

June 2003

# MILITARY PERSONNEL

## Navy Actions Needed to Optimize Ship Crew Size and Reduce Total Ownership Costs



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# Highlights

Highlights of [GAO-03-520](#), a report to Congressional Requesters

## Why GAO Did This Study

The cost of a ship's crew is the single largest incurred over the ship's life cycle. One way to lower personnel costs, and thus the cost of ownership, is to use people only when it is cost-effective—a determination made with a systems engineering approach called human systems integration. GAO was asked to evaluate the Navy's progress in optimizing the crew size in four ships being developed and acquired: the DD(X) destroyer, T-AKE cargo ship, JCC(X) command ship, and LHA(R) amphibious assault ship. GAO assessed (1) the Navy's use of human systems integration principles and goals for reducing crew size, and (2) the factors that may impede the Navy's use of those principles.

## What GAO Recommends

To facilitate the Navy's efforts to optimize ship crew sizes and minimize total ownership costs, GAO is recommending that the Secretary of the Navy: (1) require that ship programs use human systems integration to establish crew size goals and help achieve them, (2) clearly define the human systems integration certification standards for new ships, (3) formally establish a process to examine and facilitate the adoption of labor-saving technologies and best practices across Navy systems.

In commenting on a draft of this report, DOD agreed with GAO's recommendations.

[www.gao.gov/cgi-bin/getrpt?GAO-03-520](http://www.gao.gov/cgi-bin/getrpt?GAO-03-520).

To view the full product, including the scope and methodology, click on the link above. For more information, contact Henry L. Hinton, Jr., at (202) 512-4300 or [hintonh@gao.gov](mailto:hintonh@gao.gov).

## MILITARY PERSONNEL

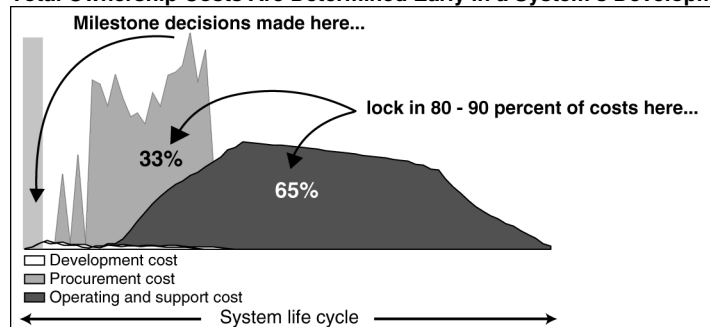
# Navy Actions Needed to Optimize Ship Crew Size and Reduce Total Ownership Costs

## What GAO Found

The Navy's use of human systems integration principles and crew size reduction goals varied significantly for the four ships GAO reviewed. Only the DD(X) destroyer program emphasized human systems integration early in the acquisition process and established an aggressive goal to reduce crew size. The Navy's goal is to cut personnel on the DD(X) by about 70 percent from that of the previous destroyer class—a reduction GAO estimated could eventually save about \$18 billion over the life of a 32-ship class. The goal was included in key program documents to which program managers are held accountable. Although the Navy did not set specific crew reduction goals for the T-AKE cargo ship, it made some use of human systems integration principles and expects to require a somewhat smaller crew than similar legacy ships. The two other ships—the recently cancelled JCC(X) command ship and the LHA(R) amphibious assault ship—did not establish human systems integration plans early in the acquisition programs, and did not establish ambitious crew size reduction goals. Unless the Navy more consistently applies human systems integration early in the acquisition process and establishes meaningful goals for crew size reduction, the Navy may miss opportunities to lower total ownership costs for new ships, which are determined by decisions made early in the acquisition process (see figure). For example, the Navy has not clearly defined the human systems integration certification standards for new ships.

Several factors may impede the Navy's consistent application of human systems integration principles and its use of innovations to optimize crew size: (1) DOD acquisition policies and discretionary Navy guidance that allow program managers latitude in optimizing crew size and using human systems integration, (2) funding challenges that encourage the use of legacy systems to save near-term costs and discourage research and investment in labor-saving technology that could reduce long-term costs, (3) unclear Navy organizational authority to require human systems integration's use in acquisition programs, and (4) the Navy's lack of cultural acceptance of new concepts to optimize crew size and its layers of personnel policies that require consensus from numerous stakeholders to revise.

**Total Ownership Costs Are Determined Early in a System's Development**



Source: U.S. Navy.

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## Abbreviations

DD(X)	destroyer
DOD	Department of Defense
JCC(X)	joint command and control ship
LHA(R)	amphibious assault ship replacement
MSC	Military Sealift Command
T-AKE	auxiliary cargo and ammunition ship

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United States General Accounting Office  
Washington, DC 20548

June 9, 2003

The Honorable Jim Talent  
Chairman  
The Honorable Edward M. Kennedy  
Ranking Minority Member  
Subcommittee on Seapower  
Committee on Armed Services  
United States Senate

The cost of a ship's crew is the single largest expense incurred over a ship's life cycle. As such, transitioning from the personnel- and workload-intensive ships of the past to optimally crewed ships with reduced workloads has tremendous potential to free up resources for the Navy to use in recapitalizing the fleet. The Department of Defense's (DOD) planned procurement rate for fiscal years 2004-2008 is 7.4 ships per year, a rate that supports a fleet of about 259 ships—below the 2001 Quadrennial Defense Review goal of 310 and farther below the Navy's desired fleet of 375 ships. In recognition of the budgetary challenges the Navy faces in recapitalizing its fleet, House and Senate conferees have expressed an interest in identifying ways to reduce these personnel expenses through the acquisition of ships that would require smaller crews.<sup>1</sup>

One way to lower costs associated with personnel is to use people only when it is cost-effective to do so—determining this by using a systems engineering approach known as human systems integration. In this process, tasks and functions are systematically analyzed and assigned to the most cost-effective solution—humans, software, or hardware. When applied to ships early in their development and throughout their design, human systems integration has the potential to substantially reduce requirements for personnel, leading to significant cost savings. Additionally, it can improve operational performance by enhancing situational awareness and decision making; reduce human error, which causes an estimated 80 percent of ship accidents; and reduce training difficulty and cost. Human systems integration also has the potential to improve shipboard habitability, reduce workload and fatigue, and

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<sup>1</sup> National Defense Authorization Act for Fiscal Year 2003 Conference Report 107-772 (Nov. 12, 2002).

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thereby improve a sailor's quality of life—key enablers for recruiting and retention.

