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SHIP DESIGN MANAGER (SDM) AND SYSTEMS INTEGRATION MANAGER (SIM) MANUAL

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FOREWORD

This manual is written to serve as a guide to Ship Design Managers (SDMs), Systems Integration Managers (SIMs), and other design management personnel. It is intended to aid in indoctrination of newly assigned personnel and serve as a source for planning and execution of each design phase. Since each new ship design project experiences unique situations and continued improvement in the ship design process is sought, deviations from procedures described in this manual are expected. As the manual is used, users are encouraged to recommend changes or additions to SEA 05DT, SEA 05H, or SEA 05V in order that the next issue will benefit from user experience.

This manual covers content on Department of Defense and Navy acquisition regulations and Navy ship design policies and practice. Applicability of this manual is to all surface ship SDMs - now adding content for the SIM and for integration of mission modules. Reference citations have been verified and, where necessary, updated. For readability, selected content has been hyperlinked and moved into the Appendices. Note that the hyperlinks to the references will only work on the CD version of the manual. See Appendix XX for a list of acronyms.

This manual is planned for update every two years.

This manual does not apply to technical standards or procedures prepared under the cognizance of the Deputy Commander for Nuclear Propulsion or the Strategic Systems Program Office.

CHAPTER 1
INTRODUCTION

1.1 PURPOSE AND SCOPE.

This manual is a guide for Ship Design Managers (SDMs), Systems Integration Managers (SIMs), and other design and in-service management personnel. It is intended to aid in indoctrination of newly assigned personnel and to serve as a source for planning and execution of each design phase for the management of designs for ships being acquired by the Naval Sea Systems Command (NAVSEA) and its affiliated Program Executive Offices (PEOs).

The SDM is directly responsible for the successful management of the ship design project and for the final design package. For Warfare or Mission Systems, procured by a different Program Office, the SIM performs a similar function to integrate the systems together to a cohesive warfare or mission system and to work with the SDM to integrate the system into the ship. The SDM and SIM must ensure the development of a fully integrated, technically satisfactory ship and associated system designs that meet the specified performance requirements and cost goals. All SDMs and SIMs including in-service, are concerned with addressing technical issues associated with design deficiencies, modernization, alterations, safe operations of ships and ship systems when using equipment and systems in a non-traditional manner.

1.2 GUIDELINES FOR USE.

This manual sets forth ways and means of performing the planning, coordination, and review functions required of SDMs and SIMs presuming sufficient technical knowledge and experience to perform the required tasks. The manual contains generic samples of management products developed for or by the SDM and SIM. General SDM and SIM guidance applicable to all design phases is covered in the main body of the manual. More specific guidance is provided in the appendices.

Ship design and acquisition is a complex, lengthy process. Each one will have differing requirements; therefore, the design processes themselves will differ. No single design will follow exactly all the steps in this manual. However, the documentation of proven practices and lessons learned will facilitate planning. Each new project experiences unique situations and the management process must be tailored. Therefore, this manual is not meant to be restrictive. Introduction of new ideas and innovations is expected.

This manual is not a technical reference and does not supplant other sources of technical information. It is hyperlinked to a number of reference documents and selected web sites to ease access to additional information. It also contains numerous practical and hyperlinked appendices for direct use by SDMs and SIMs as appropriate.

1.3 ORGANIZATION OF THIS MANUAL.

The size of the main body of this document has been substantially reduced from the prior revision to make the manual more usable. This has been accomplished by eliminating redundancy and moving selected content into the appendices. The scope of responsibility for an SDM and SIM is broad and complex and this document must be similar. The content of the sections is as follows:

Section 1: Introduction

Section 2: An overview of the ship design and acquisition process

Section 3: Description of the players in the design process, how they are organized, and their roles and authorities

Section 4: How to plan the design effort and how to structure the control mechanisms for its execution

Section 5: The many aspects of design execution and control

Section 6: A summary checklist of action items required

1.4 EXAMPLE DOCUMENTS.

This manual specifies the contents and, to a certain extent, the format of a number of documents. For specific "good examples" of a given document, SDMs and SIMs are encouraged to work with their Division Director to identify a prior work that most closely resembles the current tasking expectations. Most documents are required to be serialized and placed in the online correspondence log; hence the correspondence log is a good reference tool for identifying examples of previous work.

CHAPTER 2
SHIP/SYSTEM DESIGN AND THE ACQUISITION PROCESS

2.1 ACQUISITION POLICY AND DIRECTIVES.

Overall policies for the acquisition of major systems, such as a ship, by the government are established by Office of Management and Budget (OMB) Circular A-109 of 5 April 1976 *(hyperlink)*, Department of Defense (DoD) Directive 5000.01 *(hyperlink)*, and DoD Instruction 5000.02 *(hyperlink)*. Secretary of the Navy (SECNAV) Instruction 5000.2 *(hyperlink)* provides additional implementation direction for the Navy. The Defense Acquisition Guidebook (hyperlink) and Department of the Navy (DoN) Acquisition and Capabilities Guidebook (hyperlink) provide supplemental information. Chairman of the Joint Chiefs of Staff Instruction 3170.01 *(hyperlink)* and the associated manual *(hyperlink)* describe the capabilities definition through the Joint Capabilities Integration and Development System (JCIDS). Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 6212.01 *(hyperlink)* addresses interoperability requirements. Key NAVSEA directives include NAVSEAINST 5000.9 on systems engineering *(hyperlink)*, NAVSEAINST 5400.97 on technical authority *(hyperlink)*, the NAVSEA Engineering and Technical Authority Manual *(hyperlink)*, NAVSEAINST 5400.57 on engineering agent selection, assignment, and responsibility *(hyperlink)*, NAVSEAINST 5000.8 on risk management *(hyperlink)*, NAVSEAINST 5100.12 on system safety *(hyperlink)*, and NAVSEAINST 4121.3 on technical standards *(hyperlink)*.

A listing of significant directives that define policies on ship design and acquisition is presented in Appendix A *(hyperlink*). Other DoD directives can be found at http://www.dtic.mil/whs/directives. SECNAV and OPNAV directives can be found at http://doni.daps.dla.mil, and NAVSEA directives at http://www.navsea.navy.mil/Organization/NAVSEA%20Instructions.aspx. The Under Secretary of Defense (Acquisition, Technology, & Logistics) (USD (AT&L)) Defense Acquisition Portal can be found at https://dap.dau.mil and the Assistant Secretary of the Navy for Research, Development & Acquisition (ASN (RDA)) provides acquisition information at https://acquisition.navy.mil/rda/home. Systems engineering policies and processes are described by the Assistant Secretary of Defense for Research and Engineering (ASD R&E) at http://www.acq.osd.mil/se/ and the Naval Systems Engineering Resource Center at https://nserc.navy.mil. SEA 05D and the other SEA 05 Divisions maintain websites at the NAVSEA Corporate Data Management System (CDMS) at https://cdms.navsea.navy.mil.

2.2 TYPES OF PROGRAMS.

Acquisition programs are normally assigned an Acquisition Category (ACAT) designation as they near formal Program Initiation either at Milestone A or B. ACAT designation confirms the Milestone Decision Authority (MDA) and program assessment and supporting documentation requirements. Based on their high projected costs and importance, ship acquisition programs are generally assigned ACAT level ID with USD (AT&L) as the MDA. Less costly and lower interest ship programs are sometimes assigned ACAT level IC or II with the ASN(RDA) as the MDA. Smaller ship acquisitions and modifications may be designated as ACAT III or ACAT IV with MDA delegated to Program Executive Officers (PEOs), Direct Reporting Program Managers (DRPMs), or Systems Commands. Very small programs that do not require operational test and evaluation may be designated as Abbreviated Acquisition Programs (AAPs). These require substantially less assessment and documentation. Specific criteria are identified in DoD Instruction 5000.02 *(hyperlink)* and SECNAVINST 5000.2 *(hyperlink)*.

A non-acquisition program is an effort that does not directly result in the gaining of a system or equipment for operational deployment and does not require an Initial Capabilities Document (ICD). The requirement is included in a Sponsor's Program Proposal (SPP) input to the Program Objective Memorandum (POM) and subsequent Research, Development, Test and Evaluation (RDT&E) budget item justification documentation. Non-Acquisition Programs use current documentation required by the Program Planning Budgeting and Execution System (PPBES) for management control.

An urgent need is an exceptional request from a Navy or Marine Corps component commander for an additional warfighting capability critically needed by operating forces conducting combat or contingency operations. Failure to deliver the capability requested is likely to result in the inability of units to accomplish their missions or increases the probability of casualties and loss of life. Urgent Need Program streamlines the abbreviated requirements, resources, and acquisition processes to address mission-critical warfighting capability gaps more rapidly than the normal processes permit. Subject to statutes and regulations, this process is optimized for speed, and accepts risk with regard to Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities (DOTMLPF), integration, sustainment, and other considerations.

The Rapid Deployment Capability process is a tailored approach for initiating and managing development of a capability for rapid deployment that may transition to an ACAT program. It provides the ability to react immediately to a newly discovered enemy threat(s) or potential enemy threat(s) or to respond to significant and urgent safety situations through special, accelerated procedures.

A Joint Program is any acquisition system, subsystem, component, or technology program with an acquisition strategy that includes funding by more than one DoD component (i.e., military service) during any phase of a system's life cycle. Standing up a Joint Program Office provides for centralized organization, requirements definition, and funding; greater visibility; co-location of personnel resources; and military representatives from each service enabling more coherent program execution. Joint Programs are always complex and, for success, require strong commitment and attention of the highest levels of the services involved.

Participation in International Cooperative Programs requires the establishment of an International Agreement in accordance with SECNAVINST 5710.25B *(hyperlink)*. The Navy International Programs Office (IPO) will be consulted.

2.3 UNIQUENESS OF SHIP ACQUISITION.

Ship design and acquisition presents unique challenges:

- Very low quantities, high unit costs, and a long development cycle
- First ship must be fully operational. Full ship prototyping is rare, but when a prototype is acquired, it must be a fully operational ship.
- Evolving requirements definition
- Combat systems/weapons systems development and technology changes – development cycle of 18 months or less must be synchronized with the ship development cycle
- Integration of warfighting capability with supporting functions such as mobility, training, and damage control
- The broad scope of Human Systems Integration (HSI) considerations including Habitability, Human Factors Engineering (HFE), Manpower, Personnel, Training, Personnel Survivability, Safety and Occupational Health
- Interoperability considerations for command, control, communications, computer, intelligence, surveillance and reconnaissance (C4ISR); aviation; hull, mechanical, networks and electrical; and other systems
- Extremely high parts count – on the order of 10 million on a complex program
- Industrial base considerations: availability, capability, and capacity

DoD Instruction 5000.02 *(hyperlink)* and SECNAVINST 5000.2 *(hyperlink)* provide flexibility for establishment and program assessment of shipbuilding programs. Shipbuilding programs may be initiated early at the beginning of Technology Development. That allows for approval of the Capability Development Document (CDD) prior to Preliminary or Contract Design but can require premature approval of several other program planning documents. Detail Design and Construction (DD&C) for both lead and initial follow ships may be authorized at Milestone B. Milestone C and the Full Rate Production Decision Review (FRP DR) may be combined to authorize the remaining follow ships.

The uniqueness of ship acquisitions often creates challenges for the SDM and SIM when supporting the Program Office in communicating with higher authority in DoD. There is usually little awareness of or empathy for special ship-related issues in the areas of Live Fire Test and Evaluation (LFT&E) or Test and Evaluation (T&E). For example, lead ships are not subject to live fire testing to demonstrate their survivability, but there is still tremendous pressure to perform live fire testing on surrogate (decommissioned) ships during the early design phases, an expensive undertaking. Also, shock trials are supposed to be done on the lead ship unless a waiver is granted, which usually always occurred in the past. Current expectations in DoD make it less receptive to issuing waivers, however.

The SDM must support the Program Office in preparations for program assessment including taking the lead on selected planning documentation such as the Systems Engineering Plan (SEP) and Corrosion Prevention and Control Plan. SECNAVINST 5000.2 establishes a review process to improve governance and insight into the development, establishment, and execution of acquisition programs within DoN. This review process is to ensure alignment between Service-generated capability requirements and acquisition, as well as improving senior leadership decision-making through better understanding of risks and costs throughout a program's entire development cycle. This Navy Two Pass/Six Gate process adds to the demands for special planning, reports, and submissions now being required across the board for all DoN programs at each milestone. The Gates process requires the SDM and SIM to support 6 gate reviews including developing a System Design Specification (SDS) Plan for Gate 3 and an SDS for Gate 4.

2.4 SHIP LIFE CYCLE.

This section presents a cradle-to-grave view of the design process for acquisition to serve as a framework for the discussion of SDM and SIM responsibilities. The terminology used in the following discussion may not be familiar because: (a) DoD and SECNAV guidance documents, such as DoD Instruction 5000.02 and SECNAVINST 5000.2, have been repeatedly revised in recent years and the names of the phases and even the milestone designations changed, and (b) many of the "traditional" ship design phase names look very similar to the new acquisition or system engineering phase names, but they do not mean the same thing. Experience with DoD for the approval of recent ship program Systems Engineering Plans (SEPs) shows they will insist that the System Functional Review (SFR) follow Preliminary Design (design of the Functional Baseline), the Preliminary Design Review (PDR) follow Contract Design (design of the Allocated Baseline), and the Critical Design Review (CDR) occur in Detail Design (design of the Product Baseline). For this reason this manual employs clarifying terminology such as "System Functional Review (System Engineering Technical Review (SETR) for the Functional Baseline)," "Preliminary Design Review (SETR for the Allocated Baseline)," and "Critical Design Review (SETR for the Product Baseline)." SDMs and SIMs are encouraged to use this or other equivalently explicit terminology when developing planning documentation for and briefing DoD to avoid unnecessary conflict.

The important thing to keep in mind is the level of detail and maturity that is appropriate for each step in the design process as well as the calendar time needed to get to that level.

Note that some Program Offices rename, combine, and/or shorten these design phases in an attempt to recover from schedule delays or pursue unrealistic schedule objectives. The SDM and SIM must ensure that the design process is not compromised.

Figure 2-1 shows how conduct of a typical ship design and acquisition program aligns to acquisition process defined by DoD Directive 5000.01 (*hyperlink*).

As implied in Section 2.3, warfare and other ship systems life cycles are better aligned to the policies and practices defined by acquisition statues and regulations. They are designed, often physically prototyped, and procured over a much shorter timeline. Their relatively narrower mission requirements are more easily defined and measured. The SDM needs to work with the SIM for weapons systems and the Technical Warrant Holders (TWHs) for other system types to plan for the integration of new and modified systems into the ship design and Fleet modernization process. See Section 5.

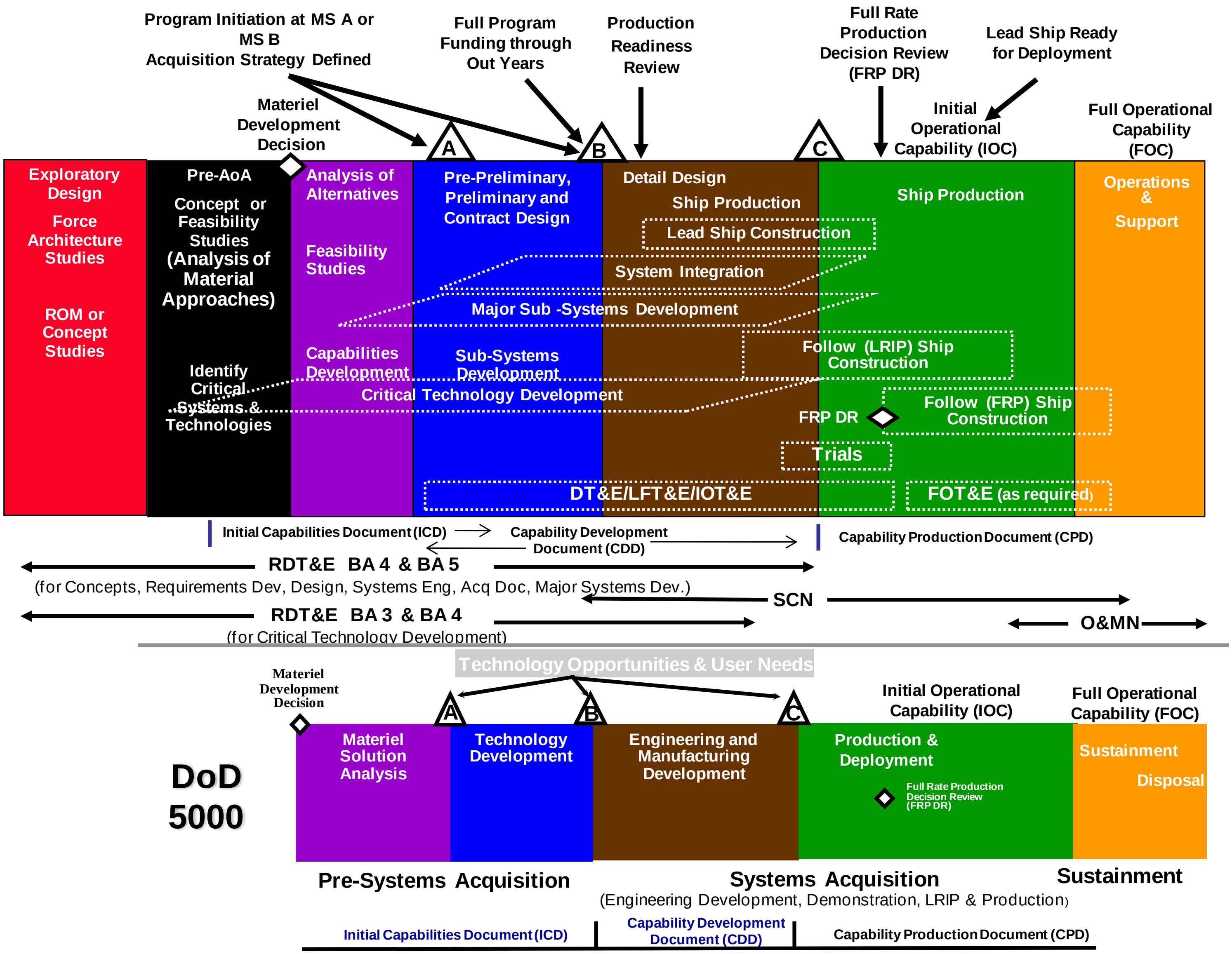


Figure 2-1. Ship Design and Acquisition Process Under DoD Instruction 5000

Figure 2-2 illustrates the Two Pass/Six Gate review cycle with Program Initiation at Milestone A and Milestone B respectively under the SECNAVINST 5000.2 (*hyperlink*). Overlaid on top of the DoD design and acquisition process, Pass One of the SECNAVINST 5000.2 Review Process aligns with and starts with the Materiel Development Decision (MDD) and continues through the Materiel Solution Analysis and, for Program Initiation at Milestone B, through the start of the Technology Development Phase.

Pass One Gates 1-3 are chaired by OPNAV N8 with the preponderance of leadership coming from the System Command for their preparations. Pass Two Gates 4-6 are chaired by ASN (RDA) with the preponderance of leadership coming from the PEO for their preparations.

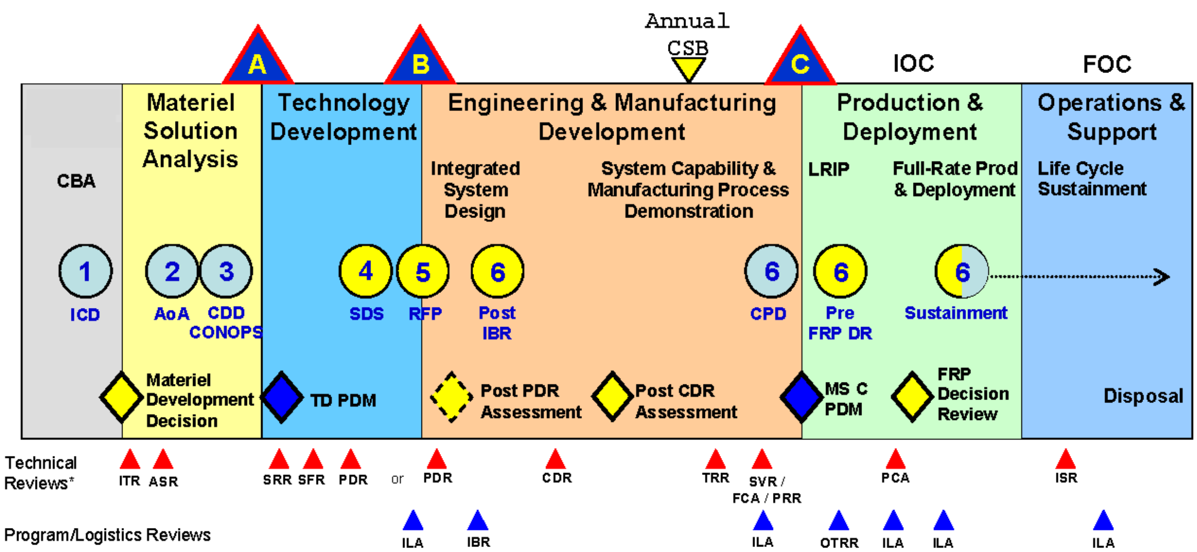


Figure 2-2. DoN Requirements/Acquisition Two-Pass/Six Gate Process

Figures 2-3 and 2-4 provide a comparison to the SETR timing figures shown in the Naval SYSCOM Systems Engineering Policy Instruction (NAVSEAINST 5000.9) (*hyperlink*) - here showing two different approaches to ship design phasing and including the timing for ship design and acquisition program Gates and SETRs.

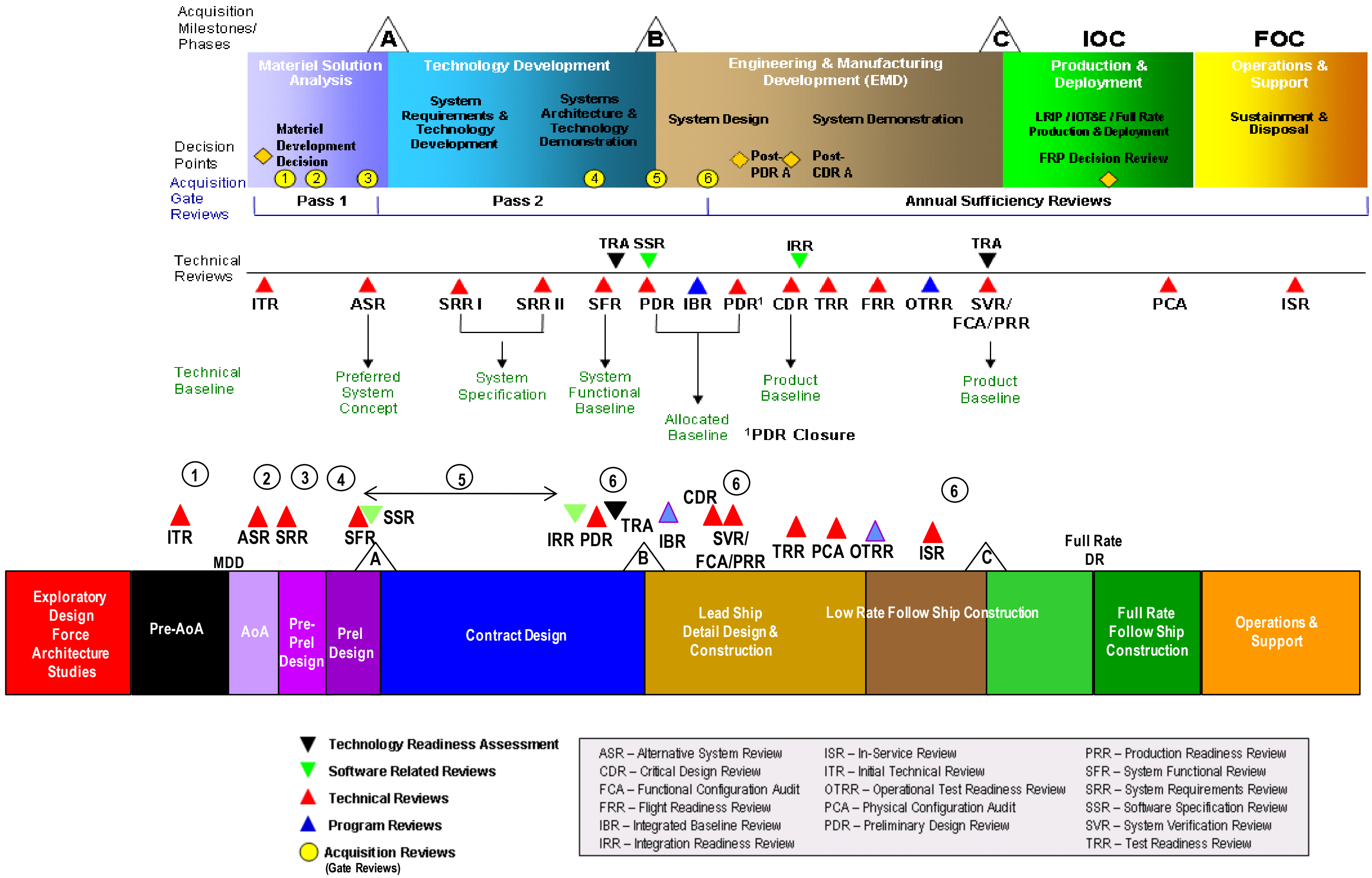


Figure 2-3. Ship Design and Acquisition Gates and SETR Reviews for Program Initiation at Milestone A

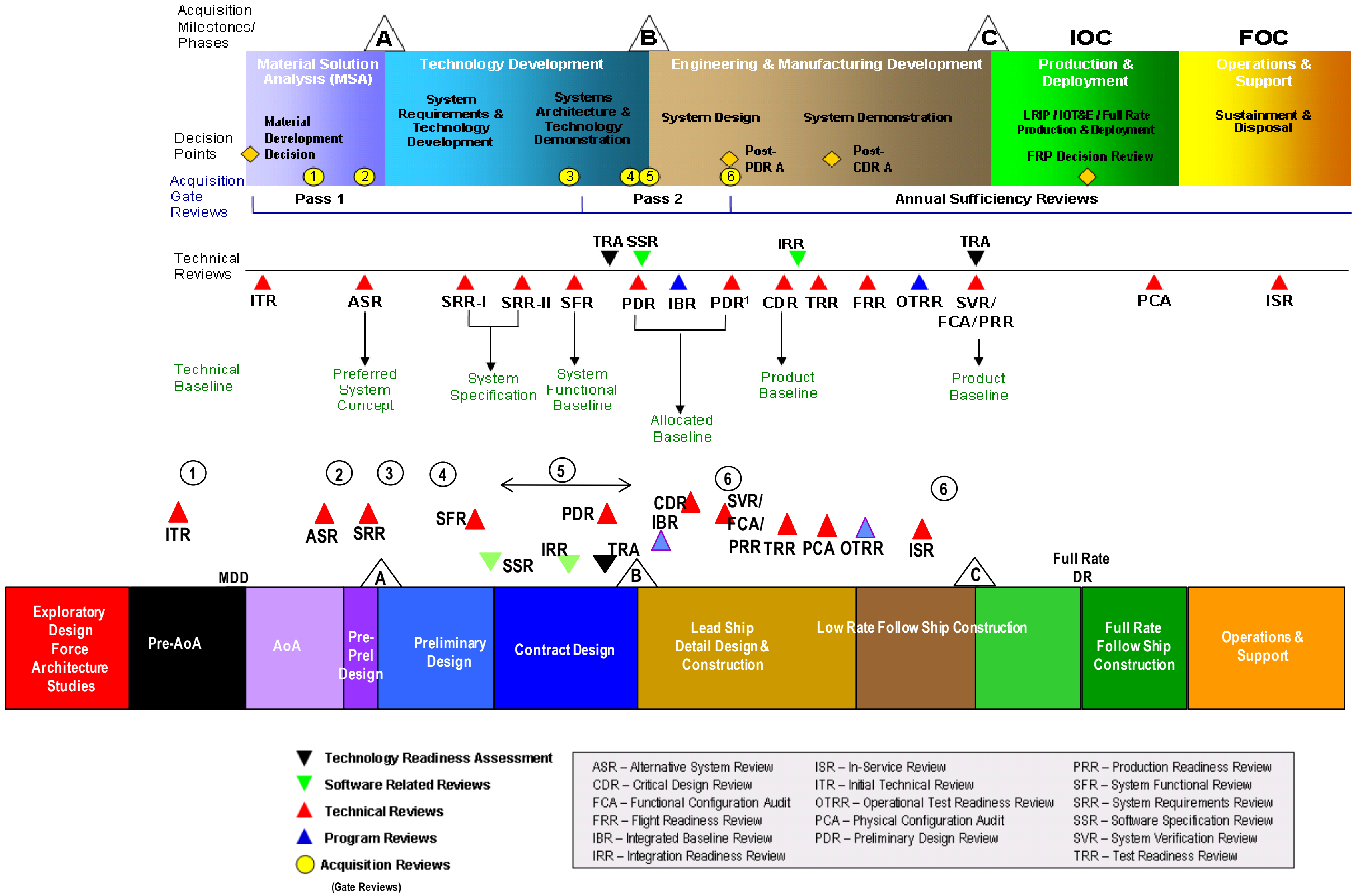


Figure 2-4. Ship Design and Acquisition Gates and SETR Reviews for Program Initiation at Milestone B

Short statements of the purpose of each design phase and their relationship to the DoD and Navy acquisition processes follow. See Appendix B through M for extended descriptions. See Appendix N (*hyperlink*), O (*hyperlink*), and P (*hyperlink*) for tabular summaries of design phase purposes, alternative approaches, leads, participants, workload, durations, System Engineering Technical Reviews (SETRs), Gate Reviews, and deliverables. See Appendix Q (*hyperlink*) for a tabular summary of typical ship program SETR and other review processes including their purpose, timing, roles, entrance and exit criteria, and products.

Concept design level Exploratory Design or Force Architecture Studies are routinely conducted to expand the base of knowledge for planning future force composition. These are not connected to any particular ship programs. See Appendix B (*hyperlink*). See also SEA 05D Memo 9830 Ser 05D/376 of 28 June 10 Surface Ship Concept Study Policy (*hyperlink*) and the Concept Design Handbook Version 1.0 of 22 December 2006 (*hyperlink*) for specific guidance on the performance of concept design.

Concept or feasibility design level Pre-Analysis of Alternatives (AoA) Studies support conduct of functional analyses such as Capabilities Based Assessments (CBA) to support the Initial Technical Review (ITR), development and approval of the ICD, Gate 1 (Navy ICD approval), conduct of the Materiel Development Decision (MDD), and planning for the AoA. See Appendix C (*hyperlink*). See the NAVSEA 05T Guide for Conducting Technical Studies of 27 December 2010 (*hyperlink)* and the Surface Ship Concept Study Policy (*hyperlink*).

Feasibility design level AoA Studies characterize the AoA materiel alternatives during the Materiel Solution Analysis acquisition phase and support an Alternative Systems Review (ASR), Gate 2 (Navy AoA approval) and the subsequent Milestone A. Conduct of a System Requirements Review (SRR), submission of the CDD to Navy staffing and Gate 3 (Navy CDD approval) prior to Milestone A is now required. Pre-Preliminary Design starts prior to Milestone A and Preliminary Design may start prior to Milestone A. See Appendix D (*hyperlink*) for AoA Studies, Appendix E (*hyperlink*) for Pre-Preliminary Design, and Appendix F (*hyperlink*) for Preliminary Design.

For ships, the Technology Development acquisition phase that follows Milestone A may include Preliminary Design and will include Contract Design to support Milestone B technology maturity, technical risk, and budgeting assessment. See Appendix F (*hyperlink*) for Preliminary Design and Appendix G (*hyperlink*) for Contract Design. Preliminary Design establishes the Functional Baseline - i.e., verifies that the design meets the requirements - and concludes with a System Functional Review (SFR) (SETR for the Functional Baseline). Contract Design establishes the Allocated Baseline – i.e., the Ship Specification and other technical documentation for Detail Design and Construction contracting - and concludes with the Preliminary Design Review (PDR) (SETR for the Allocated Baseline). Gate 4 SDS approval should be scheduled as soon as possible after Navy CDD approval to provide a firm basis for development of the Ship Specification. Gate 5 should also be scheduled as soon as possible to obtain higher authority concurrence on the approach for Request for Proposal (RFP) finalization. This approach is especially relevant to the design and acquisition of new ship programs where early buy-in by higher authority is needed to prevent costly changes in direction and associated delays later in the Program.

See Appendix H (*hyperlink*) for a discussion of Source Selections conducted in support of Pre-Preliminary, Preliminary, Contract, and/or Detail Design and Construction.

Milestone B approves Program Entry into the Engineering and Manufacturing Development acquisition phase for lead ship Detail Design and Construction and the initial follow ships. See Appendix I (*hyperlink)*. The Critical Design Review (CDR) (SETR for the Product Baseline) demonstrates design maturity and the Production Readiness Review (PRR) demonstrates manufacturing readiness to begin production of the lead ship. Gate 6 is held for production readiness.

See Appendix J (*hyperlink*) for Conversions and Major Modernizations, Appendix K for Reactivations (*hyperlink*), Appendix L (*hyperlink*) for In-Service Engineering and Appendix M (*hyperlink*) for Aircraft Carrier Modernization.

2.5 DESIGN APPROACHES.

Historically, naval architecture and ship design have been taught using the Classic Design Spiral where an initial concept is iterated until the design has converged. The Classic Design Spiral is also applicable to the impact of a proposed engineering change during Detail Design or an individual ship alteration or even a full overhaul package during Fleet Modernization. This would include weapons systems upgrades.

More recently a host of Synthesis Model Based Design Optimization techniques such as response surface methodologies, Design of Experiments, genetic algorithms, and multi-domain optimization have used many point designs, typically generated by a computer based synthesis program, to characterize the design space for the purpose of identifying the optimal characterizations of a solution to a given set of requirements. More recently, Set-Based Designs have been employed to establish a point design based on an initial identification of the feasible design space. None of these methods is universally better than the others; each is a tool that is appropriate for different stages of the acquisition process and different acquisition strategies.

2.5.1 Classic Design Spiral – Point Based Design. The design spiral approach is a Point Based Design technique. As shown in Figure 2-5, design activities are accomplished in a specific order. At the end of each cycle around the spiral, design convergence is tested. If not converged, then another cycle at the same fidelity is repeated. If converged, then the next stage of design is entered where the steps are repeated at higher levels of fidelity.

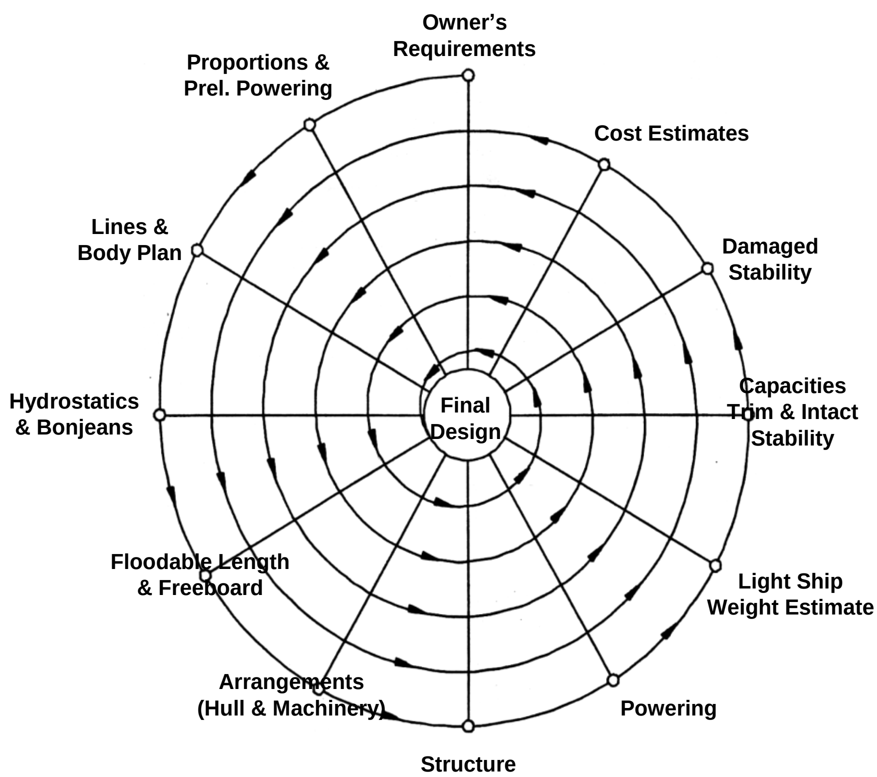


Figure 2-5. Classic Design Spiral

Figure 2-6 presents an alternate view of the Classic Design Spiral. See also Section 5.1. Since each design iteration for a complex ship takes between 8 to 12 weeks, relatively few design iterations are possible within the 40 to 50 weeks typically allocated to a given stage of design. The design is "done" when you run out of time, not necessarily when the design is converged or optimal. For this reason, the design spiral is most appropriate for refining an existing solution, rather than as a method for achieving the initial, almost-optimal converged starting concept.

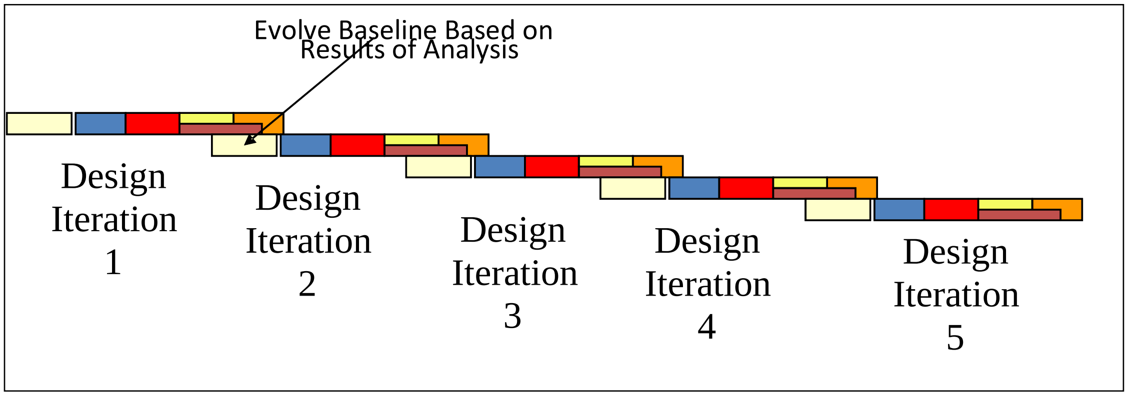


Figure 2-6. Alternate View of the Classic Design Spiral

2.5.2 Synthesis Model Based Design Optimization. Synthesis Model Based Design Optimization techniques are used extensively in the early stages of design to gain insight on the cost – performance trade-offs between requirements and the feasible material solutions. These methods include response surface methodologies, Design of Experiments, genetic algorithms, and other multi-objective optimization techniques. These methods are generally characterized by the use of many point designs, typically generated by a computer based synthesis program. Because of the need to generate large number of ship concepts, the fidelity of the designs is generally only at the concept level. As the design matures and the required design fidelity increases, the ability to create large number of synthesized ship designs becomes too difficult to employ this method. The use of high performance computing environments with high fidelity synthesis programs and physics based analysis may extend the use of these optimization methods into Pre-Preliminary Design.

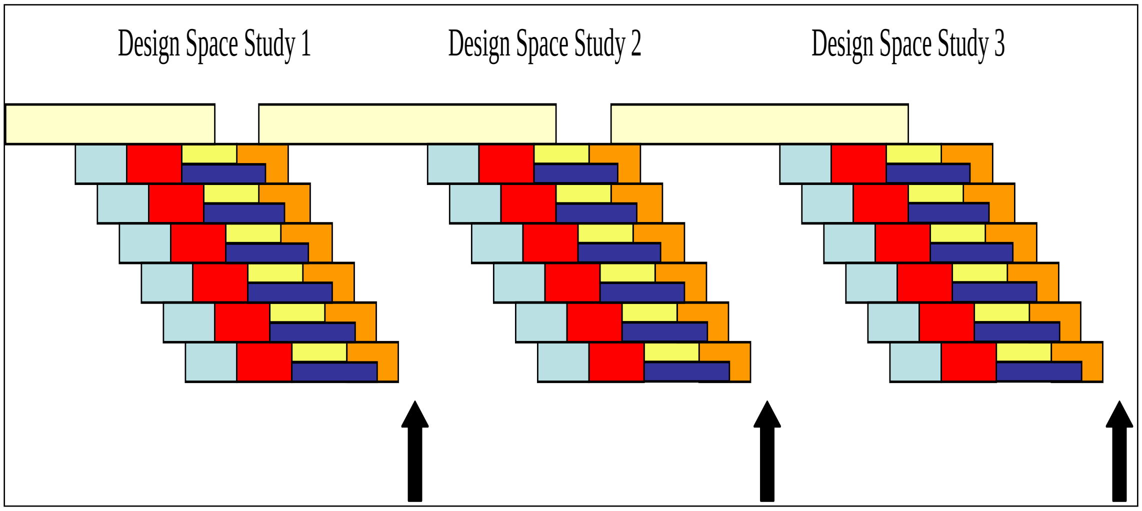


Figure 2-7. Synthesis Model Based Design Optimization

2.5.3 Set-Based Design. Set-Based Design (SBD) as described by Bernstein (1998) preserves design flexibility through three basic tenets:

- "Understand the design space
  - Define feasible regions
  - Explore trade-offs by designing multiple alternatives
  - Communicate sets of possibilities
- Integrate by intersection
  - Look for intersection of feasible sets
  - Impose minimum (maximum) constraint
  - Seek conceptual robustness
- Establish feasibility before commitment
  - Narrow sets gradually while increasing detail
  - Stay within set once committed
  - Control by managing uncertainty at process gates"

In a Set-Based Design process, engineers of different systems (i.e., electrical systems, combat systems, hull design, etc.) communicate ranges of solutions with associated derived requirements on other systems and levels of performance. As shown in Figure 2-8, regions of feasibility are determined by the intersections of the different ranges of solutions offered by the different engineering disciplines. Initially, the ranges of discipline solutions may need to grow to enable a sufficiently large region of feasibility at the intersection of independent solutions. The range of solutions for each engineering discipline is then reduced at the process gates to eliminate subsystem solutions that are not likely to contribute to a total system solution. Following the reduction in design space, engineers produce additional levels of details of the subsystems to refine the solution, improve cost estimates, and reduce risk. The design space is only reduced at a process gate if the design has sufficiently reduced the variability of design metrics to ensure with high probability that the eliminated portions of the design space are Pareto dominated by other regions. A solution is Pareto dominated when there are other solutions which perform better at lower cost. In this sense, Set-Based Design is about eliminating solutions that are likely not optimum rather than picking one and modifying it to become an optimum.

A marine engineering example of SBD would be the interaction of hull shape, propeller selection, and propulsion motor selection. For a range of required displacements and deck area, the hull designer would provide the range of speed – Effective Horsepower (EHP) curves and propeller size limitations. For this range, the propeller designer would provide the marine engineer with achievable propeller efficiencies, associated shaft speed – shaft power – ship speed curves along with maximum shaft speeds to preclude cavitation. The propulsion engineer would look at the range of powers and shaft speed required, and identify a motor architecture that could cover that region. The cost engineer would identify the cost and cost uncertainty that would apply to the different design spaces.

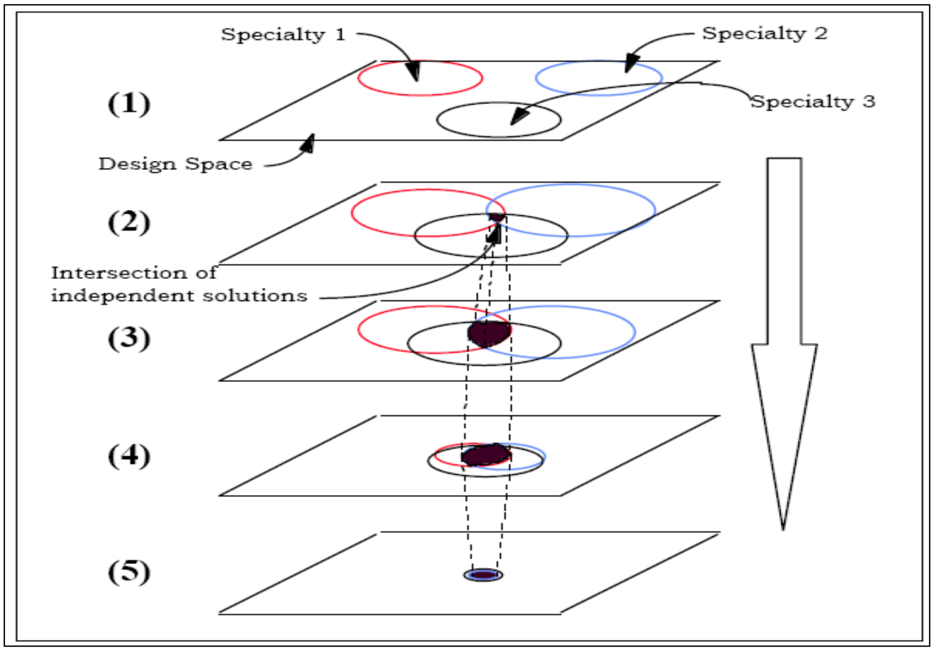


Figure 2-8. Set-Based Design (Bernstein 1998)

SBD is a design paradigm that pursues design solutions by eliminating the infeasible and the inferior from the design trade in successive analysis iterations, and in so doing, delays design decisions. This, in turn, first slows and then ultimately reduces committed costs. In successive iterations, the current design preferences are used to generate successively higher fidelity studies so that the final integrated solution is also of high fidelity. The analyses are concurrent and often nested and all must be well coordinated if the SBD is to proceed systematically toward a high value, high fidelity solution.

Based on the experience in the SBD implementation for the SSC program, here are some general findings relevant to future SBD implementations:

- There was little time to design an executable SBD process before execution had to begin. The process used was developed using the Decision Oriented Systems Engineering (DOSE) method by using the SBD principles to determine the necessary key decisions to punctuate the effort.
- The SBD effort began after some design space decisions had already been made. In the ideal implementation the SBD effort would commence with the design trade space setup lest one run the risk of prematurely constraining the initial design trade space for the problem at hand.
- The SBD process was used on the Ship-to-Shore Connector (SSC). Although the SSC Team was able to execute and boil down the data to a recommended baseline within the allotted time, the SSC Team did not have the time to generate successive design iterations across all elements with increasing fidelity. This feature is essential to a robust implementation of SBD and particularly important for flexing the design to accommodate requirement changes and the like.
- With SSC the “system” was partitioned such that one layer of partitioned design spaces sufficed. For many design problems this will not suffice.

- It is important to have members of the Integration Team attached to each of the System Engineering Manager (SEM) groups to ensure consistent adherence to SBD principles and implementation procedures once these procedures have been formulated. These Integration Team members will also be responsible for ensuring that design space reduction decisions are fully documented for traceability. The SEM trade space analyses will be concurrent and must be well coordinated to ensure a relatively uniform progression in the fidelity of design solutions. All of this means that the Integration Team should be well manned to remain well-connected with what's going on in the element analyses.
- The points discussed above warrant preparation time for the setup and organization of the SBD effort. Taken together, they almost demand that significant energies be dedicated to preparations for SBD, and applied to the following: process design, designing Integration mechanics, defining trade space reduction and decision traceability protocols, trade space setup, and Integration Team orientation regarding all of the preceding.
- For a robust implementation, it is important that the evaluation framework for valuing design solutions be sustained throughout the design effort. Once developed it remains the best context for considering subsequent design changes. While the attributes and measure used in the framework may need updating with new and better data, and the scores of the various design solutions in the attributes may need updating, only the evaluation framework will make sure that design decisions are considered in fullest possible context. The information in the evaluation framework may be less than perfect at all times, but it will continue to provide transparency into design decision influences.

See also David J. Singer, PhD., Captain Norbert Doerry, PhD., and Michael E. Buckley, What is Set-Based Design? , Presented at ASNE DAY 2009, National Harbor, MD., April 8-9, 2009 - Also published in ASNE Naval Engineers Journal, 2009 Vol 121 No 4, pp. 31-43.

Note that the amount of visibility given to SDB in this current manual should not be construed to imply that the other methods are in any way less worthy of consideration. The next section discusses the appropriate application by design phase.

2.5.4 Application of Design Approach by Design Phase. During the Pre-AoA and AoA phases, low fidelity automated models are typically used to systematically explore the design space in order to trade-off cost and performance. The synthesis model optimization techniques are appropriate to identify the region of the design space where the optimal solution is likely to reside. This region forms the basis of the ICD and the selection of a broadly defined alternative from the AoA.

Pre-Preliminary Design is a unique opportunity to perform trade-offs among individual system performance, total ship performance/requirements, the Concept of Operations (CONOPS), and cost. Because these activities are typically performed by many geographically dispersed organizations, SBD techniques are ideally suited for communicating individual design solution opportunities and requirements to systematically neck down the design space while improving design fidelity. By the end of Pre-Preliminary Design, the requirements are fixed in a CDD and the CONOPS formalized in a CONOPS document. Note that OPNAV is developing a draft format for the CONOPS. The ship design is developed to the level of detail necessary to produce a budget quality cost estimate. The SSC design is a good recent example of using SDB.

At the start of Preliminary Design following a Milestone A decision and CDD approval, the requirements and CONOPS for the ship are largely fixed. While some change is still possible, large changes are generally avoided. SBD can still be desirable to further refine system designs and integrate them into a total ship design. At some point, the design will "converge" and the point design based Classic Design Spiral is typically used to modify the design in response to detailed analysis, obsolescence management, and optimization efforts.

Use of the Design Spiral will typically continue through Contract Design, Detail Design & Construction, and for Fleet Modernization.

CHAPTER 3
SHIP DESIGN PARTICIPANTS

3.1 GENERAL.

As described in NAVSEAINST 5401.2 (*hyperlink*), NAVSEAINST 5400.57 (*hyperlink*), and the NAVSEA Engineering and Technical Authority Manual (*hyperlink*) and consistent with NAVSEAINST 5400.97 (*hyperlink*), the NAVSEA Competency Aligned Organization (CAO)/Integrated Product Team (IPT) functional design structure operates horizontally and vertically across all organizational boundaries to improve response to customer workload requirements. The operating construct maintains lines of command and technical authority. It also addresses workload forecasting and process development.

Ship acquisition and associated system design is a complex, lengthy process. Each design will have unique requirements. However, the participants' responsibilities and associated systems design processes are similar for all ship designs. SEA 05 responsibilities as the NAVSEA agent for ship design include:

- Conceive and develop integrated naval ship and associated system designs
- Act as ship and associated system designer for the command, establish overall design objectives, and evaluate engineering products and system designs recommended by the command's engineering directorates and other Systems Commands (SYSCOMs) as to their effects on the total ship design
- Serve as the principal advisor to the Commander and as the principal point-of-contact with all external activities on ship design
- Serve as technical authority throughout the ship's and associated systems' life cycle

The blue and red boxes in Figure 3-1 denote groups in the SEA 05 organization. The exceptions are two red boxes which are lead by the Warfare Center for Undersea Technical Director and Surface Technical Director. The IWS blue box is SEA 05H, the organization which provides SIMs and TWHs to PEO IWS. SEA 05V provides the SDMs to PEO Carriers and SEA 05D provides the SDMs to PEO Ships. There are Chief System Engineer/Deputy Warrant Officers leading the blue boxes and Technical Domain Managers leading the red boxes. SEA 05 and Warfare Centers overall are responsible for providing SDMs, SIMs, and TWHs to NAVSEA Program Offices (the orange boxes).

The Systems Engineering, Safety and Assurance Division of the SEA 05 Technical Policy and Standards branch develops and promulgates systems engineering policy, guidance and procedures on systems engineering (e.g., Systems Engineering Plans and the Systems Design Specifications), and specialty systems engineering disciplines such as Reliability and Maintainability and Safety Engineering.

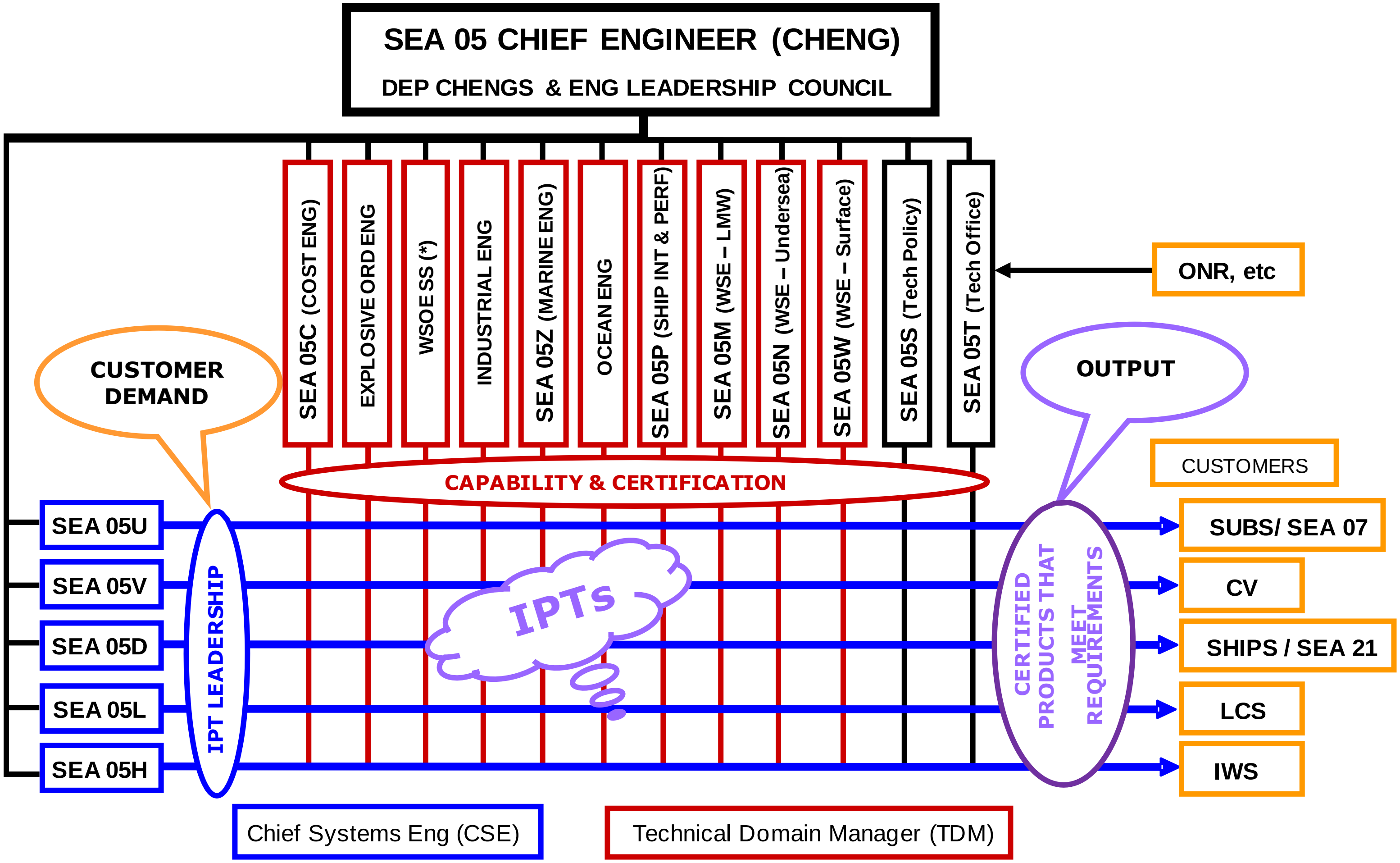


Figure 3-1. NAVSEA Competency Aligned Organization

3.2 DESIGN TEAM COMPOSITIONS.

Design team composition will depend on the details of the ship design. SDMs should work with their Division Directors to identify other ship designs to model their Design Teams after. Information on Design Team composition of other ship designs is available in the Annual Reports.

Where practicable and cost-effective, system designs shall minimize or eliminate system characteristics that require excessive manpower, cognitive or physical skills; entail extensive training or workload- intensive tasks which result in mission-critical errors; or produce safety or health hazards.

Consistent with paragraph E1.1.29 of DoD Directive 5000.01, the Program Manager shall apply HSI to optimize total system performance, operational effectiveness, suitability, survivability, safety, and affordability. Program Managers are required to consider supportability, life cycle costs, performance, and schedule comparable in making program decisions. Each program is required to have a comprehensive plan for HSI. It is important that this plan be included in the SEP or as a standalone HSI Plan as the program(s) may require.

In accordance with DoD Instruction 5000.02, the Program Manager is also required to take steps (e.g., contract deliverables and Government/contractor IPT teams) to ensure that HSI analysis and processes are employed during systems engineering processes over the life of the program.

As a SDM or SIM, it is your responsibility to help the Program Manager address these mandated requirements, and ensure that HSI requirements are addressed during the systems engineering process, included in a HSI Plan and the SEP, and properly considered during cost/performance trade-off analyses.

Since, the key to a successful HSI strategy is comprehensive integration across the HSI domains and other core acquisition and engineering processes, HSI domain technical authorities should be integral to the Design Team composition.

The Principle for Safety can help the SDM or SIM scope the required support and help identify appropriate Technical Warrant Holders, Engineers, or SMEs for the HSI domain areas. Although not always shown in the organization chart, cost engineering, and reliability and maintainability engineering support should also be established as an integral part of the design team.

3.3 CHIEF OF NAVAL OPERATIONS SPONSORS, COMMANDER FLEET FORCES COMMAND, JOINT FORCES COMMAND, TYCOMS, OPERATIONAL COMMANDS, FLEET UNITS, AND OTHER USER ORGANIZATIONS.

An OPNAV Sponsor, via a NAVSEA PEO or Program Office, usually initiates pre-AoA and AoA studies. Involvement of a Program Office is not constant from one project to another. If one is already in existence for a given ship type and has been assigned responsibility by COMNAVSEA, then the OPNAV Sponsor for a set of new ship feasibility studies will usually communicate with it directly. A new Program Office will not normally be established just for the purpose of feasibility studies. If one has not previously been designated, communication from OPNAV of the need will usually be addressed to SEA 05. In this case, SEA 05 will ensure that the appropriate PEO is involved in any programmatic decisions.

The OPNAV Sponsor is responsible for requirements definition. Starting even before the AoA, user organizations should be brought into the process. Methods for their involvement have included surveys, visits, workshops, conferences, websites, and participation in design reviews and reading sessions.

SDMs and SIMs are essential participants in requirements definition, ensuring that the performance and cost trade-offs are fully and accurately articulated. Another key aspect of this interaction is to ensure clarity and understanding of requirements between the operational and technical communities. For example, the SDM must advise the requirements setters in OPNAV and the Program Office, both of whom may be unfamiliar with Navy standards and practices, on the appropriateness of proposed "environmental" requirements for temperature, sea state, etc. that can drive the design. The SDM should work with the Program Office to ensure that the needed studies are conducted, all relevant user organizations participate, full briefings are provided to stakeholders and higher authority, and results are documented in technical reports. To this end, the SDM should be one of the Program Office representatives at all requirements working groups, meetings, and briefings.

3.4 JOINT STAFF J6, DEFENSE INFORMATION SYSTEMS AGENCY, JFCOM, AND THE JOINT INTEROPERABILITY TEST COMMAND.

The Joint Staff J6, Defense Information Systems Agency (DISA), Joint Forces Command (JFCOM), and the Joint Interoperability Test Command (JITC) are reviewing authorities for requirements documents and must be consulted beginning with ICD development regarding interoperability and interoperability testing. Please see CJCSI 6212.01 *(hyperlink)* for more information on Joint Staff J6, DISA, JFCOM, and JITC roles and responsibilities in the ship design process.

3.5 PROGRAM OFFICE.

Ship/System design and acquisition responsibility and authority are normally assigned to a PEO Program Office. SDMs are assigned by SEA 05D/V to support the Program Office for ships and SEA 05H assigned SIM to support PEO Integrated Warfare Systems (IWS). SDMs and SIMs shall participate, as appropriate, in Program IPTs, Working Groups, and reviews – assisting the Program Manager in leading all technical aspects.

Some Programs chose to establish a Technical Director within the Program Office structure but now are more often choosing to establish a Principal Assistant Program Manager for Integration who serves as the technical advisor to the Program Manager for issues related to cost, schedule, and technical risk. This new position creates less conflict with the role of the SDM. Each case is somewhat different, but it is clear that the SDM is the warrant holder for ship design technical matters and is held accountable to Commander NAVSEA. The intention has been that the SDM should fulfill the Program Manager's need for a technical advisor. In some cases a formal Memorandum of Understanding (MOU) may need to be established to clearly identify roles and functions to avoid conflict.

In the case of systems under PEO IWS, the SIM is the TWH. The agreement between PEO IWS and SEA05 as to how they are to operate is described in the SEA 05/IWS CONOPS and the Annual Execution Agreement is the financial agreement for a specific fiscal year on the specific support for that year.

The Program Office should be offered the opportunity at design kickoff meetings to highlight acquisition philosophy for the ship and associated systems.

SDMs and SIMs should limit release of information and contacts with higher authority and the news media to those approved by the Program Office.

3.6 SHIP DESIGN MANAGER.

An SDM will normally be designated when either of the following events occurs:

- The ship appears in the Future Year Defense Plan in the current year through three years beyond the current year. For example, in Fiscal Year 2012 (FY12), any ship appearing in the Plan in FY12, 13, 14, or 15 would call for an SDM.
- Upon receipt of a signed tasking from OPNAV via the Program Office

There may be situations other than the two above which justify new SDM designations. They will be considered on a case-by-case basis.

Ship Concept Managers (SCMs) in the Future Ship and Force Concepts Division (SEA 05D1) perform the ship design efforts prior to the designation of a SDM. For a period of time there may be both an SCM and SDM with overlapping responsibilities.

SDMs are designated in writing. Normally, SDMs will not be designated until competency has been verified through the completion of an SDM qualification card. See Appendix V. Upon designation, the SDM will start the interview process for gaining their SDM Technical Warrant as described in the applicable NAVSEA Instructions. Until the SDM receives the SDM Technical Warrant, the SDM will be considered an "acting" warrant holder.

SDMs provide essential technical leadership in guiding the Navy's total ship system engineering team supporting a ship program. The SDM can expect a considerable amount of assistance from line management with respect to identifying internal manpower resources. However, the SDM initiatives define the needs to which management must be responsive. The SDM is faced with executing tasks through people he does not directly supervise and who will be working part-time elsewhere. These are, in many cases, respected authorities in their fields with their own professional objectives, priorities, and programs. Leadership, tactfulness, and excellent communication skills are necessary attributes for any SDM; yet he must know when to be assertive and forceful. The ability to lead and work through people is probably the most important qualification of the SDM.

SDMs have the trust of management, as reflected by granting SDMs warranted technical authority. They are to act as objective, independent, unbiased agents when evaluating the merits of individual technical issues, considering impacts at the higher total-system level. The SDM is to bring all the competing interests together.

The SDM must find solutions that support program execution while meeting the technical requirements of the engineering directorate. A classic example is a ship whose cost estimates necessitate reductions in design features or even standards. The decisions an SDM makes are generally within the bounds of accepted policy and practice. Where potential decisions are outside those bounds, SDMs should contact the affected warrant holder to discuss the merits of the case and obtain input. In rare cases where a design standard has been compromised or a warrant holder has been overruled in the interests of a total ship concern, the SDM must document via serialized correspondence or other appropriate means the rationale for his decision. The SDM must also inform the SEA 05D/V management that such a decision has been made, and attempt to obtain the concurrence of the affected warrant holder. The SDM must tell it like it is. If an SDM is uncomfortable with the level of technical risk in the program, including the adequacy of risk reduction efforts, then the Program Manager should not be comfortable either. If concerns are not being given sufficient visibility, the SDM should exercise the SEA 05 chain-of-command to resolve that situation. The SDM is ultimately accountable for all technical aspects of the product but must work within the total program constraints.

Sometimes, the SDM must arbitrate between individual task leaders when conflicts for ship resources or design preferences arise. For example, ship space and weight limitations may mean that one task leader may gain at the expense of another. If TWHs cannot agree on a technical decision, the SDM should either arbitrate or raise the issue to the higher authority for resolution. See NAVSEA Memo Ser 05D/386 of 30 June 2010, Technical Decision Process (*hyperlink*). In the case of an American Bureau of Shipping (ABS) classed ship, an adjudication process is defined in the NAVSEA/ABS Cooperative Agreement Adjudication. Adjudication requires a mature, calm and professional outlook on the part of the SDM to maintain the proper perspective in regard to the SDM role and its obligations.

The SDM will manage the obligations and expenditures of millions of dollars. These funds will be committed to industry and various government agencies via numerous individual tasks. This business aspect of the job will at times be as important as the technical in regard to the success of the project.

The SDM is directly responsible for the successful management of the ship design project and for the final design package. The SDM has the following major responsibilities:

- Ensure the development of a fully integrated, technically satisfactory ship design that meets the specified performance requirements and cost goals (The SDM must ensure that the design is properly documented and accomplish these tasks on schedule and within the resources allocated for design.)
- Serve as the warranted technical authority for the ship assigned. The SDM must ensure other TWHs are engaged as necessary to resolve issues. If technical differences cannot be resolved, the SDM must document the issue and arbitrate or refer the issue to higher authority for resolution.
- For the ship assigned, serve as the interface between the technical community and the Program Office and OPNAV
- Establish and communicate the design philosophy for the ship
- Establish and lead the Design Team and interface with other elements of the program organization
- Oversee development and implementation of the Design Team Integrated Digital Environment (IDE)
- Manage actions assigned to the technical community and document technical decisions
- Where applicable for T-ships function as the primary point of contact for ABS classification of the ship
- Identify and manage risks
- Prepare Plan of Action and Milestones (POA&M), including cost and man-day estimates, for feasibility studies, Pre-Preliminary Designs, Preliminary Designs and Contract Designs as requested by the Program Office
- Negotiate MOUs and memoranda of agreement as necessary to document relationships with external organizations
- Prepare financial obligation plans for the Program Office (The SDM must seek to obtain all funds necessary for the work and provide to appropriate codes as required. Manage ship design funds allocated to the project.)
- Prepare management plans
- Keep the Division Director and SEA 05D/V/05B informed of progress and major events
- Maintain, report, and use metrics in the implementation of Continuous Process Improvement
- Serve as mentors to the next generation of SDMs
- Remain technically current through training and symposium attendance
- Share lessons learned through annual reports, presentations, and papers
- Provide the demand signal to the SEA 05 TWH community for independent review, assessment, hazard and risk identification, and problem resolution
- Capture, coordinate, advocate for, and document TWH assessments, risks, concerns, issues and resolutions
- Facilitate practical trade-offs and solutions to issues to address TWH concerns

3.7 SYSTEMS INTEGRATION MANAGER.

A SIM will normally be designated when either of the following events occurs:

- The area of expertise and or technology has been identified either by a PEO or SEA05
- Program establishment

There may be situations other than the two above which justify new SIM designations. They will be considered on a case-by-case basis.

SIMs are designated in writing by the Technical Domain Manager (TDM). Normally, SIMs will not be designated until approved by the CHENG (SEA 05).

The SIM executes the Integrated Warfare System Engineering (IWSE) Technical Authority and will be the primary liaison to the IWS SEA05H Chief System Engineer. The SIM provides technical oversight to ensure compliance with DoD/DoN standards, specifications (non-system specific), systems architecture guidance, performance metrics, tools, and best practices. The SIM ensures compliance with PEO IWS Enterprise System Engineering guidance. See the PEO IWS Systems Engineering Concept of Operations (*hyperlink*). Specific responsibilities include:

- Implements SEA05/PEO IWS CONOPS
- Provides leadership for warfare systems engineering process adherence and guidance for the ship class/classes
- Works directly with the SDM to identify competency resource requirements
- Ensures adherence to policy and guidance for the planning, coordination, and execution of warfare system technical authority across platforms as provided by the IWS SEA 05H Chief System Engineer
- Provides oversight for the review process to align it with emerging Navy guidance regarding system of systems design review processes
- Acts as technical Point of Contact (POC) for the Naval Warfare System Certification
- Develops and implements processes to ensure independent technical review of warfare system products including requirements, architecture, design, testing, and certification
- Provides the demand signal to the SEA05 TWH community for independent warfare system review, assessment, risk identification, and problem resolution
- Provides senior level leadership to coordinate technical authority efforts across multiple PEOs and SYSCOMs
- Captures, coordinates, and documents functional TWH assessments, risks, concerns, issues and resolutions
- Facilitates practical solutions to issues to address TWH concerns
- Provides coordination/leadership to ensure proper interface of components, submittal of Government Furnished Information (GFI), Required In Yard Date (RIYD) supply, vendor drawing approval, and identification of risks and risk mitigation plans for system, system of systems, and components
- In addition, may provide assistance in Technical Instruction/Technical Data Package development, Warfare Systems POM issues, and schedule and cost estimates
- Ensures appropriate TWH participation in Warfare System Engineering Technical Teams
- Ensures PEO IWS Technical Authority is aware of any significant technical issues

Figure 3-2 illustrates SEA05 H CAO, and how the SIM will interact with the PEO IWS organization.

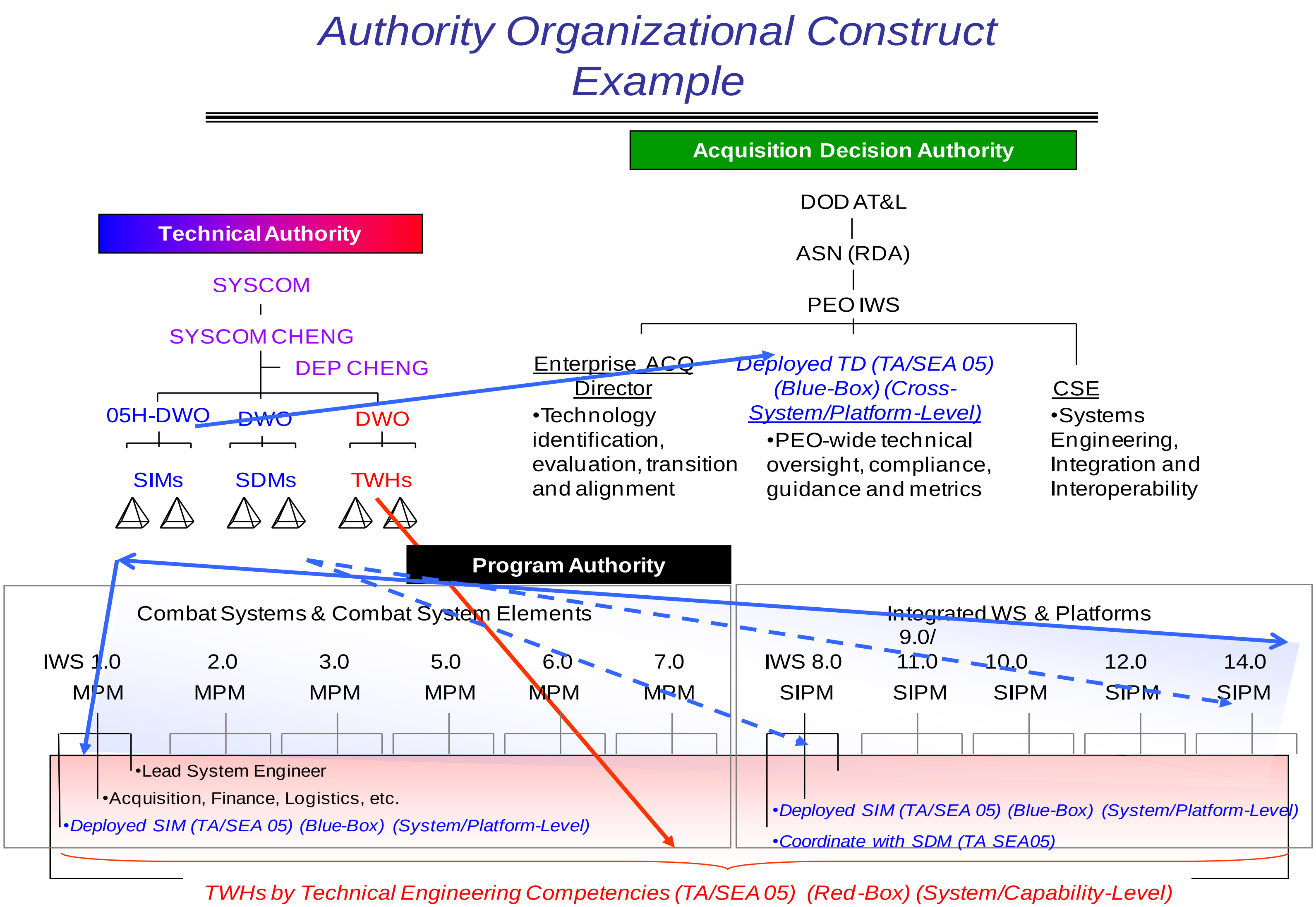


Figure 3-2. SEA 05H – PEO IWS Competency Alignment Organization

3.8 OTHER DESIGN PARTICIPANTS.

Short statements of the role of other design participants follow. See NAVSEANOTE 5400 (*hyperlink*) and Appendix W for extended descriptions.

- Deputy Ship Design Manager is often assigned in the case of major or multiple concurrent designs or in the planning and execution of a major overhaul. This position has proven to be justified for a major ship in Contract Design or in a Refueling Complex Overhaul, as past experience shows that a large portion of the SDM's time is devoted to communication outside the Design Team.
- Design Integration Manager (DIM), often the existing Project Naval Architect (PNA), will generally be responsible for integrating the various elements of the design and configuration control during the Preliminary and Contract Design phases.
- Ship Concepts Manager (SCM) leads the JCIDS-defined pre-Milestone A tasks associated with the development of a CBA, ICD, and sometimes the AoA. He then translates the insights and knowledge gleaned from that involvement to later stages of the program, so as to further the SDM's ability to be fully responsive to those analyses.
- Project Naval Architect (PNA) reports to the DIM and provides assistance with vessel design integration and configuration control. The primary focus areas for the PNA relate to hull form, hull strength, hydrodynamics, sea keeping and survivability, stability, structures, arrangements, habitability, lifesaving and mooring systems, cargo handling systems, and deck systems.
- Project Marine Engineer (PME) reports to the DIM and provides assistance with machinery design integration and configuration control. The primary focus areas for the PME relate to propulsion, power generation, and auxiliary systems.
- System Engineering Managers (SEMs) integrate and represent systems level elements of the ship design such as hull systems, machinery systems, combat systems, aviation, C4ISR, and others, as the design demands. Each SEM is responsible to the SDM, associated SIM and TWHs, and their respective Group Directors for providing a fully developed and properly integrated system that is technically acceptable and meets the operational requirements of the ship design.
- Specification Manager, Specification Task Manager, Specification Editor, and Requirements Traceability Manager manages development of the Ship Specifications and performs requirements traceability.
- Data Manager is responsible for preparation and processing of the Data Requirements List (DRL) and corresponding Data Items (DIs).
- Environmental, Safety, and Occupational Health (ESOH) and/or Safety Manager, and perhaps a Principal for Safety for weapons and (explosives safety) manage ESOH for the Program.
- HSI. Note that the Technical Authority for HSI now flows from the Deputy Warranting Officer to the SDM. It is up to the SDM to ensure there is an HSI SME on the design team.
- Task Leaders are part of the technical core of the Design Team and are responsible to the SEMs for the execution of their parts of the various tasks.
- Interfacing Technical Warrant Holders and Other Subject Matter Experts – Selected TWHs and other SMEs will be needed to review the technical products and participate in certification of the ship and or systems.
- SEA 05C Cost Estimators are critical to the performance of the AoA, subsequent milestones, and source selection. Higher authority needs to assess cost versus performance and establish suitable budgets. The SDM has the lead responsibility for providing design information to SEA 05C.

- SEA 05T provide expertise in Research and Development (R&D) program and project management, provide expertise in technology transition, administer the Small Business Innovative Research (SBIR) program, and provide assistance in conducting Technology Readiness Assessments.
- Government Furnished Equipment and Information Managers (GFE/GFI) must be brought into the design process by the SDM to verify the performance; space; weight; manpower, personnel and training; and services impacts of their systems. GFE/GFI adequacy and timeliness must be monitored.
- Naval Reactors (SEA 08) is responsible for management of all aspects of design, acquisition and maintenance pertaining to nuclear propulsion in U.S. Naval ships and submarines.
- Naval Surface Warfare Centers (NSWCs) are the Navy's full spectrum research, development, T&E, engineering, and Fleet support centers for ship hull, mechanical and electrical systems, surface ship combat systems, coastal warfare systems, and other offensive and defensive systems associated with surface warfare.
- Naval Undersea Warfare Centers (NUWCs) are the Navy's full spectrum research, development, T&E, engineering, and Fleet support centers for ship hull, mechanical and electrical systems, surface ship combat systems, coastal warfare systems, and other offensive and defensive systems associated with undersea warfare.
- Ship's Force has the overall responsibility for the maintenance and operations of all shipboard systems and equipment.
- Independent Review Teams conduct design and technical assessments in areas where technical risks are high. Sources of independent reviewers include "graybeards," academia, professional organizations, and industry.
- United States Coast Guard and American Bureau of Shipping - Ships crewed by the Military Sealift Command (MSC) normally make maximum use of commercial standards and construction practices. They are normally required to be built to ABS rules, classed by ABS and under USCG and Navy standards as applicable. See Appendix T (*hyperlink*).
- Shipbuilders, Integrators, and Vendors - Consistent with the acquisition strategy, industry should participate in the design process early to gain an understanding of Navy requirements, help identify cost drivers, incorporate producibility considerations, and ensure the clarity and consistency of the specifications.
- Supervisors of Shipbuilding (SUPSHIP) offices and their design divisions should be involved early to leverage lessons learned for development of the Ship Specifications as well as enforce NAVSEA requirements during construction. See Appendix I (*hyperlink*) and NAVSEAINST 5400.95 (*hyperlink*).
- Fleet Modernization Organizations are described in Appendix L and Appendix M.

CHAPTER 4
DESIGN MANAGEMENT PLANNING

4.1 SHIP DESIGN PLANNING.

The planning effort and a documented plan are the keys to the success of a complex ship design project. Therefore, they should be accomplished as the first effort in all ship design projects. Urgency to proceed with the design should not be an excuse to bypass the planning step.

The extent of planning needed and the size of the formal plan will vary with the nature of the product and the design phase. Planning should be tailored to the need. A greater degree of formal planning is needed for more complex ships, more unusual procedures, later design phases, larger numbers of participants, and more unusual organizations.

This section describes major ship design planning considerations. Most of this information will be captured in an Engineering Management Plan (EMP) authored by the SDM. Requirements for developing this plan are described later in this section. It should be emphasized that a solid plan is needed to support the SDM's budget request. Furthermore, financial and schedule planning are equally important as technical planning in arriving at a fully executable plan. Note that the SDM will need to work with the Program Office to develop the separate SEP required in support of program assessment.

4.2 AUXILIARY & SPECIAL MISSION SHIPS.

Auxiliary & Special Mission ships (commonly referred to a "T-SHIPS") are generally procured for the MSC via a PEO Ships Program Office. Their design and acquisitions differ somewhat from those conducted for naval warships. See Appendix X (*hyperlink*) for guidance based on proven past practice. See ASTM F1547 and ASTM F1547-9 for listings of relevant standards and publications for commercial shipbuilding.

4.3 COMMUNICATIONS.

Program Offices are normally the releasing authority for correspondence and other external communications concerning their ships. SDMs must be compliant with both SEA 05D/H/V and Program Office protocols for communications with other organizations, adhering to the most stringent requirements of each. Specific instructions have been issued governing internal routing, formal review, and approval of acquisition program documents and official correspondence before official program responses are forwarded. See SEA 05 Policy on Review and Approval of Products for Distribution outside Naval Systems Engineering Directorate, Ser 05B/066 of 17 November 2009 *(hyperlink).*

SEA 05D/H/V procedures, including appropriate use for different types of correspondence, sample templates, and approval authority, are summarized in their shared folders on CDMS. General practice and formats are also described in the Navy Correspondence Manual *(hyperlink).*

Good practices for briefing development are discussed in Appendix Y *(hyperlink).* See also the standard SEA 05 routesheet *(hyperlink*) and briefing sheet *(hyperlink*).

The results of design efforts shall be reported in writing by NAVSEA in the form of a concise technical report forwarded by serialized correspondence. These are usually signed by both a SEA 05D/V representative and the PEO Ships Program Office for SDM reports. For SIM reports they are usually signed by SEA 05H and PEO IWS Program Office. Please see Appendix Z *(hyperlink)* for a report template. PowerPoint® presentations are useful primarily as a summary of, and not a substitute for, concise technical reports and memorandum for the record.

SDMs deal with many matters that relate to interactions taking place at the Flag/SES level both inside and outside of SEA. SEA 05 management depends on SDMs to keep them apprised on such matters. It is also important to brief them when there is a need for their involvement, or when it is anticipated that another senior principal may contact them. SDMs must facilitate continuous awareness on technical issues in the SEA 05D/H/V and SEA 05 front offices. This should also include advance visibility on key program decision meetings, Fleet or Type Commander (TYCOM) actions and higher level reviews outside the Command.

4.4 ACQUISITION STRATEGY.

The single largest factor in planning any design effort is selection of the acquisition strategy. The process of arriving at the strategy is the responsibility of OPNAV, SECNAV, and the Program Office and is beyond the scope of this document. The SDM's and SIM's role during this phase is to be an advisor to the Program Office on how process choices can affect design evolution. From a design standpoint, the acquisition options generally align with whether the government (i.e., Navy) or industry will perform the engineering, and for which phases. The ship design process can take place in either a cooperative or competitive design environment. In a cooperative one, a single team is formed that is composed of both government and industry team members usually operating under a Navy lead. In a competitive design environment, two or more industry teams each develop a ship design and compete for contracts to further design and build the ship. The type of design environment used for the ship design affects the role of government in the design process, but does not change the basic design process. In either approach it remains the responsibility of the government to ensure that a satisfactory product is developed and delivered to the Navy.

Figure 4-1 illustrates the range of acquisition strategies that have been considered and employed for ship procurements. SDMs should work with the Program Office to ensure their concerns are addressed in the decision making process.

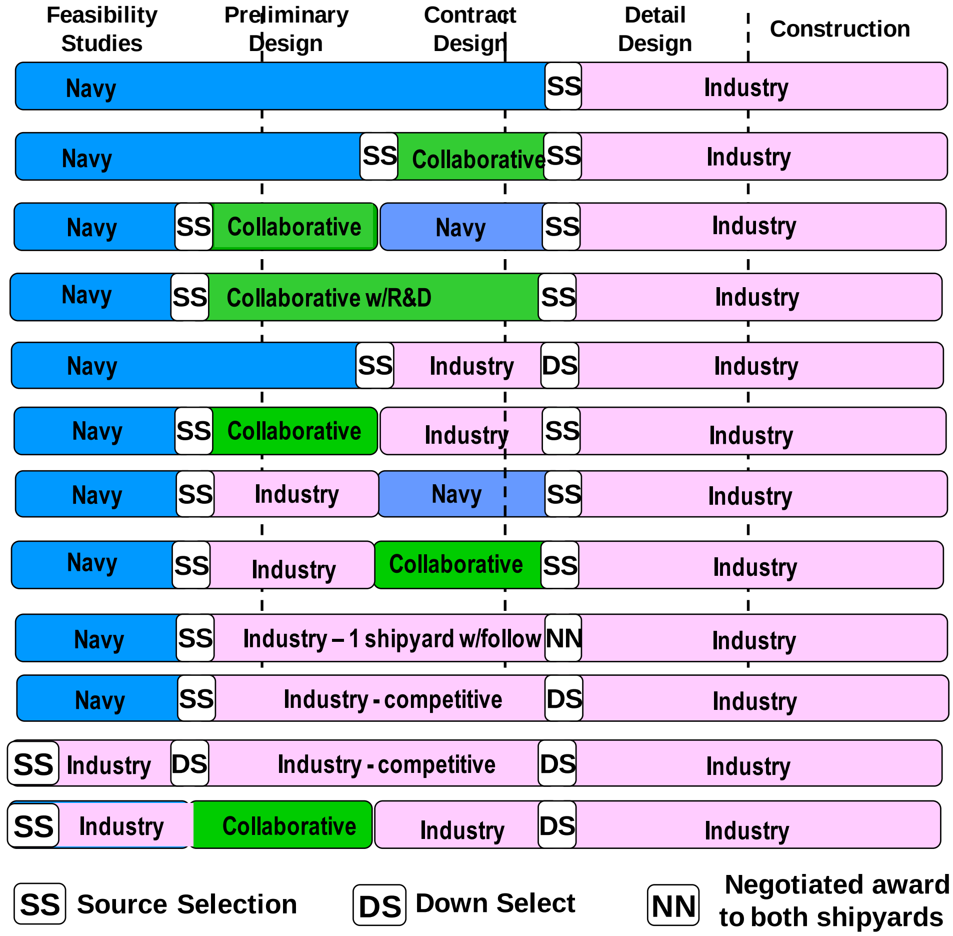


Figure 4-1. Acquisition Strategy Alternatives

Considerations for selection of the acquisition strategy include:

- Maturity of requirements definition and technology development when the design process will be turned over to the shipbuilder(s)
- Nature and severity of risks
- Projected maturity of the design and pricing at DD&C award
- Potential for competition
- Availability of funding for the conduct of multiple design efforts
- Availability of Navy personnel for design, oversight, and source selection
- Availability of schedule for the conduct of multiple source selections

Transfer of design responsibility and risk to industry is often cited as a consideration. Based on contracting experience to date, the Navy's exposure does not significantly lessen when industry performs the design. The DDG 1000, LCS, USCG Deepwater Program, and unsuccessful attempt by the CVN 77 to have an integrator develop the combat systems provide appropriate lessons.

Current policy discourages use of an integrator rather than a Shipbuilder to perform as the prime contractor.

Regardless of which acquisition strategy is chosen, delivery of a ship that meets performance, cost, and schedule thresholds remains largely dependent on day-to-day program execution. The devil is in the details. The SDM should participate in development of all contracts, including the active participation in the development of how each will be administered. Areas of interest include use of incentives, SDM participation in the incentive process, lead/follow yard relationships, integrated data environment and product model requirements, data deliverables, limitations on subcontracting, directed subcontracting, "Buy America" requirements, data rights, intellectual property, and many others. See Appendix AA *(hyperlink)* for a further discussion on contracting considerations.

4.5 DESIGN TEAM FORMATION.

Formation of the Design Team is one of the most important functions of the SDM. It typically occurs early in the design process and, once established, is lived with for an extended period of time. There are several approaches to organizing and staffing a ship Design Team. The strategy for forming the team is a function of many factors, such as:

- Acquisition strategy determined by the Program Office
- Program Manager mindset on size or makeup of the team
- Availability and continuity of government personnel
- Ability to seat certain personnel at collocated design sites and their ability to gain suitable computer access
- Funding availability for team members, especially early on (e.g., lack of funding may force use of particular organizations)
- NAVSEA and, especially, SEA 05 policy and guidance
- Whether the ship will be ABS classed and/or USCG certificated

4.5.1 Use of Contractors. SDMs should be careful not to use contractors for inherently governmental functions or personal services. Contractor work assignments should be completely and precisely specified in the task statement and formally issued to the contractor, rather than individual employees. The government and the implementation of those policies and decisions within the system shall retain the policy and decision-making function. It is proper to use contractors to develop products or draft technical inputs, which are used in the decision process. However, contractors shall not formulate government policy or define the government's needs. With the consent of NAVSEA contracting (SEA 02), support contractors may participate in development of the acquisition strategy and may serve as reviewers on source selections.

Organizational Conflicts of Interest (OCIs) may arise from the contractor's relationship with both the government and a Shipbuilder. OCI is normally prohibited under NAVSEA support contracts. Waivers may be obtained. NAVSEA Contracting (SEA 02) should be consulted for OCI determinations.

4.5.2 Support Contracting. NAVSEA design support is normally obtained through the NAVSEA multiple award contract. Multiple omnibus SEA 05 and other support contracts are currently in place. Shipbuilder team or other industry participation normally requires the award of new contracts.

For T-ships support from ABS is normally obtained through a direct contract that exists between PEO Ships and ABS.

4.5.3 Ship Design Strategy for Contractor Support. Ship Pre-Preliminary, Preliminary, and Contract Designs may be categorized as a "Navy Design" or a "Contractor Design." A "Navy Design" is one which NAVSEA retains firm "hands-on" design control, making all day-to-day design decisions, managing the creation and upkeep of design artifacts, and performing design integration. Navy Designs are rarely done entirely in-house but employ varying degrees of design agent contractor support reporting directly to Navy personnel. The SDM Design Team, in concert with other participating TWHs, makes all major design decisions and approves all other design decisions as the design develops. For T-ships ABS review and concurrence is desirable if the ship is being ABS classed. The TWHs are fully responsible for their areas throughout the design. The distinction that differentiates a Navy Design from a Contractor Design is the degree of design control the Navy retains.

A "Contractor Design" is one over which the contractor – typically a Shipbuilder or integrator – has "hands on" design control, making all day-to-day design decisions and accomplishing design integration. The role of the SDM and the government Design Team is primarily restricted to establishing design requirements, ensuring the requirements and design philosophy are understood by the contractor, tracking contractor resource use, reviewing design assumptions, and conducting periodic top level reviews to ensure compliance. NAVSEA is still fully responsible for the ship design to perform the mission in accordance with the Sponsor's requirements. Design responsibility of some "fenced" areas, such as underway replenishment and exterior communications, may be assigned to organizations other than the contractor to take advantage of specialized expertise or to ensure commonality with the rest of the Fleet. In these cases, the SDM is responsible for managing the interfaces and ensuring the integration of the efforts of multiple organizations.

4.5.4 Design Site Location. Co-location of the Design Team was recommended by the 1991 NAVSEA Ship Design, Acquisition and Construction Process Improvement Study and has proven beneficial for many Programs. Communications are much easier and the level of collaboration markedly improves when the design team is co-located. Experience with recent Programs have again proven that, despite the marvels of wide area network computers, there is no substitute for physical collocation in developing integrated ship designs. SDMs should push hard for this objective because it will make the design management and control function considerably easier. The Design Site is normally located in or within walking distance to NAVSEA headquarters to facilitate the frequent visits of NAVSEA, PEO, and local support contractor personnel who may not be co-located. Computer connectivity and seating for support contractors have proven to be major stumbling blocks for locating such sites on Navy Yard premises and must be carefully considered.

4.5.5 Design Team Organization including IPTs and Working Groups. Whether it's a Navy or Contractor Design, a substantial SDM-led, in-house technical organization is required to carry out the NAVSEA responsibility of delivering quality ships to the Fleet. Design Team organization is typically functionally based and must also embody some form of "matrix" behavior in which so-called "total system engineering" disciplines such as HSI, general arrangements, signatures, logistics, cost, safety, etc. must be involved with all the hardware and software disciplines, such as machinery, deck systems, communication systems, etc. For example, safety is not a design function that can be executed by itself; it must necessarily influence all the others. Similarly, designing the mooring system cannot be done independently of the goals and requirements of the total ship, such as safety. In an attempt at addressing the problems of matrix organizations, Design organizations now incorporate ESOH, HSI, RAM, Corrosion Control, Risk Management and other Integrated Product Teams (IPT) and Working Groups. Appendix BB (*hyperlink*) provides guidance on the implementation of IPTs and Working Groups.

The SDM, SIM, and other Design Team members shall also participate in Program IPTs and Working Groups – providing technical leadership and input as needed.

4.5.6 Evaluating Design Team Capability. When assembling a Design Team, the SDM should evaluate its capabilities to determine organizational risk areas and to establish a basis for implementing activities to improve the Design Team efficiency and effectiveness. Appendix CC *(hyperlink)* provides evaluation guidance.

4.6 FINANCIAL PLANNING AND EXECUTION.

Budget development, defense, and execution are among an SDM's most important functions. Without budget the SDM cannot perform. Securing excessive funding or failing to obligate and expend in a timely fashion, however, is a sure way to lose credibility. The Deputy Warranting Officers (DWOs) are responsible for securing funding for the SIM and their TWHs. The funding can be a combination of project or Sponsor funding. The demand signal and funding will be established yearly in the Annual Execution Agreement. See Appendix DD (*hyperlink*) and Appendix EE (*hyperlink*).

