languages.

Program: An activity involving the development and operation of a hardware system. A strategic investment by Enterprises or Codes having defined goals, objectives, and funding levels, and consisting of one or more projects or research activities.

Program Objective Memorandum (POM): Phase in which resources are mated to requirements, done in even-numbered years.

Program Review: Phase in which resources are mated to requirements, done in odd-numbered years.

Program Work Breakdown Structure (WBS): A family tree, usually product oriented, that organizes, defines, and graphically displays the hardware, software, services, and other work tasks necessary to accomplish the project objectives.

Project: An investment with a finite time span having defined goals, objectives, requirements, and total cost, that yields new or revised products, services, or capabilities that meet the Agency's strategic needs.

Quantifiable Benefits: Quantifiable benefits are those that can be measured or assigned a numeric value, such as dollars, physical count of tangible items, time, revenue, or percentage change. Dollar valued benefits comprise cost reductions, cost avoidance, and productivity improvements. Quantifiable benefits are calculated by subtracting the cost of an alternative from the cost of baseline operations over the period of the estimate (normally 10 years for IT investments). The difference is the "savings" that is often referred to as ROI.

Real Discount Rate: Rate of return used to calculate the present value for costs/benefits that are expressed in real (or constant) dollars.

Real Options Approach: The real options approach is a financial technique for valuing investment alternatives. This approach is primarily a decision tool that indicates whether or not to proceed with an investment after pre-established decision points are reached. This approach integrates NPV techniques with a decision-tree framework to determine the whether a project should proceed or be terminated.

Regression Analysis: A quantitative technique used to establish a line-of-best-fit through a set of data to establish a relationship between one or more independent variable and a dependent variable. That line is then used with a projected value of the independent variable(s) to estimate a value for the dependent variable.

Request for Proposal (RFP): A formal invitation containing a scope of work, which seeks a formal response (proposal) describing both methodology and compensation to form the basis of a contract. The Request For Proposal consists of a Solicitation Letter, Instructions to Bidders, Evaluation Criteria, Statement of Work, and a System Specification. The provider issues an RFP to potential subcontractors.

Reserve: A provision in the project plan to mitigate cost and/or schedule risk. Often used with a modifier (e.g., management reserve, contingency reserve) to provide further detail on what types of risk are meant to be mitigated.

Return on Investment (ROI): The strict meaning of ROI is "Return on Invested Capital." Most business people, however, use "ROI" simply to mean the incremental gain from an investment, divided by the cost of the investment. ROI is the net benefit expressed as a percentage of the investment amount:

ROI = NPV / PV Investment

Risk: A situation in which the outcome is subject to an uncontrollable event stemming from a known probability distribution.

Risk Analysis: Process of examining each identified risk area to: isolate the cause; investigate the associative risk effects (e.g. dependencies/correlations); and determine the probable impacts.

Risk Assessment: Process of identifying and analyzing critical process and entity risks to increase the likelihood of meeting cost, performance (technical), and schedule objectives.

Rough Order of Magnitude (ROM) Estimate: It is an estimated cost based on approximate cost models or expert analysis. It is usually based on top-level requirements or specifications, and an overall prediction of work to be done to satisfy the requirements. The ROM is usually used for financial planning purposes only.

Savings to Investment Ratio (SIR): The NPV of the savings divided by the NPV of the investment. The savings is the difference in the recurring costs between the status quo alternative and the proposed alternative. When the SIR equals one then discounted payback occurs.

Service Cost: Service costs are costs that cannot be specifically and immediately identified to a project, but can subsequently be traced or linked to a project and are assigned based on usage or consumption. Examples of services costs include automatic data processing and fabrication.

Sensitivity Analysis: A technique used to discover how sensitive the results from economic and financial models are to changes in the input values of the variables used to calculate the results. A high degree of sensitivity is a warning to interpret the results of the model with care and circumspection, especially because many of the input variables themselves, will have been estimated and therefore be subject to error. Use of econometric models must not obscure awareness of their limitations and possible pitfalls, especially when they are being used for forecasting.

Ship Work Breakdown Structure (SWBS): SWBS groups are defined by basic function. The functional segments of a ship, as represented by a ship's structure, systems, machinery, armament, outfitting, etc., are classified by a system of 3-digit numeric groups. There are ten major groups, the last two of which are utilized primarily for cost estimating and progress reporting. The major functional groups are:

000 General Guidance and Administration
100 Hull Structure
200 Propulsion Plant
300 Electric Plant
400 Command and Surveillance
500 Auxiliary Systems
600 Outfit and Furnishings
700 Armament
800 Integration/Engineering
900 Ship Assembly and Support Services

Since the SWBS is an hierarchical system, the level of subcategorization is flexible. Volume 2 of the ESWBS alphabetically lists SWBS items, the SWBS element title of the items, and the SWBS element number of the items. The first digit of the SWBS element number will correspond to the first digit of the functional group.