Because the size of ship crews has such a significant impact on long-term costs, you asked us to evaluate the Navy's progress in optimizing the crew size in four new ships that DOD was in the process of developing and acquiring: the DD(X) destroyer,<sup>2</sup> the T-AKE cargo ship,<sup>3</sup> the recently canceled JCC(X) command ship,<sup>4</sup> and the LHA(R) amphibious assault ship. During our review, three of these ships were in the early stages of development while only one ship, the T-AKE, had entered acquisition phase three, production and deployment. (App. II includes a description of the ships' missions and acquisition program history and status.) In this report, we assess (1) the Navy's use of human systems integration principles and goals to reduce crew size on these four ships and (2) the factors that may impede the Navy's use of human systems integration principles in developing new ships.

To assess the Navy's use of human systems integration principles and crew size reduction goals, we obtained and analyzed key program and ship crewing documents as well as human systems integration plans and analyses. We also assessed whether and to what extent human systems integration principles and crew reduction goals were addressed in the first two acquisition phases (concept and technology development and system development and demonstration) and reflected in key acquisition documents. To evaluate factors that may impede the Navy's application of human systems integration principles, we interviewed DOD officials,

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<sup>2</sup> At the time the ship's mission need statement was developed, it was referred to as the Surface Combatant 21, a term used in the early stages of the Land Attack Destroyer program. It eventually became known as DD 21 and subsequently as the DD(X). For uniformity, we will refer to the ship as the DD(X) in all of its stages.

<sup>3</sup> The ship program was previously known as the Auxiliary Dry Cargo Carrier (ADC(X) or T-ADC(X)). The program subsequently became known as the Auxiliary Cargo and Ammunition Ship (T-AKE). For uniformity, we refer to the ship as the T-AKE or the T-AKE cargo ship in all of its stages.

<sup>4</sup> The program was formally named the Joint Maritime Command and Control Capability Ship Program, hereafter referred to as the JCC(X) command ship. DOD's fiscal year 2004 Program Objective Memorandum canceled the JCC(X) program. Instead, DOD has directed that the analysis of alternatives for the Maritime Prepositioning Force (Future), or MPF(F), examine the feasibility of incorporating as a module or variant an additional mission package that provides joint and coalition command and control. MPF(F) ships are the Marine Corps' forward-deployed floating warehouses of military ammunition, fuel, and food that are the centerpiece of the Navy's future sea basing concept.

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contractors, and human systems integration experts and reviewed acquisition guidance to determine the extent to which it discusses or requires the use of human systems integration principles in ship programs. We conducted our review from June 2002 through April 2003 in accordance with generally accepted government auditing standards. The scope and methodology used in our review are described in further detail in appendix I.

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## Results in Brief

The Navy's use of human systems integration and crew size reduction goals varied significantly in the four ship programs we examined. Only the DD(X) destroyer program placed a significant emphasis on human systems integration early in the acquisition process and established an aggressive goal to reduce crew size. The Navy's goal for the DD(X) destroyer, which was included as a principal program goal or key performance parameter, is expected to cut the ship crew size by about 60 to 70 percent from that of the previous destroyer ship class,<sup>5</sup> a reduction we estimated could save about \$18 billion (fiscal year 2002 dollars)<sup>6</sup> in personnel-related costs over the service life of a future class of 32 ships.<sup>7</sup> This goal was established at program initiation, provided the initiative for developing a comprehensive human systems integration plan, and was reiterated in the key program documents to which the program manager is held accountable at key milestone reviews. For the T-AKE cargo ship, the Navy made some use of human systems integration and expects to require somewhat fewer personnel than the legacy ships it is replacing. It did not, however, establish specific crew size reduction goals or apply human systems integration principles to the ship's primary mission, intership underway replenishment. The remaining two programs, the JCC(X) command and the LHA(R) amphibious assault ships, did not develop comprehensive human systems integration plans early in the acquisition process and do not have crew size reduction as a formal program goal. Because the Navy did not consistently apply human systems integration principles and set goals for reducing crew size for three of the ships we reviewed, it may have missed opportunities to reduce crewing requirements and lower total ownership costs, which are determined largely by decisions made early in

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<sup>5</sup> A ship class represents a number of vessels built alike or nearly so.

<sup>6</sup> Unless otherwise noted, all dollars are expressed as current dollars (also known as then-year dollars).

<sup>7</sup> Although the DD 21 destroyer program consisted of 32 ships, it is not yet clear how many DD(X)s will be purchased.

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the acquisition process but which will be incurred throughout these ships' 30-40 year life spans.

Based on briefings and discussions with agency officials and a review of acquisition policies, we found that a number of related factors contribute to the Navy's inconsistent application of human systems integration principles and may impede the adoption of innovations to optimize crew size. These factors include the following:

- DOD and Navy acquisition policies allow program managers considerable latitude in optimizing crew size and in determining the timing and extent to which they employ human systems integration.
- Funding challenges when acquiring new ships encourage the use of legacy subsystems to save near-term costs instead of the investment in research and development of labor-saving technologies that would reduce costs over the long term.
- Most Navy organizations responsible for human systems integration oversight are not empowered to require the use of human systems integration to optimize crew size. The Naval Sea Systems Command's newly established directorate for human systems integration, which is responsible for certifying that ships delivered to the fleet have optimized crews, had not established a process or criteria for achieving certification.
- Even when new labor-saving approaches and technologies are identified during the concept and technology development phase, implementing them is a difficult and time-consuming process due to the Navy's long-standing traditions and culture and the extensive network of personnel, safety, training, maintenance, and other policies and procedures that affect ship personnel levels. Moreover, there is no process to help Navy program managers identify and coordinate with other stakeholders to modify or eliminate policies and procedures that may impede the introduction of labor-saving practices and technology identified during ship design.

These factors cause Navy decision makers to set goals of not exceeding the crew size of 30-year old ships, for program managers to wait until preliminary design to begin human systems integration efforts, and exclude primary and secondary ship functions from rigorous analysis. As a result, the Navy is designing and procuring some new ships that may not cost-effectively address one of the biggest cost drivers in the Navy—personnel. The DD(X) experience also shows that even when these practices are followed, the program will still face challenges in achieving these goals and encounter pressures to relax the goals as the system design progresses, thereby supporting human systems integration experts' view that human systems integration plans and activities should receive

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continued review and focus throughout the acquisition process. Unless the Navy more consistently applies human systems integration at the earliest stages of the development process and establishes meaningful goals for crew size reduction, the Navy may miss opportunities to lower total ownership costs for new ships, which are determined by decisions made early in the acquisition process.