4.7 SCHEDULE PLANNING.

Project schedules developed by the SDM must be consistent with the schedules put forth by the Program Office. Based on the acquisition strategy, the SDM should establish preliminary project schedules for the conduct of the intervening design effort. Ideally, SEMs will prepare Work Task Assignment/Statement of Work (WTA/SOW) schedules using the preliminary project schedule as guidance. The SDM then integrates these, revises the schedules, and negotiates differences and conflicts with both the Program Office and the SEMs. The importance of a sound initial schedule cannot be overstated. Change inevitably will occur and disrupt the most careful planning. However, a well thought out schedule should provide contingency room in risk areas wherever practical. A comprehensive knowledge of milestone interdependencies will be invaluable in restructuring planning when such needs arise during the actual design activity. See Appendix FF for an expanded discussion on schedule management *(hyperlink)*.

The IWS DWO will develop an Integrated Master Schedule (that will include all major reviews including gate reviews). This IMS will be used to estimate the demand signal for a specific fiscal year as well as a planning tool for SIM and TWH to develop their work schedule for a specific year. See Appendix GG for a template *(hyperlink)*.

4.8 DESIGN WORK PLANNING.

4.8.1 Work Breakdown Structures. The Work Breakdown Structure (WBS) is the basic context within which the entire ship design effort is planned, managed, and documented. Care must be taken to coordinate development of the WBS with all elements of the Design Team with emphasis on weights, cost, systems engineering, and production. MIL-STD-881 *(hyperlink)* provides guidance. The Expanded Ship Work Breakdown Structure (ESWBS) should be used as a basis for ship systems. See the ESWBS Manual S9040-AA-IDX-010/SWBS 5D (*hyperlink*). This provides a link to historical data.

Sea System		
	Ship	
		Hull Structure
		Propulsion Plant
		Electric Plant
		Command, Communication and Surveillance
		Auxiliary Systems
		Outfit and Furnishings
		Armament
		Total Ship Integration/Engineering
		Ship Assembly and Support Services
	Systems Engineering/Program Management	
	System Test and Evaluation	
		Development Test and Evaluation
		Operational Test and Evaluation
		Mock-ups/System Integration Labs (SILs)
		Test and Evaluation Support
		Test Facilities
	Training	
		Equipment
		Services
		Facilities
	Data	
		Technical Publications
		Engineering Data
		Management Data
		Support Data
		Data Depository
	Peculiar Support Equipment	
		Test and Measurement Equipment
		Support and Handling Equipment
	Common Support Equipment	
		Test and Measurement Equipment
		Support and Handling Equipment
	Operational/Site Activation	
		System Assembly, Installation and Checkout on Site
		Contractor Technical Support
		Site Construction
		Site/Ship/Vehicle Conversion
	Industrial Facilities	
		Construction/Conversion/Expansion
		Equipment Acquisition or Modernization
		Maintenance (Industrial Facilities)
	Initial Spares and Repair Parts	

Figure 4-2. Ship Work Breakdown Structure from MIL-STD-881

4.8.2 Ship and Software Architectures. Development of the SEP requires a detailed description of definition of ship and software architectures and asks about the employment of the DoD Architecture Framework (DoDAF) (*hyperlink*). Recent Programs such as MLP have employed ESWBS for the ship systems and simply broken out GFE and outfit as the other components of the ship architecture. The software architecture has also been defined as a simple functional listing. DoDAF use for ships is normally limited to development and documentation of the C4I requirements in the CDD. DoDAF could be employed on a whole ship basis but that will require a considerable investment and may or may not genuinely facilitate requirements definition and ship design.

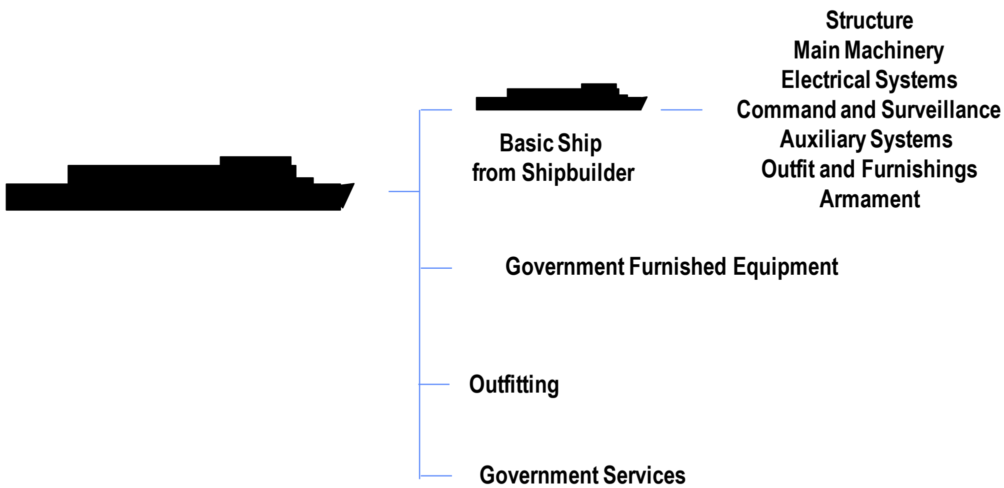


Figure 4-3. Sample Ship Architecture

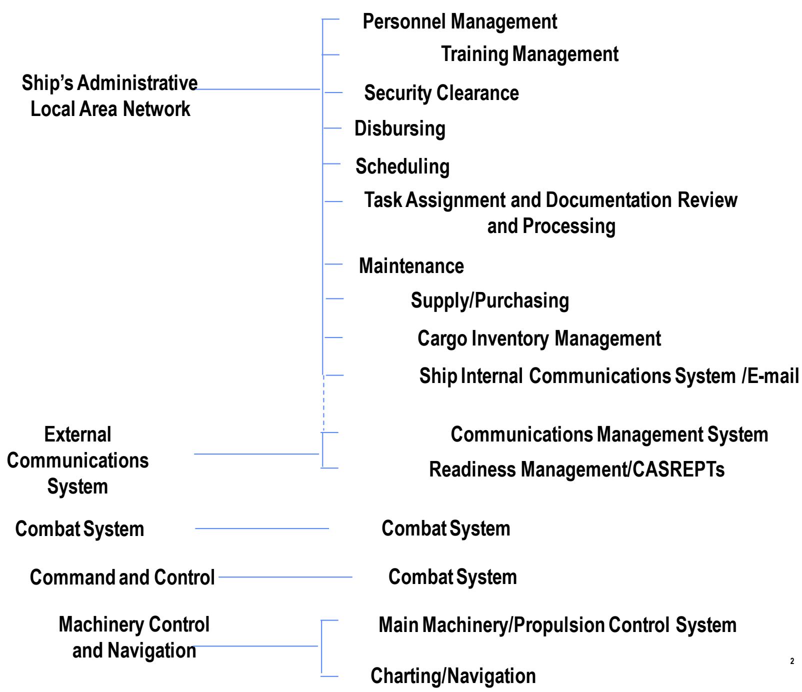


Figure 4-4. Sample Software Architecture

4.8.3 Design Structure Matrix and Design Process Modeling. Design Structure Matrix (DSM) and Multi Domain Matrix compactly represent the relationships between design activities. Figure 4-5 shows an example of a Multi Domain Matrix. In this representation, each of the rows corresponds to a Design Activity, and each of the columns a Design Variable. The numbered diagonal represents that Design activity for row *n* produces as output variable the design variable in column *n*. A dot in a cell indicates that the associated design activity for the row takes as input the design variable corresponding to the column of the dot. By sequencing the design activities within the matrix in the order of execution, much can be learned. Dots below the diagonal indicate variables that have been produced by previous design activities. Dots above the diagonal indicate variables that are needed by a design activity, but are not scheduled to be produced until the future. The value of the variable must be assumed, a "cluster" of activities must be solved simultaneously, or the design activities must be re-sequenced. Determining the optimal ordering of design activities is relatively easily accomplished using well known matrix operations.

Another insight that can be easily observed is shown by variables 1 and 2 of Figure 4-5. These two variables do not depend on each other in any way and could be solved in parallel.

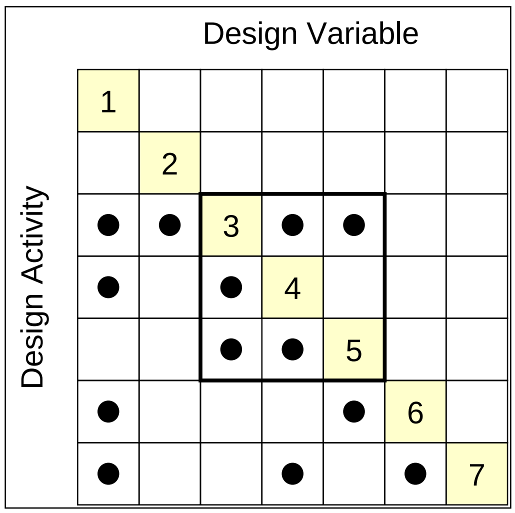


Figure 4-5. Multi Domain Example

See Appendix HH (*hyperlink*) for a more detailed discussion of the application.

Efforts have also begun to model the ship design processes using PLEXUS and other software tools. This will provide an initial template for new ship design programs to use to define, model, and optimize schedule, resource availability, and resource requirements for each design phase.

4.8.4 Sponsor Tasking and Annual Execution Agreements. NAVSEA ship acquisition programs will develop ship designs in response to formal, signed, Chief of Naval Operations (CNO) tasking statements accompanied by funding and explicit statements of requirements. One formal Program Office vehicle for conveying program direction, funding authorization, and delegation of authority for ship acquisition programs to the Participating Acquisition Resource Managers (PARMs), other SYSCOMs, SUPSHIPs, and SDMs has been the Ship Project Directive (SPD). The use of the term SPD, at least for SDM and SIM funding, appears to be falling out of use.

The Customer Service Agreement (CSA) or CONOPS for SEA 05H addresses the naval engineering demand signal from the PEO, and how that demand signal will be satisfied by the NAVSEA Research & Systems Engineering (R&SE) Competency. The CSA/CONOPS is agreed to by SEA 05 and the applicable PEO. Subordinate to the CSA/CONOPS, individual Annual Execution Agreements (AEAs) are negotiated between each Program Manager and SDM assigned to each program. In the case of SEA 05H the AEA is negotiated between PEO IWS (all IWS PO) and IWS DWO (SEA 05H). Once the AEA is in effect, it shall be reviewed and updated annually. A template for the AEA is provided in Appendix JJ *(hyperlink)* .

The CSA/CONOPS and AEAs are overarching in nature, and focus on the research and systems engineering needs of all PEO ship acquisition programs using a common process and common metrics. The R&SE Competency will either provide or manage all naval research and engineering services in support of the PEO. That scope includes the following areas:

- Ship Design, Total Ship Integration, and Total Ship Systems Engineering
- Cost Engineering
- Human Systems Integration
- Systems Safety
- Marine Engineering (Propulsion, Auxiliary Systems, Hydro, Stability, Electrical, & Power Systems)
- Ship Integrity & Performance (Hull, Structures, Survivability, Materials, & Environment)
- Test and Evaluation Policy/Infrastructure
- Warfare Systems Ship Technical Integration
- Cargo/Mission Systems Engineering
- C4ISR/FORCENet Ship Technical Integration
- Aviation Systems Ship Technical Integration
- Network Systems, Ship Technical Integration

In general, the execution of that effort will be focused through a warranted SDM/SIM, under the day-to-day guidance of the Program Manager. This scope will include support from all the research and systems engineering provider communities. This agreement does not impinge upon relationships between PEOs that involve the conduct of design and engineering on payload shipboard systems (e.g., PARM relationships between PEO Ships and PEO IWS or PEO C4I).

Once the plan and Design Team budget are established for the coming year, the SDM/SIM is wholly responsible for execution. Significant increases/decreases in demand signal during the execution year (e.g., program expansion/restructuring, battle damage, shift of work from industry to government) should trigger a renegotiation of resources. If a funding change occurs that will impact the Design Team budget, Program Managers will enter into discussions with the SDM and DWO for IWS to renegotiate the scope of required effort. If this becomes necessary, renegotiation of the AEA should be pursued to achieve an acceptable level of government risk.

4.8.5 Work Task Assignments and Statements of Work. The basic vehicle for negotiating work agreements with the design participants is the WTA or SOW. They typically contain the following:

- Technical discipline or WBS (WTAs normally address an entire technical discipline.)
- Objective
- Task description and scope
- Deliverables and other outputs, such as support for reviews, etc.
- Schedule and milestones
- Resource requirements (usually expressed in $ by fiscal year)

A sample SOW is shown in Appendix II *(hyperlink)*.

WTAs or SOWs are developed for each element of the WBS, using the baseline or standard from a previous similar design as a point of departure. They are managed by Task Leaders (TLs) who report to their respective SEMs on the Design Team. Deliverable titles generally do not change from one design to another. However, deliverables may be added or deleted as required.

Work task assignments or SOWs may be initially drafted by the responsible SEM/TL or as a joint venture with the SDM. In the former case, adequate guidance regarding the project (such as phase completion date, evaluation criteria, and budget planning guidance) must be provided by the SDM prior to start of the design phase. It should be made clear to the TLs that no work is to start until the SDM has approved the WTA or SOW.

4.8.6 Memoranda of Understating and Memoranda of Agreement. MOUs and Memoranda of Agreement (MOAs) have been used effectively to document relationships between Program Offices that need to cooperate. MOUs and MOAs have also been employed by SDMs to formalize support arrangements with organizations from other commands. In addition to identifying roles and responsibilities, these documents usually define who pays for work that may be undertaken as a result of the agreement and how the agreement is managed.

4.9 DESIGN ENVIRONMENT.

A smoothly functioning design environment can facilitate the design process and allow participants to focus their energies on design challenges. Conversely, a poorly functioning design environment can drive up costs, disrupt schedules, and cause the design to fail. Design environment issues rarely have the appeal of ship technical issues to the SDM. Nevertheless, the design environment and the collection of design tools that will be applied to the program deserve the SDM's careful attention. See Appendix KK *(hyperlink)*.

4.10 OTHER KNOWLEDGE MANAGEMENT SYSTEMS.

While each ship Design Team will likely maintain their individual Integrated Data Environment, the SDM must interface with a number of other Knowledge Management Systems maintained by SEA 05D and other SEA 05 codes on CDMS, other Navy websites maintained by the NSWCs such as NSERC, and DoD websites such as the Defense Technical Information Center (DTIC).

Within SEA 05, the Correspondence Files are the primary means for capturing technical information for future long term re-use. In general, any technical decision by a warrant holder should be documented in a serialized memorandum and stored in the Correspondence Files. The Annual Reports document a number of lessons learned where the lack of serialized documentation of warrant holder decisions has led to significant design and production rework at great cost. SDMs should also document significant presentations made to senior Navy leadership as an attachment to a memo to file and insert the memo into the Correspondence File.

4.11 ENGINEERING MANAGEMENT PLANS AND PROGRAM SEP.

An EMP shall be prepared and approved prior to the start of the corresponding design phase. The purpose of the Engineering Management Plan is threefold:

- Serves as principal vehicle for negotiating the scope of the effort desired by the customer, generally the Program Office
- Demonstrates that the design can be successfully completed within cost and schedule
- Promulgates guidance and direction to project participants with respect to project objectives, participants, responsibilities, resource allocation and control, schedule, technical and administrative controls, presentations and reviews, and final products

Appendix LL (*hyperlink*) provides guidance on format and content of the EMP. The EMP is approved by the appropriate SEA 05D/H/V Division Director. Note that this format is intended to provide the Design Team critical organizational and process guidance while minimizing duplication with the SEP. As the Lead Systems Engineer for the Program, the SDM is also responsible for development of the SEP. Meeting with the DoD and ASN RDA Systems Engineering organizations early in SEP development is recommended.

4.12 STUDY GUIDES.

For Navy Designs, the SDM should also develop and issue more detailed design guidance under his signature to the Design Team as a design study guide. For Contractor Designs, the acquisition strategy may dictate development of specifications or a circular of requirements for incorporation in the design contract.

4.13 PROJECT DATA SHEETS.

Development and approval of Project Data Sheets (PDSs) is required in advance of selected documentation such as the SEP. See the instructions *(hyperlink*) and format.

4.14 OTHER MANAGEMENT PLANNING.

4.14.1 Risk Management. One of the SDM's/SIM's primary roles is to support and enable an effective risk management process. This program addresses programmatic risks and system safety risks. Such a program is normally begun late in the AoA to identify and mitigate risks so as to maximize the probability of a successful ship acquisition program. DoD Instruction 5000 requires a programmatic risk management process and the preparation of formal risk assessments for each Milestone. Furthermore, DoD Instruction 5000 requires using system safety risk management to ensure that hazards to system users are understood and accepted.

NAVSEAINST 5000.8, Naval SYSCOM Risk Management Policy, (*hyperlink*) provides policy for managing system acquisition risks, both programmatic and system safety. The Defense Acquisition University Publication, Risk Management Guide for DoD Acquisition, Sixth Ed., August 2006 (*hyperlink*) is a practical reference to programmatic risk management. SDMs shall conduct system safety risk management in accordance with MIL-STD-882 (*hyperlink*), which provides the framework and is referenced in DoD Instruction 5000, and NAVSEAINST 5100.12B, System Safety Engineering Policy, Ser 05S/2011-183 of 3 August 2011 (*hyperlink*), which provides policy and direction tailored for NAVSEA system safety risk management.

A primary goal of risk management is risk acceptance and approval. The policy for this is in NAVSEAINST 5000.8 (*hyperlink*) and shall be followed. It is shown therein and in Figure MM-5.

See Appendix MM *(hyperlink*) for additional information on risk management.

4.14.2 Design Budgeting. Allocation of design constraints such as weight, electrical power, bandwidth, and signatures to the subsystem leads may facilitate the design process. This process is known as "design budgeting."

The design budget technique as a management tool for control of values of key parameters such as weight and space and selected ship services during the Preliminary Design and Contract Design phases has been implemented in previous designs such as the FFG 7, 3K SES, DDG 51, and most recently LCS and its mission modules. This technique has also been used to permit continued combat system development during Detail Design and was successfully used in the CG 47 and DDG 51 programs. The intended use of the design budget concept is to serve as an auxiliary design control tool in the Preliminary Design and Contract Design phase and to be available for use during early stages of Detail Design.

Design budgeting is a ship design and acquisition strategy that provides the structure for contractual accommodation and management of change. Design budgeting allows continued development of weapon systems and supporting ship systems following the award of the ship design and construction contract. Boundaries on time, compartment arrangement, and ship services established prior to contract award form the limits of change without affecting construction schedules or contract cost. Budgeting is applied to systems that are a part of the basic ship and will be aboard the ship at delivery. It is not applied to systems that are planned for future installation by Ship Alteration (SHIPALT).

Design budgeting allows earlier, more independent and detailed system architectures earlier in design. When design budgeting is used, design budget zones or physical boundaries are set within the ship during Preliminary Design and Contract Design. The zone boundaries shall be established by identifying the perimeter of those compartments that contain developmental systems or equipment. Limits on space, weight, Heating, Ventilation and Air Conditioning (HVAC), electrical power, and auxiliary requirements shall be established for each zone. Each limit is set by establishing the service requirements of each component planned for installation in the design budgeted zones. Certain equipment in each zone will not be developmental and explicit requirements can be set. Requirements for developmental system components shall be negotiated with the system developers, and design budgets, or limits, are set for each service. A margin on each service is reserved for the aggregation of all services required in all design budgeted zones. This margin is debited against Preliminary Design and Contract Design phases, GFE, and Detail Design margins. A schedule shall be established for the release of data for each zone. The schedule is to be based upon estimated system development lead times and Shipbuilder design and construction schedules.

An example for time budgets for warfare systems would be how far the sensor needs to see/identify so the operators have time for appropriate response. This time will be allocated across warfare systems as appropriate.

4.14.3 Configuration Management. Configuration management is the process by which changes to the design baseline are subjected to management attention and approval. During feasibility studies and Preliminary Design, because of the relatively small numbers of participants, an informal configuration management process may be followed. During Contract Design, the SDM may choose to delegate to the SEMs authority to approve changes to the baseline, with only selected exceptions being referred to the SDM for approval. A level of formal documentation sufficient to keep the Design Team informed of changes, ensure analysis is conducted on the proper configuration, and to assure design traceability must accomplish this. The key to configuration management is effective communication accomplished by:

- Easy access by all participants to the current and historical design baselines. Each iteration of the design must be clearly identified by its defining set of design artifacts.
- Frequent informal drawing board reviews conducted by the PNA or DIM, SEMs, and the SDM
- Timely advisories from SEM to SDM/SIM when significant changes have been authorized

As the design converges, more and more of the ship system design will be frozen and require formal configuration control boards to change. For example, because of their effect on the design of other elements of the ship system, the hull design and propulsion main equipment selections are expected to be finalized relatively early in Preliminary Design.

During Contract Design, the Specifications, Contract Drawings, and Project Peculiar Documents (PPDs) should be progressively placed under formal configuration management. Planning which documents are to be brought under formal control and their timing is an important function of the SDM/SIM. These dates should be shown in the EMP for each design phase.

Since the Program Office maintains budget authority, the Program Manager must be involved in the configuration management process. The level of involvement of the Program Manager in this process will increase as the design matures. As early as Contract Design, the Program Manager may assume leadership of the configuration management process. The DD&C contract should include language requiring the contractor to continue configuration management through delivery. For contractor Preliminary Designs and Contract Designs, the contractor should be required to perform configuration management equivalent to what would be performed for a Navy Design.

Starting in DD&C, a formalized engineering change process is generally implemented to develop, price, and approve changes in the contract. SDMs should ensure that they and the appropriate TWHs are reviewing authorities.

See Appendix U (*hyperlink*) for additional information on configuration management.

4.14.4 Design Review and Approval. Naval ship designs are normally subjected to a series of informal and formal reviews by NAVSEA engineering and others. The scope of this review should be tailored to the complexity of the design project, with major combatants generally completing all, while auxiliary, T-ship, amphibious ships, and smaller craft use a subset. The process should include documentation of requirements, standards, and products, together with the corresponding TWHs and stakeholders.

4.14.4.1 Design Decision Memoranda. The SDM will develop a process to record major design decisions and agreements reached during meetings. These records are generally referred to as “design decision memorandums” or “statements of findings” and serve as supporting documentation to the SDM, TWHs, and Program Manager to ensure all stakeholders are not only aware of design decisions at the time the decisions are made but also serve as a historical record or “design history” if questions arise during subsequent design phases.

4.14.4.2 In-Process Design Reviews. Informal and formal in-process reviews are scheduled at the peer and higher levels typically at the end of each design iteration. Subsystems will have special reviews, especially for those undergoing new development with extensive prototyping and testing.

4.14.4.3 End-of-Phase, System Engineering Technical, and Program Support Reviews. End-of-phase formal reviews are generally conducted in concert with the Program Office, supporting SYSCOMs, and affiliated PARMs and support the larger Gate and Milestone program-level reviews. Close coordination with the Program Office is required.

The recent revision to SECNAVINST 5000.2 provides for a common System Engineering Technical Review (SETR) process. See NAVSEAINST 5000.9 (*hyperlink*). Each technical assessment culminates in a formal meeting that documents recommendations to program management concerning the continuation of work into the next stage of development. For ship Programs SETRs are normally conducted in conjunction with a Technical Review Board (TRB) and Stakeholder Steering Board (SSB) and results in issuance of a Technical Feasibility Assessment (TFA). The SDM should work with the Program Office to consider whether or not the TRB and SSB should be held as separate briefings. See Section 2.4 and Appendix Q (*hyperlink*) for additional description of SETR reviews and Appendix NN (*hyperlink*) for a description of typical design review content.

DoD Systems Engineering will conduct a Program Support Review for ACAT I Programs roughly six months prior to Milestone A and then for each subsequent milestone. The Program Support Review is basically an inspection of Program readiness focusing on systems engineering planning and execution but touching on all functional areas.

4.14.4.4 ABS Review. Where applicable for T-ships, ABS is expected to review the design and approve those aspects of it related to classification. In addition, the Navy will review and approve the entire design. See Appendix T (*hyperlink*) for additional information on ABS involvement.

4.14.4.5 Fleet Inputs. It is important that each ship design receive broad Fleet inputs. As a minimum, the SDM shall arrange, through the appropriate TYCOM, a Design Team visit to one or more similar ships which the new design is intended to replace or supplement. Fleet and INSURV reviews usually take place in the later design phases when enough definition is available to show specific operating system concepts. These can be formal or informal and may or may not include stand-up of an operational advisory group to improve continuity of Fleet membership over time. Fleet contact is usually managed through the Program Office with the involvement of the OPNAV Sponsor.

4.14.4.6 Independent Review. SDMs must be prepared for and accommodate independent review of the ship design by senior authorities from across the Navy engineering community, academia, industry, the Fleet, and other subject matter experts. Part of the process that must be fostered by SDMs/SIMs is regular interaction between individual team members and their senior managers in the technical authority chain.

4.14.4.7 Other Reviews. Lastly, outside reviews are often required on an individual program basis and are not covered here. For example, the Weapons Systems Explosive Safety Review Board (WSESRB) will conduct multiple reviews of weapons safety during the design development where applicable. See Appendix S (*hyperlink*) for additional information on typical certifications.

4.14.4.8 Program Office Involvement. All significant technical issues that cannot be resolved with the Program Office will be addressed in an issue paper. These one- or two-page papers must be concise and easily read. They will be developed by or in conjunction with the responsible TWH. All shall be serialized and entered into the SEA 05D/V/H information management system.

The SDM/SIM must provide technical information and backup material to assist the Program Office in preparing for review by higher authority.

4.14.5 Staff Meetings. The SDM should hold staff meetings on a regular basis. These meetings provide a forum for the discussion of issues that affect the cost or schedule of the design as well as technical problems, risk areas, design integration, and status of assigned action items. The meetings also help to keep team members informed of overall design progress and problems, as well as to build team cooperative spirit. Meetings with the SIM and SEMs could be held weekly with less frequent meetings scheduled for TLs as well as SEMs.

4.14.6 Action Items. An effective action item tracking system will be of great benefit to an SDM by not letting things “slip between the cracks.” Even simple methods like Excel spreadsheets or MS Outlook “to do” lists are more effective than trying to remember everything. The best system is one that is program-wide and used by all parties. However, there is often reluctance by the Program leadership to have its actions visible to large groups and, conversely, to have its system inundated with lower level concerns.

4.14.7 Master Calendar. Another important activity is keeping a master calendar for technical events. Again, the Program Office may have one but it may not suffice for all the engineering needs. It should reflect key meetings, trips, tests, deliverables, etc. and be updated daily if required. It should be available to the entire Design Team. The SDM/SIM must cause this to happen if it does not by other means.

4.14.8 Security Classification and Document Marking. The SDM should work with the Program Office and SIM at the beginning of the Program to identify the applicable security classification in accordance with OPNAV Instruction (OPNAVINST) 5513.1F (*hyperlink*) and OPNAVINST 5513.3C (*hyperlink*) and to develop new guidance as required. Remember that security is a balance between risk and cost; every program needs to tailor the "standard" guides to suit its needs. It is critical for the SDM to influence the classification guide for the specific project to allow the most flexibility in executing the program. A good example is that past classification guides required the general arrangement drawings to be Confidential. Recent programs have fought hard to get this changed to Unclassified For Official Use only to avoid the entire CAD/CAM (computer-aided manufacturing) computer system from having to be classified. Every item to be classified should be reviewed, with cognizant experts identified in the program specific security classification guide and its level reduced or eliminated to the maximum extent possible. Remember that Unclassified does not mean it is publicly releasable. All unclassified documents should have the appropriate distribution statements per DoD Directive 5230.24 (*hyperlink*) as well as any required International Traffic in Arms Regulations (ITAR) warning.

4.14.9 Program Protection. Well in advance of Milestone A as the Program begins, the Program Office, with the SDM and SIM, must assess whether they will be developing Critical Program Information (CPI). This covers the critical elements of the system that makes it unique and valuable to U.S. defense forces. These items, if compromised, would cause a degradation of combat effectiveness, decrease the combat-effective lifetime, or allow a foreign activity to clone, kill, or neutralize the U.S. system. In addition to the elements organic to the system, the Program Office shall consider any engineering process, fabrication technique, diagnostic equipment, simulators, or other support equipment associated with the system for consideration as possible CPI. Note that recently the definition of CPI and the measures required for its protection have greatly expanded.

Programs now must develop a Program Protection Plan (PPP) whether or not they have CPI. The PPP shall include a classified anti-tamper annex that has ASN (RD&A) CHENG's technical concurrence. Anti-tamper refers to design of new systems such that they cannot be reverse-engineered if they fall into enemy hands. While whole warships are not considered at such risk, parts such as ammunition, missiles, or unmanned aerial vehicles can be captured. Furthermore, attention must be paid to computer system hacking via external communications systems. Draw a box around the ship. Anything that crosses that box is a candidate for anti-tamper.

An additional aspect of new system development is the potential for overseas sales. For example, the new X-band radar on DDG1000 may be sold in altered forms oversees. It, therefore, needs to be developed with an anti-tamper program plan.

4.15 REPORTING.

4.15.1 Keeping Management Informed. SDMs/SIMs are the eyes and ears of SEA 05 management. Accordingly they are responsible for keeping SEA 05 management informed of progress and significant technical issues on a timely and regular basis. This should be done weekly at the very least, and daily as the situation dictates. SEA 05 should not be the first to hear about issues from the PEO or Program Manager. SDMs and SIMs deal with many matters that relate to interactions taking place at the Flag and Assistant or Deputy Assistant Secretary of the Navy levels, both inside and outside of SEA. SEA 05 management depends on SDMs and SIMs to keep it apprised on such matters. It is also important to brief SEA 05 when there is a need for involvement or in anticipation that another senior principal may contact SEA 05 management. SDMs and SIMs must facilitate continuous awareness on technical issues in the SEA 05D/H/V and SEA 05 front offices. This should also include advance visibility on key program decision meetings and higher level reviews outside the Command. To these ends, SDMs and SIMs should not limit themselves to the reports listed below. Status reports should be provided orally or through email, as needed, to division directors. For significant technical issues, SDMs and SIMs should produce formal documentation in the form of serialized memos, white papers, and technical reports.

4.15.2 Management Metrics. SEA 05, Program Offices, and Shipbuilders have employed metrics to measure progress and manage ship design and construction efforts. Examples include:

- Independent collection and analysis of production data by PMS 377 to progress DD&C
- Use of an Oracle-based workflow system with automated status by the Sealift SDMs to manage review of the large quantity of design deliverables produced by the Shipbuilders
- Tracking by PEO Carriers of planned and unplanned action completions versus schedule

Some metrics tracking efforts have worked and others have not. It is important that the value of tracking the metrics be generally recognized and that the process not impose a significant new workload for its own sake. Ideally, the process should either be fully automated or only involve data collection by a single analyst. Two things should be considered in selecting a metric:

- Will it be used to actually manage the program? (Who will look at it and what actions will be based on it?)
- Will this be useful in providing feedback to the people who will provide the data? (If the workers do not also see and use the results, they will quickly stop supporting submission of quality data.)

The metrics most commonly used are:

- Financial (obligated and expended versus plan, earned value management system [EVMS])
- Deliverables (on-time, late, quality measures)
- Schedule progress (tracking against milestones in WTA plans)
- Staffing levels (actual versus planned)

SDMs, SEA 05D1, the National Shipbuilding Research Program, MANTECH, and SBIR are required to collect and present their ship design project metrics.

4.15.3 Design Notebooks. Each TL should be required to maintain an electronic design notebook on the design IDE. The notebook should reflect the design rationale used and alternatives considered but discarded. Tabulated results of calculations and sources and currency of vendor data should be included. A well-prepared design notebook has been found to be a very valuable resource for the functional code in responding to queries during DD&C and afterwards. Design notebooks may take the form of computer files vice paper and should be properly backed up. Sharing of in-process files within a design notebook is an excellent way for team members to stay up with the evolving design. Design notebooks should be maintained even if the design is being done by an outside organization. SDMs should regularly remind their staff members of their importance and occasionally spot check samples for quality and recognition.

4.15.4 Annual Reports, Audit Trail, Design History, Red Book, and Lessons Learned. Each project should build a record as it progresses through the design phases. SDMs are responsible for maintaining a design history and audit trail of decisions made on their projects. This should address design constraints, ship baselines and excursions studied, trade studies conducted, and the rationale for major design decisions. A track of personnel and financial resource utilization should also be included. Comprehensive lessons learned should be prepared to add to the Navy's body of knowledge in ship design management. Such historical information and data (i.e., intellectual capital) is also shared with the Center for Innovation in Ship Design (CISD). The Red Book, which has been superseded by the annual report for surface ship designs, provides summary information from past programs. SEA 05 Memorandum 5400 Ser 05D/174 of 29 March 2010, NAVSEA Surface Ship Lessons Learned Feedback Process Technical Operating Procedures, establishes a process for identification and recording of in-service lessons learned.

See SEA 05D Memorandum 5000 Ser 05D/450 of 21 July 2010 (*hyperlink*) for Annual Report requirements. The unclassified portion of the Annual Report (minus the separately provided Ship Specifications/Contract Drawings/Project Peculiar Documents CD-ROMs) shall be stored electronically on CDMS in the appropriate folder. The annual reports shall be provided in the native format and in an Adobe Acrobat (.pdf) file format.

4.15.5 Design Reports. SDMs shall develop a formal, written design report at the end of feasibility studies, Pre-Preliminary Design, Preliminary Design, and Contract Design. Please see Appendix Z (*hyperlink*) for guidance in preparing design reports.

4.15.6 Use of Single Sheet Design Summaries – "Placemats". SDMs and management have found the use of single sheet design summaries, "placemats," a valuable reference for their day-to-day operations and for meetings with stakeholders. Surface ship SDMs are required to maintain their program "placemats" up to date on the SEA 05D shared directory.

4.15.7 Conducting Briefings. Guidelines for the conduct of briefings are provided in Appendix Y (*hyperlink*).

4.15.8 Earned Value Management System. SECNAVINST 5000.2 (*hyperlink*) requires EVMS implementation for certain Programs in accordance with the guidelines in American National Standards Institute (ANSI)/Electronic Industries Alliance (EIA) -748-1998. Shipbuilding Programs will typically be required to implement a plan (Performance Measurement Baseline) within their EVMS. The SDM generally is involved as a member of the program team conducting the Integrated Baseline Review and evaluating monthly and quarterly EVM performance reports.

4.15.9 Disposition of Design Data. See Appendix OO (*hyperlink*).

CHAPTER 5
DESIGN PHASE EXECUTION

5.1 DESIGN PROCESS.

Ship and associated system design is an inherently iterative process. This is because the end result, the technical definition of the ship and associated systems, is based on assumptions that cannot be validated until all aspects of the design have been developed to approximately the same level of technical maturity or confidence. In the context of naval ship design, the iterations are accomplished by a series of “design cycles.” The purpose of this is to successively diminish the variation between the assumptions implicit at the start of the iteration and the technical definition at its end. This process is known as “convergence” and applies to all aspects of the design. For instance, the displacement of the ship may be assumed at the start of a design cycle to be 8,000 tons, based on the previous cycle. After going through a design iteration in which structure, outfitting, mission systems, fuel load, etc. are recalculated, the new displacement is estimated to be 8,100 tons.

During each cycle, the team attempts to ensure that the design (1) is self consistent (e.g., area available equals area required); (2) satisfies established performance requirements, such as speed and endurance, as well as established design practices, and (3) meets cost goals.

Sometimes the ship design process is illustrated as a spiral in which design activities are performed sequentially and repeatedly until the design converges to a self-consistent technical definition. The spiral analogy is not entirely appropriate for naval ship design since schedule and budget considerations require that many design activities be accomplished in parallel rather than in series as the spiral analogy implies. Figure 5-1 is an illustration of a typical design cycle (i.e., design iteration) in which most tasks are conducted in parallel. It indicates the nominal scheduling relationships and general data flow that occur during Preliminary Design and Contract Design. A key responsibility of the SDM with the SIM is to manage this complex process.

A typical design cycle will last from 6 to 10 weeks. Work in most disciplines will be continuous. However, at certain periods the activity in any particular discipline may become critical to the overall schedule. The bold lines in Figure 5-1 show the nominal critical path through the design cycle. The start and end points for a given cycle are somewhat arbitrary since this is a continuous process. The figure starts with the issue of the configuration baseline for the n^{th} iteration of the model. The configuration baseline represents the ship configuration that will form the basis for analyses and trade-studies during the n^{th} iteration of the design.

Typically a “drawing board” review is held after each design iteration. This examines the current state of the design as reflected in the Computer-Aided Design (CAD) drawings, three-dimensional model, and trade studies conducted during that iteration. A determination is made as to which changes will be incorporated into the design and which trade studies need to be conducted during the next iteration. The review and design integration process, along with scheduling and configuration management issues, is typically delegated to the DIM.

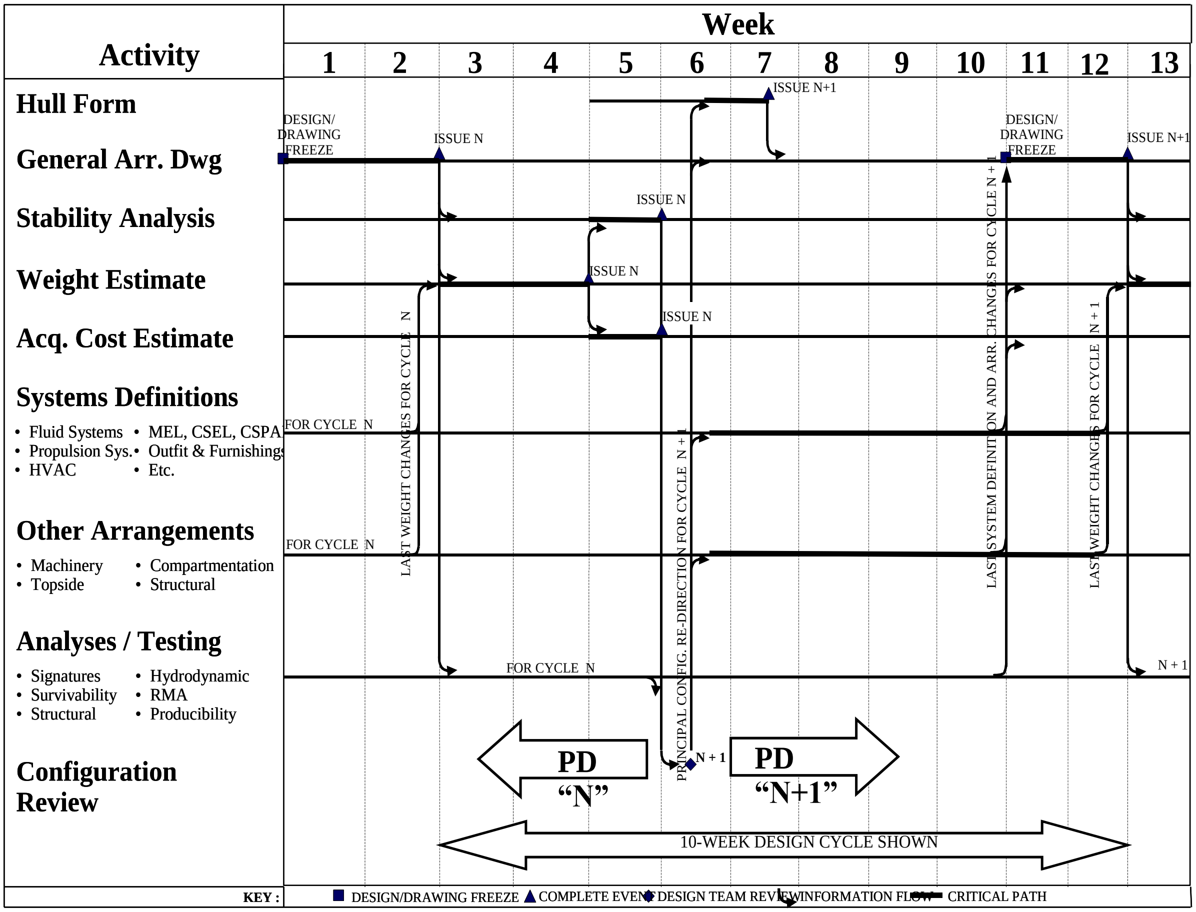


Figure 5-1. The Design Process

Critical path activities generally include development of the weight report and stability analysis. A preliminary "quick look" weight report can be issued approximately 12 working days after release of the baseline configuration. The final weight report for the n^{th} design cycle takes approximately 25 working days. The stability analysis takes approximately five working days.

Costing efforts will begin starting with the weights "quick look" report and end approximately seven working days after issuance of the final weight report for each iteration.

When the weight and stability reports for the n^{th} cycle have been completed, a configuration review will be held. The purpose of the review is to evaluate the changes proposed for the $(n+1)^{th}$ iteration. For the next several weeks, the arrangement and design for the $(n+1)^{th}$ configuration are performed while in-depth analyses of the n^{th} configuration go forward. At the end of this period the general arrangement drawings for the $(n+1)^{th}$ cycle are frozen and the above process repeats. Experience has shown that multiple design cycles are required. The first few cycles typically result in insufficient or unbalanced performance, do not meet required cost or performance objectives, contain significant design flaws, or contain unacceptably risky features.

This discussion is representative of the timing and sequencing once all technical efforts are up to speed and the Design Team has been firmly established. As the design progresses, schedules should be periodically updated and distributed to all team members to communicate when critical deliverables are needed to support the overall process. The SDM must pay close attention to critical path activities. The SDM needs to continuously assess the readiness of each discipline to feed the associated analysis. It is also a key responsibility of the SDM to direct those changes and trade-offs that will lead to design convergence while meeting established performance and cost objectives.

Design development depends primarily on two types of activities and transactions (or transfers) of data between them: DEFINITION and EVALUATION. While the order of execution and the number of repetitions of these basic activities and transactions vary widely, the basic elements are largely the same from ship to ship, time to time, and organization to organization.

DEFINITION is the activity of developing an arrangement of the physical components of a ship as a trial solution to the set of requirements and constraints facing the designer at any particular stage. DEFINITION activities define what, in the end, will be the products of design, the tangible elements of the resulting ship – what will be built. DEFINITION includes hull shaping and subdivision (molded DEFINITION), structural arrangement, component selection and placement, and distributive system design and arrangement. These are accomplished at successive levels of DEFINITION as the design is "filled in."

Table 5-1. Types and Levels of Definition

Hull Shaping & Subdivision	Structural Arrangement	Component Selection & Placement	Distributed System Design and Arrangement
Parametric	Parametric	Parametric	Parametric
		Schematic	Schematic
3D Surface Definition	Stiffener Location	Diagrammatic	Diagrammatic
	3D Space Reservation	3D Space Reservation	3D Space Reservation
Manufacturing Detail	Manufacturing Detail	Manufacturing Detail	Manufacturing Detail
		Maintenance Detail	

Every component must eventually be located on some structural elements which themselves are located relative to some molded surface. Part of design completion is having all DEFINITIONS consistently derived from the same master model or common geometry model.

General purpose CAD software is predominately used for the development of ship DEFINITION, although Advanced Surface Ship Evaluation Tool (ASSET) and special purpose hull development software such as FASTSHIP contribute substantially to DEFINITION. Distributed systems are typically designed with discipline specific tools. Where multiple CAD systems are in use for design development, or where the Design Team wishes to capitalize on DEFINITION information from previous ships, the SDM will be confronted with data transfer issues.

There are International Organization of Standardization (ISO) industry standards (ISO 10303 STEP) in place specifying content and format for exchanging ship product model data. Prototype translators have been built for several CAD systems, but they are not generally commercially available at present. The ISO standards are applicable to CAD to computer-aided engineering, CAD to Product Data Model (PDM), and CAD to Enterprise Resources Planning (ERP) data transfer as well as CAD to CAD data transfer. Increasingly they will be required for ship product model data delivery under developing DoD and DoN policy. Currently, cooperating engineering organizations can pass a great deal of useful geometric and engineering information between systems. However, there is plenty of grist for contention, obstruction, and fault-finding for organizations not motivated to cooperate.

EVALUATION is the activity of estimating or forecasting the characteristics, performance, cost, schedule, or risk associated with a particular DEFINITION. DEFINITION defines what will be built. EVALUATION explains why the specific design will be built. EVALUATION of different characteristics is done primarily by computer tools, including spreadsheets, visualization tools, computer-aided engineering tools, and simulations. Model and full-scale testing are the ultimate forms of EVALUATION.

Each EVALUATION requires DEFINITION information as input. Particular EVALUATIONS may require a minimum level of DEFINITION as input. Some examples:

- Stability Analysis. A single program, Ship Hullform Characteristics Program (SHCP) and derivatives, is used at all stages of design. It requires three-dimensional surface definition but uses parametric distributions of structural, component, and systems information.
- Survivability Analysis. One program, FastSVM, is used in early stage design to provide estimates based upon ship characteristics and parameters. Another program, Ship Vulnerability Model (SVM)/Advanced Survivability Assessment Program (ASAP), requires structural arrangement and system arrangement information to model blast effects and system deactivation. The former can be run at any stage of design. The latter cannot be run until definition has progressed to the point where the required information is available.

Other than these information-availability limitations, there is no restriction or pre-determined order in which EVALUATIONS must be run. Individual designs will follow different paths depending upon a variety of considerations. However, most of the EVALUATIONS will be used at some time during each design.

The SDM/SIM will have given considerable thought to the EVALUATIONS needed for the particular program and phase. In cooperation with the respective TWH, the SDM must consider the availability and suitability of the software tool to be used to support each EVALUATION, both by the design agent during design and by the Navy during design review and ship certification. In cooperation with the respective TWH, the SDM/SIM must persuade the Program Office to make timely investments in critical analysis tools to support EVALUATION requirements of later design stages.

Each DEFINITION – EVALUATION iteration will require labor and time to pull configuration information from a DEFINITION and prepare it for use in an EVALUATION. Frequently, translation or reformatting is necessary. Most EVALUATION programs rely upon an analysis model that is different in form from CAD models used for DEFINITION.

A quick measure of the efficiency of a design process is the length of time and the amount of labor required to complete a DEFINITION – EVALUATION iteration. For example, in the early 1980s signature EVALUATIONS required months to complete, so long that it was extremely difficult to incorporate the design modifications suggested by the results. Over the two decades since, the cycle time has been reduced to days and hours, allowing many alternatives to be evaluated and allowing designs to be shaped for reduced signatures.

The principal information needed by an EVALUATION is ship DEFINITION. An EVALUATION may also call for the results of another EVALUATION as input. For example, a structural loads estimation program may require the results of a ship motion program as input. However, the amount of information to be transferred and the labor required is generally minimal compared to the DEFINITION – EVALUATION transaction.

There is also a need to return the results of an EVALUATION for consideration in subsequent definitions. Again, this is a lightweight TRANSACTION. Consider the substantial amount of information required to convey a structural DEFINITION for a grillage EVALUATION. Compare that to the feedback: “Use the next larger size for longitudinal stiffeners.”

NAVSEA is rapidly moving to Leading Edge Architecture for Prototyping Systems (LEAPS) as a standard means for facilitating DEFINITION – EVALUATION iterations, for storing EVALUATION results for later reference, and for design configuration management. LEAPS is suitable as a design environment and will be the principal mechanism for importing design agents’ designs to NAVSEA for warrant holder review.

A fuller discussion of this view of the ship development process and associated tools is contained in the paper ICCAS 2002, "An Activity/Transaction Model for Ship Design Development."

5.1.1 Impact of Design on Total Ownership Cost. As the design proceeds and ship requirements and resulting characteristics become better defined, much of the ultimate Total Ownership Cost (TOC) is determined. Ship design has a major impact on most TOC components, including manning, fuel, maintenance, and disposal cost. Typically, the funding allocated to define and design the ship is grossly disproportionate to the cost of construction and operations. The design, which expends less than 5% of the total life cycle cost of the ship, largely determines the other 95% of the TOC. See the figure below.

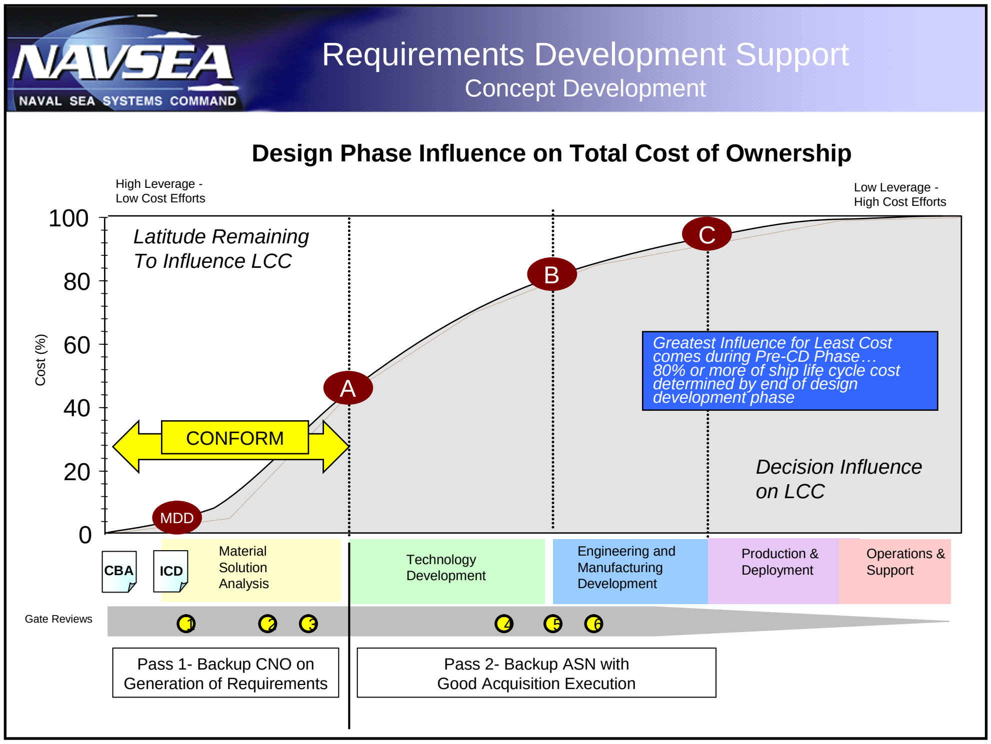


Figure 5-2. Design Phase Influence of Total Cost of Ownership

5.1.2 Design Margins and Service Life Allowances. To accommodate changes to the ship's configuration during future iterations of the design, as well as uncertainties regarding the material and equipment in the constructed ship, all ship designs must incorporate margins and allowances consistent with the evaluation of risk. This is a key SDM responsibility. The SDM must balance technical risk mitigation against increased procurement cost. As shown in Figure 5-3, the level of risk is tied to the probability that the System Capacity is sufficient to serve the predicted load, including the variability of the load estimate. As shown in Figure 5-4, a smaller variance in the load estimate, resulting from higher design fidelity, can enable a reduction in design margin. Managing the rate in which the margin is allowed to reduce as the design matures is an important SDM responsibility. To aid the SDM in determining the adequacy of remaining margin, the Design Team should estimate the variability of the load predictions. Appendix A provides selected references on application of design, build, and service life margins.

For most ship designs, it is prudent to apply margins to weight and KG; distributed system capacity such as electric power, chill water, and network loading; accommodations; arrangeable area; and propulsion power.

Margin usage is a key design metric that can necessitate major redesign efforts.

Additionally, service life allowance requirements are typically levied on ship designs to accommodate the installation of changes in the ship over the service life of the ship. Typical areas for which a service life allowance is specified include weight, KG, and distributed system capacity.

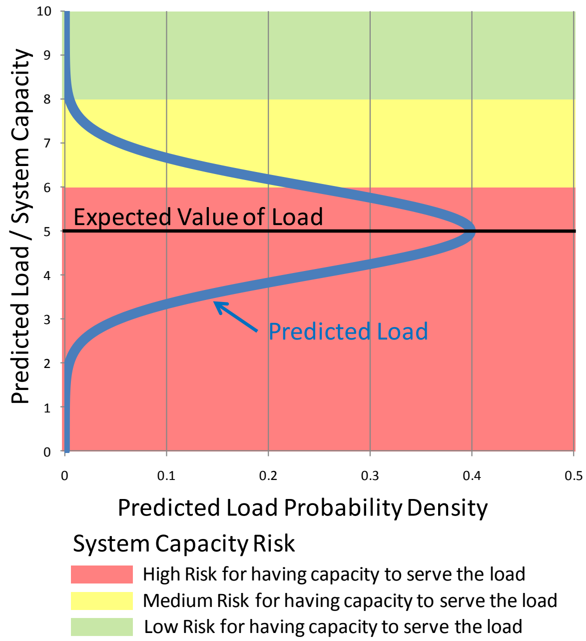


Figure 5-3. Predicted Load Probability Density and System Capacity Risk

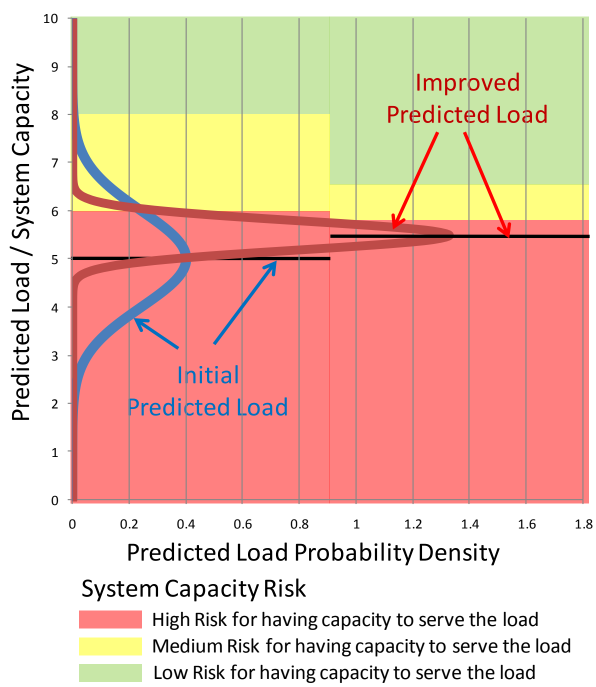


Figure 5-4. Impact of Improved Predicted Load on System Capacity Risk

5.1.3 <u>Systems Engineering Process</u>. SDMs and SIMs should be NAVSEA's experts in the conduct of systems engineering. Per the DoD and SECNAV instruction 5000 series, system engineering should be a foundation for ship/system design. There is a wealth of information on the subject available throughout the defense acquisition community. Section 2.1 cites websites and applicable references. See also Appendix A for selected references related to the process. The challenge for the SDMs and SIMs is to translate this guidance into actionable, practical advice for managing a ship/system design.

Figure 5-5 shows the systems engineering design process featuring three stages: requirements analysis, functional analysis/allocation, and systems design. System analysis and control is continuously applied to keep the process on track. The purpose of the requirements analysis effort is to properly identify and document the user's requirements and translate those requirements into a set of technical requirements for the system. During functional analysis/allocation, the requirements identified in requirements analysis are translated into a functional decomposition that describes the product in terms of an assembly of configuration items where each configuration item is defined by what it must do, its required performance, and its interfaces. Finally, during design synthesis, specific hardware, software, and "humanware" (that is, human operators considered as configuration items in the functional analysis) are defined to meet the requirements of the configuration items. Systems analysis and control provides the technical management activities necessary to keep the entire process moving on schedule with acceptable performance and cost.

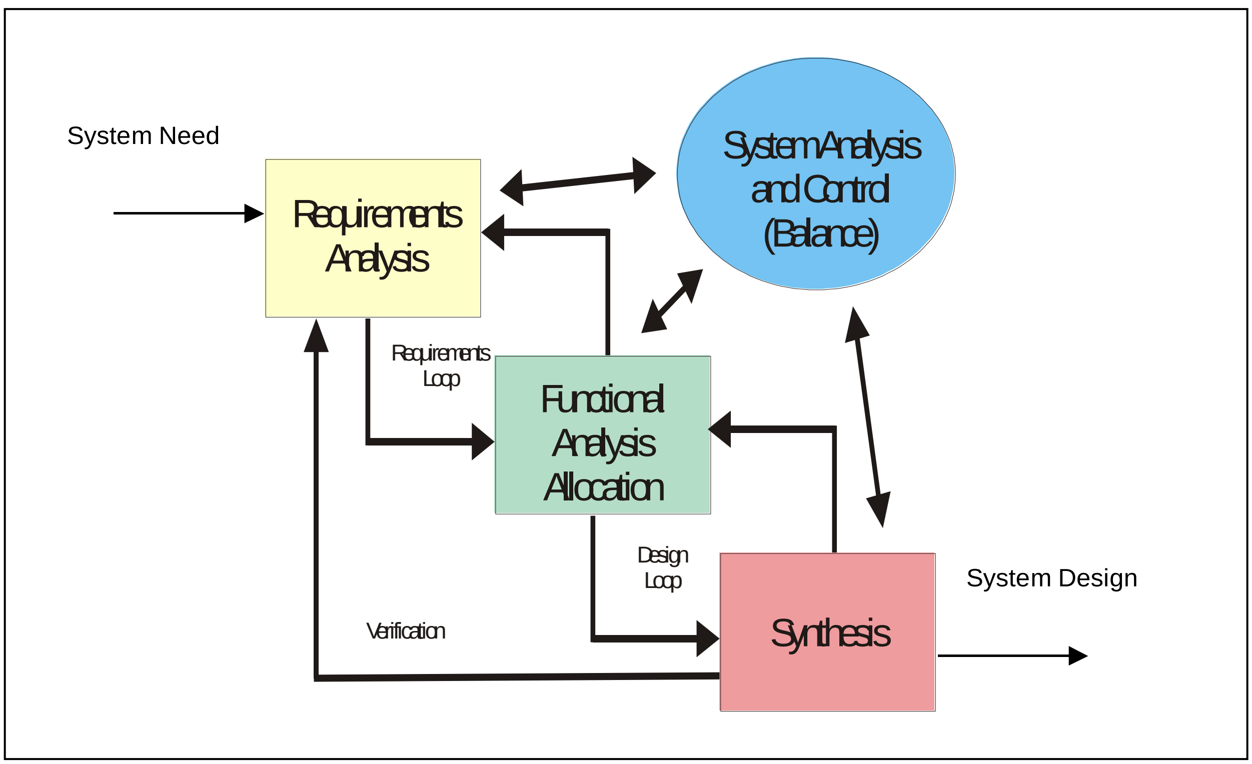


Figure 5-5. The Systems Engineering Design Process

This is an idealized process and it is typically interpreted to be serial and iterative. In practical application, all of the components occur concurrently. See Appendix PP (*hyperlink*) for an expanded discussion of the application of system engineering.

5.1.4 Establishing Requirements and Constraints. Ship design tasks relating to ship acquisition programs, including requests for feasibility studies, are generally accompanied by a formal OPNAV request and explicit statement of requirements. The SDM and SIM are essential participants in requirements definition, making certain requirements are complete and executable.

The CDD and Capability Production Document (CPD) represent negotiated agreements between the Program Office and Sponsor for minimum ship performance and maximum cost. They do not provide adequate direction for design and are not written as specifications. For Navy Designs, the SDM should develop and issue detailed design guidance under his signature to the Design Team. For Contractor Designs, the acquisition strategy may dictate development of specifications or a circular of requirements for incorporation in the design contract.

The task of translating requirements into design direction should begin with consultation with the project SEMs and Program Office on the design philosophy. Discussions should address topics like cost and performance targets, design process metrics, interoperability, open systems, standardization, risk management, technology insertion, data management, and design certification. The applicability of NAVSEA design standards, practices, and policies should be addressed.

5.1.4.1 Requirements Traceability. Software like DOORS©, RTM©, SLATE©, and Requisite Pro© have been successfully employed to verify the flow down of requirements from the Initial Capabilities Document (ICD) to the CDD to the TEMP, specifications, and other contracting documentation. Requirements from other sources such as statutes, OPNAV instructions, and regulations should also be traced. Additionally, every derived requirement should be tracked and traced to the functional allocation or synthesis decision that spawned it.

Verifying consistency of the various program documents is also possible through the use of requirements traceability software. Requirements traceability and its tools are a necessary part of the systems engineering process, but these processes and tools, in themselves, do not constitute systems engineering. Requirements analysis, functional allocation, and design synthesis must all work together to ensure the design will work and meet customer requirements. Please see Figure 5-6.

Note that the Commander, Operational Test and Evaluation Force (COMOPTEVFOR) will be developing a comparable database – an Operational Testing Framework – to support their planning and conduct of Operational Test and Evaluation.

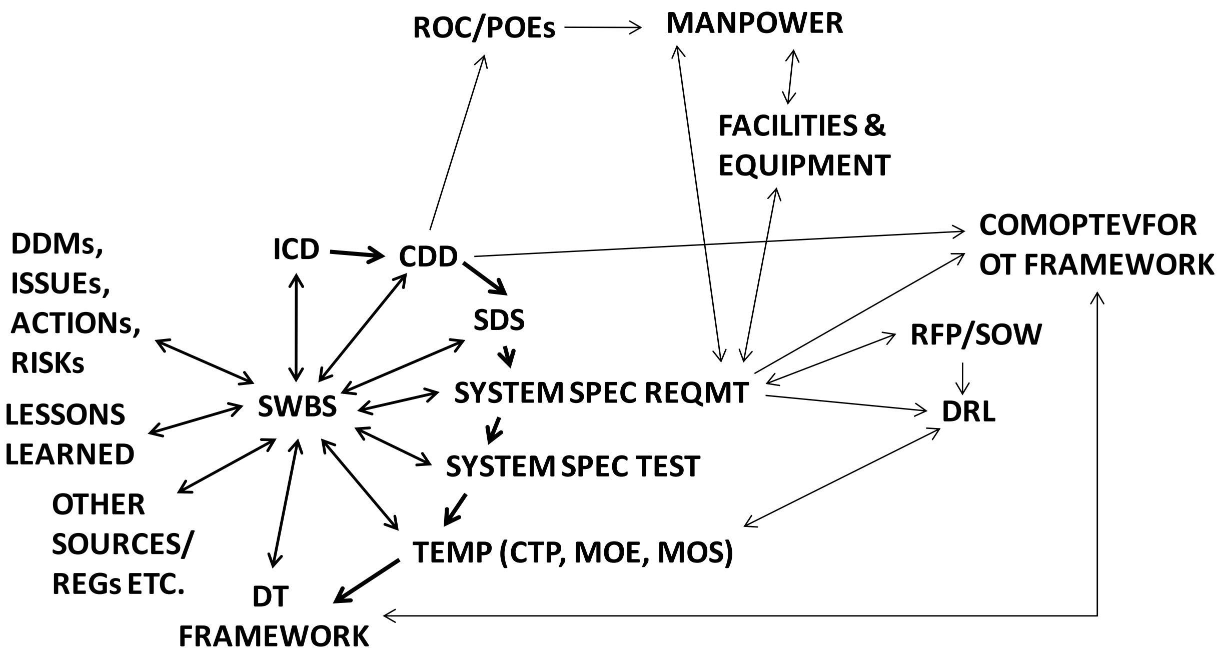


Figure 5-6. Example of Typical Requirements Traceability Flow

5.1.4.2 Study Guides and Design Kickoff Meetings. The SDM is required to prepare and publish by official serialized memorandum a study guide to document the requirements for a study. This is a critical tool for controlling the technical discussion and managing expectations. A kickoff meeting should be conducted with the Program, other stakeholders, and where appropriate, SEA 05C. The study guide should be a focus of this meeting. It's usually best not to start the effort until the study guide has 80 percent acceptance and definition. This will prevent wasting resources and time.

5.1.4.3 Development of Specifications and Other Contract Content. Requirements definition activity naturally evolves into the SDM leading the Navy effort on preparation of a Specification for the ship, as well as drafting the SOW and DRL design content for the DD&C RFP.

Whether the Navy or industry prepares the Specification, the SDM is responsible for its completeness and technical acceptability. SDMs should guide the process for selecting an acceptable combination of design standards and verification/validation requirements for Navy approval in the Specification. Appendix A provides selected references offering guidance related to development of Specifications.

The SDM's role in Specification development is first to establish an overall approach in conjunction with the acquisition strategy. A "spec tree" showing the organization and hierarchy of the Specifications is then developed. Specification section development responsibilities and technical authorities are defined. Review and certification processes are established. The Program Office should have a significant role, often co-equal to the SDM, in the review process.

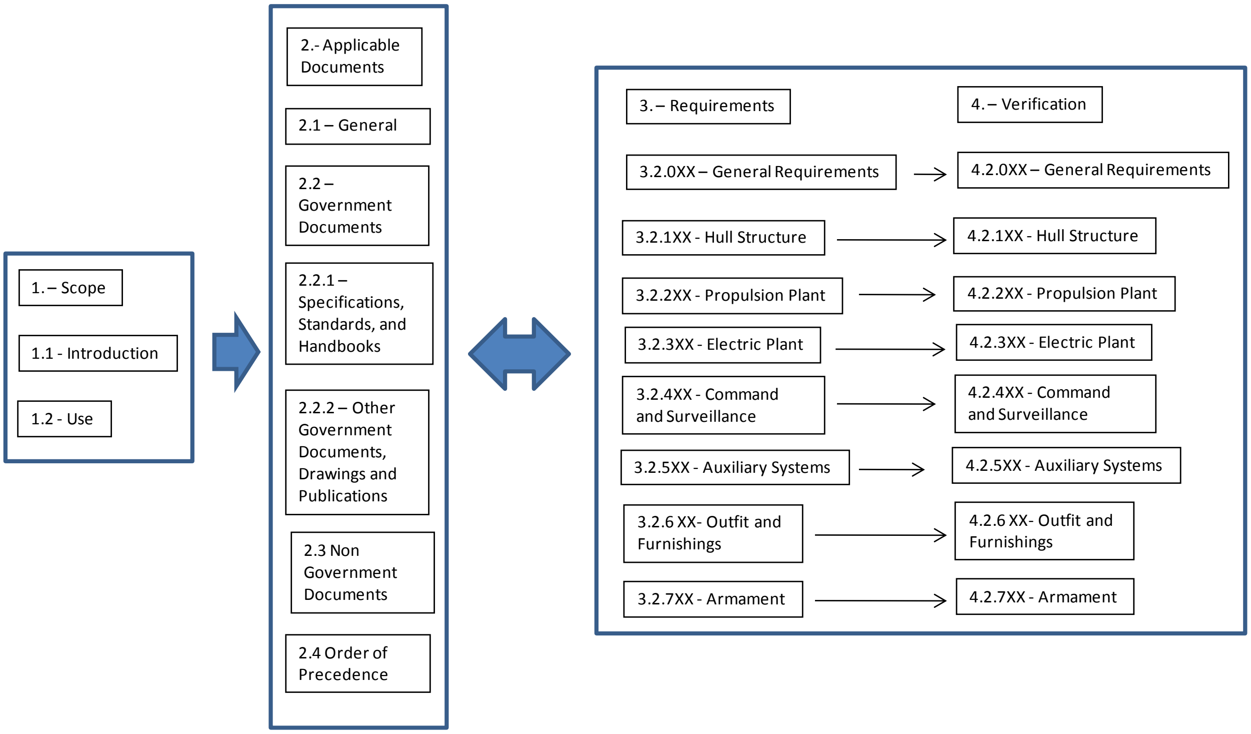


Figure 5-7. Specification Tree

The SDM and SEA 05S must instruct the Design Team on Specification preparation in order to get clarity and consistency in the finished product. A variety of training presentations have been developed for previous efforts.

The Specification must be written to ensure each requirement is measurable and has a corresponding and explicitly identified test. It is common for a test section to be written in the same sequence with a paragraph numbering scheme corresponding to the main requirements section.

Duplication of content between Specification sections, the Specifications and SOW, and the Specifications and any other contracting documents should be avoided to prevent the introduction of inconsistencies. The SOW should define what the contractor will be required to do, and the Specifications should provide the criteria. Should the T-ship be required to be classed by ABS, the relevant ABS Rules will form a major set of invoked criteria. It is extremely important to ensure that care is taken to deconflict the Specifications with the invoked Rule sets.

The SDM will conduct Specification reading sessions during Contract Design, a major undertaking and extremely time-consuming effort. For new designs, two reading sessions are held, the SEM Reading Session and the Final Contract Design Reading Session. The SEM Reading Sessions will be held to ensure that the design reflects the requirements of the CDD, that no major technical inconsistencies exist, and that the required system interfaces are accounted for prior to configuration control of the Specification, Contract Drawings, and Project-Peculiar Documents. These normally proceed from general to more specific requirements sections, with the corresponding testing sections read in parallel and the HSI, safety, DRL, GFE/GFI, contract SOW, and other considerations reviewed for each section. A typical Final Specification Reading Session lasts about six weeks. Sections are traditionally "read" beginning with the General Sections, SWBS Group 100, SWBS Group 500, SWBS Group 200, SWBS Group 300, SWBS Group 400, SWBS Group 700, and SWBS Group 600. The SDM can alternately employ a matrix to track the interdependency of Specification sections and identify the optimal order for reading Specification sections.

After Certification by the TWHs of the Specification and PPDs and Contract Drawings, the SDM will present the completed Technical Data Package to SEA 05 via SEA 05D/V for approval and signature at the end of Contract Design. SEA 05 will rely to a large degree on the SDM's appraisal of the Specification in deciding to approve it.

The Contract will establish order of precedence between the SOW, Specifications, and other contract attachments. The Contract should also establish an effective date for all references.

Other lessons learned include the need for:

- Careful definition of an approach for Specification content and development that suits the acquisition strategy
- Clarity in DRLs to ensure that the specific information needed is received
- Reviews of drawings, PPDs, other contractual documentation, and associated references conducted with as much effort as and in parallel with the Specifications
- Agreement and publication of criteria and content for review comments
- Strong management of the support provided by organizations such as PEO C4I, PEO IWS, NAVAIR, and NSWC DD
- Resolution and documentation of design issues through a design decision memorandum or equivalent process
- Resolution and documentation of Specification and other contractual documentation changes through a Naval Adjudication Board or equivalent process

There have been a number of terms used for ship Specifications but we are currently trying to limit usage to two types. The term "Ship Systems Specification" should be used for the Specification developed for the conduct of design efforts prior to Detail Design and Construction and the term "Shipbuilding Specification" should be used for the Specification developed for the conduct of Detail Design and Construction.

The preferred method of stating requirements in a Ship Systems Specification is in terms of the required results with verifying compliance, but without stating the methods for achieving the required results. A Ship Systems Specification defines the performance and functional requirements of an item, the environment in which it shall operate, and interface and interchangeability characteristics. A Ship Systems Specification also specifies and tailors the standard technical architecture or "building code(s)" that are to provide the foundation for the design. Example standard technical architectures include the ABS Steel Vessel Rules.

A Ship Shipbuilding Specification contains the construction materials, items, and component requirements which pertain to their selection, installation, shipboard performance, shipboard inspection and tests, and pre-installation handling, inspection, and tests performed by the Shipbuilder. Government or industry Specifications and standards invoked in the Shipbuilding Specification delineate requirements for material, components, and systems. Performance and functional requirements that were in the Ship System Specification may have been further decomposed during Preliminary and Contract Design into design solutions, such as a specific hull form and arrangement, that are included in the Shipbuilding Specification. In addition, further tailoring of the standard technical architecture may be included if those exceptions are known during design.

The Ship System Specification may be used as a contract Specification when the acquisition strategy calls for a contractor to conduct Concept, Pre-Preliminary, Preliminary, or Contract Design.

Specifications shall normally be structured in accordance with ESWBS as follows:

- 000 General Guidance and Administration
- 100 Hull Structure
- 200 Propulsion Plant
- 300 Electrical Plant
- 400 Command and Surveillance
- 500 Auxiliary Systems
- 600 Outfit and Furnishings
- 700 Armament

Numbers for major groups have double zeros (000, 100, 200); subgroups end with a single zero (110, 120, 320); and subgroup elements do not end with a zero (111, 121, 321).

Hierarchy of requirements within a system section should be organized in accordance with the following content layout:

- Number and Title – ESWBS number and title of section.
- Definitions – Definitions of terms not contained in the dictionary that are unique to and used in that section (Only if necessary for clarity.).
- General Requirements – Requirements that apply to all systems, equipment, and components specified in the section (Always before detail requirements).
- Detail Requirements – Requirements describing the systems, equipment, and components, and their required performance capabilities. Reference to applicable equipment and material specifications.
- Shock – The specific show grade defined in Section 072 and unique shock qualification requirements for systems, equipment, and components. Where different shock qualification requirements apply to different systems or parts of a system, the boundaries of the various shock levels shall be clearly and specifically defined.
- Technical Documentation – The general requirements for drawings, manuals, and other technical documentation shall be contained in Sections 085 and 086. Specific technical documentation requirements not covered in Sections 085 and 086 shall be included in this paragraph. Contract data tasking statements shall be included to identify the technical documentation to be prepared by the Shipbuilder. Each deliverable item shall be listed here and in the DRL.
- Tests – This section shall include pre Stage 2-7 test requirements for subsystems or components where there is a high risk associated with performing the test after delivery to the shipyard or installation on the ship. All shipboard testing to demonstrate compliance with the Specification requirements by the delivered Shipbuilder and Government furnished equipments, subsystems, and systems shall be specified by the Shipbuilder test program covered in Sections 090 through 095.

5.1.4.4 Use of Performance Specifications. Under the DoD and SECNAV 5000 series instructions, specifications for the procurement of new systems and subsystems shall be written in performance-based terms (i.e., DoD performance specifications, commercial item descriptions, and performance-based non-government standards) to the extent practicable. A waiver is no longer required in order to invoke military specifications or standards, but its use should be limited to government-unique requirements and interface requirements.

Since the military standards and specifications were minimized for LPD 17 and subsequent procurements, significant strides have been made in updating Navy ship design procedures to incorporate the most advantageous level of military standards and specifications. Although current policy favors “performance specifications,” current System Specifications are appropriately a mix of:

- Performance language
- Citations of commercial standards, and, sometimes, classification requirements
- Reference to a few selected military specifications and standards, like shock, where there is no commercial equivalent
- Detailed specifications and installation control drawings for areas where the Navy has customer preference and/or special knowledge, such as combat systems, survivability, underway replenishment, and aviation

5.1.4.5 ABS Naval Vessel Rules and ABS Steel Vessel Rules. The development of the Naval Vessel Rules (NVR) was begun in the early 90s to simplify the naval ship design process. It was restarted with the advent of acquisition reform, lack of funding for updating standards, and the desire to modernize military standards and specifications. Some combatant Ship Specifications such as DDG 1000 and LCS were calling out applicable sections of the NVR followed by any program-specific amplifications or modifications. However, a decision has been made to limit the use of ABS in the classification of surface combatants. Transition plans are in place to ramp down ABS involvement. Applicable NVR content is to be incorporated into a Navy publication. Further detail will be provided in the next revision to this manual.

The ABS role for MSC ships (T-ships) remains unchanged. They will generally follow modified-commercial standards including ABS Steel Vessel Rules.

5.1.4.6 Commercial vs. Navy Construction. In general, Navy combatant ship construction methods are more expensive than commercial ship production. This difference is largely due to the differing approaches to survivability between commercial ships and naval combatants. Commercial ships are designed to survive damage from typical accident scenarios such as groundings, collisions, and main-space fires. If the damage cannot be contained within a few hours, doctrine calls for the merchant crew to abandon ship. Since loss of the ship and cargo are covered by insurance, preservation of life is of paramount concern. Naval warships, on the other hand, are expected to survive weapons effect damage and be capable of restoring their primary mission, to continue the fight. Different classes of ships are provided different levels of survivability based on their projected operational environments. For example, although MSC T-ships are not expected to operate in high threat areas, their increased complexity and survivability features are more expensive than commercial single product ships.

5.1.4.7 Modified Repeats. Modifying an existing design to produce a new ship with different, presumably enhanced, capabilities is a practice that has been followed for many ship types. In 2004, the LHA(R) program was redirected to develop a Contract Design that was very closely derived from the LHD 8 design. During the Preliminary Design and Contract Design development, the LHA(R) configuration management process was tightly coupled to the configuration management process for the LHD 8. Design decisions were evaluated with one of the key considerations being, "How is the issue being addressed on the LHD 8?" Changes to major blocks and assemblies were kept to a minimum to reduce non-recurring engineering costs. Shipbuilder involvement was emphasized so that every change was carefully evaluated from a design and production cost standpoint. When the LHA(R) is acquired following the modified repeat strategy, a new ship will be delivered with the required capability, yet engineering costs will be minimized and operating similarities maximized.

Achievement of cost savings by using a modified repeat strategy requires that a careful management minimizes changes to the design, and, in particular, to the production engineering and build strategy. Benefits are increased when production can continue without a significant gap. It is remarkable how small changes can have significant effects on the non-recurring engineering required to design a modified repeat. During the LHA(R) design, considerable program management attention was applied to minimize this. It was clear to the Design Team that the Program Manager placed a high priority on minimizing changes that would increase non-recurring engineering costs. Following a modified repeat strategy adds constraints that would not apply to a "clean sheet" design approach. Before a modified repeat strategy is followed, the SDM must evaluate the effects on the design due to constraints imposed by minimizing change. If the mission of the required ship differs significantly from that of the "parent" ship, then the cost associated with a new design may be less than modifying an existing one. The changes may be so substantial that production benefits do not accrue to the same degree. Similarly, the mission requirements may be more effectively achieved by a new design rather than through a modified repeat approach. Such considerations should be addressed in the earlier phases of concept and feasibility assessment.

See Naval Engineers Journal, May 1983 paper "Repeat Ship Designs Facts and Myths" by Phil Covich and Michael Hammes *(hyperlink)*.

5.1.4.8 Conversions. Conversions of existing ships have been accomplished to enhance or completely alter their mission capabilities in order to meet new requirements. There are three major motivations for this approach:

- Rapid delivery of a ship, when re-use of an existing hull, propulsion plant, and other major systems minimizes the engineering, material, and schedule requirements so that the desired ship can be produced more quickly than if a new ship were built "from the keel up".
- Maximizing commonality with other ships.
- Minimizing cost by re-use of existing components.

Balancing the positive aspects of conversions are the obvious negatives that must be considered:

- Converting ships to meet new mission requirements results in re-use of old material, designs, and technology rather than new material, current design practice, and the latest technology.
- Conversions may involve unexpected engineering or logistics challenges.
- The conversion approach may persuade the designers to accept engineering solutions that would otherwise not have been considered attractive, such as use of a steam plant for a ship that, if designed as a new ship, would have been diesel propelled.
- The complexity of a conversion can result in a ship that is not as cost-effective to operate in comparison with a new design.
- Remaining service life is limited by retained systems.
- Workforce efficiency is reduced because the majority of work must be performed aboard ship in conditions that minimize productivity.
- The converted ship will likely include compromises such as accepting certain system designs or equipment selections due to existing conditions, rather than designing the ship to incorporate the best possible engineering solutions.

An example of a conversion that experienced major delays, disruptions, and other problems is the conversion of the USNS LCPL ROY M. WHEAT (T-AK 3016). During the conversion process, unexpected engineering problems were addressed, including structural issues, material readiness issues, regulatory body issues, and hazardous materials mitigation. These added cost, delayed production, and complicated the acquisition. Other new ships were acquired for the same mission more rapidly and at less cost. The WHEAT conversion was complicated by the facts that it was originally a Ukrainian ship built to very different standards and that there was a lack of documentation for many systems.

Conversions can be cost-effective or desirable when: only limited changes are made to an existing ship; when the changes can be implemented as modules or with other means of improving productivity such as the installation of pre-outfitted midship plugs; or when a new capability is required more rapidly than new construction could permit.

An example of limited changes resulting in an attractive conversion is the use of a T-AGOS class ship as a school ship and as a platform to investigate new propulsion systems. In this case, removal of towed array sensor systems was easy to accomplish and minimal additions needed to be made. The propulsion system was diesel electric and sufficiently modern for training purposes.

The conversion of the AO-177 through jumboization was an effective means of increasing the Fleet’s capacity to conduct refueling. The new capability was largely accomplished through the addition of a plug and upgrade of refueling-at-sea systems. As another example, building on the success of the LMSR program, one was converted to provide maritime prepositioning enhanced (MPF[E]) capability. The converted ship not only met the requirements efficiently, it was rapidly brought on line and included systems that were common to the other ships in the LMSR class.

The conversion of the collier USS JUPITER to the first aircraft carrier, USS LANGLEY, was an historic and successful conversion that permitted experimentation with new capabilities. Carrier operations were perfected on LANGLEY and helped in developing the requirements for the following classes of aircraft carriers. Cargo ships such as the USNS MARSHFIELD and USNS VICTORIA were converted to carry specialized cargos in secure environments, serving the government for another lifetime, as were several range tracking ships such as the USNS REDSTONE and USNS OBSERVATION ISLAND.

The Fiscal Year 1994 conversion of LPH-12 to MCS 12 was accomplished based on a limited scope Cost and Operational Effectiveness Analysis and a procurement cost constraint. The converted ship fell short of the 15-year service life that was required - largely due to steam plant reliability, availability, and maintainability issues.

When ships are procured through lease arrangements or other competitive offerings, the conversion risks and life cycle operating cost risks may be shifted away from the government to private industry. In such cases, conversions may prove to be effective in providing rapid capability. Success with such conversions includes an offshore supply boat converted to investigate well hydrodynamics in support of the TAGS 45 program. Unfortunately, the WHEAT and other less successful conversions provide reminders of the problems that can be encountered. Even if the government can shift financial risk to private industry, the needed capability may be critical. If conversions are considered, special engineering studies and condition reports may be called for to document material conditions and to validate engineering solutions.

While conversions may be attractive or worth considering, it is instructive to review the LMSR program that included both new construction and conversion designs built to very similar requirements. Note that one reason conversions were pursued was due to industrial base level loading rather than overall cost-effectiveness. The cost of the SEALIFT conversions was less than the new construction designs, approximately $220M versus $300M per ship. The conversion construction schedules (award to delivery) were on the order of three years in comparison with the lead ship new construction schedule of five years. The advantages of cost and time were offset by the acceptance of existing equipment and constraints imposed on the configurations due to the existing arrangement. Any use of a conversion approach must carefully consider the limitations and risks relative to the potential benefits and time line of military mission requirements for the asset.

5.1.5 Cost Engineering and Producibility. The cost and producibility engineering functions must be recognized as important and integral parts of the design process. For economic effectiveness, every design and engineering decision must include cost and producibility as pertinent parameters. Appendixes UU and TT provide additional information on cost engineering (*hyperlink*) and producibility (*hyperlink*).

5.1.6 Cost As an Independent Variable. With a Cost As an Independent Variable (CAIV) approach, operational requirements provided by the customer are given in terms of threshold and objective values. The range between these two values provides the Program Manager with trade-space to match the available funds with the capabilities that can be bought for that amount – the total program cost remains a constant. See Appendix UU (*hyperlink*).

5.1.7 Technology Insertion. A ship acquisition or in-service program will very likely plan technology development to achieve performance goals. Opportunities for insertion of new technology systems, subsystems and/or components are driven by affordability and the ability to address expected threats, but also are heavily influenced by the ability to mature proposed technology solutions in the time available.

Further complicating this picture, differing acquisition timelines (e.g., varying by ship class), coupled with technology maturation tempos (e.g., varying by the category of the developing technology, as well as the characteristics of the organizations developing them), tend to drive Science and Technology (S&T) as well as R&D demand signals in a wide variety of directions. This phenomenon is not unique to “New Build” acquisition programs, but also occurs with efforts to insert new technology during “Modernizations” and “Overhauls”.

As a result of the variable demands associated with shipbuilding plans and technology development writ large, a number of S&T/R&D programs across a range of potential funding streams have emerged in addition to the traditional programmed (“POMed”) approach. This has led to the present situation, wherein a variety of different funding paths (various programs and initiatives referred to as the “Heinz 57 List”) are available to enable transition of ready technologies, sufficiently demonstrated and tested, into shipboard usage with minimum risk and additional cost. The variety of these possible technology development paths provide the SDM myriad opportunities but should not replace a technology development roadmap tailored to the scale, scope, schedule, risk, and maturity of evolving technologies against solid program requirements.

A properly architected technology development roadmap therefore reflects a balanced portfolio of funded efforts. Wherein a mix of less risky development efforts with greater likelihood of incremental improvement over the present state, is balanced against riskier efforts that may provide significant advancement in capability. In developing this plan, the SDM should consult with technologists and managers familiar with various funding streams to identify and quantify risk levels, technology off-ramps, and budget-based development, test, and evaluation events.

Once the roadmap is laid out and agreed upon with the organizations developing the technologies (Office of Naval Research (ONR), Defense Advanced Research Projects Agency (DARPA), Navy Labs, Industry, Academia, etc.), development according to the agreed upon timeline must be monitored continuously. Under DoD Instruction 5000.2 (*hyperlink*), a formal technology readiness assessment must be conducted, documented, and reviewed by ONR and DoD staff. Technology Readiness Level 7 must normally be achieved to proceed forward with the implementation of the new technology within the acquisition program. Please see Table 5-2. Appendix A provides selected references related to evolving technologies and their insertion into ship design. SEA 05T can also provide guidance and assistance in technology development planning and technology transition planning. SEA 05T also provides assistance in conducting Technology Readiness Assessments.

Table 5-2. Technology Readiness Levels

Technology Readiness Level	Description
1. Basic principles observed and reported.	Lowest level of technology readiness. Scientific research begins to be translated into technology's basic properties. Examples might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated.	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept.	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment.	Basic technological components are integrated to establish that the piece will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of "ad hoc" hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment.	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in simulated environment. Examples include "high fidelity" laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment.	Representative model or prototype system, which is well beyond the breadboard tested for level 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment.	Prototype near or at planned operational system. Represents a major step up from level 6, requiring the demonstration of an actual system prototype in an operational environment. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and qualified through test and demonstration.	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this level represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets specification requirements.
9. Actual system proven through successful mission operations.	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.

5.1.8 In-Service Maintenance and Cost Drivers. Visibility and Management of Operation and Support Cost (VAMOSC) and TYCOM data should be reviewed to identify maintenance and cost drivers for in-service ships. Improving performance in these areas without increasing acquisition costs should be a goal of every design effort. VAMOSC data is available at https://vamosc.navy.mil.

5.1.9 Single-Source Vendor for Propulsion and Ship Service Electrical Plants. For some DD&C contracts it has been considered beneficial to specify that the Shipbuilder employ a single-source vendor for propulsion and ship service electrical plants. This approach has most often been used for oceanographic survey ships and programs where second tier shipyards which do not have strong in-house design capabilities are likely to win the Detail Design and Construction contract.

5.1.10 GFI and Interface Control. The SDM must work with the Program Office to ensure appropriate technical review. Errors, PARM changes, and delayed deliveries of GFI, including interface control drawings, have been responsible for significant disruptions to past shipbuilding programs.

5.1.11 Units of Measure. The Omnibus Trade and Competitiveness Act of 1988 requires that all government procurements made after 30 September 1992 use the metric system as the primary system of measurement. Specific exceptions are allowed for systems and equipment that have already been developed in other measurement systems and for new systems where the use of metric standards can be demonstrated to be impractical. NAVSEA publication, Metric Guide for Naval Ship Systems Design and Acquisition *(hyperlink)*, provides assistance. The SDM is a key adviser in the Program Office decision on metrication strategy. Recent programs have actually done the design in metric, but report out in "customary" or dual units to improve communication with the OPNAV Sponsor and others who do not use metric units on a daily basis.

5.1.12 Weapons Systems Explosive Safety Review Board Process. All ship installations of new or modified weapons or weapon systems shall be formally reviewed and safety approval received during the system development and demonstration phase. NAVSEAINST 8020.6D provides guidance on implementation of a weapons system safety program. Weapons and explosives risks shall be identified and managed using the process identified in applicable directives and shall be briefed to the Navy's WSESRB, whose charter is no longer just limited to weapons but to total ship safety. Therefore, all Navy weapons systems acquisition programs shall be reviewed by the WSESRB to ensure safety requirements are met. In ships that are the first of a class or where there are significant variations in a class, installation of a weapon system shall be formally reviewed and approved. WSESRB safety identification shall be obtained before initial delivery to the Fleet. Programs shall not advance to the next stage of development without certification by the Board. For new ship designs, drawings for review must detail proposed weapon system installations. Include locations of weapons (including cargo), magazines, and handling space, as well as adjacent spaces, associated fire protection, and all other equipment related to weapon system operations.

SDMs of major combatants should expect to prepare and participate in major technical briefings to the WSESRB several times before the completion of Contract Design. While much of new weapons systems description will be the responsibility of PEO IWS, the ship Design Team must present weapons handling, stowage, and – more recently – fire fighting and other safety design features. It is recommended to start high-level reviews of the total ship to uncover WSESRB issues early in Preliminary Design when there is some definition of the ship's major characteristics, features, and equipments.

5.1.13 Complexity. Design complexity is hard to define, but its impact is well known. It has been claimed complexity leads to fragile designs that are very sensitive to small perturbations. It also complicates design management because few engineers understand the whole design. This can lead to sub-optimal design or different design teams working to cross-purposes. Complexity has not been quantified but is seen as a function of:

- "Number of ideas you must hold in your head simultaneously;
- Duration of each of those ideas; and
- Cross product of those two things, times the severity of the interactions between them."

See Appendix VV (*hyperlink*) for additional discussion on complexity.

5.1.14 Design Maturity Assessment. Near the end of each stage of design, the SDM shall prepare a Design Maturity Assessment to demonstrate readiness for proceeding into the next stage of design or production. Tasks comprising the assessment are detailed in Appendix WW *(hyperlink*).

5.1.15 Surface Ship Lessons Learned Feedback Process. SEA 05 letter 5400 Ser 05D/174 of 29 March 2010 "NAVSEA Surface Ship Lessons Learned Feedback Process Technical Operating Procedures" establishes procedures to incorporate maintenance lessons learned into the acquisition process.

5.2 DESIGN GUIDANCE, TOOLS, AND RESOURCES.

5.2.1 Industry Best Practices. SDMs are encouraged to review and adopt, as applicable, industry best practices. Sources include the Best Manufacturing Practices Center of Excellence Website, http://www.bmpcoe.org, http://www.onr.navy.mil/en/Science-Technology/Directorates/Transition/Manufacturing-ManTech/Center-Excellence/B2PCOE.aspx, and various industry sources.

5.2.2 Center for Innovation in Ship Design. The CISD, managed jointly by SEA 05D1 and Carderock Code 20, is chartered to advance the theory and practice of ship design by facilitating partnerships wherein the best ideas and experience of industry, government, and academia can be combined to explore new and innovative ways to design and develop naval ships. CISD activities are focused in three areas:

- People: Developing technically skilled ship designers for the naval ship design community
- Knowledge: Identifying, learning, and integrating new technologies, engineering methodologies, and management tools to improve the naval ship design and development process
- Innovation: Drawing upon the combined strengths of ONR, NAVSEA, the shipbuilding industry, and academia in a collaborative, team-learning environment for innovative whole-ship design studies

SDMs can use CISD resources along with program assets to develop innovative approaches to ship design and then share "best practices" developed within their respective programs with the community at large.

SDMs should try to attend briefings and review CISD reports for possible use in planning. Additionally, they should share their experience in implementing innovative new approaches to help capture lessons learned with the ship design community.

The CISD helps support the activities of the Naval Engineering Education Center (NEEC) – a unique organization for the development of talented engineers necessary to lead the Navy forward. The goal is to provide an education experience unparalleled in terms of student, educator, professional, private, industrial, and military cooperation. The NEEC provides young engineers and scientists access to projects of interest and importance early in their academic careers which builds knowledge and enthusiasm for the field. The NEEC is composed of the Navy, The American Society of Naval Engineers, The Society of Naval Architects & Marine Engineers, and 15 institutions of higher education all of which are based in the U.S. See http://www.neecportal.org.

5.2.3 Design Standards. A number of ship design standards were generally recognized as effective in ensuring ship performance. In the past, these were developed and formally issued under the provisions of NAVSEAINST 9070.6 that has since been cancelled. Design standards have been largely incorporated into ABS and other commercial standards.

5.2.4 Design Data Sheets. A number of ship design data sheets have become generally recognized as effective in ensuring ship performance in areas such as seakeeping, survivability, powering, and endurance. Design data sheets still recognized, and that should be considered for use in ship design, are available from SEA 05S.

5.2.5 Design Tools including Product Model. The SDM must be careful in their selection to ensure compatibility and the utility of the design products for subsequent phases. SDMs and SIMs shall perform one or more tools readiness reviews to ensure the design process and certification can be executed to plan. Accessing availability of tools is not sufficient; assessing the validation and verification of the tools is also required. The tools readiness reviews should be scheduled to provide sufficient time to address shortfalls in the toolset before the tools are needed to support the design.

The SDM needs to plan how he will leverage use of the shipbuilder’s product model to monitor the progress of their design efforts.