Should Cost Analysis: A study of contract price, which reflects reasonably achievable contractor economy and efficiency. It is accomplished by a government team of procurement, contract administration, audit and engineering representatives performing an in-depth cost analysis at the contractor's and subcontractor's plants. Its purpose is to develop a realistic price objective for negotiation purposes.

Software Size: The size of the application being developed. Usually described in terms of SLOC.

Source Lines of Code (SLOC): Counting physical SLOC is accomplished by tallying the number of carriage returns in the source document. Logical SLOC are counted by tallying logical units (e.g., an IF-THEN-ELSE statement is considered one logical unit). SLOC is often an input variable in the generation of software cost estimates. The SLOC methodology is based upon estimating the lines of code (deliverable) and the man-months effort required to develop a software program, with the advice of Subject Matter Experts (SMEs).

Synthesis: The assembling of separate or subordinate parts into a whole.

Target Costing: Structured approach to determine the cost at which a system or product with specified performance and reliability must be produced to shift the decision point toward proceeding with the project.

Then-Year Dollars (TY): Dollars that are escalated into the time period of performance of a contract. Sometimes referred to as escalated costs, inflated costs, or nominal year dollars.

Time Phased: Related to the deployment schedule and operating concept, shows costs over time.

Time Value of Money: The time value of money refers to the fact that a dollar in hand today is worth more than a dollar promised at some future time. By compounding and discounting, the time value of money adjusts cash flow to reflect the increased value of money when invested. The time value of money also reflects that benefits and costs are worth more if they are realized earlier.

Tool-Driven Software Estimation: Tool-driven software estimation can produce more thorough and reliable estimates than manual methods. These parametric tools are based on data collected from hundreds or thousands of actual projects. The algorithms that drive them are derived from the numerous inputs to the models from personnel capabilities and experience and development environment to amount of code reuse and programming language.

Total Ownership Cost (TOC): Sum of all financial resources necessary to organize, equip, train, sustain, and operate military forces sufficient to meet national goals in compliance with all laws, all policies applicable to DoD, all standards in effect for readiness, safety, and quality of life, and all other official measures of performance for DoD and it's components. TOC is comprised of cost to research, develop, acquire, own, operate, and dispose of weapon and support systems, other equipment and real property, the costs to recruit, train, retain, separate and otherwise support military and civilian personnel, and other cost of business operations in DoD.

Total Obligational Authority (TOA): The dollars the Department of Navy may obligate in a given period (usually a year).

Uncertainty: A situation in which the outcome is subject to an uncontrollable event stemming from an UNKNOWN probability distribution.

Variance: A measure of the degree of spread among a set of values; a measure of the tendency of individual values to vary from the mean value. It is computed by subtracting the mean value from each value, squaring each of these differences, summing these results, and dividing this sum by the number of values in order to obtain the arithmetic mean of these squares.

Vendor Quote: Obtaining a written cost estimate directly from the vendor on WBS items such as hardware, facilities, or services.

Work Breakdown Structure (WBS): A technique for representing all the components, software, services and data contained in the project scope statement. It establishes a hierarchical structure or product oriented "family tree" of elements. It is used to organize, define and graphically display all the work items or work packages to be done to accomplish the project's objectives.

"What-If" Analyses: The process of evaluating alternative strategies.

Appendix J

Acronym List

ABS: Amended Budget Submission

ABS: American Bureau of Shipping

ACAT: Acquisition Category

ACWP: Actual Cost of Work Performed

AIS: Automated Information System

AMS: Acquisition Management System

Ao: Availability for Operations

AoA: Analysis of Alternatives

AP: Advanced Procurement

APB: Acquisition Program Baseline

ARB: Acquisition Review Board

ASD(PA&E): Assistant Secretary of Defense, Program Analysis and Evaluation

ASN: Assistant Secretary of the Navy

ASN(FMB): Assistant Secretary of the Navy, Office of Budget/Fiscal Management Division

ASN(RD&A): Assistant Secretary of the Navy, Research, Development and Acquisition