To facilitate the Navy's efforts to optimize ship crew sizes and minimize total ownership costs, we are recommending that the Secretary of the Navy (1) require that ship programs use human systems integration to establish crew size goals and help achieve them, (2) clearly define the human systems integration certification standards for new ships, (3) formally establish a policy evaluation function to examine and facilitate the adoption of cost-saving technologies and best practices across Navy systems. In commenting on a draft of this report, DOD agreed with our recommendations.

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## Background

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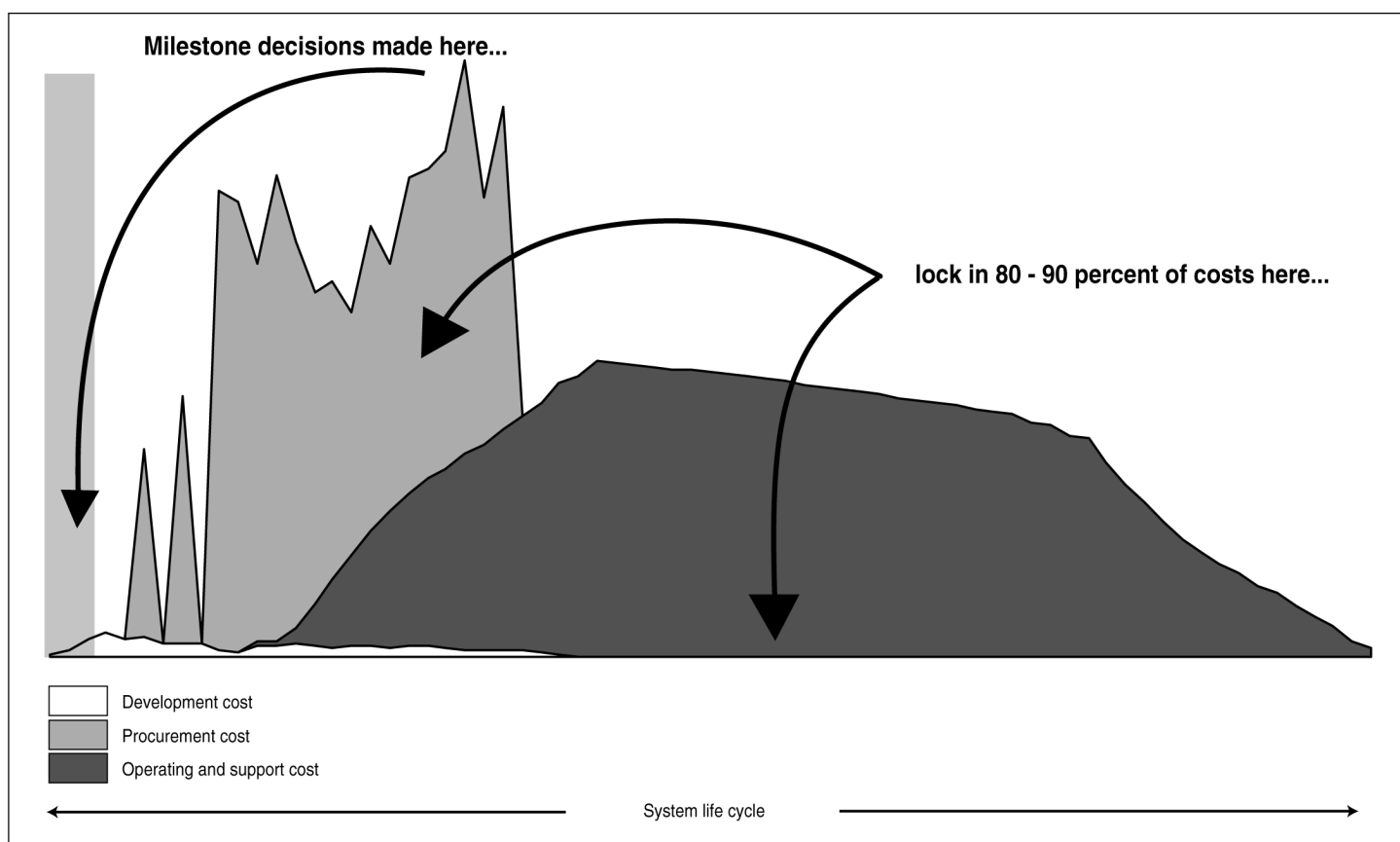
### Total Ownership Costs Are Determined Early in a System's Development

Decisions made in setting requirements very early in a ship's development have enormous impact on the total ownership costs.<sup>8</sup> Total ownership costs include the costs to research, develop, acquire, own, operate, maintain, and dispose of weapon and support systems; the costs of other equipment and real property; the costs to recruit, retrain, separate, and otherwise support military and civilian personnel; and all other costs of DOD's business operations. Navy analyses show that by the second acquisition milestone (which assesses whether a system is ready to advance to the system development and demonstration phase), roughly 85 percent of a ship's total ownership cost has been "locked in" by design, production quantity, and schedule decisions while less than 10 percent of its total costs has actually been expended. (See fig. 1.)

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<sup>8</sup> In another report we recommend that DOD treat total ownership costs as a performance requirement equal in priority to any other performance requirement prior to beginning the acquisition program. See U.S. General Accounting Office, *Best Practices: Setting Requirements Differently Could Reduce Weapon Systems' Total Ownership Costs*, [GAO-03-57](#) (Washington, D.C.: Feb. 11, 2003).

**Figure 1: Total Ownership Costs Are Determined Early in a System's Development**



Source: U.S. Navy.

Figure 1 depicts the relative apportionment of research and development, procurement, and operating and support costs over the typical life cycle of a ship program (the complete life cycle of a ship, from concept development through disposal, typically ranges from 40 to 60 years). Research and development funds are spent at program initiation and generally comprise only a small fraction of a new ship's total ownership costs. Then, in the next acquisition phase, procurement funds, comprising about 30 percent of total ownership costs, are spent to acquire the new ship. The vast majority of the total ownership costs, about 65 percent, is comprised of operating and support costs and is incurred over the life of the ship. Personnel costs are the largest contributor to operating and support costs—approximately 50 percent.

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## Defense Acquisition Policy Requires Setting Goals to Optimize Performance and Minimize Cost

Recognizing that fiscal constraints pose a long-term challenge, DOD policy states that total ownership costs of new military systems should be identified and that DOD officials should treat cost as a military requirement during the acquisition process.<sup>9</sup> This approach, referred to as treating cost as an independent variable, requires program managers to consider cost-performance trade-offs in setting program goals.