5.2.6 Use of Point Designs. Developing and maintaining an in-house Navy “point” or “reference” design throughout the design phases where industry has the lead is a good risk mitigation technique. A reference design is useful in demonstrating that the design requirements as expressed by the Functional and Allocated Baselines are technically feasible and the described ship can be acquired within the existing budget. Reference designs are also useful for identifying technical risks that should be mitigated as early as possible. Finally, they can be compared to contractor proposed designs to identify differences and potentially identify weaknesses and strengths in it. Experience since the 1980s has shown that unless the government develops a reference design, adequately assessing industry designs for feasibility and reasonableness is very difficult.

The point design can be used to:

- Validate the effects of mission requirements at the total ship level and identify those requirements that drive ship size and cost
- Identify areas of ship design complexity and technical risk
- Quantify the whole-ship impact of new technologies
- Establish a technical baseline against which to assess proposed industry concepts and major system and subsystem trade-offs
- Establish a basis for shipboard manning estimates
- Establish a basis for Class F estimates of ship construction cost and estimates of annual operating and support costs
- Characterize the design’s key performance and other features to enable early assessments of mission effectiveness by the government

5.3 DESIGN ANALYSIS AND VALIDATION.

5.3.1 Operations Analysis. Operations analysis is the process of using the results of modeling and simulation and other studies and research to develop alternative solutions. The SDM should engage with the Program Office, OPNAV Sponsor, Center for Naval Analyses, and others in framing the early studies.

5.3.2 Modeling and Simulation. Modeling and simulation is playing an increasing role in design and testing. Verification, Validation and Accreditation (VV&A) must be accomplished for results to be accepted. The SDM should take the lead in planning all modeling and simulation. Appendix A provides selected references related to modeling and simulation.

5.3.3 Hydrodynamic Model Testing. Model tests for surface ships are carried out to confirm hydrodynamic performance predictions or to determine characteristics that cannot be accurately assessed through analytic means. To the extent desired by the overall systems engineering approach, hull form characteristics may be optimized using model tests or a combination of model tests and computational fluid dynamics. Model tests are typically carried out during the later part of Preliminary Design and during Contract Design. Some examples of model test objectives are provided in Table 5-3.

Table 5-3. Hydrodynamic Model Testing

Resistance and Propulsion Tests	• Determining resistance and propulsion characteristics. It may be important to improve the accuracy of the prediction beyond that estimated using predictive standard series techniques. For some ships, the hull form parameters may be outside of the range of available data and model tests may be particularly important. Appendage details may require investigation. • Determining the impact of changes, comparing alternative hull forms, or optimizing the hull for a particular purpose. Selecting final bulbous bow characteristics to suit various operating conditions may require comparative tests. • Improving the level of confidence in a powering prediction. This could be desirable for many reasons, including the selection of a specific diesel engine or gas turbine.
Propulsor Tests	• Evaluating wake characteristics of the hull to assist in propeller design and optimization. • Evaluating alternative propulsors or improving the accuracy of propulsor efficiency predictions. • Determining propulsor cavitation or noise characteristics. For some ships where these characteristics are KPPs, such tests may be essential to confirming such performance.
Maneuvering Tests	• Determining the maneuvering characteristics. This may be particularly important for hull forms that have unusual proportions for which prediction techniques are not accurate. Also, ships that conduct alongside operations such as underway replenishment maneuver in very confined areas or have particularly demanding maneuvering requirements. They may require tests where predictions are not accurate or a higher degree of accuracy is required. • Evaluating alternative control surfaces relative to maneuvering requirements.
Ship Motions Tests	• Predicting accelerations, periods, and magnitudes of motions. Unusual hull forms or characteristics may require tests to accurately determine the range of accelerations. This could be to assess operating limits, to provide structural or system design information, or to support HSI objectives. • Predicting slamming characteristics.
Special Hydrodynamic Tests	• Determining astern powering or stopping characteristics. • Flow visualization. This may be needed to align appendages, or for special mission ships, to assist in minimizing hydrodynamic noise. • Fin stabilizer alignment. • Determination of propeller-induced vibratory forces. • Shaft and strut alignment. • Topside airflow. • Dynamic Stability. The increasing interest in dynamic stability and unusual hull forms may require tests to assess stability characteristics in special conditions. • Examining special hydrodynamic phenomena. An example of this might be the behavior of water within a well under specific conditions. • Determining structural loads. These may be required for structural design purposes or to investigate operating constraints.

Early in the design process, hydrodynamic characteristics are estimated using various predictive techniques or judgments. Depending on mission requirements, the sensitivity of the design to the predictions will vary. Where the result of the prediction has a significant effect on the overall design, increasingly refined predictions are required. As Preliminary Design continues, the characteristics of the ship become more firm, more aspects of the ship are defined, and changes are more difficult to incorporate. For these reasons, model testing is frequently conducted during the later stages of Preliminary Design so that there is high confidence in the predictions at the start of Contract Design. The SDM must assess the potential influence of aspects of the design and determine if model tests are needed to improve estimates.

The more critical a requirement is that model tests more likely will be required to validate that the requirement can be met. Hydrodynamic tests also provide a reference for full-scale trials that provide the final confirmation that a ship meets certain requirements.

Since model tests cannot be performed instantly, the SDM must allow sufficient time to accomplish them. This requires that the configuration to be tested is defined, that test facilities can be selected, that the schedule permits the tests to be accomplished, that contractual documentation and tasking be completed, and that results can be produced in a timely manner. The TWH for hydrodynamics will provide expertise in planning such tests, selecting facilities based on the tests desired, arranging for and overseeing such tests, and evaluating and documenting the results.

5.3.4 Test and Evaluation. "Testers" generally divide their efforts into developmental testing, operational testing, and LFT&E. All three categories of test come into play during the course of a typical ship acquisition program. It is not unusual for all three categories to be supported by some type of planning or development effort by the ship Design Team.

While these three types of tests are separate and serve different purposes (and sometimes different customers), they are interrelated and should be closely coordinated. The SDM/SIM and the Program Office should have a single point of contact for all test matters, and must have a clear understanding of the overall test effort, the interrelationships of the various test programs, and the division of authority between them.

It is important that all requirements identified in the CDD and CPD be testable. COMOPTEVFOR will pursue operational testing for each. These requirements should flow down to the Specifications that should, in turn, flow down to Specification testing requirements and test planning documentation. Demonstration of performance is critical when Specifications are defined in performance terms.

Since T&E programs are reviewed by DoD at each Milestone, they have a greater influence on the design effort than might be expected. Significant SDM/SIM resources may be needed to develop and monitor tests. For example, LFT&E is usually done early in a program so it can influence the design. It may require modifying and blowing up or burning decommissioned ships and may be expensive, time consuming, dangerous, and force significant design changes downstream. Also, a working-level IPT is often formed from DoD, OPNAV, COMOPTEVFOR, and Program Office personnel to regularly review the progress of tests and test planning. Much of the subject matter of this group consists of the technical issues of design, requirements, and tests – all SDM/SIM-cognizant areas.

The governing document is the Test and Evaluation Strategy (TES) and subsequent Test and Evaluation Master Plan (TEMP), which outline the total testing approach for the entire program. The TEMP specifies critical technical parameters against which the design will be measured. It also contains funding requirements for testing which are often in competition with the SDM's other funding needs. Within a Program Office, T&E responsibility is often given to someone outside the SDM organization. However, close attention must be paid to this document and engineering resources must be diverted from regular design work to avoid losing control of the T&E process to outside entities. It has been said that the Director, Operational Test and Evaluation (DOT&E) is one of the few organizations that can stop a Program. It hasn't happened to a Navy ship program – yet.

Other test and evaluation documentation that will need to be developed includes an LFT&E management plan, modeling and simulation plan, and VV&A Plan.

Early involvement by COMOPTEVFOR in development of the CDD is useful to ensure requirements are testable. Appendix A provides selected references related to test and evaluation.

5.3.5 INSURV. The SDM should review Board of Inspection and Survey (INSURV) results of similar classes for possible consideration in the design. INSURV may be requested to review and recommend improvements for new ship designs. This is normally accomplished prior to the end of Preliminary Design and Contract Design.

5.3.6 Real Options. There is a large and growing literature on “real” options, that is, on the application (or potential application) of financial options analysis methods to the evaluation of certain kinds of non-financial investments such as large engineering projects. It is generally accepted that an options perspective (1) “leads analysts to adopt a substantially different perspective on how to design systems for uncertainty,” (2) will tilt investments toward “broad classes of projects that are much more valuable than they have appeared to be,” and (3) will encourage information-gathering “on the ways uncertainties resolve, so that the system managers can exploit the value in the options” (de Neufville, Richard. 2003. “Real options: Dealing with uncertainty in systems planning and design.” Integrated Assessment, vol. 4, no. 1, 26-34.).

The options-based approach is a supplement to existing processes for valuing alternative capital investment projects. With further development, options-based analysis could offer a way to document a component of project value which has, so far, been implicitly, tacitly, or indirectly perceived.

Explicit recognition and documentation of option value is likely to have three kinds of effects:

- In the design stage, options analysis enables more realistic assessments of technologies and design features that add flexibility during development and adaptability during the post-commissioning life cycle. Under conventional engineering economics approaches, these are undervalued.
- During the project management stage, options analysis focuses more attention on uncertainty, because the implications and opportunities created by uncertainty are more completely defined. The value of project modifications and adaptation as future information comes to light and uncertainty is resolved, are more clearly highlighted.
- Finally, options analysis adds a new perspective on project risk, as option value increases with the level of volatility and uncertainty in the final project outcome.

What are the “broad classes of projects” whose true worth, currently undervalued, will be more accurately revealed using options analysis? In terms of naval ship design and planning, the most obvious are R&D, early stage design, and the development of modularity design features. These are notoriously difficult to value.

The above text is taken from Dr. Phil Koenig, “Real options in ship and force structure analysis: A research agenda,” presented at ASNE Day 2009. For further information on applying Real Options, please refer to this paper. Note that there is concern by some that this is based on industry and financial experience and application of this to government programs needs work and investigation.

5.3.7 Requirements Risk (Market Risk). Typically Risk Analysis is used to control Schedule, Cost, and Performance Risk. Requirements Risk Analysis should also be performed to anticipate and mitigate the cost of changes in customer or derived requirements. Requirements Risk is an analog of "Market Risk" in the commercial sector which tries to measure the risk of the developed product not meeting customer expectations and failing in the market place. Requirements Risk Analysis is a means for applying well known risk management techniques to identify requirements that are likely to change over the service life of the ship and to develop mitigation plans for dealing with these changing requirements.

Typically an engineer desires to develop systems that meet a specific set of requirements. In reality, the requirements are not always that firm and change over time. To date, the approaches for dealing with uncertainty in requirements has been ad hoc such as using margins and service life allowances based on past performance problems and indiscriminately mandating open systems architectures or modularity (whether or not they are warranted). This had led to many missed opportunities for building flexibility into the design where they can have significant payoff.

The requirements analysis block of the systems engineering process should incorporate a requirements risk analysis. In this manner, the functional allocation block can help mitigate high-risk requirements by partitioning them into their own configuration items, ideally as part of an open-systems architecture. A good architecture will have rigidity in those areas where requirements are not likely to change, and provide substantial flexibility in those areas where requirements are likely to change. Modularity and carefully crafted margins and service life allowances become effective tools for enabling a design to adapt to future changes in requirements. In this manner, Requirements Risk Analysis becomes an integral part of the systems engineering process and should result in robust systems capable of quickly adapting to changing requirements.

5.4 ADDITIONAL DESIGN CONSIDERATIONS.

5.4.1 Modular Design. Many of our ships, particularly surface combatants, have in the past failed to achieve their design service life. In many cases this was due to the inability to affordably upgrade the combat systems to ensure continued military relevance. Where appropriate, Modular Adaptable Ship (MAS) technologies can improve affordability in addition to improving the military relevance of warships to their service life. MAS technologies include, but are not limited to, modular hull ships, mission bays, container stacks, weapon modules/zones, aperture stations, electronic module enclosures, and flexible infrastructure. For more information see: "A Guide for Design of Modular Zones on US Navy Surface Combatants," SEA 05T ser 05T/04 of January 2011 and "Modular Adaptable Ship (MAS) Total Ship Design Guide for Surface Combatants," 05T Ser 05T/09 of February 2011(*hyperlink*).

5.4.2 Topside Design. Navy surface ships provide a significant challenge for locating components on their topsides. These ships typically have limited topside space and, in the case of many new designs, all topside equipment must meet rigid signature control requirements. Naval topside design for surface ships is, by necessity, a search to find innovative ways to meet competing requirements for system functionality within space, weight, and cost constraints. The topside must accommodate a wide array of combat, C4I, anti-terrorism and force protection, and hull, mechanical, and electrical functions while maintaining maximum functionality of all systems to do their individual jobs. The topside must also serve the basic ship operational functions such as UNREP, flight operations, small boat deployment, docking and maneuvering, navigation, and safety of personnel movement. All of this must be done while meeting overall ship signature requirements and imposing minimal manning and operating effects. Please see Figure 5-8 and NAVSEA 05 Memorandum 9830 Ser 05D/312 of 11 October 2007 "Integrated Topside Design and Certification Process for New Construction Ships" (*hyperlink*).

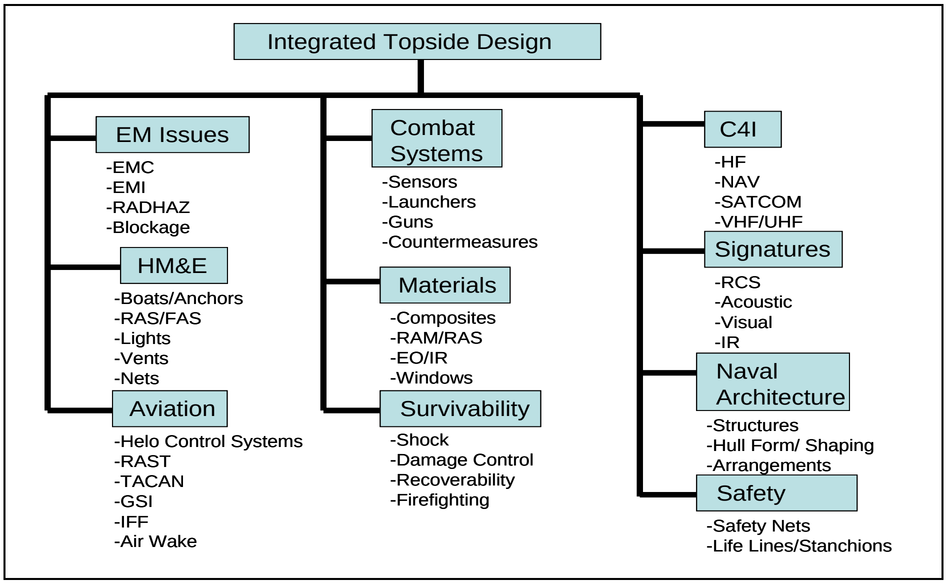


Figure 5-8. Topside Incorporates Many Disciplines

5.4.3 Survivability and Force Protection. Survivability addresses susceptibility, vulnerability, and recoverability. It should be considered a fundamental design requirement of no less significance than other inherent ship characteristics, such as weight and stability margins, maneuverability, structural integrity, and combat systems capability. Survivability is now also a mandatory KPP. It should be discussed in terms of the expected exposure of the ship to threat weapons (available from the System Threat Assessment Report (STAR)) within the projected operating environment, as well as the expected performance of the ship after suffering weapons induced damage. Is the ship expected to remain afloat? Is it expected to be able to restore mission capability quickly? Is it expected to maintain mission capability, even though damaged? The performance of the ship within the projected environment can be evaluated through a total ship survivability analysis. Such planning should begin early to ensure the availability of sufficient resources. It should also ensure survivability performance can be considered as part of the AoA and in deciding the operational requirements for the ship. Appendix A provides guidance related to survivability.

Force protection is another new mandatory KPP. It addresses protection for embarked personnel against tertiary threats including preemptive attacks or covert action from special operations forces, combat divers, and terrorists. Integrated designs of weapons, sensors, and associated support have been developed for installation onboard new and existing ships.

5.4.4 Energy Efficiency. Per USD AT&L Memo of 14 September 2010, Implementation Directive for Better Buying Power – Restoring Affordability and Productivity in Defense Spending (*hyperlink*), and ASN(RDA) Memo of 20 June 2011, Energy Evaluation Factors in the Acquisition Process (*hyperlink*), energy efficiency is now required to be considered during the AoA and addressed in requirements definition and budgeting.

5.4.5 Reliability, Availability, and Maintainability. Reliability, Availability and Maintainability (RAM) is a significant design factor and RAM requirements definition and analysis should be managed by the SDM, not the Program Office Logistics Division. Materiel availability is now a required KPP and materiel reliability a required KSA for the CDD and CPD. RAM must be considered during the AoA and a RAM-C Report is a required attachment to the AoA Report. The SDM must be careful to ensure that the criteria and assumptions for the analysis are carefully defined, fully vetted, and documented. In particular, failure data on commercial equipment is very difficult, if not impossible, to obtain.

For RAM to be useful, the definitions of what constitute a failure, as well as the definition of "time," must be carefully made. In particular, failures should be defined in terms of the ability to perform primary and secondary missions. In any case, the RAM analysis should influence the selection of hardware, software, redundancy, and system architecture. It should be considered to be closely associated to HSI in that a major contributor to system reliability is human reliability, and that the maintainability of shipboard systems has a major effect on personnel workload and skill requirements. SDMs need to develop a design reference mission as the basis for assessing RAM adequacy against a postulated set of ship functions. Contract requirements need to support Shipbuilder consideration of RAM for DD&C. See the RAM-C Guidebook (*hyperlink*).

5.4.6 Environmental, Safety and Occupational Health Compliance. Preparation of applicable National Environmental Policy Act and Executive Order 12114 documentation is considered an integral part of planning for testing, production, and deployment. Environmental planning process should be initiated at the outset of new program planning and incorporated into the subsequent design and acquisition.

Hazardous material is defined as anything that, because of its quantity, concentration, or chemical, biological, or physical characteristics, may pose substantial hazard to human health or the environment and generate environmental, safety, and occupational health related concerns that require an elevated level of effort to manage. This definition includes materials that may be used in manufacturing, operations, maintenance, and disposal over a system's life cycle that may result in the release of hazardous materials. Specifications must contain provisions to strictly limit their use.

The SDM should consider pollution prevention methods, practices, and technologies early in the program to mitigate their cost, and schedule risks. Pollution prevention should be an integral part of systems engineering throughout the life cycle of the program. Total ship, systems, and equipment-level disposals should be planned.

A formal system safety program will also need to be implemented by the Program and the Shipbuilder.

The references listed in Appendix A provide guidance on ESOH compliance.

5.4.7 NAVSEA Critical Safety Item Program. The NAVSEA Critical Safety Item (CSI) Program was created to combat a trend of nonconforming material issues in critical safety parts. Section 130 of the John Warner National Defense Authorization Act for Fiscal Year 2007 re-established technical authority over procurement of ship CSIs lost under the Federal Acquisition Reform Act of 1996. NAVSEAINST 9078.1 details NAVSEA policy, responsibilities, coordination, and awareness in the procurement, modification, repair, and refurbishment of ship non-nuclear CSIs. NAVSEAINST 9078.2 details the technical requirements and procedures for implementing the ship CSI program.

CSI is defined as “Any ship part, assembly, or support equipment containing a critical characteristic whose failure, malfunction, or absence may cause a catastrophic or critical failure resulting in loss or serious damage to the ship, or unacceptable risk of personal injury or loss of life.” Since this definition is rather broad, the LHA 7 program is currently piloting a CSI review of the LHS 7 in an effort to refine the definition.

Per NAVSEAINST 9078.2 (*hyperlink*), SDMs shall participate in the CSI determination process for modernization, overhaul, and new construction programs. SDMs review the CSI definition, any established CSI determination criteria, and consult with the component/system as necessary to determine when an item should be a CSI. Concurrence with any new CSI determination criteria is obtained from the component/system TWH.

For new construction designs where a Design Agent (DA) is performing the Design, the DA shall conduct the CSI and critical characteristic review and forward to the SDM team via DRL for review. For in-house designs, the SDM leads the review. An overview of the review process is outlined below.

- The systems for the ship shall be identified
- Interfacing systems shall be identified
- For each system identify
  - System function
  - Interfacing function with other systems
  - System failure modes
- Question each system to determine if system failure would result in:
  - Loss of, or serious damage to the ship or
  - Unacceptable risk of personal injury or
  - Loss of life
- For systems identified with potential CSI, forward SDM analysis to component/system TWH for CSI determination

In the process of identifying CSI, the following can be assumed:

- Determining factor is consequence of failure, NOT probability
- Shock loading and loss of mission capability are not considered
- Assume equipment is being operated in accordance with approved operating and casualty procedures
- Assume single failure occurs in the locations that would result in the greatest consequence to the ship
- If strength is degraded due to a single failure, determine if progressive failure occurs
- Evaluate consequence of failure under the most severe condition at which the item is designed to operate

The final determination for declaring equipment to be CSI is made by the applicable DWO.

5.4.8 Human Systems Integration. HSI addresses the human component (operators, maintainers, and decision makers) of the total system design. Just as integration and information exchange requirements must be defined for hardware and software interfaces, operator and maintainer interfaces with hardware and software and with one another must be explicitly defined and optimized to support overall system performance requirements. HSI provides the methods and discipline to ensure effective and efficient utilization of human resources within the total system design.

HSI is composed of the systems engineering process and program management efforts that provide integrated and comprehensive analysis, design, and assessment of requirements, concepts, and resources for:

- Manpower
- Personnel
- Training
- HFE
- Safety
- Occupational Health
- Personnel Survivability
- Habitability

Under SECNAVINST 5000.2 *(hyperlink)*, the Navy requires its Program Managers and Sponsors to initiate an HSI effort as early in the acquisition process as possible and address HSI throughout all phases of the acquisition process to optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system. Human factors engineering and safety reviews should be incorporated into the Preliminary, Contract, and Detail Design process.

Note that the Technical Authority for HSI flows from the Deputy Warranting Officer to the SDM. It is up to the SDM to ensure there is an HSI SME on the design team.

See Section 3.2 and Appendix QQ (*hyperlink*) for additional discussions.

5.4.9 NAVSEA Commonality Program and Standardization. The Commonality Program reduces the variety of systems, subsystems, and components used in ship systems installed in the Fleet, fosters cross-platform commonality and reduces total ownership costs. Commonality through reduction in variation based on requirements, total ownership cost, and quality supports a reduction in new acquisition, and modernization costs while supporting a reduction in new acquisition, modernization and upgrade program risk in component selection, acquisition and life cycle costs and parts within the Navy logistics system. NAVSEAINST 4120.8 (*hyperlink*) establishes requirements to develop, manage, and communicate standard engineering specifications and parts lists to reduce program risk and cost by implementing a Virtual Shelf commonality concept.

The Virtual Shelf is an online repository of information for programs to use in designing ship systems during acquisitions and modernizations. The Shelf systems and components are aligned by SWBS. The Shelf can contain detailed system or component specifications, system architectures and components with related Allowance Parts List/Navy Item Identification Number information. The Shelf, if appropriate, will identify those components which have Commodity Contracts. Commodity Contracts will be available to the shipyards to use and procure shelf items via the Naval Inventory Control Point contracts.

The "Shelf" will contain standard engineering specifications including:

- Engineering descriptions of shelf items to enable integration of shelf items into standard architectures
- Specifications for shelf items to facilitate procurement of shelf items
- A shelf selection tool to support the user in selecting shelf items based on the components' design requirements
- Total Ownership Cost Data and Business Case Analysis templates to support developing the Business Case Analysis
- A Shelf Roadmap indicating the expected lifespan of each element on the shelf

These items are collectively referred to as Shelf Items in the context of the Commonality Program.

SDMs have responsibilities under the Commonality Program to:

- Assist SIMs & TWHs in establishing and managing the engineering standards included in the Shelf
- Develop ship systems designs with use of Shelf items as described in the *Commonality Handbook*
- Facilitate contractors use of Shelf items in the design of ship systems
- Ensure that Shelf requirements are included in technical data packages

Details of the Commonality Program are outlined in the Commonality Handbook for Program Managers and Ship Design Managers (*hyperlink*).

Standardization of parts and equipment within the individual ship, ship class, and the Fleet is desirable and is sometimes incentivized by the contract. Standardization goes beyond the implementation of Commonality as described above. Standardization includes minimizing the total number of different types of parts used in the ship design.

Standardization can also take the form of "class standard equipment" which may be procured or managed separately from the ship construction contracts. This was accomplished for SEALIFT programs. SDMs may be asked to manage separate design packages, source selections, etc. in support of such efforts. Appendix A provides selected references related to standardization.

5.4.10 Interoperability and Net Readiness. Net readiness, including interoperability, is a mandatory KPP under the provisions of CJCSI 6212.01 *(hyperlink)*. Development of related architectures must begin to support development of the ICD and continue for the CDD and Information Support Plan (ISP). The SDM should ensure the C4ISR SEM begins to address net readiness from the start of the project. Interoperability testing presents a technical challenge. Appendix A provides guidance related to interoperability and net readiness.

5.4.11 C4ISR and Weapons System Integration. DoN Policy is to:

- Provide the C4ISR and Weapons System Suite as GFE for new Ship Construction, with PEO C4I and PEO IWS as the providers
- Integration for new Ship Construction will use the "Design Budget" process
- The Government will establish, use, and manage a Government owned ship Network Architecture
- OPNAV N6 and N8 will determine a resourcing construct to fund C4ISR developments, "Design Budget" process, network architecting, and supporting engineering.

The SDM must work closely with the SIM and C4ISR SEM to implement these policies.

The SIM is technical authority for warfare systems on Navy surface ship classes. The SIM provides technical oversight to ensure compliance with policies, instructions, publications, standards, specifications, and other guidance, performance metrics, tools, and best practices. The SIM coordinates and oversees technical reviews of surface ship warfare systems requirements, specifications, systems designs and analyses, design criteria, design products, and design waivers in accordance with the NAVSEA 05H and PEO IWS Technical Review Manual.

The SIM is the primary point of contact for warfare systems integration efforts for assigned warfare systems and their specific ship. The assigned SIM is responsible for the review of system level artifacts that meet the warfare systems requirements and is safe for the ship. They will perform warfare systems level risk assessments where the system does not meet the requirement and recommend solutions to mitigate that risk. Objective Quality Evidence will be reviewed for warfare systems certification panels. SIMs will participate in Enterprise level Change Control Board's (eCCB's) (PEOIWSINST 4130.1, Integrated Warfare Systems (IWS) Enterprise Configuration Control Process and COMUSFLTFORCOMINST/COMPACFLT 4720.3 C5ISR Modernization Policy) for configuration control of the warfare systems of the platforms. They will review artifacts that will define interface, weight, distributive system (electrical, cooling, etc.), test requirements for system installation. Coordination between the platform SDM(s), SIM, and ship class Program Offices is essential.

5.4.12 Information Assurance. Information assurance is a key performance capability for the design of ship information technology and command and control systems. Under the Clinger-Cohen Act, Programs must demonstrate planning through development of an information assurance strategy. The SDM should ensure the C4ISR SEM begins to address this capability beginning with CDD development. Appendix A provides selected references related to information assurance.

5.4.13 Open Systems. The DoD and SECNAV 5000 series instructions require programs to employ an open systems approach where feasible. The best current source document is the Naval Open Architecture Contract Guidebook for Program Managers. Implementation is normally focused on systems that employ information technology.

5.4.14 Electromagnetic Compatibility. The SDM must ensure that the ship will be electromagnetically compatible within itself and with other platforms in the operating environment. Ships need to incorporate measures to avoid Electromagnetic Interference (EMI), electromagnetic vulnerability, and Radiation Hazard (RADHAZ). Ships need to be compliant with requirements for topside design and electromagnetic compatibility (EMC) certification. Emission control may be required. SEA 05H EMI TWH shall be involved in all Electromagnetic design and review meetings. Appendix A provides selected references related to electromagnetic compatibility.

5.4.15 Electromagnetic Spectrum Certification and Supportability. Spectrum certification is obtained with approval of DD Form 1494 by CNO (N6) for Navy programs and Headquarters, Marine Corps (HQMC) (C4) for the Marine Corps. The approved form is submitted to the Navy and Marine Corps Spectrum Center for coordination with the Military Communications-Electronics Board. Program Offices shall obtain approval of DD Form 1494 prior to Milestone B and confirm currency of the frequency allocation at each subsequent milestone. Appendix A provides selected references related to electromagnetic spectrum.

5.4.16 DoD Architecture Framework. Architectures within the DoD are created for a number of reasons. From a compliance perspective, the DoD's development of architectures is compelled by law and policy (i.e., Clinger-Cohen Act, Office of Management and Budget (OMB) Circular A-130) and the derivative regulations such as CJCIS 6212.01. From a practical perspective, experience has demonstrated that the management of large organizations employing sophisticated systems and technologies in pursuit of joint missions demands a structured, repeatable method for evaluating investments and investment alternatives, as well as the ability to effectively implement organizational change, create new systems, and deploy new technologies. Towards this end, the DoD Architecture Framework (DoDAF) was established as a guide for the development of architectures. See Appendix RR (*hyperlink*). Note that for ship Programs the proven utility of DoDAF is, so far, confined to definition of the C4I and weapons system requirements.

5.4.17 Corrosion Prevention. Corrosion prevention is a significant life cycle cost reduction measure. At the time of program initiation, the SDM should identify the corrosion susceptibility of the prospective system. For all programs deemed "corrosion susceptible," the SDM should establish a corrosion prevention and control program. It should identify attributes of the system's design and construction that are likely to facilitate or exacerbate corrosion during operational use. The SDM should adopt environmentally compliant materials selection and corrosion prevention techniques during the design and manufacture of weapon systems. The SDM may prepare a Corrosion Prevention and Control Plan (CPCP) and stand up a Corrosion Prevention Advisory Team (CPAT) early in the Program. The Shipbuilder will also be required to stand up a corrosion prevention and control program.

5.4.18 Material Selection. Material selections should consider performance, procurement cost, and total ownership considerations such as environmental and corrosion control. Use of selected materials is prohibited by statute and regulation. Please see Appendix A for guidance on the list of hazardous materials prohibited from use in ship acquisition programs.

5.4.19 At Sea Environmental Planning. Efforts are currently underway to conduct planning for Navy military readiness and scientific research activities at sea including the impact weapons testing and use of SONAR.

5.4.20 Underwater Ship Husbandry. Requirements for underwater maintenance should be considered in the design.

CHAPTER 6
SHIP DESIGN MANAGER'S CHECKLIST

The following is a generalized list of action items required of the SDM in the preparation of a new construction ship design. This list should be studied and used by the SDM in developing a checklist of action items to suit the peculiarities of his own ship design. Although many actions occur concurrently, the action items are listed in approximately chronological order. An "X" in the column for feasibility studies (FS), Pre-Preliminary Design (Pre-PD), Preliminary Design (PD), Contract Design (CD), or DD&C indicates an action required for that phase. See Appendix Q for SETR entrance/exit criteria that should also be considered in planning.

ACTION	FS	Pre-PD	PD	CD	DD&C
Obtain and review a copy of the Program Office tasking and the OPNAV tasking document that authorizes the design effort.	X	X	X	X	X
Identify SEA 05 and Program Office protocols for external communications and correspondence.	X	X	X	X	X
Conduct turnover with former SCM.	X				
Become familiar with earlier phase efforts. Obtain copies of related earlier phase planning, historical documents and products.	X	X	X	X	X
Obtain a copy of any acquisition strategy and acquisition plan and, if no draft is available, at least the Program Office's Program Objectives and Milestones.	X	X	X	X	X
Review the Shipbuilder's master schedule of key events and production milestones.			For Industry Design	For Industry Design	X
Discuss program planning with the Program Office acquisition manager, technical director/integration manager (if applicable), test and evaluation manager, technology manager, logistics manager, and business and financial manager.	X	X	X	X	X
Identify design requirements, constraints and ensure they are sufficiently defined to support this design phase.	X	X	X	X	X
Establish design budgets as required.		X	X	X	X
Establish requirements traceability.		X	X	X	X
Establish Technical Performance Measures.		X	X	X	X
Define design phase entrance/exit criteria such as the degree of ship system definition and design products.		X	X	X	X
Develop Engineering Management Plan and inputs for the Program System Engineering Plan.	X	X	X	X	X
Establish minimum reporting requirements and guidelines.	X	X	X	X	X
Consult lessons learned for past programs and "best practices."	X	X	X	X	X
Establish Action Item Tracking.	X	X	X	X	
Establish Risk Management.	X	X	X	X	X
Develop WBS.	X	X	X	X	X
Develop physical and software architectures.	X	X	X	X	X
Establish Design Team organization.	X	X	X	X	X
Make contact with SEA 05C to discuss design inputs required for cost estimating.	X	X	X	X	

ACTION	FS	Pre-PD	PD	CD	DD&C
Make contact with AoA Study Director, and begin discussion of support studies required.	X				
Review data from ship design project history book (the Red Book) and annual reports (copies are in the SEA 05D/V library) to determine rough data for schedule and funding requirements.	X	X	X	X	X
Conduct Design Activity Modeling, Develop DSM, Produce Integrated Master Schedule with Critical Path and Resourcing.	X	X	X	X	X
Focus on development and approval of mission scenarios, threat sets, concept of operations and design reference mission.	X				
Begin discussion of Corrosion Control, ESOH, HSI, RAM-C and other horizontal activities and potential support.	X	X	X	X	
Prepare memo from Division Director to SEA 05D/V requesting project support personnel.		X	X	X	X
Set up meeting with PNA or DIM and SEMs to define the task and to establish relationships and responsibilities.	X	X	X	X	X
Determine design strategy for use of contractor support. Evaluate potential OCI.	X	X	X	X	X
Determine and, if required, arrange for Shipbuilder participation.	X	X	X	X	
Evaluate the need for Fleet, INSURV, and other organizational participation.	X	X	X	X	X
Determine need, and, as necessary, prepare letter to and/or negotiate MOU or MOA with SPAWAR, PEO (C4I), PEO IWS, NAVSUP, BUMED, NAVAIR, COMOPTEVFOR, MSC, ABS, USCG, and other participating organizations, informing them of the design effort and requesting a liaison point of contact.	X	X	X	X	X
Establish relationship with SUPSHIP office to define roles and responsibilities.			For Industry Design	For Industry Design	X
Complete planning for independent design assessment.	X	X	X	X	X
Complete Design Team staffing planning.	X	X	X	X	X
Identify the need for a Design Site and obtain pricing.	X	X	X	X	X
Identify the need to establish an IDE and obtain pricing.	X	X	X	X	X
Prepare memo requesting SOWs and WTAs from each TL. Forward same through the appropriate SEM. Complete.		X	X	X	X
Prepare budget and obligation plan. Negotiate the basis for funds transfer from the Program Office. Establish an AEA with the Program Office.	X	X	X	X	X
Establish the financial management system for the project including budgeting, tracking, and reporting.		X	X	X	X

ACTION	FS	Pre-PD	PD	CD	DD&C
Request SEMs obtain names of TLs and functional code contacts. Distribute to all team members.	X	X	X	X	X
Establish project data management system and IDE, including provisions for action items, documentation management, requirements traceability, and design history.	X	X	X	X	X
Verify that the Shipbuilder's IDE is ready to support DD&C.					X
Determine modeling and simulation and associated VV&A to be employed.	X	X	X	X	
Select design tools to be used. Consider CAD system compatibility.	X	X	X	X	
Identify design standards and margins to be employed.	X	X	X	X	
Determine subsystems having high risks or a potentially significant impact on ship performance, configuration, weight, cost, or manpower, personnel, and training requirements so emphasis can be placed on these subsystems.	X	X	X	X	X
Using the DRL deliverable schedule, prepare a list of DRLs requiring review and approval by headquarters that includes the schedule for the review and who is responsible for the review. Forward to the Design Team.		For Industry Design	For Industry Design	For Industry Design	X
Establish relationships with PARMs and other supporting activities on information necessary for design and to establish manpower, personnel, and training requirements.		X	X	X	X
Review Program Office schedule for GFE/GFI. Continue to update as delivery dates are firmed up.				X	X
Hold kick-off meeting with entire Design Team to ensure everyone has the same understanding of the job to be done and to define clearly specific design directions and responsibilities. Cover preparation of SOWs/WTAs and start of tasking document preparation for contractor support. Distribute copies of the Engineering Management Plan and any other design requirements or restraints imposed by OPNAV or the Program Office. Follow up with memo and subsequent management review meetings.	X	X	X	X	X
Identify required studies, analyses, model testing, and associated technical reports.	X	X	X	X	X
Coordinate to ensure appropriate participation in implementation of ship master test plan.				For Industry Design	X
Review and sign out all tasking documents for design support.	X	X	X	X	X
Schedule weekly or other regular meetings with SEMs and Project Office personnel to keep clear lines of communication. Send out memo with schedules and identify those who are expected to attend.		X	X	X	X
Develop master calendar and procedures for status reports and action items.	X	X	X	X	X

ACTION	FS	Pre-PD	PD	CD	DD&C
Establish configuration control system, including requirements traceability and design history.		X	X	X	X
Define and document security classification requirements. Develop Program Protection Plan.	X	X	X	X	X
Establish a Design Decision Memorandum or equivalent process.	X	X	X	X	X
Determine schedule for design reviews and reviews by senior level personnel and establish procedures to be followed.	X	X	X	X	X
The following reviews should be scheduled and documentation developed:					
In-process/peer reviews	X	X	X	X	X
ITR	X				
ASR	X				
SRR		X			
SFR			X		
PDR				X	
CDR					X
PRR					X
Participate in contractor or Shipbuilder design reviews.		X*	X*	X*	X
Identify award fee criteria and participate on the award fee board.		X*	X*	X*	X
Monitor Shipbuilder's management of design margins.					X
Participate in development and review of ECPs and Requests for Clarification, Information and Assistance (RCIAs) in support of CCB evaluation and approval.					X
Coordinate SEA 05 review and comment on DRL deliverables.		For Industry Design	For Industry Design	For Industry Design	X
Obtain feedback from INSURV, the Fleet, COMOPTEVFOR, and safety center on problems with similar ships or equipment.		X	X	X	X
Participate in INSURV inspection and arrange for technical support during and after it. Obtain feedback for use in follow ships.					X
Task development of design notebooks.		X	X	X	
Develop and implement procedure for formal and informal management briefings and problem reporting.	X	X	X	X	X
Develop and implement a system for progress reporting and financial status – overall status as well as status by SOW/WTA.	X	X	X	X	X

ACTION	FS	Pre-PD	PD	CD	DD&C
Develop and schedule presentations to the Fleet on significant features of the design. Also schedule INSURV presentations when appropriate for the design (major combatant ship designs).		X	X	X	X
Keep SEA 05C informed of design and design changes, and get periodic updates on ship acquisition cost estimates.	X	X	X	X	X
Participate in SEA 05C cost estimate peer reviews.	X	X	X	X	X
Prepare final design report.	X	X	X	X	
Receive Ship Specification certification sheets from TLs through the SEMs.				X	
For final approval of the design package determine: What will be signed Who will sign each document Correct signature blocks Attendance at signature ceremonies Distribution of signed copies.	X	X	X	X	
Participate in development of SOW and other contract documentation.	X*	X*	X*	X	
Participate in source selection.	X*	X*	X*	X	
Determine disposition of project records.	X	X	X	X	X
Prepare SEA 05D/V annual report.		X	X	X	X
Work with SEA 05S to develop the Specification Development Plan.		X	X	X	
Work with SEA 05S to develop the Specifications Matrix.		X	X	X	
Chair the Reading Session.		X	X	X	
Review the Reading Session Plan.		X	X	X	
Get the Master Index of References.		X	X	X	
Work with SEA 05S on Specification Training.		X	X	X	
Work with the Program Manager on Specification Type Selection.		X	X		
Get a Specification Delivery Schedule from the Shipbuilder.			For Industry Design	For Industry Design	X

* If required by acquisition strategy.

APPENDIX A
SHIP DESIGN AND ACQUISITION DIRECTIVES AND REFERENCES

Acquisition Management

Federal Acquisition Regulation

Defense Federal Acquisition Regulation Supplement

DoD Directive 5000.01, The Defense Acquisition System, 12 May 2003 (Certified current as of 20 November 2007)

DoD Instruction 5000.02, Operation of the Defense Acquisition System, 8 December 2008

Defense Acquisition Guidebook, 5 May 2010

SECNAVINST 5000.2E, Implementation and Operation of the Defense Acquisition System and the Joint Capabilities Integration and Development System, 1 September 2011

SECNAV M-5000.2, Department of the Navy Acquisition and Capabilities Guidebook, 22 December 2008

SECNAVINST 5400.15C, DoN Research, Development and Acquisition, and Associated Life Cycle Management Responsibilities, 13 September 2007

Aviation

OPNAVINST 3120.28B, Certification of Aviation Capability of Ships Operating Aircraft, 21 October 1991

OPNAVINST 3120.35J, Requirements for Air Capable, Amphibious Assault, and Mine Countermeasures Ships to Operate Aircraft, 27 June 2000

C4I

OPNAVINST 2300.44G, Communications Characteristics for Navy Ships, MSC Ships, Coast Guard Cutters, Designated Craft, Portable Radio Users and Major Shore Communications Stations, 23 June 2007

OPNAVINST 3090.1, (C4I) Capability Requirements Definition For New Construction And Intelligence Systems Program Roadmap, 5 October 2009

Configuration Management

NAVSEAINST 4130.12B, Configuration Management (CM) Policy and Guidance, 21 July 2004

Commonality

NAVSEAINST 4120.8, NAVSEA Policy for Commonality of Systems, Subsystems, and Components, 6 Apr 2009

Contracting

USD (AT&L) Memo Strengthened Sustainment Governance for Acquisition Program Reviews, 5 April 2010

NAVSEAINST 4200.03B, Unsolicited Proposals Processing, 14 January 1988

NAVSEAINST 4200.17C, Contracting Officer's Representative (COR), 20 January 2006

NAVSEAINST 4200.19, Service Contract Restrictions & Safeguards, 25 January 1990

NAVSEAINST 5400.57D, Engineering Agent Selection, Assignment, Responsibility, Tasking and Appraisal, 3 February 2003

USD RD&A Memo Rescission of Award Fee Contracts Memoranda, 31 January 2011

USD RD&A Public Disclosure of Justification and Approval Documents for Non Competitive Contracts, 24 February 2009

USD RD&A Memo Department of the Navy Peer Review Program, 26 March 2009

USD RD&A Memo DoDIG Contracting Action Areas of Concern, Purchases Made With Earmarks, 28 September 2010

USD RD&E Memo Required Documented and Signed Component Level Cost Position for Milestone Reviews, 12 March 2009

Correspondence and Records Management

DoD Directive 5230.24, Distribution Statements on Technical Documents, 18 March 1987

NAVSEAINST 5200.11A, Decision Process and Format, 17 December 1986

NAVSEAINST 5230.012, Release of Information to the Public, 21 November 2003

NAVSEAINST 5730.01D, Legislative & Congressional Matters, 18 July 2002

SECNAV Manual M-5216.5, Navy Correspondence Manual, March 2010

NAVSEAINST 5216.02B, Signature Authority for Correspondence, Directives, and Naval Messages, 30 June 1986

SECNAVINST 5210.8D, Department of the Navy Records Management Program, 31 December 2005

NAVSEAINST 5200.11A, Decision Process and Format, 17 December 1986

NAVSEAINST 5210.5, Records Management, 3 April 1997

Corrosion Prevention

NAVSEAINST 9630.001, Corrosion Prevention and Control Policy, 2 March 2006

Cost Estimating

SECNAVINST 5223.2, Department of the Navy Cost Analysis, 16 December 2008

NAVSEAINST 7300.14B, Classification of Cost Estimates for Ships, 16 May 1996

DoD Manual 5000.4-M, Cost Analysis Guidance and Procedures, December 1992

DoD Directive 5000.04, Cost Analysis Improvement Group, 16 August 2006

NAVSEA Cost Estimating Handbook

USD RD&A Memo Shipbuilding Pricing, 19 February 2004

Data Management/Integrated Digital Environment

Guidance on Acquisition and Conversion of Logistics Technical Data to Digital Form, 2004

DoD Manual 5010.12-M, Procedures for the Acquisition and Management of Technical Data, May 1993

NAVSEAINST 4130.12B, Configuration Management Policy and Guidance, 21 July 2004

SECNAVINST 5200.39A, Participation in the Government-Industry Data Exchange Program (GIDEP), 23 December 2005

DoD Directive 5230.24, Distribution Statements on Technical Documents, 18 March 1987

NAVSEAINST 4000.06A, Data Management Program, 18 April 1989

NAVSEAINST 9040.03, Development, Maintenance, and Exchange of Product Model Data by Ship and System Programs, 4 March 1998

NAVSEAINST 9085.003A, Selected Record Drawings for Ship Acquisition, 12 September 1989

NAVSEAINST 9085.04, Engineering Drawing Technical Data Package Acquisition Requirements, 20 May 1988

NAVSEAINST 9085.01, Standard and Type Drawings, 1 March 1983

OPNAVINST 4120.5, DoN Computer-Aided Acquisition and Logistics Support (CALS) Policy and Signature Plan, 1 July 1992

SECNAVINST 5000.37, Provision of Department of the Navy Documentary Material, 21 September 2009

Design

SEA 05D Memo, serial 05D/376 of 28 June 2010, Surface Ship Concept Design Policy

NAVSEA Memo, serial 05D/386 of 30 June 2010, Technical Decision Process

Concept Design Handbook version 1.0, 27 December 2006

SEA 05D Memo, serial 05D/023 of 31 January 2005, System to Categorize Concept and Feasibility Study Efforts

SEA 05D Memo, serial 05D/135 of 22 November 2004, Internal Review Release Process for Ship Concepts

SECNAVINST 5031.1C, Ship Naming, Keel Layings, Christenings, Commissioning and Decommissioning, 29 September 2009

USD AT&L Standardization of Work Breakdown Structures to Support Acquisition Program Management, 9 January 2009

Ser 05B/066 of 17 November 2009, SEA 05 Policy on Review and Approval of Products For Distribution Outside Naval Systems Engineering Directorate

Naval Engineers Journal, May 1983 paper Repeat Ship Designs Facts and Myths by Phil Covich and Michael Hammes

SEA 05 letter 5400 Ser 05D/174 of 29 March 2010, NAVSEA Surface Ship Lessons Learned Feedback Process Technical Operating Procedures

Ser 05T/33 of 27 December 2010, NAVSEA 05T Guide for Conducting Technical Studies

SEA 05D Memorandum 5000 Ser 05D/450 of 21 July 2010, SEA 05D Annual Reports for FY 2010

David J. Singer, PhD., Captain Norbert Doerry, PhD., and Michael E. Buckley, What is Set-Based Design? , Presented at ASNE DAY 2009, National Harbor, MD., April 8-9, 2009.
Also published in ASNE Naval Engineers Journal, 2009 Vol 121 No 4, pp. 31-43.

Earned Value Management

DoD Earned Value Implementation Guide, October 2006

NAVSEAINST 7000.04G, Earned Value Management, 31 January 2005

ANSI/EIA-748B, ANSI Standard for Earned Value Management Systems, June 2007

USD RD&A Memo Earned Value Management Requirements and Reporting, 30 September 2008

Electromagnetic Compatibility and Spectrum Management

DoD 5200.1-M, Acquisition Systems Protection Program, January 1997

OPNAVINST 2400.20F, Electromagnetic Environmental Effects and Spectrum Supportability Policy and Procedures, 19 July 2007

SECNAVINST 2400.1, Electromagnetic Spectrum Policy and Management, 6 February 2006

NAVSEAINST 2450.1, Frequency Allocations and Frequency Assignments, 9 December 1991

OPNAVINST 2400.7F, Frequency Usage Report, 24 April 1987

NAVSEAINST 2450.2, Electromagnetic Compatibility, 24 February 1992

NAVSEAINST 8020.07C, Hazards of Electromagnetic Radiation to Ordnance Safety Program, 1 July 1999

MIL-STD-464A, Electromagnetic Environmental Effects, Requirements for Systems, 19 December 2002

MIL-HDBK-237D, Electromagnetic Effects and Spectrum Supportability Guidance for Acquisition Process, 20 May 2005

Environmental, Safety and Occupational Health

OPNAVINST 5090.1C, Environmental Readiness Program Manual Program Manual, 11 February 2008

DoD Manual 4160.21-M-1, Defense Demilitarization Manual, 14 February 1995

DoD Manual 4160.21-M, Defense Materiel Disposition Manual, 18 August 1997

DoD Instruction 4715.6, Environmental Compliance, 24 April 1996

OPNAVINST 8026.2B, Navy Munitions Disposition Policy, 18 May 2007

SECNAVINST 5090.6A, Environmental Planning for Department of the Navy Actions, 26 April 2004

OPNAVINST 5090.1C, Environmental Readiness Program Manual, 11 February 2008

SECNAVINST 5090.8A, Policy for Environmental Protection, Natural Resources, and Cultural Resources Programs, 30 January 2006

NAVSEAINST 5100.02A, Asbestos Elimination, Substitution Personnel Protection Program, 11 September 1979

NAVSEAINST 5100.03D, Mercury, Mercury Compounds & Components Containing Mercury or Mercury Compounds, 26 January 1998

NAVSEA ESH Integration Guide for Program Managers, September 1999

DCNO (N4) memo Environmental Readiness in Sys Acquisition, 29 July 2008

OPNAVINST 5100.8G, Navy Safety and Occupational Safety and Health Program, 2 July 1986

SECNAVINST 5100.10J, Department of the Navy Policy for Safety, Mishap Prevention, Occupational Health and Fire Protection Programs, 26 Oct 2005

OPNAVINST 5100.23G, Navy Occupational Safety and Health (NAVOSH) Program Manual, 30 December 2005

MIL-STD-882D, Standard Practice for System Safety, 10 February 2000

NAVSEAINST 5100.12A, Requirements for NAVSEA System Safety Program for Ships, Ship borne Systems and Equipment, 11 December 1995

NAVSEAINST 5100.15A, NAVSEA Occupational Safety Health (OSH) Program Policy and Guidance, 20 December 1999

OPNAVINST 5100.19E, Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat, 30 May 2007

OPNAVINST 5100.24B, Navy System Safety Program, 7 February 2007

OPNAVINST 8020.14, Department of the Navy Explosives Safety Policy, 1 October 1999

NAVSEAINST 8020.6D, Navy Weapon System Safety Program, 15 January 1997

USD AT&L Memo Reducing Preventable Accidents - Memorandum of Agreement, 17 July 2007

NAVSEAINST 9078.1, Naval Ship’s Critical Safety Item Program, Non Nuclear, 1 May 07

NAVSEAINST 9078.2, Naval Ship’s Critical Safety Item (CSI) Program Technical Requirements, 15 May 2008

Fleet Modernization Program

COMFLTFORCOMINST 4790.3, Joint Fleet Maintenance Manual (JFMM)

IDEA Operations Manual

SL720-AA-MAN-030, Surface Ships and Carriers Entitled Process for Modernization Management and Operations Manual

Integrated Project Teams for Aircraft Carrier Maintenance (IPT4ACM)

COMFLTFORCOMINST 4790.3, Joint Fleet Maintenance Manual (JFMM)

Habitability

OPNAVINST 9640.1A, Shipboard Habitability Program, 3 September 1996

Human Systems Integration

Navy Ship Systems Program Manager's Human Systems Integration (HSI) Guide, 14 Jul 2003

NAVSEAINST 3900.008A, Human Systems Integration (HSI) Policy in Acquisition and Modernization, 20 May 2005

NAVSEA 3900.8-M, NAVSEA Human Systems Integration (HSI) Technical Processes (currently in revision and formerly SEA 05 HSI Best Practices Guide)

Human Systems Integration Guide, Volume 1, HSI Overview, May 2005

OPNAVINST 5310.23, Navy Personnel Human Systems Integration (NAVPRINT), 10 November 2009

Naval Sea Systems Command Human Systems Integration Integrated Product Team Charter of 17 May 2011

2009 Naval Human Systems Integration Management Plan, Version 2.2

HSI Plan Preparation Guide (draft)

Information Assurance

SECNAV M-5510.36, Information Security Program, June 2006

DoD Directive 5105.21, Defense Intelligence Agency (DIA), 18 March 2008

OPNAVINST 5239.1C, Navy Information Assurance (IA) Program, 20 August 2008

SECNAVINST 5239.3B, Department of the Navy Information Assurance Policy, 17 June 2008

SECNAV Manual M-5239.1, Department of the Navy Information Assurance Manual, 1 November 2005

NAVSEAINST 5239.2A, NAVSEA Information Assurance Program, 15 December 2008

DoD Directive 8500.1E, Information Assurance, 24 October 2002 (certified current as of 23 April 2007)

DOD Instruction 8510.01, Department of Defense Information Assurance Certification and Accreditation Process (DIACAP), 28 November 2007

DoD Instruction 8500.2, Information Assurance (IA) Implementation, 6 February 2003

DoN CIO Memo 01-09, Information Assurance Policy for Platform Information Technology, 30 January 2009

DoN CIO Memo 02-10, Information Assurance Policy Update for Platform Information Technology, 26 April 2010

Platform Information Technology (PIT) Information Assurance (IA) Policy Amplification for NAVSEA Afloat Programs Memo, 8 May 2009

International Agreements

DoD Directive 5230.20, Visits, Assignments, and Exchanges of Foreign Nationals, 22 June 2005

SECNAVINST 5710.25B, International Agreements, 23 December 2005

SECNAVINST 5510.34A, Disclosure of Classified Military Information and Controlled Unclassified Information to Foreign Countries, International Organizations, and Foreign Representatives, 8 October 2004

SECNAVINST 4900.46B, The Technology Transfer and Security Assistance Review Board (TTSARB), 16 December 1992

Interoperability

Department of Defense Architecture Framework (DoDAF) Document, 23 April 2007

DoD Directive 4630.5, Interoperability and Supportability of Information Technology (IT) and National Security Systems (NSS), 5 May 2004 (certified current as of 23 April 2007)

DoD Instruction 4630.8, Procedures for Interoperability and Supportability of Information Technology, 30 June 2004

SECNAVINST 5000.36A, Department of the Navy Information Technology Applications and Data Management, 19 December 2005

CJCSI 6212.01E, Interoperability and Supportability of Information Technology and National Security Systems, 15 December 2008

OPNAV N6/N7 FORCENET Requirements/Capabilities and Compliance Policy, 27 May 2005

Logistics

SECNAVINST 3960.16A, Navy Test, Measurement, and Diagnostic Equipment, Automatic Test Systems, and Metrology and Calibration, 4 August 2005

NAVSO P-3692, Independent Logistics Assessment Handbook, September 2006

SECNAVINST 4105.1B, Independent Logistics Assessment (ILA) and Certification Requirements, 18 December 2008

DoDD 4140.1-R, DoD Supply Chain Material Management Regulation, 22 April 2004

USD (AT&L) memorandum, Total Life Cycle Systems Management and Performance Based Logistics, 24 October 2003

NAVSEAINST 4340.001A, Government-Furnished Information (GFI) Management System, 5 February 1990

NAVSEAINST 4341.002A, Government-Furnished Material for New Construction Programs, 7 February 1986

NAVSEAINST 9083.01, Commercial Off the Shelf Policy, 21 July 2000

OPNAVINST 4700.7L, Maintenance Policy for U.S. Naval Ships, 25 May 2010

OPNAVINST 4442.1F, Storage Space Requirements for New Construction and Major Conversions of Ships, 23 October 1998

OPNAVINST 4857.1D, Department of Defense Master Urgency List (MUL), 10 May 1979

OPNAVINST 4440.19E, Policies And Priority Rules For Cannibalization Of Operational Equipment And Diversion Of Material At Contractor Plants To Meet Urgent Operational Requirements, 18 August 2003

OPNAVINST 4460.1A, Management Of Material Handling Equipment (Mhe) And Shipboard Mobile Support Equipment In Navy, 22 April 2004

SECNAVINST 4440.33, Sponsor-Owned Material, Government-Owned Material And Plant And Project Stock Management, 11 February 2009

Law of War and Treaty Compliance

SECNAVINST 5710.23C, Implementation of, and Compliance with, Arms Control Agreements, 21 September 2002

SECNAVINST 3300.1C, Department of the Navy Law of War Program, 28 May 2009

Maintenance

OPNAVINST 4700.7K, Maintenance Policy for U.S. Naval Ships, 11 July 2003

NAVSEA S9AA0-AB-GOS-010, General Specifications for Overhaul of Surface Ships (GSO) 04 Edition

Manpower

OPNAVINST 1500.76B, Navy Training System Requirements, Acquisitions, and Management, 28 April 2010

OPNAVINST 1223.1C, Navy Enlisted Occupational Classification System, 12 December 2009

Modeling and Simulation

DoD Directive 5000.59, DoD Modeling and Simulation (M&S) Management, 8 August 2007

DoD Instruction 5000.61, DoD Modeling and Simulation (M&S) Verification, Validation and Accreditation (VV&A), 13 May 2003

SECNAVINST 5200.38A, Department of the Navy Modeling and Simulation Management, 28 February 2002

SECNAVINST 5200.40, Verification, Validation, and Accreditation (VV&A) of Models and Simulations, 19 April 1999

DoD Manual 5000.59P, DoD Modeling and Simulation (M&S) Master Plan, October 1995

OPNAVINST 5200.34, Navy Modeling and Simulation (M&S) Management, 28 May 2002

Modular Design

NAVSEA 05T Report Modular Adaptable Ship (MAS) Total Ship Design Guide for Surface Combatants of 7 February 2011

Oceanography

SECNAVINST 5430.79C, Naval Oceanography Policy, Relationships and Responsibilities, 24 June 2006

Program Protection

SECNAVINST 3501.1B, Department of the Navy (DoN) Critical Infrastructure Protection (CIP), 5 February 2010

SECNAVINST 3850.2C, Department of the Navy Counterintelligence, 20 July 2005

DoD Instruction 5200.39, Critical Program Information (CPI) Protection Within the Department of Defense, 16 July 2008

OPNAVINST 3432.1, Operations Security, 29 August 1995

Power Trials

OPNAVINST 9094.1B, Full Power and Economy Trial Requirements for Non-Nuclear Surface Ship Classes, 1 August 1996

Quality

SECNAVINST 4855.3B, Product Data Reporting and Evaluation Program (PDREP), 22 December 2005

ISO 9001 Quality Management Systems - Requirements

NAVSEAINST 4855.33, Application of the International Organization for Standardization (ISO) 9000 Standards in NAVSEA Programs, 19 February 1997

Reliability, Availability, and Maintainability

OPNAVINST 3000.12A, Operational Availability of Equipments and Weapons Systems, 2 September 2003

USD RD&A Memo Reliability, Availability and Maintainability Policy, 26 August 2008

RAM-C Manual

Requirements Definition

Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3170.01G, Operation of the Joint Capabilities Integration and Development System, 1 March 2009

Manual for the Operation of the Joint Capabilities Integration and Development System, 31 January 2011

OPNAVINST 5420.108D, Chief of Naval Operations (CNO) Executive Decision Process, 24 February 2011

OPNAVINST 3500.37C, Navy Lessons Learned System (NLLS), 16 February 2001

OPNAVINST 3500.38B, Universal Navy Task List (UNTL), 10 November 2008

Risk Management

Risk Management Guide for DoD Acquisition Sixth Edition v1.0, August 2006

NAVSEAINST 5000.8, Naval SYSCOM Risk Management Policy, 21 July 2008

System Safety

OPNAVINST 5100.19E, Safety and Occupational Health Program for Forces Afloat, 27 July 2006

OPNAVINST 5100.8G, Navy Safety and Occupational Safety and Health Program, 2 July 1986

SECNAVINST 5100.10J, Department of the Navy Policy for Safety, Mishap Prevention, Occupational Health and Fire Protection Programs, 26 October 2005

OPNAVINST 5100.23G, Navy Occupational Safety and Health (NAVOSH) Program Manual, 30 December 2005

MIL-STD-882D, Standard Practice for System Safety, 10 February 2000

NAVSEAINST 5100.12B, System Safety Engineering Policy, Ser 05S/2011-183, 03 August 2011

NAVSEAINST 5100.15A, NAVSEA Occupational Safety Health (OSH) Program Policy and Guidance, 20 December 1999

OPNAVINST 5100.19E, Navy Occupational Safety and Health (NAVOSH) Program Manual for Forces Afloat, 30 May 2007

OPNAVINST 5100.24B, Navy System Safety Program, 7 February 2007

OPNAVINST 8020.14, Department of the Navy Explosives Safety Policy, 1 October 1999

USD AT&L Memo Reducing Preventable Accidents - Memorandum of Agreement, 17 July 2007

NAVSEAINST 9078.001, Naval Ship’s Critical Safety Item Program, Non Nuclear, 1 May 2007

NAVSEAINST 9078.002, Naval Ship’s Critical Safety Item (CSI) Program Technical Requirements, 15 May 2008

Security

OPNAVINST 3432.1, Operations Security, 29 August 1995

OPNAVINST 5510.161,Withholding of Unclassified Technical Data From Public Disclosure, 29 July 1985

OPNAVINST S5511.35K, Policy for Safeguarding the Single Integrated Operational Plan (SIOP)

Security Classification

OPNAVINST 5513.1F, Department of the Navy Security Classification Guides, 7 December 2005

OPNAVINST 5513.3C, Department of the Navy (DoN) Security Classification Guidance for Surface Warfare Programs, 21 July 2008

OPNAVINST 5513.5C, Department of the Navy List of Security Classification Guides for Undersea Warfare Program, 21 July 2008

OPNAVINST 5513.7D, Department of the Navy List of Security Classification Guides for Mine Warfare, 21 July 2008

OPNAVINST 5513.8C, Department of the Navy List of Security Classification Guides for Electronic Warfare Program, 21 July 2008

OPNAVINST 5513.10C, Department of the Navy List of Advanced Technology and Miscellaneous Program Guides, 21 July 2008

OPNAVINST 5510.6OM, Security Regulations for Offices Under the Cognizance of the Chief of Naval Operations, 23 Mar 2009

Ship Project Directives

NAVSEAINST 5000.05, Ship Project Directive System, 19 June 1984

Specifications

NAVSEAINST 4121.3A, Technical Standards Policy, 14 July 2006

NAVSEA Metric Guide for Naval Ship Systems Design and Acquisition

Survivability

OPNAVINST 9070.2, Signature Control Policy for Ships and Craft of the US Navy, 5 December 2006

OPNAVINST9072.2, Shock Hardening of Surface Ships, 12 January 1987

OPNAVINST 9070.1, Survivability Policy for Surface Ships of the U.S. Navy, 23 September 1988

OPNAVINST 3400.10F, Chemical, Biological and Radiological (CBR) Defense Requirements Supporting Operational Fleet Readiness, 22 May 1998

DoD Instruction S-5230.28, Low Observable (LO)/Counter Low Observable (CLO) Programs, 26 May 2005

DoD Instruction 3150.9, CBRN Survivability Policy 17 September 2008 (Incorporating Change 1 August 17, 2009)

Systems Engineering

USD AT&L Memo Policy for Systems Engineering in DoD, 20 February 2004

USD AT&L SSE SoS Systems Engineering Guide, 22 December 2006

DoD Systems Engineering Plan Preparation Guide, 2011

DoD Guide to Integrating Systems Engineering into DoD Acquisition Contracts, Version 1.0, 22 December 2006

DoD Architecture Framework (DoDAF) v2.0, 18 May 2009

DoN System Design Specification Guidebook

NAVSEAINST 5000.9, Naval SYSCOM Systems Engineering Policy, 7 July 2009

Naval Systems Engineering Technical Review Handbook, 19 January 2010

S9800-AB-MAN-010, NAVSEA Engineering and Technical Authority Manual (ETAM), 03 June 2011

PEO IWS Systems Engineering Concept of Operations, 22 April 2010

System Threat Assessment

OPNAVINST 3811.1D, Threat Support to Weapon System Planning and Acquisition, 5 June 2008

OPNAVINST 3880.6A, Scientific and Technical Intelligence Liaison Officer (STILO) Program and Intelligence Support for the Naval Research, Development, Test & Evaluation, and Acquisition Communities, 5 November 2007

OPNAVINST 3432.1, Operations Security, 29 August 1995

OPNAVINST F3300.53C, Navy Anti Terrorism Program

SECNAVINST 3300.2B, Department of the Navy (DON) Antiterrorism (AT) Program, 28 December 2005

Tasking

NAVSEAINST 5400.57D, Engineering Agent Selection, Assignment, Responsibility, Tasking and Appraisal, 3 February 2003

Technical Authority and Technical Warrant Holders (TWHs)

NAVSEAINST 5401.2, Competency Aligned Organization (CAO)/Integrated Program Team (IPT) Implementation, 9 July 2008

NAVSEAINST 5400.97C, Virtual SYSCOM and Technical Authority Policy, 31 January 2007

NAVSEAINST 5400.95E, Waterfront Engineering and Technical Authority Policy Ser 05B5/2010-044, 08 April 2010

NAVSEA 05D ltr 5400 Ser 05D/031 of 13 April 11, FY11 SEA 05D Technical Authority Assessment Plan

NAVSEA ltr Ser 05/014 of 22 February 2010, Annual Qualification Assessment of Technical Warrant Holders in the NAVSEA Research and Systems Engineering Competency

NAVSEA Note 5400, Ser 05S/200, 07 October 2010 NAVSEA Technical Authorities

Test and Evaluation

SECNAVINST 5200.40, Verification, Validation, and Accreditation (VV&A) of Models and Simulations, 19 April 1999

NAVSEAINST 3960.02D, Test and Evaluation, 22 April 1988

NAVSEAINST 3960.04A, Implementation of Total Ship Test Program for Ship Production (TSTP/SP), 1 October 1985

NAVSEAINST 3960.05, Policy on Ship Testing, 31 May 1984

NAVSEAINST 4700.11, Trials, Acceptance, Commissioning, Fitting Out, Shakedown & Post Shakedown Availability of U.S. Naval Ships Undergoing Construction, Conversion & Modernization, 28 March 1983

OPNAVINST 4700.8H, Trials, Acceptance, Commissioning, Fitting Out, Shakedown, and Post Shakedown Availability of U.S. Naval Ships Undergoing Construction or Conversion, 5 December 90

NAVSEAINST 9091.01A, Certification of Aviation Facilities in Naval Ship Operating Aircraft, 3 October 1986

OPNAVINST 3120.28B, Certification of the Aviation Capability of Ships Operating Aircraft, 21 October 1991

NAVSEAINST 9093.01C, Combat System Ship Qualification Trials for Surface Ships, 30 August 2006

NAVSEAINST 9094.05, Ship Performance Trials, 14 June 1985

OPNAVINST 4730.5Q, Trials and Material Inspections (MI) of Ships Conducted by the Board of Inspection and Survey, 23 February 2010

Topside

NAVSEA 05 Memorandum 9830 Ser 05D/312 of 11 October 2007, Integrated Topside Design and Certification Process for New Construction Ships

NAVSEAINST 9700.02, Integrated Topside Safety and Certification Program for Surface Ships, 11 September 1998

ASN (RD&A) and VCNO Joint Letter, Topside Integration and Certification Policy for Surface Ships, 7 Oct 2002

ASN (RD&A) memo, Surface Ship Topside Design Principles, 1 August 2005

Training

OPNAVINST 1500.76B, Navy Training System Requirements, Acquisitions, and Management, 28 April 2010

OPNAVINST 3500.23D, Assembly, Organization, and Training of Crews for the Commissioning of U.S. Navy Ships, 16 March 2010

Underwater Ship Husbandry

ASN (RD&A) letter of 24 March 2006

Weapons System and C4ISR Integration

NAVSEA 05H and PEO IWS Technical Review Manual (TRM)

NAVSEAINST 9410.2, Naval Warfare Systems Certification Policy

PEOIWSINST 4130.1, Integrated Warfare Systems (IWS) Enterprise Configuration Control Process

COMUSFLTFORCOMINST/COMPACFLT 4720.3 C5ISR Modernization Policy

Weight Management

NAVSEAINST 9096.6B, Policy for Weight and Vertical Center of Gravity Above Bottom of Keel (KG) Margins for Surface Ship, 16 August 2001

NAVSEA Weight Control TWH policy summary presentation, Weight and Vertical Center of Gravity Margin Policy for Surface Ships, 19 June 2007

OPNAVINST 9096.1, Weight and Stability Limits for Naval Surface Ships, 12 November 1985

Work Breakdown Structure

NAVSEAINST 4790.01B, Hierarchical Structure Codes (HSC) for Ships, Ship Systems & Surface Combatant Systems, 10 April 2007

MIL-STD-881, DoD Handbook – Work Breakdown Structure, 14 January 2011

S9040-AA-IDX-010/SWBS 5D Expanded Ship Work Breakdown Structure

APPENDIX B
EXPLORATORY DESIGN AND FORCE ARCHITECTURE STUDIES

Exploratory Design and Force Architecture Studies are undertaken prior to program starts. These efforts anticipate overall future needs without requiring each program to undertake the burdensome effort of divining the future. These expand the base of knowledge upon which assessments of the bounding capabilities of naval-based forces are made. In short, they provide a means to accurately characterize the "art of the possible." Such studies are short in duration, notably lacking in specifics. They may be done as concept or even feasibility level ship and system studies to explore novel concepts or the application of new technologies; POM studies to support insertion of ship programs into the Ship Construction Navy (SCN) plan or Expanded Planning Annex; or platform level trade studies of varying sets of requirements applied to a range of platforms for the purposes of studying force architecture and influencing future force composition. Many times theses studies are conducted by innovation cells in support of war games and external customers like the Navy Warfare Development Command and the Chief of Naval Operations Strategic Studies Group or specific Resource Sponsors. The results of such studies must be reviewed for completeness, accuracy, and conformance with high-level design policies, including cross platform interoperability.

A SCM normally leads these studies using a small team of just a few engineers including where applicable SIM participation. Generally a synthesis tool such as ASSET will provide the bulk of the design data and analysis for these designs. Prospective SDM(s) must keep informed of this work for its impact on future designs and possible information of use in ongoing designs. Prospective SDM(s) or Division Director(s) will normally be given the opportunity to review and comment on results by attending the design reviews and reviewing the reports.

See SEA 05D Memo 9830 Ser 05D/376 of 28 June 2010, Surface Ship Concept Study Policy (*hyperlink*), and the Concept Design Handbook Version 1.0 of 27 December 2006 for specific guidance on the performance of concept design. SEA 05D/135 of 22 November 2004 (*hyperlink*) details an internal review process which helps maintain the quality and consistency of concept studies. A system for categorizing concept and feasibility study efforts, introduced in Ser SEA 05D/023 of 31 January 2005 (*hyperlink*), assists in tailoring the studies to meet customer expectations.

In order to rigorously flow down mission performance requirements to the individual ship level, the analysis of ship concept alternatives must be carried to the next higher level, which is the battle group or strike force. In many cases, a new ship design is initiated for the purpose of replacing ships with the same mission that are approaching the end of their expected service lives. Force level assessments in this case are fairly straightforward. The new ship is basically a functional replacement for the ship to be retired, albeit with upgrades to account for changes in statute, Navy policy and standards (e.g., new shipboard habitability standards or margin policy), and state-of-the-art improvements in command, control, communications, and combat systems.

Study Guide should be developed and approved prior to beginning work. Successful reviews of feasibility studies often depend on the level of confidence the reviewers have in these early parametric design tools and the experience of their operators. Thus, interim "peer" reviews should be conducted with applicable technical codes and key stakeholders early and often as the studies progress to build up credibility rather than waiting until the end of the design efforts. Study results should be documented in a formal report.

APPENDIX C
PRE-ANALYSIS OF ALTERNATIVES STUDIES

Prior to beginning an AoA, a small Design Team lead by an SCM and including a few engineers and, where applicable, SIM participation, will generally begin to develop multiple, high-level ship concept or feasibility level designs to investigate the impact of trading off requirements on ship performance, size, and cost. Note that for modified repeats these design efforts generally involve modifications of existing Contract and Detail Design level arrangements, weight statements, and other design artifacts rather than reverting to the use of ASSET or other early stage design tools.

These efforts support formulation of a mission need during conduct of a Capabilities Based Assessment (CBA), Senior Warfighter Forum (SWARF), or comparable functional analysis. The analysis results are recorded in an ICD. Then an MDD typically results in kickoff of an AoA. Technology assessment and any required technology development continues.

This is a good time to focus on development and approval of mission scenarios and the Concept of Operations (CONOPS). This is an important prerequisite for conduct of the AoA. Programs like MPF(F) have experienced difficulties conducting a useful AoA and then proceeding with requirements definition when the basic assumptions of how the ship will be employed have not been established. A Design Reference Mission (DRM) should be employed to characterize the CONOPS in terms of the ship requirements for speed, endurance, stores, and other characteristics. The CONOPS and DRM are often developed by the SDM out of necessity but still need to be approved by the Program Office and Sponsor. There is a draft OPNAV Instruction prescribing CONOPS format.

This is also a good time to focus on the development and approval of threat sets that will be used in survivability and later live fire test and evaluation assessments. This is an important prerequisite for conduct of the AoA, PD, and CD. Survivability design approaches should also be vetted with Technical Warrant Holders during this stage in preparation for AoA kickoff.

It is also during this phase that Pass 1 of the Six-Gate Process begins. Gate 1 grants authority for the DoN-initiated ICD that has completed Navy review to be submitted to the Joint Staff (J-8) for routing using the JCIDS. Gate 1 will also validate the proposed AoA Guidance and authorize a program to proceed to the MDD.

Design efforts should be preceded by development and approval of a Pre-AoA Engineering Management Plan and study guide(s). Development of an Engineering Management Plan this early hasn't typically been done before but the SDM has ended up doing equivalent planning anyway which would benefit from being more formally documented. Event-based design reviews should be scheduled at the peer level including participation by the prospective Program Office, OPNAV Sponsor, TWHs, other supporting technical codes, and stakeholders. As detailed in Appendix Q, a formal Initial Technical Review (ITR) in conjunction with a Technical Review Board (TRB) and Stakeholder Steering Board (SSB) should be held prior to submission of the ICD to Navy staffing to review the technical inputs to the ICD and planning for the AoA. A formal design report should be written to document design phase results.

APPENDIX D
ANALYSIS OF ALTERNATIVES STUDIES

The MDD will initiate the Materiel Solution Analysis Phase shown in Figure 2-1. Materiel Solution Analysis consists of an AoA and supporting studies whose objectives are to define a set of feasible alternative whole ship solutions to a set of operational requirements. AoA options considered must span the full range of reasonable possibilities, including performance, cost, and risk. The AoA must identify early those elements of performance that are major cost drivers and their underlying requirements. This is critical to the design process and provides valuable feedback to the OPNAV Sponsor, who will review the requirements and make necessary adjustments to the developing CDD.

Generally, the studies are lead by an SCM or SDM and conducted by a small team – one to three full time equivalents with SIM participation as applicable over three to 12 months. However, this may vary depending on the number of alternatives considered and the specific program schedule constraints. They are based on a selected, broadly-stated, ship mission and a set of minimum capabilities as documented in the ICD. The studies are usually done in the context of a desired schedule for design and construction. This design phase provides the technical definition basis for a Rough Order of Magnitude (ROM) or Feasibility level cost estimate. Once a design alternative is selected, it is necessary to proceed into a more thorough analysis to validate and refine it.

In the case of “mod-repeat” designs, feasibility studies will be based on an existing design that is to be modified and built as new construction (i.e., “forward fit”). The constraints of existing designs coupled with the evolution of design practices and standards since the baseline design was completed often present challenges. In such cases, ensuring feasibility means taking the design to a finer level of detail than for a “clean sheet of paper” design based on parametric predictions. CG47 is a good example of how much effort is required to develop highly adapted mod-repeats. It took 2.5 years from start of feasibility studies (then called, “concept design”) to completion of the Materiel Solution Analysis and had as large a Design Team as the DDG51, which took 4.3 years for the same phases.

Typical study output will start to go beyond the ASSET level – with PowerPoint level topside, outboard profile, and inboard profiles arrangements showing the major weapons systems and topside items along ship volume allocations and with weight and space estimates. Development of major equipment lists has begun. Ship manning estimates are needed but not typically high fidelity at this point. Consequently, ship accommodations are often imprecise. These products are needed for the cost forms developed for SEA 05C procurement and life cycle cost estimating and the PowerPoint-type briefing material developed for the AoA Integrated Product Team and Executive Steering Committee or Senior Advisory Group. See Appendix P for a listing of typical design deliverables. Much remains to be defined. Thus, significant margins should be included to allow for future design definition. Current Navy margin policy is summarized in Part 0, Chapter 10 of the American Bureau of Shipping Naval Vessel Rules (ABS NVR).

A formal risk management process should commence late in the AoA to support conduct of the subsequent Gate 2 and Milestone A. It normally follows the standard approach typified in Defense Systems Management College literature and widely used on other ship design programs in which risk “waterfall” or “burndown” paths are generated to depict the steps, schedule, and resources needed for risk mitigation. Areas perceived as having significant risk need to be identified; mitigation strategies, including fallback plans, have to be defined. Potential risks that will need to be specifically addressed at the post AoA Gate 2 review and Milestone A include affordability, technology readiness, and the adequacy of the industrial base. The Program should also be prepared to demonstrate that they have begun planning for ESOH, HSI, sustainability, energy efficiency, open systems, and the other design considerations appropriate to subsequent design efforts.

As soon as a Program Office has been established, it will normally become the releasing authority for correspondence and other external communications. The SDMs must be compliant with both SEA 05 and Program Office protocols for communications with other organizations, adhering to the most stringent requirements of each. Specific instructions have been issued governing internal routing, formal review, and approval of acquisition program documents and official correspondence before official program responses are forwarded. In addition cognizant TWHs' concurrence shall be ensured by the SDM and or SIM before reporting results which are high risk or likely to be controversial.

Design efforts should be preceded by development and approval of an AoA Engineering Management Plan and study guide(s). Event-based design reviews should be scheduled at the peer level including participation by the prospective Program Office, OPNAV Sponsor, TWHs, other supporting technical codes, and other stakeholders. An Alternative Systems Review (ASR) in conjunction with a TRB and SSB should be conducted prior to completion of the AoA to review the technical inputs to the AoA. See Appendix P. A formal design report should be written to document design phase results.

The Gate 2 review to review the results of the AoA will occur after completion of the AoA and prior to a Program submitting Milestone A documentation. At Milestone A, an MDA review will be held to evaluate the results of the AoA, technology maturity, technical risk, and international availability or potential for international cooperation; to approve the preferred system solution and technology development strategy; and to authorize entry into the Technology Development Phase.

Early development and approval of a CDD immediately following the AoA may be accomplished to focus design efforts. If so, conduct of a System Requirements Review (SRR) in conjunction with a TRB and SSB and submission of the CDD to Navy staffing may precede Milestone A. Gate 3 should proceed when approval for the CDD to enter Joint staffing is needed. Early Program Initiation at Milestone A, however, may not be desirable since it would require premature development and approval of several planning documents additional to the CDD. Depending on the acquisition strategy, Pre-Preliminary Design and even Preliminary Design may start prior to Milestone A.

Concurrent development and approval of the Test and Evaluation Strategy should also happen during this phase prior to Milestone A. It is a good time to focus on development of developmental testing and life fire test and evaluation strategies and key events.

APPENDIX E
PRE-PRELIMINARY DESIGN

At the conclusion of the AoA, recent experience has shown that there is often not sufficient design detail or requirements definition to complete a Milestone A or enter into Preliminary Design. Thus Preliminary Design may be preceded by a Pre-Preliminary Design stage employing either Set-Based Design methods or the creation of an Indicative Design to validate that the design requirements developed in the AoA are achievable within the framework of an acquisition program. For an Indicative Design, this is done through development of a single design solution, a feasible though not necessarily optimal solution to the design requirements that is within the program parameters of ship size, cost, and performance. Indicative designs are most often developed using a parametric ship synthesis modeling tool and other methods that rely on information from past similar or comparable designs. In a Set-Based Design approach, the design requirements, CONOPS, and different disciplines of ship design are developed concurrently. Information of each area is conveyed to the design integrator in the form of feasible sets. The range of possible design solutions is determined by the intersection of these different sets. At each design gate, the design space is reduced to eliminate regions where the optimal solutions are likely not to reside. Each area is then refined by increasing the level of detail to enable further reductions in the design space. At the end of this design stage, the goal is to have a narrow set of material solutions, CONOPS, and requirements that meet the affordability constraints.

The time period can range from as short as about a month for a very simple design to a year or longer for complex ships. Since this phase is usually the first part of a ship acquisition program of record, the length of the phase is usually set by the acquisition schedule or budget available, either of which tends to limit the level of design detail developed. By the end of the phase, top-level requirements have stabilized and a CDD should have been drafted. This is sometimes applied as the first phase in an industry led competitive design process.

Pre-Preliminary Design should normally be led by an SDM with roles are very similar to those for the feasibility studies that supported the AoA. The effort will be in considerably more depth for engineering and the size of the Design Team will be just starting to ramp up to levels required to support Preliminary Design. For competitive designs, the government provides industry with “insight” rather than “oversight,” in most cases avoiding giving specific technical direction or design solutions to the industry teams. The technical evaluations are provided to the Program Manager who, in turn, decides the disposition of the evaluation.

While initial risk reduction activities such as material tests or industry surveys can be undertaken, there is usually insufficient total ship design information to initiate a major developmental effort. For example, the specific horsepower and rpm needed in a new engine or the weight limits for a new composite structure will not be finalized until near the end of the phase. Nevertheless, performance and physical characteristics need to be estimated and acceptable plans for fallbacks (“off ramps”) developed for high risk and high ship impact items. The design should permit the fallback to be physically accommodated, usually through design budgeting (e.g., space, weight, and support systems reservations). Similarly, margin allocations must be tailored to reflect the magnitude of the risks caused by design unknowns. Larger risks require larger margins. Weight growths of 50 percent or more are not uncommon in new systems. This approach also needs to account for uncertainty introduced by applying an open systems approach and the requirement to accommodate open competition for major elements of the ship, such as prime movers. That means it generally makes sense to size machinery spaces applying a composite worst-case envelope so that any of the candidate engines in a range of performance can be fit in the ship.

Design efforts should be preceded by development and approval of a Pre-Preliminary Design Engineering Management Plan and study guide(s). Event-based design reviews should be scheduled at the peer level including participation by the prospective Program Office, OPNAV Sponsor, TWHs, other supporting technical codes, and other stakeholders. A formal design report should be written to document design phase results.

A final design review of the Pre-Preliminary Design should be scheduled when a complete and balanced design baseline has been achieved and the planned work for this phase is nearing completion. At this point, the ship has been sized (displacement), the overall ship dimensions are generally fixed, major subsystems and weapons have been selected after appropriate trade studies, and notional descriptions of lower level systems have been developed, often relying on previous or similar ship experience. In general, design maturity has progressed to a state where a feasible solution has been found within the overall program parameters of ship size, cost, and performance. This means that the predicted total ship system capabilities will meet the CDD and there are no technical "show stoppers" at the subsystem level. No problems are anticipated that cannot be corrected in subsequent design phases within the total program constraints. Subsequent phases will evolve the design from a merely feasible solution to a more optimal solution and some changes to major subsystems may still be needed in the next phase but should not require resizing of the ship. Please see additional discussion on risk below. The CONOPS, requirements, materiel solution, and cost estimates should be aligned.

It is advisable to begin selected outside reviews during this phase, such as with the WSESRB, while there is still much design flexibility. Similarly, Fleet input can be initiated, particularly for quality of life topics.

If not performed earlier, the SRR should proceed. The primary objectives of this review can be stated as follows: "Are the system level requirements clear, complete, compatible, achievable, and affordable?" From an engineering standpoint, they also need to be "testable" so that their achievement can be demonstrated at ship delivery. The review will necessarily involve the customer in resolving misunderstandings. CDD finalization and submission to Navy staffing should follow. Gate 3 should proceed following the completion of CDD Navy staffing when approval to enter Joint staffing is needed.

The deliverables prepared will show greater detail than those prepared for feasibility studies, but will not be up to the level of detail prepared for Preliminary Design. They will reflect the more in-depth analyses performed as part of the design development to demonstrate the ship's performance. Design deliverables will include engineering memos, a number of reports, and selected sketches and drawings (and/or an initial ship product model (SPM)) with limited detail, primarily showing the feasibility of arranging major equipments, validating the overall adequacy of ship resources (e.g., weight, space, power generation, cooling, computer networks), and demonstrating that CDD performance can be achieved, particularly the KPPs. A formal Pre-Preliminary Design Report should be prepared. See Appendix P for a listing of typical design deliverables.

To help manage the volume of information generated in a typical ship design program, several recent design programs, most notably LPD 17 and DDG1000, have maintained this data in an SPM environment. This includes a three-dimensional electronic representation of the baseline ship. It includes geometry, structure, compartmentation and arrangements, machinery, auxiliary systems and components, C4ISR and weapon systems, etc. As the design evolves from initial concept through construction, delivery, and, eventually, disposal, the type and amount of information stored in the product model is ever increasing. Specific design products are extracted from the product model in electronic format to document the design, trade studies, and analyses, and design decisions made throughout each design phase.

Depending upon the risk assessment, the SDM can recommend that parallel designs must be carried forward into Preliminary Design to accommodate alternate technologies if the ship impact is too great to use design budgeting. The review can also conclude that a specific technology presents unacceptable risks from a technical, cost, or schedule standpoint even before a developmental program has fully started.

Although margin policies do specify expected usage, the final design must contain the full recommended margins needed for subsequent phases, regardless of usage during this phase. This sometimes requires resizing of the ship before completing Pre-Preliminary Design in order to accommodate them. In this regard, the more uncertainty that exists in a particular design area (i.e., technical risk), the more design detail and margins are required at the time of the review.

APPENDIX F
PRELIMINARY DESIGN

Preliminary Design is performed to support a budget quality cost estimate and verify ship performance and functionality. The requirements for the chosen baseline design and principal characteristics will be documented in the CDD that either should have been approved or at least be in Navy staffing. Preliminary Design emphasis is on establishing ship size, external configuration, and the overall allocation of space to various functions, major propulsion, electrical, and mission essential mechanical and combat system elements. System architectures shall be defined. Examples of essential mission systems would include replenishment systems on an underway replenishment ship, towing system on a salvage (i.e., ARS) ship; and aviation, ship signature, C4ISR, and weapon systems on a combatant ship. Changes in ship requirements initiated after this phase of the ship design process should normally be incorporated as modifications to the existing baseline, rather than re-optimizing the design, in order to remain on schedule for contracting the ship.

Ship Preliminary Design is typically 6 months for single mission ships or a modified repeat to 12 months long for a more complex ship, but may be more if a source selection or down-select is involved. Its conclusion is a significant event for the engineering evolution of a ship design.

Preliminary Design will be led by an SDM and developed by a team whose size will vary depending on the complexity of the design and the degree of contractor support. A typical Preliminary Design effort for a combatant will exceed 100 man years with a Design Team of mostly part-time personnel. A core team of about a dozen of these, representing key functional areas, should be collocated to a common work site. This will enhance communication and improve design efficiency through the many iterations of ship size and configuration necessary in arriving at a Preliminary Design baseline.

The collocated core team should typically include the SDM, DIM, PNA, PME, a general arrangement engineer, structural engineer, weight engineer, a SIM, C4I integrator, and one or two naval architecture generalists. Others should be included based on the particular needs of the program. If possible, including the SEMs in the core team is highly desirable. The core team will interact continuously with the other Preliminary Design team members, requesting and receiving formal and informal inputs. A key aspect of having the core team co-located, and perhaps geographically separated from other Preliminary Design team members, is having integrated digital environment connectivity together with telephone and video conferencing support. Having a technical data management specialist onboard to support the core team is highly desirable. The Contract Design team should be assessed for its readiness to conduct the planned effort. Training for the Design Team should be conducted prior to the beginning of the phase to include team training and the planned design process and methods.

The SIM is responsible for ensuring achievement of the safety, cost, and requirements of any associated weapons systems under development. The SDM and SIM are also responsible for technical problems identification and resolution within the scope of their technical warrants. Other problems are referred to the SDM and SIM for resolution by the appropriate TWH. The SDM retains technical authority for the total ship and also normally advises the program on the resolution of technical issues and supports the development of and approves the technical adequacy of engineering changes. The SDM is responsible for managing the developing Functional Baseline. The SIM is responsible for the overall system integration on the ship for applicable weapons systems, and will assist the SDM for all system integration issues.

The SDM, DIM, PNA, PME, SIM, and C4I integrator must involve the designated TWHs, as well as representatives of other Navy Systems Commands, ABS, and other government activities, in Preliminary Design planning. Tasks, products, schedules, and costs for design support must be negotiated and documented. Each TWH is responsible for the technical integrity of that portion of the design over which it has cognizance.

Current NAVSEA staffing levels dictate that the majority of the Design Team will come from outside sources such as NSWC Carderock, Philadelphia, or Dahlgren, or from contractors. Depending upon the acquisition strategy, the design will either be a government controlled one where the NAVSEA SDM controls the design and makes the design decisions. Or it may be a contractor controlled design, where a contractor team prepares it and makes the design decisions except for any "fenced areas" over which NAVSEA maintains control. In the latter case, the role of the NAVSEA Design Team, including the SDM, is to review and monitor the design and to identify areas where it might be technically deficient or not compliant with the requirements. The PEO and the Contracting Officer must review technical direction from the NAVSEA Design Team in this type of design, because in many cases it will change the terms of the design contract.

To ensure it remains focused on the overall program objectives, members must avoid conflicts of interest or the appearance of a conflicts within their parent organizations. Often, individual members of the Design Team are required to sign a non-disclosure/conflict of interest agreement as a condition of participation in the design effort.

It may also be possible that the acquisition strategy calls for the conduct of Contractor Designs. In this case SDM will be responsible for supporting the development of the RFP and subsequent source selection. Although a contractor may perform the Preliminary Design, responsibility for the technical adequacy of the construction specifications, contract drawings, and PPDs, etc. always remains with the government SDM.

Design efforts should be preceded by development and approval of a Preliminary Design Engineering Management Plan and study guide(s). Event-based design reviews should be scheduled at the peer level including participation by the prospective Program Office, OPNAV Sponsor, TWHs, other supporting technical codes, and other stakeholders.

Preliminary Design should conclude with a System Functional Review (SFR) (SETR for the Functional Baseline) in conjunction with a TRB and SSB when sufficient design maturity is achieved to establish a Functional Baseline. If technical feasibility has not been demonstrated in the broad sense, or if a stable Functional Baseline has not been achieved, the conduct of SFR should be delayed. The entire SFR process can take a substantial amount of time. A series of lower level reviews should be conducted over the course of the Preliminary Design leading to a final review which itself may be conducted in multiple sessions. In very complex programs with a high degree of concurrency for system developments, the whole process can last months. On the plus side, the benefits of such a long process are the discovery of issues early enough in the phase to influence the design prior to the final review. However, a significant planning effort to successfully execute this cascade of reviews and planning should be initiated early in the phase. Outside reviews started in Pre-Preliminary Design and Fleet interface activities should be expanded.

SDS development and CDD approval should normally proceed in parallel to support SDS approval and Gate 4 conduct as soon as possible after CDD approval. This proves a firm, timely basis to begin or even finalize the System Specification in Preliminary Design. This is essential for early finalization of the System Specification for conduct of contractor Preliminary and/or Contract Designs. Gate 5 ensures that the Program has completed needed actions and recommends to the MDA approval of the release of the RFP to industry as authorized by the Acquisition Strategy. Gate 5 scheduling is highly dependent on the Program's acquisition strategy. For a contractor Preliminary and/or Contract Design Gate 5 conduct should also be accelerated.

The principle product of this phase is the Preliminary Design Report. This is a comprehensive description of the characteristics and capabilities of the ship at the end of the design phase. It describes how the ship meets the requirements contained in the CDD and the significant trade studies performed, with the supporting rationale for selections made. Many drawings, studies, tests, and analyses are developed to support the preparation of the design report and the Preliminary Design Report. They can easily number in the hundreds of documents. A typical set of supporting documents, taken from the standard SOWs, is shown in Appendix P. Not all of these documents will be required for each program.

The Design Certification Matrix is an important document that is developed early in Preliminary Design. It is finalized for inclusion in the RFP, and updated as appropriate during later stages of design if necessary and depending on the contracting approach. As a contract item, it will be under formal configuration control. The Design Certification Matrix documents which organizational entity is the technical lead for judging the contractor's design (and finished product) to be in compliance with the requirements, and resolving any associated issues. The technical entity with that responsibility is called the "Certification Authority". Certification authority is not the same as technical authority. The Navy, acting through the SDM, SIM, and accountable TWHs, always retains technical authority. The requirement for the government to exercise technical authority is based in statute and cannot be delegated to industry or other entities. If the Certification Authority is outside of NAVSEA, the Navy will, in the preponderance of instances, defer to the Certification Authority in judgments about compliance. But the SDM must stay fully engaged in that process. Using a risk-based spot checking approach, the SDM may disagree with the Certification Authority. In those typically very limited number of cases, the SDM will then elevate the issue as appropriate, working with a diligent sense of urgency toward resolution in order to minimize impact on the contractor. Other Certification Authorities should participate in design reviews/problem solving groups as necessary.