AT&L: Acquisition, Technology and Logistics

ATP: Authorization to Proceed

BA: Budget Activity

BAC: Budget at Completion

BCWP: Budgeted Cost of Work Performed

BCWS: Budgeted Cost of Work Scheduled

BES: Budget Estimate Submission

BFM: Business Financial Manager

BLS: Bureau of Labor Statistics

BOE: Basis of Estimate

BSCI: Bureau of Ships Consolidated Index

BSO: Budget Submitting Office

BUMED: Bureau of Medicine and Surgery

BVS: Best Value Selection

BY: Budget Year

C4I: Command, Control, Communications, Computers and Intelligence

CAIG: Cost Analysis Improvement Group

CAIV: Cost as an Independent Variable

CARD: Cost Analysis Requirements Description

CAS: Cost Account Standards

CBA: Cost Benefit Analysis

CBS: Cost Breakdown Structure

CBO: Congressional Budget Office

CSDR: Cost and Software Data Reports

CDD: Capability Development Document

CDR: Critical Design Review

CDR: Contract Design Report

CDRL: Contract Data Requirements List

CE: Cost Estimating

CEH: Cost Estimating Handbook

CEM: Cost Engineering Manager

CER: Cost Estimating Relationship

CFE: Contractor Furnished Equipment

CFM: Contractor Furnished Material

CFSR: Contract Funds Status Report

CIA Central Intelligence Agency

CLIN Contract Line Item Number

CMC Commandment for the Marine Corp

CNA: Center for Naval Analysis

CNO: Chief of Naval Operations

COCO: Contractor Owned Contractor Operated

COGO: Contractor Owned Government Operated

COM: Cost of Money

COMNAVSEA: Commander, Naval Sea Systems Command

COMNAVSURFOR: Commander Naval Surface Forces

COR Circular of Requirements

CPA: Critical Path Analysis

CPAF: Cost Plus Award Fee

CPD: Capability Production Document

CPFF: Cost Plus Fixed Fee

CPIF: Cost Plus Incentive Fee

CPM: Critical Path Method

CPR: Cost Performance Report

CRD: Capstone Requirements Document

CSDR: Contractor Software Data Report

CSEL: Combat System Equipment List

CSS Contract Support Services

C/SSR Cost/Schedule Status Report

CWBS: Contractor Work Breakdown Structure

CY: Calendar Year

CY: Constant Year

DAB Defense Acquisition Board

DAES: Defense Acquisition Executive Summary

DASN: Deputy Assistant Secretary of Navy

DBR: Dual Band Radar

DCAA: Defense Contracts Audit Agency

DCARC: Defense Cost Analysis Resource Center

DCMA: Defense Contracts Management Agency

DCARC: Defense Cost Analysis Resource Center

DCNO : Deputy Chief of Naval Operations

DIA: Defense Intelligence Agency

DoD: Department of Defense

DON: Department of the Navy

DPG: Defense Planning Guidance

DRPM: Direct Reporting Program Manager

DTC: Design to Cost

EA: Economic Analysis

EAC: Estimate at Completion

ESLOC: Equivalent Source Lines of Code

ESWBS: Expanded Ship Work Breakdown Structure

EVM: Earned Value Management

EVMS: Earned Value Management System

FAR: Federal Acquisition Regulation

FCC: Future Characteristics Changes

FCCM: Facilities Capital Cost of Money

FFP: Firm Fixed Price

FMB: Financial Management and Budget

FMS: Foreign Military Sales

FOC: Full Operational Capability

FPI: Fixed Price Initiative

FPRA: Forward Pricing Rate Agreement

FRP: Full-Rate Production

FPRP: Forward Price Rate Proposal