During the acquisition process, program managers are held accountable for making progress toward meeting established goals and requirements at checkpoints, or milestones, over a program's life cycle.<sup>10</sup> (See app. III for a discussion of the DOD acquisition process). These goals and requirements are contained in several key documents. The first to be generated is a mission need statement that describes a warfighting deficiency, or opportunity to provide new capabilities, in broad operational terms and identifies constraints such as crewing, personnel, and training that may affect satisfying the need. These capabilities and constraints are examined during the initial phase of the program in a second key document, a study called the analysis of alternatives. This study assesses the operational effectiveness and estimated costs of alternative systems to meet the mission need. The analysis assesses the pros and cons of each alternative and their sensitivity to possible changes in key assumptions. The analysis should consider personnel as both a life-cycle cost and a design driver. Systems engineering best practices dictate that the analysis of alternatives should be supported by a front-end analysis<sup>11</sup> and trade-off studies so that better and more informed decisions can be made. Using the results of the analysis of alternatives, program objectives are formalized in an operational requirements document. This third key document specifies those capabilities or characteristics (known as key performance parameters) that are so significant that failure to meet them can cause for the system to be canceled or restructured. In establishing key performance parameters, DOD officials specify both a threshold and an

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<sup>9</sup> Deputy Secretary of Defense Memorandum, *Defense Acquisition, Attachment 1, The Defense Acquisition System*, October 30, 2002, sec. 3.23.

<sup>10</sup> According to defense acquisition system policy, the program manager is assigned the single point of accountability for accomplishment of program objectives—a minimum number of cost, schedule, and performance parameters that describe the program over its life cycle. Progress toward meeting these objectives is assessed at milestone decision meetings and during interim senior management reviews.

<sup>11</sup> In Navy new ship acquisitions, the front-end analysis consists of a top-down requirements analysis supported by a variety of mission and functional analyses that together inform designers about the human requirements for the ship under study.

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objective value. For performance, the threshold is the minimum acceptable value that, in the user's judgment, is necessary to satisfy the need. For schedule and cost, the threshold is the maximum allowable value. The objective value is the value desired by the user and the value the program manager tries to work with the contractor(s) to obtain.

During our review, DOD was revising its acquisition guidance. On October 30, 2002, the Deputy Secretary of Defense canceled three key DOD documents governing the defense acquisition process and issued interim guidance in a memorandum. DOD officials expect to issue a new acquisition guidance in the near future.<sup>12</sup> The Deputy Secretary's interim guidance retains the basic acquisition system structure and milestones, emphasizes evolutionary acquisition, modifies the requirements documents, and makes several other changes. For example, the mission need statement and the operational requirements document are replaced by three new documents: (1) the initial capability document replaces the mission need statement at milestone A, (2) the capability development document replaces the operational requirements document at milestone B, and (3) the capability production document replaces the operational requirements document at milestone C. (See app. III for a discussion of the acquisition process and milestones.)

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## Human Systems Integration Has Potential to Optimize Ship Crew Size and Reduce Costs for New Systems

Human systems integration is a systems engineering approach to optimize the use of people. Optimized crewing for ships refers to the minimum crew size consistent with the ship's mission, affordability, risks, and human performance and safety requirements. When initiated from the outset of a new ship acquisition (during concept exploration and prior to establishing key performance parameters) and continued through ship design, human systems integration has the potential to reduce workload leading to smaller, optimized crews; reduced operating and support costs; and improved operational performance. According to human systems integration experts, for Navy ship acquisitions, human systems integration may begin with a top-down requirements analysis that examines the ship's functions and mission requirements and determines whether human or machine performance is required for each task. By reevaluating which functions humans should perform and which can be performed by

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<sup>12</sup> On May 12, 2003, DOD released a new version of DOD Directive 5000.1 and DOD Instruction 5000.2. A streamlined version of the nonmandatory *Guidebook* is under development. Because this guidance was issued following the completion of our audit work, the description of the acquisition process in this report is based on DOD's interim guidance issued on October 30, 2002.

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technology, human systems integration minimizes personnel requirements while maximizing gains from technological applications. A human systems integration approach also ensures that a person's workload and other concerns, such as personnel and training requirements, safety, and health hazards, are considered throughout the acquisition process. In a recent memorandum, the Assistant Secretary of the Navy for Manpower and Reserve Affairs stated, "failure to incorporate HSI [human systems integration] approaches can only lead to increasing manpower costs in the future that will threaten the ability of the Department to sustain the transformation, readiness and investment priorities we have established."

Human systems integration has been used successfully in military and commercial settings. MANPRINT, the Army's human systems integration program, reports that the Comanche helicopter program, when fielded, will avoid \$3.29 billion in operating and support costs (\$2.67 billion of which resulted from personnel reductions) due to the application of human systems integration. Human systems integration has also been used in airplane cockpit design, aircraft maintenance, and in rear-center automobile brake lights design. Additionally, foreign navies' efforts, such as those to develop British Type 23 and Dutch M-Class Frigates, achieved a 30 to 40 percent reduction in crew size relative to the previous generation of ships by employing a human systems integration approach.

DOD's acquisition policy for using human systems integration is general in nature but requires program managers to develop a human systems integration approach early in the acquisition process to minimize total ownership costs. The Navy's acquisition guidance requires that human systems integration costs and impacts be adequately considered along with other engineering and logistics elements beginning at program initiation, but the guidance does not provide for specific procedures and metrics.<sup>13</sup>

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<sup>13</sup> Secretary of the Navy Instruction 5000.2B, "Implementation of Mandatory Procedures for Major and Non-Major Defense Acquisition Programs and Major and Non-Major Information Technology Acquisition Programs," December 6, 1996.

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## Navy's Use of Human Systems Integration to Optimize Crew Size and Efforts to Establish Crew Size Goals Vary Considerably Across Ship Programs

Despite the potential of human systems integration to optimize crew size and reduce total ownership costs, the Navy's use of human systems integration and goals to reduce crew size varied considerably across the four new ship acquisition programs we examined. Only the DD(X) destroyer program used human systems integration extensively to optimize crewing during the concept and technology development phase of the acquisition. In doing so, the program developed a comprehensive plan that describes the human systems integration objectives, strategy, and scope and mandated its use by means of key program documents. The T-AKE cargo ship program was required to apply human systems integration principles to the ship's design, but not to the ship's primary mission of intership underway replenishment. In contrast, the JCC(X) command ship and LHA(R) amphibious assault ship programs had not emphasized human systems integration early in the acquisition process or developed a comprehensive human systems integration approach. The Navy's crew size reduction goals for the four ships range from an aggressive goal of about 60 to 70 percent on the DD(X) destroyer, to a lack of any formal reduction goal on the JCC(X) command ship and the LHA(R) amphibious assault ship. The inconsistent use of human systems integration to optimize ship crews and the lack of formal crew size reduction goals for three of the four programs we examined represent a missed opportunity to potentially achieve significant savings in total ownership costs.