Preliminary Design should see the active execution of approved risk mitigation plans. By the conclusion of the phase, all risks should have been mitigated to medium or low (preferred), be advancing on schedule, and be in keeping with ship resource limits of weight, space, power, etc. Space and weight budgets for fallbacks can be considered for elimination if the new technology has achieved "low" risk by the end of the phase, which may help in margin availability for the rest of the design. Similarly, if parallel designs have been maintained, a "down select" should occur as early in the phase as practical, based on pre-agreed success criteria, usually involving testing.

By the SFR, the production schedules for the ship and for the new technologies should be known and their acceptability determined. Schedule alone may force the decision to postpone the technology to a later flight of the ship class. A thorough review of risk mitigation activities is an essential prerequisite to a satisfactory SFR.

As previously noted, design margins should be being consumed at the planned rate during this phase. Large deviation from the plan is a good indicator of design immaturity and inherent risks. If needed, special "weight reduction" efforts, etc. should be employed to get back to the planned expenditure rate. The SFR should not conclude unless adequate margins are available for subsequent design phases.

As the Preliminary Design is wrapping up, it is important to begin preparations for the start of Contract Design so that the transition happens seamlessly in a timely manner. Planning should be reviewed and updated to reflect the latest acquisition strategy for the program and specifically the latest plans for Contract Design, including schedule, participants, and key decisions. By the end of Preliminary Design the initial Contract Design Engineering Management Plan and associated study guides must be completed. Further, they should be approved prior to the start of Contract Design. The SDM is responsible for ensuring the content of the Contract Design Engineering Management Plan is consistent with the SEP issued by the Program Office. Scheduling and funding of events must agree with the PEO acquisition strategy and the OPNAV budget line. The SDM must work closely with the OPNAV Sponsor and the Program Manager to ensure that the plans for Contract Design are in agreement.

APPENDIX G
CONTRACT DESIGN

Contract Design translates the engineering findings and decisions from Preliminary Design into a biddable technical package. It provides a design baseline budget quality cost estimate suitable for Milestone B review. There is a general validation of the Functional Baseline developed in Preliminary Design through increased levels of system/subsystem definition to create an Allocated Baseline.

This “bid package” includes a Ship Specification, Contract Drawings, ABS approval requirements (as applicable), DRL, PPDs, GFE and GFI lists, and the contracts. Other important products of this phase, which are not part of the contract package, are study drawings, study reports, Engineering Management Plan, Contract Design History, and a Contract Design Report. See Appendix P. The end result of Contract Design is a technical package that will enable bids for the construction of the ship. The technical portion of the phase concludes with design approval by the TWHs as manifested by signing of the Ship Specifications and associated Contract Drawings.

Ship Contract Design is typically 12 months for single mission ships or a modified repeat to 24 months long for a more complex ship, but may be more if a source selection or down-select is involved. Its conclusion is a significant event for the engineering evolution of a ship design.

During Contract Design, the Design Team will typically evolve from the Preliminary Design team with additional resources added to address the increased workload and technical disciplines associated with development of the Ship Specification, Contract Drawings, and other deliverables. A typical Contract Design effort for a combatant ship will consist of about 200 man years using mostly part-time personnel, with a nucleus or core group of 18-24 individuals collocated at a common worksite. This core group will serve as the “integration” team to steer the design, identify required trade studies, maintain configuration documents such as the general arrangements, and pull resources from the available government or contractor technical pool. This will enhance communications and improve design efficiency through the many iterations of ship configuration necessary to arrive at an optimized design solution. The Contract Design team should be assessed for its readiness to conduct the planned effort. Training should include team training and training in planned design processes and methods.

The collocated core group should include the SDM, DIM, PNA, PME, Specifications Manager, and TWHs from general arrangements, weights and stability, structures, propulsion systems, electrical systems, SIM, C4I integration, HVAC systems, fluid systems, mechanical and deck systems, and HSI. The core team should also include two or three general naval architects. A small support staff should also be included to monitor and track products and deliverables and coordinate meetings, briefings, and other team activities. For combatant ships, the core team should include a survivability specialist to coordinate the various studies and analyses related to susceptibility, vulnerability, and recoverability. If possible, having the SEMs included in the core team is highly desirable. Core team members will interface with their SEM counterparts to coordinate design efforts across the organization.

It may also be possible that the acquisition strategy calls for the conduct of Contractor Designs. In this case SDM will be responsible for supporting the development of the RFP and subsequent source selection. Although a contractor may perform the Contract Design, responsibility for the technical adequacy of the construction specifications, contract drawings, and PPDs, etc. always remains with the government SDM.

Once a program reaches Contract Design, the maturity of the design is such that a firm Functional Baseline has been achieved and no significant changes in the principal characteristics is expected. As such, during Contract Design the primary focus of the Design Team shifts from design development to the development of the contract documentation which describes an Allocated Baseline. There is particular emphasis on development of a Ship Specification that can be used as the basis to award ship Detail Design and Construction. See NAVSEA Technical Standards Procedures and NAVSEA Instruction 4121.3A (*hyperlink*). All systems will have been diagrammed; all design trades completed; space arrangements showing all compartmentation, accesses, and significant equipments will exist; all risks will have been reduced to "low" (unless planned to be otherwise); and a Specification or set of specifications will exist. A SPM should exist and, if so, should be the basis for design development and reviews. The design will be ready for transition to Shipbuilder production personnel who will develop the Detail Design and fully refine construction planning.

Lessons Learned from recent ship construction programs has shown that the government should maintain configuration control of the development of the contract documentation. Shipbuilder developed Ship Specifications have not resulted in delivered ships fully meeting government expectations and have not generally benefitted from lessons learned on other ship acquisition programs.

The development of the Ship Specification, Contract Drawings, and other design products continues throughout the entire Contract Design. During this effort minor design changes may occur as analysis is performed to verify the feasibility of the Ship Specifications and drawings. This analysis may include the development of system level diagrams and calculations. Although a Detail Design is not performed for each system during Contract Design it is important that the appropriate level of verification is performed to ensure the design documented in the specifications and drawings is feasible. The appropriate level of verification will vary from program to program based on several factors such as whether the design is a clean sheet or a modified repeat of an existing ship. If it is a modified repeat the amount of analysis necessary to verify the feasibility of the requirements may be limited to only those areas where the design has been changed. A determination of how much analysis should be performed will be decided by the system technical lead and the SDM.

The development of contract documentation (Ship Specification, Contract Drawings, PPDs, and DRL) may be accomplished using several different approaches. In general, the task and level of effort to develop this documentation can be significantly reduced if a parent ship with similar system requirements can be identified. If so, specific Ship Specification sections and possibly drawings can be used as an initial baseline and modified to suit the specific requirements and ship configuration changes of the design. If a parent can not be identified, the contract documentation must be developed from a clean sheet approach. With this approach the specific Ship Specification sections are prepared using design standards and criteria from documents such as Naval Vessel Rules, Design Data Sheets, and Design Criteria Manuals. The General Specifications for Overhaul should also be reviewed. These documents form the basis of the current design standards and are tailored to suit specific design requirements. Either method is an acceptable approach for developing a Ship Specification however since these documents do not necessarily conform to the format requirements of a Ship Specification the author must ensure compliance with appropriate specifications writing format and protocol. These documents form the basis of the current design standard and are then tailored to suit the specific design requirements. Either method is an acceptable approach to developing contract documentation.

The development of contract documentation is an iterative effort and continues through Contract Design. Since it is an iterative process it is necessary for the SDM to implement a rigorous and formal configuration management process. The process must be documented in the Specification Management Plan and fully understood by the entire Design Team. An effective configuration management process documents change, tracks reviews, documents approvals, and traces requirements. Since ship design is a multi-disciplinary iterative process it is imperative that changes are initiated, reviewed, and ultimately approved through a process that will ensure all secondary and tertiary impacts are identified and resolved. The contract documentation, particularly the specifications, should be managed in a requirements traceability program such as DOORS©. Traceability is an important aspect of configuration management and ensures that proposed changes can be verified or traced to a specific requirement. Without a formal requirements traceability process it is not possible to ensure the current design and proposed changes meet and not exceed the threshold requirements.

Particular attention should be placed on the DRL. The required content of every document provided to the government should be unambiguous. The required delivery date of the deliverables must also be carefully defined to avoid having "shell" documents submitted by the contractor to meet the delivery schedule but devoid of the required content.

In defining GFE, GFI, and Government Property, the contract should be unambiguous as to the identification and planned use for design, construction, and/or testing.

Lessons Learned from recent ship construction programs have shown that because of the impact of software development on cost and schedule, development of Software Configuration Items should generally complete before the end of Contract Design. Software Integration in Detail Design is acceptable. Any software development planned for Detail Design should be tracked as a program risk.

Design efforts should be preceded by development and approval of a Contract Design Engineering Management Plan and study guide(s). Event-based design reviews should be scheduled at the peer level including participation by the prospective Program Office, OPNAV Sponsor, TWHs, other supporting technical codes, and other stakeholders. If Gate 4 wasn't conducted during Preliminary Design, it will need to be conducted as soon as possible during Contract Design so the SDS can be approved as a basis for System Specification development. The SDM will also be required to provide input to the Gate 5 which will approve the RFP.

Contract Design should conclude with a Preliminary Design Review (SETR for the Allocated Baseline) in conjunction with a TRB and SSB. The PDR requires extensive preparatory work, similar to the SFR, but this time focused primarily on the Ship Specifications and contract drawing package. The heart of this effort is called, "spec reading sessions," during which a myriad of ship integration details are finalized. It is an extremely time-consuming and arduous function performed over a period of months and must be done in a close working relationship with the Program Office with strong participation by the technical authorities and ABS as applicable. Numerous additional reviews are conducted throughout the phase as indicated below in the entrance criteria section. If the vessel is to be ABS classed, ABS should have been asked to conduct a design review of all artifacts that relate to the appropriate Rule set. A Contract Design Assessment letter shall be sent signifying that no "fatal flaws" exist which will preclude the vessel ultimately receiving ABS classification. Again, careful planning for this review should start early in the phase.

The Engineering Management Plan will indicate who will review and approve each design product. The TWHs will normally review and approve the Ship Specifications and Contract Drawings. Other drawings and contract documents will be reviewed and approved by the SDM. The Program Office may have special preferences for additional reviews and approvals that must be considered. The SDM will ensure that certification sheets have been approved for each Ship Specification section. Requirements traceability will be employed to ensure that all CDD requirements are adequately covered in the Ship Specifications. The SDM will certify that the coverage is complete and the quality of the design package is adequate.

APPENDIX H
SOURCE SELECTION

For a Contractor Design, the Program Officer and the Contract Directorate may develop and issue an RFP or equivalent document for Preliminary and/or Contract Design followed by a down selection for Detail Design or issuance of a new RFP. For a Navy Design, the RFP would be issued for DD&C. Although this is the prime responsibility of the Program Office and the Contract Directorate, the SDM, SIM, and Design Team are involved to ensure that it addresses the technical issues and references the appropriate specifications, drawings, data requirements, and other appropriate documents.

The first step in the source selection process is preparation of the RFP. The SDM will be responsible for preparing input to the SOW, describing all of the ship design efforts required of the Shipbuilder during DD&C. In addition, the SDM will coordinate development of the list of technical DRLs which will include all of the technical deliverables that will be submitted by the Shipbuilder during DD&C. The SDM will also coordinate development of the schedule for technical deliverable submittal, and the government review and approval required.

Ships and their systems and equipment are defined by, and their performance is directly related to, the technical documentation generated for their design, production, installation, test, and follow-on in-service operation and support. The identification and control of key technical documentation is fundamental to ensuring sound and sustainable products are delivered to the Fleet. Particular attention must be given to documentation related to those systems and equipment that are critical to the ship's mission, survivability, and safety. Collectively, these systems, equipments, and attributes are hereafter referred to as, "critical ship elements."

It is the policy of NAVSEA that headquarters control is exercised over technical documentation developed for critical ship elements during the ship acquisition process. DRL deliverables are designated as one of three levels of technical control: approval, review, or receipt. These levels are defined as follows:

- **Approval** indicates that written approval by a government representative is required prior to final acceptance by the government, prior to publication and distribution of final revisions of the item or prior to some action defined in the SOW or Specification. Only the Program Office will approve DRL deliverables requiring NAVSEA headquarters approval. The Design Team will conduct a detailed technical review of DRL items requiring approval. The Design Team will prepare the approving (or disapproving) letter for Program Office release or will furnish detailed comments for inclusion in Program Office correspondence.
- **Review** indicates that the Design Team will subject the DRL deliverable to a positive technical review to ensure compliance with contract Specifications. Items designated for review do not require formal approval action by the government. However, the Design Team will certify in writing to the Program Office that the DRL deliverable has been reviewed and either meets or does not meet contract Specifications. In the latter case, a letter will be prepared for the Program Office's release, identifying where the deliverable does not conform to specifications or the design as described in the deliverable does not conform to the specification and requiring corrective action by the contractor.
- **Receipt** indicates the DRL deliverable will not be subjected to any specific technical review, but is needed by the government for information or reference purposes. In general to avoid needless DRL preparation cost, this type of DRL should be avoided. Instead the SOW should contain a requirement for electronic access to such data on a shared IDE with periodic updates.

The approval level of control imposes responsibility and accountability on the Design Team for the accuracy, adequacy, and completeness of the DRL item itself, as well as performance of the end item. It carries with it the contractual risk of potential delay and, to some extent, shifts the burden of responsibility for satisfactory performance of the end item from the contractor to the government. It is imperative that the SDM and TWHs be sensitive to this potential liability and ensure the necessary resources are identified and committed to insure thorough technical review and timely response on a priority basis. Consideration should be given to implementing a “paperless” process for review and approval of design documentation.

The SDM will also support the Program Office and the Contracting Officer in providing specific technical input to other aspects of the RFP development.

After release of the RFP to prospective bidders, but prior to award of the contract, bidders submit questions, requests for clarification, and recommended changes. The Program Office responds to these items in writing. The SDM will coordinate the TWH responses to technical bidders’ questions for forwarding to the Program Office. If necessary, the SDM will also prepare and submit to the Program Office modifications to the contract package, generally in the form of modification pages to the Specifications and DRL and drawing revisions.

Once the proposals have been received from the bidders, the SDM will be responsible for the technical review of the proposals. The SDM will establish a Technical Evaluation Review Panel from the Design Team to review the portions of the proposal in their technical areas. The SDM must ensure that all technical areas are covered by the panel so that a complete evaluation can be made.

The SDM will be responsible for collecting and compiling all of the results from the technical evaluation and providing these results and scoring to the contracting officer and source selection team.

Following the contract award, the SDM will participate in any debriefs to the bidders.

APPENDIX I
DETAIL DESIGN AND CONSTRUCTION

During Contract Design, emphasis was placed on development of a firm technical baseline to support Shipbuilder proposals to perform DD&C of the ship. Detail Design is the production of all design and engineering deliverables required to construct, test, and certify the ship. Note that Detail Design is often broken into phases. The most commonly used terminology is for Detail Design to begin with "Functional Design" and then proceed to "Transitional Design."

With the possible exception of a new combat system, all systems will have been designed, built, and tested; unless the ship is a "demonstrator" or developmental prototype, all risks will have been reduced to "virtually zero" or have an accepted mitigation plan. In the event that there are technologies involving risk (e.g., new composite deckhouse), by the time of the first design review or Ship Production Progress Conference (SPPC), any risk mitigation plans should be executing on schedule. When a technology in this category not meeting these criteria is applied, it is best to have a fallback option completely detailed to the Contract Design level of definition and a "design budget" that will permit the new technology to be installed at the proper time if it completes development successfully. In some cases, the fallback option may be reflected as the baseline in the contract package (e.g., insertion of Advanced Enclosed Mast/Sensor System (AEM/S) on LPD 17). Firm off-ramp and decision dates should be established early in the phase for any such items.

The ship will be delivered, and all DRL items dealing with design, testing, technical documentation, provisioning, and training will be completed. Changes resulting from combat system land-based test sites and operational testing and engineering changes are incorporated in-stride, and the ship and engineering deliverables are modified as appropriate.

Use of design margins should be as planned with the full allowance available for DD&C and agreed service life allowances available at delivery. At this point, significant design changes are almost impossible due to the schedule. One of the few options available to recoup margins is to eliminate redundancies or even whole systems. Such decisions should follow the design philosophy and retain as many of the CDD capabilities as possible.

Upon award of the contract, lead ship DD&C will be performed almost entirely by the Shipbuilder, with NAVSEA headquarters retaining technical control over critical ship elements, such as key mission systems. This may be a shift in design responsibility from a government Design Team with contractor support during the previous design stages, depending upon the acquisition strategy. If, however, it has been a Contractor Design with government oversight there will be little or no change in responsibility.

Ship Detail Design durations can range from as low as 12 months for single mission ships or a modified repeat to 36 months or even longer for a more complex ship. Detail Design should largely complete prior to the start of lead ship construction to avoid expensive rework.

The Design Team will normally evolve with relatively few changes in positions but significant adjustments in assigned workload from the organization employed during Contract Design. The emphasis will shift to review of Shipbuilder Detail Design deliverables and monitoring and control of action items, Request for Clarification, Information, and Assistance (RCIAs), and Engineering Change Proposals (ECPs). The SDM should work with the SEMs to ensure resources are in place to support the review of design products/deliverables as they are received from the Shipbuilder. The Shipbuilder's integrated master schedule, along with the DRL schedule, can be used as a guide to assist in planning for this effort. The timely return of comments and approvals of these drawings and other documents is critical to prevent Shipbuilder delay claims. If a field activity or contractor will perform the detail review, this must be scheduled and funded. The total number of manhours required may or may not significantly decrease from Contract to Detail Design depending on the acquisition strategy and schedule. Roles and responsibilities should be clearly defined during final stages of Contract Design and documented in the Detail Design EMP. Where supporting field activities or contractors are required to participate, arrangements must be made two or three months in advance of contract award to have these activities ready to start their work as needed. Periodic review of the support team structure will ensure an effective and active organization. The Detail Design team should be assessed for its readiness to conduct the planned effort. Training should include team training and training in planned design processes and methods.

SUPSHIP is a key player in DD&C and as such the SDM must quickly establish a good working relationship with them. Because they have not traditionally been involved in the design until this phase, this is a new relationship that must be established. SUPSHIP serves as the on-site technical representative for the Navy where they will make many technical decisions regarding the design and construction of the ship. The SDM must work with the SUPSHIP to establish bounds on their authority and ensure that all parties clearly understand their roles. Clearly defining under what circumstances SUPSHIP can make autonomous decisions and when to involve the SDM and the Design Team must occur at the start of DD&C. Ultimately, the SDM must have a close relationship with SUPSHIP, so that they understand and trust each other's judgment, with the roles clearly defined. The relationships should be defined in the Engineering Management Plan. See NAVSEAINST 5400.95E (*hyperlink*).

Should the requirement exist that the T-ship be ABS classed, ABS will function as an independent agent to review and approve drawings as required by the defined Rule set and to provide surveyor attendance during construction to assess compliance of the ship with the defined Rule set. See Appendix T.

The split in responsibility between the SDM and the SUPSHIP Office and the relationship of ABS is documented in the Engineering Management Plan. Typically, the SDM will retain responsibility for new and high-risk systems while SUPSHIP will take responsibility for low-risk systems.

The Program Office will implement configuration management and establish a Configuration Control Board for the ship contractual baseline. The SDM and associated SIM as members of the Board, are responsible for coordinating the review of all ECPs prepared by the Shipbuilder or other activities outside NAVSEA. The SDM must develop procedures for handling ECPs and for preparing them to cover subjects required by the Program Office. These procedures will be documented in the Engineering Management Plan. Specific guidance for implementation of Configuration Management is provided in NAVSEAINST 4130.12B, Configuration Management (*hyperlink*). See also Appendix U (*hyperlink*).

The topic of performing Detail Design reviews in an integrated digital environment is discussed in recent technical papers. Centralizing information and de-centralizing model review capability has increased stakeholder involvement. The true value of employing integrated digital environments for review will be determined as DDG-1000 and other recent ship programs deploy their first ships.

A Quick Circuit Technical Resolution Process common to the Shipbuilder and the government can expedite the resolution of emergent issues that have "immediate and significant" impact to a critical path, key event, or ship schedule, and that require SUPSHIP, ABS and/or NAVSEA approval. This process is typically implemented via a Memorandum of Agreement (or similar document) among the Shipbuilder, NAVSEA 05, SUPSHIP, and ABS. The Shipbuilder contacts the appropriate SUPSHIP Technical Code and they must jointly agree to enact this process for each emergent issue identified. Once agreed, the following actions are taken:

a. Initial Notification:

Upon identification of an issue determined to qualify for the quick circuit process, the Shipbuilder and SUPSHIP Engineering notify all parties that may potentially be involved in the resolution of the issue. The purpose of this notification is to ensure all parties are aware of the issue and their potential involvement in the development and/or approval of the resolution. The objectives of this task are:

(1) To make all potential stakeholders aware of the issue
(2) To provide a summary/explanation of the issue
(3) To identify the ships/contracts impacted by the issue
(4) To identify the potential schedule impact
(5) To establish a preliminary timeline (target Estimated Completion Date (ECD)) for resolving the issue
(6) To establish a date and time for follow-up contact (Telecom) on the issue
(7) To identify points of contact

b. "Upfront" Collaborative Discussion:

As soon as practicable, the Shipbuilder, SUPSHIP, and NAVSEA (if appropriate) shall meet/teleconference to discuss the issue. The purpose of this collaboration is to have an "upfront" discussion on the issue and to jointly develop a course of action for resolving the issue. Typically, the Shipbuilder engineering department will provide the details of the issue and the potential options for resolving the issue.

Note: Additional collaborative discussions may be necessary to resolve complex issues.

The objectives of this task are:

(1) To jointly develop and agree on a course of action for resolving the issue
(2) To identify required supporting technical products
(3) To determine and identify the appropriate approval circuit (TWHs)

c. Development of Plan Details:

The Shipbuilder engineering department will typically have the primary responsibility for developing the technical analysis associated with the issue and its resolution. SUPSHIP and the other technical shareholders (NAVSEA, Planning Yards, etc…) may be requested to provide additional information and technical support. The objectives of this task are:

(1) To complete technical evaluation of the issue
(2) To validate the schedule or key event impact
(3) To develop technical justification for accepting any out of spec conditions that will not be corrected
(4) To identify and develop technical details for resolving the issue
(5) To identify material needed to accomplish resolution
(6) To identify required shop/trade/vendor support
(7) To develop required supporting technical products

d. Collaborative Review of Resolution Plan

The Shipbuilder, SUPSHIP, and NAVSEA (if appropriate) will meet/teleconference to discuss and review the details and supporting technical products associated with the resolution of the issue. The objectives of this task are:

(1) To review and discuss the technical details of the resolution with all stakeholders
(2) To identify and resolve any issues/concerns related to the resolution
(3) To identify any additional actions/supporting technical products required to resolve the issue
(4) To finalize the timeline for completing and submitting the supporting technical products for approval
(5) To verify the required approval circuit
(6) To establish a timeline/ECD for completing the approval process
(7) To identify any portions of the resolution that can be accomplished prior to the official completion and approval of supporting documents

e. Develop/Finalize Supporting Technical and Approval Products:

The Shipbuilder engineering department develops and forwards required supporting technical products to SUPSHIP for approval. If the technical products require NAVSEA approval, SUPSHIP develops the forwarding documents and submits the package to the applicable Program Office. SUPSHIP discusses/reviews the final resolution with the appropriate TWHs, as necessary, to ensure that the resolution is acceptable to all parties and that there are no concerns that would potentially delay the approval process. The objectives of this task are:

(1) To complete all technical products needed to support resolution
(2) To submit the technical product package to SUPSHIP for approval
(3) To forward technical products to the established outside approval circuit when required

SUPSHIP approves all technical products that are within the scope of their technical approval authority. SUPSHIP and NAVSEA approve technical products for issues that extend beyond the boundaries of SUPSHIP technical approval authority. SUPSHIP provides approval notification (verbal/written, as appropriate) to the Shipbuilder engineering department. The objective of this task is to quickly obtain the appropriate level of customer approval.

The RFP includes a schedule of GFE, GFI, and Government Property. Primary responsibility for timely delivery belongs to the PARM, but the SDM and associated SIM should remain aware of the required delivery schedule and monitor possible problem areas. As events on the schedule or tracking system approach, the SDM must keep informed of the progress and likelihood of meeting assigned dates. If dates will not be met, the PARM must determine a fallback position for the Program Office. Alternatives and costs must be developed for presentation to the Program Office.

The PARM is responsible for providing and validating all data required for the installation, storage, test, operation, and maintenance of equipment being furnished to the Shipbuilder by the government. However, the SDM is responsible for verifying that the GFI being forwarded to the Shipbuilder is consistent with the Ship Specifications, Contract Drawings, PPDs, etc. If inconsistencies are identified, the SDM will work with the PARM to either change the GFI or to develop a contract modification to ensure consistency. GFI delivered to the Shipbuilder becomes part of the contractual baseline. The Program's IDE provides an excellent mechanism for maintaining GFE and GFI up to date and available to the entire Design Team.

Design efforts should be preceded by development and approval of a Detail Design Engineering Management Plan and study guide(s). The end of the Detail Design engineering effort occurs at delivery, but periodic reviews conducted by the SDM are needed to mark progress and support a CDR focusing on design maturity and then a PRR focusing on manufacturing readiness at the start of construction. Through the SDM's design reviews and Program Manager's SPPCs or periodic program reviews, the Shipbuilder must demonstrate that the design is complete, and that all outstanding design issues are completely resolved. Status of GFE/GFI issues and parallel development efforts are also tracked. These reviews are made to ensure that the Shipbuilder is interpreting the Ship Specifications and drawings as intended by the NAVSEA TWHs and to respond to Shipbuilder questions about the design or intent of requirements, within contract limitations. If omissions are found in Specification requirements that could lead to future problems, these omissions can be corrected, by change order if necessary. Recommended changes to one system may have major impacts on other systems. Care must be exercised during design reviews not to impose unilateral changes on the Shipbuilder. As long as the drawings meet Specification requirements, the only way the Shipbuilder can be forced to change is by a contract change order. However the Shipbuilder may elect to change if it appears to be to his benefit. A proper attitude by all concerned is critical during design reviews. The Engineering Management Plan should identify key participants for each design review. In general, these design reviews should not be scheduled to coincide with the Program Office quarterly program review because key individuals may be needed at both reviews at the same time. The SDM and associated SIM should attend all quarterly program reviews to insure the technical effects of decisions are understood. An agenda and exit criteria should be established for each design review. Typically, the Shipbuilder will prepare the agenda and identify the exit criteria for SDM review and concurrence, with the Program Office responsible for making the final decision.

Detail Design should conclude with a CDR (SETR for the Product Baseline) in conjunction with a TRB and SSB. Again, the CDR requires extensive preparatory work, similar to the PDR, but this time focused primarily on the maturity of the Detail Design. If the vessel is to be ABS classed, ABS should have been asked to conduct a design review of all artifacts that relate to the appropriate Rule set. For applicable T-ships, a Detail Design Assessment letter shall be sent signifying that no "fatal flaws" exist which will preclude the vessel ultimately receiving ABS classification. Again, careful planning for this review should start early in the phase.

Following the CDR, a PRR is normally held to assess manufacturing readiness. Facilities, staffing, training, procurement, GFE, GFI, first article testing, and delivery of a new technology to the Shipbuilder should all dovetail with the notional lead ship construction schedule. Projected production costs should be within bounds to meet the total lead ship cost. Per contract, only after successful completion of the PRR can ship construction begin. In some cases, a phased PRR may be employed to enable early commencement of fabrication of assemblies and sub assemblies in order to comply with schedule constraints.

After satisfactory completion of the PRR, the first Gate 6 can proceed – assessing overall program health including readiness for production. Follow-on Gate 6 reviews will be conducted to endorse or approve the CPD, review program health prior to and post Milestone C and the FRP DR, and serve as forums for Configuration Steering Boards (CSBs) which are required to review proposed major changes in ship configuration and associated cost.

A major objective for DD&C is achievement of ship certification by the PEO, based upon system level certifications conducted by TWHs or their designated agents in accordance with a ship master certification plan. This includes matters such as the following. See Appendix S for a summary of current certification requirements. Three mechanisms for executing the certification process are:

- Review and approval of many documents, including DRLs, deliverables, drawings, calculations, reports, Engineering Change Proposals (ECPs), and other technical documents
- Attendance at design reviews, SPPCs, and other reviews conducted throughout the phase to track progress against schedule and to identify any potential problem areas
- Witnessing of tests and review of test reports

Achieving these objectives requires extensive preparatory work. A Master Certification Plan should be available at the start of this phase to guide the organization and management of the certification process. Agreements, such as MOAs, will likely be required to obtain needed support from other organizations. The Certification Plan should have been reviewed and approved as soon as possible during Preliminary Design so that the associated certification criteria could be applied as first-order influences in the design development process.

The “Certification Results Summary Memo” will document the status of all the certification efforts in the Design Certification Matrix. The memo will be co-authored by the SDM, associated SIM and the Waterfront CHENG, and signed out by CSE SHIPS to the Program Manager. Outstanding certification issues will be identified, and related risks assessed. This memo will be an important technical basis for the “Readiness for Trials Memo”.

The “Readiness for Trials Memo” should be jointly authored by the SDM and the Waterfront CHENG, and signed out as a serialized memo by CSE SHIPS to the Program Manager. The memo will address key outstanding technical risks (including recommended mitigation actions). The memo will also provide an overall go/no go recommendation from a technical standpoint, and will address any operational restrictions.

Ideally, the follow-ship technical data package will consist of a reissue of the lead technical data package. However, the follow-ship package will need to consider all modifications and change orders from the lead ship. Also considered will be OPNAV directed changes in characteristics, INSURV items if the lead ship has completed trials, and changes not incorporated in the lead ship because of expense to change drawings or hardware. The extent of work to be accomplished will have to be negotiated with the Program Office in consideration of the budget and schedule constraints.

The SDM shall prepare a Turnover Book for the successor In-Service SDM and coordinate technical turnover from SUPSHIP CHENG to RMC/Naval Shipyard CHENG. The Turnover Book shall be issued as an attachment to a serialized memo. At a minimum, the Turnover Book shall contain:

- Design History
- List of Design Features to facilitate modernization
- Summary of Service Life Allowances and stability status
- Ships Force Contact Information
- Placemat
- Safe Operating Envelopes
- List of significant technical risks and status with respect to their mitigation
- List of all outstanding deficiencies (trial cards, ABS Outstanding Recommendations, DFS, warranty work, etc.) and current status
- List of equipment warranties
- A description of how to gain access to the Ship Selected Records
- A description of how to gain access to the LEAPS Product Model (if available) or Digital Product/Technical Data as required by ASN(RD&A) Memo of 23 Oct 2004
- A copy of Post Shakedown Availability (PSA) work package and a description of how to gain access to PSA work specs
- A description of engineering resources available (including a list of POCs) in the event that tech issues require PSA extended warranty period design support
- List of ECPs and other modifications, deviations, and waivers not accomplished and incorporated

APPENDIX J
CONVERSIONS AND MAJOR MODERNIZATIONS

During the typical high-value ship’s service life, it will undergo a major modernization or conversion every 10 to 15 years. A modernization is a major updating of equipment and systems to support OPNAV requirements. A conversion can change the basic mission of the ship, as well as updating equipment and systems, and the ship designation can change to a different ship type.

An abbreviated design process for both conversions and major modernizations is basically a simple feasibility study followed by Contract Design. The primary differences between major modernizations/conversions and new ship design are due to the fact that the basic ship and ship systems already exist. An SDM is usually assigned to ensure proper system integration for these projects but it may not be a fulltime job, depending on the scope of the effort. Though conceptually appearing less complex, the constraints of existing space, weight, ship’s center of gravity above the keel (KG), electric power, accommodations, structural margins, and other elements, coupled with the realities of the physical condition of the ship obtained during ship checks, can make these efforts extremely challenging for the SDM and Design Team.

Proper implementation of Navy Open Architecture and use of MAS technologies should reduce the scope, schedule, and cost of future conversions and modernizations. SDMs and SIMs should leverage these opportunities where they appear.

APPENDIX K
REACTIVATIONS

At the end of a ship's service life it may be deactivated and assigned to the Reserve Fleet. Sometimes, after the conclusion of a ship's service life, another phase of the ship's life cycle may be initiated. Ships may be reactivated to fulfill again the original mission with newer equipment or to fulfill a completely different mission. The design process often involves a simple feasibility study followed by Contract Design. This design package generally consists of work packages similar to those created for overhauls.

The technical responsibility for reactivation, conversion, or major modernization may reside in the in-service SDM or, if significantly complex, may be assigned to a dedicated SDM in SEA 05D/V. Again, constraints of existing ships can be extremely challenging. The battleship reactivation program is an excellent example of the possible scope of such an effort, using approximately 77 man years of effort for the BB 62 (first ship to be reactivated) over a nine-month period.

APPENDIX L
IN-SERVICE ENGINEERING

After delivery of the ship to the Navy and the completion of the Post Shakedown Availability, if conducted, SDM responsibility will typically shift from the New Construction SDM to the In-Service SDM. This transfer will be implemented via a Turnover Book and a letter of transfer. The Turnover Book contains details of all technical issues that remain unresolved. The Turnover Book should be jointly developed by the SDM and SUPSHIP CHENG to provide to the In-Service SDM and RMC/Naval Shipyard CHENG.

The preponderance of the life span of ships, systems, and equipment is spent in-service. A service life in excess of 30 years is now almost routine practice. The Fleet Modernization Program (FMP), now implemented through ship maintenance, provides the management structure by which characteristics of ships in the Fleet are improved. Such improvements are effected as either program or Fleet alterations. The SDM will coordinate the Naval Systems Engineering Directorate’s (SEA 05) participation in the alteration program including technical review and approval and involvement of ABS if the ship is ABS classed.

The responsibility for the maintenance and modernization of in-service ships is split among many organizations. In general, the Fleet is responsible for routine preventative, condition based, and corrective maintenance. The In-Service SDM is primarily concerned with addressing technical issues associated with design deficiencies, modernization, alterations, safe operation of ships and ship systems with degraded equipment/systems, and safe operation of ships and ship systems when using equipment/systems in a non-traditional manner.

The exact timing of the shift of responsibility for a given ship from the New Construction SDM to the In-Service SDM will vary from ship to ship. In general, it will occur no earlier than Ship Delivery, and no later than the Obligation Work Limiting Date (OWLD). In many cases, between delivery and the assumption of full responsibility by the In-Service SDM, responsibility will be shared with the New Construction SDM. The New Construction SDM will generally retain responsibility for correcting trial card deficiencies, Warrantee Work, and the PSA work, while the In-Service SDM will take on all remaining SDM responsibilities. SEA 05D/V should issue a Turnover Plan detailing the timing of the shift of responsibility before ship delivery. In particular, the transition plan shall detail technical authority assignments during the period between delivery and OWLD. This Turnover Plan shall also include any special instructions for the Turnover Book described in Appendix K.

The RMC CHENG is responsible and accountable for all engineering, technical work, and technical decision-making accomplished by his or her assigned activities as defined by NAVSEAINST 5400.95E (*hyperlink*). Ship and work period specific MOAs are issued to delineate agreements between the RMC CHENG and other activities involved in the construction, conversion, and refit or repair work. Note that Aircraft Carriers employ the SUPSHIP CHENGs with the Shipyards for these roles.

SDM Roles and Duties

In today’s environment of constrained in-house resources, SDMs provide essential technical leadership in guiding the Navy’s Design Team under the overall direction of a Ship Program Manager. To strengthen that relationship, SDMs have the trust of the management, as reflected by granting SDMs warranted technical authority for Total Ship Systems Engineering and Total Ship Integration on their assigned ships. The SDM must be a trusted technical leader for the in-service Program Manager, TYCOMs, and the ships’ Commanding Officers. Independent and objective, the SDM must facilitate the timely resolution of technical issues through rapid assessment, involvement of key stakeholders (including Fleet, Program Offices, and technical authorities) and expert communication of issues and acceptable resolution options to decision makers. The SDM is counted on to know the technical risks for his/her ships and be able to articulate the risks (consequence and probability) along with proposed mitigation efforts. The SDM must have a thorough working knowledge of specifications and plans used to maintain ships, as well as class specific applicable technical specifications, standards, and drawings. Relationships with other PEOs concerning the ship class are essential as well.

The role of the SDM is focused on the “Design” of in-service ships. In particular, the SDM is concerned with how well the design of the ship, as well as the physical implementation of that design, is meeting the ship’s operational requirements. The SDM must therefore have a good understanding of the operational requirements of the assigned ships as documented in CDDs. The SDM must also know the physical condition of the ships as reported in inspections/surveys/weight reports, and Casualty Reports (CASREPs). The SDM is expected to participate in periodic INSURV Underway Material Inspections (UMIs) to maintain current awareness of the condition of his/her assigned ships. The SDM must understand the remaining Service Life Allowances for all ships under his/her cognizance as well as the stability status and the basis for the stability status for each ship. A thorough knowledge of risk analysis with respect to Departure From Specifications (DFS) adjudication and Integrated Class Maintenance Plan (ICMP) deviations is required. The SDM must be thoroughly knowledgeable in the many aspects of In Service Engineering (ISE). The SDM must be familiar with the roles the In Service Engineering Agents (ISEA) are fulfilling for their ships and where gaps exist. The SDM must also be familiar with the role and actions being taken by the respective maintenance activity for his/her ship type. For surface ships this is the Surface Ship Life Cycle Maintenance Activity (SSLCM) and for carriers this is the Carrier Planning Activity (CPA). The SDM is expected to develop relationships with RMCs, especially the RMC CHENG, and Naval Shipyards in order to be a resource as well as influence ship repair, maintenance, and modernization practices.

The SDM is also responsible for leading the review of major alterations to the ship’s configuration to ensure that the changes are safe, will work, incorporate appropriate Human Systems Integration processes and do not unknowingly degrade performance in other mission areas. Where needed, the SDM will ensure the Program Office performs or directs the performance of shipboard testing, shipboard monitoring, modeling, simulation, and analyses to accomplish the duties listed here. The SDM should coordinate the review of condition-based maintenance records and other maintenance and consumable records to identify opportunities for reducing life cycle cost and improve operational availability. The SDM will be responsible for providing inputs to update applicable sections of the General Specifications for Overhaul (GSO). The SDM is responsible for advising Program Offices to allocate resources to develop or maintain appropriate Safe Operating Envelopes for each ship (if needed). The SDM is responsible for ensuring appropriate technical data is kept up to date within the SEA 05 and NAVSEA Incident Room virtual technical library to support incident response. Should a ship experience significant damage, the SDM will lead the Headquarters analysis and evaluation efforts to support Navy leadership. The SDM shall maintain appropriate documentation and lessons-learned for sharing knowledge with other In-Service SDMs as well as New Construction SDMs. The In-Service SDM is expected to know the TWH structure, where the knowledge, expertise, and authority resides for all functional areas associated with his/her ships, and coordinate all technical issues with appropriate TWHs and Program Office. Wherever possible, the SDM will resolve technical conflicts within the competency and enterprise. When necessary, the SDM will employ the chain-of-command to resolve issues. The goal should be for the NAVSEA Technical Authority to speak with one voice to the customer.

Relationships with Engineering Field Representatives and Naval Shipyard Representative Offices

Engineering Field Representatives and Naval Shipyard Representative Offices are NAVSEA’s eyes and ears on the waterfront. They are committed to ensuring waterfront technical compliance as well as liaising with the waterfront presence of Fleet and TYCOM N43 organizations. Developing a strong working relationship with these personnel will enable the SDM to get honest and accurate feedback directly from the deckplates, similar to the Program Manager Representative’s (PMR’s) relationship to the Program Office.

CLASSRON Relationship (Note that CLASSRONs are being disestablished and this process will be changing.)

Where applicable, SEA 05 SDMs for Surface Forces (SURFOR) ships or one of their support staff are expected to be additional duty to the CLASSRON for their respective class of ship. They are expected to represent the Virtual SYSCOM as a whole, not just SEA 05. They are expected to function as a part of the CLASSRON N4 organization, directly responsible to each CLASSRON Commander to accomplish:

- Technical community liaison for class maintenance, repair, and modernization issues
- Liaison with Regional NAVSEA Engineering Field Representatives (EFR) to accomplish onsite coordination issues that the SDM or CLASSRON N43 may not be able to conduct
- Provide technical direction and management, as necessary, to integrate HM&E, Combat Systems, Aircraft systems and their interfaces, and C4ISR modernization installations for in-service surface ships
- Risk analysis and Departure from Specification (DFS) screening with RMCs, TYCOMs, and Program Offices
- R&D support and analysis
- T&E support and analysis
- Systems engineering and integration support
- Reviews planned SCDs/CONOPS (including maintenance sections) for technical adequacy, and provide comments to the Program Office as part of the SHIPMAIN process
- TMA/TMI Issues program support for each CLASSRON
- Review ICMP deferral requests. Provide appropriate technical support and information
- Coordinate CLASSRON interaction with the various warfare centers, present tasking requests to PEO Ships for approval of funding
- Participate in CLASSRON metrics monitoring and offer NAVSEA input on improvements, root causes for below benchmark observations and duplications with metrics tracked by other NAVSEA Codes or PEOs
- Provide training to the CLASSRON on general technical authority, differences with Programmatic Authority, the Virtual SYSCOM and products and services already produced by the Program Offices and SYSCOMs such as equipment monitoring programs, ISE products, modernization planning initiatives, etc.

Liaison Action Record

There is a requirement for a formal technical liaison system among ISE activities, Planning Yards (PYs), SUPSHIPs, Overhaul Yards, Space and SPAWAR, PARMs, AITs, Ship Program Managers (SPMs), and other organizations involved in the modernization process. Details for the Liaison Action Record (LAR) process are identified in the JFMM.

The technical liaison system described herein shall be used for the following reasons:

- Technical Information
- Interpretation of Drawings, Specifications, etc.
- Material Identification
- Change Requests
- Planning Yard approval of Drawings

The primary document to be used in this Liaison System is the Liaison Action Record (LAR); however, it is not the intent to require the use of LARs where other mechanisms exist such as the direct liaison between the overhauling activity and the PY On-Site Representative (OSR).

Any changes to modernization drawings which affect, material specifications, pipe stress levels or distribution, system design or operational characteristics/features, component or fitting selection, ratings and MIL-SPECS, structural integrity, power requirements, compartment/topside arrangements or require insertion in drawing for follow on ships are not permitted except where concurred on by the PY. This concurrence can be obtained either via LAR or the OSR process. Where approved changes require the revision of drawings, the appropriate activity will modify these on a priority basis. This does not apply to Nuclear Propulsion Plant matters under the cognizance of SEA 08.

Departure from Specification

Specifications are engineered requirements such as type of materials, dimensional clearances, vibration levels, flow rates, and physical arrangement to which ship components are purchased, installed, tested, and maintained. All ships are designed and constructed to specific technical and physical requirements. It is imperative that every effort be made to maintain all ship systems and components to their designed specifications. There are occasions when the applicable specifications cannot be met. In these cases, the non-conformance to specifications is controlled with a DFS as identified in the JFMM. The waterfront technical authority policy is described in NAVSEAINST 5400.95E.

During a maintenance action, a DFS is required for lack of compliance with cognizant documents, drawings, etc. For “as found” conditions during maintenance, the TYCOM, ship and Fleet Maintenance Activity (FMA) (if involved) must evaluate the non-compliance using the guidance of the JFMM. For “as found” conditions or equipment failures during operations that result in non-compliance with cognizant documents, drawings, etc., the ship and/or TYCOM (if in port) must evaluate the condition or failure using the guidance of the JFMM to determine if the non-conforming condition meets the criteria as a Major DFS. If it is not non-compliant, a DFS is not required and the non-conforming condition will be entered in the ship’s Current Ship’s Maintenance Project (CSMP).

It is incumbent upon ships, FMAs, and TYCOMs to discuss a potential DFS as early as possible (prior to the work close out or component assembly if possible) to determine direction of actions, and alternatives to the DFS. Every effort must be made to correct each deficiency prior to equipment/system operation or underway of the ship. If a DFS has to be submitted, the request for it must be processed as soon as possible to enable an engineering evaluation of the DFS request and approval/disapproval to be granted without disrupting ship’s operations.

A DFS is classified as either Major or Minor depending on its significance. Care must be exercised in evaluating and determining the type of DFS. A major DFS is one that affects performance, durability, reliability, maintainability, interchangeability, effective use or operation, weight or appearance, health or safety, system design parameters, compartment arrangements, or assigned function. A DFS which is not a Major DFS is considered to be a Minor DFS.

A DFS is approved as either permanent or temporary depending on the nature of the non-compliance and technical determination of whether the condition needs to be repaired. A temporary DFS requires subsequent action to correct the non-compliance and is approved with specific direction regarding duration and actions necessary to clear. A Major DFS accepting a temporary repair or condition is approved by the TYCOM following concurrence by an Authorized Technical Authority. A Minor DFS accepting a temporary repair will be approved by the TYCOM. All permanent Minor (and Major) DFSs will be approved by NAVSEA except those identified in the JFMM, which may be dispositioned by the TYCOM.

Request for DFS for nuclear systems will be neither requested nor approved. If a ship or FMA has a question, problem, or is unable to comply with nuclear specifications, request for technical resolution will be made using an LAR. Formal resolution of the LAR is required prior to reactor plant or propulsion plant startup.

If a nuclear powered ship or nuclear capable FMA is unable to comply with specifications for reactor plant systems or components, then a review of SEA 08 requirements shall be requested. In general, technical resolution to questions or problems for reactor plant systems or components requires use of a liaison inquiry according to the requirements of SL720-AA-MAN-030, Surface Ships and Carriers Entitled Process for Modernization Management and Operations Manual and Integrated Project Teams for Aircraft Carrier Maintenance (IPT4ACM).

Steam Plant Action Requests/Steam Plant Liaison Inquiry

If a ship or FMA has a question, problem, or is unable to comply with non-nuclear specifications, technical assistance is available from the Propulsion Plant Engineering Activity (PPEA). The PPEA was formed to provide an additional technical resource for assisting operational aircraft carriers with technical or operational issues not associated with modernization installation and configuration control. PPEA Liaison services are requested using the Steam Plant Action Request (SPAR). The SPAR allows the Fleet and overhaul activities to submit requests to the PPEA for technical assistance on non-Ship Alteration related issues; the SPAR is not intended to replace the LAR process described above or non-nuclear LARs submitted to the Hull Planning Yard. The PPEA can request information, disseminate technical information associated with the Steam Plant to the Fleet/overhaul activities, or direct work that does not require a drawing change or affect system configuration control using the Steam Plant Liaison Inquiry. Procedures for preparing SPAR/Steam Plant Liaison Inquiries (SPLIs) are discussed in NAVSEA 0989-LP-043-0000, Commissioned Surface Ship General Reactor Plant Overhaul and Repair Specification.

Trouble Reports

The Trouble Report is the vehicle to identify significant problems encountered in the construction, repair, and maintenance of naval ships. NAVSEAINST 4700.17, Preparation and Review of Trouble Reports, provides consolidated requirements for the preparation and review of Trouble Reports.

Ship Change Documents

The original Ship Maintenance (SHIPMAIN) Program was developed to streamline maintenance planning, execution, and oversight within the Surface Fleet. After inception, SHIPMAIN was broadened to include modernization planning for all surface ship and aircraft carrier programs. This was later extended to include modernization, execution, and feedback. Among the many goals and precepts of the modernization leg of SHIPMAIN are: Upfront review and approval of shipboard changes early in their life to ensure only the most important changes are designed/developed; a reduction of the multiple types of changes (Machinery Alterations (MACHALTS), ECPs, Ordnance Alterations (ORDALTs), etc.) to a single designation and form established as a Ship Change Document (SCD); a formalized process for evaluating SCDs as they evolve to include Technical Assessment Team (TAT) review, CBA and military utility or Alteration Figure of Merit (AFOM) parameters; a ship change and Navy Modernization Plan approval process ensuring only approved changes are funded for development and shipboard installation. The SHIPMAIN modernization component ultimately evolved into the Navy Modernization.

Program and the business rules and operating guidance are invoked in the Surface Ship and Carrier Entitled Process for Modernization (SSCEM) Management and Operations Manual (SL720-AA-MAN-030). This manual provides overall guidance for TAT reviews.

APPENDIX M
AIRCRAFT CARRIER MODERNIZATION

The IDEA Operations Manual was developed to define the Carrier modernization process under the IDEA concept. It complements the Navy Modernization Process (NMP) that supplants the SHIPMAIN Cross Functional Team Four (CFT-4) Entitled Process, including SL720-AA-MAN-030, Surface Ships and Carriers Entitled Process for Modernization Management and Operations Manual, Integrated Project Teams for Aircraft Carrier Maintenance (IPT4ACM) and JFMM (*hyperlink*), and other related modernization directives.

The entitled process significantly modifies the FMP and reduces over 40 alteration types to two categories, Fleet (TYCOM) alterations and program (SYSCOM or PEO) alterations, streamlines and consolidates a number of existing modernization practices, processes, meetings, and supporting documents and provides a single, hierarchical decision making process for modernizing surface ships and aircraft carriers. The goal of the entitled process is to populate the President's budget with approved, fully funded alterations, selected based on technical, war fighting, readiness, and cost benefits using one structured process involving TYCOM and OPNAV senior decision makers.

The process is based on approved business rules. It consists of a five-phase process (Preliminary Analysis, Concept Design, Design Development, Implementation, and Installation/Checkout/Feedback) supported by Decision Points at the end of Phases I-III and Readiness Assessment during Phase IV.

A single database is maintained by SEA 04. The SCD, which replaces the Justification Cost Form, Ship Alteration Record, in-service ECP, and all other alteration documents used in the FMP, will be entered and tracked in the database from inception through installation in the last applicable ship. Only SCDs entered in the database are considered for inclusion in modernization plans for specific hulls.

Involvement of Fleet, OPNAV, TYCOMs, SYSCOMS, and PEOs in the decision-making process is incorporated through the use of three boards of stakeholders at the O-6, 1 and 2-star Admiral and 3-star Admiral level. Voting members of the boards represent appropriate Fleet and OPNAV organizations. SYSCOM and PEO representation is included to validate the readiness of the alteration to proceed to the next steps.

The SDM for In-Service Carriers is responsible for the Carrier SCD Technical Assessment Team Review program as a whole and specifically is the Technical Authority responsible for the completeness of all necessary technical reviews. As such, the In-Service SDM shall designate Core TAT Leads for each functional area to review and adjudicate the appropriate level of review.

The TAT reviews and concurs with each phase of an SCD. Core and Virtual TATs consisting of SYSCOM and PEO technical personnel review the SCD to ensure the SCD is technically feasible and to identify any ship integration issues that may impact its overall benefit to the Fleet, such as Weight and Moment, HVAC requirements, interoperability, certifications or conjunctiveness with other changes. ILS considerations are also assessed.

The TAT review shall assess the technical feasibility of an SCD as it is developed, using technical experts, including TWH, as applicable. The TAT review shall be limited to comments technical in nature. Administrative or grammatical changes will not be made unless required to clarify technical intent or if made in conjunction with technical comments on the same section of the SCD. Questions regarding the technical merit of the changes shall be submitted to the Deputy Ship Design Manager for In-Service Carriers (DSDM) or directly to the appropriate SDM.

Air Craft Carrier Refueling Complex Overhaul

When an aircraft carrier transitions from new construction to in service, technical authority shifts from SEA 05V3 (CVN 78 Class) or V2 (CVN 68 Class) to SEA 05V1. SEA 05V1 leads the interface of systems engineering efforts with the TWH community for in-service carriers, and are warranted to make integration decisions. As such, the In-Service Carrier SDM leads the technical efforts of the In-Service Aircraft Carrier Program Office (PMS 312E). Midway through its service life, an aircraft carrier undergoes a Refueling Complex Overhaul. The planning and execution oversight for this extended availability is SCN funded via PMS312D, and the engineering effort is led by SEA 05V2. PMS 312D is the branch organization within PEO Carriers responsible for managing overall direction of the RCOH program to re-deliver the ship within cost/schedule/capabilities. This organization develops and executes budgeting, plans, policies, procedures, and acquisitions pertaining to the RCOH program. Subsequent to the RCOH, ownership is transitioned back to PMS312E and SEA 05V1.

Aircraft Carrier Baseline Authorized Work Package

The Baseline Authorized Work Package (BAWP) contains the Aircraft Carrier Class Maintenance Plan maintenance requirements sequenced to support the aircraft carrier's 50-year life and operating cycles, while maintaining materiel readiness and combat ready aircraft carriers. Due to the technical nature of the decisions being made, all potential maintenance reprogramming requests must be reviewed at the appropriate technical level to minimize compromising long-term readiness and prevent non-executable maintenance bow waves.

The Carrier Planning Activity (CPA) develops BAWP work items derived from: higher-level mandatory requirements (e.g., Naval Ships Technical Manual [NSTM], GSO, etc.), SHIPMAIN CFT4 modernization plan, the Reactor Plant Planning Yard (RPPY) baseline (e.g., reactor plant modernization, Reactor Plant Manual maintenance, etc.), Intermediate (I)/Depot (D) level PMS, Program Office IMP life cycle strategies (e.g., Carrier Availability Planning System [CAPS], Life Cycle maintenance strategies, etc.), and other sources (e.g., Team One initiatives, hot wash lessons-learned, ships force items, etc.). The BAWP work items will be grouped according to one of the following source codes that identify change request/notification requirements for non-accomplishment:

- **Mandatory** – Requires a change request for non-accomplishment
- **Modernization** – Requires a change request for non-accomplishment under the SHIPMAIN CFT-4 Entitled Process
- **Discretionary** – Requires notification to the CPA (not a change request) for non-accomplishment

CPA will also coordinate/negotiate a combined mitigation strategy, ensure evaluation/input from all applicable technical authorities and Engineering Agents (EAs) (CPA, SEA 08, SEA 05, NAVAIR, SPAWAR, Naval Surface Warfare Centers [NSWCs], RPPY, PPEA, etc.), and other stakeholders. If not already submitted, they will advise CNAF if a formal DFS is to be submitted.

Technical Authorities and EAs will evaluate BAWP work item DFS and mitigation strategies to determine the technical impacts and risks associated with the work reprogramming or change-in-scope. Additionally, they will provide recommendations, with appropriate justifications, for approval or disapproval and alternative mitigation strategies or actions as required to reduce risk. If required, they will adjudicate changes to the mitigation actions with CNAF and stakeholders.

Finally, they will provide approval or disapproval recommendations to the PMS 312 BAWP Change Requests/Notifications Disposition letter.

Ship Change Documents

For aircraft carriers, SEA 05V maintains the process for the technical review of SCDs. Technical assessments are conducted by Core TAT Leads. Under the cognizance of SEA 05V, Core TAT Leads are responsible for ensuring that the appropriate technical stakeholders including CVN 68 Class Engineering Configuration Manager (ECM), Engineering Agents, Life Cycle Managers (LCM), SEA 08 and TWHs review SCDs. There are currently six Core TAT Leads: Aviation, Auxiliary, Hull, Electrical/Networks, Propulsion, and Warfare Systems/Command, C4I. When the Refueling Complex Overhaul (RCOH) program or new construction program has a more urgent need for an SCD, the Core TAT Lead will assign the responsibility for managing the virtual TAT review to his counterpart, who will act as the Virtual TAT Lead. This will allow for more efficient and timely use of resources but also preserves the single entry and exit points for TAT reviews. Figure M-1 depicts the TAT review process while Table M-1 presents the TAT review timeline. Additional details of the SEA 05V process is documented in a Memorandum of Understanding among Commander, Naval Sea Systems Command (COMNAVSEA) SEA 05V, COMNAVSEA SEA 08P, COMNAVAIR AIR 4.1, and PEO-CV PMS 312.

To provide a consistent process for both NOFORN and unclassified SCDs and to address current problems associated with the Navy Data Environment (NDE) software, tasking for review of SCDs may be accomplished using SEA 05's MOS, assignment within NDE-Entitled Process (EP), or via email for outside activities. Upon completion of a review, comments and supporting data will be posted to the NDE. SEA 05V will post supporting data, technical input, comments, and recommendations for a particular SCD in a common file structure within the PEO Carriers IDE.

The Core TAT Lead recommends to the TAT Change Manager (CM) that SCDs be approved, approved with changes, or returned for rework. SCDs that are approved with changes contain minor comments that can be added to the next SCD phase but do not affect the technical contents.

Minor changes for Phase III SCDs can be captured by supplying the comments as an attachment in the SCD. SCDs that require significant change will be sent back to the TAT CM with a recommendation for rework. The TAT Lead will determine whether SCD changes are minor or major based on how they affect technical content.

When a legacy alteration has to be converted to an SCD to complete the installation for the class, the Phase III SCD will be evaluated by the TAT lead to determine the following:

- Concurrence to the legacy documentation such as a SHIPALT Record (SAR) or Alteration Equivalent to Repair (AER) is available and still germane
- Interfaces and system impacts have not changed
- New requirements have not resulted in a need to modify the legacy alteration
- There are no outstanding LARs written against legacy alteration and all existing LARs have been incorporated into the Phase III SCD

If all four are evaluated as true, the TAT lead will recommend approval of the SCD to the TAT CM. The approved SAR will be provided as an attachment to the SCD. If it is a SEA 08 interest alteration, a copy of the SCD with legacy SAR will be provided to the applicable SEA 08 codes for information. It is incumbent upon the Submitter to provide historical documentation on the legacy alteration in question.

A Phase III SCD can also be initiated when a legacy Justification Cost Form (JCF) has been approved. In this case the SCD will go through the full TAT review process.

The TAT Leads may provide supporting data for CBA when the SCD is in the initiation or submittal stage, but this is outside of their chartered responsibility. They will assess ILS elements for technical accuracy. The Submitter is responsible for populating the fielding plan, CBA, and AFOM.

Phase I and Phase II (not including Phase II non-permanent changes or prototypes) SCDs will only be reviewed by the TAT Lead except where the TAT Lead deems that a virtual TAT review is necessary. The SCDs may be distributed for information.

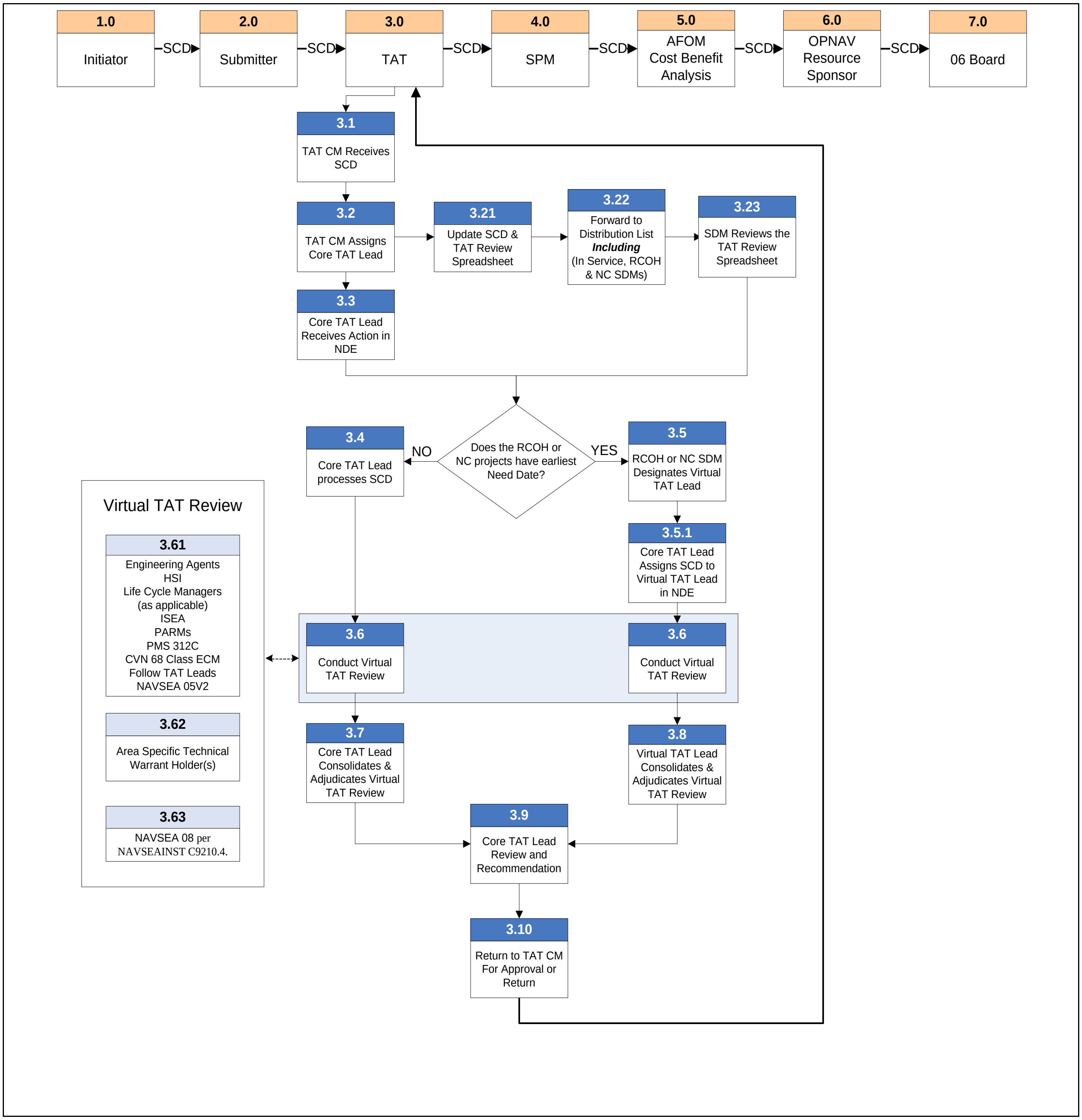


Figure M-1. TAT Review Process Diagram

Table M-1. TAT Review Timeline

	Phase I	Phase II	Phase IIA/III
Processing Time	1 – 2 Weeks	2 – 4 Weeks	4 – 6 Weeks

Note: Phase III SCDs documenting previously approved legacy alterations also fall under the 1 – 2 week processing timeline.

APPENDIX N
TYPICAL DESIGN PHASE CHARACTERISTICS

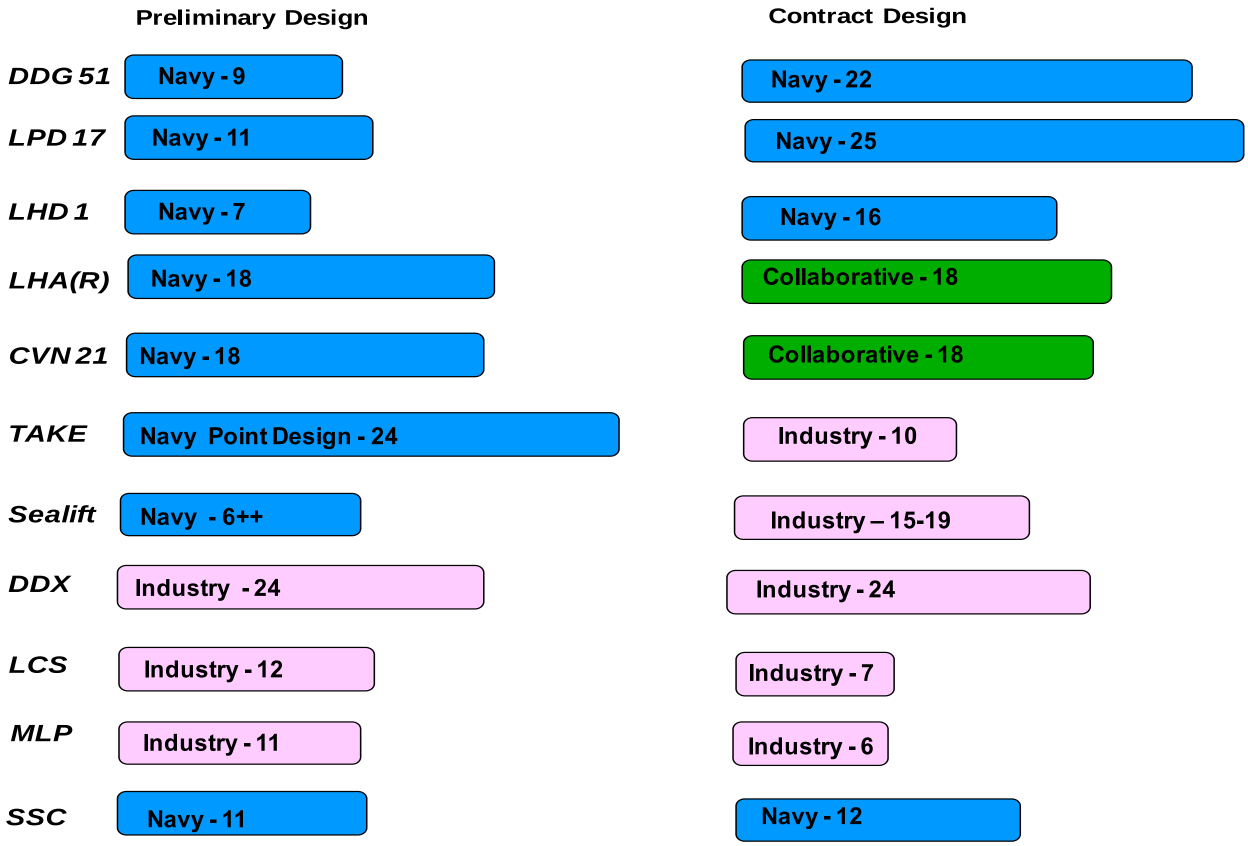
The following provides a summary of typical design phase characteristics

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary	Contract	Detail	FMP	Reactivation	Conversion
Purpose	Rough order of magnitude and even feasibility level ship and system studies of force options and technologies.	Rough order of magnitude or feasibility level ship and system studies to support a CBA, SWARF, or other analysis for ICD then MDD to define AoA performance/ cost trade space.	Feasibility level ship and system studies to define AoA alternatives.	Start ramp up from Feasibility to Preliminary Design level effort for the selected AoA concept to support requirements and budget definition for CDD finalization, Milestone A, and possibly Ship Specification development and contracting for Preliminary Design.	Focus on establishing ship size, external configuration, and the overall allocation of space to various functions – the Functional Baseline.	Translate the results of Preliminary Design into a biddable technical package.	Production of all design and engineering deliverables required to construct, test, and certify the ship.	SHIPALTs to provide for ship improvements.	Up to Contract Design level effort to support reactivation.	Up to Contract Design level effort to support conversion.
Alternative Approaches	SEA 05 in-house with lab and/or contractor support.	SEA 05 in-house with Navy lab and/or contractor support.	SEA 05 in-house with Navy lab and/or contractor support to provide inputs to AoA Director. SEA 05 may provide AoA Director.	SEA 05 in-house with Navy lab and/or contractor support.	SEA 05 in-house with Navy lab and/or contractor support or contracting for conduct of a Shipbuilder Preliminary Design.	SEA 05 in-house with Navy lab and/or contractor support or contracting for conduct of a Shipbuilder Contract Design.	Shipbuilder design.	In accordance with Fleet Modernization Program.	SEA 05 in-house with Navy lab and/or contractor support or contracting for conduct of a Shipbuilder Design.	SEA 05 in-house with Navy lab and/or contractor support or contracting for conduct of a Shipbuilder Design.

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary	Contract	Detail	FMP	Reactivation	Conversion
Lead, Workload and Participants	SCM with a few part time engineers; SIM participation as applicable.	SCM with a few part time engineers; SIM participation as applicable.	SCM or SDM with a few part time engineers; SIM participation as applicable.	SDM starting with the AoA Feasibility Design support team and starting to expand to Preliminary Design levels and participants	SDM with an effort of over 1 00 man years using mostly part time people for a combatant design. Collocated core team including a DIM, PNA, PME, general arrangements, structures, weights, SIM, C4I integrator, and one or two naval architectural generalists.	SDM with an effort of about 200 man years using mostly part time people for a combatant design. Collocated core team including a DIM, PNA, PME, Specifications Manager, general arrangements, structures, weights and stability, propulsion, electrical, SIM, C4I integrator, HVAC, fluids, mechanical, deck, HSI, two or three naval architectural generalists, and support.	SDM with organization similar to that for Contract Design but with emphasis on review of Shipbuilder deliverables. Addition of SUPSHIP support. Overall workload may or may not significantly decrease.	SDM with a small support staff.	SDM with organization similar to that for Contract Design	SDM with organization similar to that for Contract Design.
Duration (See Note 1)	3-6 months	3-12 months	3-12 months	1-12 months	6-12 months	12-24+ months	12-36+ months	Ongoing	12-36+ months	12-36+ months
Design Reviews, SETRs Reviews, Gates	Event Based Design Reviews	Event Based Design Reviews, ITR, Gate 1	Event Based Design Reviews, Possible SRR and Gate 3 if CDD is entering Navy staffing prior to Milestone A	Event Based Design Reviews, SRR and Gate 3 if not held prior to support CDD submission to Navy staffing.	Event Based Design Reviews, SFR (SETR for the Functional Baseline), Gate 4, and possibly Gate 5 for early verification of RFP content.	Event Based Design Reviews, PDR (SETR for the Allocated Baseline)	Event Based Design Reviews, IBR, FCA, SVR, CDR (SETR for the Product Baseline), PRR, SPPCs, Gate 6	Gate 6, ISR	Event Based Design Reviews, PDR (SETR for the Allocated Baseline)	Event Based Design Reviews, PDR (SETR for the Allocated Baseline)

APPENDIX O
HISTORIC TIMELINES FOR PRELIMINARY AND CONTRACT DESIGN

The following are timelines in months for recent Preliminary and Contract Design efforts. Note that T-AKE efforts were delayed because of funding and other factors.



APPENDIX P
TYPICAL DESIGN PHASE DELIVERABLES

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
General Management	Study Guide, Annual Report, Design Phase Report including Design History, Draft Next Phase EMP	Design Phase EMP, Study Guide(s), Schedule, Budget, Annual Execution Agreement, Annual Report, Design Phase Report including Design History, Draft Next Phase EMP	Design Phase EMP, Study Guide(s), Schedule, Budget, Annual Execution Agreement, Annual Report, Design Phase Report including Design History, Draft Next Phase EMP	Design Phase EMP, Study Guide(s), Schedule, Budget, Annual Execution Agreement, Annual Report, Design Phase Report including Design History, Draft Next Phase EMP	Design Phase EMP, Study Guide(s), Schedule, Budget, Annual Execution Agreement, Annual Report, Design Phase Report including Design History, Draft Next Phase EMP	Design Phase EMP, Study Guide(s), Schedule, Budget, Annual Execution Agreement, Annual Report, Design Phase Report including Design History, Draft Next Phase EMP	Design Phase EMP, Study Guide(s), Schedule, Budget, Annual Execution Agreement, Annual Report, Design Phase Report including Design History, Draft Next Phase EMP, Shipbuilder SEMP, Shipbuilder Drawing Schedule, Ship Drawing Index, Shipbuilder Progress Reports, Monitoring of Shipbuilder Progress
Design Tools	Inputs to EMP on planned use of design tools	Inputs to EMP on planned use of design tools	Inputs to EMP and SEP on planned use of design tools	Inputs to EMP and SEP on planned use of design tools	Inputs to EMP and SEP on planned use of design tools	Inputs to EMP and SEP on planned use of design tools	Inputs to EMP and SEP on planned use of design tools
Modeling and Simulation	Inputs to EMP on planned use of Modeling and Simulation; development of Modeling and Simulation planning documentation including VV&A as needed	Inputs to EMP, on planned use of Modeling and Simulation; development of Modeling and Simulation planning documentation including VV&A as needed	Inputs to EMP, SEP and Test Planning on planned use of Modeling and Simulation; development of Modeling and Simulation planning documentation including VV&A as needed	Inputs to EMP, SEP, and Test Planning on planned use of Modeling and Simulation; development of Modeling and Simulation planning documentation including VV&A as needed	Inputs to EMP, SEP, and Test Planning on planned use of Modeling and Simulation; development of Modeling and Simulation planning documentation including VV&A as needed	Inputs to EMP, SEP, and Test Planning on planned use of Modeling and Simulation; development of Modeling and Simulation planning documentation including VV&A as needed	Inputs to EMP, SEP, and Test Planning on planned use of Modeling and Simulation; development of Modeling and Simulation planning documentation including VV&A as needed

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Risk Management	Risk identification, assessment, mitigation planning as required to support design	Risk identification, assessment, mitigation planning as required to support design	Risk identification, assessment, mitigation planning as required to support design; Start to develop, Risk Management Plan and Risk Register.	Execute Risk Management Plan. Maintain Risk Register.	Execute Risk Management Plan. Maintain Risk Register.	Execute Risk Management Plan. Maintain Risk Register.	Execute Risk Management Plan. Maintain Risk Register. Monitor Shipbuilder Risk Management Program.
Technology Assessment and Development	Technology assessment and planning as required to support design	Technology assessment as required to support design, Gate 1 and AoA planning	Technology assessment as required to support design, AoA and Gate 2	Technology assessment and development as required to support design and Gates	Technology assessment and development as required to support design and Gates	Technology assessment and development as required to support design, Gates and Milestone B	Technology assessment and development as required to support design and Gates
Manufacturing Readiness Assessment	Manufacturing readiness assessment and planning as required to support design	Manufacturing readiness assessment as required to support design, Gate 1 and AoA planning	Manufacturing readiness assessment as required to support design, AoA and Gate 2	Manufacturing readiness assessment and development as required to support Gates and design	Manufacturing readiness assessment and development as required to support Gates and design	Manufacturing readiness assessment and development as required to support design, Gates and Milestone B	Manufacturing readiness assessment and development as required to support design and Gates
Mission Scenarios, Threat Sets, CONOPS and Design Reference Mission		Develop mission scenarios, Threat Sets, CONOPS and Design Reference Mission	Updates as required	Updates as required			
Regulatory Body Compliance	Define initial approach and document in EMP	Define initial approach and document in EMP	Define initial approach and document in EMP and SEP	- Ship Specification inputs as required - ABS (for T-ships as applicable) and other reviews of the Design	- Ship Specification inputs as required - ABS (for T-ships as applicable) and other reviews of the Design	- Ship Specification inputs as required - ABS (for T-ships as applicable) and other reviews of the Design	ABS (for T-ships as applicable) and other regulatory reviews of the Design and Inspections
Concept or Feasibility Design	ASSET or equivalent	ASSET or equivalent	ASSET or equivalent; sketches and other PowerPoint descriptions to support presentation to AoA IPTs.				

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Cost Forms and Cost Estimate	Cost Forms to support SEA 05C ROM level cost estimates	Cost Forms to support SEA 05C ROM level cost estimates	Cost Forms to support SEA 05C ROM level cost estimates	Cost Forms to support SEA 05C budget level cost estimates	Cost Forms to support SEA 05C budget level cost estimates	Cost Forms to support SEA 05C budget level cost estimates	- Cost Forms to support SEA 05C budget level cost estimates - Shipbuilder cost reporting
SDS				Develop plan for Gate 3 and complete following CDD approval for Gate 4	Complete following CDD approval for Gate 4		
Ship Specification				- Specification Management Plan - May start and even complete and approve Specification depending on Acquisition Strategy	May start and even complete and approve Specification depending on Acquisition Strategy	Complete and approve Specification	- Possible change from approved System Specification to an approved Shipbuilding Specification - Engineering Change Proposals - Waivers and Deviations
Data Requirements				DRL inputs as required for contracting	DRL inputs as required for contracting	DRL inputs as required for contracting	Review of DRL deliverables
Ship Product Model (SPM)	Define initial approach and document in EMP	Define initial approach and document in EMP	Define initial approach and document in EMP and SEP	- Initial SPM and SPM development plan	Update	Update	Shipbuilder SPM

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
General Arrangements	ASSET or equivalent assessment.	ASSET or equivalent assessment.	- Initial sketches - Area/Volume summary	- General Arrangement Drawings that show major subdivisions, compartments and accesses for all decks - Area/Volume Report	- General Arrangement - Area/Volume Report -Tankage Report - Habitability Design Report - Access Study Report - Weapons Handling Flow Diagram - Troop, Cargo and Vehicle Flow Diagrams	- General Arrangement - Area/Volume Report - Tankage Report - Habitability Design Report - Access Study Report - Weapons Handling Flow Diagram - Troop, Cargo and Vehicle Flow Diagrams	- DRL Deliverables such as Shipbuilder Product Model outputs and Arrangements Related Technical Reports such as Equipment Access Studies for Maintenance and Removal

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Topside Design			- Initial sketches	- Topside Arrangement that shows major functional areas	- Topside Arrangement - Visibility Study - Panama Canal Clearance Report - Bridge Clearance Report - Antenna Arrangement - Topside Electromagnetic Compatibility Assessment - EMC/RADHAZ Analysis Report including HERO, HERF, HERP, NEMP, EMI - TEMPEST - Stack Design Analysis for Airflow and Dispersion - Navigation Lights Drawing - Flight Deck Arrangement with Airflow Assessment - Weapons Pointing, Firing, Blast and Radiation Zones	- Topside Arrangement - Visibility Study - Panama Canal Clearance Report - Bridge Clearance Report - Antenna Arrangement - Brass Model - Topside Electromagnetic Compatibility Assessment - EMC/RADHAZ Analysis Report including HERO, HERF, HERP, NEMP, EMI - TEMPEST - Stack Design Analysis for Airflow and Dispersion - Navigation Lights Drawing - Flight Deck Arrangement with Airflow Assessment - Weapons Pointing, Firing, Blast and Radiation Zones	- DRL Deliverables such as Shipbuilder Product Model outputs and Topside Design Related Technical Reports
Major Equipment List		Major Equipment List	Major Equipment List	Major Equipment List	Major Equipment List	Major Equipment List	- Equipment History Data Package -Certification of compliance/ equivalency

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
GFE/GFI	Define notional list of GFE for cost estimating	Define notional list of GFE for cost estimating	Define notional list of GFE for cost estimating	Define notional list of GFE and GFI for cost estimating and for contracting if required	Define notional list of GFE and GFI for cost estimating and for contracting if required	Define notional list of GFE and GFI for cost estimating and for contracting if required	Track GFE and GFI delivery status and impact on design
Survivability (SWBS 072)	Cost/ performance trade-off studies	Cost/ performance trade-off studies	Cost/ performance trade-off studies	Cost/ performance trade-off studies	- Survivability Assessment - Damage Control Systems Design Report - Preliminary Vital Space List - Collective Protection System General Arrangements - Degaussing System Design Report	- Survivability Assessment - Damage Control Systems Design Report - Vital Space List - Collective Protection System General Arrangements - Air Lock and Decon Station Drawings - Degaussing System Specifications	- Survivability Assessment - DRL Deliverables such as Shipbuilder Product Model outputs - Shock Management Plan - Equipment Shock Test Procedures - Mathematical Model Reports - Shock Dynamic Analysis Report - Equipment Shock Test Reports - Shock Qualification Data Sheets - List of Foundation Shock Design Drawings - Damage Control Book - Degaussing System Drawings

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Noise and Vibration (SWBS 073)					- Noise and Vibration Analysis Report	- Noise and Vibration Analysis Report	- Noise Control Program Plan - Noise Control/Design History Booklet - Equipment Vibration Test Validation Report - Noise Control Program Management Report
					- SONAR Self Noise - Radiated Noise	- SONAR Self Noise - Radiated Noise	- SONAR Self Noise - Radiated Noise
Reliability, Availability, and Maintainability (SWBS 076)			RAM-C Report (if an AoA discriminator)	RAM- C Report	RAM- C Report Update	RAM- C Report Update	Track and review Shipbuilder RAM-C deliverables including equipment and systems RAM data and failure mode and effects analysis reports
Environmental, Safety, and Occupational Health (ESOH) (SWBS 077 for safety)	ESOH risk identification, assessment, mitigation planning as required to support design	ESOH risk identification, assessment, mitigation planning as required to support design	ESOH risk identification, assessment, mitigation planning as required to support design	ESOH Working Group and review of design deliverables	ESOH Working Group and review of design deliverables	- WSESRB and/or SWIT review letters and recommendations - ESOH Working Group and review of design deliverables	- ESOH Working Group and review of design deliverables - Shipbuilder ESOH Program and Working Group

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Seaworthiness (SWBS 079)	- Dimensions and hull form coefficients	- Dimensions and hull form coefficients	- Body plan and appendages	- Preliminary Lines Plan and appendages	- Hull Lines - Hydrostatic Analysis Report - Curves of Form Data	- Hull Lines - Hydrostatic Analysis Report - Curves of Form Data	DRL Deliverables such as Shipbuilder Product Model outputs and Hydrostatic Descriptions such as Final Hull Lines and Curves of Form
					- Propulsor Design - Control Surface and Appendage Design Report	- Propulsor Design - Control Surface and Appendage Design Report - Roll Stabilization Study Report	DRL Deliverables such as Shipbuilder Product Model outputs and Propulsion System Technical and Test Reports
	- Seakeeping assessment (if a concern)	- Seakeeping assessment (if a concern)	- Seakeeping assessment (if a concern)	- Seakeeping assessment (if a concern)	Seakeeping and Maneuvering Assessment	Seakeeping and Maneuvering Assessment	DRL Deliverables such as Shipbuilder Product Model outputs and Steering System Technical and Test Reports
	- Initial Powering Prediction	- Initial Powering Prediction	- Initial Powering Prediction	- Initial Powering Prediction	- Speed and Power Analysis - Endurance Analysis	- Speed and Power Analysis - Endurance Analysis	- Speed and Power Analysis - Endurance Analysis
					- Preliminary Model Test Plan - Preliminary Model Test Report	- Model Test Plan - Model Test Report	- Model Test Plan - Model Test Report

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Human Systems Integration (SWBS 080)	HSI planning and analysis as required to support design	HSI planning and analysis as required to support design	HSI planning and analysis as required to support design	HSI Working Group and review of design deliverables	HSI Working Group and review of design deliverables	HSI Working Group and review of design deliverables	- HSI Working Group and review of design deliverables - Shipbuilder Program and Working Group
Manpower and Personnel (SWBS 088)	Initial low fidelity estimates	Initial low fidelity estimates	Initial low fidelity estimates	- Preliminary Ship Manning Document for Gate 4 - Specification inputs as required	- Preliminary Ship Manning Document for Gate 4 - Specification inputs as required	- Preliminary Ship Manning Document for Gate 4 - Specification inputs as required	
Training (SWBS 089)				- Navy Training Systems Plan for Gate 4 - Specification inputs as required	- Navy Training Systems Plan for Gate 4 - Specification inputs as required	- Navy Training Systems Plan for Gate 4 - Specification inputs as required	- Crew Familiarization Curriculum
Testing (SWBS 090-095)				- May start and even approve Certification Matrix depending on Acquisition Strategy - Specification inputs as required	- May start and even approve Certification Matrix depending on Acquisition Strategy - Specification inputs as required	- Certification Matrix - Specification inputs as required	- Comprehensive Test Plan - Test Status - Test Reports - Builders Trial Readiness, Memo, Procedures, Schedule, Agenda, Report - Ship Acceptance Test Readiness, Memo, Procedures, Schedule, Agenda, Report

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Mass Properties (SWBS 096)	- Three-digit weight report	- Three-digit weight report	- Three-digit weight report	- Three-digit weight report	- Preliminary Design Weight Estimate - Weight Control Plan - Weight Trend Report	- Contact Design Weight Estimate - 20 Station Longitudinal Weight Distribution Report - Weight Control Plan - Contract Weight Control Clause (as applicable) - Weight Moment of Inertia Estimate	- Weight Control Plan - Accepted Weight Estimate - Mass Properties Design Data Sheet - Input Data Cards - Government Furnished Material Report - Contract Modification Reports - Quarterly Weight Reports - Launching Information - Final Weight Report - Accepted Ship Report
	- Intact Stability Analysis	- Intact Stability Analysis	- Intact and Damage Stability Analysis	- Intact and Damage Stability Analysis	- Intact and Damage Stability Report - Limiting KG and Subdivision Displacement Limit and Limiting Drafts - Flooding Water Levels (V Lines)	- Intact and Damage Stability Report - Limiting KG and Subdivision Displacement Limit and Limiting Drafts Flooding Water Levels (V Lines)	- Preliminary and Final Inclining Experiment Reports

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Hull Structure (SWBS 100)	- Parametric ratio	- Parametric ratio	- Midship section	- Midship and typical sections drawings	- Midship Section - Longitudinal Sections - Scantlings - Structural Trade-Off Study Report	- Midship and/or Longitudinal Section - Shell Expansion and Typical Sections - Scantlings - Decks - Platforms - Superstructure - Structural Details - Hull Structure/Longitudinal Strength Report - Structural Profile and Sections – Primary and General - Strength and Inertia Curves for Critical Hull Loading Conditions - Structural Design Criteria Report - Superstructure and Mast Vibration Analysis	DRL Deliverables such as Shipbuilder Product Model outputs and Technical and Test Reports
Producibility				Address producibility in Design Report	Preliminary Producibility Report	Producibility Report	DRL Deliverables such as Shipbuilder Product Model Outputs

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Propulsion Plant (SWBS 200)		- Endurance Fuel Calculation - Plant type and number of propulsors	- Endurance Fuel Calculation - Plant type and number of propulsors	- Endurance Fuel Calculation - Plant type and number of propulsors	- Propulsion System Report - Propulsor Design Results - Propulsor Shafting Sizing Calculations - Preliminary Machinery Arrangement Shafting and Intake/Uptake Drawings	- Propulsion System Report - Propulson Design Results - Propulsor Shafting Sizing Calculations - Propulsor Hydrodynamic Design Report - Propulsor Shaft Alignment Analysis Report - Propeller Cavitation Inception and Radiated Noise Report - Machinery Arrangement Shafting and Intake/Uptake Drawings	- DRL Deliverables such as Shipbuilder Product Model outputs - Propulsion Shafting Material Test Report - Propulsion Shafting System Conference Report - Propeller Viewing Conference Report - Propeller Test Reports - CP Propeller Calculations - Test Reports
Machinery Arrangements (SWBS 201)	- Rough sizing/ arrangement via ASSET or equivalent	- Rough sizing/ arrangement via ASSET or equivalent	- Block Machinery Arrangements	- Block Machinery Arrangements	Machinery Arrangements Drawing	Machinery Arrangements Drawing	DRL Deliverables such as Shipbuilder Product Model outputs and any requirements for 3D Modeling of the Machinery Spaces
Machinery Plant Central Control (SWBS 202)					Machinery Centralized Control System Design Report	Machinery Control System Design Report	- DRL Deliverables such as Shipbuilder Product Model outputs and Physical or Virtual Mock Ups of the Control Spaces - Test Reports

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Electric Plant (SWBS 300)		- Electric Power Load Analysis	- Electric Power Load Analysis	- Electric Power Load Analysis - One Line Diagram	- Electric Power Load Analysis - One Line Diagram for Ship Service, Electric Propulsion, Emergency, and Shore Power Distribution	- Contract Design Level Design Reports - Inputs for Specifications as required	- Shipbuilding Specification - DRL deliverables such as Shipbuilder product model outputs - Shipbuilder electric load analysis and system diagrammatic
C4ISR (SWBS 400) and Armament (SBWB 700)		- Notional Equipment List	- Notional Equipment List	- Notional Equipment List	- Notional Equipment List	- Equipment List - Parameter Accounting Report - Block Diagrams - Combat Systems Arrangements Drawings - Functional Flow Diagrams and Listings - Specification - Operational Sequence Diagrams - Software Design and Specification Documents	DRL Deliverables such as Shipbuilder Product Model outputs and any Requirements for Physical or Virtual Mockups of the Control Spaces

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Auxiliary Systems (SWBS 500)		- System Sizing and Notional Equipment Lists as required for ship arrangement and weights	- System Sizing and Notional Equipment Lists as required for ship arrangement and weights	- System Sizing and Notional Equipment Lists as required for ship arrangement and weights - Inputs for Specifications as required	- Preliminary Design Level Auxiliary System Design Reports - Sketches for boats, cargo, and vehicle stowage and handling systems - Sketches for anchor, mooring, towed body, and over-the-side handling systems - Underway replenishment system drawing - Aviation facilities drawings - Inputs for Specifications as required	- Contract Design Level Design Reports - Inputs for Specifications as required - Contract Drawings, Guidance Drawings or PPDs for HVAC, Boats, Aviation Facilities, Underway Replenishment and other major auxiliary systems - Study drawings for other major auxiliary systems	DRL Deliverables such as Shipbuilder Product Model outputs and System Technical and Test Reports
Outfit and Furnishings (SWBS 600)		Habitability Standards and Outfit assumptions that impact arrangement and weights	Habitability Standards and Outfit assumptions that impact arrangement and weights	- Habitability Standards and Outfit assumptions that impact arrangement and weights - Inputs for Specifications as required	- Habitability Standards and Outfit assumptions that impact arrangement and weights - Hull Outfitting Equipment Study to provide inputs for Specifications as required - Preliminary Design level Design Reports for Habitability, Workshops, Medical and other major outfit areas	- Inputs for Specifications as required - Contract Drawings, Guidance Drawings or PPDs for Habitability, Workshops, Medical and other major outfit areas	DRL Deliverables such as Shipbuilder Product Model outputs and System Technical and Test Reports

	Exploratory Design and Force Architecture	Pre-AoA	AoA	Pre-Preliminary	Preliminary (Functional Baseline)	Contract (Allocated Baseline)	Detail (Product Baseline)
Corrosion Control, Preservatives and Covering (SWBS 630)				- Inputs for Specifications as required	- Corrosion Prevention and Control Plan and Design Report - Conduct Corrosion Prevention Advisory Team - Cathodic Protection Study - Input for Specifications as required	- Corrosion Prevention and Control Plan and Design Report - Conduct Corrosion Prevention Advisory Team - Input for Specifications	- Shipbuilder Corrosion Prevention and Control Plan - Shipbuilder conduct Corrosion Prevention Advisory Team - DRL Deliverables such as Shipbuilder Product Model outputs - Paint/Coating Schedules, Data Sheets, and Conformance Certifications

APPENDIX Q
SYSTEM ENGINEERING TECHNICAL REVIEWS

Table Q-1. SETR and Other Reviews

ASSESSMENT	PURPOSE	TIMING	NOTE(S)
Initial Technical Review (ITR)	Supports the technical basis for initial cost estimates and POM submissions, ICD development, and AoA Guidance.	Conducted as early as possible for initial program planning.	
Alternative Systems Review (ASR)	Reviews results of the Materiel Solution Analysis Phase with AoA to ensure one or more of the proposed materiel solutions have the potential to meet the customer's needs and assess planning for the Technology Development Phase.	Conducted near the end of the AoA prior to Gate 2.	
Independent Logistics Assessment (ILA)	Assesses suitability of Logistics planning.	Prior to MS B.	
System Requirements Review (SRR)	Assesses technical readiness for CDD submission for Navy staffing.	Conducted in advance of submission of the CDD for initial Navy staffing then Gate 3 and in advance of Milestone A.	
System Functional Review (SFR)	Assesses Functional Baseline and readiness to begin functional allocation.	Conducted during Preliminary Design to verify definition of the Functional Baseline in advance of Gate 4.	
Preliminary Design Review (PDR)	Assesses Allocated Baseline and readiness to begin Detail Design.	Conducted during late Contract Design prior to Milestone B or early in Detail Design following Milestone B.	
Critical Design Review (CDR)	Assesses Product Baseline and Supports Production Readiness Review.	Conducted in mid to late Detail Design. May or may not be combined with PRR. May support Gate 6.	
Integrated Baseline Review (IBR)	Assesses risk areas in contract. Produces Performance Measurement Baseline to ensure technical scope of work is realistically and accurately scheduled, has proper resources, utilizes correct techniques, and employs appropriate management processes.	Prior to start of DD&C.	1
Functional Configuration Audit (FCA)	Assesses whether necessary analyses and tests have been completed to assure system compliance with Functional Baseline.	Conducted in late Detail Design just prior to beginning production. May support Gate 6.	2
System Verification Review (SVR)	Assesses system compliance with Functional Baseline.	Conducted in late Detail Design just prior to beginning production. May support Gate 6.	2
Production Readiness Review (PRR)	Assesses system readiness to enter production.	Conducted in late Detail Design just prior to beginning production. May support Gate 6.	2,3

ASSESSMENT	PURPOSE	TIMING	NOTE(S)
Sustainment Review I	Assess Shipbuilder progress in logistics planning & documentation.	After DD&C Award.	4
Sustainment Review II	Assess Shipbuilder progress in logistics planning & documentation.	Two years After Sustainment Review I.	4
Test Readiness Review (TRR)	Assesses system readiness to begin Developmental Test and Evaluation (DT&E).	During early DD&C phase.	
Integrated Readiness Review (IRR)	Assesses readiness of software systems.	In Contract Design to assess progress of development of software specifications.	
Operational Test Readiness Review (OTRR)	Assesses system readiness to proceed into Operational Test and Evaluation (OT&E) with high likelihood of success.	Prior to OPEVAL.	
In-Service Review (ISR)	Assesses the in-service technical health of a fielded system from a risk, readiness, and resources perspective. Assesses lead ship's demonstrated capability to meet customer's need.	Following lead ship initial deployment Conducted following lead ship Initial Operational Capability or deployment. May support Milestone C and/or FRP DR and a Gate 6.	