FTC: Fleet Training Center

FTD: Foreign Technology Division

FY: Fiscal Year

FYDP: Future Years Defense Plan

G&A: General & Administrative

GAO: Government Accounting Office

GFE: Government Furnished Equipment

GFI: Government Furnished Information

GFM: Government Furnished Material

GI: Global Insight

GOCO: Government Owned Contractor Operated

GOGO: Government Owned Government Operated

GR&A: Ground Rules and Assumptions

GUI: Graphical User Interface

HAC: House Appropriations Committee

HASC: House Armed Services Committee

HM&E: Hull, Mechanical and Electrical

H/W: Hardware

IBR: Integrated Baseline Review

ICA: Independent Cost Assessment

ICD: Initial Capabilities Document

ICE: Independent Cost Estimate

IFB: Invitation for Bids

IFF: Identification Friend or Foe

IIPT: Integrating Integrated Product Team

ILS: Integrated Logistics Support

IOC: Initial Operational Capability

IOT&E: Initial Operational Testing and Evaluation

IPPD: Integrated Product and Process Development

IPR: Integrated Program Review

IPS: Integrated Power System

IPS: Integrated Program Summary

IPT: Integrated Product Team

IPVT: Investment Pricing Validation Team

IRP: Independent Review Panel

ISO: International Standards Organization

ISR: Intelligence, Surveillance, and Reconnaissance

ISRB: Industrial Shipbuilding and Repair Base

IT: Information Technology

IWS: Integrated Warfare System

JCIDS: Joint Capability Integration and Development System

JCS: Joint Chiefs of Staff

JROC: Joint Requirements Oversight Council

LCC: Life Cycle Cost

LCCE: Life Cycle Cost Estimate

LCS: Littoral Combat System

LLTM: Long Lead Time Material

LMW: Littoral and Mine Warfare

LOA: Letter of Offer and Acceptance

LOA: Length Overall

LRIP: Low Rate Initial Production

LSBF: Least Squares Best Fit

MARAD: Maritime Administration

MATCER: Material Cost Estimating Relationship

MCC: Major Category Codes

MDA: Milestone Decision Authority

MDAP: Major Defense Acquisition Program

MEL: Master Equipment List

MER: Manpower Estimate Report

MH/TON: Manhours per Ton

MIS: Management Information System

MOU: Memorandum of Understanding

MSC: Military Sealift Command

MYP: Multiyear Procurement

NALG: Navy Aviation Leadership Group

NAVAIR: Naval Air Systems Command

NAVSEA: Naval Sea Systems Command

NAVSHIPSO: Naval Ship Support Office

NCAD: Naval Cost Analysis Division

NEC: NAVSEA Executive Council

NGNN: Northrop Grumman Newport News

NGSS: Northrop Grumman Ship Systems

NOAA: National Oceanic and Atmospheric Administration

NPDM: Navy Program Decision Meeting

NPV: Net Present Value

NSWC: Naval Surface Warfare Center

NTE: Not-to-exceed

NWCF: Navy Working Capital Fund

NWODB: New Ways of Doing Business

ODC: Other Direct Costs

O&MN: Operations and Maintenance, Navy

OIPT: Overarching Integrated Product Team

OMB: Office of Management and Budget

OLS: Ordinary Least Squares

OPN: Other Procurement, Navy

OPNAV: Chief of Naval Operations Staff

O&S: Operations and Support

OSCAM: Operating and Support Cost Analysis Model

OSD: Office of the Secretary of Defense

OSD (C): Office of the Secretary of Defense (Comptroller)