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## DD(X) Program Has Aggressive Crew Size Reduction Goals and Uses Human Systems Integration Extensively

From the inception of the program through the selection of a design agent in 2002, the DD(X) program has had a significant crew size reduction goal and has used human systems integration to identify potential ways to achieve this goal. Requirements for using human systems integration and crew size goals were included in the key acquisition documents to which program managers are held accountable. The program began human systems integration activities in the first acquisition phase—concept and technology development—by inviting industry to develop conceptual designs to meet these goals and produce a human systems integration plan. Subsequently, the Navy restructured the program in November 2001 and is reevaluating the ship's operational requirements, including crew size. However, the Navy's contract with the design agent continues to specify a significant crew size reduction calling for a crew of between 125 and 175. These revised crew size requirements still represent a greater than 50 percent reduction when compared to the legacy ship it is replacing.

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From the earliest stages of the program and continuing through award of the design agent contract, the program maintained a focus on optimizing crew size. For example:

- The 1993 mission need statement directed “the ship must be automated to a sufficient degree to realize significant manpower reductions.” The document also required a human systems integration-type analysis,<sup>14</sup> to recommend options to exploit technology to reduce crewing, personnel, and training requirements and directed that trade-offs to reduce these requirements be favored during design and development.
- The 1998 cost and operational effectiveness analysis (currently known as the analysis of alternatives) included an analysis of the ship crew and personnel requirements for the various alternatives that ultimately influenced the Navy’s decision to initially establish an aggressive crew size goal of 95 and identify human systems integration requirements to be included in the operational requirements document. This goal represents a greater than 70 percent reduction in crew size from that of the *Arleigh Burke*-class destroyers developed in the 1980s.
- In 1997, the DD(X) operational requirements document specified a crew size goal of between 95 and 150 as a key performance parameter.<sup>15</sup> It also required that human systems integration be used to minimize life-cycle costs and maximize performance effectiveness, reliability, readiness, and safety of the ship and crew.
- In 1997, the program also established a ship crewing/human systems integration integrated process team whose charter requires a top-down functional analysis, the analytical centerpiece of the Navy’s human systems integration approach, in the early phases to obtain a major reduction in personnel.
- In 1998, the Under Secretary of Defense for Acquisition and Technology continued to hold DD(X) destroyer program managers accountable for achieving an aggressive crew size reduction when he required validation that the DD(X) crew size will meet the key performance parameter threshold before ship construction begins.

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<sup>14</sup> The *Surface Combatant for the 21st Century [DD(X)] Mission Need Statement* recommended performing a military crewing/hardware integration (“HARDMAN”) analysis in accordance with Office of the Chief of Naval Operations (OPNAV) Instruction 5311.7, “Determining Manpower, Personnel, and Training (MPT) Requirements for Navy Acquisitions,” August 12, 1985. HARDMAN is one type of human systems integration methodology.

<sup>15</sup> The document specified 95 as the objective value and 150 as the threshold value. These values represent a 60 to 70 percent reduction from the DDG-51 class crew level of 365.

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- The Phase 1 solicitation issued in 1998 for trade studies and analyses and development of two competitive system concept designs required that both contractors provide a human systems integration plan.
  - The design agent contract awarded in 2002 requires the contractor to develop and demonstrate a human systems integration engineering effort that addresses the crewing, personnel, training, human performance, sailor survivability, and quality of life aspects of the DD(X) design. It also relaxed the original crew size goal, stating that crewing requirements shall not exceed 175.

To achieve the proposed reductions, the DD(X) program plans to employ human-centered design and reasoning systems, advances in ship cleaning and preservation, a new maintenance strategy, and remote support from shore-based facilities for certain administrative and personnel services. For example, cleaning requirements are expected to be reduced by a ship design that capitalizes on commercial shipping practices such as cornerless spaces and maintenance-free deck coverings. The ship will also rely on an integrated bridge system that provides computer-based navigation, planning and monitoring, automated radar plotting, and automated ship control.

DD(X) program officials stated that their experience in using the human systems integration engineering approach, establishing an aggressive crew size reduction goal early in the acquisition process, and including this goal as a key performance parameter in the operational requirements document has been critical in maintaining a focus on reducing crew size. Moreover, these practices led to examining innovative approaches from the beginning and holding program managers accountable during program reviews. Program officials anticipate that the emphasis on reducing crew size will help to minimize DD(X) operating and support and total ownership costs once the ship is built and enters the fleet. For illustrative purposes, we calculated that the Navy could avoid personnel-related costs of about \$600 million per ship over a 35-year service life if it achieves a crew of 150 sailors rather than requiring the 365 sailors needed to operate its legacy ship, the *Arleigh Burke*-class destroyer. This could potentially save more than \$18 billion for a class of 32 ships (both amounts are in fiscal year 2002 dollars).<sup>16</sup> See appendix V for a comparison of crew functions and workload on the DDG 51 *Arleigh Burke*-class destroyer and those proposed for the DD(X).

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<sup>16</sup> Although the DD 21 destroyer program consisted of 32 ships, it is not yet clear how many DD(X)s will be purchased.

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DD(X) program officials also stated that, even with sustained early emphasis on crew size reduction and the use of human systems integration for crew optimization, achieving such an aggressive crew size goal remains a significant technological challenge as the program is relying on a number of immature labor-saving technologies, such as those required to conduct damage control and run the ship's computers. Program officials stated that informal goals or those established later in the acquisition process would not have been nearly as effective in getting the program to focus on achieving significant personnel reductions. However, in recognition of the technological challenge of achieving the crew size goal and several other technological challenges, the Navy restructured the DD(X) program in November 2001 to better manage the program's risk. As such, it adopted an acquisition strategy consisting of multiple capability increments, or "flights." The newly restructured program relaxed the crew size goals to between 125 and 175, which still represents a greater than 50 percent reduction below legacy ship levels, for the first of three planned DD(X) flights. While briefings prepared by Navy officials retain the original crew size goals for the third DD(X) flight, it is unclear whether these goals will be retained as key performance parameters in the operational requirements document currently under revision.