Notes:

1. A requirement for event-based design, program, and sustainment reviews will be incorporated into the DD&C contract. In-process design reviews shall be held during Detail Design.
2. SVR, PRR, & FCA are conducted as parts of one consolidated Review.
3. SPPCs shall be conducted following the PRR.
4. The Sustainment Review will be Program Manager-chaired to assess Shipbuilder progress in the logistics planning and documentation development required to support life cycle logistics. These will be preceded by a series of regularly scheduled working level status meetings. Development and delivery for logistics documentation by the Shipbuilder are provided for in the DD&C Statement of Work, System Specification and subsequent Shipbuilding Specification, and Data Requirements List (DRL). This includes the regulatory body certifications, equipment logistics support information packages, recommended shore based spares, technical manuals, damage control book, selected record drawings, and other information for ships operations, maintenance, and upgrade.

Table Q-2. SETR Roles

	ITR, ASR, SRR, SFR	PDR, CDR	SVR/FCA/PRR	In-Service Reviews
Responsibility, Authority, and Accountability	SEA 05D and the Program Office supported by the SDM determine whether the entry criteria have been met, what action items are to be tasked, that tasked items have been closed appropriately, that exit criteria have been met, and sign any resulting reports.	Same as in preceding column.	Same as in preceding column.	Same as in preceding column with addition of Life Cycle Program Manager and SDM.
Chairperson	SEA 05D DWO serving as a Peer Review or more formal Technical Review Board (TRB)/Stakeholder Steering Board (SSB) Chair and supported by the SDM as the Program Lead Systems Engineer (LSE).	Program Manager or his representative supported by the SDM as the SEA 05D DWO representative and LSE.	Same as in preceding column.	Procurement and Life Cycle Program Managers.
Program Management Office Participants	Principal Acquisition Program Manager, Acquisition Program Manager, Test and Evaluation Manager, Logistics Manager, Contracting Officer(if contracting issues will be discussed), Counsel (if legal issues will be discussed), Design Team leads, Cost Team representative.	Same as in preceding column.	Same as in preceding column plus the Program Manager's Representative at the Shipbuilder.	Same as in preceding column.
Anticipated Stakeholder Organizations	Resource Sponsor representatives, User Organization.	Same as in preceding column plus representatives from COMOPTEVFOR, DoD DOT&E, OSD/DDT&E, OSD SE, and ASN RDA CHENG as appropriate for Program ACAT.	Same as in preceding column plus representatives from the Supervisor of Shipbuilding and possibly the Shipbuilder.	Same as in preceding column.
Anticipated Peer and Program-Independent Subject Matter Expert Participant Organizations	Applicable TWHs.	Same as in preceding column.	Same as in preceding column.	Same as in preceding column.

Entrance criteria for each review are summarized in the table below. The Exit Criteria are qualitative assessments of design maturity and for their corresponding Entrance Criteria represent a determination that:

- Accomplished work submitted as Entrance Criteria is of sufficient quality, completeness, and maturity to warrant moving forward to the next phase.
- The prevailing risks are acceptable and/or manageable.

Table Q-3. SETR Entrance/Exit Criteria

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Overall Design Status								
Action items from prior internal and external reviews have been completed or a plan established to complete them.	Not applicable – no prior reviews.	SDM tracks.	SDM tracks.	SDM tracks.	SDM tracks.	SDM tracks.	SDM tracks.	Procurement and Life Cycle SDMs track.
Design efforts have been conducted in accordance with current design phase Design Team Engineering Management Plan (EMP) including involvement of appropriate TWHs and other stakeholders.	CBA whole ship concept design Development of EMP beginning.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Production and Life Cycle Design Teams' EMPs. Input for Program SEP.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Design scope has been appropriate for the design phase.	CBA whole ship concept design.	Whole ship concept designs, system trade studies, white papers defining AoA materiel solution(s).	Pre-Preliminary Design supporting CDD finalization and cost estimating.	Preliminary Design sufficient to establish Functional Baseline.	Contract Design sufficient to establish Allocated Baseline.	Detail Design sufficient to establish Product Baseline.	Detail Design sufficient to support start of construction.	Ongoing Production Engineering Changes and Fleet Modernization Program SHIPALTs are receiving engineering review.
Design considerations/ specialty engineering approaches appropriate for the phase have been addressed.	Limited to those supporting whole ship concept design and procurement and life cycle costing.	Limited to those supporting concept design and procurement and life cycle costing.	Limited to those supporting Pre-Preliminary Design supporting CDD finalization and cost estimating. Begins to address all areas for SDS.	Focuses on those for ship sizing and budgeting for Preliminary design but addresses all areas for Ship Specification.	Covers all areas applicable to the ship class.	Covers all areas applicable to the ship class.	Covers all areas applicable to the ship class.	Covers all areas applicable to the ship class.
Design products are complete, reviewed, adequate, under configuration control, and provide a suitable baseline to proceed to the next phase.	CBA whole ship concept design, system trade studies.	Whole ship concept design, system trade studies, white papers.	Pre-Preliminary Design products.	Preliminary Design products that comprise the Functional Baseline.	Contract Design products that comprise the Allocated Baseline.	Detail Design products that comprise the Product Baseline.	Detail Design products supporting construction startup.	Product Baseline with ongoing Engineering Changes and SHIPALTs.
Technical Performance Measures (TPMs) have been established and are on track.	Defined in draft EMP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Production and Life Cycle Design Teams' EMPs. Input for Program SEP.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Design budgets are established and the design is within budget.	Not applicable.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Updated as required in Design Team EMP. Input for Program SEP.	Engineering Change and SHIPALT cost estimates.
Basis for the cost estimates are defined in a CARD like document. Assumptions are fully defined and are executable. Risks are described and are manageable.	Cost forms provided to SEA 05C provide basis. Initial risk assessment.	Cost forms provided to SEA 05C provide basis. Initial Risk Register.	Cost forms provided to SEA 05C provide basis and CARD developed for Milestone A. Updated Risk Register.	Cost forms provided to SEA 05C provide basis. Updated Risk Register.	Cost forms provided to SEA 05C provide basis and CARD developed for Milestone B. Updated Risk Register.	Shipbuilder cost reports. Updated Program Risk Register. Shipbuilder risk assessments.	Shipbuilder cost reports. Updated Program Risk Register. Shipbuilder risk assessments.	Shipbuilder cost reports. Engineering Change and SHIPALT costs. Updated Program Risk Register. Shipbuilder risk assessments.
Cost estimates have been completed and an independent assessment obtained.	SEA 05C performs cost estimates for whole ship concept designs. Service Cost position to be developed following AoA.	SEA 05C performs cost estimates for whole ship concept designs. Service Cost position developed.	SEA 05C performs cost estimates for Pre-Preliminary Design. Service Cost position developed. Independent Cost Estimate performed for MS A.	SEA 05C performs cost estimates for whole ship concept designs. Service Cost position developed.	SEA 05C performs cost estimates for whole ship concept designs. Service Cost position developed. Independent Cost Estimate performed for MS B.	Service Cost position developed/ maintained based on Shipbuilder cost reports.	Service Cost position developed/ maintained based on Shipbuilder cost reports.	Service Cost position developed/ maintained based on Shipbuilder cost reports and projected Fleet Modernization costs.
CAIV targets are defined and can be met.	Cost estimates provide basis for draft ICD and AoA Guidance content which is documented with rationale.	AoA materiel solution cost estimates are used to continue to refine and validate.	Pre-Preliminary Design cost estimates provide basis for draft CDD cost threshold/ objective content. ICE for MS A also confirms.	Preliminary Design cost estimates validate that design meets CDD cost thresholds/ objectives.	Preliminary Design cost estimates validate that design meets CDD cost thresholds/ objectives. ICE for MS B also confirms.	Program tracks Shipbuilder costs.	Program tracks Shipbuilder costs.	Production Program tracks Shipbuilder costs. Life Cycle Program tracks Fleet Modernization costs.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Design efforts are supporting maintenance of the Program's critical path.	Initial Design PowerPoint schedule integrated with Program milestones.	Initial Design Microsoft Project or equivalent schedule integrated with Program milestones.	Full Program Microsoft Project or equivalent schedule including Design.	Full Program Microsoft Project or equivalent schedule including Design.	Full Program Microsoft Project or equivalent schedule including Design.	Design Team and Program oversight of the Shipbuilder's schedule.	Design Team and Program oversight of the Shipbuilder's schedule.	Design Team and Program oversight of the Shipbuilder's schedule.
Shipbuilder EVMS trends are on track including drawing/design data releases.						Program tracks Shipbuilder EVMS trends.	Program tracks Shipbuilder EVMS trends.	Program tracks Shipbuilder EVMS trends.
Design issues have been resolved sufficiently to permit proceeding to the next design phase.	SDM tracks.	SDM tracks.	SDM tracks.	SDM tracks.	SDM tracks.	SDM tracks.	SDM tracks.	Production and Life Cycle SDMs track.
Requirements, Specification, Test and Evaluation								
Scenarios, Threat Sets, CONOPS and Design Reference Mission (DRM) has been defined and validated through design process.	Draft Scenarios, Threat Sets, CONOPS in ICD and DRM being developed for AoA.	Scenarios, Threat Sets, CONOPS and DRM update as required.	Scenarios, Threat Sets, CONOPS and DRM update as required.	Scenarios, Threat Sets, CONOPS and DRM update as required.	Scenarios, Threat Sets, CONOPS and DRM update as required.	Scenarios, Threat Sets, CONOPS and DRM update as required.		Scenarios, Threat Sets, CONOPS and DRM update as required based on operational experience.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Design efforts support definition of proposed Materiel Solution(s)	CBA whole ship concept design, system trade studies, white papers support development of material solutions for ICD and AoA Guidance.	Whole ship concept design, system trade studies, white papers support AoA definition of proposed materiel solution.						
Requirements are defined, verifiable, traceable, and under configuration control with supporting analysis.	Draft ICD and AoA Guidance content are documented with rationale.	Development of content for CDD begins in conjunction with completion of the AoA and to be addressed at Gate 2.	CDD is ready for Navy staffing and SDS Plan is prepared to support Gate 3.	CDD is approved and SDS is ready for approval to support Ship Specification development. Requirements traceability from the CDD has started.	Ship Specification is being finalized with requirements traceability from CDD demonstrated.	Traceability from the CDD to Ship Specification to Shipbuilding Specification (if applicable) is confirmed.	CDD update or CPD development and staffing as required.	CDD update or CPD development and staffing as required.
Design efforts support fulfillment of the user's requirements.	Alternative materiel solution(s) developed to meet user needs.	Proposed materiel solution(s) satisfy user needs.	Pre-Preliminary Design validates draft CDD content which reflects user requirements.	Preliminary Design validates CDD content which reflects user requirements.	Contract Design validates CDD content which reflects user requirements.			Operational experience validates CDD content which reflects user requirements.
Work Breakdown Structure has been established.	Being defined in draft SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.
Systems and software architectures have been defined and validated by design process.	Being defined in draft SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.	Updated as required in SEP.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
System Design Specification (SDS) has been developed.			SDS Plan for Gate 3.	SDS for Gate 4.				
Ship Specification has been developed and validated through the design process.				Ship Specification development is beginning.	Ship Specification is ready for finalization.			Ongoing production and lead ship operational feedback for Ship Specification updates.
Physical and functional interfaces and standards are defined.				SDS addresses.	Ship Specification addresses.	Ship Specification addresses.		Ongoing production and lead ship operational feedback for Ship Specification updates.
Verification methods and standards are defined.				SDS addresses.	Ship Specification addresses.	System or Shipbuilder Specification addresses.		Ongoing production and lead ship operational feedback for Ship Specification updates.
Certification requirements are defined.	Being defined in draft SEP.	Updated as required in SEP.	Updated as required in SEP.	SEP and SDS address.	SEP and Ship Specification address.	SEP and System or Shipbuilder Specification address.		Ongoing production and lead ship operational feedback for Ship Specification updates.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Design Considerations								
Technology readiness has been assessed and is appropriate to the phase.	Draft ICD, AoA Guidance, initial risk assessment address.	Address for Gate 2.	CDD describes. Technical Readiness Assessment and TDS/AS for MS A addresses.	Address for Gate 4.	Technical Readiness Assessment and AS for MS B addresses.			Updated Technical Readiness Assessment and AS for MS C and/or FRP DR addresses.
Master Equipment List Items are defined at the component level.		Design deliverable.	Design deliverable.	Design deliverable.	Design deliverable.			
Software requirements, design, and sustainment/supportability approach is established.			SEP addresses.	SEP and SDS address.	SEP, Life Cycle Sustainment Plan, and Ship Specification address.	SEP, Life Cycle Sustainment Plan, and Ship Specification address.		Ongoing production and lead ship operational feedback for Ship Specification updates.
Life cycle supportability/ sustainment approach has been defined.			SEP and TDS/AS addresses.	SEP, AS and SDS address.	Life Cycle Sustainment Plan, SEP, AS and Ship Specification address.	Life Cycle Sustainment Plan, SEP, AS and System or Shipbuilder Specification address.		Ongoing production and lead ship operational feedback for Ship Specification updates.
Reliability, Availability, Maintainability – Cost (RAM-C) requirements are documented and verified.	Draft ICD and AoA Guidance content documented with rationale based on DRM and initial RAM-C analysis.	RAM-C analysis for materiel alternatives (if an AoA discriminator).	RAM-C Report with content forming the basis of the RAM requirements for the CDD.		RAM-C Report update as required with content forming the basis of the RAM requirements for the Ship Specification.	Oversight of Shipbuilder compliance with RAM requirement.		Ongoing production and lead ship operational feedback for Ship Specification updates.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Assessment of the risk of using COTS is accomplished.		SEP addresses.	SEP and SDS address.	Life Cycle Sustainment Plan, SEP and Ship Specification address.	SEP and Ship Specification address.	SEP and System or Shipbuilder Specification address.		Ongoing production and lead ship operational feedback for Ship Specification updates.
Open Systems Approach is defined.		SEP addresses.	SEP and SDS address.	Life Cycle Sustainment Plan, SEP and Ship Specification address.	SEP and Ship Specification address.	SEP and Ship Specification address.		Ongoing production and lead ship operational feedback for Ship Specification updates.
Hardware, software, and human interface compatibility is confirmed.	Draft ICD and AoA Guidance content documented with rationale. Concept design level analysis.	Concept design level analysis.	CDD and SDS address. Pre-Preliminary Design level analysis.	Ship Specification addresses. Preliminary Design level analysis.	HSI Plan and Ship Specification address. Contract Design level analysis.	HSI Plan and Ship Specification address. Detail Design level analysis.		Ongoing production and lead ship operational feedback for Ship Specification updates.
Human job and task analysis is sufficient to provide crew workload, skill level, and total ship accommodations.	Draft ICD and AoA Guidance content documented with rationale. Concept design level analysis.	Concept design level analysis.	CDD Pre-Preliminary Design level analysis.	Ship Specification addresses. Preliminary Design level analysis.	Navy Training Systems Plan and Ship Specification address. Contract Design level analysis.	Navy Training System Plan and System or Shipbuilder Specification address. Detail Design level analysis.		Ongoing production and lead ship operational feedback for Ship Specification updates.
Environmental, occupational safety, and health compliance factors have been assessed and issues documented.	Draft ICD and AoA Guidance content documented with rationale. Concept design level analysis.	Concept design level analysis.	CDD and SDS address. Pre-Preliminary Design level analysis.	Ship Specification addresses. Preliminary Design level analysis.	PESHE and Ship Specification address. Contract Design level analysis.	PESHE and System or Shipbuilder Specification address. Detail Design level analysis.		Ongoing production and lead ship operational feedback for Ship Specification updates.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
ABS Classification Assessment is complete and any critical issues have been satisfactorily addressed.	Initial identification/ assessment of potential issues.	Initial identification/assessment of potential issues.	Initial identification/assessment of potential issues.	Preliminary Design level assessment.	Contract Design level assessment.	Detail Design level assessment.	.	ABS Classification Assessment as required for Production Engineering Changes and Fleet Modernization SHIPALTs.
Industrial Base/Manufacturing Readiness								
Design approach is producible with acceptable risk.	Concept Design level of analysis.	Concept Design level of analysis.	Pre-Preliminary Design level of analysis.	Preliminary Design level of analysis.	Contract Design level of analysis.	Detail Design level of analysis.		Assess Production Engineering Changes.
Manufacturing Readiness Level has been assessed and documented.					Assessed and documented in AS and SEP for MS B.			Updated Manufacturing Readiness Assessment in AS for MS C and/or FRP DR addresses.
Manufacturing facilities are sufficient and prepared.		Part of Industrial Base assessment in TDS/AS and Program Health assessment.	Part of Industrial Base assessment in AS and Program Health assessment.	Part of Industrial Base assessment in AS and Program Health assessment.	Part of Industrial Base assessment in AS and Program Health assessment.	Shipbuilder work performance information.	Shipbuilder work performance information.	
Shipbuilder staffing is adequate.						Shipbuilder work performance information.	Shipbuilder work performance information.	
Long lead items are identified and planned for early procurement.			Pre-Preliminary Design level of analysis. Addressed in AS.	Preliminary Design level of analysis. Addressed in AS.	Contract Design level of analysis. Addressed in AS and RFP.	Detail Design level of analysis. Addressed in AS and contract.		

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Production schedule is in place and meets Program schedule requirements.						Schedule is in draft and demonstrates production preparations are on track.	Schedule is finalized and demonstrates Shipbuilder is ready to begin production.	
Material and equipment ordering processes are in place and ordering on track.						Materiel equipment and ordering processes are in place and ordering on track to support production.	Materiel ordering is on track to support production.	
Design drawings and other configuration data exist to support production startup.						Shipbuilder work performance information demonstrates sufficient drawing and work package completions.	Shipbuilder work performance information demonstrates sufficient drawing and work package completions.	
Planning for Next Design Phase								
Design Team Engineering Management Plan has been developed for next phase and inputs provided for Program SEP.	Design Team EMP to support AoA conduct.	Updated Design Team EMP to support next phase. Inputs for MS A SEP.	Updated Design Team EMP to support next phase. Inputs for MS A SEP.	Updated Design Team EMP to support next phase. Inputs for MS B SEP.	Updated Design Team EMP to support next phase. Inputs for MS B SEP.	Updated Design Team EMP to support next phase. Inputs for MS C/FRP DR SEP.	Updated Design Team EMP to support next phase. Inputs for MS C/FRP DR SEP.	Updated Production and Design Teams' EMPs. Inputs for MS C/FRP DR SEP.
Integrated Master Schedule has been developed and is being employed to track progress.	Initial Design PowerPoint schedule integrated with Program milestones.	Initial Design Microsoft Project or equivalent schedule integrated with Program milestones.	Full Program Microsoft Project or equivalent schedule including Design.	Full Program Microsoft Project or equivalent schedule including Design.	Full Program Microsoft Project or equivalent schedule including Design.	Design Team and Program oversight of the Shipbuilder's schedule.	Design Team and Program oversight of the Shipbuilder's schedule.	Production Design Team and Program oversight of the Shipbuilder's schedule. Life Cycle Program oversight of Fleet Modernization.

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Planning for upcoming Modeling and Simulation is complete including VV&A.	Address requirement in Design Team EMP and Program SEP and develop separate plans if M&S required.	Address requirement in Design Team EMP and Program SEP and develop separate plans if M&S required.	Address requirement in Design Team EMP and Program SEP and develop separate plans if M&S required.	Address requirement in Design Team EMP and Program SEP and develop separate plans if M&S required.	Address requirement in Design Team EMP and Program SEP and develop separate plans if M&S required.	Address requirement in Design Team EMP and Program SEP and develop separate plans if M&S required.	Address requirement in Design Team EMP and Program SEP and develop separate plans if M&S required.	
Planning for competitive prototyping is complete.		Address in Program TDS/AS for MS A and reflect in Design Team EMP and Program SEP.	Address in Program TDS/AS for MS A and reflect in Design Team EMP and Program SEP.	Update in Program AS for MS B and reflect in Design Team EMP and Program SEP.	Update in Program AS for MS B and reflect in Design Team EMP and Program SEP.	Update in Program AS for MS C/FRP DR and reflect in Design Team EMP and Program SEP.	Update in Program AS for MS C/FRP DR and reflect in Design Team EMP and Program SEP.	
Flow down of design results into Milestone and other program documents.	For MDD.	For MS A.	For MS A.	For MS B.	For MS B.	For MS C/FRPDR.	For MS C/FRPDR.	

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Risk Management and Program Health								
Risk mitigation plans are developed and assessments are being conducted. Risk mitigation activities for high risk items are planned and funded.	Initial risk assessment and associated mitigation planning.	Full assessment of all areas including technological maturity and system safety. Initial Risk Register.	Updated assessment and Risk Register.	Updated assessment and Risk Register.	Updated assessment and Risk Register.	Updated assessment and Risk Register. Shipbuilder risk assessments.	Updated assessment and Risk Register. Shipbuilder risk assessments.	Updated assessment and Production Risk Register. Shipbuilder risk assessments. Life Cycle Risk Register.
rogram health for requirements, budget, program manning, planning/ execution, and external influences.	PoPS evaluation to support Gate reviews.	PoPS evaluation to support Gate reviews.	PoPS evaluation to support Gate reviews.	PoPS evaluation to support Gate reviews.	PoPS evaluation to support Gate reviews.	PoPS evaluation to support Gate reviews.	PoPS evaluation to support Gate reviews.	PoPS evaluation to support Gate reviews.

Table Q-4. SETR Products

	ITR	ASR	SRR	SFR	PDR	CDR	SVR/FCA/ PRR	In-Service Reviews
Briefing Announcement Memo issued by SETR Chairman with Agenda.	Email invitation.	X	X	X	X	X	X	X
Briefing by the SDM with Program Office inputs covering the entrance/exit criteria topics above.	X	X	X	X	X	X	X	X
Memo Summarizing SETR results including resolution of resulting action items issued by SETR Chairman.	X	X	X	X	X	X	X	X
SETR Report signed by Program Manager, PEO Ships, SEA 05D, and SEA 05.	Memo is sufficient.	X	X	X	X	X	X	X

The SETR Report shall be prepared, signed, and distributed 30 days of event. If this report does not report closure of the event, a subsequent memorandum shall document closure. The report describes the outcomes of the SETR meeting, including the following:

a. List of attendees, including name, functional area represented, phone number, and e-mail address
b. Meeting minutes, including entry criteria status, closure criteria status, and SETR results
c. Recommendations pertinent to the technical health of the program and its readiness to enter the next phase of development
d. List of all action items, assignees, and due dates
e. Identification of all system specification changes/modifications and all new performance and mission implications, as needed.

APPENDIX R
SHIP DESIGN STUDY COST ESTIMATING DATA FORM

The Ship Design Study Cost Estimating Data Form or "cost form" documents information provided to SEA 05C for the purpose of producing a cost estimate for a concept design. The cost form is sent to SEA 05C as an enclosure to a serialized transmittal memo.

Because no two ship concept design studies are alike, the cost form is not actually a "form." Instead, it is a checklist that indicates typical early-stage design information that impacts cost. The information required for a given project depends on the ship characteristics, lead time, and other factors. For some concept designs, not all of the data in the checklist is used. For others, there is additional cost-impacting design information that does not appear in the standard checklist.

In the early stages of the design project, the naval architect and the SEA 05C cost engineer discuss data requirements so that when it is time to submit the cost form, the required data elements have been defined and cost estimation work can proceed without delay.

Cost Form Information Checklist

1. Name of ship design study.
2. Requested due date for SEA 05C to supply the cost estimate.
3. Description and discussion of the design.
   - General background and mission, including requirements risk.
   - Highlights of specific design features, particularly the new and innovative aspects.
   - Characterization of the design as (a) new, clean-sheet concept, (b) a modified repeat, (c) a conversion, or (d) something else.
   - Discussion of modularity and commonality features at the ship level. It may be useful to characterize this in terms of a ratio from a baseline or some other index. However as there is no standard approach, it is left to the naval architect and cost engineer to develop the best way for a given project. Modularity and commonality are broken down by 1-digit SWBS in section 6 below.
   - Acquisition strategy information. This includes specification of the number ships to be built and a first-cut build plan showing the fiscal year of award and delivery of lead and follow ships. Non-standard acquisition approaches should be described – these could involve, for example, the spreading of Detail Design work between contractors, split production between different contractors, disintegration of hull construction from final outfitting, etc.
   - Discussion of technical and program risk factors. TRLs by technology element are provided in section 8 below.
   - Discussion of foreign technologies or participation.
   - Discussion of other relevant aspects of the design.

4. General characteristics

- Hull form type (Monohull, multihull, air cushion vehicle, Small-Waterplane Area Twin-Hull (SWATH), etc.)
- Length, waterline, and overall
- Beam, max waterline
- Breadth, extreme
- Depth, amidships
- Draft, to keel, amidships
- Draft, navigational
- Volume, total enclosed and machinery spaces
- Military/Commercial specs
- Other

5. Weights, 1-digit SWBS level

- Specification of the baseline ship for cost estimation, with a discussion of complexity by 1-digit SWBS, to enable cost estimating relationships (CERs) to be modified from those of the baseline.
- 1-digit weights. Column 3 may be better presented separately due to length.

(1) Design-related SWBS	(2) Weight	(3) Cost Considerations*
1. Structure		
2. Propulsion		
3. Electric plant		
4. Command and control		
5. Auxiliary machinery		
6. Outfit and furnishings		
7. Armament		
Sum of 1 through 7		
Design and construction margins		
Light ship weight		
Future growth margin		
Loads		
Full load displacement		

* These include complexity, modularity and commonality.

6. Key features

(1) Structure

– Materials breakdown by weight (mild steel, HY-80, aluminum, etc.)

– Ice strengthening (Y/N)

– Other.

(2) Propulsion machinery

– Type of engine configuration (GT, CODAG, etc.)

– Number and model of main engines.

– Transmission (mechanical, electrical).

– Number and characteristics (diameter, rpm, etc. as needed) of propellers.

– Other.

(3) Electric plant

– Ship service generator number and model.

– Emergency generator number and model.

– Other.

(4) Command and control

– Include specifics in the GFE equipment list (below)

– Non-standard features (flag facilities, etc.)

(5) Auxiliary machinery

– Include specifics in the GFE equipment list (below)

– Non-standard features (thrusters, elevators, etc.)

(6) Outfit and furnishings

Accommodations			
Ship-Navy	Officers	CPO	Other enlisted
Ship-MSC	Officers	----- Unlicensed -----	
Troops	Officers	CPO	Other enlisted
Air Wing	Officers	CPO	Other enlisted
Flag	Officers	CPO	Other enlisted
Total			

– Habitability Standards

(7) Armament

– Include specifics in the GFE equipment list (below)

(8) Load items

– Non-standard items that could affect cost.

(9) Protection (Note : this information is usually classified)

– Shock (Y/N)

– Blast overpressure

– Torpedo side protection system (Y/N)

– Cruise missile protection system

7. Additional information, as needed

- Sketch of the ship.
- 3-digit SWBS weight report.
- List of major GFE.
- List of developmental items with estimates of TRL.
- List of 3-digit weight changes from the baseline ship. For conversion and major modernizations, list the major equipment removals.
- Design for production features.
- Unusual manning strategies (such as Blue and Gold Crews, etc.)
- Operations and Support data (such as projected fuel consumption, operating cycles/hours, overhaul/modernization strategy, etc.)
- Any special considerations for calculating Disposal Costs.
- Life cycle costs reduction features.
- Any other relevant and helpful information.

APPENDIX S
TYPICAL CERTIFICATIONS

Note that this table contains some content applicable only to T-Ships and some content applicable only to combatants. See the notes in the titles for each entry.

Certification	Program Office Point of Contact	Activities to Obtain Certification	Certification Authority	Expected Certification Date
Intelligence	Acquisition Program Manager	CDD review by Joint Staff J2	Joint Staff J8	During CDD Approval
Interoperability	Program C4I Lead	CDD review by Joint Staff J6	Joint Staff J6	During CDD Approval
FORCENet	Program C4I Lead	CDD review by OPNAV N6	OPNAV N6	During CDD Approval
Clinger-Cohen Act (CCA) Compliance	Program C4I Lead	Signature of Compliance Statement	Department of the Navy (DoN) CIO with review by DoD CIO	Prior to Milestone A and B
Spectrum Certification	Program C4I Lead	Signature of Spectrum Supportability Plan and associated Form 1494s	OPNAV N6 with review by Spectrum Support Field Activities	Prior to Milestone A and B
DOD Information Assurance Certification and Accreditation Process	Program C4I Lead	Approval of Information Assurance Strategy, SSAA	DoN CIO	Prior to Milestone B
Early Operational Assessment (EOA)	Test and Evaluation Manager	Operational Test & Evaluation Force (OPTEVFOR) conduct of EOA	Commander, Operational Test and Evaluation Force (COMOPTEVFOR), DOT&E	Prior to Milestone B
Independent Logistics Assessment (ILA)	Logistics Manager	ILA Team Review of Program	PEO Ships	Prior to Milestone B
Training Assessment	Logistics Manager	Navy Training System Plan	OPNAV N1	Prior to Gate 4
Human Systems Integration	SDM/SUPSHIP	HSI design review	SDM	Prior to delivery

Certification	Program Office Point of Contact	Activities to Obtain Certification	Certification Authority	Expected Certification Date
System Safety	ESOH Manager and/or Principal for Safety	Design review and working group	SDM	Prior to delivery
Environmental	ESOH Manager and/or Principal for Safety	Design review and working group	SDM	Prior to delivery
Corrosion Prevention and Control	SDM/SUPSHIP	Design review and CPAT	SDM	Prior to delivery
WSESRB and/or Shipboard Weapons Integration Team (SWIT) reviews and approval	Principal for Safety	WSESRB/SWIT Review Meetings	WSESRB/SWIT	Prior to Milestone B
System Specification	SDM	TWH Review and Signature	TWH	Prior to DD&C RFP Release
Builder's Certificate (Coast Guard (CG) Form 1261) (where applicable for T-ships)	SUPSHIP	USCG review during DD&C to comply with Code of Federal Regulations (CFR)	USCG	Prior to ship delivery
Panama Canal Commission Letter	SUPSHIP	Panama Canal Commission review	Panama Canal Commission	Prior to ship delivery
Panama Canal Package (Documentation Package provided to Ship)	SUPSHIP	Panama Canal Commission review	Panama Canal Commission	Prior to ship delivery
Certificate of Inspection (CG Form 851) (where applicable for T-ships)	SUPSHIP	USCG review during DD&C to comply with CFR	USCG	Prior to ship delivery
ABS Classifications (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
Provisional Load Line Certificate (where applicable for T-ships)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
International Load Line Certificate (where applicable for T-ships)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
International Tonnage (1969 Convention) (where applicable for T-ships)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
Suez Canal Tonnage (where applicable for T-ships)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery

Certification	Program Office Point of Contact	Activities to Obtain Certification	Certification Authority	Expected Certification Date
Panama Canal Tonnage (where applicable for T-ships)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
Cargo Gear Register (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
Acceptance in the Alternate Compliance Program (ACP) (Construction) (where applicable for T-ships)	SUPSHIP	ABS/USCG review during DD&C	ABS/USCG	Prior to ship delivery
Acceptance in the Alternate Compliance Program (ACP) (Operation) (where applicable for T-ships)	SUPSHIP	ABS/USCG review during DD&C	ABS/USCG	Prior to ship delivery
USCG Code of Federal Regulation (CFR) Title 33 (Statement of Fact) (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
CFR Title 46 (Statement of Fact) (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
49 CFR Title 176 (Statement of Fact) (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
Safety Construction (Statement of Voluntary Compliance (SOVC)) (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
Safety Equipment (SOVC) (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
Safety Radio (GMDSS/SLR/SLT) (SOVC) (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
Various Equipment Type Approvals (where applicable for T-ships)	SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
MARPOL ‘73/’78 -Air Emissions – Oxides of Nitrogen (NO_x) compliance with Annex VI of MARPOL 73/78. Exhaust smoke in accordance ISO Standard 8173 Part III	SUPSHIP	Vendor action during DD&C	Shipbuilder vendor	Prior to ship delivery
MARPOL ‘73/’78 - (SOVC)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
MARPOL Annex I (Oil) IOPP, COW, etc. (SOVC)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery

Certification	Program Office Point of Contact	Activities to Obtain Certification	Certification Authority	Expected Certification Date
MARPOL Annex IV (Sewage) SOVC	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
Marine Sanitation Device (MSD) (MARPOL 73/78 Annex IV Equivalent)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
MARPOL Annex V (Garbage) SOVC	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
72 COLREGS (Statement of Fact)	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
Certificate of Sanitary Construction	SUPSHIP	United States Public Health Service (USPHS)/ Food and Drug Administration (FDA) review during DD&C	USPHS Surgeon General	Prior to ship delivery
Deratting Exemption Certificate	SUPSHIP	USPHS/FDA review during DD&C	USPHS Vessel Sanitation Inspector	Prior to ship delivery
Potable water quality compliance with United States Public Health Service (USPHS) requirements (Lab Report)	SUPSHIP	Shipbuilder Vendor review during DD&C	Approved laboratory	Prior to ship delivery
Air Purity for Emergency Air Breathing Stations	SUPSHIP	Conduct laboratory testing	Laboratory certified by the State or the EPA for testing air purity	No later than 30 days prior to Builder's Trials
Personnel Elevator Certificate (ASME A17.1)	SUPSHIP	ASME elevator inspector review during DD&C	ASME	Prior to ship delivery
Stability Letter	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
Certificate of Deadweight	SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
Radio Station License (where applicable for T-ships)	SDM/SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
ISM Safety Management Certificate (where applicable for T-ships)	SDM/SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery

Certification	Program Office Point of Contact	Activities to Obtain Certification	Certification Authority	Expected Certification Date
International Ship Security Certificate (SOVC) (where applicable for T-ships)	SDM/SUPSHIP	USCG review during DD&C	USCG	Prior to ship delivery
Shipborne Automatic Identification System (AIS)	SDM/SUPSHIP	Shipbuilder Vendor review during DD&C	USCG/Federal Communications Commission (FCC)	Prior to ship delivery
Underwater Inspection in Lieu of Dry Docking (UWILD) (Statement of Fact)	SDM/SUPSHIP	ABS or other review during DD&C	ABS or other	Prior to ship delivery
ABS statement of SOLAS compliance (where applicable for T-ships)	SDM/SUPSHIP	ABS review during DD&C	ABS	Prior to ship delivery
Tactical Air Navigation (TACAN) System	SDM/SUPSHIP	At sea using flight inspection aircraft of Shipboard Electronic System Evaluation Facility (SESEF)	Federal Aviation Administration (FAA) (Regional), SESEF	At sea after initial installation
Aviation Interface/Facilities	SDM/SUPSHIP	Inspection	Naval Air Warfare Center Aircraft Division (NAWCAD) Lakehurst	After initial installation
Shipboard Wind Measuring System and other Landing and Approach Aids	SDM/SUPSHIP	Dockside testing	NAWCAD, Lakehurst	After initial installation
Identification Friend or Foe (IFF)	SDM/SUPSHIP	Dockside testing	NAVAIR	After initial installation
Navigation Lights	SDM/SUPSHIP	Provide verification report no later than 6 months prior to first sea trials	Judge Advocate General	Prior to first sea trials
AN/WSN-5 Inertial Navigation Set or AN/WSN-7 Ring Laser Gyro	SDM/SUPSHIP	Dockside and at sea certification testing	SPAWARSYSCEN Charleston	After initial installation
Weapons Systems Pointing and Firing Cutout Zones	SDM/SUPSHIP	Inspection	NSWC CC	Prior to weapons testing
Degaussing	SDM/SUPSHIP	Inspection and testing	NAVSEA Code	Prior to delivery
C4I Interoperability	Program C4I Lead/SUPSHIP	Inspection and Testing by the Joint Interoperability Test Command (JITC)	Director, Defense Information Systems Agency	Post delivery

Certification	Program Office Point of Contact	Activities to Obtain Certification	Certification Authority	Expected Certification Date
Radio Frequency Radiation (RFR) Hazards (RADHAZ) Abatement	SDM/SUPSHIP	Dockside visual inspection and at sea instrumented testing	NAVSEA Code	Prior to Post Shakedown Availability completion for lead ship and prior to Acceptance Trials for follow ships
Electromagnetic Compatibility	SDM/SUPSHIP	Dockside visual inspection and at sea instrumented testing	NAVSEA Code	Prior to Post Shakedown Availability completion for lead ship and prior to Acceptance Trials for follow ships
Secure Electrical Information Processing System - TEMPEST	SDM/SUPSHIP	Dockside visual inspection and at sea instrumented testing	SPAWAR	One month prior to delivery
Information Systems Certification and Accreditation	SDM/SUPSHIP	Inspection	SPAWAR	One month prior to delivery
Readiness for Trials	Program Manager/ SUPSHIP	Shipbuilder demonstrates readiness for sea trials	Program Manager	Prior to beginning trials
Combat System Qualification Testing	SDM	Various Field Activities and Ranges	Various Field Activities and Ranges	Post Delivery
Operational Evaluation (OPEVAL)	Test and Evaluation Manager	Conduct of OPEVAL	COMOPTEVFOR	Prior to Initial Operational Capability

APPENDIX T
ABS INVOLVEMENT

For applicable T-ship Programs during the Detail Design, ABS works with the design agent, Shipbuilder, and HM&E system vendors/integrators to ensure that the ship, and its HM&E systems and mission system interfaces, conform to the applicable Rule set and any other requested certification standards, such as SOLAS or MARPOL. The final product used to guide DD&C will be the approved Ship Specification. Using the Rule set and Ship Specification, the agent or team building the ship (the contractor) will produce an index of the set of submittals (technical drawings, plans, studies, analyses, and other engineering documentation) they propose as necessary and sufficient to demonstrate that their design and approach is compliant with the invoked Rule set and the Ship Specification. They will submit this to ABS and the TWHs for concurrence. Once concurrence is achieved, this index becomes the baseline tracking document for assessing achievement of classification design approval. It is the contractor's responsibility to review the Rule set to identify submittal requirements and concurrence by ABS and the TWHs does not guarantee that additional submittals won't be subsequently identified as necessary. The goal is to demonstrate compliance with the Rule set. In order to facilitate this process, a summary of submittal requirements has been developed which may be used as the entry point by the contractor for this process. The documentation required as submittals is comprised of what is normally considered to be Contract and Contract Guidance level and is what is used to verify classification compliance. Documentation reviewed and stamped "Approved" or "Approved with Comment" by ABS is what is used ABS Surveyors on-site in the Shipbuilder and at vendor facilities to verify compliance with the classification requirements. In most cases, the Shipbuilder will develop or have developed for their use production or assembly drawings. It is the Shipbuilder's responsibility to ensure that these production level drawings are fully compliant with those "approved" drawings upon which they are based. Should it be found that variance from the approved drawings has occurred, it is the Shipbuilder's responsibility to either correct the error or demonstrate to ABS and the TWHs that what has been produced, although different from what was "approved", is still compliant with the Rule set. As review of submittals proceeds, ABS will provide to the submitter guidance in the form of "Comments". "Technical Comments" relate areas where the submittal is not in compliance with the Rule set or where not enough information has been provided to demonstrate compliance. "Surveyor Comments" relate areas where verification of compliance can only occur at the Shipbuilder or vendor facility and such verification is left to the attending ABS Surveyor. A Classification Certificate cannot be delivered to the Shipbuilder until all such Comments have been closed (satisfactorily addressed). The Naval Administration and TWHs will accept the design and authorize construction, based in part on the Shipbuilder's receipt of ABS and other approvals. As the contractor transitions to construction and production level drawings are produced, it may be determined by the SUPSHIP CHENG that he would like to review some of these drawings. Should he find that these drawings are not in compliance with the approved submittals or the governing Rule set, notification should be given to the contractor and ABS. Corrective action is the responsibility of the contractor. Compliance with the Rule set, building to the approved submittals, and satisfaction of comments is the responsibility of the contractor.

As mentioned above, there are a number of vendor supplied components and systems which must be certified by ABS and/or the TWHs for the vendor and appropriate certification delivered to the contractor with the equipment to verify compliance. Such equipment and systems are identified in the Rules. It is the contractor's responsibility to provide to ABS and the TWHs a consolidated list of all equipment, systems, and components being procured from vendors. ABS and the TWHs will identify to the contractor those items requiring individual certification at the vendor facility and such will be tracked using the contractor supplied Vendor Listing. A majority of this is to be attended at the vendor facility by an ABS Surveyor. Some of it – especially software – must be certified by the TWHs and ABS only tracks satisfaction of TWHs certification to facilitate ultimate classification. The TWHs may identify his desire to have Government Source Inspection at some of these facilities in addition to ABS Surveyor attendance.

A Rule requirement is that the contractor provide to ABS and the TWHs both an Integrated Test Plan and a Consolidated Trials Plan, each of which identifies those tests and trials which should be attended by ABS and/or the TWHs. ABS and the TWHs will review this and work with the contractor to ensure it is complete and appropriate and to ensure coordination of attendance. Individual test and trial procedures are to be submitted by the contractor to the ABS Surveyor and on-site SUPSHIP office for review in accordance with the approved plans in order to achieve concurrence that the tests and trials are technically sufficient and appropriate.

During the construction portion, ABS will carry out survey, inspection and testing of the ship, HM&E systems and mission system interfaces to ensure compliance with the approved submittals and the Rules. The process for carrying this out is defined in the relevant ABS Process Instruction and interface with SUPSHIP is outlined in the "Business Rules".

It is important to be aware of several facts:

1. The Surveyor uses the Approved or Approved with Comment submittals as his basis for attending the ship. His job is to ensure that the vessel is built in accordance with these drawings. He ordinarily does not use production construction drawings as these are produced far too late in the program to have been reviewed and approved prior to construction. The Surveyor must interpret through his experience the fact that the as-built configuration complies with the approved submittals and, thus, the Rules.

2. The Surveyor uses his experience and technical expertise to ensure that the fabrication processes are compliant with the Rule requirements. Inevitably situations will arise which require interpretation or assessment of the impact of non-compliant work. The Surveyor often interfaces with yard personnel to identify approaches which may be acceptable or may mitigate any adverse impact. He will consult as necessary with relevant Technical support to ensure he stands on solid ground. In these cases, it is incumbent on the Surveyor to seek concurrence from the relevant TWHs.

3. The Surveyor conducts surveys. He is not an inspector. He must use his expertise and knowledge of the yard to gauge the degree of attendance necessary for the various processes taking place. He is not a substitute for the Quality Assurance (QA) function of the yard. It is expected that the yard will have a functioning and competent QA organization. He will adjust the level of his attendance to match the degree of competence exhibited by yard production personnel and the level of quality observed. It may become necessary to cease attendance if the yard demonstrates the unwillingness or inability to adequately perform in this area. To relieve a yard of the accountability for its own quality through assumption of evermore intense inspection sets up an unwinnable game of "catch-me-if-you-can" and results inevitably in the owner assuming the risks and costs associated with the poor work.

The Surveyor really has two primary goals – to create a relationship of trust and credibility with yard personnel so that he can advise them on how to achieve success in what they are building and, at the same time, function as an agent for the TWHs to assess compliance. This is a tricky challenge but when it is successfully carried out, all parties benefit. The yard's technical abilities are improved and the owner receives a compliant ship without the investment of unaffordable amounts of inspection. A yard which tries to game this is the loser as their credibility decreases and their rework costs increase.

At the end of the Build phase, ABS issues a Class Certificate, along with other certifications as requested by the Naval Administration. These certificates are delivered to the Naval Administration as part of the overall package required for acceptance into Fleet service.

The SIM is responsible for ensuring achievement of the safety, cost, and requirements of any associated weapons systems under development. The SDM and SIM are also responsible for technical problems identification and resolution within the scope of their technical warrants. Other problems are referred to the SDM and SIM for resolution by the appropriate TWH. The SDM retains technical authority for the total ship and also normally advises the program on the resolution of technical issues and supports the development of and approves the technical adequacy of engineering changes. The SDM is responsible for managing the contractual baseline (e.g., System and/or Shipbuilding Specifications, Contract Drawings, PPDs, and other data forming the Allocated Baseline). The Shipbuilder performs CM of the Detail Design or the Product Baseline. The SIM is responsible for the overall system integration on the ship for applicable weapons systems, and will assist the SDM for all system integration issues during construction and life cycle management and sustainment.

APPENDIX U
CONFIGURATION CONTROL/MANAGEMENT

U.1 INTRODUCTION.

Configuration control is the process of establishing a design baseline, and then subjecting proposed changes to this baseline to management attention and approval. Configuration control can be formal or informal and in both there is a clearly identified review and approval hierarchy with a record of the basis for changing the design.

U.1.1 Definitions.

U.1.1.1 Configuration Control. Controlling changes to the ship design configuration documents.

U.1.1.2 Configuration Item (CI). Items may differ widely in complexity, size, and kind. Examples are a ship, propulsion system, ship arrangement and personnel access system, navigation system, combat system, embedded computer, computer program, electronic system, feed pump, test equipment, or a round of ammunition. A CI satisfies an end-use function or aggregate of functions. Thus, a top-level or "parent" item, such as a ship, is composed of a number of lower level items, such as the major ship systems, to which various functions have been allocated by the designer. Similarly, functions of these lower level items are sub allocated downward throughout a hierarchical family of CIs. This top-down hierarchy of CIs, starting with the ship, is similar to the ship work breakdown structure.

U.1.1.3 Contract Drawing. A NAVSEA drawing, or equivalent data, prepared during the Preliminary Design and Contract Design phase, delineates required design features of the ship. No departure from details of a Contract Drawing shall be made without specific NAVSEA approval.

U.1.1.4 Contract Guidance Drawing A NAVSEA drawing, or equivalent data, prepared during Preliminary and Contract Design phase, identified as "Contract Guidance Drawing," which illustrates one alternative for providing required design features of the ship. The contractor may deviate from this solution or develop his own so long as the resulting design incorporates the required design features. A Contract Guidance Drawing does not necessarily depict, nor is it intended that it depict, all features and details of the systems and structures to which it relates. It serves the purpose of providing information that, when utilized in conjunction with applicable specification requirements, Contract Drawings, project-peculiar documents, and other information, may assist in Detail Design. Contract Guidance Drawings will not necessarily be updated or revised to reflect future modification or changes to the specifications. Contract Guidance Drawings have fallen out of use because in practice they are used as Contract Drawings.

U.1.1.5 Project-Peculiar Document. A government document included in the list of Project-Peculiar Documents. No departure from details of a Project-Peculiar Document shall be made without specific approval from the government.

U.1.1.6 Formal Control. Formal control is characterized by before-the-fact approval, specific documentation, and processing requirements. A formal request must be submitted by anyone desiring to make a change to a formally controlled aspect of the ship design. The originator of the change request is responsible for identifying the ship and system level impact of the changes, such as weight, moment, cost and manning.

U.1.1.7 Informal Control. Informal control change procedures are characterized by delegation of approval authority to the SEM or TL level and a minimum of documentation. In this mode, changes to the existing ship baseline documents are identified and proposed to the cognizant TL or SEM. If the TL/SEM approves the change, he will advise custodians of the appropriate documents (e.g., the weights TL for the weight report). The SDM and DIM are kept advised by the SEM of such actions in a timely manner. The SEM determines the degree of documentation required to preserve an audit trail of design evolution for traceability and reevaluation of earlier decisions.

U.1.2 General. A configuration control plan shall be included in the Engineering Management Plan or as a separate document referenced in the Engineering Management Plan. The configuration control plan shall address an informal procedure for interface control between the various products being developed as well as formal control for selected products.

Configuration Change Control is the systematic process of evaluating, coordinating, and approving or disapproving change proposals. Once the baseline is under formal configuration control, all requested changes affecting the baseline are formally prepared and well defined to ensure that each change's impact on the overall program is fully considered.

Before establishment of the Configuration Control Baseline (CCBL), change proposals as they occur shall be identified to the responsible TL for review and evaluation. Upon a determination by the TL that the change proposal does not exceed the primary constraints of the ship's principal characteristics, the CDD, or impact other areas of the ship's design, the TL, if he concurs with the change, shall incorporate it or recommend it be incorporated into the appropriate design document. If the TL believes the change proposal exceeds the constraints placed on the design or otherwise seriously impacts the design, he shall provide rationale and recommend rejection of the change proposal via the SEM, other involved TLs, and the DIM. The SDM, DIM, SE, and primary TL shall review the rationale for rejection and recommend its acceptance or need for additional review/evaluation.

After formal establishment of the CCBL in the Preliminary Design and Contract Design phase, similar change proposals affecting the baseline shall be prepared on a change request form and shall be formally reviewed and acted on by the ship Design Team.

Long lead and government furnished or government specified material, especially equipment and systems in the combat systems area, will have an impact on what needs to be placed under configuration control. Arrangements for interface control shall be discussed in the Configuration Control Plan.

Drawings/data may show both formally and informally controlled items throughout the design. At the other extreme, only a fraction of the equipment listed in the Master Equipment List (MEL) will ever be subjected to formal control for reasons of weight and space limitations, delivery time, unique operating requirements, selection as GFE, or because of requirements direction. However major system interfaces will be controlled.

Prior to the time when significant design iterations are halted (i.e., the design "freeze"), formal control is exercised on a selective basis over changes such as those involving customer-dictated requirements or those having major impact on ship characteristics; e.g., hull lines, ship manning, ship weight, location of major topside equipment, speed, and endurance. The number of ship system elements subject to formal control increases following a design freeze.

U.2 RESOLUTION OF TECHNICAL ISSUES.

It may become necessary from the viewpoint of a Program Manager or SDM to make some compromises to meet design constraints. When such compromises jeopardize the technical adequacy of the product or the integrity of the design, each Design Team member must understand their personal responsibility to ensure the situation is brought to the attention of the SDM and the responsible TWH. In such instances, the concerns must be made known in a logical, reasonable fashion, and the rationale for final decisions must be documented.

U.3 DESIGN PHASE CONFIGURATION CONTROL.

U.3.1 Feasibility Studies. During Feasibility Studies, there is normally no formal configuration control. Control over the configuration is achieved by means of the developing CDD and formal and informal discussions with the Sponsor chaired Requirements IPT established for the specific ship program. At the completion of Feasibility Studies, the CDD becomes the configuration control baseline for the start of the Preliminary and Contract Design phase.

U.3.2 Preliminary and Contract Design Phase. During the Preliminary Design and early Contract Design phases, only the CDD, Ship Specification (depending on the acquisition strategy), and later the ship's lines are normally controlled. It is not until the middle of Contract Design that the list of controlled documents typically grows to include general arrangements, topside design, Ship Specification, master equipment list and other contract documents. The CDD and the acquisition decision memoranda (ADM) are the primary baseline control documents throughout this design phase.

Configuration control during the last half of the Preliminary Design and Contract Design phase shall consist of:

- Identification of configuration control items.
- Performing change control.
- Providing status reports on each proposed change.
- Performing design reviews.

When deliverables have been identified, the configuration items to be controlled shall be defined in the Configuration Control Baseline. Normally, the lines will have been frozen earlier. Other drawings/data and the Ship Specifications will be frozen at various stages of the Contract Design phase. The design freeze date for each item will be determined by the interface requirements necessary to have an integrated design package for review and approval prior to release of the RFP for Preliminary Design, Contract Design, LLTM, or DD&C. For example, key portions of the ship general arrangements drawings/data must be frozen early in order to permit other drawings, data, and calculations to reflect the correct ship arrangements. As each document is frozen, it will be added to the CCBL. After being added to the CCBL, all future changes to that item will be formally controlled as described later.

Judgment must be used in deciding when to impose configuration control. If it is imposed too soon, the design process will be slowed unnecessarily. On the other hand, sufficient time must be allowed to ensure that specifications and drawings are consistent at Navy circulation.

U.4 RESPONSIBILITIES.

U.4.1 Ship Design Manager. The Ship Design Manager shall:

- Approve the configuration management program to be developed, implemented, and operated.
- With Program Office participation, establish and convene, when necessary, a NAVSEA Adjudication Board (NAB).
- Approve, disapprove, or defer all baseline-impacting changes after the NAB establishment.
- Review and approve all matters affecting program resources, contract costs, and schedules.

U.4.2 Design Integration Manager. DIM shall be responsible for the operation of CM within the Preliminary Design and Contract Design project. Specifically, the DIM shall be responsible for:

- Developing and updating the Preliminary Design and Contract Design phase CM procedures and directives.
- Evaluating the ship and intersystem impact of proposed changes, including the ship and design costs as well as alternatives.
- Appraising the SDM of work priorities and status of all CM related matters.

Note: If there is no DIM assigned to the project, the SDM shall perform the tasks listed as being the responsibility of the DIM.

U.4.3 Systems Engineering Managers. Systems Engineering Managers are responsible for:

- Initiating, with the responsible life cycle manager, an appeal of any technical decision.
- Sponsoring all change request forms originating in their functional area of responsibility.
- Approving, disapproving, or deferring all baseline-impacting changes after the NAB establishment.
- Reviewing and approving all matters affecting program resources, contract costs, and schedules.

U.4.4 Task Leaders. Task Leaders are responsible for:

- Identifying any conflict, deficiency, or new requirement and initiating change requests in their areas of responsibility.
- Initiating change requests, when needed, to interfacing systems.
- Initiating an appeal of any technical decision.
- Reviewing all change requests affecting responsible areas and interface areas.
- Implementing approved changes within their cognizant technical areas.

U.4.5 Specification Manager. The Specification Manager is responsible for:

- Establishing a specification development schedule.
- Developing a specification configuration management plan.
- Providing specification writing training and guidance.
- Establishing procedures for the flow of change request forms.
- Establishing and implementing change request form control system.
- Distribution of change request forms to responsible codes.
- Maintaining a status record for each change request form.
- Ensuring Ship Specifications comply with the NTSP (drawings and ship specifications appendix) requirement.
- Assisting SDMs getting Ship Specifications certified.

U.4.6 Program Office. The Program Office will participate in the ongoing reviews of the Contract Design package to assure that the contract package, when made available to the Shipbuilder, is adequate for contractual purposes and describes a ship that meets the operational requirements established by OPNAV. A primary objective of the Review is to expose the Contract Design to OPNAV, the Fleet, INSURV, and other Material Commands for review. This exposure is intended to solicit comments on the design prior to signature and subsequent contractual actions for building the ship. Designated SUPSHIPS will be invited to participate. Design briefings for INSURV, SUPSHIPS, and the Fleet should be made prior to circulation of the package.

U.4.7 Prospective Shipbuilders. Prospective Shipbuilders will participate in the Navy Review to perform an in-depth review of the design package. They will examine the Ship Specifications, Contract Drawings, and Project-Peculiar Documents and DRL as an integrated ship design to establish adequacy, sufficiency, and producibility of the total design. The goal of this in-depth total design review is to develop comments, which, when implemented, would result in a data package that the Shipbuilder would be willing to accept as the basis for a Detail Design and ship production contract.

U.5 NAVSEA ADJUDICATION BOARD.

Once the design is under configuration control, no changes are made to the Ship Specifications, drawings, and project-peculiar documents without processing through a design evaluation system. Within NAVSEA this system has been referred to for some ship programs as the NAB system. The NAB system allows every engineer the opportunity to submit change request forms to correct design deficiencies. These change requests, submitted on NAB Evaluation Sheets, are commonly referred to as "NABs" and are forwarded to the cognizant TL. The NAB must be answered by the responsible TL. The final action on each approved or modified change request form must include the actual wording that will go into the specification or the exact changes that will be made to the drawings or project-peculiar documents. The affected TL routes the comment to the SEM for approval or concurrence prior to passing it to higher authority. The SDM or NAB must approve major and critical comments and any comments not resolved at lower levels. Often Shipbuilders are also tasked to comment on the package. In addition, other Navy activities and the Fleet may submit comments. There will typically be 3,000 to 5,000 proposed changes during circulation.

The NAB is not an exercise in shuffling paper although it may seem that way at times. Communication between dozens of TLs on thousands of comments is difficult at best and all but useless if changes and responses are not properly identified.

Proposed changes to the specifications are submitted by attaching copies of only the applicable specification pages to a completed NAB Evaluation Sheet and by marking the changes on the respective pages. Proposed changes to drawings are submitted by attaching a copy of only that portion of the drawing affected, marked up with the change. If possible, this markup should be the same size as the NAB Evaluation Sheet to facilitate reproduction efforts. Equivalent electronic workflow systems may be employed to speed the process.

The Ship Design Manager or the Deputy Ship Design Manager will chair the NAB. The Program Office shall participate – sometimes as a co-chair. The Specifications Manager and his staff provide administrative support. The SEM for each functional area will also be a member of the NAB. Shipbuilders and Supervisors of Shipbuilding representatives may also be represented.

NAB Evaluation Sheets will be processed as follows. Equivalent electronic workflow systems may be employed.

- Originators send evaluation sheets to the responsible SEM who copies to the Specifications Manager or Specifications Manager who then forwards to the responsible SEM. Evaluation sheets are logged in by the Specifications Manager.
- Cognizant SEM reviews with the responsible TL and recommends approval, denial, modification or consideration by the NAB.
- Specifications Manger distributes evaluation sheets with SEM recommendation to the originator, other stakeholders, the DIM, and SDM.
- Other stakeholders may return evaluation sheets to the Specifications Manager with comments.
- Based on the comments, the proposed change may be approved, denied, or modified by the DIM and SDM or brought to the NAB. Approved, denied, and/or modified changes will be returned to the originator and stakeholders by the Specifications Manager.
- NAB adjudicates evaluation sheets.
- The DIM and SDM sign the NAB and all other adjudicated evaluation sheets.
- The Specifications Manager maintains a file reflecting latest status of all evaluation sheets.

The procedures for processing Evaluation Sheets comments provides for all sheets to be sent to the cognizant SEM who will adjudicate (approve, approve with modification, or reject) the comment except for those items which he determines are of sufficient importance to be referred to the NAB. The decision by the SEM whether to adjudicate or refer to the NAB is critical to the whole adjudication process. It is intended that most evaluation sheets will be adjudicated by the SEM/TL, however, key adjudication decisions should be made by the NAB. Typical of Evaluation Sheets comments, which normally refer to the NAB, are:

- Comment appears desirable to the SEM/TL but implementation would result in deviation from Project and Command requirements e.g., NAVSEA policy, standards, and requirements.
- Comment appears desirable to the SEM/TL but implementation would result in change in significant ship characteristics such as weight, speed, and endurance.
- Comment appears undesirable to the SEM/TL but decision may be of interest to higher-level commands such as Program Office, SDM, etc.
- Implementation of comment appears desirable but has multiple interface ramifications.
- Approval of comment recommended by SEM but implementation of the comment would result in not meeting ship design schedules.
- Comment appears to have merit, but SEM would like NAB input into the adjudication.

Following the adjudication period, the NAB shall conduct NAB reading sessions of the specifications and drawings in order to assure that they are consistent, satisfy all imposed design constraints, and are technically adequate for use in ship procurement. The session will involve all NAB members. As each section and associated drawings are reviewed, the responsible SEM shall inform the NAB of any significant changes made since circulation for review. Comments or changes developed during the NAB Reading Session will be adjudicated.

It should be noted that each Ship Design Manager uses a NAB type of CM process during technical package development; however, it may be called a Design Decision Memorandum or Specification Change Proposal.

The particular details for specification configuration management shall be documented in each program's Specification Management Plan.

U.6 CHANGE CONTROL DURING DETAIL DESIGN AND CONSTRUCTION.

As technical life cycle managers for ships, through the ship life cycle, SEA 05 must be involved in configuration control during DD&C.

The assigned SDM shall participate in all ship-level Configuration Control Boards (CCBs). ECPs shall be forwarded to the TWHs and have progress tracked by the SDM. TWHs/SEMs shall prepare/review ECPs in a timely fashion to avoid delaying CCB actions.

The SDM shall have full agreement within SEA 05 before his position is presented to the CCB. Any disagreement between the SDM and TWH/SEMs will require prior adjudication through the chain of command up to SEA 05 if necessary.

The ECP status report should be used by the SDM and TWHs/SEMs to track action on a configuration change. The SDM shall ensure that the TWHs/SEMs receive the necessary feedback.

TWHs/SEMs/SDM shall initiate an official reclama through the Technical Authority if they do not agree with a final action taken by CCB/Program Office. The issue shall not be dropped just because the CCB or Program Manager decided contrary to Technical Authorities position. While the final decisions rests with the Program Office (the Shipbuilder can also reject an HMR because of cost or schedule reasons), SEA 05 is obligated to assure the technical adequacy of each ship design. SEA 05 must vigorously pursue its position on significant issues and the codes must keep their management informed. The SDM/TAEs shall elevate specific problems to SEA 05 on a case basis as required.

The SDM will have access to all Field Modification Requests (FMRs), Deviations, and Waivers and conduct review for technical adequacy. The SDM shall identify to the Program Office all changes considered technically unacceptable. The SDM shall issue a quarterly report listing the changes considered unacceptable.

APPENDIX V
SDM QUALIFICATION CARD

Name ______________________________

Core Competency - provide evidence of an understanding (completed training / college coursework / technical papers, etc) or demonstrate an understanding of the following competencies to a SEA 05D Division Director	**Division Director Signature**	**Date**
Knowledge of Virtual SYSCOM Technical Authority Instructions and Procedures		
Knowledge of NAVY NAVSEA and SEA 05 Mission, Values, Structure, Customers, Guiding Principles and Processes		
Basic knowledge of warfare doctrine (Navy Doctrine Library System)		
Individual and Team Performance Skills (self-direction, interpersonal relations, technical competence and integrity, positive attitude, continuous learner, foundation leadership skills, etc.)		
Oral, written, and computer-based communication skills. (Provide examples)		
Analytical skills (identify problems, root causes, recommended solutions, etc.)		
Knowledge of Project Management skills		
Knowledge of Risk Management skills		
Knowledge of Systems Engineering (e.g., Requirements analysis, Functional allocation, etc.)		
Knowledge of design, procurement, operations, and support of surface ship systems and components		
Knowledge of commercial shipbuilding standards, design practices, and ABS SVR and HSC		
Knowledge of military shipbuilding standards, design practices, and ABS and HSNC		
Knowledge of Naval Architecture & Marine Engineering through class work or a working knowledge of SNAME publication Principles of Naval Architecture and publication Marine Engineering		
Knowledge of Warfare Systems Engineering Principles and Processes (System and subsystem Interface definition/control, etc.)		
Knowledge of System of Systems Integration techniques		
Knowledge of Customer Oriented Product Development (Business Planning, IPPD, Logistics, etc.)		
Knowledge of Warfighting Systems Engineering Hierarchy and Technical Authority Policy, including use/development of technical requirements, standards, and tools		
Knowledge of Detail, Performance-based and Hybrid (e.g., System) Specifications		

Core Competency <u>- provide evidence of an understanding (completed training / college coursework / technical papers, etc) or demonstrate an understanding of the following competencies to a SEA 05D Division Director</u>	**Division Director Signature**	**Date**
Knowledge of the Total Ship System Engineering process (HSI, safety, reliability, etc.), particularly the principles of IPPD applied to Design for Warfighting, Design for Producibility, and Design for Ownership		
Knowledge of Ship Total Ownership Costs and Estimating Methods		
Ability to support contract administration (tasking, money flow, etc.)		
Knowledge of Navy Working Capital Fund (NWCF) and private sector design consortia business practices		
Knowledge of RDT&E and Acquisition Policy and Processes		
Knowledge of Configuration Management practices		
Ability to plan, coordinate, and manage complex systems development (concept studies, requirements definition, spec. development, interface definition, design cert., etc.) and support programs involving interaction with a variety of organizations		

<u>Certifications</u>	**Division Director Signature**	**Date**
DAWIA APC membership		
DAWIA SPRDE Level III career field certification		
DAWIA Program Management Level II career field certification		

Interviews - meet with the current incumbent of the following positions to discuss the relationship between the individual and the SDM. Discuss lessons learned as well as new processes and technologies within the area of expertise.	**Signature**	**Date**
Human Systems Integration TWH (equivalent such as the IWS HSI TWH)		
Waterfront CHENG		
Arrangements – Surface Ships TWH		
Damage Control, Fire Fighting, Recoverability, Personnel Protection TWH		
Environmental Requirements and Regulations TWH		
Hydrodynamics TWH		
Machinery – Climate Control Systems TWH		
Machinery – Controls, Networks and Monitoring TWH		
Machinery – Electrical Systems TWH		
Machinery – Propulsion and Power Systems TWH		
Machinery – Weapons Handling and Aviation Support TWH		
Materials – Coatings and Corrosion Control TWH		
Occupational Safety and Health Requirements and Regulations TWH		
Product Data Integration/Exchange TWH		
Reliability, Maintainability, and Availability TWH		
Ship Survivability TWH		
Structural Integrity TWH		
System Safety TWH		
Weight Control and Stability TWH		
Surface Ship Combat and Weapons Control TWH		
Topside Design TWH		
Business Financial Manager		
Cost Engineer from SEA 05C		
Program Manager or Deputy Program Manager from PEO-Ships		

Interviews - meet with the current incumbent of the following positions to discuss the relationship between the individual and the SDM. Discuss lessons learned as well as new processes and technologies within the area of expertise.	**Signature**	**Date**
Program Manager or Deputy Program Manager from PEO-IWS		

Once the above sections are complete, schedule an interview with SEA 05D/V Technical Director and Group Head:

Signature of Technical Director Date

____________________________________ __________

Signature of Group Head Date

____________________________________ __________

APPENDIX W
OTHER DESIGN PARTICIPANTS

W.1 DEPUTY SHIP DESIGN MANAGER.

In the case of major or multiple concurrent designs, the SDM may be assigned a deputy. This position has proven to be justified for a major ship in Contract Design, as past experience shows that a large portion of the SDM's time is devoted to communication outside the Design Team. Thus, while the SDM is occupied with external communications and reporting design progress to higher management, an internal representative is needed to direct and coordinate the project operations. Deputy SDMs are individuals whose training and experience have been similar to those of an SDM. They serve as representatives of the SDM and SEA 05 in all matters and are to be accorded the same respect and trust. Their attendance at a meeting or conference in lieu of the SDM should not be considered a slight to participants. The DSDM is empowered to act in the absence of the SDM in all matters and is held accountable for decisions made. However, they do not have technical warrants. Typical duties include:

- Planning the design schedule
- Defining the design task requirements
- Translating the task requirements into WTAs
- Developing and establishing technical and financial tracking systems
- Coordinating design participants who are outside the NAVSEA structure
- Directing the overall technical activities

W.2 DESIGN INTEGRATION MANAGER.

Depending upon the design scope, complexity, priority, and personnel availability, a DIM may be assigned on a full time basis. The DIM, often the existing PNA, will generally be responsible for integrating the various elements of the design and configuration control during the Preliminary and Contract Design phases. Specific duties include:

- Maintaining technical consistency among diverse disciplines contributing to the design
- Amplification and promulgation of the ship design philosophy and constraints
- Review of draft SOWs
- Review of technical products to ensure that final design products are internally consistent and meet the design engineering standards, CDD requirements, and the total system integration/optimization aspects in conjunction with the SEMs
- Development of margin and allowance policies, design budgets and design standards, as well as the monitoring and control of margins and allowances
- Identification of areas of high technical risk
- Development and implementation of CM procedures
- Preparation of the design histories

The DIM is often responsible for total ship risk assessment and preparation of the risk management plan elements.

The DIM works with the Specification Manager in the development of the Ship Specifications.

Integration is an interactive and iterative process, dependent upon trade studies and analyses performed by specialists in the various relevant technical disciplines. The integration objective is to achieve the "best" combination of subsystem performance that enables accomplishment of desired capabilities of the total ship system within the bounds of defined economic, human performance, and technological constraints. Within this context, the DIM will be responsible for the following additional tasks:

- Perform engineering analyses of customer mission and performance requirements to define whole ship attributes in engineering terms
- Perform engineering studies leading to the allocation of whole ship attributes to ship systems in terms of design direction, performance, configuration, space and weight, and arrangement
- Perform design and engineering studies to identify the degree of ship systems integration required to meet the ship mission
- Perform analyses to assure that all design proposals (or changes) affecting whole ship performance and other functional systems meet established requirements and constraints, properly interfaced in respect to the various whole ship "ilities"
- Perform continual review and analysis of the developing design to assure that the ship is functionally balanced and integrated in terms of distribution and location of functions, seaworthiness and sea kindliness, mission suitability (reaction, survivability), and performance
- Identify ship system characteristics and capabilities of alternative system configurations

W.3 SHIP CONCEPTS MANAGER.

The SCM is directly responsible for establishing the foundation upon which a successful ship design project and final design package can be built. In that context, a typical effort undertaken by the SCM is to support the JCIDS-defined pre-Milestone A tasks associated with the development of a CBA and ICD and sometimes the AoA. He then translates the insights and knowledge gleaned from that involvement to later stages of the program, so as to further the SDM's ability to be fully responsive to those analyses.

W.4 PROJECT NAVAL ARCHITECT.

A PNA may be assigned to assist the SDM. The PNA reports to the DIM and provides assistance with vessel design integration and configuration control. The primary focus areas for the PNA relate to hull form, hull strength, hydrodynamics, sea keeping and survivability, stability, structures, arrangements, habitability, lifesaving and mooring systems, and cargo handling systems. The PNA is the principal for review and oversight of the Shipbuilder's effort for the focus areas above and for deck systems development. The PNA coordinates review by the government team members at the system and subsystem levels.

W.5 PROJECT MARINE ENGINEER.

A PME may be assigned to assist the SDM. The PME reports to the DIM and provides assistance with machinery design integration and configuration control. The primary focus areas for the PME relate to propulsion, power generation, and auxiliary systems. The PME is the principal for review and oversight of the Shipbuilder's effort for systems development and coordinates review by the government team members at the system and subsystem levels.

W.6 SYSTEM ENGINEERING MANAGERS.

SEMs integrate and represent systems level elements of the ship design such as hull systems, machinery systems, combat systems, aviation, C4ISR, and others, as the design demands. Each SEM is responsible to the SDM, associated SIM and TWHs, and their respective Group Directors for providing a fully developed and properly integrated system that meets the operational requirements of the ship design. SEMs assume the responsibilities of the functional groups they represent to make priority, technical, and financial decisions that are consistent with the established line management technical policies, practices, and standards. More specifically, for a given ship design they are responsible for planning, management, and all technical activities; for keeping their portion of the design within the allocated weight and fiscal budgets without sacrificing technical performance; for ensuring that final products meet accepted design criteria and practices and meet the operational requirements as well as whole ship requirements; and for administration and control of funds within their respective areas of responsibility.

W.7 SPECIFICATION MANAGER, SPECIFICATION TASK MANAGER, SPECIFICATION EDITOR, AND REQUIREMENTS TRACEABILITY MANAGER.

SEA 05S is responsible for establishing policy and procedures for developing program-unique specifications and managing the development of Ship Specifications and processes for Navy ship and submarine acquisition programs. A SEA 05S representative, as the Specification Manager, normally oversees Ship Specification preparation including scheduling, circulation, and issuing the associated planning documents.

The Specification Task Manager's (STM's) primary responsibility is technical integration of the Ship Specification. This includes integration of reference documentation such as military and commercial standards. The STM must be familiar with all aspects of the ship design. The STM leads a small Specifications Team that includes the Specification Editor, the Requirements Traceability Manager (RTM), and the Data Manager for DRL development. The STM and Specifications Team are jointly responsible for requirements traceability, ensuring that specification requirements are measurable and testable, preparation of data inputs for the DRL, and coordination of the change control process.

The Specification Editor performs the administrative editing tasks associated with development of the Shipbuilding Specification, including establishing and periodically updating the baseline Shipbuilding Specification in the IDE, providing necessary specification information to the Requirements Traceability Manager (RTM), operating visual aids during the Reading Sessions and ensuring specification changes have been properly processed. The Specification Editor, as a member of the Specifications Team, reports to the STM.

The RTM is responsible for managing the flow down of requirements (traceability) through each phase of the program and managing the software (like the Dynamic Object Oriented Requirements System) being used to capture, analyze, and trace the requirements. The RTM obtains periodically the latest revisions to the Ship Specification from the Specification Editor to ensure continuous traceability of requirements evolution.

The Data Manager is responsible for preparation and processing of the DRL and corresponding Data Items (DIs) for all tasking statements in the Shipbuilding Specification. The Data Manager, as a member of the Specifications Team, reports to the STM and also normally to the Program Logistics Manager.

W.8 ENVIRONMENTAL, SAFETY AND OCCUPATIONAL HEALTH AND/OR SAFETY MANAGER.

An ESOH and/or Safety Manager will be assigned. A separate Principal for Safety may also be designated to handle explosives safety including Weapons System Explosives Safety Review Board (WSESRB) certification. Note that for NAVSEA Programs the Principal for Safety may assume both the ESOH and Safety Manager roles. The Program must ensure the design meets all system safety requirements and that all mishap (environmental, safety, and occupational health) and risks are identified for the full life cycle of the ship per MIL-STD-882. The Safety Manager will propose mitigation plans to reduce unacceptable risks identified in the Specifications, Shipbuilder concepts, Detail Design, process development, production, system test, and evaluation during the life cycle of the ship. Lessons learned from similar systems and systems of systems will be used during these evaluations. Risks will be identified through a working group and handled through the formal risk management process.

W.9 TASK LEADERS.

TLs are part of the technical core of the Design Team and are responsible to the SEMs for the execution of their parts of the various tasks. They are designated by and are jointly responsible to the TWHs and their cognizant SEM for technical content. They are responsible to the SEM also for adherence to the schedule within allocated funds and manpower, and final product development of their tasks. They provide the SOWs for their respective tasks; coordinate and monitor supporting functional codes as the design develops; ensure that concurrent RDT&E programs are compatible with their respective design areas; ensure that all reports, studies, and products prepared by other activities that are forwarded for review and comment get proper staffing; and make certain that an adequate technical response is formulated. The TL is the risk manager for any high or moderate risk areas in her area of responsibility.

W.10 INTERFACING TECHNICAL WARRANT HOLDERS AND OTHER SUBJECT MATTER EXPERTS.

Selected TWHs and other SMEs will be needed to review the technical products and participate in certification of the ship and or systems. SDMs and SIMs must ensure timely and productive participation by the TWHs and other experts from the NAVSEA, Naval Air Systems Command (NAVAIR), Space and Warfare Systems Command (SPAWAR), Naval Supply Systems Command (NAVSUP), ABS, MSC, Bureau of Medicine and Surgery (BUMED), Naval Safety Center, Board of Inspection and Survey (INSURV), PEO C4I, PEO IWS, Marine Corps Systems Command, Marine Corps Combat Development Center, Naval Laboratories, U.S. Coast Guard (USCG) and other applicable activities. These may or may not serve as SEMs or TLs. Relationships should be formalized and written tasking provided no later than conduct of the AoA. In the past, failure to establish and maintain agreement on required budget, personnel assignments, deliverables, and schedule have repeatedly resulted in delay and disruption of the design process.

Efforts have begun to establish a “Virtual Systems Command.” These have included establishment of a topside integration council, joint SYSCOM engineering guide, joint air-ship integration guide, and design principles. SDMs and SIMs should become familiar with these references as they apply to a specific project.

As established in Virtual SYSCOM Joint Instruction 22A (NAVSEAINST 5400.97C) (*hyperlink*), technical warrants provide the authority, responsibility, and accountability to establish, monitor, and approve technical products and policy in conformance to higher-tier policy. Such individuals are entrusted and empowered to 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. The NAVSEA Commander is the technical authority for ships, weapons systems, and their supporting infrastructure. This technical authority is delegated to NAVSEA via SECNAVINST 5400.15C *(hyperlink)*. NAVSEA, in turn, assigns warrants to individuals within their areas of technical responsibility. These include SDMs, SIMs, TWHs, CHENGs, warfare systems engineers/chief systems engineers (CSEs), and cost engineering managers. TWHs will make authoritative decisions on technical matters, engineering practices, and processes related to the design, development, construction, testing, repair, operation, in-service support, and/or disposal of platforms, systems, or tools. They also will ensure that sound technical decisions are made in a manner that complies with higher-tier requirements, meets the needs of the responsible programmatic authority, and addresses risks, alternatives, and trade-offs as appropriate.

SDMs and SIMs lead systems engineering efforts for assigned platforms/systems, and are warranted to make integration decisions for them. SDMs lead the technical efforts of the Program Offices, including compliance with DoD/SECNAV 5000 series guidance.

In NAVSEA CHENG letter "Expectations for Technical Warrant Authorities" serial TAB/010 of 17 March 2008, all NAVSEA TWHs including SDMs and SIMs are directed to ensure that they promptly notify their DWO of significant or unusual events in their warranted technical areas. TWHs are fully accountable to their DWO and must keep their DWO informed of all significant events.

DWOs are directed to ensure that they maintain regular contact with their assigned TWHs to facilitate an open dialog on issues of significance, maintain overall situation awareness, and understand when senior management help is needed to ensure technical issues get resolved. At a minimum, DWOs shall discuss issues of concern with TWHs at least monthly. While monthly is established as a minimum periodicity, DWOs must consider many factors including complexity of issues, TWH experience, and the availability of a support network to assist individual TWHs when determining the frequency of contact. DWOs should also ensure that significant issues are promptly reported to the NAVSEA CHENG to ensure that the broader Research and Systems Engineering Competency is engaged as appropriate to assist in timely resolution.

SEA 05D ltr 5400 Ser 05D/031 of 13 April 2011 "FY11 SEA 05D Technical Authority Assessment Plan" (*hyperlink*), provides for the annual assessment of SEA 05D warrant holders as required by NAVSEA ltr Ser 05/014, 22 February 2010, Annual Qualification Assessment of Technical Warrant Holders in the NAVSEA Research and Systems Engineering Competency (*hyperlink*).

W.11 COST ESTIMATORS.

Cost estimating is critical to the performance of the AoA, subsequent milestones, and source selection. Higher authority needs to assess cost versus performance and establish suitable budgets. As the designated TWHs, SEA 05C personnel normally perform cost estimating for ship programs.

The SDM has the lead responsibility for providing design information to SEA 05C for the development of program cost estimates and to the DoD or Navy Cost Analysis Improvement Group (CAIG) for the conduct of their independent cost assessments and estimates to support the milestone reviews. SDMs participate in SEA 05C cost estimate peer reviews as the technical authority for the design characteristics used in development of the estimate.

The SDM must identify his SEA 05C counterpart, who is identified as the Cost Team Leader for the SDM's ship design project, early in each phase and establish a close working relationship. It has become common practice for the SDM to continue to support SEA 05C beyond the submission of design information – conducting ship work breakdown structure (SWBS) by SWBS reviews of the design data submitted and the associated assumptions for cost estimating.

W.12 GOVERNMENT FURNISHED EQUIPMENT AND INFORMATION MANAGERS.

GFE/GFI managers (also known as PARMs) must be brought into the design process by the SDM to verify the performance; space; weight; manpower, personnel, and training; and services impacts of their systems. The Program Office will formalize agreements with each PARM for budget, delivery schedule, and the development of installation control drawings and other GFI. GFE and GFI changes and delays in deliveries have caused significant disruptions to past shipbuilding programs.

The SDM is responsible for verifying that appropriate GFI is properly described, listed, and scheduled within the RFP. Before GFI is forwarded to the contractor, the SDM is responsible for reviewing it to ensure it does not conflict with the existing contract baseline. If conflicts are identified, the SDM shall work with the Program Office and PARMs to either change the GFI or the ship contract baseline as appropriate.

W.13 NAVAL REACTORS (SEA 08).

SEA 08 is the organization responsible for management of all aspects of design, acquisition, and maintenance pertaining to nuclear propulsion in U.S. Naval ships and submarines. They define maintenance requirements for reactor plant systems and components including modernization and configuration, and provide oversight to ensure compliance with established requirements at facilities approved for nuclear related industrial work.

W.14 REACTOR PLANT PLANNING YARD.

Reactor Plant Planning Yard (RPPY) is the organization responsible for managing the nuclear portion of the Integrated Management Plan. This includes evaluating and implementing reactor plant changes proposed by the Shipbuilders, ship, and Commander Naval Air Forces (CNAF). The RPPY is responsible for incorporating reactor plant lessons learned into the IMP.

W.15 NAVAL SURFACE WARFARE CENTERS.

Naval Surface Warfare Centers (NSWCs) are the Navy's full spectrum research, development, T&E, engineering, and Fleet support centers for ship hull, mechanical and electrical systems, surface ship combat systems, coastal warfare systems, and other offensive and defensive systems associated with surface warfare.

W.16 REGIONAL MAINTENANCE CENTERS.

Regional Maintenance Centers (RMCs) are primarily responsible for executing assigned maintenance for ships in their geographical region. The RMC has access to both standard and non-standard repair organizations. The focus of the RMC is to achieve coordinated utilization of resources, maintain adequate industrial capacity, and arrange for the industrial facilities needed to support projected work requirements.

The RMCs broker work items screened by the Type Commander (TYCOM) to the appropriate organization or activity for accomplishment. The RMC provides direct support to Fleet and TYCOMs in matters of waterfront technical assistance, maintenance training, and logistics services associated with the installation, operation, maintenance, and readiness of shipboard equipment and systems. They promote Fleet readiness and maintenance self-sufficiency in shipboard systems and equipment through direct technical help in troubleshooting, maintenance and repair, on-the-job maintenance training, logistics reviews, and technical documentation support.

“Regional Repair Centers” focus on a particular product line (e.g., motors) or technology (e.g., machinery). These shops were created to increase the proficiency level of maintenance personnel by focusing each maintenance group on a particular piece of equipment or technology.

Nuclear Regional Maintenance Department (NRMD), a subset of the RMC, provides project management, planning, training, and radiological control services to accomplish nuclear maintenance, modernization, and repairs. Some key areas where their support is essential for success are radiological support for primary detector alignment, radioactive waste handling, and RADIAC calibration support.

The RMC CHENG is responsible and accountable for all engineering, technical work, and technical decision-making accomplished by his or her assigned activities as defined by NAVSEAINST 5400.95E. Ship and work period specific MOAs are issued to delineate agreements between the RMC CHENG and other activities involved in the construction, conversion, and refit or repair work.

W.17 INTEGRATED DESIGN ENGINEERING ACTIVITY.

The Integrated Design Engineering Activity (IDEA) is an integrated team composed of the three primary aircraft carrier repair and modernization activities (Northrop Grumman Newport News (NGNN), Portsmouth Naval Shipyard (PSNSY), and Norfolk Naval Shipyard (NNSY)). The IDEA has changed traditional planning yard responsibilities and assigns planning products development to the executing yards for aircraft carriers undergoing availabilities. Under the IDEA, the executing yard bears sole responsibility for all design, planning, and execution for the assigned aircraft carriers.

W.18 NAVAL SUPERVISING AUTHORITY.

The Naval Supervising Authority (NSA) is that maintenance activity with overall responsibility for the proper planning and execution of the work package during a CNO - scheduled availability, including all contractor and Alteration Installation Team (AIT) work. The function of the NSA is defined in the *Fleet Modernization Program Management and Operations Manual (NAVSEA SL720-AA-MAN-010).* The NSA is also accountable to NAVSEA regarding the conduct of all work covered by the FMP.

W.19 CARRIER AND FIELD SERVICE UNIT.

The technical representative of NAVAIR and Naval Air Warfare Center Aircraft Division, Lakehurst, NJ (NAVAIRLAKEHURSTACDIV) in all matters which concern shipboard catapult, arresting gear, Visual Landing Aid (VLA) systems, Aviation Fuels (AVFUELS), and shore-based arresting gear. Carrier and Field Service Unit (CAFSU) team members are strategically and permanently located in Field Offices at aircraft carrier homeports and repair facilities. CAFSU is responsible for technical oversight during installation operations of Aircraft Launch and Recovery Equipment (ALRE) systems installed on-board all CV/CVNs and at shore installations. CAFSU provides onsite technical expertise to the CNAF. CAFSU team maintains technical liaison with naval shipyards, ship repair facilities in support of installation, operation, overhaul, maintenance, repair, testing, and certification of ALRE, VLA, and AVFUELS.

W.20 NAVAIR WARFARE CENTER VOYAGE REPAIR TEAM.

This is the activity responsible to provide depot level maintenance and emergent repair services to a variety of ALRE, VLA, and Air Capable Ship Aeronautical Equipment (ACSAE). This maintenance service is provided to operational Fleet activities worldwide and to shore based naval activities. These services include:

- Scheduled and unscheduled maintenance
- Repair or overhaul of installed aviation equipment and support systems
- Manufacturing of repair assemblies and equipment Installation of modernization

The Voyage Repair Team (VRT) organization and supporting infrastructure provide the aircraft carrier maintenance community with a trained and ready resource to correct deficiencies that directly impact the safety of flight and the ship's mission.

W.21 CARRIER TEAM ONE.

Carrier Team One is a group of experienced aircraft carrier maintenance professionals chartered by NAVSEA in 1994 to improve maintenance processes and strategies associated with aircraft carrier maintenance. Its membership of ship's force, Shipbuilder, and other supporting organizations provides new, unique perspectives of the maintenance process. Team One is a collaborative effort led by PMS 312, SEA 08, and CNAF. The initiatives are driven by deck-plate experience. Implementation is guided and assisted by the Executive Steering Committee. Team One's purpose is to define, champion, and improve cross-organizational processes for the planning and execution of carrier availabilities. Team One provides a structure for the management and long-term systematic improvement of cost, schedule, and quality performance. The means and measures for improvement will reflect the considerations of all affected parties, including, but not limited to, ship's force, TYCOMs, shipyards/Shipbuilders (public and private), NAVSEA, SPAWAR, and NAVAIR. The focus of Team One is the integration of the efforts of contributing organizations into an effective total process. Team One is neither a technical authority, nor a substitute for the proper execution of assigned responsibilities or process improvement programs internal to contributing organizations. Refer to the *Team One Manual* for additional information.

W.22 SHIP'S FORCE.

Ship's force has the overall responsibility for the maintenance and operations of all shipboard systems and equipment. Each ship has a maintenance organization that is clearly defined in the *Ship's Organizational and Regulations Manual (SORM).* In addition to the SORM, ship's force is responsible for all matters related to the Maintenance and Material Management (3-M) System that are delineated in the OPNAV 4790 series instructions.

W.23 NAVSEA FIELD REPRESENTATIVE'S OFFICE.

The NAVSEA Shipyard Representative's Office (NSRO) is responsible for independent oversight of Shipbuilder non-nuclear operations for adherence to NAVSEA standards and requirements, for oversight of ship safety, for assisting NAVSEA in working with the Shipbuilders to resolve issues that inhibit first-time quality work, and to assist improved performance by Naval Shipyards. NSRO responsibilities also apply to Shipbuilder work at remote sites and include those of engineering field representatives.

Each NSRO will:

- Provide independent review and assessment of Naval Shipyard/Shipbuilder non-nuclear operations
- Review and evaluate test procedures, testing, and ship conditions
- Assess implementation of corporate processes, procedures, and requirements
- Assist in resolution of problems
- Assist NAVSEA in understanding process problems that inhibit timely first-time quality during ship repair work
- Review and evaluate the shipyard/Shipbuilder's quality assurance (QA) program to ensure the program results in the requisite quality of work
- Review and evaluate engineering including compliance of technical work documents with NAVSEA requirements

W.24 NAVSEA ENGINEERING FIELD REPRESENTATIVES.

Engineering Field Representatives (EFRs) provide independent oversight of CHENGs and their associated waterfront maintenance activities engaged in engineering and the exercise of technical authority for commissioned ships. EFRs may also be assigned for CHENGs overseeing ships under construction. EFRs are assigned to the field to facilitate communication on technical issues between NAVSEA SDMs, Warrant Holders, and local region's RMC, TYCOM(s). Responsibilities include:

- Providing independent oversight of the exercise of technical authority
- Evaluating and assessing implementation and compliance with NAVSEA technical requirements, standards, processes, and policies
- Facilitating collaborative technical communications among the Navy technical community, Fleet TYCOMs, RMCs, Naval Shipyard/Shipbuilders, and other waterfront maintenance activities
- Advising NAVSEA technical leadership and engineering management on significant technical issues and technical core equities
- Providing on-scene assistance and independent oversight in support of SDMs and other TWHs
- Reviewing and processing field activity trouble reports

W.25 INDEPENDENT REVIEW TEAMS.

Conduct of design and technical assessments by independent review teams is recommended in areas where technical risks are high. Sources of independent reviewers include "graybeards," academia, professional organizations, and industry. The SDM must be an advocate for obtaining funding and establishing such teams when appropriate. An example is the special review team assembled to validate the use of the "FREDYN" ship motions program for the design of DDG1000, which has a novel hull form.

W.26 UNITED STATES COAST GUARD AND AMERICAN BUREAU OF SHIPPING.

All shipbuilding programs now minimize the use of military specifications and standards. Those ships crewed by the MSC normally make maximum use of commercial standards and construction practices. They are required to be built to ABS rules, classed by ABS and under USCG and Navy standards as applicable. MSC ships may be enrolled in the alternate compliance program in which ABS performs the majority of the USCG review for them. However, anytime a deviation from the USCG regulations is requested, ABS will forward a recommendation to the USCG, the flag state authority, who will make the final decision.

NAVSEA is now moving away from the use of ABS Naval Vessel Rules (NVR) to provide the core technical standards for naval combatants. Further detail will be provided in the next revision to this manual.

Advance contact with USCG on selected compliance issues should be accomplished. In particular, areas should be discussed early on where there is a question of the proposed ship not meeting the letter of ABS or USCG standards. A significant portion of an SDM's time can be spent sorting out conflicts between the requirements for the naval mission and commercial regulations. Some of the issues may be avoided by getting all participants involved early.

W.27 SHIPBUILDERS, INTEGRATORS, AND VENDORS.

Consistent with the acquisition strategy, industry should participate in the design process early to gain an understanding of Navy requirements, help identify cost drivers, incorporate producibility considerations, and ensure the clarity and consistency of the specifications. The SDM must work closely with the Program Office in determining the best approach for industry involvement.

Equipment vendors can be expected to approach the Program Office and SDM on a regular basis to try to influence equipment selection and development of the specifications. A selective approach to dealing with vendors should be developed. For example, many items will be selected by the Shipbuilder as part of the construction phase, so send the vendors to prospective Shipbuilders instead of taking the briefings directly. Similarly, technologies that are too far in the future for the program can be sent to the ONR. SDMs must guard their time carefully and not let it be monopolized by others' marketing efforts. Listen to a briefing only to become smart on a topic of interest, not because someone wants to talk to you. Learn to just say, "no" (thanks).

Informational briefings from Shipbuilders, integrators, and vendors can and should be taken following consultation with the NAVSEA Contracting Office. Those who demonstrate relevant interest should be invited to attend briefings to industry prior to request for procurement issues.

Extra care must be employed when dealing with vendors from foreign countries. Design information for the acquisition program usually cannot be revealed. Many countries have data exchange agreements with the U.S. and these may be employed to transfer data. An individual program may also set up its own exchange agreement established through the Navy International Programs Office. SDMs should consult SEA 05D/V and the Program Office before any involvement with a foreign company or government.

W.28 SUPERVISORS OF SHIPBUILDING.

SDMs should consider employing prospective Supervisor's Offices and their design divisions to leverage lessons learned for development of the specifications. This will also help establish relationships that will be important following DD&C contract award.

W.29 SUPERVISOR OF SHIPBUILDING CHIEF ENGINEER.

The SUPSHIP CHENG is responsible and accountable for all engineering, technical work, and technical decision-making accomplished by their assigned activities as defined by NAVSEAINST 5400.95E. Ship and work period specific MOAs are issued to delineate agreements between the SUPSHIP CHENG and other activities involved in the construction, conversion, and refit or repair work.