OSD(PA&E): Office of the Secretary of Defense, Program Analysis and Evaluation

P&A: Planning and Availability

P&R: Planning and Review

PA&E: Program Analysis and Evaluation

PARM: Participating Acquisition Resource Manager

PB: President's Budget

PBCM: Performance Based Cost Model

PBD: Program Budget Decision

PCD: Program Change Decision

PCR: Program Change Request

PDM: Program Decision Meeting

PDM: Program Decision Memorandum

PDP: Production and Deployment Phase

PDR: Program Deviation Report

PDR: Preliminary Design Report/Review

PEO: Program Executive Officer

PER: Performance Estimating Relationship

PERA: Planning and Engineering for Repairs and Alterations

PERA CV: Planning and Engineering for Repairs and Alterations Carriers

PLCCE: Program Life Cycle Cost Estimate

PM: Program Manager

PMM: Permanent Magnet Motor

PMO: Program Management Office

PMS: Planned Maintenance Subsystems

POM: Program Objective Memorandum

PPBE: Planning, Programming, Budgeting and Execution

PPBS: Planning, Programming and Budgeting System

PV: Present Value

QDR: Quadrennial Defense Review

QPR: Quarterly Program Review

RCOH: Refueling and Complex Overhaul

RD&A: Research, Development and Acquisition

RDT&EN: Research, Development, Test, and Evaluation, Navy

RFP: Request for Proposal

ROI: Return on Investment

ROM: Rough Order of Magnitude

SAC: Senate Appropriations Committee

SARP: Ship Alteration and Repair Package

SASC: Senate Armed Services Committee

SCN: Shipbuilding and Conversion, Navy

SCP: Service Cost Position

SCP: System Concept Paper

SCP: Sponsor Change Proposal

SDDP: System Development and Demonstration Phase

SDM: Ship Design Managers

SDR: Ship Departure Reports

SECDEF: Secretary of Defense

SECNAV: Secretary of the Navy

SEMP: System Engineering Master Plan

SER: SCN Execution Review

SES: Senior Executive Service

SHIPALTS: Ship Alterations

SHIPMAIN: Ship Maintenance

SLEP: Service Life Extension Program

SLOC: Source Lines of Code

SMD: Ship Manning Document

SOCOM: Special Operations Command

SPAWAR: Space and Naval Warfare Systems Command

SPD: Ship Project Directives

SRDR: Software Resources Data Report

SSA: Source Selection Authority

SSAC: Source Selection Advisory Council

SSEB: Source Selection Evaluation Board

SSG: Senior Steering Group

SSP: Strategic Systems Programs

STAR: System Threat Assessment Report

SUPSHIP: Navy Supervisor of Shipbuilding, Conversion and Repair

S/W: Software

SWBS: Ship Work Breakdown Structure

SYSCOM: Systems Command

TA: Technical Authority

TAR: Technical Analysis Review/Report

TCO: Total Cost of Ownership

TDP: Technology Development Phase

TDS: Technology Development Strategy

TEMP: Test and Evaluation Master Plan

T&I: Test and Instrumentation

TOA: Total Obligational Authority

TOC: Total Ownership Cost

TWH: Technical Warrant Holder

TY: Then Year

ULC: Unit Learning Curve

UMF: Unified Modeling Language

UPA: Unit Price Analysis

USD(A,T&L): Under Secretary of Defense (Acquisition, Testing and Logistics)

USN: United States Navy

VAMOSC: Visibility and Management of Operating and Support Costs

VCNO: Vice Chief of Naval Operations

WBS: Work Breakdown Structure

WPN: Weapon Procurement, Navy

WR: Work Remaining

Appendix K

End Notes

1 Modifications to approved POM programs which breach the current thresholds are implemented by the Program Manager through either the annual POM exercise or Program Deviation Reports (PDRs) via a Request for Baseline Change.

2 On occasion, small experimental craft are built with RDT&EN funds, and a special-purpose ship modification might be funded with O&MN/OPN funds. The use of RDT&EN funds for lead ship construction in some shipbuilding programs has become less of an exception in the current budget environment. These are exceptions to SCN funding. However, there is one element of ship funding -- contract design and specifications -- that, over time, shifts between SCN and RDT&EN. Currently all efforts leading to completion of contract design and specifications are funded by RDT&EN.

3 SEA 017 does not generally estimate MILPERS and MILCON Appropriations, although these costs are included in the O&S portion of Ship Life Cycle Cost.

4 There are two other general exceptions to the end cost policy: (1) advance procurement for long-lead-time items and (2) advance economic order quantity procurement for multiyear acquisitions.

5 President's Management Agenda, Executive Office of the President, Office of Management and Budget, Fiscal Year 2002, page 7. (http://www.whitehouse.gov/omb/budget/fy2002/mgmt.pdf).

6 The Defense Acquisition Guidebook.

7 In this discussion, an assumption is made that the WBS for the estimate is obtained from the program, and often directly from the CARD provided by the program office.

8 PMs are responsible for complying with DoD risk management policy and for structuring an efficient and useful risk management approach. DoD Defense Acquisition Guidebook.

9 SCN funding for shipbuilder and GFE.

10 Note: missiles, munitions, and torpedoes are procured with Weapons Procurement, Navy (WPN) or Procurement Ammunition, Navy and Marine Corps (PANMC) appropriations. These are normally considered load items and not included in the end cost of a ship.

11 The Standish Group International, Inc., CHAOS Chronicles. Pp. 225-226.

12 Jones, T. Capers (1998). Estimating Software Costs. Washington, D.C.: McGraw-Hill. p. 173.

13 Park, Robert E., Software Size Measurement: A Framework for Counting Source Statements (by Robert E. Park) .http://www.sei.cmu.edu/pub/documents/92.reports/pdf/tr20.92.pdf

14 Jones, T. Capers (1998), p. 319.

15 For a comprehensive definition checklist for SLOC counts, refer to: Boehm, Barry W. Software Cost Estimation with COCOMO II. Upper Saddle River, NJ: Prentice Hall PTR. pp. 77-82.

16 In the context of function point analysis, the term "user" or end user" can be broadly defined as a person, another system, a piece of hardware, or anything else that "uses" data from the application under consideration.

17 For more information on function points visit www.ifpug.org.

18 OMB A-94 identifies the preferred discount factors and shows how to calculate inflation factors.

19 OMB A-76 identifies burden rates of Federal employees.