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**T-AKE Cargo Ship Program  
Used Human Systems  
Integration in Some  
Aspects of Ship Design,  
Expects Crew Size  
Reductions, but Did Not  
Establish Specific Crew  
Size Goals**

In developing the T-AKE cargo ship, which is in procurement and is expected to become operational in 2005, elements of human systems integration were used to streamline intraship cargo handling and to refine the requirements for civilian mariners and active-duty personnel. However, human systems integration was not applied to the process of intership underway replenishment, the transfer of cargo between ships while at sea.<sup>17</sup> Moreover, early acquisition documents for the T-AKE cargo ship program did not establish specific goals for reducing crew size, although they required the use of civilian mariners or Merchant Marines instead of active-duty Navy personnel and mandated the examination of cargo handling innovations to reduce crew workload. Use of Merchant Marines or Military Sealift Command personnel generally results in a smaller crew because these organizations employ more experienced seamen, have reduced watchstanding requirements, and use a different maintenance and training philosophy. The T-AKE will be operated by the

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<sup>17</sup> Underway replenishment may be accomplished via connected replenishment (in which the receiving and cargo ships are alongside and connected to each other by hoses/cables) or via vertical replenishment (in which a helicopter transfers solid cargo from ship to ship).

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Military Sealift Command, and its projected crew will be between 5 and 20 percent smaller than the crew of the command's legacy ships and about 60 percent smaller than the legacy ships previously operated exclusively with Navy sailors.<sup>18</sup>

The following examples illustrate the strengths and limitations of the program's use of human systems integration early in the acquisition process.

- The 1992 mission need statement lacked a direct reference to human systems integration, although it does indicate that the ship's size will be the result of various trade-offs, including cost and crew size, and required that the ship's design incorporate modern propulsion, auxiliary, and cargo handling systems to minimize operating and maintenance personnel requirements.
- The 2001 operational requirements document stated that "human engineering principles and design standards shall be applied to the design of all compartments, spaces, systems, individual equipment, workstations and facilities in which there is a human interface." However, this document also required the T-AKE cargo ship to use U.S. Navy standard underway replenishment equipment because of the need to interface with other U.S. Navy and allied ships, the lack of any equivalent commercial system, and the costs to redesign existing Navy equipment and maintain nonstandard equipment. As a result, human systems integration was not applied to one of the main drivers of crew size—the number of crewmembers required to perform connected replenishment at each replenishment station.

Program officials indicated that, because intership underway replenishment involves the interface between the T-AKE cargo ship and all other ship classes requiring replenishment at sea, redesign of the Navy's process of underway replenishment was not within their purview and, therefore, was not addressed in the program's human systems integration analyses. Instead, the program's focus was to ensure that the T-AKE cargo ship's design met the current requirements for performing underway replenishment and had the flexibility for future equipment modification. To address underway replenishment across ship platforms, in 2000 the Navy established a naval operational logistics integrated product team

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<sup>18</sup> The Navy's Military Sealift Command is one of three components of the U.S. Transportation Command, the DOD command that manages the defense transportation system.

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whose mission is to establish policy and doctrine for future operational systems and ensure the integration of operational logistics systems across ships.

Since reexamining intership underway replenishment was beyond the scope of the ship program, program personnel said they focused on identifying ways to reduce crew workload. In the first acquisition phase, four contractors<sup>19</sup> prepared trade studies on the integration of cargo handling functions on the ship.<sup>20</sup> In the second acquisition phase, one of the contractors, National Steel and Shipbuilding Company, was awarded the contract to design and construct the ship. Ultimately, labor-saving innovations such as item scanners; an automated, rather than paper-based, warehouse management inventory system; and safer and easier to operate elevator doors were adopted.<sup>21</sup>

Although the T-AKE cargo ship is expected to require fewer personnel than its legacy ships, early acquisition documents did not establish a specific crew size goal as a key performance parameter and thus did not hold the program manager accountable for specific reductions. Rather, the operational requirements document required that the T-AKE be crewed largely by U.S. Merchant Marines or Military Sealift Command civilian mariners. The Navy currently estimates that the T-AKE will be crewed by 172 individuals: 123 civilian mariners, 13 active-duty sailors in the military department who perform cargo management/inventory functions, and 36 active-duty sailors in the aviation detachment who perform intership cargo transfer using a helicopter (vertical replenishment).

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<sup>19</sup> The following four contractors were each awarded \$1.5 million to complete Phase I Ship/Cargo Integration Design studies: Avondale Industries (now Northrop Grumman Ship Systems Avondale Operations); Halter Marine, Inc. (now Friede Goldman Halter); Litton Ingalls Shipbuilding (now Northrop Grumman Ingalls Shipbuilding); and National Steel and Shipbuilding Company. Phase I concluded on May 5, 2000, and on October 18, 2001, the Navy announced it had awarded National Steel and Shipbuilding Company the Phase II Detail Design and Construction contract.

<sup>20</sup> The studies addressed one or more of five topic areas: (1) warehouse management system/automation; (2) material handling equipment/cargo handling systems/cargo elevators; (3) cargo flow studies/modeling and simulation; (4) general arrangements/cargo hold and transfer deck design; and (5) cargo heating, ventilation, air conditioning, and refrigeration.

<sup>21</sup> T-AKE officials also provided us with the titles of 16 studies involving safety, human engineering, manpower, personnel, training, and habitability domains of human systems integration that were included in the shipbuilding contract.

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The T-AKE cargo ship's projected crew size of 172 personnel will be somewhat smaller than that of its Military Sealift Command legacy ships, the T-AE 26 *Kilauea*-class ammunition ships and the T-AFS 1/8 *Mars*-class and *Sirius*-class combat stores ships, which have crews of 182-215 personnel and also use civilian mariners. The T-AKE's crew size is significantly smaller than when these legacy ships were crewed by active-duty personnel. When crewed entirely by active Navy personnel, these ships had crews of 435 and 508 sailors, respectively. Despite the smaller crew size, the T-AKE will have a greater carrying capacity for dry and refrigerated cargo than its legacy ships. Each T-AKE ship will be able to carry at least 63 percent of the combined cargo capacity of a T-AFS 1 and T-AE 26.

Although the ship program did not perform the top-down analyses recommended by human system integration experts to optimize crewing, it did use elements of the approach to finalize staffing requirements. To finalize the requirement for civilian mariners, program personnel performed a functional analysis (which identified ship functions and their crew size requirements) and ultimately determined that the initial crew size estimate developed by the Navy could be reduced by 12, resulting in a final requirement for 123 civilian mariners. The size of the military department is based on an analysis that projects workload and personnel requirements for every ship function during the most labor-intensive operational scenarios and then allocates the workload and personnel requirements to the minimum number of billets and skill levels.