The responsibilities of the SUPSHIP CHENG for managing waterfront engineering include the following major tasks:

- Maintaining a matrix of the engineering work force, under the control of the SUPSHIP CHENG, sufficient in scope of engineering disciplines and technical specialties to support the overall program management organization and Administrative Contracting Officer (ACO) by providing technical support and direction to meet the requirements of the Technical Authority Warrant
- Assessing manning requirements to meet the requirements of the warrant in relation to the technical requirements of contracts
- Conducting an annual Technical Authority Capability Assessment (TACA) and providing the TACA assessment to SEA 05, the SEA 05 Field Representative (when assigned), SEA 04, and SEA 04Z. The TACA will include recommendations for resolving deficiencies in engineering disciplines, technical specialties, or manning levels.
- Offering support and recommendations to future and existing ship designs and participate in the design process, including Ship Specification development and specification readings
- Establishing an organization and process for adequate oversight where a contractor and government agency personnel are performing Planning Yard responsibilities

APPENDIX X
T-SHIP CONOPS

Executive Summary

Auxiliary & Special Mission ships (commonly referred to a "T-SHIPS") are generally procured for the MSC via a PEO Ships acquisition program. In accordance with the basic tenets of the NAVSEA Competency Aligned Organization, SEA 05 (the R&SE Competency) provides all required engineering and technical support to the NAVSEA affiliated PEOs. SDMs are the single point of contact with Program Offices for providing this engineering and technical support. This document provides process guidance and defines roles and responsibilities for interactions between the Program Office and the SDM through all phases of T-SHIP acquisition. It is not intended to be a narrowly prescriptive document but to provide a guide based on proven past practice and typical T-SHIP acquisition strategies. If alternate acquisition strategies are used the guidance will need to be tailored.

Key areas addressed are:

- Interactions with other TWHs
- Ship Specification review and approval
- Conduct of focused technical assessments at key program milestones
- Establishment of criteria for reviews
- Interactions with ABS
- Ship certification

The processes and reviews should be event driven, not schedule driven, and therefore establishment of measurable entrance and exit criteria is essential.

The goal is to have more consistent processes in order to better plan and execute the design management of T-SHIP programs.

This document provides process guidance and defines roles and responsibilities for interactions between the Program Office and the SDM throughout all phases of T-SHIP acquisition. It was developed to provide consistent processes in order to better plan and execute the design management of T-SHIP programs.

SEA 05 has issued Attachment (1) which establishes the SDM as the sole accountable technical authority for these ships.

T-SHIPs are defined as Naval Fleet Auxiliary Force, Sealift, Prepositioning and Special Mission ships that are procured by PEO Ships and have an SDM assigned. In the case of designs with no military mission like the AGOR, the processes will be tailored as appropriate and the focus is expected to be on higher risk technical and customer critical areas.

X.1 INTRODUCTION/OVERVIEW OF A T-SHIP PROGRAM.

T-SHIPs are generally operated by MSC. MSC provides the sea transportation component for the United States Transportation Command (TRANSCOM). TRANSCOM operates ships that provide:

- Combat logistics support to U.S. Navy ships at sea
- Special mission support to U.S. government agencies
- Prepositioning of U.S. military supplies and equipment at sea
- Ocean transportation of Department of Defense cargo in both peacetime and war

The ships are typically operated by civilian mariners or commercial contract crews and may have a detachment of military personnel. The primary mission of MSC is to provide ocean transportation of equipment, fuel, supplies and ammunition to sustain U.S. forces worldwide during peacetime and in war for as long as operational requirements dictate. During a war, more than 95 percent of all equipment and supplies needed to sustain the U.S. military are carried by sea.

By nature, T-SHIP programs are managed somewhat differently then U.S. Navy (USN) Ship programs because the end user, MSC, has different requirements and needs than the Navy Fleet.

T-SHIPS are organized into four groups, which are:

Naval Fleet Auxiliary Force – The ships of MSC's Naval Fleet Auxiliary Force (NFAF) provide fuel, food, ammunition, spare parts, and other supplies to Navy ships. NFAF ships enable the Navy Fleet to operate at the highest operational tempo possible. NFAF ships provide underway replenishment services to U.S. Navy ships worldwide alleviating the need for them to constantly return to port for supplies. NFAF is composed of Fleet ocean tugs, fast combat support ships, Fleet replenishment oilers, combat stores ships, ammunition ships, Rescue-Salvage Ships and Dry Cargo/Ammunition Ships (T-AKE) plus two hospital ships that are kept in a reduced operating status. Besides delivering supplies at sea, NFAF ships also conduct towing and salvage operations and serve as floating medical facilities.

Special Mission – MSC's Special Mission Program controls ships that provide operating platforms and services for unique U.S. military and federal government missions. Oceanographic and hydrographic surveys, underwater surveillance, missile flight data collection and tracking, acoustic surveys and submarine support are just a few of the specialized services this program supports. Special mission ships work for several different U.S. Navy customers, including the Naval Sea Systems Command and the Oceanographer of the Navy.

Prepositioning – As a key element of sea basing, afloat prepositioning provides the military equipment and supplies for a contingency forward deployed in key ocean areas before it is needed. The MSC Prepositioning Program supports the U.S. Army, Navy, Air Force and Marine Corps and the Defense Logistics Agency. Prepositioning ships remain at sea, ready to deploy, on short-notice, the vital equipment, fuel and supplies to initially support our military forces in the event of a contingency.

Sealift – The mission of the Sealift Program is to provide ocean transportation to the Department of Defense by meeting its sealift requirements in peace, contingency and war.

There are significant differences in the requirements invoked, logistics systems, operator training, age of crew, and crew size between MSC ships and USN ships. The most significant difference is the use of commercial requirements such as ABS Rules including Steel Vessel Rules (SVR), High Speed Craft (HSC) Rules, and High Speed Naval Craft (HSNC) Guide. The use of commercial requirements means that organizations such as ABS and USCG are involved in the review and certification of the design. It is MSC's prevailing practice that new T-SHIPS are ABS classed and receive a USCG Certificate of Inspection (COI). T-SHIPs may be procured to a mix of military and commercial requirements. If there are unique military missions and operations performed by some of these vessels, it may not be feasible to obtain a traditional COI. In the future, an "annotated COI" (annotated to reflect the use of military standards in select instances) may be an available alternative.

New T-SHIPs are generally procured for the MSC via a PEO Ships acquisition program with SEA 05 as the Technical Authority for the acquisition. Considering all the differences between T-SHIPs and USN ships, it is clear that the extent of TWH involvement should be different as well.

X.2 T-SHIP REQUIREMENTS DRIVERS.

Requirements Overview

T-SHIP specifications generally contain a mix of Military (Military Specification [MILSPEC]) and Commercial requirements with the goal of being as commercial as practical given the mission of the ship.

MILSPECS were written for the intended purpose of providing direction/rules/oversight for the application of approved equipment/materials and components to USN combatants in order to obtain an inherent survivability and retain mission capabilities in a combat environment. MILSPECs focus on end use survival and performance in a hostile environment. In NAVSEA, each MILSPEC is owned by a TWH who ensures that the MILSPEC is current and accurate. MILSPECs generally address equipment and component end items and materials – pumps, piping, steel, etc. In an effort to make ships more affordable and move toward open standards, many MILSPECs have been replaced with commercial standards. In some cases the MILSPEC became the industry standard. MILSPECs will only be used on T-SHIPS when there is compelling justification.

ABS Rules and USCG Regulations are written for commercial ship applications with the primary emphasis of safety of life at sea and the ability to withstand/survive the effects of the environment and errors by operating personnel. The principal requirements used in U.S. commercial ship construction are:

USCG regulations or the applicable codes of the U.S. Code of Federal Regulation (CFR). All U.S. Flagged vessels are required to comply with these regulations. Government owned ("Public") vessels are exempt.

SOLAS – Safety of Life at Sea regulations: International safety regulations administered by the International Maritime Organization (IMO). Rules are voted on by member states. USCG is the state authority for the U.S. on IMO matters. USCG requires compliance with SOLAS regulations for a vessel certificated for International voyages, over 500 GT, and all Passenger Vessels. Public vessels are exempt from SOLAS although the Navy has chosen to comply with SOLAS for many of the vessels operated by the MSC.

MARPOL – International Convention for the Prevention of Pollution from Ships: The MARPOL Convention is the international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The Convention includes regulations aimed at preventing and minimizing pollution from ships - both accidental pollution and that from routine operations. These regulations are administered by IMO. The regulations are incorporated into the Code of Federal Regulations (CFRs), and enforced by the USCG as the flag state authority as soon as they are ratified. MARPOL compliance is sought in almost all cases. Public vessels are exempt from MARPOL, but there are ramifications of invoking the public vessel exemption that may not be in the Navy's best interest (ex: foreign port access may be denied).

ABS Rules – ABS is a not-for-profit corporation that promotes safety and environmental protection for the marine industry. This is achieved through the establishment and application of technical standards, known as Rules, for the design, construction, and operational maintenance of ships and other marine structures. Classification is a process that certifies adherence to these Rules. ABS standards are jointly accepted "consensus" standards developed by industry and vessel owners/operators to meet affordability, reliability, function, and safety criteria. ABS is a member of the International Association of Classification Societies (IACS) and many of the rules are common with other classification societies.

Owner's Requirements – These are requirements not covered in the above mentioned regulations that include the vessels mission requirements and any performance enhancements desired by the owner. Owner's requirements may include additional commercial standards such as American Society of Testing Materials (ASTM).

T-SHIP specifications invoke some military standards in areas where no commercial equivalent exists such as underway replenishment, ordnance handling at sea, and shock. ABS standards are occasionally (but rarely) more stringent than MILSPEC standards and can often conflict with a military requirement. When conflicts occur, exemptions, waivers, equivalences, or some other form of approval is generally required from USCG in order to deviate from the commercial requirement and still maintain commercial certification.

Commercial requirements are frequently used even in cases where military standards do exist. T-SHIP requirements typically include commercial standards that differ from accepted Navy standards in areas such as accommodation, manning, and damage control.

X.3 PROGRAM INITIATION THROUGH RFP RELEASE.

The SDM is the sole accountable Technical Authority for Auxiliary and Special Mission Ships and is the direct interface between the Program Office and the NAVSEA technical community.

One of the first actions for the SDM is to identify potential "fenced areas" for the program. "Fenced areas" are typically Military Unique, Higher Technical Risk, and Customer Critical areas. The SDM will then need to make an initial determination of which TWHs will be asked to fully participate in the ship design efforts.

The following steps for determining TWH involvement in T-SHIP efforts will be followed:

- SDM will conduct a TWH Engagement Planning (TWHEP) Meeting.
- The SDM will brief ALL TWHs, ABS, and other SYSCOMs on the new ship program, including identification of proposed "fenced areas."
- TWHs/ABS/Other SYSCOMs provide input to SDM on "fenced areas" for Navy certification.
- SDM, in consultation with TWHs, finalizes "fenced areas" such as:
  - Military Unique (e.g., UNREP, C4I, Aviation, Ordnance Safety to deal with combat ready vehicles — areas with no applicable commercial std)
  - Higher Technical Risk (e.g., high speed catamaran hull form)
  - Customer Critical (e.g., clean power requirements, speed for the Army LMSRs)
- SDM receives concurrence on proposed "fenced areas" from the CSE Ships and documents those in serialized correspondence.
- Only TWHs for "fenced areas" will be required to participate in the Ship Specification development. Only TWHs for "fenced areas" will be required to certify their portions of the Ship Specification using Attachment 2 (sample Ship Specification "sign off" form.)
- SDM will be focal point for discussion of these issues with the Program Manager.
- The AEA with the Program Manager will include funding requirements for "fenced areas."
- If there are "fenced area" issues internal to SEA 05, they shall be adjudicated prior to Ship Specification release by CSE Ships, or SEA 05 if necessary.
- Other TWHs may be invited to provide comments during Ship Specification development.
- SDM will negotiate funding requests for TWHs consultation services and include them in the AEA (Note: funding may not be available).
- SDM will be the technical adjudication authority for any comments resulting from TWH consultation services.
- Non fenced area TWHs will not be required to certify the Ship Specification, <u>and will not be accountable.</u>

The top level contractual technical requirements are contained in the Ship Specification. The Ship Specification is developed by SEA 05 under the direction of the SDM. The Ship Specification is signed by CSE Ships and the Program Manager prior to release of the RFP.

The SDM must ensure that the Ship Specification, DRL, and Contract SOW are well integrated. The validation requirements must match the DRL and SOW in terms of the standards to be used for validation of the requirement and who will be the certifying authority.

For T-SHIPs that have more extensive military missions, it may be impossible to obtain a traditional COI because of numerous and significant conflicts between commercial regulations and the ship's military mission requirements. USCG and SOLAS regulations allow alternatives to be proposed. However, these alternatives must be proven to have an equivalent level of safety to that required by the regulations. It will likely be impossible to achieve a level of safety equivalent to that of a commercial ship that does not perform the military mission. For these cases, the ship will meet CFR and SOLAS regulations as much as practical. In areas where a commercial level of safety cannot be achieved, the SDM, in conjunction with the appropriate TWH(s), may (if approved by the appropriate authority) act as the Flag State Authority and approve the deviation from commercial requirements. Such actions must be coordinated with ABS to ensure that actions contemplated do not negatively impact the ability of the ship to receive a classification certificate. The SDM will use the appropriate authority (such as WSESRB for weapons handling) to ensure safety of operations.

A Ship Certification Matrix (SCM) shall be developed by the SDM in conjunction with the Ship Specification. The purpose of the SCM is to:

- Map certification requirements to documentation
- Minimize duplication of inspections
- Identify of the types of certification required
- Identify the certification agent(s)

The SCM identifies the organization that will be the primary POC for coordinating and overseeing certification efforts for a particular area. However, in order to satisfy all specified requirements, some systems may require certification and verification actions by more than one agency. In these cases, the primary POC will coordinate oversight. The SCM should be included with the RFP as guidance to be used by the Shipbuilder in development of their ship certification plan.

X.4 PRELIMINARY/CONTRACT DESIGN PHASE.

SDM interface with the Shipbuilder(s) during this phase will be determined by the Program Office and Contracting Officer. The involvement may be limited prior to DD&C contract award for competitive reasons. Typically, information can be provided to Shipbuilders as long as the same information is made available to all potential Shipbuilders in a timely manner. The Program Office and SDM will work jointly to determine the best method for providing the appropriate level of comments to be passed to the Shipbuilders during this phase.

At the completion of Preliminary Design and Contract Design, the SDM will conduct SETRs and/or Design Maturity Assessments (DMAs) to review the status and maturity of the design(s) with CSE Ships and appropriate TWHs. This assessment will review the current status of the design in accordance with design review criteria established in the *Ship Design Managers Manual*. The recommendations will be provided to the Program Manager. Typically some areas of non-compliance will be identified. In those cases, the requirement may be reemphasized and enforced, or a relaxation/change may be proposed if technically appropriate.

Shipbuilders typically develop a Shipbuilding Specification in response to an RFP for DD&C. A technical review panel is formed using experts from SEA 05, ABS, NSWC, MSC, NAVAIR, SPAWAR, and support contractors to review and comment on the Shipbuilder technical proposals, including the Shipbuilding Specification. The Shipbuilding Specification becomes part of the contract upon award of the DD&C contract. The Ship Specification (developed to support the RFP) remains part of the contract and is a higher order precedence than the Shipbuilding Specification. The Shipbuilding Specification shall be approved by CSE Ships and the Program Manager. For programmatic reasons, it will be difficult to obtain approval prior to contract award. However, the SDM will coordinate approval of "fenced areas" as soon as possible. An approved Shipbuilding Specification shall be one of the entrance criteria for the Critical Design Review which will occur during Detail Design.

All changes to the Ship Specification or the Shipbuilding Specification are approved by the SDM before forwarding to the Program Office for implementation. The SDM also provides technical interpretations of Ship Specification requirements.

X.5 SHIP DETAIL DESIGN AND CONSTRUCTION PHASE.

Communications with the Shipbuilder after DD&C award are less constrained, but must still be well documented. The SDM will typically be allowed direct contact with Shipbuilder counterparts to provide requirements interpretations and help resolve issues. The SDM will be the technical lead for the review of any proposed changes to the System or Shipbuilding Specification. The SDM will be the lead for all DD&C design reviews.

During DD&C the Shipbuilder will produce data deliverables that the government will review for compliance with contract requirements. Data items will also be submitted by the Shipbuilder to ABS for review and approval, as appropriate.

A PRR shall be completed prior to allowing the Shipbuilder to begin construction of the vessel. The SDM shall be a key participant in the technical assessment conducted during the PRR. The Shipbuilder should specifically address, and the SDM will focus on, the maturity of the ship design and the degree of completion of the detailed design drawings along with the maturity level of research and development efforts of any new technologies that will be used.

X.6 ROLES AND RESPONSIBILITIES.

X.6.1 Ship Design Manager. SDM responsibilities are covered in NAVSEA technical authority instructions and Section 3 of this manual. The following items have been excerpted as particularly relevant to SDMs assigned to T-SHIP Programs: Make integration decisions and ensure interoperability

- Support programmatic authorities and MSC by providing best value engineering and technical products
- Identify and evaluate technical alternatives, determine which are technically acceptable, and perform associated risk and value assessments
- Ensure technical products are in conformance with technical policy, standards, processes, and requirements (Where they are not, identify options and associated risks and, if appropriate, approve non-conformances or engineering changes in a manner that ensures risks are technically acceptable.)
- For operational systems that do not meet technical requirements, assess and recommend options and identify associated risks
- Provide leadership and be accountable for all engineering and technical decision-making including coordination with other government activities, such as NAVAIR and SPAWAR
- Promote and facilitate communications throughout the technical community to ensure appropriate individuals and organizations are aware of and involved in technical issues and technical decisions, and that all applicable technical requirements are identified and understood (For T-SHIP programs this will include ABS and USCG in addition to other Navy organizations like NAVAIR and SPAWAR.)
- Develop cost forms for SEA 05C use in establishing the vessel's cost
- Ensure lessons learned and best practices are strongly considered for implementation
- Apprise the Deputy Warranting Officer of significant engineering and technical authority issues, including technical disagreements that cannot be resolved with programmatic authorities
- Identify technical risk and provide mitigating strategies for reducing the risk to acceptable levels
- Report the status of certification via a serialized memo to SEA 05D. These reports will be provided once at 30 days prior to the Production Readiness Review, and then again monthly starting 6 months prior to Builder's Trials (BT) and continuing until BT is complete

The SDM has the responsibility to translate the CDD into Ship Specification language and to work with ABS and MSC to ensure the appropriate commercial requirements are integrated into the design and eliminate conflicts between commercial and military requirements. To the extent the SDM can influence CDD development; the document should clearly delineate the extent of military design features desired. The clearer the CDD is with respect to commercial and military areas, the easier it will be develop the Ship Specification.

The SDM is the Technical Authority for the entire ship. While outside organizations such as ABS may be listed as the certifying authority for particular areas of the ship, the SDM must ensure the certification provided by those organizations meets the ship's top level requirements or CDD. If the SDM disagrees with an approval or approach taken by an outside certification authority the disagreement should be presented to the Program Manager with a proposal to correct the situation. If the contract only requires certification from ABS, and not Navy approval, a technically justified change from the regulatory body approved solution may require a contract modification to implement.

The SDM ensures that technical recommendations are based on sound engineering vice schedule and cost related drivers. While the SDM must be fully supportive of the cost and schedule constraints of the Program Manager, technical recommendations are focused on technical performance, operational readiness, and safety. The SDM should propose a range of cost-effective, technically acceptable solutions to the Program Manager, and while recommending a preferred technical solution, be willing to accept any technically acceptable solution that does not compromise operational readiness, safety, or the top level technical performance requirements. If the Program Manager selects a path that is not technically acceptable, the SDM must raise the issue to SEA 05D and SEA 05.

Other more typical SDM responsibilities, such as technical team budgets and document development, are covered in the relevant sections of the manual.

X.6.2 SEA 05 Technical Authorities. The SDM is the sole technical interface with the Program Manager. As T-SHIPs are built largely to commercial regulations, accountable TWH interface is limited to "fenced areas" as discussed above. SDMs interface with other TWHs to ensure consistency in selection, interpretation, and implementation of technical requirements and policies. TWH input may be sought when there is an issue with meeting a military (non ABS) requirement or a requirement interpretation is needed. TWHs are not generally involved with the day to day review of the design. The SDM's technical team, SUPSHIP, and MSC (and TWHs as needed) perform the function of monitoring compliance with the specifications. X.6.3 American Bureau of Shipping. The SDM should arrange meetings with ABS early on in the Program to ensure an understanding of the technical requirements, expectations relative to operational environments and special features of the design.

Program Initiation through RFP Release & Preliminary/Contract Design Phase – The SDM will use the support of the ABS Government Operations Office to provide interpretations of commercial regulations and to assist in resolution of conflicts between commercial and military requirements. The ABS Government Operations Office will be an active participant in the SDM's technical team throughout the acquisition. The SDM will coordinate funding for the ABS Government Operations Office for direct support to the SDM. This support includes:

- Participation in the development of the Ship Specification and ship certification matrix
- Input on the various Class notations for applicability and resulting impacts to the program
- Interpretation of ABS, SOLAS, USCG, and MARPOL regulations
- Notification of new regulations that may impact the program
- Interface with USCG when required

Ship DD&C Phase – The ABS role in this phase is to review the design and ensure it is in compliance with applicable ABS Rules and other Class Notations invoked in the contract. If invoked, ABS will review the design for compliance with SOLAS and MARPOL requirements. After contract award, the SDM will not correspond directly with ABS Americas (Houston). The ABS Government Operations Office can contact ABS Americas (Houston) on behalf of the SDM to obtain information. ABS Americas (Houston) is usually contracted by the Shipbuilder and correspondence is between the Shipbuilder and ABS with copies provided to the government for information. ABS will provide copies of all correspondence they generate directly to the government. E-mail and telecon records are also considered correspondence and must be furnished to the government. Timely distribution of correspondence is essential. This requirement should be in the contract statement of work. A sample DRL is provided as attachment (3). The SDM will rely heavily on the Program Office being proactive and vigilant in enforcing the contract requirements for correspondence.

The local Shipbuilder ABS representative and appropriate representatives from ABS Americas (Houston) should be invited to all design reviews. ABS should have a specific design review agenda item and an unconstrained speaking role to discuss overall classification status and classification issues. The Shipbuilder should have no authority to alter the information presented by ABS. ABS should be an active participant in any Working Groups established to resolve regulatory issues.

X.6.4 USCG. USCG issues the COI for US Flagged Vessels for compliance with applicable requirements in the Code of Federal Regulations. However, it may be impossible to obtain a traditional COI for some T-SHIPs because of the numerous and significant conflicts between commercial regulations and the ship's military mission requirements. The USCG Marine Safety Center performs plan review on key drawings and calculations, depending on whether the vessel is in the Alternative Compliance Program (ACP) or not. Under ACP, a vessel is reviewed and inspected by ABS acting on behalf of USCG. ABS makes a recommendation to USCG that they issue a COI. Although ABS performs the plan review, issues involving interpretation or equivalence determinations of SOLAS and MARPOL regulations must go to the USCG for final determination. ABS may provide the interface with USCG on these matters. As the U.S. representative to the IMO, USCG is the designated Flag State Authority for implementation of international safety and pollution standards.

Program Initiation through RFP Release & Preliminary/Contract Design Phase – The SDM should have early contact with USCG Marine Safety Center to provide them with an understanding of the ship and receive feedback on potential hard spots with regulatory compliance. While it may be somewhat useful to try and gain upfront concurrence on a particular aspect of the design, USCG Marine Safety Center is a detail plan review organization and final concurrence may not be achievable until the design details are completed.

Ship DD&C Phase – After DD&C award, the Shipbuilder interfaces with USCG to obtain plan approval for those items requiring USCG review. If the Program is enrolled in ACP, then ABS performs the plan review on behalf of USCG. ABS interfaces with USCG on matters of interpretation and equivalent level of safety determinations.

X.6.5 Other Government Activities (NAVAIR, SPAWAR, Marines, Army, etc.). The SDM will require extensive contact and interactions with engineering counterparts at other government activities (OGAs), especially in support of the standard Net Ready KPP required by ship CDDs, and any ship required to interface with aviation assets. Formal teaming arrangements should be established early in the acquisition process, with the goal of creating a multi-functional Design Team, led by the SDM with dedicated representatives assigned by OGAs. It is recommended that key OGA reps be collocated with the SDM, at least part time, when there is a requirement for significant interface. OGAs will be responsible for identifying system requirements, coordinating acquisition of GFE, and providing ship interface control documents necessary to support their equipment. The SDM, assisted by the OGAs, must determine the interface and certification requirements and documents the process in an attachment to the construction contract as early as possible. Additionally, roles and responsibilities will need to be worked out and formalized in Memorandums of Agreements. After interface and certification requirements are pinned down, the SDM will continue to work with select OGAs to resolve outstanding design, construction and support issues.

X.6.6 Military Sealift Command. MSC is the operator and maintainer of T-SHIPs after they are delivered. As such, they are an important customer of the SDM. MSC should be integrated into the SDM’s technical team to review and comment on all technical products. This includes early products such as the Ship Specification and other deliverables throughout the design and construction process. MSC can provide a commercial operator perspective that is not typically available within the NAVSEA community. It is recommended that each T-SHIP program have a full time onsite MSC representative who is integrated into the SDM’s technical team for review of technical products both before and after DD&C award. They should also be part of the proposal evaluation team.

During DD&C, MSC will typically provide one or more Owner’s Representatives (MSC-OR) on site at the Shipbuilder. If MSC-ORs are onsite they may be integrated into the SDM’s technical team in the same way SUPSHIP engineers are integrated, to provide technical review of data items, onsite review of construction issues and onsite interface with Shipbuilder engineers.

X.6.7 Shipbuilder. The Shipbuilder should be involved in the program as early as possible. The Shipbuilder’s DD&C experience will be valuable during early stages to the extent allowed by the acquisition strategy and the need to maintain competition/protect proprietary information.

For T-SHIP programs, the Shipbuilder, or their design agent, develops the Shipbuilding Specification. The Shipbuilding Specification provides greater detail and the “how” in response to the Ship Specification. The Shipbuilding Specification should be developed prior to, and be the primary technical basis for, DD&C award. The more review and comment iterations of the Shipbuilding Specification that can occur between the SDM’s technical team and Shipbuilder, the better the specification will be, reducing the risk of expensive changes in the future.

Communication during and after design reviews that are held prior to DD&C award may be constrained due to competition. A government only meeting should be held just after each design review to agree on comments to be provided to the Shipbuilder. These comments are then provided verbally to the Shipbuilder right after the government only meeting and then provided in writing via letter from the contracting officer. Typical comments include items where it appeared the contract was not being met as well as pointing out notable strengths and weaknesses in the Shipbuilder’s design. Suggestions for possible solutions are not provided if in a competitive phase.

The shipbuilding contract shall include a requirement that the Shipbuilder concurrently provide to the government one copy of all submittals sent to ABS. The clause shall also require ABS to provide copies of all correspondence they generate directly to the government. These requirements and specific timelines will be spelled out in the appropriate DRL. (see attachment 3 for a sample DRL.)

X.6.8 Supervisor of Shipbuilding. SUPSHIP may play a vital role in monitoring the design and construction of the ship after DD&C contract award. The SUPSHIP staff may be integrated into the SDM's technical team to support review and comment of Shipbuilder technical data items particularly for a lead ship. An IDE will help provide seamless integration for SUPSHIP and SDM's technical team reviews. SUPSHIP can also interface directly with Shipbuilder design engineers to help resolve issues and make sure government concerns are understood. The SDM can request SUPSHIP assistance to resolve issues that may require onsite interface with the Shipbuilder or hands on review of an item already under construction. SUPSHIP personnel will also request the SDM's assistance in determining whether or not a particular design solution being pursued by the Shipbuilder meets the intent of the specifications.

X.7 RESOLUTION OF TECHNICAL ISSUES.

X.7.1 Conflicts in Requirements (Regulatory and Navy). In cases where hybrid (mix of commercial and military) certification requirements exist, a Tactical Problem Solving Working Group composed of USCG, ABS, Shipbuilder, MSC, NAVSEA, SUPSHIP, and Program Office representatives should be required in the contract statement of work.. Sample statement of work wording is provided in attachment (4). This group should meet as needed to resolve issues and conflicts between commercial and military requirements. This group can substantially shorten the resolution process and make sure all organizations are in sync with the proposal put forward. The Working Group will evaluate the factors associated with regulatory requirements for the program in a disciplined and structured manner and will share information and solutions.

X.7.2 Other Technical Issues, Design Problems. Technical issues that are not regulatory in nature shall be handled between the SDM and the Shipbuilder, using established procedures. In cases where the Shipbuilder is seeking relief from a particular Ship Specification requirement, the SDM will carefully review each issue, consulting with the TWH as appropriate. The final resolution should be coordinated with the Program Office and an ECP, RFW or RFD should be processed, if needed.

X.7.3 Documentation of Technical Decisions. Significant technical decisions will be documented using an agreed upon DDM approach, and/or official, serialized memorandums as appropriate.

X.8 SUMMARY.

Auxiliary & Special Mission ships (commonly referred to a "T-SHIPS") are generally procured for the MSC via a PEO Ships acquisition Program. In accordance with the basic tenets of the NAVSEA Competency Aligned Organization, SEA 05 (the R&SE Competency) provides all required engineering and technical support to the NAVSEA affiliated PEOs. SDMs are the single point of contact with Program Offices for providing this engineering and technical support. This document provides process guidance and defines roles and responsibilities for interactions between the Program Office and the SDM through all phases of T-SHIP acquisition. It is not intended to be a narrowly prescriptive document but to provide a guide based on proven past practice and typical T-SHIP acquisition strategies. The goal is to have more consistent processes in order to better plan and execute the design management of T-Ship programs.

T-SHIP CONOPS Attachment 1
SEA 05 Policy for Executing Technical Authority on Auxiliary and Special Mission Ship Designs

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

IN REPLY TO

5400
Ser 05D/183
01 May 08

MEMORANDUM

From: SEA 05
To: SEA 05 Group Heads and Division Directors

Subj: EXECUTING TECHNICAL AUTHORITY ON AUXILIARY AND SPECIAL MISSION SHIPS

1. Effective immediately, the SEA 05 policy concerning the execution of technical authority for auxiliary and special mission ship designs is as follows:

- The SEA 05D Ship Design Manager (SDM) is the sole accountable Technical Warrant Holder (TWH).
- Only the SDM and Chief Systems Engineer (CSE) SHIPS will certify and sign the specifications.
- The SDM will identify "fenced areas" of the specifications (if any) such as pure military requirements (ex: UNREP, C4I, ATFP), higher technical risk areas (ex: firefighting to deal with combat ready vehicles), and customer critical areas (ex: Army requirement for speed on LMSRs).
- Fenced areas will be documented in a memo from the CSE Ships to the Deputy Warranting Officers and leadership within the R&SE competency.
- The SDM must engage appropriate TWHs for fenced areas
- The SDM may consult TWHs for other areas on an "advice only" basis.

2. Background/Justification: Auxiliary and Special Mission ships designs are inherently lower risk and represent the "third tier" of technical complexity in the R&SE portfolio (1st tier = nuclear powered ships, 2nd tier = USN combatants). To a large extent, the requirements are already "pre-engineered" (ex: ABS Steel Vessel Rules, CFR, SOLAS, IMO, IEEE, ASME, etc). The American Bureau of Shipping certifies ~80%+ of the ship in

Subj: EXECUTING TECHNICAL AUTHORITY ON AUXILIARY AND SPECIAL MISSION SHIPS

support of the "Classing" process. Using the SDM as the sole accountable TWH is an effective, efficient, and risk appropriate use of SEA 05 resources.

3. Intent: TWHs are not being excluded. There will be technical risks and technical challenges that need to be addressed. The SDM is accountable for engaging the appropriate TWHs for help making the "hard calls".

4. Action: SEA 05D will develop a process description suitable for incorporation into the Technical Authority Requirements Manual (which is under development), and the existing Ship Design Manager's Manual.

K. M. MCCOY
Rear Admiral, U.S. Navy
Chief Engineer

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T-SHIP CONOPS Attachment 2
Review and Release of Ship Specification "Fenced Areas"

From: TWH for fenced area: ______________________________________

To: SDM for ____

SUBJ: REVIEW AND RELEASE OF SYSTEM SPECIFICATION "FENCED AREAS"

1. I have reviewed "fenced area" portions of the Ship Specification and associated references that are applicable to my technical warranted area, and I make the following certification: (check one)

____a. **<u>CERTIFY W/O RESERVATIONS</u>**.

I certify that the Ship Specification and associated references for my warranted area meet the intent of the Program's Capability Development Document (CDD), and concur with the release of the specification.

____b. **<u>CERTIFY CONTINGENT ON RESOLVING RESERVATIONS</u>**.

I certify that the Ship Specification and associated references for my warranted area meet the intent of the Program's Capability Development Document (CDD), and concur with the release of the specification with the reservations noted in the accompanying write up.

____c. **<u>DO NOT CONCUR WITH RELEASE</u>.**

I do not concur with the release of the specification for reasons as noted in the accompanying write up.

Signature	**Code**	**Date**
Warranted Technical Authority		
CTA/Group Head		

T-SHIP CONOPS Attachment 3

Sample Data Requirements List for Regulatory Body Correspondence

PHASE II DATA REQUIREMENTS

CONTRACT NO.: N00024-07-R-2219 CLIN: 0006 CONTRACTOR:

BLOCK 1 – DATA ITEM No.: DI-B080

BLOCK 2 – DATA ITEM TITLE: REGULATORY BODY COMMUNICATIONS

BLOCK 3 – REFERENCE: SOW C 4.2.4.20 xxx

BLOCK 4 – DD FORM 250 REQ: LT

BLOCK 5 – DATA DESCRIPTION

1. Provide copies of all incoming and outgoing communications on technical matters, including attachments/enclosures, between the contractor and Regulatory Bodies and Subcontractors and the Regulatory Bodies in accordance with the Contract. Where possible, all copies shall be provided in electronic format.

2. Communications include letters, faxes, memos, electronic mail, and memos of phone conversations. Attachments/enclosures include drawings, sketches, photographs, slides, viewgraphs, presentations, specifications, manuals, studies, analyses, requests for change of class, applications for inspection, Contracts, scopes of work, and related communications.

3. Communications shall be assigned serial numbers and shall be indexed by the serial numbers and applicable dates. A cross-reference shall be made from contractor assigned serial numbers to actual incoming communication's serial numbers, where applicable.

BLOCK 6 – REVIEW REQ.: Allow 14 days for government review and comment, if provided.

BLOCK 7 - SUBMIT TAL SCHEDULE: 3 days after incoming or outgoing communications have been issued or received; R/ASR 3 days after incoming or outgoing communications have been issued or received.

BLOCK 8 – DISTRIBUTION:

Addressee	Reg/Repro
SUPSHIP	0/1
PMS385	0/1
NAVSEA 05D/V	0/1

T-SHIP CONOPS Attachment 4

Sample Statement of Work Wording for Tactical Problem Solving Working Group

C-42 TACTICAL PROBLEM SOLVING WORKING GROUP (applicable to Phase II)

The contractor shall be an active participant in support of the PEO Ships (PMS385) MPF(F) MLP Tactical Problem Solving Working Group (WG) during the DD&C to support cost-effective resolution of regulatory issues in regards to design, construction and certification of the vessel in accordance with the requirements. The WG shall consist of members of the following organizations that are empowered to make decisions and commit resources on behalf of their organizations. The Navy, MSC, ABS and the contractor will assign permanent representatives and alternates. The WG will meet bi-weekly via telephone and semi-annually at the contractor's facility. The WG will analyze the issues and risks that arise during the performance of the contract, evaluate alternative solutions, and propose and recommend solutions. The WG will evaluate all of the factors associated with regulatory requirements for the program in a disciplined and structured manner and will share information and recommended solutions in order to assist in resolving the issues.

APPENDIX Y
PRESENTATION GUIDELINES

Title Slide

- Who gave the briefing
- The date of the briefing
- Include NAVSEA logo
- Good descriptive title
- Who you are giving the brief to (optional)
- Classification and/or Distribution Statement

All Follow on Slides

- Classification and/or Distribution Statement
- Date of the briefing (at least month and year)
- Page Number
- NAVSEA Logo
- Last name of presenter (optional)

First Slide (possibly two)

Address the following:

- Is this for information or is a decision needed?
- Make sure the audience knows what level of their participation is required.
- What is the issue?
- What is the answer?
- What is the urgency of the issue?

Outline Slide

- Provide an outline for the remainder of the presentation.

Follow On Slides

- Treat each slide as a paragraph – one distinct message per slide.
- The message for each slide should be clear – possibly use bumper stickers.
- The message of the succeeding slides should follow a logical progression to support the conclusions or provide the background for making a decision.
- Use images instead of words where possible.
- Only include information needed to convey the message – eliminate distracting details.
- In general, don’t repeat information unless you have a good reason.

Decision Slides

- If a decision is needed, include a decision slide in the appropriate place in the presentation.
- The decision slide should clearly articulate the decision needed and provide check boxes next to the different options.
- During the presentation, consider checking the box for the decision made and have a decision official sign the slide.

Closing the Presentation

- Should include a summary – restate issue and the answer.
- If a decision presentation, review the decision made.
- If applicable, should include "what's next."

Notes

- The reasons for putting the answer up front include:
  - Many times you'll only have a fraction of the time you originally thought you had. If you get the answer out at the start, you make sure you have conveyed your message.
  - By knowing the answer, the audience has the framework to interpret the rest of the slides. Hopefully, you'll stop the tendency of the audience to wonder where the presentation is leading them. Many times, your audience will focus on a specific aspect of the solution; this gives you the opportunity to jump to the appropriate slide in the presentation (or even to a backup slide if necessary).
- Many engineers structure their presentation like a photo-album; they present their journey through the study. Unfortunately, while this may be interesting to the presenter, it's not effective in rapidly conveying information. Only that information which is central to the conclusions made by the presentation should be incorporated. The presentation should be structured around the conclusions, not the process used to develop the conclusions. In other words, the presentation should be like a story, but the plot of the story should be the topic itself, not the analysis of the topic.
- If data is of questionable quality or does not directly address the issue at hand, leave it out.
- You must be honest. DO NOT suppress information that appears to run counter to your conclusions. Rather, show the information and give the reasons why you believe the information does not invalidate your conclusions.
- Never include any data that you don't understand or can't clearly explain.
- Don't read the slides, tell the story.
- Use page numbers on all slides. For CM reasons, also consider putting the date and filename on all slides. Adding organizational logos to every slide further helps ensure that the originator of a hard copy slide that's been faxed multiple times can be determined.
- Have a good understanding of the accuracy of your results.
- When comparing results on options, you need to focus on statistical significance of the differences. If numbers are presented, ensure precision of display does not exceed the accuracy of the metric. Don't claim one option is better than another if the differences in the metrics are not statistically significant.
- Provide interpretations of results. What generalized lessons can be learned? Often we aren't concerned with the particular details of the concept studied; rather we are interested on what is learned to impact decisions at hand. Are the results a function of the details or can they provide the generalized answers?
- Don't use too many slides. Use the fewest necessary to make your point. In no case should you have more than 1 slide per minute of presentation. Ideally, the ratio should be about 1 slide per 2 to 3 minutes – it allows you to tell the story and allows the story to be heard instead of just "getting through the slides."
- One should strive to have an engineering level of detail about an order of magnitude greater than that which is presented. This helps ensure that what you present has a solid foundation, not just a fantasy, and can likely remain accurate even if one of the lower level details is found to be inaccurate. The increased level of detail could be included in backup charts, should questions come up.
- If you use data generated by another study, make sure you reference that other study.
- If you use color slides, make sure the message still can be determined if it is photocopied or printed in black and white.

APPENDIX Z
TECHNICAL REPORT AND DESIGN REPORT FORMATS

The general format for a technical report is defined in Data Item Description DI-MISC-80711 which in turn specifies that reports should be in accordance with "ANSI/National Information Standards Organization (NISO) Z39.18 Scientific and Technical Reports — Elements, Organization, and Design." The following format is consistent with ANSI/NISO 7.39.18 and should be considered the minimum standard for reports (Additional elements from ANSI/NISO 7.39.18 should be included as needed):

Title Page with authorship statement, signatures, and distribution statement

Report Documentation Page (Standard Form [SF] 298)

Abstract

Table of Contents

List of Figures and Tables

Executive Summary

1.0 Introduction

1.1 Objectives
1.2 Approach
1.3 Key Assumptions
1.4 Background

2.0 Related Requirements

3.0 Evaluation Procedures (including identification of tools and tool versions used)

4.0 Alternatives

5.0 Results and Discussion

6.0 Conclusions/Recommendation

References

Appendixes (including electronic data files for analysis tools)

List(s) of Symbols, Abbreviations, and Acronyms

TYPICAL DESIGN REPORT OUTLINE (consistent with ANSI/NISO Z39.18)

Title Page
SF 298, Report Documentation Page
Abstract
Table of Contents

4.5.3 Space

4.6 Stability and Hydrodynamic Performance
4.6.1 Reserve Buoyancy
4.6.2 Damage Stability
4.6.3 Intact Stability
4.6.4 Seakeeping and Maneuverability
4.6.5 Powering Estimate
4.6.6 Dynamic Stability

4.7 Systems Engineering
4.7.1 Survivability
4.7.2 Supportability
4.7.3 Reliability, Maintainability, and Availability
4.7.4 Costs (RDT&E, Acquisition, and Life Cycle)
4.7.5 Electromagnetic Compatibility
4.7.6 Measures of Effectiveness (MOE)
4.7.7 Human Systems Integration
4.7.8 Design Tools Used
4.7.9 Design for Producibility
4.7.10 Design for In-Service Cost Reduction
4.7.11 Design Certification Approach

5. SUBSYSTEM DESCRIPTIONS

5.1 Hull Structures	ESWBS 100
5.2 Propulsion Plant	ESWBS 200
5.3 Electric Plant	ESWBS 300
5.4 Command and Control	ESWBS 400
5.5 Auxiliary Systems	ESWBS 500
5.6 Outfit and Furnishings	ESWBS 600
5.7 Armament	ESWBS 700
5.8 Loads	

6. R&D NEEDS

7. RISK ASSESSMENT

8. CONCLUSIONS AND RECOMMENDATIONS
8.1 Conclusions
8.2 Recommendations

REFERENCES

APPENDIXES

Requirements Documents
Functional Analysis and Allocation Report
Body Plan
Ship Arrangements
Plan View
Outboard Profile

Inboard Profile
Deck Plans
Area/Volume Summary
Midships Section Calculations/Sketch
Machinery Arrangement Sketch
Propulsion and Electric Plant Engine Characteristics
Electric Plant Load Estimate
Weight Estimate
Stability Calculations
Speed/Power/Endurance Calculations
Manning Estimate
Cost Forms
Cost Analysis Results/Details
Master/Major Equipment List (with GFE/CFE recommendations)
EMI Matrix and Frequency Utilization Chart
Design Tools Used (including version and VV&A status)

List(s) of Symbols, Abbreviations, and Acronyms

REPORT FORMAT

General – Try to keep the report at the CONFIDENTIAL or below level of classification for expeditious handling. SECRET classified references or detachable CONFIDENTIAL, or SECRET, appendices are preferred over inclusion in the report. Ensure classification markings are accomplished in accordance with SECNAV M-5510.36.

The International Traffic in Arms Regulations are codified in the Code of Federal Regulation (22 CFR Ch. I, part 120-130)

The items covered under ITAR are described in Part 121 and constitute the United States Munitions List. Part 121 includes virtually all ships that would fall under the cognizance of an SDM. Other systems or subsystems may also be included in Part 121. Part 120.3 describes the policy for designating items to be on the United States Munitions List:

"120.3 Policy on designating and determining defense articles and services.

An article or service may be designated or determined in the future to be a defense article (see § 120.6) or defense service (see § 120.9) if it:

(a) Is specifically designed, developed, configured, adapted, or modified for a military application, and

(i) Does not have predominant civil applications, and

(ii) Does not have performance equivalent (defined by form, fit and function) to those of an article or service used for civil applications; or

(b) Is specifically designed, developed, configured, adapted, or modified for a military application, and has significant military or intelligence applicability such that control under this subchapter is necessary."

Any technical report that discusses items covered by ITAR shall include the following statement on the cover:

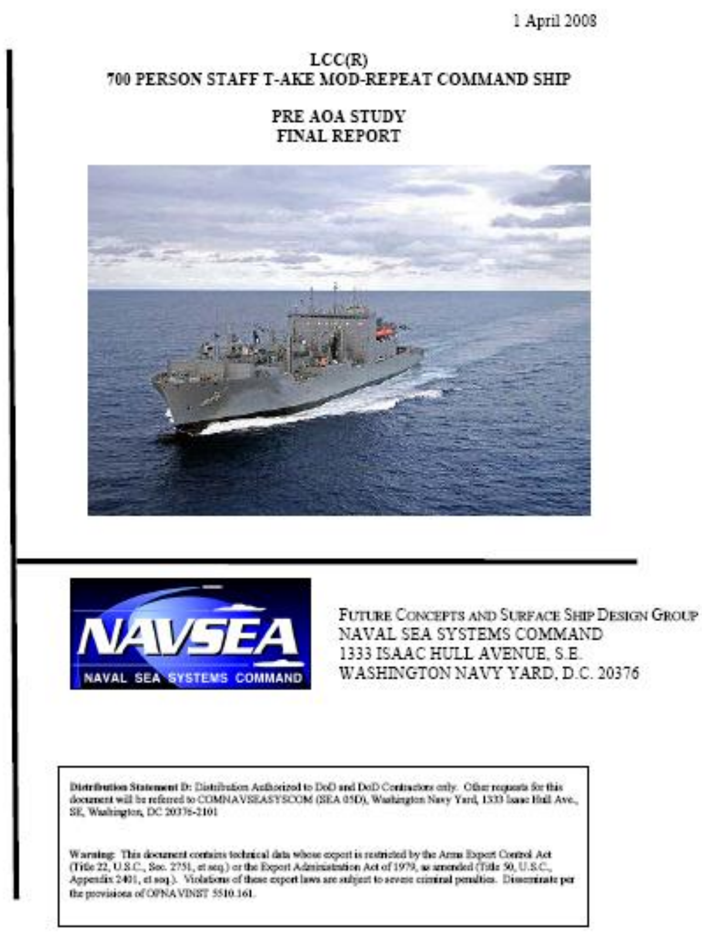
"**WARNING** – This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C. Sec. 2751 et seq.) or the Export Administration Act of 1979, as amended, Title 50, U.S.C., App 2401, et seq. Violations of these export laws are subject to severe criminal penalties. Disseminate per the provisions of OPNAVINST 5510.161."

References to previous work should be used to prevent excessive redundant information.

The exclusive use of standard 8.5 inch by 11 inch paper is highly encouraged to facilitate printing and viewing on computer monitors. The report body should use standard serif fonts such as Times New Roman. Likewise the size of the report body text should be between 10 and 12 points (headings and titles can be larger). The use of 12 point Times New Roman type, single space, with 6 point spacing before and after each paragraph is encouraged. The use of color is encouraged, but the report must be legible and understandable if printed in black and white.

Distribution Memo – The Distribution Memo provides the means for capturing the report within the correspondence file and implementing report distribution. It is formatted using standard Navy Memorandum formats, includes a serial number, date, releasing authority signature(s), and distribution instructions. The body of the memo indicates who tasked the report, and a short abstract of its contents. If the report has been coordinated with other organizations, that should be indicated in the memo. The Distribution Memo includes the report as an enclosure.

Title Page – The title page must contain the report title, report date, NAVSEA Logo, Organizational Address, distribution statement, and classification statement. Guidance for distribution statements can be found in DoDD 5230.24. Whenever possible, a graphic image of the design will be prominently displayed on the title page. An example of a title page is shown in Figure Z-1.



1 April 2008

LCC(R)
700 PERSON STAFF T-AKE MOD-REPEAT COMMAND SHIP

PRE AOA STUDY
FINAL REPORT

NAVSEA
NAVAL SEA SYSTEMS COMMAND

FUTURE CONCEPTS AND SURFACE SHIP DESIGN GROUP
NAVAL SEA SYSTEMS COMMAND
1333 ISAAC HULL AVENUE, S.E.
WASHINGTON NAVY YARD, D.C. 20376

Distribution Statement D: Distribution Authorized to DoD and DoD Contractors only. Other requests for this document will be referred to COMNAVSEASYSCOM (SEA 05D), Washington Navy Yard, 1333 Isaac Hull Ave., SE, Washington, DC 20376-2101

Warning: This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Sec. 2751, et seq.) or the Export Administration Act of 1979, as amended (Title 50, U.S.C., Appendix 2401, et seq.). Violations of these export laws are subject to severe criminal penalties. Disseminate per the provisions of OPNAVINST 5510.161.

Figure Z-1. Cover

SF 298, Report Documentation Page – All reports shall include a completed SF 298. Where a report has been prepared by a contractor, that contractor may be credited on this page only. Otherwise, all contractor markings, letterhead, labels, etc. shall be removed prior to distribution. Reports marked for public distribution must be approved for public release by a NAVSEA Public Affairs Officer.

Abstract – An abstract is a concise, informative statement (about 200 words) stating the purpose, scope, methods and major findings of the report, including results, conclusions, and recommendations. The abstract is usually included as part of the SF 298.

Table of Contents – This table shall be broken into sections, subsections, and appendices with the corresponding page number.

List of Tables and Figures - This list shall have a number, title, and corresponding page number for each table and figure.

Foreword – This section shall be located on a separate page after the List of Tables. It shall include background or context for the report, task history, and other information, e.g., organizations involved in the effort.

Acknowledgements – This section shall include a list of individuals, companies, and government activities that made a significant contribution to the report. Where a NAVSEA code provides the information for a particular section, that input should be recognized in the applicable section.

Executive Summary – The executive summary shall include a description of tasking leading to preparation of the report, author of the study, general guidance/documents used (e.g., ICD or CDD), and the fundamental design parameters resulting from this guidance. Principal features and mission critical subsystems shall be described. If the Baseline Ship is not the recommended configuration, then the Baseline Ship, plus trade-offs and the resulting feasible ship with its principal characteristics and capabilities compared with the stated or derived requirements shall be presented. Critical issues, highlights, or concerns shall be included, such as major deviations from NAVSEA policies, design imbalances, RDT&E issues, cost questions, schedule constraints, or technical risks. In this regard, the valued judgment of the ship designer on the overall reasonableness of the design is appropriate and desirable. The summary is not the presentation of "just the facts", but also the technical "conclusions" to be drawn from those facts as seen by the persons most intimately knowledgeable about the design. Note, however, that the balance of the report should be factual rather than subjective in nature, except for "Conclusions and Recommendations".

1. INTRODUCTION

The introduction shall state what the Study presents, with a brief description of the sections involved.

1.1 Background

The background should state the uses of the proposed ship, comparing it to similar ships of the past or ships further along in the acquisition process. Discuss the details of tasking.

1.2 Objectives

A list of objectives and goals, which were established at the start of the Feasibility Study, are stated in this section.

1.3 Approach

Describe the basic approach to establishment of design requirements and alternatives, trade-offs, and development of design. How did the operational requirements of the ICD or CDD get translated into design requirements?

1.4 Summary Characteristics

When the study includes major variants in either the combat system or the hull, mechanical, and electrical systems, then the Variant, Flight, Option, or Alternative definitions must be provided. A tabular presentation of principal characteristics and key features, accompanied by an outboard profile and plan view, is expected.

2. REQUIREMENTS SUMMARY

The requirements for the ship shall be briefly discussed here, in addition to a general paragraph explaining the origin of the requirements. Top-level constraints (e.g., weight, cost, manning, etc.) would be highlighted here and then discussed subsequently, in the appropriate section.

Note: Only include a brief summary. Any guidance not in the ICD or CDD should be discussed and source documented. The ICD or CDD is to be included as Appendix A.

2.1 Force Interaction

If the ship is to deploy with military (e.g., U.S. Navy, USCG, or NATO ships and aircraft) and/or commercial (e.g., merchant, MSC operated, or University operated ships and aircraft) units, as either a command or a coordinated unit, then those requirements are presented here.

2.2 Concept of Operations

The primary and secondary naval warfare tasks and mission areas, in general, are documented along with a general, brief discussion of the theater of operations. The reader needs to understand how the ship will be used typically.

2.3 Mission Requirements

These shall be broken down into two parts:

2.3.1 Functional Requirements

These are the specific primary mission descriptions, including the characteristics that will be required, and specific secondary mission descriptions.

2.3.2 Environmental Factors

These include hydrographical and weather factors such as: wind, sea state, visibility, and temperature.

2.4 Target/Threat Statements

These shall be stated for the particular ship being designed. The requirements for target/threat shall be listed including typical targets and where threats would possibly originate.

2.5 Operating Profile

This profile shall be developed to determine the percentage of time that the ship will be operating during a given year. It shall include the major logistic factors that result from the primary mission requirement, how the ship will draw its operational logistic support from other units, and the length of time between minor and major overhauls. The expected life of the ship and its different phases shall be shown in a figure and the underway availability of the ship shown in a graphic table on the figure.

2.6 Design/Program Requirements/Criteria/Constraints

This section lists any specific program requirements/criteria/constraints that bounded the design solution space. Examples include specific hull, propulsion, range, environmental control, ship control, complement, accommodations, mission equipment electrical power, ship service electric power, navigation, communications, scientific spaces, and/or weights, deck systems, rescue/workboats, noise, electromagnetic compatibility, Classification or certification requirements cited in the ICD or CDD shall be highlighted here as design requirements, criteria, goals, or constraints.

3. TECHNOLOGY BASE

A summary table or matrix shall be included near the beginning of this section showing the key technology options or characteristics examined. Each option can be further explained in the following sections.

3.1 Projected Technology Dates

This is typically the initial operational capability date but may be earlier if the design is restricted to items or equipment that have been approved for production or are in a funded development program or are in a funded component improvement program.

3.2 Technical Risk Constraints

These may be configuration, operation, or equipment development risks. These risks or areas of uncertainty will require additional study during later stages of design but do not necessarily require an R&D program.

3.3 Projected Technology Considered

Major acquisition programs usually include something “new”. The impact of that new or projected technology on the ship design is presented here. It may be several items, equipments, procedures, capabilities, or technologies. It may be a combination or integration of items, equipments, procedures, or technologies that gives the design impetus.

3.4 Projected Technology Used

A simple recap of the selected technologies is provided here.

3.5 Technology Readiness Assessment

For each of the new technologies, the TRL should be identified with supporting rationale. The report should indicate if this assessment was conducted as part of a form TRA or performed by the Design Team.

4. SHIP DESIGN DESCRIPTION

This section shall include information on performance, configuration, margins, manning, size, stability, hydrodynamic performance, and whole ship engineering. Sketch(es) identifying the baseline design and the differences among the Variants, Flights, Options, or Alternatives will be included here.

4.1 Mission Effectiveness

The purpose of this section is to compare the expected performance against the performance in the ICD or CDD.

4.1.1 Primary Missions

4.1.2 Secondary Missions

4.2 Configuration

General comments on configuration drivers (e.g., foil configuration, aircraft flight paths, arcs of fire for armament, etc.) are cited here and then developed subsequently.

4.2.1 Combat System Arrangements

The combat system spaces and the rationale for their arrangement in the context of the total ship must be clearly presented. This rationale will generally carry through subsequent design phases to preserve functional capability. The major combat system equipment is listed; any item, which is included for space and weight reservation purposes, must be clearly marked. Based on the notional combat system equipment, the expected performance results are to be compared with required performance. Topside design features/requirements must also be stated.

4.2.2 Ship Arrangements

The machinery or non-combat, mission related system spaces and the rationale for their arrangement in the context of the total ship must be clearly presented. This rationale, too, will generally carry through subsequent design phases. The major machinery/auxiliary or non-combat, mission related system equipment is listed; any item, which is included for space and weight reservation purposes, must be clearly marked. A brief description of the influence of stability, seakeeping, maneuverability, survivability, signatures, or electromagnetic compatibility on the overall ship arrangements will be presented here and developed subsequently.

4.2.3 Topside Design

4.3 Margins

A summary table or matrix of the applicable margins will be included.

4.3.1 Performance Margins

Margins for propulsion power, noise, Radar Cross Section (RCS), or any other applicable performance parameters will be aggregated here.

4.3.2 Acquisition Margins

Margins for weight, CG, Accommodations, electric load, space, or any other ship "internal" design parameter will be presented here.

4.3.3 Service Life Allowance

All weight, CG, electric plant, space, or other margins reserved for post-delivery use will be discussed here.

4.4 Manning

A summary table or matrix is appropriate.

4.4.1 Assumptions

Where habitability or manning requirements (e.g., MSC standards) have been invoked, the impact on the design shall be presented here. The assumptions on ship's organization (e.g., Combat Systems Department vs. Weapons Department), Flag, Aviation or Marine Detachments, or Troops will be documented here.

4.4.2 Manning Estimate

The estimating techniques will be cited along with the baseline ship source.

4.4 .3 Accommodations

This is a simple tabulation of accommodations for the baseline ship plus each variant, flight, option, or alternative.

4.4.4 Impact of optimized manpower on human performance, workload, and safety

4.5 Size

The considerations driving the principal dimensions are cited here and then developed subsequently.

4.5.1 Hull Form

The hull form shall be discussed including the original (parent) of the hull form selected. Principal characteristics shall be shown in the text and in a table, along with a body plan that may be provided in an appendix. The minimum requirement for this section is a body plan with displacement and center of buoyancy (CB) estimates.

4.5.2 Weights

The method of estimating the weight and CG shall be discussed along with the results of the estimate and how it affects the ship. The weight and CG numbers shall be shown in tabular format. A comparison with recent, similar ships is appropriate. A clear statement of weight margins shall be provided here.

4.5.3 Space

At least spring style sketches of the general arrangement will be provided (e.g., in the appropriate appendix) to illustrate important design features. Remarks on the superstructure or deckhouse size and location, provisions for weapons or cargo, and any feature that affects the overall size or performance of the ship will be highlighted here. An Area/Volume Summary tabulation is appropriate.

4.6 Stability and Hydrodynamic Performance

The purpose of this section is to describe the intact and damaged stability criteria and to discuss seakeeping and related hydrodynamic performance of the hull. The stability criteria (i.e., U.S. Navy or U.S. Coast Guard) must be stated.

4.6.1 Reserve Buoyancy

Compartmentation and floodable length requirements and the ship impact are presented here.

4.6.2 Damage Stability

An investigation shall be made of the damage stability. The results of this investigation shall be discussed here, specifically including limits on displacement and CG. Graphic depictions may be necessary.

4.6.3 Intact Stability

The effects of high-speed turns, icing, 80 knot or 100 knot beam winds, etc. are presented here.

4.6.4 Seakeeping and Maneuverability

Methods of calculating seakeeping and maneuvering performance as well as the method for calculating hydrodynamic loads shall be discussed along with results. It is anticipated that a family of curves will be necessary to show performance in various sea states. A figure to show the speed/power curve and speed/endurance curve will be included here. For designs having seakeeping, maneuvering, or recovery from control surface failure requirements, predicted performance results will be presented in a suitable figure or trajectory plot.

4.6.5 Powering Estimate

Calm water powering estimates with allowances for appendages; surfaced, foil borne or cushion borne operations, or sea state will be presented. Sources used in deriving the propulsive coefficient will be documented. A graphical presentation of the resultant powering estimate is appropriate.

4.6.6 Dynamic Stability

The results of any dynamic stability analysis or testing should be presented. If applicable this section will include descriptions of the anticipated Safe Operating Envelope.

4.7 Systems Engineering

4.7.1 Survivability

This section addresses the ship's ability to survive in a man-made hostile environment by coping with all phases of an engagement; i.e., avoiding damage by going undetected, avoiding damage by shooting down incoming threats, resisting damage by means of passive protection, and controlling damage after it occurs to permit the ship to continue to fight "hurt". These phases are usually described in terms of Susceptibility, Vulnerability, and Recoverability.

Survivability requirements and the design features explicitly incorporated in response to these requirements will be discussed along with a risk assessment.

Signatures are an important part of Susceptibility and are generally a function of the whole synthesized ship. Signature discussion can include the following:

Underwater Radiated Noise

Sonar Self Noise

Airborne (Compartment) Noise

Radar Cross Section

Magnetic

Infrared

Electromagnetic Radiation

Hydrodynamics

Other

4.7.2 Supportability

Supply plus Maintenance and Repair shall be discussed here. The Supply portion shall discuss all consumables, storage of fuels and lubricants, storage of ammunition, missiles, torpedoes, etc., provisions and other consumables. The other portion shall describe the capability for shipboard maintenance and repair, including designation of the level of support to be rendered by ship's force, tender, and Shipbuilder. Shipboard maintenance also includes accessibility for maintenance, equipment removal provisions, etc. Any special provisions f or removal of large items (e.g., gas turbine engines) will be presented here.

4.7.3 RAM shall be briefly discussed. Comparisons with other ships and design features that have been adopted to improve RAM should be provided.

4.7.4 Costs (RDT&E, Acquisition, and Life Cycle)

All costs, if available, of various ship configurations and the economic effect of the various propulsion and/or electric plant trade-off studies on total cost should be shown.

4.7.5 Electromagnetic Compatibility

The electromagnetic environment including electromagnetic pulse effects shall be described, including the protection features to be incorporated into the ship. Based on known (selected) combat system and/or communication equipment, a Frequency Utilization Chart and an EMI Matrix shall be provided. The data and level of detail (system definition) incorporated in sections 5.4.4 and 5.7 are the basis for these two efforts.

4.7.6 Measures of Effectiveness

Where total ship performance can be expressed in terms of operational goals or requirements, those expressions are discussed here. Of particular interest are the analytical relations between ship design features (e.g., number of missiles or torpedoes carried) vs. the operational requirements (e.g., conduct anti-air warfare [AAW] or anti-submarine warfare [ASW]). These analytical relationships are expected to be instrumental in sizing the combat system and balancing the complementary hull, mechanical, and electrical requirements within the total ship.

4.7.7 Human Systems Integration

The results of any Human Systems Integration analysis should be included here as well as the design strategy employed to ensure the design is compatible with effective and efficient operation by the crew.

4.7.8 Design Tools Used

The report should list all of the design tools used. For each design tool, the version should be identified as well as a brief discussion of how the tool was used and any assumptions that were made. The VV&A status of the tools should be included.

4.7.9 Design for Producibility

The report should describe design attributes to enhance the producibility of the ship.

4.7.10 Design for In-Service Cost Reduction

The report should describe design attributes to reduce the In-Service Costs.

4.7.11 Design Certification Approach

The report should detail the approach for Design Certification to include whether classification societies will be employed. If appropriate, a design certification matrix should be included.

5. SUBSYSTEM DESCRIPTIONS

The following sections shall follow the Expanded Ship Work Breakdown Structure (ESWBS), with a detailed description of the design's attributes in each ESWBS category. Each section shall include applicable requirements and assumptions. Where options or trade-offs (e.g., diesel vs. gas turbine prime movers, wet vs. dry fire mains, etc.) have been examined, each section shall include a discussion of the topic examined with regard to the option.

5.1 Hull Structure (ESWBS 100)

This section shall discuss the type of material to be used in construction. This section shall also discuss structural arrangement and design detail, deck heights and holds, structural weight and how the calculations were performed to arrive at the estimated weight. Calculations shall be of sufficient detail to support a minimum one-digit ESWBS weight and cost estimate. This section shall also discuss the analysis of structural loads that may include: longitudinal, transverse, pressure, and acceleration or joint loads.

5.2 Propulsion Plant (ESWBS 200)

Results from the propulsion plant trade-off studies and the number, size, and type of propulsor(s) are to be included here. The number, type, and size of the propulsion engine(s) and any special features (e.g., integrated electric or propulsion derived ship service electric) will be highlighted with a risk assessment.

5.3 Electric Plant (ESWBS 300)

Results from the electrical plant trade-off studies are to be included here. The number, type, and size of the ship service generator(s) and any special features will be highlighted with a risk assessment.

5.4 Command and Surveillance (ESWBS 400)

A discussion of the origin, source, or rationale for the C&S suite is the focus of this section. The major pieces of electronics shall be listed, along with the applicable weight, space, volume, electric, and HVAC loads for each item. Based on the EMI Matrix and the Frequency Utilization Chart, C&S impacts on the topside design shall be documented here.

5.5 Auxiliary Systems (ESWBS 500)

Such information as is available on the HVAC, refrigeration plant, Replenishment at sea, fire extinguishing system, fresh water system, environmental pollution control system, and mooring and towing system are to be presented here. If it is an air-capable ship, then the number, size, and type(s) of aircraft along with the necessary handling, stowage, and maintenance facilities will be included here. If it is a cargo ship, then the cargo handling, stowage, and maintenance facilities will be discussed here.

5.6 Outfit and Furnishings (ESWBS 600)

A discussion of the living, commissary, recreation, and service spaces shall be provided along with a comparison to the applicable habitability standard (e.g., OPNAVINST or MSCINST). A summary table listing the number, type of accommodations, and square feet per person will be included here.

5.7 Armament (ESWBS 700)

A discussion of the origin, source, or rationale for the weapon suite is the focus of this section. The major weapons shall be listed along with the applicable weight, space, volume, electric, and HVAC loads for each item.

5.8 Loads

All the various load items are summarized here, particularly weapon load out/mix assumptions, endurance fuel, ballasting criteria, or any unusual condition.

6. R&D NEEDS

The purpose of this section is to identify specific research and development initiatives essential to the project. The presentation may be divided into combat system and ship R&D needs. In some cases, existing programs will be identified for supplemental funding to expedite development matching project schedules. In other cases, new R&D initiatives may be necessary.

7. RISK ASSESSMENT

A risk element is any feature or characteristic specified in the design that is subject to a business, schedule or technical risk or both. Business risk is the uncertainty relating to lack of knowledge or control of the end cost of the item to the government. Technical risk is the uncertainty relating to the ability to obtain satisfactory performance in the acquisition or end use of the item (including design, development, test and evaluation leading to shipboard installation, use, and maintenance). Each risk element will be identified, along with a brief description of the steps necessary to reduce the risk and the identification of the Risk Element Manager (normally a TL from the responsible functional code). These risk elements will then be “fenced” in subsequent design phases, until they are satisfactorily resolved. If the risk element requirement requires concurrent RDT&E, then a POA&M will be included in an appropriate appendix.

8. CONCLUSIONS & RECOMMENDATIONS

This section will by its nature include subjective evaluations by the author of the “value” of ship options under study. However, there should be clear linkage to factual information previously presented in the report.

8.1 Conclusions

Based on the results of the Feasibility Study, briefly discuss the conclusions of the study’s options relative to stated requirements. Deviations from accepted practice and major risks from section 7 shall be identified for each of the study’s options.

8.2 Recommendations

The recommendation(s) shall be based upon the conclusion(s) and economic considerations. State the recommended option.

REFERENCES - The references are to be listed by author, report title, report or document number (if applicable), enclosure (if applicable), date, and security status, if any. For example:

2. “Operating Requirement for Acoustic Research Vessel (YAG) Er 1 to CNO ltr Ser 224D/383011, 23 June 1982 (Confidential)

APPENDIX AA
CONTRACTING CONSIDERATIONS

AA.1 INCENTIVES.

The SDM should actively participate in the definition of contract incentives. Performance, cost, and schedule incentives must be employed with great care. There is always the danger that setting incentives in one area will result in compromise elsewhere.

Establishment of a payment schedule for performance improvement has occasionally been used with success. Performance incentives are normally limited to no more than a few areas like weight control. Flexible incentives may be structured to target areas as needed.

It is more common to establish subjective performance categories with a Navy award fee panel meeting periodically to award a percentage of an allowable pool. The SDM should chair any technical evaluations. The contract may be set up to allow the Navy to change the award fee categories prior to the next performance period. Some contracts provide for un-awarded fee to be “rolled” to a final assessment at the end of the contract. This may have the negative effect of turning consistently low ratings into a much higher total award.

Cost share lines are commonly established to share cost risk between the Navy and the Shipbuilder.

AA.2 LEAD/FOLLOW YARD RELATIONSHIPS.

For large procurements like DDG51, which must be built at multiple Shipbuilders, a lead/follow yard arrangement may be set up to permit all ships to be constructed to the same Detail Design. There are a number of pitfalls, including how to deal with a potential “bid to lose strategy.” Where a contractor expects to be selected as the follow yard, he has little incentive to “sharpen his pencil” for the price proposal. One approach is to limit follow yard profit to less than the lead yard.

AA.3 SUBCONTRACTING.

Contracting for “industry participation” may result in “industry” subcontracting to local design agent contractors. If this is not desired, the SDM should ensure that the contract limits subcontracting and/or limits substitutions for those personnel that are bid.

AA.4 “BUY AMERICAN” REQUIREMENTS.

The SDM should become familiar with current “Buy American” legislation for its effects on the specifications and contract.

AA.5 AVOIDANCE OF “TECHNICAL LEVELING” DURING COMPETITION.

In the competitive phases, SDMs must take care not to provide favorable information to one contractor or another. Information provided to all contractors in the competition must be consistent in content and over time. SDMs can and should let contractors know when the solution they propose may not meet requirements. Information released to contractors or potential bidders must be disseminated through the Program Manager, documented, and shared consistently.

AA.6 DATA RIGHTS AND INTELLECTUAL PROPERTY.

The SDM should ensure that the government retains the data and intellectual property rights needed to support the ship’s life cycle and any follow-on procurement. This has proven difficult for contractor IDEs and Product Models. Neglect of these considerations has proven costly.

AA.7 OPEN SYSTEMS, PROGRAM PROTECTION, ITEM UNIQUE IDENTIFICATION, AND OTHER NEW MANDATE CONTRACTING GUIDANCE.

The current pattern is that detailed guidance for contracting including proposed SOW clauses and, where applicable, source selection criteria follows the issuance of every new mandate within months. For areas under his cognizance, the SDM should ensure that this language is tailored to the Program to produce a productive result and minimize costs. For example, open systems requirements has been limited to selected information technology based systems and then implementation required only if a business case analysis demonstrates that it have beneficial life cycle cost results.

APPENDIX BB
INTEGRATED PRODUCT AND PROCESS DEVELOPMENT, IPTS, AND WORKING GROUPS

BB.1 TRADITIONAL DESIGN PROCESS.

Problems with the traditional design process have included:

- Difficulty in designing for simplicity and reliability
- Failure to pay enough attention at the design stage to the likely quality of the manufactured product
- Excessive development times
- Weak design for producibility
- Inadequate attention to customers
- Weak links with suppliers
- Neglect of continuous improvement

BB.2 INTEGRATED PRODUCT AND PRODUCT DEVELOPMENT.

Basic concurrent engineering or Integrated Product and Process Development (IPPD) has received much attention and application in naval ship design since about 1992. It made a strong start on overcoming some of the major problems in new product development and was a major element of many leading companies' improved competitiveness.

IPPD has two essential characteristics:

- It is a concurrent process, and
- It is carried out by a multifunctional product development team or IPT.

Product design, production-process engineering, Fleet-support development, and all other elements of product success are addressed from the beginning as an integrated set of activities and objectives. The ideal is simple: to have one team working on one system in one total development activity, all focused on benefit to the customer. The system is the product, the production capability, and the Fleet-support capability. The design parameters, production parameters, and Fleet-support parameters all integrated together define the unified IPPD system. It is the responsibility of the IPT to define and quantify all of the parameters in one total development activity.

The major benefits of IPPD stem from a few principles:

- Start all life cycle tasks as early as possible
- Utilize all relevant information as early as possible in an IDE
- Empower individuals and teams to participate in defining the objectives of their work
- Achieve operational understanding for all relevant information
- Adhere to decisions and utilize all previous relevant work
- Make decisions in a single trade-off space; that is, treat design, production, and Fleet support as a single system within which trade-offs can be made
- Make lasting decisions, overcoming a natural tendency to be quick and novel
- Develop trust among teammates
- Strive for team consensus
- Use a visible concurrent process

All of these principles may seem to be unexceptionable. However, relative to traditional product development, they are major improvements.

The essence of the concurrent process and the multifunctional IPT is both simple and subtle. The mind literally cannot work on two tasks concurrently (at least not consciously). In the concurrent process, frequent information exchanges occur at the level of the small unit design tasks that drive the need for an Integrated Data Environment (IDE). In the traditional design process the work blocks were huge before information transfer occurred. At the micro level the tasks in the concurrent process are sequential or iterative, but from the macro perspective the effect is the concurrent process. The rugby image of cooperatively moving the scrum downfield is appropriate.

BB.3 IPTs.

It may seem a small difference whether two people are members of the IPT or, alternatively, are assigned to the same project but remain in separate organizations, but that difference is critical. If the two people are not members of the same IPT, the probability is greatly increased that some of the new product development principles will be violated, with a very detrimental effect on the development program. When an individual’s primary allegiance is to a cloistered group of functional specialists, the performance within the specialty may be elegant, but there is usually inadequate benefit to the overall development program. This is sub optimization.

When an individual is a member of the IPT, he or she is much more likely to participate in defining the objectives of the IPT’s work and thus the objectives are likely to be both more relevant to the program and better understood by the participants. Often, definition of the objectives is the most difficult part of any task; an IPT is more likely to succeed at this than separate groups of specialists.

Membership in a team also greatly improves the exchange of information. Specialists like to communicate in terms that are dear to their own specialty but not fully understood by other people. Membership in the IPT greatly increases the probability that individuals and small groups will help others to effectively use the output from their work, going beyond a perfunctory communication. This greatly improves understanding of and commitment to the decisions that they make, which are vital success factors.

BB.4 CONCURRENT PROCESS.

In the best practice of IPPD, the design of the production system and of the Fleet-support system starts early, concurrently with the design of the product. This has five major benefits:

- The development of the production and Fleet-support system has an early start.
- Trade-offs occur among design, production, and logistics concurrently, as one system.
- Good design for manufacturability and Fleet supportability is facilitated.
- The production and Fleet-support people gain a clear understanding of the design, and are committed to its success.
- Prototype iterations or engineering change orders/rework are reduced because the design is more mature before the first full-system is built.

Although the concurrent process is emphasized during the design phase, it is used throughout the development of the new product.

The concurrent process is first used during the development of the system concept. In the past it was common for market research to determine customer or user needs and throw its conclusions over the wall to planning, which in turn outlined the requirements for the product and then threw its results over the wall to product design engineering. This sequence of first determining users' requirements and then developing the system concept made it unlikely that the needs of the customer or user were adequately considered in choosing the system. The activities of determining users' requirements and developing the system concept are now in the best practice combined and carried out by one multifunctional IPT.

The best concurrent process treats development as one activity that incorporates product, production system, and Fleet-support system. There are no upstream and downstream activities in the traditional sense. Of course, in the natural flow of the work some things are done before others. For example, concepts are selected before detailed design, and production tools are designed before they are built. However, the best concurrent process avoids the unnatural separation of work into upstream and downstream in accordance with organizational rigidities.

In the traditional process, tasks were clearly labeled product development, production-capability development, or Fleet-support development, and tasks of the first type (upstream) were completed before tasks of the other two types (downstream) were started. In the best concurrent process the tasks are not defined in this divisive upstream and downstream style. All tasks now incorporate the product view, the production view, and the Fleet-support view. Subtasks may still remain "pure." For example, the finite-element analysis (FEA) is typically performed by a specialist. However, the results of the analysis can now be put to much better and more immediate use. The FEA specialist works closely with a subsystem Design Team-with a Hull IPT, for example. In the best concurrent process, producibility and functionality are optimized together. We combine the FEA with the design of the production process to minimize penetrations of the hull structure and the cost of producing it at the same time. The FEA specialist works closely with the subsystem team to define the objectives of the FEA and then presents the results to the team in a form they can easily use. The FEA specialist further works with the team to help in the application of the results, probably as electronic data. For the duration of this task the FEA specialist is effectively a member of the team.

Contrast this with the dysfunctions of the traditional design process. The FEA specialist received drawings of the preliminary hull design, did the FEA and tossed the printout over the wall to the structural design engineer-there was no team, so producibility was not considered.

Multiply this vignette by a thousand and the contrasting superiority of the concurrent process is apparent.

BB.5 TOTAL SYSTEM DESIGN.

The ideal design process is to have one activity that addresses all parameters in the total system. In traditional product development the total set of parameters that must be defined and quantified is decomposed in three ways: by program phase, subsystem, and discipline. We can visualize this as a three-dimensional structure, with each cell defined by a single phase, subsystem, and discipline. In a complex system this easily creates several hundred cells each with its dedicated set of parameters. Sub optimization is done within each cell, with very inadequate attention given to parameters that lie outside that cell.

The best concurrent process eliminates partitioning into cells defined by development phase, subsystem and discipline. All parameters that are relevant to a decision are considered in making the decision. (Which parameters are considered relevant is determined in part by their function in satisfying customer needs.) The objective is to make the design process seamless. In IPPD, we achieve a seamless process by forming the multifunctional IPT and strongly motivating it to use a seamless process. (This is not completely sufficient; vigilant information processing or an IDE is also required).

BB.6 PROBLEM PREVENTION.

The problem-prevention approach emphasizes considering all parameters as early as possible and thus provides a shift of activity level to the earlier part of the design. Frank Pipp (1990), who led the implementation of basic concurrent engineering within the Xerox Corporation from 1980 to 1983, cautions, “Don’t yield to the temptation to save money in the early stages of a product program. Invest enough time and money to be sure customer requirements are known and faithfully translated to specifications. Passing on immature technology will surely cost you more money eventually than properly completing and engineering new technologies. One thing we have learned is that bad engineering and design go all the way to the customer; it never seems to get fixed along the way.”

BB.7 OTHER ELEMENTS OF IPPD IMPROVEMENTS.

In addition to (1) being the practice of the concurrent process and (2) being carried out by a multifunctional IPT, basic concurrent engineering or IPPD includes other improvements over traditional product development that reinforce these two major thrusts. These additional enablers are described next.

BB.7.1 Focus Quality, Cost, and Deliver (QCD). The Program should focus all activities on the quality, cost, and delivery (development schedule) of the new product. This overcomes many fragmented bits of game plans with other, more local objectives, which have adverse effects on quality, cost, and deliver (QCD). In the past, much work that appeared very elegant by some functional criteria was eventually found to add little to the QCD of the product, and in many cases was actually dysfunctional. The focus on QCD is part of the general approach of using all relevant information to make decisions that satisfy all of the relevant objectives.

BB.7.2 Emphasis on Customer Satisfaction. Inward-looking organizational metrics are de-emphasized and are replaced by responses from customers. The emphasis on customer satisfaction extends throughout all of product development, and all other organization activities. All objectives are put to the test of the effect upon the customer. The team devotes much effort to learning and understanding the opinions of customers. In developing the Taurus in the early 1980s, Ford developed a list of 1401 features that car buyers were looking for. The team’s interest in the customers’ views extended from the customers’ needs at the start of a new development to the reactions from the users of the finished product.

BB.7.3 Emphasis on Competitive Benchmarking. Not only are the products benchmarked against the best of the competition, but also all processes are subject to being benchmarked. IPPD itself is to a considerable extent the result of competitive benchmarking, which is applied to many detailed sub processes within IPPD and is important for continuous improvement. The Massachusetts Institute of Technology Commission found that parochialism was a major weakness of American companies. It is very unlikely that a large percentage of all improvements around the globe will occur within one organization. Therefore, an important element of success is vigilance in finding, understanding, bringing in, and implementing major improvements. To a large extent this Best Ship Design Practices is the result of benchmarking.

BB.8 IPT MANAGEMENT.

BB.8.1 IPPD is best carried out by a multifunctional IPT led by a strong product design manager. All functions of the organization should participate. People who are doing significant work for the specific product development project should be part of the IPT while they are doing the project's work. There is a vast psychological difference between performing a task within a support group and performing it as a member of the IPT. As an IPT member, the contributor will (1) understand the specific requirement, (2) have the necessary close communications with other members of the IPT, and (3) be dedicated to the utilization of the task results to make design decisions. All three of these benefits are much less likely to materialize if the contributor remains outside the IPT.

It is important that the people on the IPT from each technical function be able to (1) represent the knowledge of that function and (2) gain the commitment of that function to the decisions that are made. Dysfunctions will occur if the information is not provided or is wrong, or if the function subsequently disowns the decisions and wants major changes. For example, if the IPT decides to use an aluminum die-casting and if later, when the product enters into production, the production operations people want a fiber-reinforced polymer part, and then rework of the development will become rampant. The strong, complete multifunctional IPT is essential for success.

Some people will stay on the IPT throughout the development project, while others will be on the team only during the phase or task that requires their expertise. The important criterion is that there should not be any sudden changes in the composition or size of the IPT, since that would reduce teamwork and cause lack of continuity.

Even while a member of a team, the individual still does much independent work, but the work is done for the team. Membership in the team makes the goals of individual work more holistic, more applicable to the total system or product. The individual's work is integrated into the team's activities and objectives. The individual's work contributes effectively to the overall development program.

Although we refer to *the* team, it is actually a team of teams. The design manager who leads the IPT and the systems engineering managers who report directly to him or her constitute one team. They are responsible for everything related to the total product and its development program. They include the subsystem leaders, for each product subsystem has a team. Many critical interfaces have a dedicated team. Teams are formed wherever they are needed to achieve an integrated approach to the development of the new product. Although the complete IPT for a large, complex product may have several hundred members, it is rare for any one operational team to have more than 20 members. Many have only a few members. The formation of the best interlocking structure for integrating the teams is a key success factor.

The DSM matrix can be a useful tool for identifying the ideal boundaries and composition of each of the member teams. One could argue that the greatest need for integration and concurrency across multiple disciplines is within the boundaries of a "Cluster." By examining the resources needed as part of the Mechanisms of the design activities that constitute the "Cluster," one can identify which organizations are needed to participate in the IPT. Once all of the design products of the "Cluster" are completed, the IPT should be disestablished.

BB.8.2 Avoid Dysfunctional Specializations. The effectiveness of an IPT is strongly influenced by the spectrum of generalization and specialization that characterizes its capabilities and leadership style. Prior to 1940 most product development was done by generalists, and the problems of segmentalism were not usually severe. This approach sufficed for products that were not high in technical sophistication. However, during the period 1940-1960 the shortcomings of this approach became obvious, and the emphasis shifted to technical depth and sophistication. However, this led to segmentalism or cloistered groups of technical specialists looking inward within their own specialty. This caused tremendous problems that concurrent engineering or IPPD is now overcoming.

The successful IPT uses a balanced modulation of specialization, with clear emphasis on total ship systems engineering. Even the most specialized people broaden themselves sufficiently to be able to communicate effectively with the in-house customers for their work. Most of the product development work is done by the core of the IPT, which consists of people who are not narrow specialists but combine a good combination of breadth and depth. Thus, the traditional product design engineers become quite knowledgeable about production, and traditional production-process engineers become knowledgeable about customer needs and product function. This enables them to function effectively as a team, to work on the complete set of parameters as one system to be developed in one activity.

The FEA specialist, mentioned earlier, is a good example of the new model in specialization. In the days of dysfunctional specialization, the FEA specialist was an example of the segmented specialist. The FEA specialist did not understand design and production, and the design and production people did not understand FEA. Therefore, they often did not reach a common definition of objectives, and the FEA results were thrown over the wall in a format that the design and production people did not interact with effectively. Now, in the new model IPT, they have all broadened sufficiently to reach common objectives, and to use the FEA to quickly improve cost and quality early in the development process.

The example of FEA can be taken a step further. Should sophisticated design tasks be performed by specialists, or should they be moved into the work domain of the core IPT people? Should the design engineer do the FEA or go to a specialist? If the design engineer can do the FEA, that is preferred, because it sidesteps some of the inefficiencies of human interaction. As computers become more user-friendly, the design engineer can incorporate more and more specialized tasks into his or her portfolio of capabilities. Specialized knowledge is utilized both by bringing specialists into the IPT and by making the knowledge available to the core IPT people via user-friendly computers. The best balance between the two is constantly evolving in a process of continuous improvement. The same principle of broadened perspective to enable effective cooperative work applies here also. The specialist and the core IPT people must be cooperative to produce computer systems that are effective in the IPT environment.

BB.8.3 Strong Product Design Managers for Success. Clark and Fujimoto (1991) identified four modes of development organizations in the global automotive industry. In all four of these modes the people have a functional "home"; the modes differ in the degree of focus on a specific product. The modes are configurations employing (1) a functional design structure, (2) a lightweight product design manager, (3) a heavyweight product design manager, and (4) a project execution team. Outside the automotive industry, and therefore not identified by Clark and Fujimoto, yet a fifth mode is used: (5) the independent IPT. The first two of these - the least product–focused of the five - may suffice for products characterized by high technical sophistication, low complexity, and relatively static concepts, but Clark and Fujimoto found that these modes had shortcomings in automobile development. In general, they will not offer a competitive advantage, so they will not be discussed further.

In two of the more product-focused modes - heavy-weight product design manager and project execution team - the development people are managed by a strong product design manager. In the project execution team the people are temporarily assigned (seconded) to the IPT. In the fifth mode, the independent IPT, which goes beyond the structure that was observed by Clark and Fujimoto (1991) in the automotive industry, the development people are members of the IPT only; they do not have a functional home, which makes the product manager even stronger.

The independent IPT (which has no functional home) goes the furthest in adhering to the principles of concurrent engineering or IPPD. However, any of the three product-focused methods of organization (of the five) can undoubtedly be made to work well. All three product-focused modes, the heavy weight product design manager, the project execution team, and the independent IPT, will work well if the other principles of IPPD are observed. The organizational structure is not the end objective, but rather a means to the end of implementing the principles of IPPD to make product development sufficiently holistic and focused on customers for the specific product.

Clark and Fujimoto compiled a list of characteristics of effective product design leaders. These are valid for all three types of product-focused organization, and are restated here with some modifications. The effective product design leader:

- Has responsibility that is broad in scope (for which he or she has the requisite broad knowledge) and endures over the entire duration of the development project
- Has responsibility for specifications, product concept, costs, and schedule
- Has responsibility for ensuring that the product concept is accurately translated into technical detail
- Has frequent and direct communications with IPT people at the working level
- Maintains direct contact with customers
- Has enough knowledge and experience in a variety of disciplines to communicate effectively with all relevant people
- Takes an active role in managing conflict; may initiate conflicts to prevent deviation from the original product concept
- Possesses market imagination, and the ability to lead in discerning the true voice of the customer
- Circulates among IPT people, and leads in achieving the winning product concept, rather than doing paperwork and conducting formal meetings

By following these guidelines and the other IPPD/IPT principles described above, an organization can achieve success with any of the three product-focused modes: heavyweight product design manager, project execution team, or independent IPT. The choice will often depend in the short run on ease of implementation, which in turn will depend strongly on the local culture (that of the organization, the project, or even the IPT).

BB.8.4 The Team Is Not Enough. The formation of the multifunctional IPT is a good start, but teams can go wrong, with disastrous results. The planning for the Bay of Pigs invasion is often cited in the social psychology literature as an example of groupthink, the downside of team potential. Although the planning of a military invasion may seem far from product development, the same things can go wrong. The team can develop a hubris, a strong desire to please each other and demonstrate their loyalty to the team, and a feeling of omnipotence, all of which can lead to disaster. The social psychologist Ian Morley, who has studied Design Teams in collaboration with the engineering design leader Stuart Pugh, has found that groups can go wrong by having too much confidence and afterward be unable to understand what happened (Hosking and Morley, 1991).

Morley, very largely on the basis of the work of Irving Janis, has analyzed the nature of the problem: (1) “stress generates strong need for affiliation within the group….People who have misgivings keep silent and increasingly give the benefit of the doubt to the emerging group consensus.” (2) The team members seek to “avoid the stress of actively open minded thinking.” They tend to focus on the popular option, and use “non-vigilant information processing” (lack of an IDE) to downplay the risks that later become all too obvious (Hosking and Morley, 1991).

Overcoming the possible dysfunctions of teams is straightforward but not easy. Successful teams use the vigilant information processing (or IDE) that is included within total quality development. Also, teams can help themselves by simply being on guard against problems, to realize that teams are not a panacea. Total quality development helps the team to be vigilant in processing information, as will be described later in IDE. The successful team runs down a clear path between facile consensus on the one hand and egocentric, disputatious behavior on the other.

BB.8.5 Ten Principles of Successful Teams. Ian Morley (1990) developed 10 principles of teamwork in doing total development work:

- Select cohesive teams, based on sentiments of mutual liking and respect for each other's expertise
- Bring specialists from all relevant major functional areas into the IPT while maintaining a systems engineering perspective
- Ensure a common vision of the concurrent process
- Organize controlled convergence to solutions that everyone understands and everyone accepts
- Organize vigilant information processing (an IDE) and encourage actively open-minded thinking
- Avoid the facile, premature consensus
- Maintain the best balance between individual and group work. Let individuals do the things that individuals do best - for example, the initial generation of new concepts
- Use disciplined methods reflecting best engineering practice
- Use both formal and informal communication
- Select at least some of the members according to how well suited they are to the specific type of development work. One example is how static or dynamic the concepts underlying the work are. A person who is proficient in applying standards to rapidly complete static designs may have difficulty with dynamic conceptual work. The opposite is also true.
- Provide principled leadership. The leader must emphasize the improved process, making it visible to the team. He or she must take the primary responsibility for helping to empower members of the team.

The organization and leadership that were described earlier on the multifunctional IPT help to develop the successful practice of these 10 principles of teamwork. If these and the principles that were stated earlier for IPPD are practiced, then any of the three product-focused modes can be successful-heavyweight product design manager, project execution team, or independent IPT.

BB.8.6 Early Outstanding Successes. Two of the early, outstanding successes with basic concurrent engineering or IPPD in the United States were at Ford and Xerox. At Ford the development of the new Ford Taurus was done by Team Taurus, led by Lewis Veraldi, from 1980 to 1985. The organizational mode was the heavyweight product design manager mode; it was judged far more successful than the previous lightweight product manager design mode. According to Veraldi (1988), "Teamwork was a major factor in the success of Taurus and Sable. Early and dedicated involvement by all members of the team was key."

At Xerox the change was even more radical. Implemented by Frank Pipp when he became manager of copier development and production, the change in 1982 was to the independent IPT. This has been highly successful in completing the development of the 10 series (Marathon) copiers, and in developing the more recent 50 series. At Xerox, the independent IPT was led by a chief design engineer, and the IPT was given a large degree of autonomy, as recounted by Pipp (1990):

To implement the concurrent engineering approach a new position, called Chief Engineer, was created. The CHENG was responsible for taking the product concept and the technology, engineering, designing and testing the product before turning it over for volume manufacturing. Testing included not only design verification tests, field machine tests, alpha and beta tests but also in their own pilot facilities the CHENGs were responsible for building sufficient pilot and pre-production models to prove that the production process would meet their design intent. This phase included meeting with major suppliers to ensure that they understood drawing specifications and could produce parts on soft and hard tools to meet quality and volume requirements. The CHENG also was responsible for delivering the product in accordance with the quality, schedule, and cost goals contained in the business plan and to accomplish this following the formal guidelines contained in the Xerox Product Delivery Process.

The next steps were the ones that truly allowed a concurrent engineering or IPPD approach to work, namely the transfer of advanced manufacturing engineers, quality control engineers, QA engineers, procurement specialists and field service engineers to the CHENG.

At the same time personnel from departments we called Shared Resources were assigned to the CHENG’s team on a dotted line basis. These shared resource activities included: Industrial Design and Human Factors, Competitive Analysis Laboratory, Software and Electronics Division and our Supplies Group which developed the necessary toners, developers and photoreceptors.

The Xerox CHENG and the independent IPT do the pilot production. Of course, production operations people are seconded into the IPT for this purpose. The principle is that the CHENG is responsible for all developmental problem solving. When the fully developed system is transferred to production operations, the seconded people return along with some of the core IPT people.

BB.8.7 IPT Pitfalls to Avoid. The independent IPT, as utilized at Xerox, is clearly very successful, at least in the short run. In the long run there are potential problems to guard against: (1) functional obsolescence, (2) weak organizational learning, (3) stale technology, and (4) outlasting its usefulness. Without a functional home, the core IPT people may remain strongly focused on their product and gradually fall behind in functional competence. Organizational learning is hindered because each IPT tends to be isolated; learning does not spread easily between IPTs. The focus of the IPT is on their current product, not on developing new technologies. In summary, the independent IPT is susceptible to the parochialism that was observed as weakness by the Massachusetts Institute of Technology Commission on Industrial Productivity.

As the ship progresses through different stages of development, the IPTs should be reviewed to ensure they are still needed, or new IPTs need to be chartered.

One approach to avoiding these problems is to have a shared resource organization that is responsible for the three problem areas. This group, often titled “advanced development” or some similar name, has as its primary mission the development of new technology. The advanced development group is usually functionally organized and is charged with also maintaining the functional competence of the IPTs. A companion role is to facilitate the transfer of learning among the IPTs. These objectives have been successfully accomplished by forming functional users’ groups, networks of advisers or mentors, and a Design Institute, all of which extend across the full scope of technical activities.

No matter what form the organization takes, there will still be boundaries that must not be allowed to create a throw-it-over-the-wall culture. The modes that focus on the product have been the most successful. The product-oriented IPT using the concurrent process has been found to be much more successful than functional groups using a sequential process. The switch to the multifunctional IPT using the concurrent process can be made in less than a year with strong leadership.

BB.8.8 Reinforcing the Teams. The improvements to cooperation are:

- The multifunctional IPT (described above)
- Employee involvement and participative management
- Strategic relationships with suppliers

BB.8.8.1 Employee Involvement and Participative Management. The second aspect of closer cooperation, reinforcing the multifunctional IPT, is employee involvement and participative management. The full talents of all people are utilized, and responsibility is decentralized to empowered teams in their local areas of expertise and action. The ultimate form is layered organizational and communication networks. Communications occur horizontally and diagonally, on a need basis, not excessively constrained by the vertical orientation of treelike organization charts. Sometimes the lament is heard, "Just tell me what to do and I will do it." Often, however, determining the right objectives is the most difficult part of the task. The principle is that the people who have the relevant information set the objectives, unconstrained by any ideology that says that objectives should be set by some particular segment or layer of the organization. Similarly, communications should occur in natural patterns as required for effectiveness in doing the work, unconstrained by the formal organizational chart or traditional culture. QCD to satisfy the customer is always the guiding light, and anyone who can contribute effectively should participate.

BB.8.8.2 Strategic Supplier Relationships. The third aspect of closer cooperation is strategic relationships with suppliers. In addition to bringing the organization's own production and Fleet-support people upstream to work concurrently with the product design engineers, it is also an essential element of IPPD to bring in suppliers to play a major role in the design of the new product. In the old, serial form of product development, suppliers were usually brought in very late, at which time they could only respond to designs that were already completed and compete with other potential suppliers primarily on the basis of lowest quoted cost. This led to a proliferation of a company's suppliers, none of whom were contributing significantly to the design of new products. As a result, designs were often ill suited to the capabilities of suppliers.

In many cases the number of suppliers has been reduced substantially - at Xerox, for example, from more than 3000 in early 1980s to fewer than 400 in the late 1980s. This enables beneficial strategic relationships with suppliers.

In his excellent study of the interactions of higher-level (more integrative) manufacturers and their suppliers, Toshihiro Nishiguchi (1989) observed the effect of strategic relationships with suppliers as it emerged with new inter-firm practices:

Institutionally, there emerged a range of new inter-firm practices that were designed to ensure the continuous output of high-quality, low-cost products. Principally, these practices were based on "problem solving" commitments between customer and subcontractor. Examples include joint price determination based on objective value analysis (VA), joint design based on value engineering (VE), the "target cost" (or "cost planning") method of product development, "profit sharing" rules, subcontractor proposals, "black box" design, "resident engineers," subcontractor "grading," QA through "self-certified" subcontractors, and just-in-time (JIT) delivery circumscribed by "bonus-penalty" programs. Along with these institutional changes, the main purchasing function of the customer shifted from downstream price negotiation to the assessment of subcontractor performance and the coordination of various intra- and inter-firm functions.

The most important outcome from this evolution of subcontracting in Japanese manufacturing was a transformation in the underlying logic of contractual relations. The basis for these relationships shifted from the notion of classical exploitation onto a new view of collaborative manufacturing, in the sense that both purchasers and subcontractors came to benefit, under newly established rules, from the synergistic effects of an orientation to bilateral problem-solving.

In his comparative study of electronics suppliers in the United Kingdom and in Japan, Hishiguchi (1989) observed:

Japanese subcontractors also noted their customers' readiness to help improve product quality and reduce costs. Subsequent case studies, of Hitachi's subcontractor improvement programs and of the interesting interactions between British subcontractors and their Japanese "transplant" customers in the United Kingdom, then indicated an important conclusion. Japanese subcontracting relations have institutional attributes that promote continuous improvement in quality and cost reduction through "problem-solving" oriented commitments between customer and subcontractor. This contrasted with the "bargaining" orientation of United Kingdom subcontracting relations, which tended to produce adverse effects.

Although this was a comparison between the United Kingdom and Japan, it does not appear to be primarily a result of culture. The distinction is of the new-model strategic relationships with suppliers versus the traditional arms-length relationships.

The principle is simple: make the suppliers members of the IPT. There are two impediments to implementation: (1) collocation is difficult, if not impossible; and (2) residues of traditional practices may linger - for example, the supplier participates in the design but then does not receive the production business. The second problem is straightforward to solve. A strategic relationship means that the supplier will receive the production business. Usually there is a long-term (several years) contract that provides guidance and an infrastructure for the specific purchases.

BB.8.9 LPD 17 Experience. The DD&C SOW specified that an IPPD team approach be used. The management structure is notionally shown in Figure BB-1.

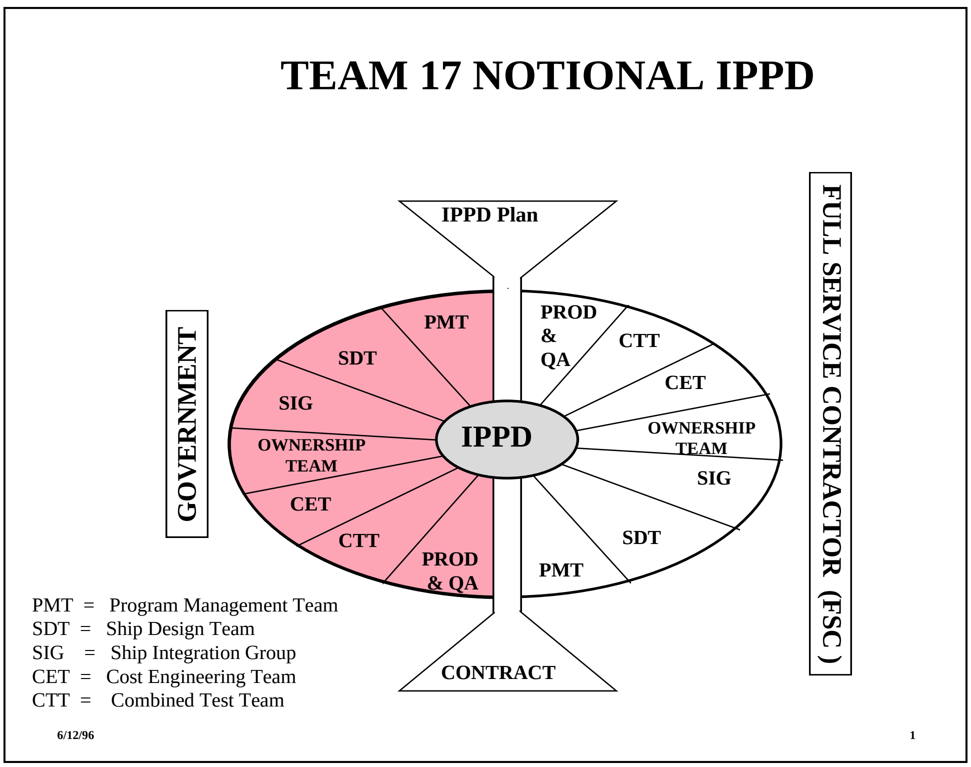


Figure BB-1. Team 17 Notional IPPD Approach

The IPPD team consists of co-located government/contractor personnel. Co-located means sharing the same floor, walls, and overhead with no intervening walls. The IPPD team was to be composed of persons possessing the appropriate disciplines, specialties, and functions from both government and contractor organizations and was to include subcontractor/vendor representation. Major subcontractors'/vendors' participation was to be addressed in the IPPD Team Plan. Participation of other than major subcontractors/vendors was to be addressed in the IMP. The contractor was to select its team members, making certain they possess the requisite knowledge and experience in key functional areas. The team members were delegated the responsibility, authority, and accountability for decision-making and management actions necessary for successful performance of the Contract. (No member of the IPPD team was authorized to change the scope of the Contract other than the Procuring Contracting Officer (PCO) assigned to the team.)

The contractor was to apply a multi-functional IPPD team approach to the integrated, concurrent development of the products and the associated processes applicable to the Detail Design, ship systems integration, construction, testing, logistics and life cycle planning support of the LPD 17 and in performance of all other efforts required by the Contract. The IPPD team was to operate in an environment that allows for verification of product and processes as they evolve.

The IPPD team was to interact in accordance with Contract requirements, the approved IPPD Plan, the Integrated Management Plan (IMP), and the Master Integrated Resource and Work Schedule (MIRWS). The IMP and the MIRWS were to be maintained as part of the Integrated Product Data Environment. This is an information capability which implements, through phases, the integration of a product model database with support and execution data, in order to satisfy the data and usage requirements of both the government and contractor. The IDE provides the capability to concurrently develop, capture, and re-use data in electronic form.

The contractor was to provide the management effort necessary to ensure effective cost, schedule, and technical performance under the Contract. The contractor was to identify methods to be used to fully integrate major subcontractors/vendors to provide overall direction and guidance, track progress and status, and integrate products and services provided by major subcontractors/vendors' with the products and services provided by the Full Service Contractor (FSC) personnel.

The contractor was to provide the members of the IPPD team with visibility into the Detail Design, ship systems integration, construction, testing, logistics and life cycle support planning effort. The contractor was to identify problems and potential problems that could adversely impact ship performance, cost, and/or delivery schedule accompanied by proposed solutions.

The government was to co-locate its members of the IPPD team at a mutually agreed upon contractor site to participate in the LPD 17 government/contractor IPPD team.

The government/contractor IPPD team was to monitor the contractor's QA activities to verify conformance with the approved Quality Program of the IMP.

No actions of the IPPD team were to relieve the contractor of the responsibility to perform all contract requirements.

Facility/Support for IPPD Team. The contractor was to provide all office space, office furniture, office equipments (phone, computer network interconnectivity, computer workstations, software applications, Video Tele-Conferencing, facsimile machine, photocopy machine, etc.) and parking facilities identified in the contractor's approved IPPD Plan.

IPPD Team Training. The contractor was to provide IPPD training to the government/contractor IPPD team. The team training was to commence within 20 days after contract award. The training was to address, at the minimum, the following topics:

- Development of IPPD team Goals/Objectives
- Development of IPPD team tools and metrics
- Development of IPPD Core Team Worksite layout
- Development of IPPD team rules of behavior and
- Mapping of the key processes

BB.9 COLLOCATION.

Computers are tantalizing. Enthusiasts have suggested that the need for collocation can be eliminated by the use of electronic networks. However, this seems to overlook the psychological advantages of face-to-face collaboration. Electronic systems may ameliorate the advantages of collocation in the future, but much development is still needed. Today, physical collocation continues to have great advantages.

A related problem is the splitting of the IPT itself between two major sites. For example, the system engineering and electromechanical design may be in New York, and the electronic and software development in California. To make this work successfully, the chief design engineer spends much time on a frequent basis at both sites. Also, the other enablers of collaborative work that were mentioned-meetings, temporary collocation, and computers-are fully used.

In 1982, when Xerox switched to the independent IPT, the people were scattered at various sites in the Rochester, New York area. Great effort was made to collocate the teams. This facilitated the informal communications that greatly improved the effectiveness of the IPT.

Strategic relationships with suppliers are a great extension of the multifunctional IPT. They are an essential element of IPPD.

Why Collocation Works. It is easy to get enthusiastic about the great improvements in team communications that technology has brought us. However, this enthusiasm should not blind us to a fundamental truth of product development. Collocation works. It consistently produces astonishing improvements in team performance. Everyone who has ever experienced a collocated team understands this. Those lacking this experience have many interesting theories about why collocation shouldn’t matter. But, why does collocation have such a dramatic effect? In real collocation, where team members are located within 50 feet of one another, teams function differently than when the same people are connected by electronic communications. Let’s examine some of these differences.

First, collocated teams are rich in face-to-face interactions. Such interactions provide enormous non-verbal information, the very information that conveys most of the emotional content of a message. Facial expressions, shifts in posture, and gestures speak volumes. They are rarely under conscious control, making them highly reliable indicators. Unfortunately, we tend to underestimate their importance because we react subconsciously, not consciously, to their messages.

Second, collocated teams are rich in verbal rather than textual communications. Verbal communications convey an order of magnitude more information than text. Intonation, speech volume, and hesitations convey information that is never present in written text. It is no accident that teenagers who spend most of the time communicating in the textual environment of Internet chat rooms often lack competencies in face-to-face communications with their peers. Verbal communication consists of much more than its textual content.

Third, collocated teams are rich in real-time, interactive, communications. This real-time interactivity is critical to clarifying and smoothing communications. A poor choice of words produces an instant response, and an immediate opportunity for damage control. Time lags deprive us of the feedback that allows us to sense the effectiveness of our communications.

Fourth, collocated teams are rich in accidental task-oriented communications. Overheard conversations and accidental interactions provide a rich flow of information that is fundamentally different from the deliberate communications of a dispersed team. These accidental communications act as a parallel channel to deliberate formal communications. Team members are confident that they understand what is going on, and the fidelity of formal communications is preserved.

Fifth, collocation increases interdependency. This is important because the more times you must depend on others, the more calibrated you become to their behavior, attitudes, and values. A branch of psychology called social expectancy theory suggests that the ability to accurately predict the behavior of other group members is essential to group productivity. The fabric to trust is woven from the threads of many small interactions.

Sixth, collocated teams are rich in non-task-oriented, interpersonal, communications. Team members inevitably learn about the families, hobbies, values, and lives of their teammates. With this knowledge comes an important shift in attitude. As we begin to see teammates as real, complex, human beings, instead of as stick figures, we perceive their behaviors differently. We are much more prone to make negative judgments on the behavior of outsiders than insiders. S uch judgments lead to negative behaviors that can easily spiral into conflict.

Seventh, collocation increases team cohesion. For many psychological reasons we are more likely to share values, attitudes, and beliefs of people with whom we interact intensely. This alignment leads to motivation, acceptance of team goals, and mutual support. Team cohesion is always highest on collocated teams.

Finally, collocated teams reduce waste. For example, collocated teams are often so in tune with each other that they don't even bother to hold meetings. "Why should we gather in a conference room doing presentations for each other when there is real work to do?" The high-quality communications created by collocation quickly truncate unproductive activities.

So, there really is much more to collocation than mere ease of communication. Certainly every product developer must master the art of managing a team that cannot be collocated. However, don't let this capability delude you into underestimating the **ex**traordinary power of collocation. It remains an irreplaceable tool in any product developer's toolkit.

APPENDIX CC
DESIGN TEAM ASSESSMENT

Ship Design Workforce Metrics

Have done ship design
Have actually done it all the way through the design process
Record of on-time performance producing a Contract Design/shipbuilding technical package
Have done a variety of ship designs
Have worked with different types of engineers from a range of organizations
Have produced designs for a range of different ship types
Have documented ship design procedures and processes
Have a process for passing on corporate memory of experience to younger engineers
Number of designs of different ship types have actually been built
Understanding of inter-relationships of technical areas and stakeholder organizations
Distribution of workforce across generations
Number and types of ship design tools available to engineers
Many of design team members have worked together before
Ability to use high fidelity design software effectively
Ability to anticipate problems and communicate effectively to non-engineers
Years of actual design experience
High technical competence
Understanding of maritime history
Matrix of skill areas required, who has them, and to what degree of robustness
Have senior people who have done the work and a mechanism to transfer to others
Feedback on number and types of design errors in construction
Matrix of organizational and individual experiences by ship type, and mechanism to pass the experience on to other organizations and individuals

Design Team Readiness Levels

Level	Description	Advancement Strategies
1	**A loosely-federated team with ad hoc processes** - Technical specialists work in narrow areas on design variants. Little process documentation exists. Retaining needed talent is a problem. Team management has little formal leadership training. Workforce administration activities (performance reviews, etc.) are given low priority. Individual team members have varying commitment and understanding of how current work can benefit their future career opportunities. Budget and schedule are often exceeded to complete projects.	Establish processes for design and distribute documentation of processes to the team. Implement regular drawing board reviews. Establish periodic training sessions that focus on key areas or skills that support design objectives. Publish metrics regarding design progress. Train team members in Lean Six Sigma. Identify mentorship opportunities.
2	**Design Managers assigned, with planning at unit level organization** - Teams include members from signatures, structures, stability, survivability, etc. Process is developed to meet the current needs with Management focus on unit level administrative activities. Upper-level management commits to continuous improvement of the workforce (Knowledge, skills, motivation, performance [PCMM]).	Improve process documentation and implement processes so that unit teams and individuals can suggest alternative approaches. Identify areas where improvement is needed and apply Lean Six Sigma practices to achieve some improvements in processes. Develop dashboards to provide easy access to team and unit performance, and to show team members status of design development relative to objective.
3	**Established processes & practices tie unit level processes together to align workforce competencies** - The team's overarching process is "open" and easily modified for use on any part of the project. The purpose of the process and practices framework is to facilitate the development of the workforce and give guidelines for unit level team interactions, thereby allowing the teams to function with more decision-making authority & effectiveness.	Review performance data and continue LSS process improvement efforts. Provide feedback to demonstrate how process improvements have benefited the team. Apply design strategies such as set-based design to explore broader range of alternatives for given amount of time. As team awareness and responsiveness improves, seek greater autonomy in decision-making. Expand dashboard use, increasing level of detail and visibility of performance metrics.
4	**Effective overarching process with metrics to quantify team's ability** – The team includes the proper, skilled people and the system in which they operate is defined and understood. Unit level teams perform tasks autonomously with results that upper-level management can trust. Progress and performance are measured.	Expand training activities to include other project teams that will benefit from or could contribute to team skills. Seek interns and entry level talent and provide mentorship at all levels. Develop succession strategies. Expand planning horizon to integrate with organizational needs; proactively seek to learn from other programs.
5	**Mature Team** – Team skill requirements are known and the right talent is available. Team members have worked together to produce and manage designs through milestone B to Critical Design Review (CDR) in the past. Processes are documented. The team follows a living process and continually revises and refines it to improve results.	Export processes and skills to other programs. Publish technical papers and proactively collaborate with other programs, including those outside the parent organization. Review performance metrics and rigorously seek improvements. Define core value stream, prioritize improvement needs, and conduct rapid improvement events to address needs.

APPENDIX DD
FINANCIAL PLANNING AND EXECUTION

Budget development, defense, and execution are among an SDM's most important functions. Without budget the SDM cannot perform. Securing excessive funding or failing to obligate and expend in a timely fashion, however, is a sure way to lose credibility. The DWOs are responsible for securing funding for the SIM and their TWH pyramid. The funding can be a combination of project or Sponsor funding. The demand signal and funding will be established yearly in the AEA.

SDMs should develop and fully document the rationale for their budget requests early. They should define the linkage between the performance requirements and required engineering support. Budgeting should include negotiations with and development of written tasking for all participants, including SEA 05 Group Heads on mission funded and reimbursable support. The budget must consider applicable design approval and certification requirements. SDMs are intended to have full control over resources approved by the Program Manager. Given that, the SDM has overall responsibility for delivering a fully integrated, technically acceptable product.

SDMs should establish procedures for the timely receipt of near current obligation and expenditure data and for tracking that data. Ship design phases up through Contract Design are usually funded through RDT&E money. Technically, this money has a two-year life span for obligation, meaning it can theoretically be carried over for almost one whole year beyond its appropriation year. In practical terms, however, the OMB has established obligation and expenditure guidelines on a monthly basis that require virtually all the money to be obligated within the first year. More than half the expenditures need to be made during the first year. Therefore, holding a "reserve" beyond April or so places that money in jeopardy of being taken by the Program Office for other, emergent needs.

Money that is carried over is handled differently between government organizations, such as NSWC laboratories and design agents. The former have been under increasing scrutiny for carrying over funds and will likely not be able to expend any funds beyond the first quarter (i.e., December) of the second year, even if they still have some on the books. Private industry should still be able to expend the funds, however. In either case, careful attention should be paid to project "carry over" funds by early summer and money shifted if necessary. Carryover of at least one month and up to two months is desirable to prevent a work stoppage at the beginning of the fiscal year since it takes about that long to process tasking for the new money.

SDMs should be careful to budget considering the possibility of an extension of the AoA or a requirement to continue feasibility studies long after completion of the AoA.

Financial Planning Tasks

The following tasks represent the minimum effort required by the SDM in financial planning:

- Analyze customer program requirements and develop a proposed budget
- Negotiate budget with SEMs at the WTA/SOW level
- Verify that receiving organizations can provide the needed quality of support
- Analyze risk and allocate funds for risk mitigation early
- Negotiate project budget with Program Office or other source as part of the AEA. (The SDM should remember that SDMs are always in competition for funds, so have a good justification for every dollar requested.)
- Establish project financial management procedures. (It is especially important to institute monthly reporting from Navy labs to track actual expenditures. They have had a poor record in the past, resulting in either shortfalls or large carryovers at the end of the fiscal year.)
- Develop current year quarterly obligation profiles based on analysis of rate of fund expenditure projections at the WTA/SOW, task group, and project level
- Identify, prepare, and initiate funding and tasking documents critical to the proposed ship design schedule

The final budget is documented with an obligation plan, which is sent to the Program Office or other source. Please see Appendix EE for an example of an obligation plan.

Factors Affecting Design Cost

There are no standard cost estimates for accomplishing design of a certain type of ship. The cost of each must be developed on the basis of the specific design effort needed to accomplish the task at hand. This is not to say that there is no relevance of one design experience to another. The costs of designing two similar auxiliary ships will have relationships that would not be applicable to the cost of designing a destroyer.

Historical cost data for many designs conducted since 1970 and up to 1990 are contained in the Ship Design Project Histories Book, commonly referred to as the “Red Book.” Copies of it may be found in the SEA 05D library. Sample budgets from recent design efforts are also available from the division directors and other SDMs. Ship design annual reports will contain the historical data. Remember that older design efforts used more in-house NAVSEA personnel and far fewer reimbursable laboratory personnel than is the typical case today.

With this database, the estimate for the overall design process should be developed, taking into account the scope of the effort required by the Program Office, particularly efforts which go beyond SEA 05’s direct responsibility. Estimated costs should be escalated in accordance with escalation rates provided by SEA 05C. The significant Shipbuilder overhead rates should be considered.

The amount of man-days expended during a particular design effort is a reflection of several characteristics of the design problem itself, the personnel, and their organization. Consideration must be given to:

- Duration of the design process
- The design strategy for use of contractors and Shipbuilders
- The newness of the design concept or technology
- Program risks
- The ability to reuse design documentation and design features from previous designs
- The amount of knowledge available from earlier design efforts
- The confidence in building directly on available knowledge
- Ship manpower and enhancement of shipboard human performance, safety, survivability, and quality of life
- The number of organizational interfaces requiring concurrence and coordination
- The personnel available and their experience
- Engineering data availability
- Dependence on developmental systems and technologies
- The level of design and consequent level of detail required both to perform the engineering and to adequately define the output

As the design proceeds from the feasibility studies phase to Contract Design, the cost estimation process becomes less and less dependent on historical comparisons and more and more on specific activities flowing from the individual design.

Funded Activities Supporting Ship Design

The following activities are considered to be essential and integral to the ship design process. They are to be funded as elements of the ship design:

- Preparation of the Engineering Management Plan and other design planning documentation
- Preparation of feasibility study, Pre-Preliminary Design, Preliminary Design, and Contract Design reports
- SDM and SEM management support
- Whole ship design engineering analysis, e.g., system safety; survivability; ILS; RAM; T&E; manning; supportability; HSI; electromagnetic environmental effects, and hull signatures
- System level human performance requirements analysis, including top down requirements analysis
- Systems level architecture engineering analysis
- Final technical reviews at completion of each design phase and as otherwise required
- Funding of Navy laboratories for model tests and other work
- Design feedback data acquisition and analysis
- Development of design deliverables
- Maintenance of an IDE
- Ship specification development and comment adjudication
- Review of contractor technical deliverables
- Design tools and modeling and simulation
- Requirements traceability
- Risk mitigation efforts
- Preparation of annual reports
- Travel
- Design site operations
- ABS involvement as appropriate for classed ships
- Cost team
- Industry requests for information
- Design decision memoranda
- Model tests

APPENDIX EE
SAMPLE OBLIGATION PLAN

WBS	Task	Task Lead	FY 2010 Task Support Activity	FY 2010 Total Man-hours	FY 2010 # Staff	FY 2010 Total Man-hours	FY 2010 Average Man-hour Rate	Total Cost

APPENDIX FF
SCHEDULE MANAGEMENT

Project schedules developed by the SDM must be consistent with the schedules put forth by the Program Office. Based on the acquisition strategy, the SDM should establish preliminary project schedules for the conduct of the intervening design effort. Ideally, SEMs will prepare WTA/SOW schedules using the preliminary project schedule as guidance. The SDM then integrates these, revises the Preliminary Design schedules, and negotiates differences and conflicts with both the Program Office and the SEMs. The project schedule will contain many important milestones. They indicate when tasks must be completed to ensure successful accomplishments that provide measurable and demonstrable evidence of progress of the design toward the project goals. Milestones are, therefore, not isolated events and their interrelationship should be described in the management plan. They provide both visibility and control points for the project and should be selected accordingly. Thus, they should be selected so that their accomplishment will be useful for gauging the progress of the project both technically and financially. By definition, there will be a minimum number of milestones. They may take any form such as a meeting, design review, or document issue so long as the event, if successful, signifies meaningful design progress. See the Virtual SYSCOM System Engineering Technical Review Handbook NAVSEAINST 5000.9 (*hyperlink*).

Interdependencies and predecessor relationships should be incorporated into the schedule. This will identify the "critical path," the sequence of interdependent events that establishes the current completion date. For most programs, DD&C contracting depends on conduct of a Navy Program Decision Meeting (for ACAT IC, II, III, IV) or DAB (for ACAT ID) which is dependent, in turn, on approval of all planning documentation, including the performance, cost, and schedule thresholds and objectives of the acquisition program baseline. Approval of the baseline depends, in turn, on agreement on the current POM, approval of the acquisition strategy, and approval of the CDD or CPD. Agreement on the POM turns on completion and reconciliation of the independent cost estimate and program life cycle cost estimate. Completion of these estimates depends on approval of the CDD or CPD. Their finalization is required before completion of the design effort, preferably well before the end of Preliminary Design.

In organizing the schedule, attention should be given to the frequency of the design reviews. No specific formulas can be set down to guarantee the benefits resulting from judicious planning and scheduling of design reviews. Each design project will have a unique design review schedule. Clearly, though, in structuring the schedule, design reviews should be planned to occur with a frequency sufficient to preclude large man-day expenditures occurring without the SDM's participation. More important, design reviews should be scheduled to occur at the points in time when the decisions are being molded, still fluid, and amenable to modification with minimum disruption to the remaining schedule.

The schedule is therefore not just a depiction of a collection of independently established and planned activities and events. Properly developed, it provides a representation of the coordinated and integrated activity of a variety of organizations. Further, it becomes a means to assure the SDM of adequate visibility of the progress of the design.

A useful design schedule must go to a significant level of detail to identify critical items and must include at least the following:

- Iterative total ship design cycles (e.g., design baseline issues). (Typically, the engineering effort for each cycle will span four to six weeks. An additional two to three weeks should be added to each cycle to allow for proper documentation, briefing, and cleanup.)
- Key documentation deliveries to support program milestones and deliveries to outside activities (e.g., TEMP, Cost Analysis Requirements Description [CARD])
- Documentation to support internal Program Office acquisition activities such as RFPs and source selections
- Documentation to support annual budget submissions, especially for doing the design itself
- Design review schedules (Block out overall prep times and major review dates.)
- Production-driven dates for information or technology-driven dates for testing (e.g., what size engine should be tested depends on ship powering calculations)
- Critical decision dates for selecting the hull form, or other major system decisions
- Key management reporting dates

The importance of a sound initial schedule cannot be overstated. Change inevitably will occur and disrupt the most careful planning. However, a well thought out schedule should provide contingency room in risk areas wherever practical. A comprehensive knowledge of milestone interdependencies will be invaluable in restructuring planning when such needs arise during the actual design activity.

Whatever systems are used to display milestones and other events, they should be simple to administer, visible to all concerned, and flexible enough to accommodate the inevitable changes from planning to reality.

The IWS DWO will develop an Integrated Master Schedule (see Appendix GG) that will include all major reviews including gate reviews. This IMS will be used to estimate the demand signal for a specific fiscal year as well as a planning tool for SIM and TWH to develop their work schedule for a specific year.

APPENDIX GG
IWS-IMS REQUIREMENTS

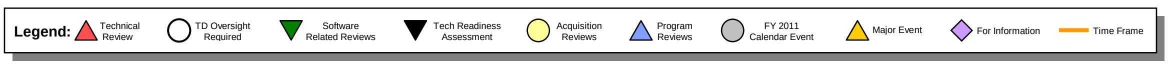
1. All ACAT, NON ACAT funded programs or funded Pre-Systems Acquisition programs shall report all systems Engineering and Acquisition program events.

2. Each program needs to indicate program status (active/non-active) and indicate ACAT category (approved or proposed) Example: SSDS (Blue character will indicate is a non-ACAT program, Black is an ACAT program)

   Post MLS C – "Indicates the Program status"

3. The schedule shall include the program Technical Reviews and Acquisition Milestones following events including but not limited to: ITR,ASR,SRR,PDR,IBR,CDR,TRR,FRR,OTRR,SVR,FCA,PRR,PCA,ISR, all gate reviews, SSSTRP/WSERB,MRA,PCD,IPCD, Certification meetings, program review, major test and or qualification events, QER, contract awards (i.e., .LRIP), demonstrations.

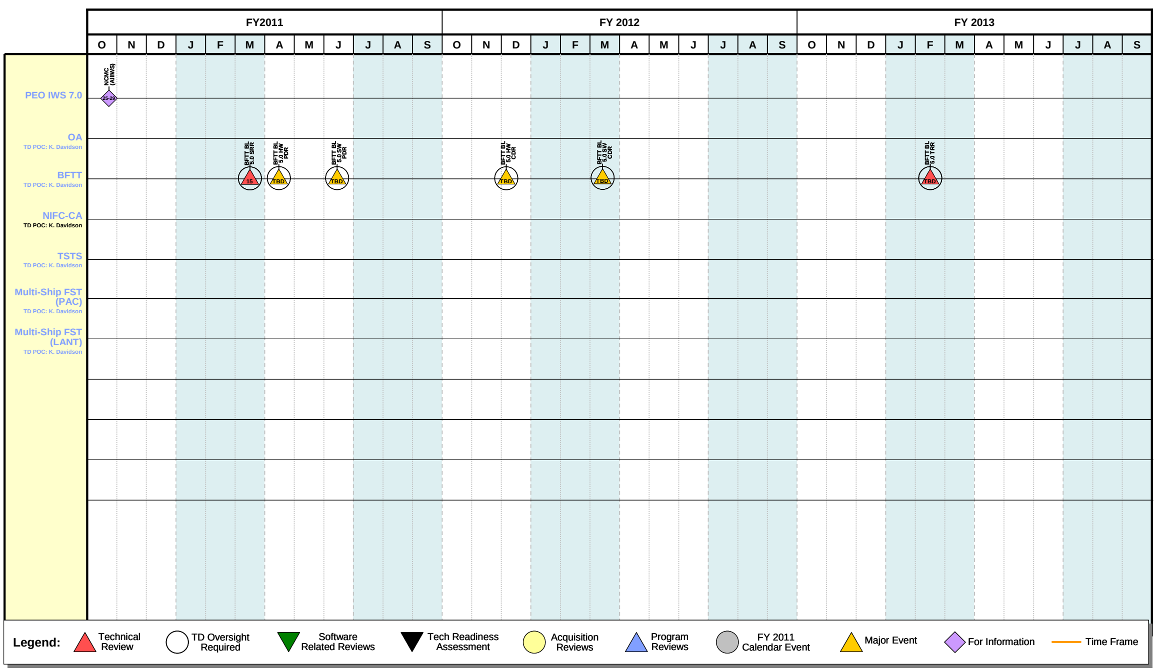
4. The following legend will be use to indicate the type of event:



5. Update to the schedule should be monthly if no changes are required an email should indicated it.

6. For schedule format see the following figure.

PEO IWS FY 2011 - 2013 MAJOR TECHNICAL MEETINGS AND EVENTS- PEO IWS 7.0



APPENDIX HH
DESIGN STRUCTURE MATRIX AND DESIGN PROCESS MODELING

HH.1 OVERVIEW.

A Design Structure Matrix (DSM) and Multi Domain Matrix compactly represents the relationships between design activities. Figure 4-5 shows an example of a Multi Domain Matrix. In this representation, each of the rows corresponds to a Design Activity, and each of the columns a Design Variable. The numbered diagonal represents that Design activity for row *n* produces as output variable the design variable in column *n*. A dot in a cell indicates that the associated design activity for the row takes as input the design variable corresponding to the column of the dot. By sequencing the design activities in the order of execution, much can be learned. Dots below the diagonal indicate variables that have been produced by previous design activities. Dots above the diagonal indicate variables that are needed by a design activity, but are not scheduled to be produced until the future. The value of the variable must be assumed, a "cluster" of activities as shown in Figure HH-2 must be solved simultaneously, or the design activities must be re-sequenced. Determining the optimal ordering of design activities is relatively easily accomplished using well known matrix operations.

Another insight that can be easily observed is shown by variables 1 and 2 of Figure HH-2. These two variables do not depend on each other in any way and could be solved in parallel.

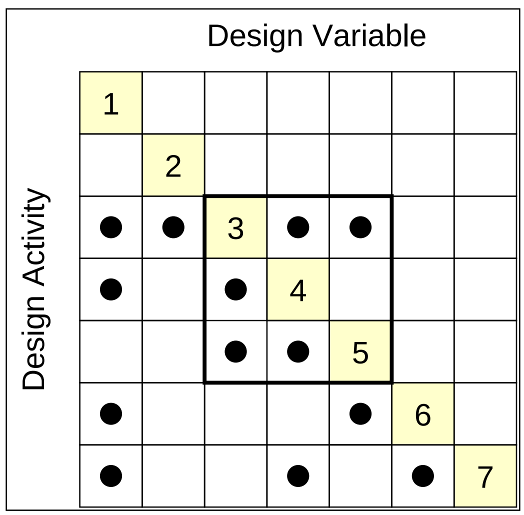


Figure HH-1. Multi Domain Example

As the level of fidelity of design activities increase with time, the number of relationships between design activities as well as the total number of design activities is expected to increase. The design process should not be expected to be constant over the evolution of a design. The matrix provides valuable insight on how the design process must evolve as fidelity increases.

While Figure HH-2 shows the relationships between design activities and design variables as "dots", these dots can represent data structures defining the fidelity and data format used in the data transaction. Likewise, the diagonal "numbered boxes" could represent the data structure defining the characteristics of the design activity.

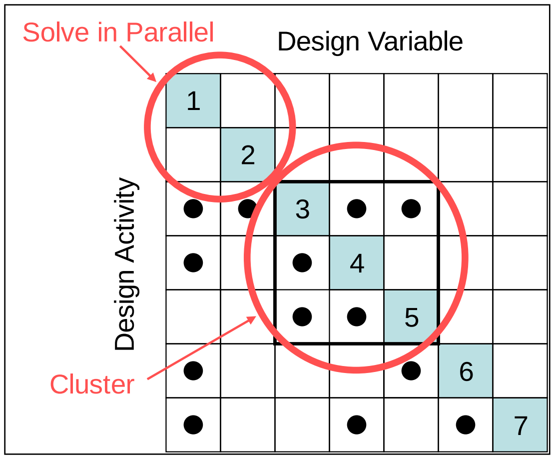


Figure HH-2. Insights

HH.2 ACTIVITY MODELING.

There are many ways to model a ship/system design activity for integration. A modeling technique that has proven useful over time is based on the IDEF0 definition of a function. As shown in Figure HH-3, a Design Activity interacts with external activities via Inputs, Outputs, Controls, and Mechanisms. Inputs are those data elements needed to perform the design activity. Outputs are those data elements that are produced by the design activity. Controls impact the manner in which the design activity is performed, and Mechanisms are the resources needed to perform the design activity.

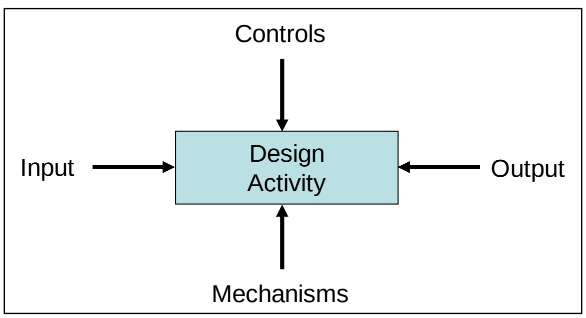


Figure HH-3. IDEF0 Activity Model

In executing a process, much of the focus is on the interaction of the design activities via the Input and Output Variables. In constructing the matrix from a set of design activities however, the controls become equally important; the controls govern the list of input variables, the properties of the Input Variables, and the properties of the Output Variables associated with the Design Activity.

The primary Control Variable used in Design Activity modeling is the requisite fidelity of the Input and Output Variables. The level of fidelity of the Output Variable may govern which design tool is used for that part of the design process; it may also require a different set of Input Variables of varying levels of fidelity.

Other Control Variables include input variable data formats, output variable format, type of hull, major hull material, and mission type.

Defining a Design Activity in this manner can result in multiple sets of design tools being employed depending on the Control Variables.

This dynamic nature of the number and type of input variables based on the value of a Control Variable differentiates ship design processes from classical IDEF0 process modeling. Consequently, a different technique for interconnecting design activity models is needed. Instead of IDEF0 process modeling, using a matrix for describing the inter-relationships of design activities is more appropriate.

More than one design activity can share the same Output Variable. For example, one Design Activity that fulfills the "Hull Resistance Analysis" function may be based on model testing while another may be based on detailed computational fluid dynamics. The two Design Activities could differ in the required input variables and would likely result in a differing set of Mechanisms.

HH.3 DESIGN PROCESS MODELING.

Figure HH-4 shows a simplified process model. In addition to the core matrix shown in Figure 4-1, it also shows dependencies on assumptions, as well as the dependency of output activities on the design variables and assumptions. Note that all the Outputs are independent of each other and all of the assumptions are independent of each other. Also note that while the matrix is inherently square, the number of assumptions does not have to equal the number of outputs, hence the Design Process Model is not required to be "square."

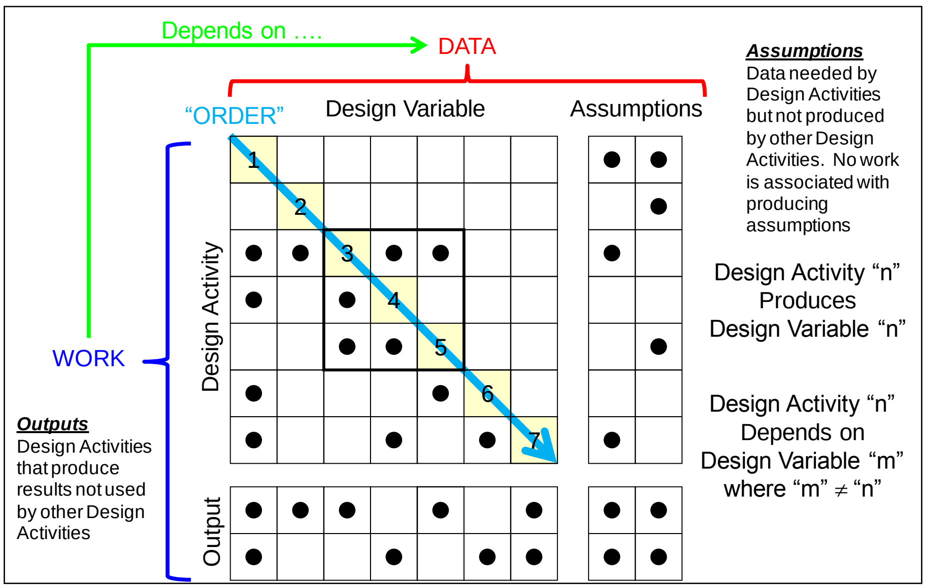


Figure HH-4. Design Process Model

HH.4 ANALYSIS.

This is a powerful tool for identifying integration issues within a given design process.

When using the design spiral, common practice is to ignore any dependencies above the diagonal of the matrix. Instead the results from the previous iteration are assumed for the design activity. In this way, the design spiral ensures a lower triangular matrix for a given design iteration. This will generally work if the dependencies above the diagonal are weak compared to other dependencies.

In certain cases, it will be impossible to eliminate a strong dependency from above the diagonal. In this case, convergence may be faster if this internal "cluster" of Design Activities is solved as a spiral within the overall ship design spiral.

Alternatively, the Design Activities and the variables they produce may be redefined to eliminate dependencies above the diagonal. One way is to redefine each design activity within a “cluster” to produce a response surface instead of a point solution. After all of the response surfaces from the Design Activities in the cluster are produced, an additional design activity is employed to find the intersections of the response surfaces which would constitute the design point for that iteration.

Clusters of Design Activities should also be the focal point of efforts to automate data exchange, to conduct process improvement efforts in the conduct of the design activities, as well as to establish the boundaries for IPTs.

In Set-Based-Design, the matrix can be effectively used to define the required dimensions of the “sets” or response surfaces provided by each discipline. At each process gate however, the level of fidelity of the design must improve. This implies that additional Design Activities and dependencies may be required. In planning a Set-Based Design iteration, one has to understand these ever-increasing dependencies to ensure the domain specific design and analysis produces the requisite response surfaces (design variables) of the right dimensions (dependencies). The end result is that in execution a Set-Based Design matrix may have additional integration activities, but the matrix will be lower triangular.

HH.5 DESIGN PROCESS MODELING.

Efforts have also begun to model the ship design processes using PLEXUS and other software tools. This will provide an initial template for new ship design programs to use to define, model, and optimize schedule, resource availability, and resource requirements for each design phase.

APPENDIX II
SAMPLE STATEMENT OF WORK

SOW TITLE

SOW B3 - Systems Engineering

RESOURCES

NAVSEA -

Level of Effort (LOE) Support -

Government Activities -

Other -

OBJECTIVE

Provide support to the Ship Design Team in the evaluation of alternative design features, for the tracking of key parameters, and assisting in design integration.

PRELIMINARY DESIGN TASK DESCRIPTION

1. Conduct engineering and cost evaluations and trade-off studies for design alternatives on the basis of a total ship system perspective.

CONTRACT DESIGN TASK DESCRIPTION

1. Periodically update and issue the Parameter Allocation Report which tracks trends in weight, KG, electric power, HVAC load, area/volume, manning, speed, and endurance.

2. Evaluate the impact of concepts proposed to reduce weight and cost and recommend actions. Total ship impacts of individual features or combinations of features will be systematically analyzed to define primary and secondary impacts in a consistent manner. Special studies will be undertaken as directed to define the performance, cost, and weight impacts of new technologies and alternative features.

3. Assist in the evaluation of concepts proposed to enhance producibility. Emphasis will be on identifying the impact on ship performance, size, and weight, so that the cost benefits postulated for the concept can be considered in conjunction with changes to technical considerations and possible secondary impacts.

4. When directed by the SDM, evaluate the impacts of major technical issues with total ship impact in an “off-line” environment, and prepare input necessary for the decision-making process to the SDM.

5. Conduct special studies in support of mainstream efforts on an as needed basis.

DESIGN ACTIVITY MODEL

1. DESIGN ACTIVITY

Conduct total ship analysis to include development of the Parameter Allocation Report, impact studies of weight reduction, cost reduction and producibility enhancement proposals as well as other major total ship technical issues.

2. INPUTS

All design variables associated with the ship configuration

All system analysis reports

3. OUTPUTS

Parameter Allocation Report and Study Reports

4. CONSTRAINTS

Reports shall be accurate enough to make good decisions

5. MECHANISMS

Tools

Personnel required per study

Time required per study

PRELIMINARY DESIGN PRODUCTS/SCHEDULE

Para. No.	Title	Issue	Date
1.	Preliminary Design Technical History Input	Final	

CONTRACT DESIGN PRODUCTS/SCHEDULE

Para. No.	Title	Issue	Date
1.	Parameter Allocation Report	Monthly	
2.	Various Special Study Reports	As Req’d	
3.	Contract Design Technical History Input	Final	

APPENDIX JJ
ANNUAL EXECUTION AGREEMENT TEMPLATE FOR SDM

JJ.1 PROGRAM CONTEXT.

Provide a short narrative description of where the program is in the stream of ship design and construction activities. Indicate who has the lead for design development efforts, and provide a general description of how the Navy Design Team manages risk and provides engineering support for the program. If the program is in-line construction, indicate which hulls are still being actively worked by the Design Team. Include in this section a listing of significant technical and program milestones or evolutions that are either ongoing, or will occur during the coming year.

JJ.2 NATURE OF REQUIRED ENGINEERING SUPPORT.

Provide a detailed listing of engineering products and services that must be produced by the Navy Design Team. The listing should include an estimate of the average manhour work content associated with each category of items, as well as an estimate of the anticipated volume of items over the coming year. Where practical, specific categories of items should be ranked relative to risk, to facilitate discussions of funding priorities in cases where all necessary work cannot be funded due to funding cuts. Significant separate risk reduction efforts (e.g., conduct of a scale model test program) should be shown as separate activities (i.e., apart from the core Design Team) for ease of understanding. Adequate focused Risk Management and Systems Safety efforts are a necessary part of all AEAs.

JJ.3 REQUIRED CYCLE TIMES.

Turnaround times for each category of items shall be stated, and it should be noted how, when, and by whom due dates for individual items are assigned. Where needed, a procedure for arranging tailored due dates for more complex items should be included in the AEA.

JJ.4 RESOURCE AND FUNDING ALLOCATIONS.

A tabular listing of funding commitments (by performing activity) shall be included for approval by the Program Manager. Mission funded assets being made available to the program shall be shown as well. Separate risk reduction efforts should be shown as separately identified line items, with those costs being segregated from the overall Design Team budget. This section of the AEA should state the SDM's presumptions relative to the level of risk inherent in the agreed upon funding. If negotiations will not support a minimum level of government effort required to support certification of the ship by the warranted technical authorities, the matter should be elevated to CSE Ships and PEO Ships for resolution.

JJ.5 METRICS AND TEAM PERFORMANCE.

The SDM/SIM/TWH is responsible for delivering on the commitment made in the AEA that he or she signs along with the Program Manager. The SDM/SIM/TWH shall manage the resources allocated in the AEA as a business, including the Design Team budget. The SDM will monitor obligations of funds, expenditures of funds, and performance at both Warfare Centers and LOE contractors. A control point for work flow and measuring throughput will be established by the SDM/SIM/TWH. Metrics required by the Program and CSE will be tracked and reported by the SDM on a continuing basis.

APPENDIX KK
DESIGN ENVIRONMENT

A smoothly functioning design environment can facilitate the design process and allow participants to focus their energies on design challenges. Conversely, a poorly functioning design environment can drive up costs, disrupt schedules, and cause the design to fail. Design environment issues rarely have the appeal of ship technical issues to the SDM. Nevertheless, the design environment and the collection of design tools that will be applied to the program deserve the SDM’s careful attention.

A variety of acronyms are used to describe design environments. These include:

- Integrated Data Environment
- Integrated Design Environment
- Integrated Digital Environment
- Integrated Product Development Environment (IPDE)
- Integrated Product Data Environment (IPDE)
- Integrated Data Environment/Smart Product Model (IDE/SPM)
- Integrated Data and Product Model Environment (IDPME)

The variety of acronyms illustrates two points important to the SDM. First, people have widely varying concepts of the functionality and scope of the design environment. The SDM must be careful to understand what individuals mean to imply when they use these terms. Second, design environments tend to be recreated for each individual program. While many elements of the design environment will pre-exist, the program, changes in teaming arrangements, business relationships, information technology, etc. will usually cause participants to “improve” the process used on the previous program.

There are two major groups of design environment functions of interest to the SDM. These are discussed in following sections. The first is to document management and design process control. The second is ship design development. Throughout the remainder of this section, the acronym “IDE” denotes a design environment fulfilling both these functions.

Planning for an IDE should start very early in the life of a project. Initially, the number of people with access to the IDE will be relatively limited because of the small size of the Design Team. As time progresses, the IDE may include thousands of participants. SDMs should work closely with the Program Office to ensure adequate resources are assigned to implement the IDE.

IDE development must be at least one phase ahead of design development. Parallel development of an IDE and the ship design it supports is a recipe for disaster. The SDM must oversee an IDE development and/or implementation effort that provides adequate scope, capacity, and function for the next phase. He must insist on readiness reviews and testing to ensure capability.

<u>IDE</u>

An IDE is a collection of business processes, computer systems, and associated services, which house the product model data, and enable people to work in concert towards common business goals throughout the life cycle of a product.

A common drawback of these environments is their proprietary (closed) architecture, inhibiting the flexibility to reconfigure and adapt to changing program requirements without significant, costly customization. Despite all of the effort in building and maintaining these IDEs there are still many deficiencies. Two major issues to be addressed when designing an IDE is how to efficiently manage changes and how to share product information with other Navy activities and Shipbuilders.

It is usually not possible for a single project to specify the hardware and software solutions for the multiple organizations that participate in a typical complex project. Generally, the hardware and software procurement decisions for an organization are made independent of any one specific project. Concentrating on specifying interface standards will likely be a more successful strategy. The interface standards to support a given program may not be completely compatible with the hardware or software of a given organization. If the infrastructure is not compatible, the organization may need to invest additional resources to gain the requisite level of interoperability.

Ideally, a given project should not have to invest in developing the hardware and software infrastructure to implement an IDE. In reality however, projects may have to provide funding to organizations to enable interoperability. On the other hand, projects should be expected to expend resources to develop documented business processes, and to actively manage the information within the IDE.

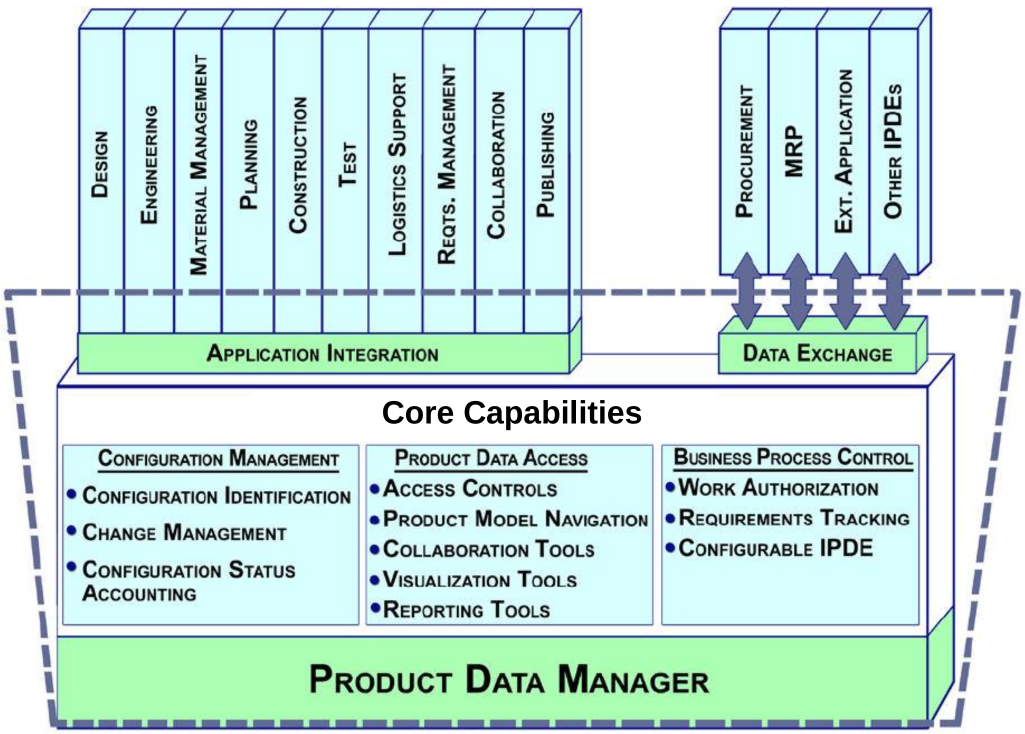


Figure KK-1. IDE Notional Architecture

Figure KK-1 notionally depicts the core capabilities of an IDE along with requirements for Interoperability and Data Exchange between the major applications that make up an IDE. The dashed line illustrates the boundary of the IDE specification in the scope of an overall IDE. This notional model shows the applications supporting the major shipbuilding and support functions as vertical columns. These vertical applications are different for each implementation of an IDE; some IDEs will not have all the applications shown or may include additional applications. The IDE core capabilities support the vertical applications and provide management of and control access to the product model data. The functional requirements for an IDE include:

- **Communication** – For most projects, this consists of email. The posting of documents such that others can retrieve it is another form of communication.
- **Collaboration** – Collaboration is the cooperative action of two or more individuals resulting in a total effect that is greater than the sum of the individual efforts. This synergistic effect can be achieved through appropriate business rules that take advantage of the IDE software and hardware infrastructure.
- **Data Storage** – The ability to save project information for future use is key to having the information available to participants.
- **Data Retrieval** – Similarly, once data is within the IDE, participants must have the ability to retrieve the data for their use.
- **Configuration Control** – Configuration Control is necessary to ensure that participants are using the right data in the accomplishment of their jobs.
- **Search Capability** – It's not only important to be able to retrieve data, but it is also important for participants to quickly find all relevant data to assist in the accomplishment of their jobs.

Key IDE processes needed to implement these functions include:

- **Access Control** – Access Control ensures that those with a need to know information have access to the appropriate information.
- **Information Security** – Information Security ensures those without a need to know don't have access to sensitive information.
- **Business Process Definition** – Defines how participants interact with one another and with the information within the IDE.
- **Information Structure Development** – The information structure defines who is responsible for managing different types of information from creation through disposal, how that information is stored within the IDE, and how access to the information is determined.
- **Interface Specification** – Defines the interface requirements between hardware, software, and people necessary to implement an IDE.
- **Life Cycle Management of Information** – Life Cycle Management of Information is the day-to-day implementation of the Information Structure using the Business Process
- **Training** – An IDE can only be effective if all participants understand how to properly employ it. Training is key to ensuring a successful IDE.

Summary of SDM IDE Concerns

Are IDE planning, development, and implementation verifiably adequate and on track for the next design phase?

Are systems and procedures in place to support IDE functions and processes across the Design Team, which may be geographically and corporately distributed and use products from different software vendors?

Among the CAD, etc., systems in use for DEFINITION development on the design project, how are hull shaping and subdivision (i.e., molded DEFINITION), structural arrangement, component placement, and distributive system arrangements kept consistent? What is the authoritative source of configuration/geometry data and how are the others kept in synch as the design evolves?

What characteristics and performance of the ship are the Design Team trying to predict with computer tools (i.e., visualization, spreadsheets, computer-assisted engineering, simulation, etc.)? These should align with check elements and TWHs. What tools will the Design Team use? What is the process or system for confirming alignment between the analysis results and the configuration and geometric data defining the current design?

What software or process will the Design Team use to relate document images, such as technical manuals, reports, trade-off studies, etc., to configuration data and analysis results?

What software or process will the Design Team use to relate requirements and specifications to the configuration elements that satisfy them and the analysis results, simulations, and tests that prove their satisfaction?

APPENDIX LL
ENGINEERING MANAGEMENT PLAN

This appendix is intended to provide guidance for preparation of the Engineering Management Plan. The Engineering Management Plan should be an unclassified document. Necessary classified information can be provided under separate cover. The Engineering Management Plan should be approved by the Division Director.

Prior to New Construction DD&C, the SUPSHIP CHENG and SDM will jointly author the EMP to further elaborate and define roles and responsibilities tailored to the specific program. The EMP will include (among many other details) that:

- The SDM will lead all design reviews.
- The SUPSHIP CHENG and SDM will jointly accomplish the technical review/disposition of Test problems (including Test Procedures and actual testing) with accountability split as described in NAVSEAINST 5400.95E.
- The SDM and SUPSHIP CHENG will co-author a “technical readiness for trials” memo. This will be a serialized memo from the Chief Systems Engineer (Ships) to the Program Manager.
- The SUPSHIP CHENG and SDM will jointly accomplish providing the technical review/recommendations during the Program Office disposition of Trial Cards with accountability split as described above.
- The SUPSHIP CHENG has the lead for technical approval of all specifications for post-delivery work, but will rely on the SDM for design related issues.
- A formal turnover of technical authority at the OWLD (usually end of warranty period) from the SUPSHIP CHENG and SDM to the In-Service SDM and RMC/Shipyard CHENG (for USN ships) or to MSC (for USNS ships). The turnover documentation will provide full disclosure and transparency of engineering decisions made and outstanding items/non-conformances remaining at transfer. For MSC ships, MSC assumes operational technical authority after delivery, and all aspects of technical authority at OWLD.

For in-service ships, the SDM and RMC CHENG will not generally author or execute an EMP. An exception to this may occur during major overhauls where the scope of alteration to the ship systems requires further refinement of roles and responsibilities associated with Technical Authority.

The Engineering Management Plan should include the following elements:

1.0 Introduction - This element is intended to describe the content, status, and use of the management plan. The following items should be included (as applicable).

(a) General Description of plan content and use.

(b) Provisions for plan revision.

2.0 Design Strategy - Define the use of headquarters personnel, field activities, contractor support, complete design farm-out, or other means of accomplishing the design phases. Discuss the type of design, Navy Design or Contractor Design.

3.0 Background

(a) General description of acquisition program including overarching schedule.

(b) Brief summary of work accomplished in previous phase.

(c) Brief statement of work planned for the next phase.

4.0 Organization - This section shall briefly describe:

(a) Organizational relationships to Program Office, SUPSHIP, ABS and any other government/industry members of the Program Office team. The interface with the participating SYSCOMs will be specifically discussed. Responsibilities and interfaces of Design Team members will be discussed.

(b) Project team organization from SDM to SEMs to TLs to TWHs including responsibilities.

(c) Project directory with names, organizations, area of responsibilities, and telephone numbers of participating NAVSEA personnel and those from other activities.

(d) In-house manpower projections.

(e) Identify purpose and membership of IPTs, Working Groups, and special ad-hoc groups, such as Shipbuilder's Review Team.

(f) Who will sign Ship Specifications, drawings, and other design products.

5.0 Technical Approach - This section shall describe the technical environment of the project:

(a) Project Objective and Primary Constraints

(b) Design Scope and General Methodology

(c) Design Products

6.0 Task Planning and Budget

7.0 Design Activities and Technical Control

(a) Architectures, Interface Control, and Work Breakdown Structure

(b) Requirements Definition, CONOPS, Design Reference Mission, Specification, and Technical Baseline Definition

(c) Technical Performance Measures and Metrics

(d) Design Budgets

(e) Design Considerations

(f) Technical Certifications

(g) Integrated Master Schedule

(h) Reporting and Technical Reviews

(i) Engineering and Integration Risk Management

(j) Design Team Meetings, Action Items, Issues, Design Decision, Specification Change/Configuration Management Processes, and the Integrated Digital Environment

APPENDIX MM
RISK MANAGEMENT

One of the SDM's/SIM's primary roles is to support and enable an effective risk management process. This program addresses programmatic risks and system safety risks.

A programmatic risk is a measure of future uncertainties in achieving program performance goals and objectives within defined cost, schedule, and performance constraints. Programmatic risk addresses the potential variation in the planned approach and its expected outcome. Programmatic risks have three components:

- A future root cause (yet to happen), which, if eliminated or corrected, would prevent a potential consequence from occurring
- A probability (or likelihood) assessed at the present time of that future root cause occurring, and
- The consequence (or effect) of that future occurrence

A system safety risk is a combined measure of both severity and probability that a hazard that could result in a mishap. A hazard is threat of harm to an asset having value one would wish to protect. Each system safety risk involves a brief narrative description of a potential mishap attributable to the hazard. A hazard description contains three elements that express the threat:

- A source, an activity, or a condition that serves as the root
- The mechanism, a means by which the source can bring about the harm, and
- An outcome, the harm itself that might be suffered

Programmatic risk management programs include:

- Identification and submission of risk by team members
- Assessment of likelihood and consequences, prioritization, and assignment
- Development and implementation of effective risk mitigation plans
- Tracking and reporting

Acquisition programs have come to use very similar processes and documentation. Figures MM-1, MM-2, MM-3 and MM-4 illustrate typical risk process elements, a scheme for assessment of risk severity, and a risk summary worksheet. A variety of supporting software is available. The SDM should coordinate with the Program Office in software selection. Figure MM-5 summarizes residual risk approval requirements.

A formal risk management process may be integrated into the normal program action item identification and tracking process with little additional effort. Often, however, programs either make the mistake of overdoing it by establishing a large and manpower-consuming risk management organization or, conversely, not progressing beyond the PowerPoint level.

The SDM/SIM must ensure that the Design Team actively participates to make certain that technical risks are accurately described and appropriate mitigation plans are developed.

The SDM/SIM should be alert to the effects of compound integration risks. For example, program establishment of a severe crew size limit can ripple through a design, generating technical risk for a number of areas.

From an SDM/SIM perspective, identifying and rating risks is important at the total system level rather than the subsystem level. For example, a communications system antenna may assume requirements that are considered high-risk to achieve, but from a total system viewpoint there may be multiple other communication channels at different frequencies that can get the same information across so that, overall, the risk of not communicating is much less.

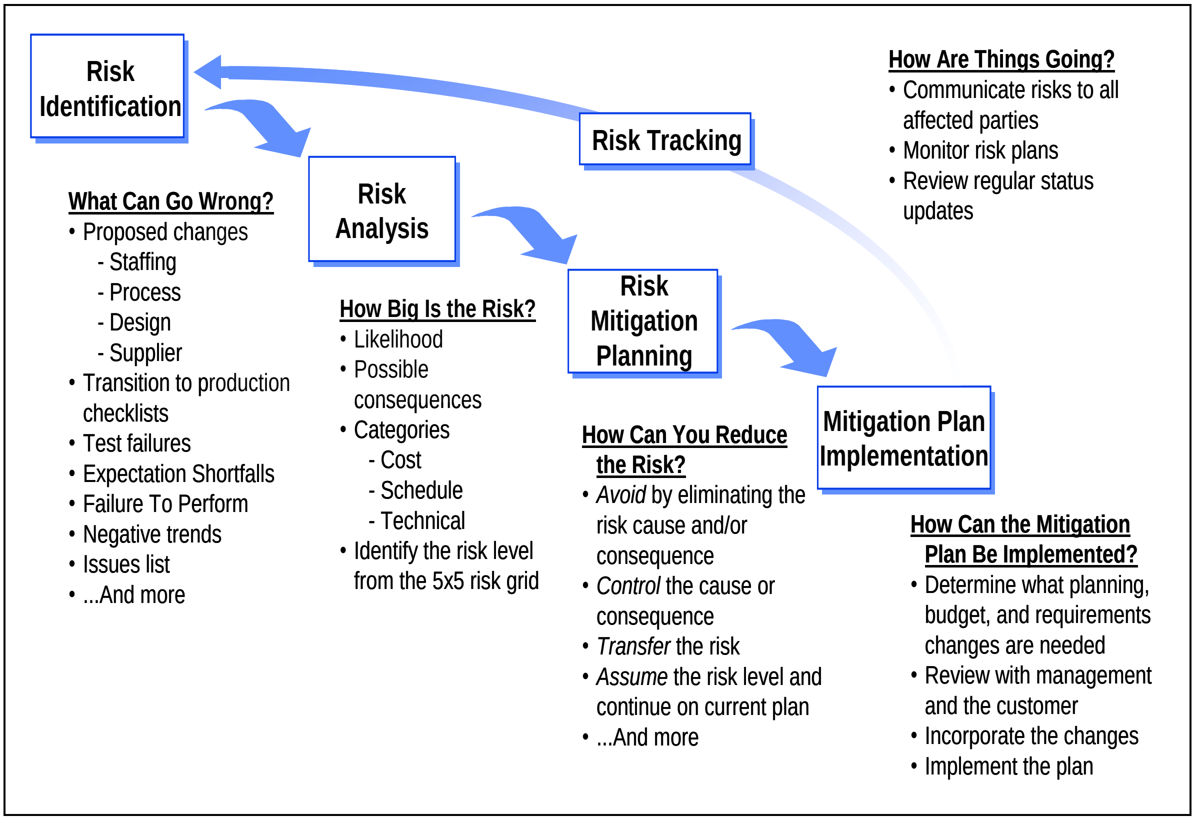


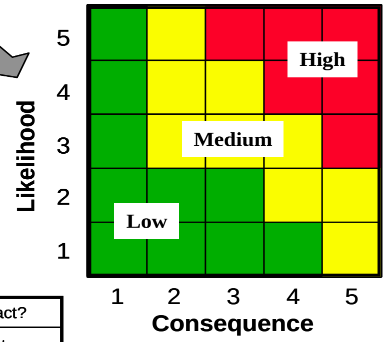
Figure MM-1. Risk Process Elements

An important consideration in executing the risk management process is the allocation of resources needed to perform the risk mitigation steps identified in the plan. Without adequate funding, the process will not achieve the desired result of reducing risk. The SDM needs to aggressively pursue such support for the important technical risks. Further, since the allocation of big money is at stake, getting the risk ratings correct is worth the investment of SDM energy.

Note that DoD, as evidenced in the current SEP template, now expects Programs to manage issues and opportunities thought a comparable if not the same process as risks.

Likelihood

What Is the Likelihood the Risk Will Happen?		
Level		Your Approach and Processes...
1	Not Likely:	...Will effectively avoid or mitigate this risk based on standard practices
2	Low Likelihood:	...Have usually mitigated this type of risk with minimal oversight in similar cases
3	Likely:	...May mitigate this risk, but workarounds will be required
4	Highly Likely:	...Cannot mitigate this risk, but a different approach might
5	Near Certainty:	...Cannot mitigate this type of risk; no known processes or workarounds are available



Consequence

Given the risk is realized, what would be the magnitude of the impact?			
Level	Technical	Schedule	Cost
1	Minimal or no impact	Minimal or no impact	Minimal or no impact
2	Minor perf shortfall, same approach retained	Additional activities required; able to meet key dates	Budget increase or unit production cost increase <1%
3	Mod perf shortfall, but workarounds available	Minor schedule slip; will miss need date	Budget increase or unit production cost increase <5%
4	Unacceptable, but workarounds available	Program critical path affected	Budget increase or unit production cost increase <10%
5	Unacceptable; no alternatives exist	Cannot achieve key program milestone	Budget increase or production cost

Figure MM-2. Assessment of Risk Severity (Notional Criteria)

Risk Summary Worksheet

Page __of __

Risk Title ____________________ Team ________________ Date __________

Team Leader ________________

Description of Risk

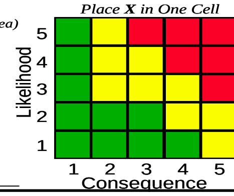
Statement of Basic Cause

Consequence if Risk is Realized

Risk Type
(Check one in each area)

- ☐ Technical
- ☐ Schedule
- ☐ Cost
- ☐ EMD
- ☐ LRIP
- ☐ PROD
- ☐ Other_______

Place X in One Cell



Risk Reduction Plan

Action/Event	Date		Success Criteria	Risk Level if Successful	Comments
	Scheduled	Actual			

Figure MM-3. Typical Risk Form

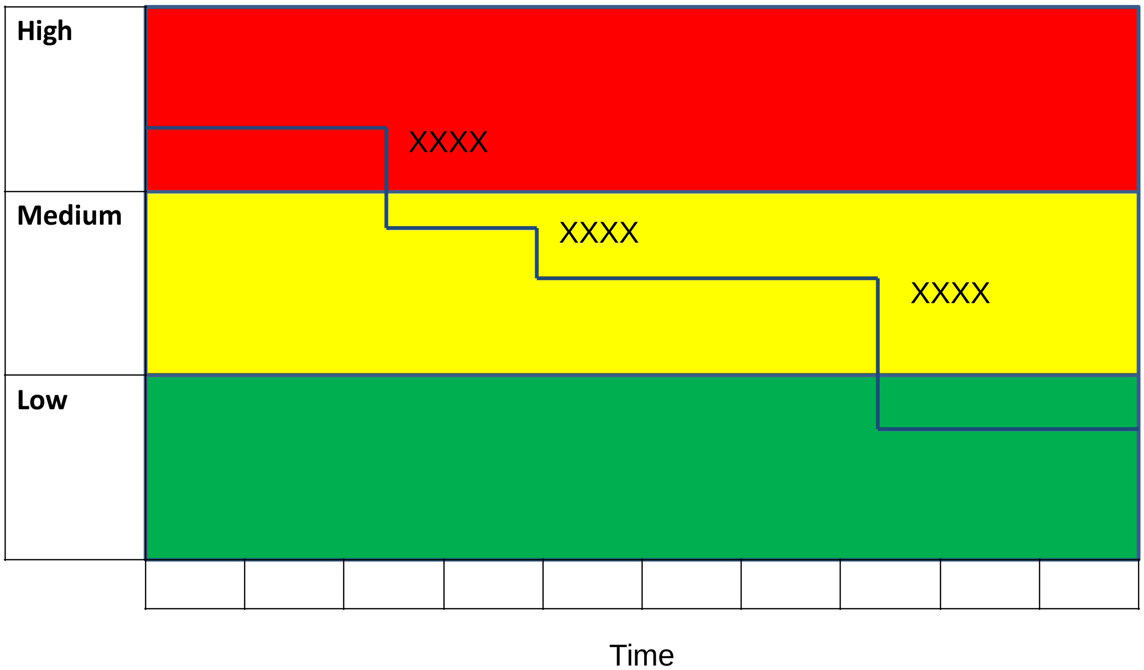


Figure MM-4. Risk Waterfall or Burn Down Chart

Level of Risk	Technical Authority: Approves Analysis of Residual Risk	Programmatic Authority: Accepts Residual Risk	User/Fleet Coordination	
Program:			Acquisition	In-Service
High	Systems Command (SYSCOM) Commander	MDA or Assistant Secretary of the Navy for Research, Development and Acquisition (ASN(RDA))	Sponsor	Type Commander
Moderate	Deputy Warranting Officer	Program Executive Officer	Sponsor	Type Commander
Low	TWH	PM	Sponsor	Type Commander
System Safety:			Acquisition	In-Service
High	SYSCOM Commander	ASN RDA	Sponsor	Type Commander
Serious	Deputy Warranting Officer	PEO	Sponsor	Type Commander
Medium	TWH	PM	Sponsor	Type Commander
Low	TWH or Certificate Holder	PM		

Figure MM-5. Residual Risk Acceptance Requirements

APPENDIX NN
DESIGN REVIEW CONTENT

This section addresses those reviews conducted by the Navy on its own ship designs or concepts, as well as reviews of industry designs where the Navy is gauging technical acceptability of the engineering products and the inherent technical risks involved.

This Appendix provides a general view of items that are (or, depending upon the phase, could be) applicable to all design reviews and should be considered for inclusion in all of them. If any of the below factors and design topics are not included in the review, there should be a good reason why it was not addressed at some level. Appendix Q provides SETR entrance and exit criteria that should also be considered in development of the briefing.

Major design review objectives include:

- Ship/System Size – Confirm that the ship/system has been sized properly from the naval architectural perspective, including provision of adequate design margins and service life allowances.
- Stability – Appropriate ship/system control, acceptable ship/system dynamics, and adequate ship/system stability have been provided.
- Technically Feasible – Confirm that the ship/system is technically feasible. Ascertain that there are no design conditions that would preclude arriving at a technically acceptable ship across all areas, including compliance with applicable design rules.
- Design Strategy – A comprehensive design and risk management strategy has been developed that is executable within the time and resources available. Any base assumptions, both programmatic and technical, have been validated by the Navy stakeholder involved.
- HSI Strategy – A comprehensive HSI strategy will or has demonstrated that sufficient crew size and skill levels are successfully matched to the ship configuration (including accommodations and automation features) in a manner consistent with prevailing Navy policies such as mixed gender, hybrid sailor, and total ship training architecture. This strategy must employ functional workload analysis; identification of required knowledge, skills, and abilities; and usability testing of operator interfaces.
- Safety – The ship/system and its crew will be safe to operate. Sufficient active and passive survivability has been provided, consistent with program requirements.
- Effectiveness – Mission effectiveness has been demonstrated in accordance with the applicable requirements documents (e.g., CDD), applicable force-level interoperability requirements. (e.g., FORCEnet compliance), and higher level configuration management/capability evolution policies (e.g., open architecture compliance).
- Top-Level Requirements – Confirm that other non-mission KPPs and ICD/CDD requirements have been met, such as speed, endurance, operational availability, and time on station.
- Build Strategy – A coherent build strategy has been developed, consistent with lean shipbuilding principles. The ship is buildable using the intended facilities and production techniques.
- Readiness for Release – Assess the completeness and accuracy of the design and make a determination regarding release outside the command or display at a higher level.
- Design Approval – For completed Contract Designs, assess the design for the purposes of design approval.

Prior to conducting any design review, an agenda should be issued that provides an outline of the material to be discussed in the review. The review date should be published well in advance so that participants can come prepared. The timing should be progress-based vice calendar-based. For instance, a PDR should not be scheduled to occur at a time when it is clear the basics of Contract Design have not been finished. The agenda should specify the following:

List of technical efforts, topics, and systems to be reviewed:

- Objective of the review, desired outcome, or decision
- Review approach
- Requirements and criteria applicable to material under review
- Exit criteria (if applicable)

Generally, less is better. The primary objective is to present the distilled facts pertinent to the decision at hand, vice a comprehensive portrayal of the depth of work accomplished in the design phase. For government reviews of industry designs, the evaluation of output is generally intended to provide a tool for the Program Manager to apply in influencing both the industry engineering effort (scope and strategy) and the industry products (engineering deliverables and ship). So, it is important to not only identify risk gaps and technical issues, but also to present assessments (How bad is it?) and constructive recommendations (What should the Program Manager do about it?). Technical authorities also owe the Program Manager contrasting perspectives on what issues represent features of the design that are technically unapprovable, vice those that could be made approvable with additional effort.

<u>Top-Level Outline:</u>

Purpose of the Review

Entrance and Exit Criteria

Overview of the Program

- State of requirements development
- Schedule showing milestones and key events
- Primary participants (government and industry) and their relationships
- Any governing top level direction (e.g., acquisition decision memoranda (ADMs) exit criteria or other direction from the MDA)

Overview of Requirements

- ICD
- CDD
- Other
- Process for requirements flowdown to the design and specifications

Overview of Execution Strategy

- Acquisition Strategy
  - Phasing and competition
  - Payload development strategy
  - Role of industry (cooperative or competitive)

- Design Strategy
  - Who has the lead, government or industry?
  - Support strategy (warfare centers versus level-of-effort contractors)
  - Review and approval strategy
  - Risk management and risk tracking approach
  - Design decision process and baseline configuration controls
  - Design philosophy, i.e., priority order for competing functions and features or capacities that are desired on the ship. Conversely, what is the SDM most willing to trade-off to preserve or optimize functionality higher on the list?
  - Macro interface control approach
  - Margins utilization policy

Overview of Design

- CONOPS deployment concept
- Design reference mission
- State of total ship system engineering, the functional analysis, and requirements flow down process
- Mission effectiveness analyses, measures of effectiveness/performance, and interoperability
- General arrangements and machinery arrangements
- Design tools methodology, SPM, IDE, and product data management
- Ship and system descriptions (Include aviation and off-board vehicle interfaces where applicable.)
- Margins utilization status against plan
  - Weight/KG
  - Electric generating capacity
  - Air conditioning capacity
  - Accommodations
  - Speed/powering
  - Area/volume/tankage
  - Service life allowances provided
- Status of critical analyses
  - Weight estimate
  - Electric load analysis
  - Air conditioning load analysis
  - Vulnerability/survivability analysis
  - Signature analysis
  - Speed/power prediction
  - RAM analysis
  - HSI analysis - crew size estimate, workload estimates, training impacts, link analysis, usability and/or other human performance testing
- Status of hull/propulsor model test results
- Unresolved technical issues

Conclusions/Exit Criteria

Proposed Next Steps or Recommendations

Ship/System Pricing, performed by or validated by SEA 05C, should be available. This information is usually considered in executive session at the end.

With regard to technical content, there are a number of topic areas that should be fully addressed, depending on design phase. Using the following general approach within each topic area ensures that the material is presented in a logical and consistent manner:

- Configuration Description – The presentation should provide a general description of the layout and functional operation of the system(s) under review and its performance characteristics.
- Design Validation – Demonstrate that the design meets requirements (including applicable design rules) and will perform its intended function. Trade-off studies and other supporting materials may be presented to demonstrate that the design is the preferred solution.
- Design Interface – Demonstrate that all interfaces between systems and subsystems have been recognized and are controlled. Where appropriate, design budget allocations have been established.
- Risk – Principal elements of risk, risk mitigation efforts, and current issues being addressed.

The following is a typical list of topics that should be covered during a design review broken down by major discussion areas. These should be mapped into the review outline in a fashion that fits the context of the particular review.

- Total Ship/System
  - Ship characteristics
  - General arrangements
  - Design margins and service life allowances
  - Mission capability
  - Hull capability
  - Survivability
  - Reliability, availability, and maintainability
  - Regulatory body compliance
- Ship and Mission Systems
  - Hull structure
  - Propulsion plant
  - Machinery arrangements
  - Electric plant
  - Command and surveillance
  - Auxiliary systems
  - Outfit and furnishings
  - Armament
  - Ship assembly and build strategy
  - Logistics support assumptions
- Integration/Engineering
  - Mission Systems Integration (including land based test sites and battle force integration) test strategy
  - System technical architecture
  - Human systems integration
  - Computing plant and network infrastructure
  - Information security architecture

- System Safety
- Systems engineering and program management
- Requirements traceability analysis
- Risk management
- Schedule to complete ship design, construction, and delivery (including critical path analysis)
- Schedule and commitments from parallel interdependent payload system programs
- Configuration management
- System test and evaluation
- Definition of any engineering development models
- Development and operational test and evaluation
- Design Tools
- Modeling and simulation (including VV&A)
- Test and evaluation support
- Test facilities
- Training
  - Training concept and architecture
  - Equipment
  - Services
  - Facilities
- Status of data deliverables
- IDE
- Technical documentation, including design history
- Engineering data
- Management data
  - Support data
  - SPM
- Peculiar support equipment
  - Test and measurement equipment
  - Support and handling equipment
  - Common support equipment
- Operational/site activation
  - System assembly, installation, and checkout on site
  - Contractor technical support
  - Site construction
  - Site/ship/vehicle conversion
- Production/industrial facilities
  - Production approach
  - Labor force
  - Construction/conversion/expansion
  - Equipment acquisition or modernization
  - Maintenance (industrial facilities)

- Life cycle engineering and support
  - Logistics concept including Performance Based Logistics (PBL) approach
  - Initial spares, outfitting, and repair parts
  - Shore facilities/pier facilities
- Affordability
  - Cost as independent variable trade-off studies
  - Life cycle cost estimate (including basis of estimate and supporting data)
- Research and development cost
- Procurement cost
  - NRE (non-recurring engineering)/Design
  - Recurring
- Operating and support cost
- Disposal cost

While it always makes sense for the most knowledgeable person to brief technology-specific content, as a general rule the SDM (government or industry as appropriate) should be the primary briefer, particularly for overview, strategy, and integration related topics. The presentation should be supported by appropriate drawings and specification sections, as well as study reports, design notebooks, etc. These materials do not have to be presented, but must be organized and available if needed.

For any review to be meaningful, there must be a set of top-level exit criteria against which the design may be evaluated. Each design review will have its own specific criteria. Factors to consider in defining these are:

- Requirements: The design must meet the documented requirements of the program.
- Technical Adequacy: All aspects of the design solution must satisfy the documented technical standards, be internally consistent, and interconnect properly with the other parts of the design. The ability of the solution to meet the requirements must be validated.
- Risk: The major areas of technical risk in the design solution must be identified and risk mitigation plans developed that include provisions for fallback solutions. If no realistic fallbacks are available, this fact must be stated.

Following the conclusion of the review, the results must be documented in a set of minutes. The minutes need to include:

- Identification of the review topics
- List of attendees
- General assessment of design progress
- List of decisions and directives made
- List of action items, actionees, and due dates for responding to action items

These minutes need to be issued in a timely manner to all participants and interested parties. In the case of government reviews of competitive industry designs, the distribution may be restricted to government recipients only.

APPENDIX OO
DISPOSITION OF DESIGN DATA

OO.1 INTRODUCTION.

Retention of Navy records is required by SECNAVINST 5210.8D Department of Navy Chief Information Officer (DoN CIO) dated 31 December 2005, Department of the Navy Records Management Program. The implementing instruction is SECNAV M-5210.1, Records Management Manual, November 2007 (Rev.), which can be found at http://doni.daps.dla.mil/SECNAV%20Manuals1/5210.1.pdf.

This guide provides instructions for the disposition of design project data created by SEA 05D/V. Upon completion of a project, and after screening in accordance with this guide, retained project data will be put in a long-term accessible electronic format on long-term storage/retrievable electronic media. The guide provides for minimum requirements that shall be met by all projects. Proper disposition of project data is a Ship Design Manager responsibility. Proper disposition will assure the usefulness of these data so future projects can profit by lessons learned and make use of technical work already performed.

OO.2 CATEGORIES OF DATA.

The data to be deposed of by a design project generally fall into the following categories:

- Project required deliverables.
- Technical data developed to support deliverables.
- Reference matter acquired for project use.
- Management reports such as fiscal reports and progress reports.

OO.3 OBJECTIVES OF RETAINING DATA.

The decision regarding what data are to be retained after completion of a design project depends on the potential need or benefit expected for use of these data as (a) reference use to answer questions which may arise during the ship DD&C period, (b) use in current/future design projects or (c) of interest to future naval historians.

OO.4 STORAGE OF RETAINED DATA.

All data whose retention is considered to be in the government interest shall be kept in an accessible electronic form by the 05D/V division to which the SDM reports. It is highly desirable that the material be stored with links to CDMS via the Navy Marine Corps Internet (NMCI) network. This will allow the material to be searched for and used by authorized remotely located organizations. Paper material and removable electronic media such as compact disks may be sent to the Federal Record Center (FRC) for storage. Note that the FRC is now a reimbursable organization so files kept there must be paid for each year.

The DoN point of contact for records storage is Charlie Barth – 202-433-2434.

OO.5 DISPOSITION OF DESIGN PROJECT DATA.

During the course of a project, and particularly at the completion of a project, data should be reviewed and a decision made as to retention or disposition. The following steps are provided as guidance to retaining sufficient data to meet the objectives of paragraph 3.0 while keeping the quantity of data retained to a minimum.

a. Review holdings against deliverable requirements and fill deficiencies.
b. Purge the file of insignificant data, e.g., data not required to meet the objectives of paragraph 3.0.
c. Purge the file of all preliminary documents for which approved finals are on file.
d. Purge the file of documents where the data are contained in summary documents such as design histories.
e. Segregate, identify, and purge duplicates.

Consideration should be made to submit technical reports to DTIC.

OO.6 DISPOSITION OF MODELS AND PAINTINGS.

If a physical model of a ship or a system is not need by the project, the Office of the Curator of Models, Code 301 within the Business Directorate at the David Taylor Model Basin [http://www.dt.navy.mil/cnsm/hist.html] should be contacted to see if the model should be included in the Navy's permanent collection.

If artwork (such as an oil painting or ink sketches representing the ship) is not needed by the project, the Navy Art Collection Branch of the Naval History and Heritage Command [http://www.history.navy.mil/branches/org6-1.htm] should be contacted to see if they wish to include it in the permanent collection.

APPENDIX PP
SYSTEMS ENGINEERING

SDMs and SIMs should be NAVSEA's experts in the conduct of systems engineering. Per the DoD and SECNAV 5000 series, system engineering should be a foundation for ship/system design. There is a wealth of information on the subject available throughout the defense acquisition community. Section 2.1 cites websites and applicable references. See also Appendix A for selected references related to the process. The challenge for the SDMs and SIMs are to translate this guidance into actionable, practical advice for managing a ship/system design.

Figure PP-1 shows the systems engineering design process featuring three stages: requirements analysis, functional analysis/allocation, and systems design. System analysis and control is continuously applied to keep the process on track. The purpose of the requirements analysis effort is to properly identify and document the user's requirements and translate those requirements into a set of technical requirements for the system. During functional analysis/allocation, the requirements identified in requirements analysis are translated into a functional decomposition that describes the product in terms of an assembly of configuration items where each configuration item is defined by what it must do, its required performance, and its interfaces. Finally, during design synthesis, specific hardware, software, and "humanware" (that is, human operators considered as configuration items in the functional analysis) are defined to meet the requirements of the configuration items. Systems analysis and control provides the technical management activities necessary to keep the entire process moving on schedule with acceptable performance and cost.

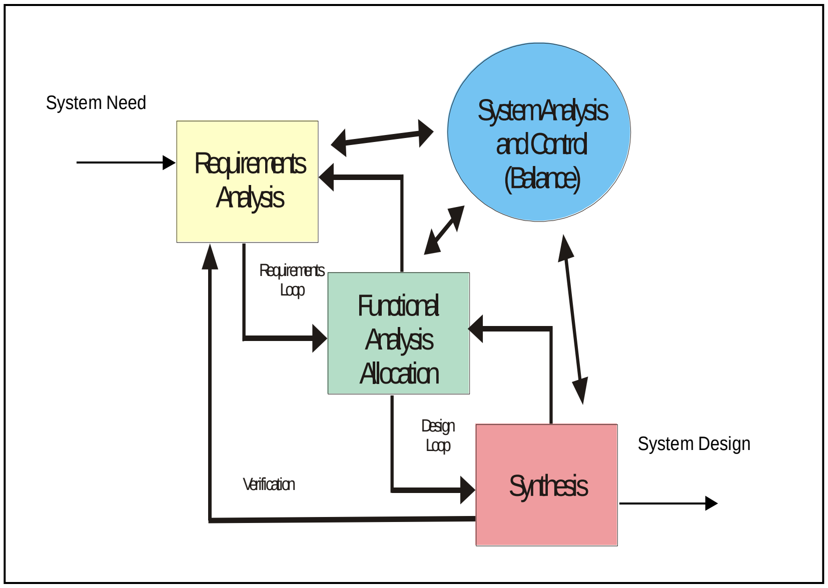


Figure PP-1. The Systems Engineering Design Process

This is an idealized process and it is typically interpreted to be serial and iterative. In practical application, all of the components occur concurrently. Additionally, the feedback loop from synthesis to requirements analysis is more than just verification. The systems engineering process as applied to ship design proceeds with the following parallel efforts:

- The operational requirements, policy, practices, customs, and statutory requirements are analyzed and allocated to functional components (to include humans). These become configuration items. The probability that each requirement will change over the life cycle of the product is assessed and functions allocated in an attempt to isolate the impact of likely changing requirements.
- The configuration items are synthesized by selecting and designing system architectures and associated hardware, software, and humanware system elements. The SDM's/SIM's design organization is generally aligned with these system architectures and there is a clear definition of responsibility for each.
- The selection of hardware, software, and humanware system elements during synthesis results in the creation of derived requirements. Typically these include specific details for elements such as the distributed systems onboard ship (e.g., electrical power, compressed air, sewage, potable water, etc.).
- The derived requirements generated during synthesis feed back to the requirements analysis block, in addition to verification that the design and the developed product meet the requirements. Feedback regarding functional analysis and allocation may develop additional configuration items, or change existing configuration items, to fulfill the derived requirements. These new configuration items are then synthesized, which in turn may create even more derived requirements. The process continues until the synthesis loop does not create any additional derived requirements and the design is verified to satisfy all direct, derived, and statutory requirements.

The SDM must orchestrate the Design Team to conduct this process under the watchful eyes of the Program Manager and other interested parties. Activities will be conducted concurrently and the SDM will rely heavily on the DIM to ensure that configuration management is implemented and that the Design Team is informed regarding design development. Presentations and deliverables must be anchored in the requirements, whether direct, statutory, or derived.

- Direct requirements are "owned" by the customer. Changes in them require customer approval. Many are in policy, practices, and customs imposed by the responsible Program Office.
- Statutory requirements are imposed from external regulatory bodies such as federal law or other federal agencies such as the Environmental Protection Agency or the USCG. Ship classification societies such as the ABS play a significant role in naval ship design for T-ships. Even helicopter certification by NAVAIR can be considered as an external requirement from the SDM perspective, since NAVAIR acts as an outside source of requirements.
- The designer controls derived requirements. The customer does not have to approve changes to derived requirements, although a successful SDM will work closely with the Program Manager to ensure agreement.

There are many tools and techniques available to the SDM/SIM to implement successful systems engineering throughout the design, and many of these are discussed in other sections of this manual. Recognizing that requirements management is key, along with demonstrating that requirements are satisfied, it is useful to track these requirements using a disciplined process. When an issue arises, knowing what organization must be approached is important.

- For direct requirements, the SDM/SIM will work through the Program Manager to address any issues, recognizing the distinction between customer requirements, policy, practices, and customs.
- For statutory requirements, interpretation may vary and the SDM/SIM may need to involve regulatory body representatives directly on the Design Team. Theoretically, a program or the customer can negotiate exemptions or waivers to statutory requirements, but the track record of doing so within reasonable time and costs for the value of the change is not good.
- Within the Design Team, the SDM must have a process for managing derived requirements and maintaining configuration control.

Configuration management and the resulting common understanding of the design is what ties the process together and permits effective systems analysis and control.

APPENDIX QQ
HUMAN SYSTEMS INTEGRATION

NAVSEA Instruction 3900.8A (*hyperlink*), Human Systems Integration (HSI) Policy in Acquisition and Modernization, establishes policy and responsibilities within NAVSEA including affiliated PEOs. The NAVSEA 3900.8-M, NAVSEA Human Systems Integration (HSI) Technical Processes, (currently in revision and formerly SEA 05 HSI Best Practices Guide) is a companion document that addresses specific HSI engineering activities.

HSI addresses the human component (operators, maintainers, and support personnel) of the total system design. Just as integration and information exchange requirements must be defined for hardware and software interfaces, operator and maintainer interfaces with hardware and software and with one another must be explicitly defined and optimized to support overall system performance requirements. HSI provides the methods and discipline to ensure effective and efficient utilization of human capabilities and limitations within the total system design.

The following activities are fundamental to systems engineering in general and HSI in particular:

- A thorough understanding of total system functional and performance requirements and expectations (This may be achieved through execution of a top-down functional analysis or similar decomposition methods.)
- A thorough understanding of the roles of the operators and maintainers within the system (This requires, based on an overall functional analysis, an allocation of functionality among hardware, software, and humans.)
- Definition of the requirements and availability of personnel to fill multiple roles across the functionality of the system (This includes not only watch standing duties associated with warfighting capabilities but also activities such as training, maintenance, and own-unit support.)
- Subsystems must be optimized to support operator and maintainer performance and training requirements – both individually and across the platform as a whole.
- Ship-level T&E needs to incorporate an evaluation of operator and maintainer performance and its contribution to overall ship and system performance.

HSI is composed of the systems engineering process and program management efforts that provide integrated and comprehensive analysis, design, and assessment of requirements, concepts, and resources for the following HSI domains:

- Manpower – The numbers of personnel (military, civilian, and contractor) required, authorized, and potentially available to operate, maintain, train, administer, and support each capability and/or system. (OPNAV N1 has oversight of this area. The PEOs are responsible for working with the manpower community to determine the most efficient and cost-effective manpower levels required to attain mission accomplishment.)
- Personnel – The human knowledge, skills, abilities, aptitudes, competencies, characteristics, and capabilities required to operate, maintain, train, and support each capability and/or system in peacetime and war. (OPNAV N1 has oversight of this area. The PEOs are responsible for consulting with personnel authorities to identify qualification, readiness, personnel tempo, and funding issues that impact program execution.)
- Training – The instruction, education, and resources required to provide Navy personnel with requisite knowledge, skills, and abilities to properly operate, maintain, train, and support Navy capabilities and/or systems. (OPNAV N15 and Naval Education and Training Command (NETC) have oversight of this area. The PEOs are responsible to consult with the training community to develop options for individual, collective, and joint training for operators, maintainers, and support personnel.)
- Human Factors Engineering (HFE) – The systems engineering design of human-machine interfaces in terms of human performance requirements, capabilities, and limitations. (Human-machine interfaces include those between humans and information, environments, organizations, operations, hardware, software, courseware, and other humans.) (The application of HFE to acquisition activities is the responsibility of the PEOs.)
- Environment, Safety and Occupational Health – The systems engineering process involving hazard identification, risk evaluation, design analysis, hazard mitigation and control, and management. (The process manages the design and operational characteristics of a system that eliminate or minimize the possibilities for accidents or mishaps caused by human error or system failure.) Software safety also needs to be addressed. Occupational Health is the systematic application of biomedical knowledge, early in the acquisition process, to identify, assess, and minimize health hazards associated with the system's operation, maintenance, repair, or storage. (The PEOs are responsible to ensure that appropriate ESOH efforts are integrated across disciplines and into systems engineering. ESOH in the Navy is managed through compliance with the National Environmental Policy Act (NEPA) and Executive Order (EO) 12114.) For further guidance on NAVSEA System Safety, see NAVSEAINST 5100.12 (series), and on Occupational Safety and Health, see NAVSEAINST 5100.15 (series).
- Personnel Survivability – The characteristics of a system that reduce the risk of fratricide and personal detection or targeting, prevent personal attack if detected or targeted, increase survival and prevent injury if personally attacked or located within an entity being attacked, minimize medical implications if wounded or otherwise injured, and minimize physical and mental fatigue. Personnel Survivability at NAVSEA is managed through the Damage Control and Personal Protective Equipment competencies established in SEA 05P.
- Habitability – System characteristics that provide living and working conditions which result in levels of personnel morale, safety, health, and comfort adequate to sustain maximum personnel effectiveness to support mission performance and avoid personnel retention problems. (The PEOs are responsible to consult with the habitability community to develop options for living space designs that have a direct impact on quality of life and morale. The Navy recognizes that recruitment or retention may be degraded by poor habitability. SEA 05P has oversight of this area.) Medical spaces are a subset of habitability. The BUMED liaison to SEA 05P facilitates incorporation of medical space concerns into new ship designs and modernizations.