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### JCC(X) Command Ship Program Made Limited Use of Human Systems Integration and Had No Formal Goals to Reduce Crew Size

The recently canceled JCC(X) command ship program made very limited use of human systems integration to optimize crew size and planned to wait until preliminary design in the next acquisition phase to begin human systems integration activities. The program also did not hold program managers accountable for reducing crew size below that of the legacy command ships. The following are examples.

- The mission need statement did not require the use of human systems integration. Instead, the document required that the ship “be automated wherever practical to reduce workload and manpower requirements” and directed that operation by Military Sealift Command personnel be considered for selected functions rather than Navy personnel. However, the document stated that “changes to manpower requirements are not expected.”
- The analysis of alternatives examined crew sizes ranging from 60 percent smaller to 50 percent larger than those of current command ships and

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using civilian mariners to perform JCC(X) crew functions to reduce crew size. The analysis found that using a mix of military and civilian personnel rather than all military personnel would reduce personnel costs by nearly a third, saving \$2.3 billion for four ships over a 40-year service life. However, the analysis did not include a full human systems integration assessment of each design alternative.

- At the time of its cancellation, the program had not received approval of its operational requirements document, which would have established key performance parameters.

Program officials stated that although achieving crew size reduction was not included in key program documents, they expected to achieve some crew size reductions on the JCC(X) when compared to existing command ships through the use of modern, more reliable equipment, for example, diesel propulsion instead of steam propulsion.<sup>22</sup> Yet, despite the program's informal interest in reducing the size of the crew needed to operate the ship, the analysis of alternatives did not examine optimizing via human systems integration one of the main drivers of crew size—the size of the embarked command staff. The total crew size of the JCC(X) equals the sum of the embarked joint command staff and the crew needed to operate the ship and perform basic ship functions. Navy analyses show that the crew size needed to operate the ship depends upon the joint command staff size and the mission equipment that is to be maintained by the crew. Yet, all of the Navy analyses examined joint command staff alternatives, ranging from 500 to 1,500 staff, which were larger than the fleet commander's staff of 285 to 449 currently embarked on existing command ships. None of the analyses used human systems integration to determine the optimal size of the joint command staff.

The program did fund three crewing studies as part of its early industry involvement effort that included ship crewing, workload, and functional analyses. However, these analyses were performed only on the command ship's crew and not on the embarked joint staff. These crewing studies, prepared by contractors for the JCC(X) command ship program in June 2002, also reiterated the importance of beginning human systems integration efforts at the earliest opportunity in the ship acquisition process and called into question the adequacy of the human systems

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<sup>22</sup> To achieve these reductions, the Navy would have to adopt the latest fleet work practices and automation, eliminate functions not relevant to the JCC(X), reduce engineering watchstanders, and use a centralized galley and Military Sealift Command-like food service.

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integration efforts to date. For example, a study by one contractor stated that

“The HSI [human systems integration] team was not part of a larger JCC(X) System Engineering effort, as would be expected in a full-up proposal or system development activity. The HSI [human systems integration] team also did not have contact with potential JCC(X) users or with Navy/Joint HSI [human systems integration] Team members, as would be expected and desired in a normal system acquisition environment. This was due to the unique nature of a very limited scope manning study with very limited funds.”

The study also urged the program to adopt a human systems integration approach stating that “a human-centered design approach, implemented at the front-end and as part of an integrated system engineering process, will yield an optimal crew size.” The study also stated that the same human systems integration tools could be effectively used to optimize the size for the embarked command staff.

JCC(X) command ship program officials stated that the program planned to employ human systems integration to optimize crew size in the next acquisition phase by contracting with industry to perform a functional analysis. However, according to Navy officials, the program was canceled before these efforts began, in part because of the unacceptably high crew size estimated for the program.

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### **LHA(R) Amphibious Assault Ship Made Limited Use of Human Systems Integration and Had No Formal Goals to Reduce Crew Size**

The LHA(R) program has not yet developed a comprehensive human systems integration strategy to outline the program’s human systems integration objectives and guide its efforts. In addition, officials told us that very little human systems integration work was done early in the acquisition process because officials plan to begin human systems integration activities during preliminary design in the next acquisition phase, called system development and demonstration. Also, early acquisition documents for the LHA(R) amphibious assault ship program did not establish formal goals to reduce the number of personnel required to operate the ship. The following are examples.

- The mission need statement required the use of human systems integration to optimize manning. However, it also stated that no changes to Navy personnel requirements were expected. Currently, the program plans only to not exceed the crew size of the older ships that perform similar missions. These legacy LHA 1 class ships have a crew of about 1,230 to operate the ship and can embark about 1,700 Marines.

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- The analysis of alternatives stated that in order for the LHA(R) to achieve major reductions in personnel, significant new technology and research and development funds to integrate this technology into the LHA(R) design would be required as well as changes in culture (organization and procedures) to adapt reduced crew size practices of the commercial sector to the naval environment.
  - At the time of our review, the operational requirements document for the LHA(R) had not been developed.

The Navy's plans for the LHA(R) are not in concert with the Chief of Naval Operations' desire for major reductions in the personnel levels for all new shipbuilding programs. In August 2002, the Chief of Naval Operations commented on the size of the LHA-1 (the legacy ship that the LHA(R) is replacing) saying, "I don't want any more ships like that. The more low technology systems that are on it, the more people we will need. And we will need more crewmembers for support services. It [the LHA-1's replacement] will be built from the keel up to support the type of striking capability that you need in your aviation arm. It is going to be a totally different ship."<sup>23</sup>

Program officials offered two major reasons for not conducting human systems integration early in the acquisition process: (1) they believed it was not appropriate to start human systems integration during the very early phases of the acquisition program (i.e., in concept and technology development) and (2) the program lacked funding to conduct human systems integration activities in the first acquisition phase. Program officials plan to conduct human systems integration efforts during the system development and demonstration acquisition phase when the program begins preliminary design efforts. Some of these efforts, scheduled to begin in February 2003, are to include a top-down requirements analysis and a total ship manpower assessment.

In contrast to the opinions of LHA(R) program officials, the Navy's human systems integration experts stated that human systems integration is a critical part of planning and design in the early stages of acquisition, including the concept and technology development phase. In addition, experience with the DD(X) program shows that the potential personnel-related cost savings resulting from the application of human systems

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<sup>23</sup> Kauchak, Marty, "Navigating Changing Seas, Navy Chief Harbors No Illusions About the Challenges That Lie Ahead," *Armed Forces Journal International*, August 2002.