Under SECNAVINST 5000.2 *(hyperlink)*, the Navy requires its Program Managers and Sponsors to initiate an HSI effort as early in the acquisition process as possible and address HSI throughout all phases of the acquisition process to optimize total system performance, minimize total ownership costs, and ensure that the system is built to accommodate the characteristics of the user population that will operate, maintain, and support the system. Human factors engineering and safety reviews should be incorporated into the Preliminary, Contract, Detail Design, and Test & Evaluation process.

The key determinant of naval success in effective HSI integration with acquisition programs is integration with systems engineering activities. The *Naval Systems Engineering Technical Review Handbook* now contains specific references to HSI responsibilities within the acquisition processes including specific guidance regarding HSI requirements, processes, responsibilities, and analyses needed in acquisition programs. The SETR Handbook identifies the Program Managers' HSI responsibilities to work with the manpower, personnel, training, safety and occupational health, habitability, survivability, and HFE communities to translate and integrate the HSI thresholds and objectives into quantifiable and measurable system requirements. The SETR Handbook and other Naval policy require HSI insertion into Program IPTs, and Program documentation (such as the SEP, HSIP, TEMP, and the SOW). This support strategy should help SEs identify responsibilities and describe the technical and management approach for meeting the HSI requirements.

Manpower, personnel, and training optimization have a major effect on ship performance and TOC and are an essential part of the design process. Manpower and training KPPs are now mandatory. SDMs should establish strategies early for achieving these manpower objectives. Special consideration should be given to identifying and mitigating risks associated with ship manpower optimization and human performance, safety, survivability, and quality of life. This includes efforts to reduce the incidence and effect of human errors, the direct cause of 80 percent of accidents and mishaps on existing ships.

HSI requirements are derived from a top down requirements analysis directed at analysis and allocation of function requirements to human performance or to automation in the context of a mission scenario, and development of requirements for manpower optimization, workload reduction, human-machine interface design, and human performance requirements (knowledge, skills, and abilities). A budget line shall be developed for estimating manpower; developing training requirements and concepts; developing human-machine interface concepts and criteria; developing control space layouts; providing personnel survivability and quality of life requirements and concepts; providing medical space layouts and medical equipment requirements; and for evaluating and verifying human performance, workload, and safety for the total ship as well as for individual ship systems, zones, equipment, and facilities. Depending on the complexity of the HSI effort, and the relative importance of manpower and human performance in TOC, the budget allocated to HSI studies will vary by program.

At a minimum, HSI assessments are made formally at technical reviews and reflect the confidence of the reviewers that the program is on track to deliver an acceptable product. These assessments address both program process execution and technical quality. HSI assessments will take place at or around the following points:

- System Requirements Review (SRR)
- System Functional Review (SFR)
- Preliminary Design Review (PDR)
- Critical Design Review (CDR)

Draft criteria for each of these HSI assessments has been developed for incorporation into NAVSEAINST 3900.8B, the HSI Policy for Naval Sea Systems Command.

Appendix A provides selected references with guidance related to HSI. The Naval HSI Working Group, of which NAVSEA is represented, is issuing two reference documents that will benefit NAVSEA Program Managers and HSI practitioners:

- HSI Language for Source Selection and Contract Documentation Guide (draft)
- The HSI Plan Preparation Guide (draft)

APPENDIX RR
DODAF ARCHITECTURES

Architectures within the DoD are created for a number of reasons. From a compliance perspective, the DoD's development of architectures is compelled by law and policy (i.e., Clinger-Cohen Act, OMB Circular A-130). From a practical perspective, experience has demonstrated that the management of large organizations employing sophisticated systems and technologies in pursuit of joint missions demands a structured, repeatable method for evaluating investments and investment alternatives, as well as the ability to effectively implement organizational change, create new systems, and deploy new technologies. Towards this end, the DoD Architecture Framework (DoDAF) was established as a guide for the development of architectures.

The DoDAF provides the guidance and rules for developing, representing, and understanding architectures based on a common denominator across DoD, Joint, and multinational boundaries. It provides insight for external stakeholders into how the DoD develops architectures. The DoDAF is intended to ensure that architecture descriptions can be compared and related across programs, mission areas, and, ultimately, the enterprise, thus, establishing the foundation for analyses that supports decision-making processes throughout the DoD.

DoDAF defines a set of products that act as mechanisms for visualizing, understanding, and assimilating the broad scope and complexities of an architecture description through graphic, tabular, or textual means. These products are organized under four views: Operational View (OV), System View (SV), Technical Standards View (TV), and All-View (AV). Each view depicts certain perspectives of an architecture as described below.

<u>Operational View</u>

The OV captures the operational nodes, the tasks or activities performed, and the information that must be exchanged to accomplish DoD missions. It conveys the types of information exchanged, the frequency of exchange, which tasks and activities are supported by the information exchanges, and the nature of information exchanges. An example of an OV-1 is shown in Figure RR-1. Currently there are seven Operational Views defined:

- OV-1 High-Level Operational Concept Graphic
- OV-2 Operational Node Connectivity Description
- OV-3 Operational Information Exchange Matrix
- OV-4 Organizational Relationships Chart
- OV-5 Operational Activity Model
- OV-6a Operational Rules Model
- OV-6b Operational State Transition Description
- OV-6c Operational Event-Trace Description
- OV-7 Logical Data Model

Figure RR-1. OV-1 Example

Systems and Services View

The SV captures system, service, and interconnection functionality providing for, or supporting, operational activities. DoD processes include warfighting, business, intelligence, and infrastructure functions. The SV system functions and services resources and components may be linked to the architecture artifacts in the OV. These system functions and service resources support the operational activities and facilitate the exchange of information among operational nodes. An example of an SV-2 is shown in Figure RR-2. There are currently eleven Systems and Services Views defined:

- SV-1 Systems/Services Interface Description
- SV-2 Systems/Services Communications Description
- SV-3 Systems-Systems Matrix, Services-Systems Matrix, Services-Services Matrix
- SV-4a Systems Functionality Description
- SV-4b Services Functionality Description
- SV-5a Operational Activity to Systems Function Traceability Matrix
- SV-5b Operational Activity to Systems Traceability Matrix
- SV-5c Operational Activity to Services Traceability Matrix
- SV-6 Systems/Services Data Exchange Matrix
- SV-7 Systems/Services Performance Parameters Matrix
- SV-8 Systems/Services Evolution Description
- SV-9 Systems/Services Technology Forecast
- SV-10a Systems/Services Rules Model
- SV-10b Systems/Services State Transition Description
- SV-10c Systems/Services Event-Trace Description
- SV-11 Physical Schema

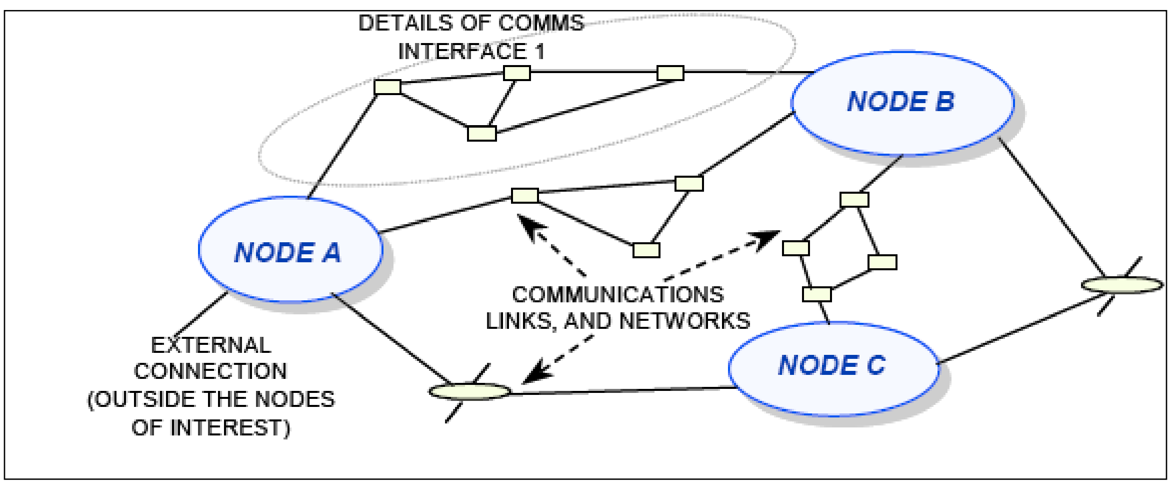


Figure RR-2. SV-2 Example

Technical Standards View

The TV is the minimal set of rules governing the arrangement, interaction, and interdependence of system parts or elements. Its purpose is to ensure that a system satisfies a specified set of operational requirements. The TV provides the technical systems implementation guidelines upon which engineering specifications are based, common building blocks are established, and product lines are developed. It includes a collection of the technical standards, implementation conventions, standards options, rules, and criteria that can be organized into profile(s) that govern systems and system or service elements for a given architecture. Currently there are two Technical Standards Views defined:

- TV-1 Technical Standards Profile
- TV-2 Technical Standards Forecast

All-View

There are some overarching aspects of an architecture that relate to all three views. These overarching aspects are captured in the AV products. The AV products provide information pertinent to the entire architecture but do not represent a distinct view of the architecture. AV products set the scope and context of the architecture. The scope includes the subject area and time frame for the architecture. The setting in which the architecture exists comprises the interrelated conditions that compose the context for the architecture. These conditions include doctrine; tactics, techniques, and procedures; relevant goals and vision statements; CONOPS; scenarios; and environmental conditions. Currently there are two All Views defined:

- AV-1 Overview and Summary Information
- AV-2 Integrated Dictionary

APPENDIX SS
DESIGN FOR PRODUCIBILITY

SS.1 INTRODUCTION.

This appendix describes policy and actions taken to ensure that ship designs developed within SEA 05 incorporate design for production among their design criteria. The goal of design for production is to **minimize production time and cost by reducing shipbuilding work content, while meeting mission performance requirements.** The goal of low cost and short build time (that is, making the design more 'producible') is implicitly addressed to some extent in all ship designs. However, the concept of design for production makes this need explicit; it is formally included among the design objectives to be traded off in an effort to arrive at the optimum multi-criteria design. Some design for production concepts have no significant impacts on other requirements or on Shipbuilder competition and can be immediately adopted. Others adversely impact other design criteria and must be evaluated through trade-off studies.

In a few cases (notably the emergency cargo ship programs of World Wars I and II), design for production has been a key design driver. In other ship design projects, producibility has been assigned a lower priority in favor of other requirements. In general, it is good practice to assess the role of design for production in the ship acquisition program early in the design process. Early identification of the role of producibility in achieving overall ship acquisition program objectives aids in specifying an effective schedule of design deliverables. It can also allow for the development of production technology enhancements that can contribute to a more effective ship acquisition program.

The shipbuilding industry plays an important role in design for production. Shipbuilders are engaged in numerous efforts to streamline the transition from design to production and the Navy must ensure that the Contract Designs are consistent with the Shipbuilders' processes. Each of the Shipbuilders in the U.S. Navy's industrial base has different facilities and producibility enhancements must be designed to be applicable to all (except where the ship acquisition program is limited to specified Shipbuilder(s).

SS.2 SCOPE.

Guidance provided here applies to feasibility studies, Preliminary Designs, and Contract Designs but not Detail Design.

SS.3 POLICY.

SS.3.1 Generic Actions. SEA 05 ship design personnel shall budget for, and apply resources, to identify producibility concepts and develop cost/design impact relationships. Effective practices for reducing ship production cost and/or schedule duration should be identified and added to SEA 05's corporate knowledge. Methodologies to evaluate ship performance as a function of producibility-driven design changes must be prepared.

SS.3.2 Specific Ship Designs.

a. Examine producibility concepts. Identify those having no significant adverse impacts on ship performance or other program needs and incorporate them into the ship design baseline. Producibility concepts having adverse impacts on other goals must be evaluated via trade-off studies.

b. Industry and other experts shall be invited to offer producibility guidance at appropriate stages of the ship design. This guidance can be in the form of producibility suggestions and proposals, and reviews of the producibility of the ship design at suitable design stages.

SS.4 PROCEDURES.

Shipbuilding cost and time is minimized when the ship is designed to take advantage of the most efficient methods and technologies of construction. Incorporating industrial engineering considerations into the ship design process does this. A general approach may be summarized as:

1. Identify key ship production resources and constraints.
2. Relate these to ship design characteristics.
3. Adjust ship design characteristics and/or apply new ship design concepts (consistent with meeting other requirements) to minimize use of the key production resources and to satisfy the constraints.

   a. It may also be possible to relax a constraint through development of new industrial technologies or strategies.

Steps #2 and 3 are challenging as they depend on detailed knowledge of Shipbuilder processes and costs. This often requires business-sensitive data. If this data is not available to the Design Team, then experience and general industrial engineering approaches can be used. Shipbuilders, shipbuilding researchers, and other experts can offer design for production concepts and guidance on specific designs.

Steps 2 and 3 should be checked at appropriate design stages before the aspects they impact are frozen.

SS.5 PRODUCIBILITY CONSIDERATIONS.

The ship Design Team must be aware of ongoing developments in Shipbuilder production technologies, as these may lead to changes in what is producible and what is not. Here, some currently applicable basic principles of design for production are offered:

Some current basic principles of design for production:

- Simplicity in design:
  - Minimum number of parts.
  - Minimum number of different parts and assemblies.
  - Minimum number of parts to be formed, especially complex shapes.
  - Minimum weld length.
  - Avoid curved welds and welds that are not parallel.
  - Minimum use of materials that are slow or costly to form and join.
  - Minimum fitting and fairing at erection joints.
  - Elimination of need for highly accurate fitting.
  - Integration of structure and outfit.
  - Elimination of staging.
  - Adequate access and visibility.
- Matching to Shipbuilder facilities, resources, technologies:
  - Check that blocks and machinery package units are within Shipbuilder crane lift capacity.
  - Assembly and block sizes need to fit panel line, workstations, and door openings in the Shipbuilders.
  - Design for maximum plate sizes and blocks.
  - This minimizes joint weld length, number of parts, and material handling.
  - Design for in-shop versus on-ship work.
  - Evaluate required manual processing versus automated processing.
  - Design out the need for high accuracy.

These are basic principles. At first glance they may seem detail-oriented, but they can impact the earliest stages of ship design. (For example, selection of deck height in a surface combatant, basic configuration of hull structure, and so forth.)

From these basic principles, the ship Design Team should develop more detailed producibility approaches applicable to the specific ship design project. Some that have often been useful are suggested below. However, this is not a comprehensive checklist and not all items in this list are applicable in every instance. Therefore, producibility approaches must be continually reviewed, with new ones developed to support each ship design case.

Examples of design for production suggestions that follow from the basic principles:

- Hull form:
  - Use parallel midbody and flat bottom.
  - Maximize flat plates.
  - Use straight lines whenever possible.
  - Minimize compound curves.
  - Avoid combined sheer and camber and use straight lines for both.
- Structure:
  - Maximize uniformity in plate and stiffener sizes.
  - Use flat innerbottoms.
  - Run deck longitudinals parallel to ship centerline at bow and stern.
  - Consider efficient coating in laying out the structure.
- Materials:
  - Define and evaluate the forming and joining characteristics of each material under consideration (mild steel, high tensile steels, aluminum, composites, etc.)
    - In most cases, lower-technology materials are quicker and easier to form and join.
- Arrangements:
  - Design for efficient block construction and erection.
    - Work with Shipbuilders to determine block size.
    - Locate athwartship passageways at block breaks.
    - Avoid locating complex compartments at block breaks.
    - Design block breaks so that blocks are self-supporting.
    - Major equipment or foundations should not extend over breaks between blocks and assemblies as this will prevent the installation of the equipment prior to joining.
  - Group functionally related compartments together.
  - Maximize commonality of access penetrations during construction and post delivery.
  - Provide deck heights and space arrangements that provide good access for production work.
  - Arrange distributive systems to facilitate installation.
- Machinery and combat systems:
  - Arrange machinery and combat systems to facilitate the use of pre-outfitting packages.
  - Incorporate modularity.
  - Maximize the commonality (i.e., reduce the variety) of equipment, pre-outfit packages, and modules.
  - Use commercial machinery and equipment where acceptable.
  - Integrate machinery foundations into the ship structure.
  - Group small items onto a common foundation.

SS.6 LONG RANGE PRODUCIBILITY ACTIONS.

To enable designers to effectively implement design for production, some management actions that are required are:

- Train ship design engineers in ship construction practices and design for production.
- Research and develop evaluation methodologies and cost estimating processes to allow evaluation of producibility concepts during early stage ship design.
- Consider changes to the ship design process that will facilitate design for modular construction during early stage design.
- Incorporate design for production in standard NAVSEA design practice.

SS.7 ACQUISITION PLAN INTERFACES.

SEA 05 is not only responsible for producing ship designs, but also for developing trade-off studies that support acquisition program objectives. Some aspects of ship acquisition planning that affect design for production trade-offs are:

- Planned duration of DD&C.
- Multiple vs. single ship procurement.
- Capabilities and breadth of the industrial base.
  - Multiple vs. single Shipbuilder.
  - Characteristics of each Shipbuilder.
    - Capacity.
    - Technology.
    - Facilities.
    - Labor.
    - Corporate strategy and core competences.
    - Etc.
  - Characteristics of the vendor base.
- Characteristics of the shipbuilding contract (for example, fixed price vs. incentive, etc.)

Results of design for production trade-offs can influence Program Office acquisition strategy (and vice-versa), so the ship designers and the Program Offices must work together on design for production decisions and affected aspects of the acquisition plan. This should be accomplished early enough in the design cycle to be considered in Preliminary Design trade-offs. This will allow the results of producibility studies to be considered in firming up acquisition plans. Ship Design Managers must provide ship acquisition planning information to the functional codes to ensure that it is included in producibility trade-off studies where applicable.

SS.8 REFERENCES.

Lamb, T., ed., Ship Design and Construction. Jersey City, N. J.: Society of Naval Architects and Marine Engineers, 2003. Please see Chapter 14, ‘Design/production integration.’

Tibbits, B. A. and P. A. Gale, P. A., ‘The naval ship design/production interface.’ Journal of Ship Production, vol. 2, no. 3, August 1986, pp. 185-195.

Wilkins, J. R., Singh, P., and Cary, T. ‘Generic build strategy – A Preliminary Design experience.’ Journal of Ship Production, vol. 12, no. 1, 1996.

APPENDIX TT
COST ENGINEERING

This appendix prescribes policy, responsibilities, and procedures to ensure that cost is properly considered in design and engineering trade-off decisions throughout the naval ship acquisition design process from Feasibility Studies through Contract Design. This appendix addresses cost as a design criterion to be invoked in all NAVSEA ship design projects under the management of SEA 05D/V. It is not intended to address cost in connection with ship alterations and FMPs that are the responsibilities of the Program Manager, nor does it address cost related to the POM, budget, or other NAVSEA official estimates that are the responsibilities of SEA 05C.

The effort involved in preparing costing documents can be substantial and should be carefully planned. For example, during Contract Design the CARD must describe the entire ship and contents to a high level of detail and is typically hundreds of pages long. The Program Office is responsible for the development of the CARD which includes significant input from the SDM.

Discussion

Cost engineering analysis has a continuing role throughout design. It can provide the cost information needed for concept selection, subsystem optimization, equipment selection, and cost control. The cost engineering function must be recognized as an important and integral part of the design process along with ship design and systems engineering. For economic effectiveness, every design and engineering decision must include cost as a pertinent parameter.

Policy

During ship design and development, cost requirements and the achievements of cost goals will be evaluated with the same rigor as technical requirements and the achievement of performance goals. Practical trade-offs between system capability, cost, and schedules must be continually examined to ensure that the systems developed will have the lowest life cycle cost consistent with schedule and performance requirements. Therefore all new ship acquisition design projects, modified repeats, and major ship conversions shall include cost engineering analysis as a requirement in performing ship design trade-offs.

Ship design participants shall consider cost as an integral part of their trade-off studies throughout the ship acquisition design process. This policy applies not only to in-house designs but also to Contractor Designs and to all design agents.

Responsibilities

The PNA is responsible for ensuring that cost engineering analysis is included as an essential part of the Feasibility Study POA&M and that task funding for cost engineering analysis is included.

The SDM is responsible for ensuring that cost engineering analysis is included as an essential part of the Statement of Work in the Management Plan for Preliminary Design, and for Contract Design, modified repeats, and major conversions and that task funding for cost engineering analysis is included. Statement of Work for Contractor Ship Designs shall also include provisions for cost engineering analysis in support of design trade-offs.

SEA 05C is responsible for providing historical and current cost data, economic and programmatic factors, and overall policy guidance in support of cost engineering analyses.

Each SEM and TL is responsible for considering the cost impact of their design decisions in trade-off studies.

Procedures

Cost and Feasibility Studies will require major ship characteristics trade-offs to produce a mix of ship designs with appropriate hull forms covering a reasonable range of capabilities. Typical characteristics issues would include weapons, sensors, speed, endurance, and survivability which affect both ship size and cost. The viable options, with their preliminary characteristics, and ROM acquisition cost and total life cycle cost, will be provided. These official estimates for lead ship, first follow ship, and ship class average are prepared by SEA 05C. Cost estimates for trade-off studies to support design decisions, however, are prepared by the SCM or SDM.

At the initiation of Preliminary Design, a ship cost baseline consistent with the approved NAVSEA official estimate will be established for tracking major trade-off decisions and changes in ship requirements. For traceability of successive cost estimates, the SDM will allocate cost budgets to the SEMs and estimate the cost impact of their trade-off studies on the Allocated Baseline cost. Typical design trade-off issues could include the heights of decks throughout the ship; distribution of different types of structural materials in the hull; frame spacing; superstructure material; habitability schemes; manning and maintenance levels; type of propulsion, electrical, and auxiliary plants; number and capacity of major HM&E equipment; and selection of major combat system components. Trade-off results are evaluated on the basis of total ship impact that should include, but not be limited to, such considerations as the impacts on weight, space, electric power, manning, maintenance, reliability, and survivability versus impacts on acquisition and life cycle cost. The final Preliminary Design configuration, which should be the basis for a budget quality cost estimate, will be documented in the Preliminary Design Report.

During Contract Design:

- The ship cost baseline will be refined.
- Detailed weight estimates will be produced.
- Producibility issues will be investigated.
- Lower level trade-off studies will be performed.
- Functional codes will identify and provide technical data on alternate design configurations at both the subsystem and equipment level.
- Specifications and drawings will be developed.

Typical options could include such items as types of fuel/ballast systems, levels of passive protection, types of distilling units, and kinds of piping materials. The Cost Engineer on the Design Team will provide the installed costs of the options to the system's designer or engineer for comparative cost/benefit analysis to be used as a basis for selection or recommendation. Trade-off decisions and refinements in the Contract Design Weight Estimate will be reflected in the updated ship cost baseline on a periodic or as needed basis. An analysis of the changes from the previous update will be reported. At the completion of the Contract Design, the Contract Design Report will be developed summarizing how the ship design meets the requirements and constraints of the CDD.

The degree of design and cost information available for the development of ship end cost estimates varies considerably from the time a ship is initially identified to the time a shipbuilding contract is awarded. To indicate the degree of maturity and reliability of cost estimates a system of classifications and Cost Readiness levels (CRLs) for ship cost estimates is provided in NAVSEAINST 7300.14 (*hyperlink*). Classifications of budget, feasibility, and Rough Order of Magnitude (ROM) with CRLs of 6-9, 4-5, and 1-3 respectively are indicators of the availability and degree of detail of technical design, program planning, and economic information. A separate assessment of the confidence level of the estimate is provided by SEA 05C through a cost risk curve that defines the probability that a program can be executed within a given estimate.

The determination of the CRL and subsequent cost classification for a given estimate is based on the evaluation of a combination of attributes related to the maturity of the design, cost, and programmatic components of the estimate. The cost engineer in developing the CRL should consider characteristics such as depth of the design data available, economic or market conditions and assumptions, maturity of design and technology of individual ship system technologies, and the overall maturity of the ship platform design and technology. These characteristics should be evaluated relative to the cost impact of specific characteristics on the overall cost estimate.

As an example, in considering the appropriate CRL for a ship cost estimate of a modified in-service ship design that includes a new advanced radar system and a cutting edge developmental propulsion plant, individual major components could be at significantly different classification levels based on the maturity of cost and technical characteristics. In this instance the CRLs associated with the individual components might be values such as:

Ship System Area	CRL
Reuse of proven hull	7
Advanced radar with some development complete	4
Propulsion Plant in very early concepts	2

Based on an assessment of the relative cost impacts of the ship system areas and overall CRL for the ship cost estimate could be in the “Feasibility” cost category and have a Cost Readiness Level of 4 or 5 depending on the actual cost impacts for the ship system areas.

The intended use and a brief description for each classification of a cost estimate are as follows:

<u>Budget Quality Estimate (CRL 6-9)</u>

This is the highest quality estimate in the planning, programming, budget, and execution process for a new construction ship. A budget quality estimate is recommended to be used for budget submittals for the current budget year.

Generally, a budget quality cost estimate is developed by the professional cost engineers in SEA 05C, and is associated with a cost risk curve that defines the probability that a program can be executed within a given estimate. In most circumstances the cost risk curve should have a more narrow range as the CRL increases from CRL 1 through CRL 9 and the cost category changes from ROM, Feasibility and Budget Quality as more mature data and methodology is used for the development of the cost estimate.

A budget quality cost estimate is based on a Preliminary Design and associated three-digit SWBS level weight estimate. A list of potential Shipbuilders will support development of appropriate labor rate, overhead rate, and other factors such as profit and cost of money, as applicable. Industry analysis will establish realistic award dates and build periods.

Projected Shipbuilder escalation cost calculations should be based on Program Manager developed ship contract award, start of construction, and delivery schedules and SEA 05C realistic shipbuilding indices.

The maturity of technical design characteristics, program planning, and economic/market conditions and assumptions should be considered by the SEA 05C cost engineer in development of the appropriate CRL “score.”

Feasibility Design Estimate (CRL 4-5)

Feasibility design estimates are those costs prepared using design information available from ship feasibility studies. The feasibility study produces three-digit SWBS weight data and general guidance with respect to major electronics and weapons systems, but may not identify all major equipment items that have significant cost impact. Feasibility studies are often conducted before program requirements are finalized. Cost estimates that fit into this category include those derived by inflating to current dollars a previous cost for a similar ship and making gross adjustments for expected changes in design, program requirements, and program cost factors. A cost estimate that is derived from a current POM/Budget estimate by deflating or inflating to some other year using shipbuilding labor and material escalation would be considered a feasibility design estimate. The major elements generally missing that necessitate using a designation of a feasibility design estimate rather than budget quality are the lack of a completed Preliminary Design and current economic/market conditions and assumptions. The cost risk curve for a feasibility design estimate would in most circumstances have a wider range than the curve for a budget quality estimate.

ROM Estimate (CRL 1-3)

An ROM estimate is based on design information that does not meet the standards equivalent to a ship feasibility study. The design study may produce rough order ship weights, but the basis for the weights and other ship design parameters may be engineering judgment rather than analysis. Some examples are: (1) a new design of an unconventional ship platform, (2) a ship concept design effort with insufficient time or resources to validate key assumptions with analysis, (3) a ship platform that is initially designed to carry unconventional or developmental equipment, and (4) a ship designed beyond the current state of the art. Other conditions that call for use of the ROM category are:

- 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 specification or outdating of technology
- Projecting out year 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. Possible use of a composite of a group of Shipbuilder rates based on the type of ship.

A cost risk curve for a ROM would normally have the widest range, reflecting the increased range of uncertainty for the estimate.

Directed or Modified Estimate

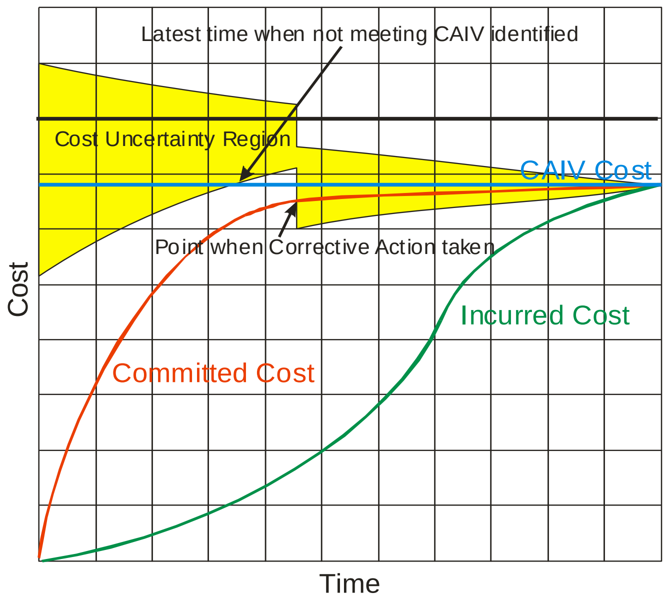
A cost estimate that is: (1) not developed by SEA 05C through the normal estimating process, (2) provided by other commands or agencies, or (3) directed by higher authority will be classified as Directed. Directed cost estimates are generally a total cost limitation that is established without the benefit of a fully developed design concept and related cost estimate.

A directed estimate is generally any previous cost estimate (Cost Readiness Levels 1-9) that was changed to conform to budget cuts or restrictions on a total cost that is not based on an estimate developed through the normal estimating process. Directed estimates are sometimes referred to as “Congressional Control Number,” “OPNAV Control Number,” or “OPNAV Planning Wedge.”

APPENDIX UU
COST AS AN INDEPENDENT VARIABLE

Cost As an Independent Variable

With a Cost As an Independent Variable (CAIV) approach, operational requirements provided by the customer are given in terms of threshold and objective values. The range between these two values provides the Program Manager with trade-space to match the available funds with the capabilities that can be bought for that amount – the total program cost remains a constant.



CAIV Target – Dollar Value that the program office is managing to.
Cost Uncertainty Region – The range of predicted costs within a given confidence level. There is no guaranty that the actual program costs will fall within this range. If they don't however, cost overruns are certain.

The CAIV theory is graphically illustrated to the left and is predicated on the assumption that the final program costs (focusing for now on procurement rather than life cycle) are directly dependent on the capability requirements and can be predictably influenced as needed during acquisition. In practice, though, much of the final cost of an acquisition program is fixed early in the design process through decisions on basic design architecture and requirements allocation (both operational and derived) to systems. Unfortunately, while much of the cost is determined early in the design process, estimating that cost to any degree of certainty is nearly impossible. As the costs of the program are better understood, the remaining design flexibility to adjust to increasing costs may not be sufficient to enable the Program Manager time to take corrective action when the cost estimates indicate a possible problem.

Successfully implementing CAIV depends on understanding certain cost estimating, system architecting, and program management principles.

Cost Estimating for CAIV

In CAIV, a program budget is set somewhere between the estimated levels needed to achieve operational requirement threshold and objective values. The range between these two values is intended to provide the Program Manager with trade-space to match available funds with the capabilities that can be bought for that amount. The CAIV target (a dollar value that the Program Office will manage to) must be set at or above the actual costs to achieve threshold program capabilities, or else there will be no chance that the program will remain within budget. Actual costs, of course, are only known with certainty after the product has been delivered. Therefore, the cost estimate that is used to establish the CAIV target is critical to program success.

A good ship acquisition cost estimates can be considered to have two distinct elements. The first is the Design Cost Estimate and is based on the known characteristics of a specific design point between the threshold and objective values for each requirement. It does not take technical or program risks into account. The second and often neglected portion of the CAIV cost estimate is a Risk Contingency.

Better Risk Contingencies – Budgeting for Risk

For many programs, cost estimates for a system do not directly account for technical risks. If technical risks are accounted for at all, their impact is assessed as a gross fraction of the total ship cost. Most alarming, risk-reduction activity is considered "non-value added" because this activity does not impact the material properties of the end product. By not properly accounting for risk in cost estimation, a Program Manager will be tempted to cut risk reduction activity because the cost estimation methodology only includes the cost of the risk reduction activity and not the reduction in the cost of the risk contingency due to the resulting reduction in risk. Within these cost models, risk-reduction activity only adds costs; hence they suggest that risk reduction activity should perversely be eliminated.

Cost Terms and Relationships

Product Cost

Final Product Cost = f(Final Requirements, Requirement Change Costs)
Requirement Change Costs = f(Design Flexibility at Time of Change)

Cost Estimating

Overall Cost Estimate = Design Cost Estimate + Risk Contingency
Overall Cost Uncertainty = Design Cost Uncertainty + Risk Contingency Uncertainty
Design Cost Uncertainty = f(Cost Estimating Methods)
Risk Contingency Uncertainty = f(Risk Levels, Risk Mitigation Cost Estimating Methods)

Cost As an Independent Variable (CAIV)

CAIV Target = Dollar Value that the program office is managing to
Cost Margin = The difference between the CAIV Target and the Cost Estimate

The SDM and SIM risk assessments are vital for determining a reasonable Risk Contingency based on adverse outcome probabilities and consequences. Ideally a cost contingency should be incorporated for each risk in the program risk register. The cost contingency should be considered an "insurance" payment to account for the impact on the ship program should the risk be realized. Because the likelihood of a risk outcome is not 100 percent, (if so, then it would be a problem and not a risk) the cost contingency reserved for a risk should typically be a fraction of the cost to recover from the risk outcome. This fraction will depend on the aggregation of all program risks, and the program's risk tolerance. Within a CAIV environment, the sum of the cost margin plus the cost contingency should have a high probability (say 90 percent) of being sufficient to fund the aggregation of realized risks as well as risk mitigation efforts designed to reduce cost contingency requirements.

Implementing a good cost contingency method requires careful definition of risk outcomes as well as allocating cost contingencies only when risks are realized or for cost-effective risk mitigation. Risk outcomes should be defined in terms of precisely what adverse event will occur and what required efforts would be needed to recover from the adverse event. A Program should conduct a risk mitigation activity if the cost of the risk mitigation activity is less than the reduction in cost contingency for that risk that is realized by the risk mitigation effort.

If cost contingencies are allocated to non-risk mitigation activities before risks are realized, the funds will likely be spent without mitigating or recovering from the realized risk. The effect of "Money allocated is Money Spent" becomes evident. Careful management of the cost contingency funds is needed to ensure work is conducted in a controlled-risk manner to avoid unforeseen problems while undertaking cost-effective risk mitigation efforts.

<u>The Cost Uncertainty Region</u>

Both the Design Cost Estimate and Risk Contingency portions of the overall cost estimate will have uncertainties, because development and construction of a complex system is difficult to predict with precision. Often, the acquisition schedule will span 10 to 20 years, and many of the assumptions used to develop a cost estimate will prove to be incorrect. Sources of uncertainty include:

- Changes in labor rates
- Changes in material rates
- Uncertainty in the amount of manhours needed (especially true for new technology)
- Contractor expertise (competition for workforce with other industries)
- Cash flow impacts (generally a result of program funding instability)
- Poorly specified, misunderstood, or emergent safety requirements requiring rework
- Realized risks – problems
- Unpredicted problems
- Waste

Furthermore, existing financial management policies discourage Program Managers from maintaining a contingency fund for addressing much of the cost uncertainty. Funds allocated for change orders can only be used to address poorly specified, misunderstood, or emergent safety requirements requiring rework. Management Reserve is used to address realized risks and unpredicted problems. Funds are not typically allocated to cover other sources of uncertainty.

Removing sources of cost risk from a program is an effective way of reducing the amount of Risk Contingency needed. Some elements of cost uncertainty are outside the control of a Program Manager. Inflation for example, is very difficult to predict but can have a major impact on the cost of materials. Forcing a Program Manager to account for inflation within a CAIV environment may in itself consume all cost flexibility. Instead, that portion of the cost of a product allocated to materials can be adjusted according to a standard industry index. The Bureau of Labor Statistics publishes a number of indices that could be used. In previous years, ship acquisition program used this method in the form of Escalation Payments.

Key to implementing CAIV is keeping Committed Costs (due to design decisions) below the minimum bound of the Cost Uncertainty region. Unfortunately, determining either the Committed Cost or the Cost Uncertainty region with any precision is extremely difficult, if not impossible. Therefore, good cost estimating techniques alone will not keep a program out of trouble. System architecting and program management CAIV principles are also needed.

System Architecting for CAIV

One of the fundamental CAIV ideas is that a program can control costs by managing required capability levels. This, however, is only true if the design is flexible enough so that change costs do not dominate cost versus requirements relationships.

Improving Design Flexibility through Modularity

Modularity implemented in a scalable architecture enables the development of subsystems independent of the overall platform development. To work in a CAIV environment, providing scalable performance at scalable cost is critical. Furthermore, the architecture should enable the Program Manager to delay deciding how much performance to provide for as long as possible without impacting the cost-performance relationship.

The systems architect should use modularity strategically to control costs. Areas to apply modularity include:

- Material solutions to address operational requirements with a threshold and objective value. The modularity should enable a scalable solution to cover most or the entire threshold to objective range.
- Material solutions for technologies that are anticipated to become obsolete and not logistically supportable during the design service life of the system.
- Material solutions for operational requirements likely to change over the life of the system.

In each of these cases, the modularity must enable a cost-effective change in system capability.

Examples of modularity that preserve flexibility for the Program Manager in adjusting system performance to meet cost targets include:

- Sizing modular radar arrays to achieve the objective value, but only partially populating the radar array.
- For distributed systems such as electrical power and chill water, design the system for full service life allowances, but only populate generation and distribution system "modules" to meet the delivery condition. The system design must incorporate the ability to easily add the modules to achieve full service life requirements.
- Sizing network equipment racks to hold the full number of blade-servers to meet objective requirements, but only partially populating racks with blade-servers.
- Designing a scalable software architecture that is capable of achieving objective requirements, but only developing, testing, and installing software modules to achieve a lesser level of performance.
- For ships with an Integrated Power System, design the power generation and propulsion motors to achieve a sustained speed greater than threshold speed. Use some portion of the power generation installed above threshold speed as a design and construction margin and/or service life margin.

Reinertsen[1] describes three underlying principles for developing a product architecture:

- Make decisions with regard to how modular to make the product
- Partition the design to control the impact of variability
- Manage the internal interfaces of the design

[1] Reinertsen, Donald G., "*Managing The Design Factory: A Product Developer's Toolkit,*" The Free Press, New York, New York, 1997

With respect to modularity, he states that the secret art of product architecture is that the benefits will only come when the system is portioned properly and the interfaces are properly defined and stable. Stable interfaces require an adequate margin to prevent changes during the design and the resultant rework.

Reinertsen emphasizes that a broad benefit of modularity is that it permits reuse of modules from other designs. A carefully designed reuse plan can save enormous amounts of design time and expenses. Within the CAIV environment, each increment of performance corresponds to a different systems design and corresponding cost. The reuse in this context is the reuse of design work for different levels of performance.

Estimating system costs of modular systems is not easy. At the interface level, costs usually increase because we add parts and potentially complexity. At the module level, costs can either rise or fall because the module is designed to meet the needs of many system designs instead of just one. The cost impact of modularity depends on both cross-program economics and the need to accommodate many "designs" to implement CAIV, and cannot be assessed on the basis of a single design. For a CAIV program, the greater the number of times that requirements are adjusted to maintain the cost target, the required non-recurring engineering to implement the change in requirements will likely be increasingly less for modular systems than for non-modular systems.

If not done properly, modularity can affect performance. Interfaces can act as bottlenecks as compared to a tightly coupled non-modular system. As a result, Reinertsen differentiates between low-expense architectures, low-cost architectures, high-performance architectures, and fast-development architectures. He particularly emphasizes that architecture should be an economic decision, not a technical one. Technical people are still likely to play a dominate role in selecting the architecture; however, they cannot do the job alone. Acquisition professionals, ship design engineers, and cost engineers must collaborate from the earliest stages of design.

Improving Design Flexibility through Set-Based Design

Set-Based Design, as described by Bernstein[2], preserves design flexibility through three basic tenets:

- "Understand the design space
  - Define feasible regions
  - Explore trade-offs by designing multiple alternatives
  - Communicate sets of possibilities
- Integrate by intersection
  - Look for intersection of feasible sets
  - Impose minimum (maximum) constraint
  - Seek conceptual robustness
- Establish feasibility before commitment
  - Narrow sets gradually while increasing detail
  - Stay within set once committed
  - Control by managing uncertainty at process gates"

As an example of how set-based design has been applied in commercial industry, Ward *et. al*.[3] describe Toyota's successful implementation of set-based design to produce competitive automotive designs faster and cheaper than traditional design methods.

[2] Bernstein, Joshua, "Design Methods in the Aerospace Industry: Looking for Evidence of Set-Based Practices," Thesis for the degree of Master of Science at the Massachusetts Institute of Technology, Technology and Policy Program, May, 1998.
[3] Ward, A., J. K. Liker, J. J. Cristiano, and D. K. Sobek II, "The Second Toyota Pardox: How Delaying Decisions Can Make Better Cars Faster," Sloan Management Review, Spring 1995.

In a set-based design process, engineers of different systems (i.e., electrical systems, combat systems, hull design, etc.) communicate ranges of solutions with associated derived requirements on other systems and levels of performance. As shown below in the figure, regions of feasibility are determined by intersecting different ranges of solutions offered by the different engineering disciplines. Initially, the ranges of discipline solutions may need to grow to enable a sufficiently large region of feasibility at the intersection of independent solutions. The range of solutions for each engineering discipline is then reduced at the process gates to eliminate subsystem solutions that are not likely to contribute to a total system solution. Following the reduction in design space, engineers produce additional levels of details of the subsystems to refine the solution, improve cost estimates, and reduce risk. Within a CAIV environment, the size of the feasible design space must remain large enough to encompass the cost uncertainty. The design space is only reduced at a process gate if the design is sufficiently detailed to enable an accurate enough cost estimate to eliminate regions of the design space.

A marine engineering example of set-based design would be the interaction of hull shape, propeller selection, and propulsion motor selection. For a range of required displacements and deck area, the hull designer would provide the range of speed – Effective Horsepower (EHP) curves and propeller size limitations. For this range, the propeller designer would provide the marine engineer with achievable propeller efficiencies, associated shaft speed – shaft power – ship speed curves along with maximum shaft speeds to preclude cavitation. The propulsion engineer would look at the range of powers and shaft speed required and identify a motor architecture that could cover that region. The cost engineer would identify the cost and cost uncertainty that would apply to the different design spaces.

Initially, intersections of the different solutions would be identified. Areas of the design space that are Pareto-dominated, that is, there are solutions that perform better at lower cost, are eliminated from consideration. Likewise, regions of the design space for which the estimated cost minus cost uncertainty exceed the CAIV target are also eliminated, because there is a small probability that the CAIV target will be achieved in that portion of the design space. In this manner, a design solution is arrived at by eliminating potential solutions rather than by trying to make a point design “work.”

Because a portion of the cost uncertainty will not be realized until after the design is completed, set-based design is not sufficient by itself to ensure CAIV. Other techniques that can be implemented after design is complete, such as modularity, can be combined with set-based design to implement an overall CAIV acquisition strategy.

Reducing Risk Contingencies through Requirements Stability

Requirements Stability is extremely important to CAIV. Requirements instability can quickly result in unplanned design (and production) rework. This rework usually results in additional costs that must be offset by reductions elsewhere. In general, making design changes late in the design process or during construction should be avoided to the greatest extent practical. Unless unavoidable, requirements should not be altered following the Preliminary Design Review, and configurations should not be altered following the Critical Design Review. If a specific requirement cannot be fixed or there is risk that it may change late in design or construction, then the systems architecture should be modular and scalable as indicated in the previous section. This implies that a program should continuously evaluate the risk of a requirement changing over the design and construction period, as well as during the service life of the system. The choice of how to implement modularity must also account for when the risk is likely to be realized (during design, construction, or in-service).

Requirements Stability is not limited to growth in requirements. Late reductions in requirements, as in de-scoping efforts to reduce program costs, are also sources of additional work that often consume much of the cost that is intended to be saved.

Improving Design Flexibility by Maintaining a Trade-Space

For CAIV to work, the Program Manager must have flexibility to trade performance for cost. If the Program Manager only budgets to achieve the threshold requirements, then the Program Manager has lost all flexibility to address unforeseen cost increases. Early in the design of a system, the budget should be set to achieve close to the objective values (about 65 percent to 85 percent of the threshold to objective range). The difference in cost for the capability between the threshold capability and the budgeted capability becomes a margin that can be consumed during the design and construction of the system. This can only work if the system design is such that the management flexibility is preserved (through modularity for example) to enable the consumption of this margin.

Common CAIV Challenges

The best way to control costs is to have sufficient funds available to get the job done, and manage those funds wisely. Unfortunately, for a variety of reasons a Program Manager will discover that the program does not have sufficient funds to execute the current program plan. When funding becomes "tight," usual responses include:

- Spreading cuts along all cost accounts – increasing the risk that the work cannot be done correctly and on schedule with the amount of available funds. Rework will result in increased costs.
- Reviewing every task to cut any perceived margin – increasing the risk of a cost overrun. Tasks that are perceived underfunded are rarely plussed up. By cutting only the "overfunded" tasks without increasing the "underfunded" tasks, on average the program will be underfunded.
- Deferring work to post-delivery – often at an increase in overall cost because work is done onboard where labor efficiency is much lower than work performed in a shop environment during the construction process.
- Cutting engineering, analysis, documentation, testing, and Government engineering oversight – increasing risk that technical issues will be discovered late when corrective action is very expensive. Keane, Fireman and Billingsley[4] provide evidence that "the most important factor in ensuring that programs are delivered on time and on budget is increased funding in the early stages of development." Yet many programs reduce this early stage work and rush into production in a generally unsuccessful attempt to control costs.
- De-scoping capability – If not preplanned, then the cost to eliminate a capability from a design will require significant engineering (and potentially production) rework. If not de-scoped early enough, removing capability may increase costs. In any case, if not preplanned, the cost to restore a de-scoped capability can be much larger than the amount of funds recovered from the de-scoping effort.

[4] Keane, R. G., H. Fireman, D. W. Billingsley, "Leading a Sea Change in Naval Ship Design: Toward Collaborative Product Development," SNAME Journal of Ship Production, Volume 23, Number 2, May 2007 , pp. 53-71.

While each of these responses can in the short-term appear to cut costs, the resultant increase in risk over the life of the program will likely result in increases in cost and schedule slippage as individual risks are realized. As shown in the Figure, a RAND study for the U.K. MoD found that 69 percent of schedule slippage was due to change orders, late product definition, and lack of technical information (Arena et. al. 2005). These results are consistent with the normal program management response to predicted cost over-runs.

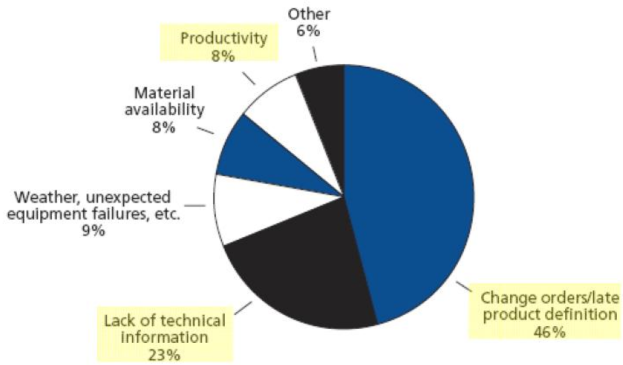


Figure UU-1. Causes of Schedule Slips Reported by Shipbuilders (percentage) (Arena et.al. 2005)

In practice, the traditional responses to predicted cost over-runs often increase program risk, but current methods of establishing risk contingencies are not sensitive to individual risk items. The net impact is that the acceptance of risk results in an increase of the cost uncertainty, such that the region of uncertainty includes the CAIV target. In this way, the Program Manager can be convinced that achieving the CAIV target is possible, when in reality, the likelihood of success is even lower. The impact of these typical responses is shown in the Figure. Because the Committed cost is already above the CAIV Cost target when the cost problem is identified, the "Corrective Action" merely appears to solve the cost problem by increasing the size of the Cost Uncertainty Region to encompass the CAIV Cost target.

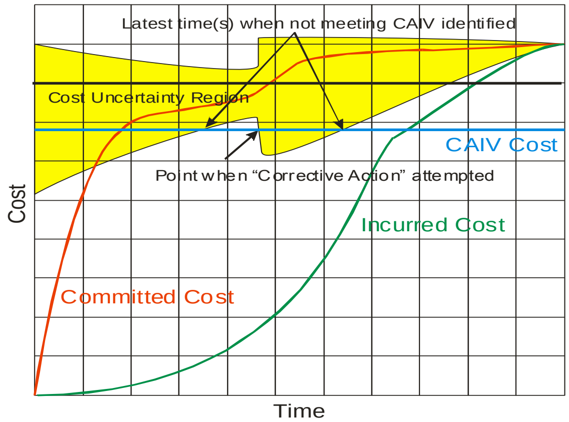


Figure UU-2. CAIV Attempt Failure

CAIV is intended to provide the Program Manager with the flexibility to trade performance for cost. For this to successfully happen, the Program Manager must have the ability to identify a potential cost problem and take corrective action before the Committed Cost curve crosses the CAIV Cost target.

Keeping committed costs low for a prolonged period of time is difficult. Often, the point where a design will fall between the threshold and objective values of a requirement will be fixed early in the design process through the selection of equipment and systems. Once equipment decisions are made and the design evolves to incorporate the equipment, the flexibility offered by the threshold and objective values is largely eliminated – the design point becomes a de facto fixed requirement. For CAIV to work, the system architecture must be scalable such that the design point between the threshold and objective can be affordably adjusted to respond to cost perturbations over as much of the life of the acquisition program as possible.

To minimize costs, some Program Managers (or customers) immediately direct that the program only fund for threshold performance. The view is "If the minimum wasn't good enough, it wouldn't be the minimum." The budget is then established at the current cost estimate for meeting only the threshold requirements. As normal variances in the projected cost become apparent over time, the typical responses listed above are implemented. The net result is that the program is not executed in a CAIV environment, but rather on a fixed set of requirements, with the normal increase in costs due to the typical response to reduce the apparent cost resulting in actual cost increases.

CAIV Summarized

The Figure shows the essence of CAIV. For it to work, the CAIV Margin should remain positive over the life of the acquisition. This is difficult because all of the elements of the cost model (with the exception of the CAIV Target) have associated uncertainties and will change values over time. We would expect the Risk Contingency to decrease as risks are either realized or mitigated. The Cost Uncertainty Region is likely to become smaller as uncertainties are resolved. The Design Cost Estimate will mature as more is known about the details of the design and the cost of design, construction, and testing. Finally, the design flexibility can be expected to decline as design decisions are made.

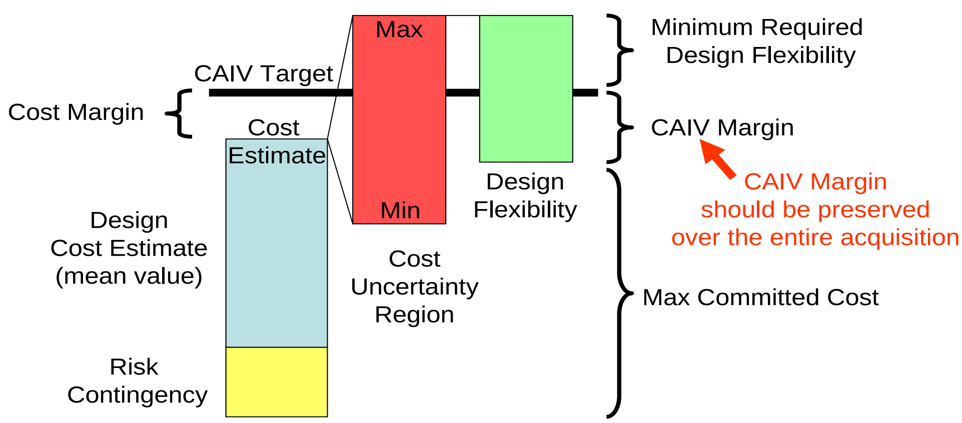


Figure UU-3. Major CAIV Elements

For a program to employ a CAIV acquisition strategy effectively, the design, engineering, and cost estimating methods must be aligned to ensure that costs are not committed so early as to eliminate the flexibility necessary to react to unpredictable cost variances. Techniques that assist the Program Manager and lead design engineer include:

- Implement modularity to provide flexibility.
- Stabilize Requirements – use modularity to address requirements risks.
- Provide a trade-space – don't fix a design point too early between the threshold and objective values.
- Establish program budget wisely – include a budget for risk.
- Use cost contingencies wisely – be aware of the effects of "Money allocated is Money Spent".
- Employ Set-Based Design to improve design flexibility.
- Eliminate Sources of Cost Risk to reduce the funds allocated to risk contingencies.

By employing these techniques, final design decisions can be delayed without impacting the overall acquisition schedule. By prolonging decisions, flexibility is preserved and cost better controlled.

APPENDIX VV
COMPLEXITY

Complexity deals with functions and the way they interact and interfere with each other to prevent achieving the overall objectives. With this definition, complexity is a function of process, not product. It can also exist in multiple dimensions such as:

- Design Complexity
- Acquisition Complexity
- Production Complexity
- Testing Complexity
- Operations Complexity
- Maintenance Complexity
- Modernization Complexity

While the dimensions of complexity are independent of each other, the activities they act on are inter-related. For example, the design process has a great influence on the other dimensions of complexity. Hence when we speak of "Design for Production" we are generally addressing ways to reduce Production Complexity. In fact we may elect to accept increased Design Complexity to reduce the other dimensions of complexity in search of the lowest Total Ownership Cost.

Design complexity is hard to define, but its impact is well known. It is claimed that complexity leads to fragile designs that are very sensitive to small perturbations. It also complicates design management because few engineers understand the whole design. This can lead to sub-optimal design or different design teams working to cross-purposes. Complexity has not been quantified but is seen as a function of:

- "Number of ideas you must hold in your head simultaneously;
- Duration of each of those ideas; and
- Cross product of those two things, times the severity of the interactions between them."

Nam Suh, in his book "Complexity, Theory and Application," defines complexity as:

"A measure of the uncertainty in understanding what it is we want to know or in achieving a functional requirement (FR). Functional requirements (FR) are defined, as in axiomatic design, as a minimum set of independent requirements that completely characterize the functional needs of the product in the functional domain."

Based on this definition, Suh further categorizes complexity into Real Complexity, Imaginary Complexity, and Combinatorial Complexity. He also highlights the importance of functional periodicity for achieving stability over long periods of time.

<u>Real Complexity</u>

As defined by Suh, Real Complexity is time-independent and depends on the ability of the design activities to produce the requisite fidelity. That is, the probability that the design activity results are inaccurate. In matrix based process modeling, this can be addressed by having a good understanding of the Controls and Mechanisms to ensure the output variable has the requisite level of fidelity. The Controls can influence the number and required fidelity of the input variables.

<u>Imaginary Complexity</u>

Imaginary Complexity is a result of not being able to produce the desired results, not because of the inherent inaccuracies of the design activities, but because we don't know the optimal order of conducting the design activities. Ideally, the systematic use of matrix during design iterations should eliminate much of the Imaginary Complexity.

Combinatorial Complexity

Combinatorial Complexity results from having many dependencies between the design activities, especially those above the diagonal of the matrix. In a design process with combinatorial complexity, it becomes difficult to determine how to adjust individual variables to ensure the design converges.

Functional Periodicity

Suh observes that systems that are long-lived and stable tend to have functional periodicity. Within the design processes described above, each method has distinct iteration boundaries or gates: each spiral of the design spiral, each generation of Synthesis Model Based Design Optimization, and each gate in SBD. These serve to “reset” the instabilities caused by Combinatorial Complexity.

Complexity Metrics

A metric is a measure of something of interest. To be useful, one must be able to calculate or measure the metric and be able to place a value on the metric. Ideally an “improvement” in the metric should reliably result in an “improvement” in the desired outcome. There are many theoretical metrics for complexity, but most fail the test of being readily calculable.

One proposed complexity metric (Figure VV-1) is based on a Space Complexity Factor that in turn is a function of the number of systems and functional requirements that impact that space. This complexity metric recognized that many of the design activities in later stages of design are focused on the arrangement and design of individual spaces on a ship. The first equation in Figure VV-1 shows the calculation of an individual space complexity factor, and the second equation is a summation of the space complexity factors to provide a ship-level complexity metric.

$$SCF_i = \sqrt{\frac{1}{2}\left(\left(\frac{m_{systems\_touching}}{n_{3\_digit\_NTT}}\right)^2 + \left(\frac{m_{spaces\_impacting}}{n_{spaces}-1}\right)^2\right)}$$

$$SCM = \sum_{i=1}^{n_{spaces}} SCF_i$$

Where:

SCF_i	Space Complexity Factor
SCM	Ship Complexity Metric
$m_{systems\_touching}$	Number of Systems touching a space
$n_{3\_digit\_NTT}$	Number of 3 digit Tasks in the NCETL
$m_{space\_impacting}$	Number of other Spaces, which if modified within limits, will impact a system within this space
n_{spaces}	Number of spaces in the ship

Figure VV-1. Space and Ship Complexity Metrics

The matrix however, offers the opportunity to develop a more generalized metric of Combinatorial Complexity. Combinatorial Complexity is singled out because it should have a strong influence on the planning for a design process. As shown in equation [1], the proposed metric is the sum of the square of the sizes of the clusters.

$$Complexity = \sum_{i=1}^{n} C_i^2 \qquad [1]$$

Where: *n = Number of Clusters and* C_i *= Size of Cluster "i"*

For example, Figure VV-1 shows a matrix with complexity equal to 1+1+9+1+1=13. Eliminating the cluster of size 3 by redefining design activities 3, 4, and 5 and inserting a new integration activity 6, the complexity becomes 1+1+1+1+1+1+1+1=8. In this manner, beneficial changes to the design process can be measured and articulated to senior management as a reduction in the complexity metric.

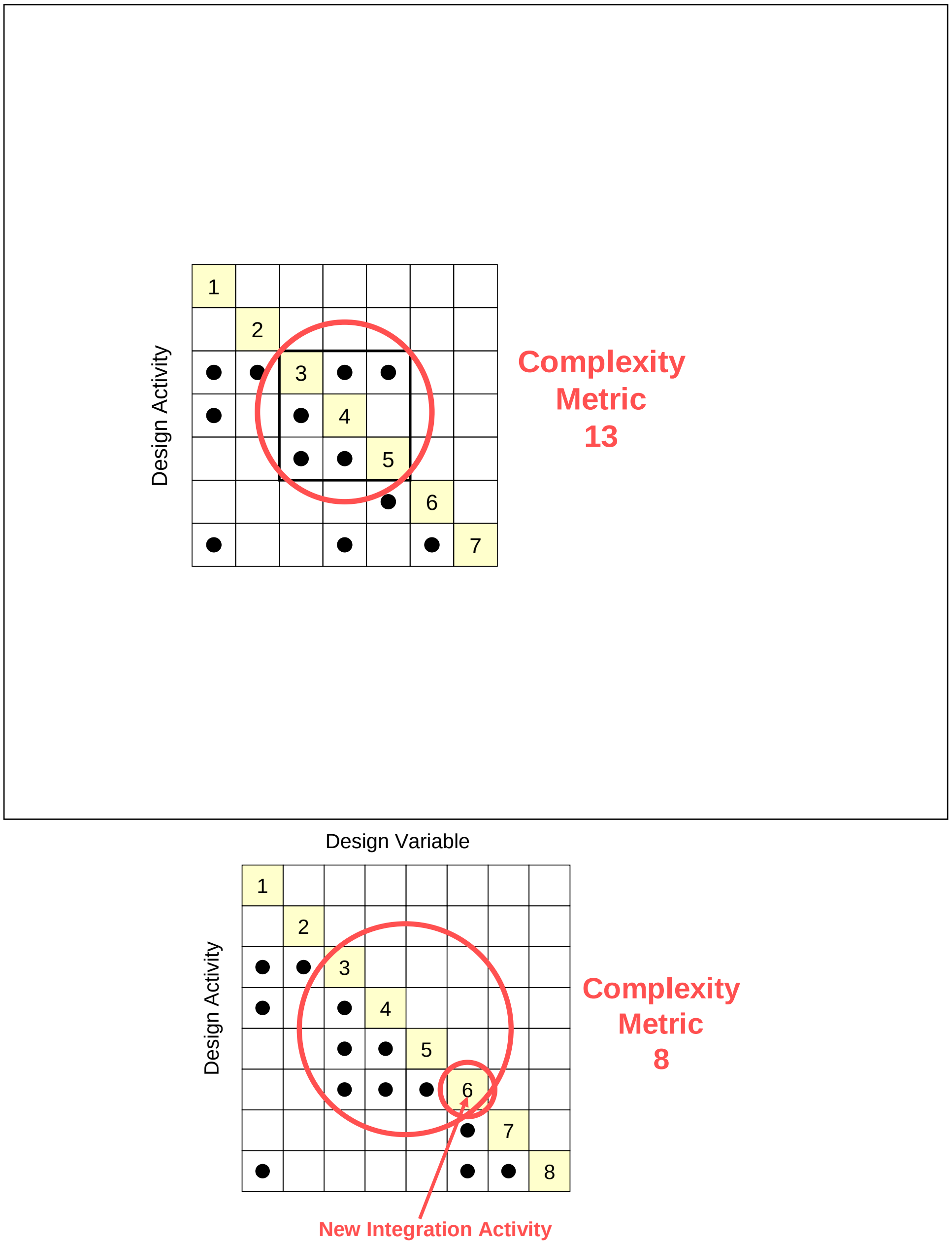


Figure VV-2. Less Complex Matrix By Redefining Activities

Complexity has a direct impact on cost. SEA 05C has developed a pseudo complexity metric called "outfit density" which is equal to (Light Ship Displacement minus Group 100 weight) divided by ship volume. Figure VV-3 shows a correlation in the first ship normalized engineering hours and outfit density. Likewise, Figure VV-4 shows a correlation in the first ship production hours and outfit density.

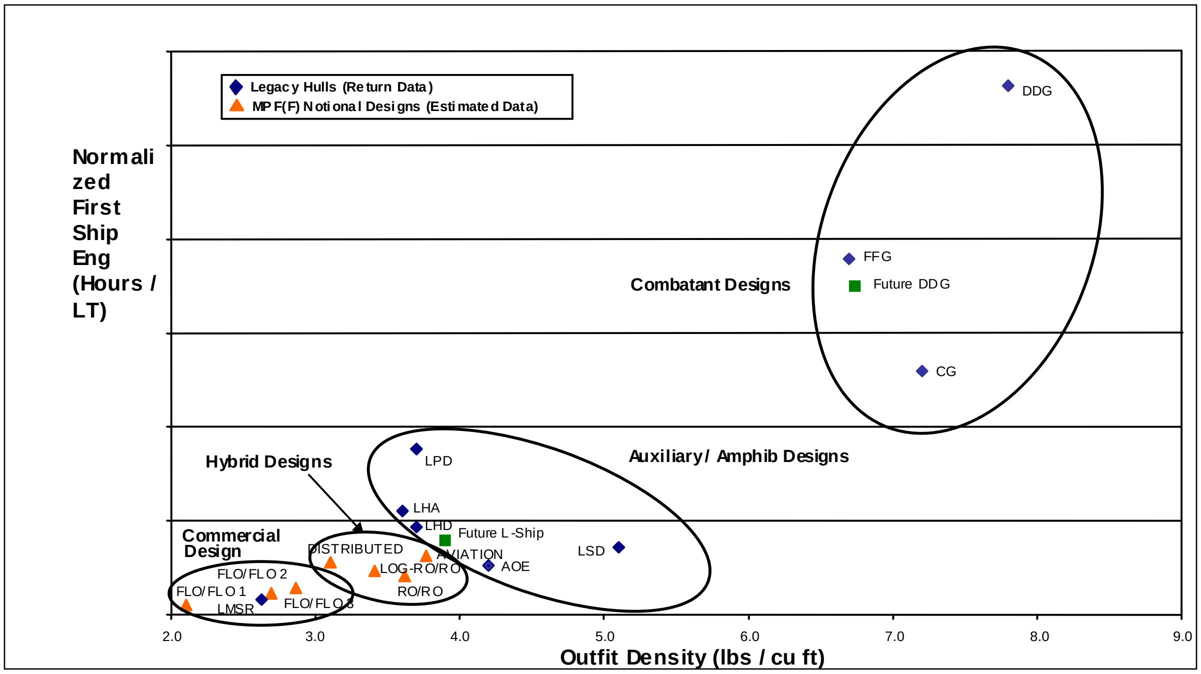


Figure VV-3. First Ship Engineering Hours versus Outfit Density

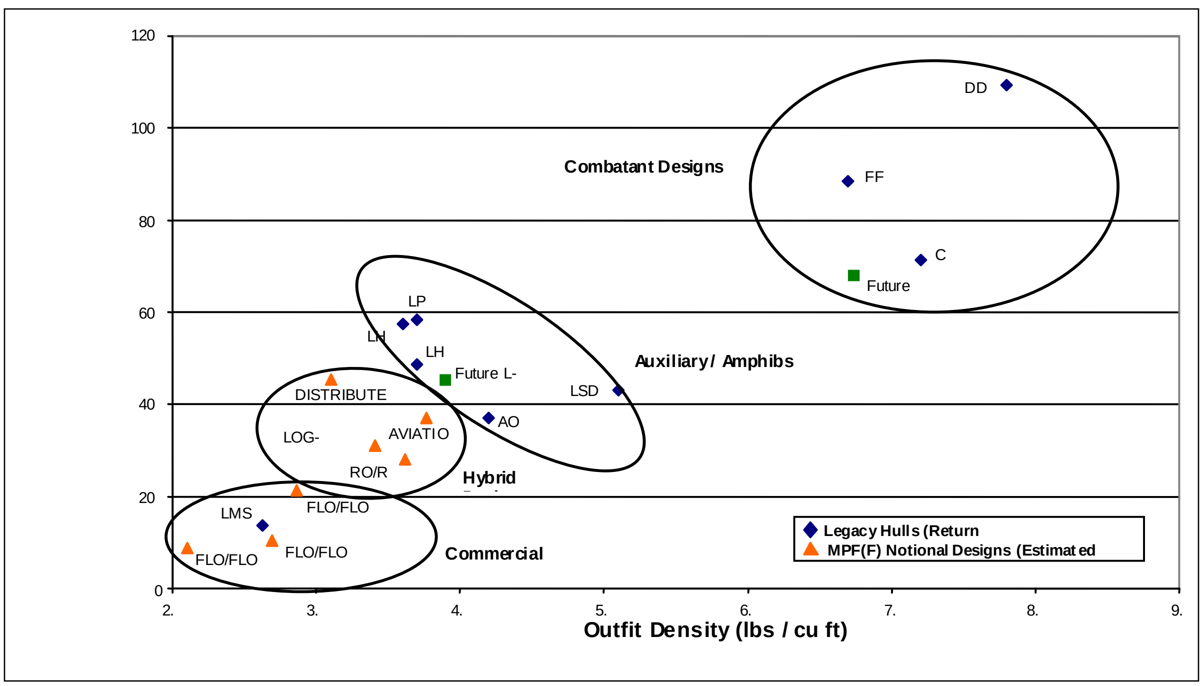


Figure VV-4. First Ship Production Hours versus Outfit Density

APPENDIX WW
DESIGN MATURITY ASSESSMENT

Near the end of each stage of design, the SDM shall prepare a Design Maturity Assessment to demonstrate readiness for proceeding into the next stage of design or production. Tasks comprising the assessment include:

1. Identify the systems that had modifications made to their architectures. Cite the number of full design iterations (spirals) that have been performed. For each design iteration, assess the overall magnitude of design changes since the previous iteration. Examples of architectures include:

- Hull – Hull form, stability, and arrangement architectures
- Energy – Propulsion, electrical, and dynamic positioning architectures and their integration
- Ship Information – Machinery control and C4I architectures and their integration

Architectures are considered "fixed" when subsequent design development will not require any changes to these architectures.

2. To begin the design convergence assessment the Design Team should develop a flow chart for each system similar to the ones shown in Figure WW-1. In the example depicted, risks are assigned based on analytical validation. With a "Converged Design" there is a high confidence that any subsequent changes to the design will not result in significant changes in principal characteristics (light ship and full load displacement, volume, KG, etc.) and that future changes will not deplete the remaining margins. If the design has not converged:

- Provide details of exactly which portions of the design have not converged
- Identify specific actions required to bring those items into convergence
- Delineate the technical risks associated with each non-convergence item

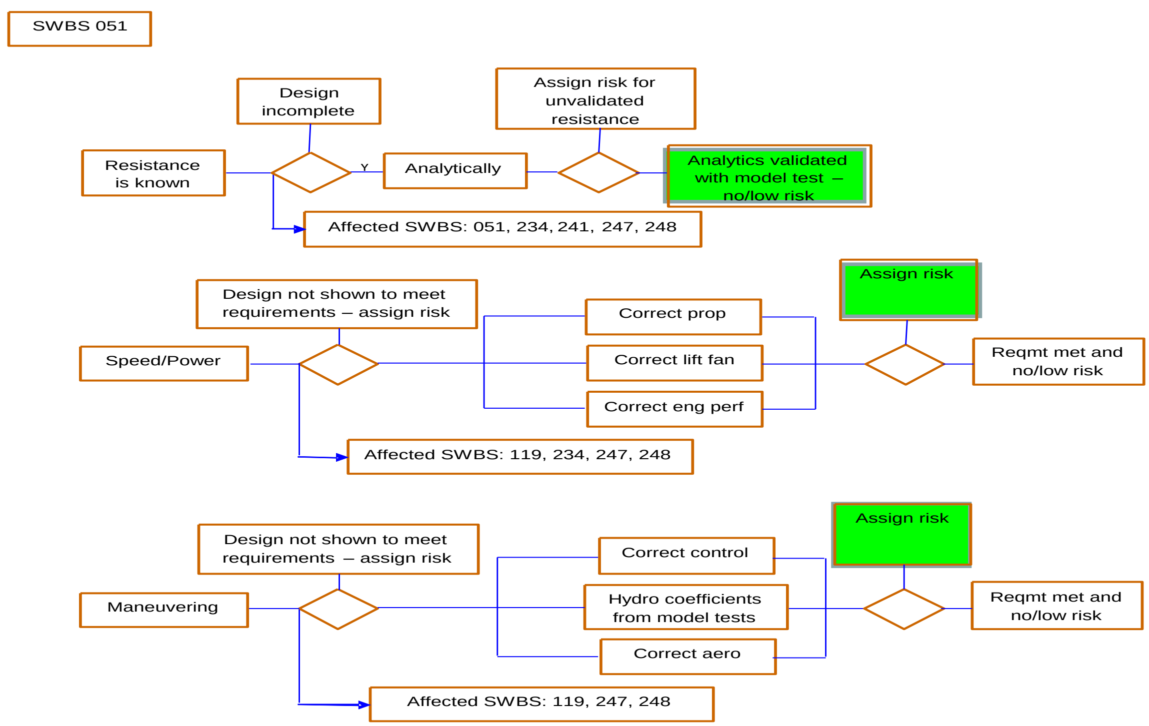


Figure WW-1. System Design Convergence Flow Chart

3. Establish that design artifacts reflect fixed architectures and are consistent with each other. State which design iteration number and/or design baseline date that each design artifact is based on). Examples of design artifacts to assess include:

- General Arrangement Drawings
- System Design 1 Weight Estimate
- Intact & Damaged Stability Report
- Speed and Power Analysis
- Dynamic Positioning System Report
- Ship Structural Design Analysis
- Propulsion System Report
- Machinery Arrangement Drawings
- Machinery Centralized Control System Report
- Master Equipment List
- Electrical Plant Load Analysis
- Electrical System One-Line Diagram
- Command, Control, Communications, Computers and Intelligence (C4I) Report
- Interior Communications System Design Report
- Rapid Ballast System Diagram
- Firemain System Design Report & Diagram
- Fixed Firefighting System Design Report
- Aqueous Film Forming Foam (AFFF) System Design
- Report and Diagram
- Aviation Support Systems Design Report
- Surface Connector Interface, Stowage, & Handling Report
- Vehicle Maneuvering and Stowage Study Report
- Vehicle Transfer System (VTS) Design Report

4. Identify novel features of the design.

5. Assess the risk that significant design changes will occur in subsequent stages of design. Use the Program's Risk Management System to report risks and develop risk mitigation plans.

6. Identify all areas of non-compliance with the Ship Specification. For any areas of non-compliance, list those areas with a supporting explanation, provide the remediation plan and identify which (if any) of those areas will have an effect on design convergence.

7. List the analyses done in support of the converged design and analyses remaining for future stages of design.

8. Identify the margins allocated for the current stage of design and how much of each margin was consumed. Provide supporting evidence to confirm that adequate margins exist for the remaining design phases and production.

9. Assess the overall risk that a ship constructed based on the information contained in the design artifacts will ultimately be successfully classified by ABS for applicable T-ships and recommended for acceptance by INSURV. Use the program's Risk Management System.

APPENDIX XX
ACRONYMS

AAP	Abbreviated Acquisition Program
ABS	American Bureau of Shipping
ACAT	Acquisition Category
ACO	Administrative Contracting Officer
ACP	Alternative Compliance Program
ACSAE	Air Capable Ship Aeronautical Equipment
ADM	Acquisition Decision Memorandum
AEA	Annual Execution Agreement
AEM/S	Advanced Enclosed Mast/Sensor System
AER	Alteration Equivalent to Repair
AFFF	Aqueous Film Forming Foam
AFOM	Alteration Figure of Merit
AIT	Alteration Installation Team
AoA	Analysis of Alternatives
ALRE	Aircraft Launch and Recovery Equipment
ANSI	American National Standards Institute
AP	Acquisition Plan
APB	Acquisition Program Baseline
AS	Acquisition Strategy
ASAP	Advanced Survivability Assessment Program
ASSET	Advanced Surface Ship Evaluation Tool
ASN(RD&A)	Assistant Secretary of the Navy (Research, Development, and Acquisition)
ASR	Alternative Systems Review
ASTM	American Society of Testing Materials
ASW	Anti-Submarine Warfare
AV	All-View
BAWP	Baseline Authorized Work Package
BUMED	Bureau of Medicine
C4I	Command, Control, Communications, Computers and Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAD	Computer-Aided Design

	Computer-Assisted Design
CAFSU	Carrier and Field Service Unit
CAIG	Cost Analysis Improvement Group
CAIV	Cost as an Independent Variable
CALS	Computer-Aided Acquisition and Logistics Support
CAM	Computer-Aided Manufacturing
CAPS	Carrier Availability Planning System
CARD	Cost Analysis Requirements Description
CASREP	Casualty Report
CB	Center of Buoyancy
CBA	Capabilities Based Assessment
	Cost Benefits Analysis
CBR	Chemical, Biological, and Radiological
CCB	Change Control Board
	Configuration Control Board
CCBL	Configuration Control Baseline
CD	Contract Design
CDD	Capability Development Document
CDM	Competency Domain Manager
CDMS	Corporate Document Management System
CDR	Critical Design Review
CER	Cost Estimating Relationships
CET	Cost Engineering Team
CFE	Contractor Furnished Equipment
CFM	Contractor Furnished Material
CFR	Code of Federal Regulation
CFT-4	Cross Functional Team Four
CHENG	Chief Engineer
CI	Configuration Item
CISD	Center for Innovation in Ship Design
CJCSI	Chairman, Joint Chiefs of Staff Instruction
CLIN	Contract Line Item
CLO	Counter Low Observable
CM	Configuration Management

	Change Manager
CMC	Commandant of the Marine Corps
CNAF	Commander Naval Air Forces
CNSF	Commander Naval Surface Forces
CNO	Chief of Naval Operations
COI	Certificate of Inspection
COMFLTFORCOMINST	Commander, Fleet Forces Command Instruction
COMNAVAIR	Commander, Naval Air Systems Command
COMNAVSEACOM	Commander, Naval Sea Systems Command
COMOPTEVFOR	Commander, Operational Test and Evaluation Force
CONOPS	Concept of Operations
COSAL	Coordinated Shipboard Allowance List
CPA	Carrier Planning Activity
CPAT	Corrosion Prevention Advisory Team
CPCP	Corrosion Prevention and Control Plan
CPD	Capability Production Document
CPI	Critical Program Information
CPSD	Cost Performance Schedule Description
CRD	Certification Requirements Document
CRL	Cost Readiness Level
CSA	Customer Service Agreement
CSB	Configuration Steering Board
CSE	Class Standard Equipment
	Chief Systems Engineer
CSEL	Combat Systems Equipment List
CSI	Critical Safety Item
CSMP	Current Ship's Maintenance Project
CTT	Combined Test Team
DA	Design Agent
DAB	Defense Acquisition Board
DARPA	Defense Advanced Research Projects Agency
DASN	Deputy Assistant Secretary of the Navy
DC	Damage Control
DCA	Defense Contracting Agency

DD&C	Detail Design and Construction
DDR	Design Decision Review
DFARS	Defense Federal Acquisition Regulation Supplement
DFS	Departure from Specification
	Deviation from Specification
DI	Data Item
DIM	Design Integration Manager
DISA	Defense Information Systems Agency
DMA	Design Maturity Assessment
DoD	Department of Defense
DoDAF	DoD Architecture Framework
DoN	Department of the Navy
DoN CIO	Department of Navy Chief Information Officer
DOSE	Decision Oriented Systems Engineering
DOT&E	Director, Operational Test and Evaluation
DOTMLPF	Doctrine, Organization, Training, Materiel, Leadership, Personnel, and Facilities
DRL	Data Requirements List
DRM	Design Reference Mission
DRPM	Direct Reporting Program Manager
DS	Down Select
DSEM	Deputy Systems Engineering Manager
DSM	Design Structure Matrix
DUSD	Deputy Under Secretary of Defense
DT&E	Developmental Test and Evaluation
DTIC	Defense Technical Information Center
DWO	Deputy Warranting Officer
EA	Engineering Agent
ECD	Estimated Completion Date
ECM	Engineering Configuration Manager
ECP	Engineering Change Proposal
EFR	Engineering Field Representatives
EHP	Effective Horsepower
EIA	Electronic Industries Alliance
EMC	Electromagnetic Compatibility

EMD	Engineering Manufacturing and Development
EMI	Electromagnetic Interference
EMP	Electromagnetic Pulse
EO	Executive Order
EP	Entitled Process
ERP	Enterprise Resources Planning
ESOH	Environmental, Safety and Occupational Health
ESWBS	Expanded Ship Work Breakdown Structure
EVMS	Earned Value Management System
FAA	Functional Area Analysis
FAR	Federal Acquisition Regulation
FAS	Fueling at Sea
FCA	Functional Configuration Audit
FCB	Functional Coordination Board
FEA	Finite-Element Analysis
FLO FLO	Float On Float Off
FMA	Fleet Maintenance Activity
FMP	Fleet Modernization Program
FMR	Field Modification Request
FNA	Functional Needs Analysis
FOC	Full Operational Capability
FOUO	For Official Use Only
FRC	Federal Record Center
FRP DR	Full Rate Production Decision Review
FS	Feasibility Study
FSA	Functional Solution Analysis
FSC	Full Service Contractor
FTE	Full-Time Equivalent
FY	Fiscal Year
GFE	Government Furnished Equipment
GFI	Government Furnished Information
GFM	Government Furnished Material
GIDEP	Government-Industry Data Exchange Program
GSO	General Specifications for Overhaul

HCDD	Human Capital Digital Dashboard
HERF	Hazards of Electromagnetic Radiation for Fuel
HERO	Hazards of Electromagnetic Radiation for Ordnance
HERP	Hazards of Electromagnetic Radiation to Personnel
HF	High Frequency
HFE	Human Factors Engineering
HM&E	Hull, Mechanical and Electrical
HQMC	Headquarters Marine Corps
HSC	High Speed Craft
HSI	Human Systems Integration
HSNC	High Speed Naval Craft
HVAC	Heating, Ventilation, and Air Conditioning
IA	Information Assurance
IACS	International Association of Classification Societies
IBR	Integrated Baseline Review
ICD	Initial Capabilities Document
ICMP	Integrated Class Maintenance Plan
I/COSAL	Integrated Coordinated Shipboard Allowance List
IDE	Integrated Digital Environment
IDEA	Integrated Design Engineering Environment
IDEF	Integration Definition
IDPME	Integrated Data and Product Model Environment
IEEE	Institute of Electrical & Electronics Engineers
IFF	Identification Friend or Foe
ILA	Independent Logistics Assessment
ILS	Integrated Logistics Support
IMO	International Maritime Organization
IMP	Integrated Management Plan
INFOSEC	Information Systems Security
INSURV	(Board of) Inspection and Survey
IOC	Initial Operational Capability
IOT&E	Initial Operational Test and Evaluation
IPDE	Integrated Product Development Environment
	Integrated Product Data Environment

IPPD	Integrated Product and Process Development
IPT	Integrated Product Team
IPT4ACM	Integrated Project Teams for Aircraft Carrier Maintenance
IR	Infra Red
IRR	Integrated Readiness Review
ISE	In Service Engineering
ISEA	In Service Engineering Agents
ISO	International Organization of Standardization
ITAR	International Traffic in Arms Regulation
ITD	Integrated Topside Design
ITR	Initial Technical Review
IWS	Integrated Warfare Systems
IWSE	Integrated Warfare Systems Engineering
JCB	Joint Capabilities Board
JCF	Justification Cost Form
JCIDS	Joint Capabilities Integration and Development System
JFCOM	Joint Forces Command
JFMM	Joint Fleet Maintenance Manual
JIT	Just-In-Time
JITC	Joint Interoperability Test Command
JROC	Joint Requirements Oversight Council
KG	Ship's Center of Gravity Above Keel
KPP	Key Performance Parameter
KSA	Key System Attribute
LAR	Liaison Action Record
LCM	Life Cycle Manager
LEAPS	Leading Edge Architecture for Prototyping Systems
LFT&E	Live Fire Test and Evaluation
LO	Low Observable
LOE	Level of Effort
LSE	Lead Systems Engineer
MACHALTS	Machinery Alterations
MARPOL	International Convention for the Prevention of Pollution from Ships
MAS	Modular Adaptable Ship

MDA	Milestone Decision Authority
MDD	Materiel Development Decision
MEL	Major (or) Master Equipment List
MI	Material Inspections
MILSPEC	Military Specification
MIL-STD	Military Standard
MIRWS	Master Integrated Resource and Work Schedule
MIT	Massachusetts Institute of Technology
MOA	Memorandum of Agreement
MOS	Management Operating System
MOSA	Modular Open Systems Architecture
MOU	Memorandum of Understanding
MPF(F)	Maritime Prepositioning Force (Future)
MRP	Multiservice Route Processor
MS	Milestone
MSC	Military Sealift Command
NAB	NAVSEA Adjudication Board
NACT	Naval Advanced Concepts and Technologies
NATO	North Atlantic Treaty Organization
NAVAIR	Naval Air Systems Command
NAVAIRLAKEHURSTACDIV	Naval Air Warfare Center Aircraft Division, Lakehurst, NJ
NAVCOMPT	Navy Comptroller
NAVMED	Naval Medical Command
NAVOSH	Navy Occupational Safety and Health
NAVSEA	Naval Sea Systems Command
NAVSEAINST	NAVSEA Instruction
NAVSO	Navy Staff Office
NAVSUP	Naval Supply Systems Command
NCAD	Naval Cost Analysis Division
NCETL	Naval Concept Essential Task List
NDE	Navy Data Environment
NEEC	Naval Engineering Education Center
NEMP	Nuclear Electromagnetic Pulse
NEPA	National Environmental Policy Act

NETC	Naval Education and Training Command
NFAF	Naval Fleet Auxiliary Force
NGNN	Northrop Grumman Newport News
NIPO	Navy International Programs Office
NISO	National Information Standards Organization
NKO	Navy Knowledge Online
NLLS	Navy Lessons Learned System
NMCI	Navy Marine Corps Internet
NMP	Navy Modernization Process
NN	Newport News
NNSY	Norfolk Naval Shipyard
NOFORN	Not Releasable to Foreign Nationals/Governments/Non-US Citizens
NPS	Naval Postgraduate School
NRE	Non-recurring Engineering
NRMD	Nuclear Regional Maintenance Department
NSA	Naval Supervising Authority
NSRO	NAVSEA Shipyard Representative's Office
NSS	National Security Systems
NSTISSP	National Security Telecommunications and Information Systems Security Policy
NSTM	Naval Ships Technical Manual
NSWC	Naval Surface Warfare Center
NUWC	Naval Undersea Warfare Center
NVR	(ABS) Naval Vessel Rules
NWCF	Navy Working Capital Fund
O&MN	Operations and Maintenance, Navy
OCI	Organizational Conflict of Interest
OGA	Other Government Activity
OIPT	Overarching Integrated Product Team
OMB	Office of Management and Budget
ONR	Office of Naval Research
OPEVAL	Operational Evaluation
OPNAV	Office of the Chief of Naval Operations
OPNAVINST	OPNAV Instruction
OPSEC	Operations Security (Manual)

OR	Owner's Representative
ORD	Operational Requirements Document
ORDALT	Ordnance Alteration
OSJTF	Open Systems Joint Task Force
OSR	On-Site Representative
OTRR	Operational Test Readiness Review
OV	Operational View
OWLD	Obligation Work Limiting Date
PARM	Participating Acquisition Resource Manager
PART	Program Assessment and Rating Tool
PBL	Performance Based Logistics
PCO	Procuring Contracting Officer
PD	Preliminary Design
PDM	Product Data Model
	Program Decision Meeting
PDR	Preliminary Design Review
PDS	Project Data Sheet
PEO	Program Executive Officer
	Program Executive Office
PLCCE	Program Life Cycle Cost Estimate
PM	Program Manager
PME	Project Marine Engineer
PMR	Program Manager Representative
PMT	Program Management Team
PNA	Project Naval Architect
POA&M	Plan of Action and Milestones
POC	Point of Contact
POM	Program Objectives Memorandum
PPBES	Program Planning Budgeting and Execution System
PPD	Project Peculiar Document
PPEA	Propulsion Plant Engineering Activity
PPP	Program Protection Plan
PRR	Production Readiness Review
PSA	Post Shakedown Availability

PSI	Pounds Per Square Inch
PSNSY	Puget Sound Naval Shipyard
PY	Planning Yard
QA	Quality Assurance
QCD	Quality, Cost, and Deliver
R&D	Research and Development
R&SE	Research and Systems Engineering
RADHAZ	Radiation Hazard
RAM	Reliability, Availability, and Maintainability
RAS	Replenishment at Sea
RAST	Recovery, Assist, Secure and Traverse
RCIA	Request for Clarification, Information and Assistance
RCOH	Refueling Complex Overhaul
RCS	Radar Cross Section
RDT&E	Research, Development, Test and Evaluation
RFD	Request for Deviation
RFP	Request for Proposal
RFW	Request for Waiver
RIYD	Required In Yard Date
RMC	Regional Maintenance Center
ROM	Rough Order of Magnitude
RPPY	Reactor Plant Planning Yard
RS&E	Research and Systems Engineering
RTM	Requirements Traceability Manager
S&T	Science and Technology
SAMP	Single Acquisition Management Plan
SAR	Ship Alteration (SHIPALT) Record
SATCOM	Satellite Communications
SBD	Set Based Design
SBIR	Small Business Innovative Research
SCD	Ship Change Document
SCF	Space Complexity Factor
SCM	Ship Concepts Manager
	Ship Certification Matrix

	Ship Class Manager
	Ship Complexity Metric
SCN	Ship Construction Navy
SDCN	Ship Design and Certification Network
SDM	Ship Design Manager
SDR	Ship Design Review
SDS	System Design Specification
SDT	Ship Design Team
SECNAV	Secretary of the Navy
SECNAVINST	Secretary of the Navy Instruction
SEM	System Engineering Manager
SEP	System Engineering Plan
SETR	Systems Engineering Technical Review
SF	Standard Form
SFAC	Statements of Financial Accounting Concepts
SFR	System Functional Review
SHCP	Ship Hullform Characteristics Program
SHIPALT	Ship Alteration
SHIPMAIN	Ship Maintenance
SIG	Ship Integration Group
SIM	Systems Integration Manager
SIPM	Systems Integration PM
SLEP	Service Life Extension Program
SME	Subject Matter Expert
SOLAS	Safety of Life at Sea
SOM	SUPSHIP Operations Manual
SORM	Ship’s Organizational and Regulations Manual
SoS	System-of-Systems
SOW	Statement of Work
SPAR	Steam Plant Action Request
SPAWAR	Space and Warfare Systems Command
SPD	Ship Project Directive
SPLI	Steam Plant Liaison Inquiry
SPM	Ship Program Manager

	Smart Product Model
SPP	Sponsor's Program Proposal
SPPC	Ship Production Progress Conferences
SRG	Survivability Review Group
SRR	System Requirements Review
SS	Source Selection
SSAC	Source Selection Advisory Council
SSB	Stakeholders Steering Board
SSC	Ship-to-Shore Connector
SSLCM	Surface Ship Life Cycle Maintenance Activity
SSP	Source Selection Plan
STAR	System Threat Assessment Report
STILO	Scientific and Technical Intelligence Liaison Officer
STM	Specification Task Manager
SUPSHIP	Supervisor of Shipbuilding
SURFOR	Surface Forces
SV	System View
SVM	Ship Vulnerability Model
SWARF	Senior Warfighter Forum
SWATH	Small-Waterplane Area Twin-Hull
SWBS	Ship Work Breakdown Structure
SYSCOM	Systems Command
T&E	Test and Evaluation
TACA	Technical Authority Capability Assessment
TACAN	Tactical Air Navigation
TAT	Technical Assessment Team
TD	Technical Director
TDM	Technical Domain Manager
TEMP	Test and Evaluation Master Plan
TEMPEST	Telecommunications Electronics Material Protected from Emanating Spurious Transmissions
TES	Test and Evaluation Strategy
TFA	Technical Feasibility Assessment
TIM	Topside Integration Manager
TL	Task Leader

TMA	Top Management Attention
TMI	Top Management Issues
TOC	Total Ownership Cost
TPM	Technical Performance Measures
TRANSCOM	Transportation Command (U.S.)
TRB	Technical Review Board
TREE	Transient Radiation effects in Electronics
TRL	Technology Readiness Level
TRR	Test Readiness Review
TSSE	Total Ship System Engineering
TSTP/SP	Total Ship Test Program for Ship Production
TTSARB	Technology Transfer and Security Assistance Review Board
TV	Technical Standards View
TWH	Technical Warrant Holder
TYCOM	Type Commander
UMI	Underway Material Inspection
UNREP	Underway Replenishment
UNTL	Universal Navy Task List
USC	United States Code
USCG	United States Coast Guard
USD (AT&L)	Under Secretary of Defense for Acquisition, Technology and Logistics
USNA	U.S. Naval Academy
VA	Value Analysis
VAMOSC	Visibility and Management of Operation and Support Cost
VE	Value Engineering
VERTREP	Vertical Replenishment
VLA	Visual Landing Aid
VRT	Voyage Repair Team
VT	Virginia Tech (Virginia Polytechnic Institute and State University)
VTL	Virtual Technical Library
VTS	Vehicle Transfer System
VV&A	Verification, Validation, and Accreditation
WBS	Work Breakdown Structure
WG	Working Group

WIPT	Working-level Integrated Product Team
WSESRB	Weapons Systems Explosive Safety Review Board
WTA	Work Task Assignment