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integration early on in a program can be significant. Moreover, experts stated that every program, regardless of its funding levels or its reliance on legacy systems, can benefit from a comprehensive human systems integration approach, especially those developing crew-intensive platforms such as the LHA(R).

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## Several Factors Contribute to the Inconsistent Application of Human Systems Integration and May Impede the Navy's Ability to Optimize Crew Size

The program managers and the human systems integration experts we spoke to identified four factors that inhibit the Navy's ability to consistently implement human systems integration across programs. These factors are (1) neither DOD nor Navy acquisition policies establish specific requirements for using human systems integration, such as its timing and whether the approach should be addressed in the key acquisition documents; (2) funding challenges often result in decisions to defer human systems integration activities and use legacy subsystems when acquiring new ships to save near-term costs instead of investing in research and development to reduce costs over the long term; (3) DOD and Navy oversight of human systems integration activities is limited and the Naval Sea Systems Command's role in certifying that ships delivered to the fleet have optimum crew sizes is unclear; and (4) the Navy lacks an effective process to change its long-standing culture and the extensive network of policies and procedures that have institutionalized current manning practices. As a result, some programs we examined set goals not to exceed the crew size of 30-year old ships, waited until preliminary design in the second acquisition phase to begin human systems integration efforts, and excluded primary and secondary ship functions from a rigorous analysis. In recognition of these impediments, the Navy has taken steps to resolve some of these issues.

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## Lack of Specific Navy Requirements to Use Human Systems Integration Results in Inconsistent Implementation Across Programs

Recent DOD and Navy acquisition guidance provides program managers with latitude about the timing and extent of human systems integration activities and whether the approach should be addressed in key acquisition documents. DOD guidance on the role of human systems integration in acquisition is contained in two documents, the *Defense Acquisition* memorandum and the *Interim Defense Acquisition Guidebook*, issued by the Deputy Secretary of Defense, both dated October 30, 2002. Compliance with the *Defense Acquisition* memorandum is mandatory; compliance with the *Interim Defense Acquisition Guidebook* is discretionary. Both documents state that program managers will develop a human systems integration strategy early in the acquisition process to minimize total ownership cost. Neither document, however, specifies how early in the process these efforts should begin or requires

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that human systems integration analyses be performed on the various alternatives considered in the formal analysis of alternatives.

The Navy's main acquisition instruction requires that human systems integration costs and impacts be adequately considered along with other engineering and logistics elements beginning at program initiation but does not provide for specific procedures.<sup>24</sup> The Navy's section of the acquisition deskbook<sup>25</sup> provides more detailed guidance on human systems integration (such as providing a format for the human systems integration plan and discussing the contents of a human systems integration program). However, because these sources provide only broad guidelines or are discretionary, a program manager can decide when, how, and to what extent they will use human systems integration in their acquisition program.

The Navy also has developed other guidance on using human systems integration, but its use is also discretionary. For example, human systems integration experts developed a guide for the Office of the Chief Naval Operations, which states that a human systems integration assessment and trade-off of design alternatives should be conducted during the first acquisition phase. *The Surface Warfare Program Manager's Guide to Human Systems Integration* also states that human systems integration cost, schedule, and design risk areas for each alternative concept should be identified and evaluated. The guidance also recommends that human systems integration assessments should be conducted at each milestone decision review.

Because of the wording of DOD guidance and the discretionary nature of some Navy guidance, new ship program managers vary in when they use human systems integration during ship development. For example, the DD(X) program specified using the approach in the mission need statement and the analysis of alternatives further specified human systems integration requirements be included in the operational requirements document. In contrast, the program managers for both the JCC(X)

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<sup>24</sup> Secretary of the Navy Instruction 5000.2B, "Implementation of Mandatory Procedures for Major and Non-Major Defense Acquisition Programs and Major and Non-Major Information Technology Acquisition Programs," December 6, 1996.

<sup>25</sup> "Department of the Navy (DON) Section (Discretionary) of Defense Acquisition Deskbook (Reference Library), Appendix XI-Acquisition Program Plans Formats, February 12, 1997 (the "Acquisition Deskbook" is now called the "Acquisition Knowledge Sharing System").

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command ship and the LHA(R) amphibious assault ship told us that they planned to begin their human systems integration efforts during preliminary design after the design alternative has been selected in the next acquisition phase—system development and demonstration. Neither program conducted human systems integration analyses of the alternative designs during the analysis of alternatives. As such, program officials lacked information on how each of the alternatives compared with respect to their proposed crew size and how their crew size would affect total ownership costs.

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### Challenges in Funding Acquisition Programs Discourage Investment in Labor-Saving Technology

Both JCC(X) and LHA(R) program officials cited challenges in funding a new acquisition program as a barrier to using human systems integration to optimize crew size and therefore reduce total ownership cost. These challenges affect whether programs conduct crew-optimizing human systems integration activities in the earliest phases of acquisition and whether the program will choose to invest in labor-saving technologies.

JCC(X) program officials told us that achieving personnel reductions and using human systems integration to optimize crew size could increase acquisition costs. The Navy's human systems integration experts stated that program managers have long been incentivized to hold down acquisition costs without considering how such choices may affect operating and support costs, such as personnel-related costs, over the life of the ship. According to the Navy's human systems integration experts, labor-saving technology may add to the acquisition cost of a ship but may also reduce the operating and support costs incurred over the ship's service life. Whether to use technology or sailors to perform a function should be determined by a systematic analysis of costs and capabilities performed as part of the human systems integration functional analysis—an effort not undertaken by the JCC(X) command ship program.

Similarly, at the time the LHA(R) program was initiated in 2001, the Navy decided not to invest in human systems integration activities and research and development on new labor-saving technologies for the ship. The program plans to capitalize, where appropriate, on systems already in development for other ships such as the DD(X) destroyer and the CVN(X) aircraft carrier but has not yet identified any labor-saving technologies or processes that might be adapted from these programs. Program officials said the program was not resourced to develop new technologies, having received only \$20 million in research and development funds from program initiation through fiscal year 2002. However, the up-front savings of not investing in research and development and human systems

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integration activities must be weighed against the higher operating and support costs incurred over the life of the ship and the foregone capability and quality of life improvements that can accompany new technology and human-centered design. For illustrative purposes, we calculated that a nominal 25 percent reduction in a 1,245-person crew could provide a personnel cost avoidance of nearly \$1 billion over the service life of a ship, or nearly \$4 billion for a 4-ship class.<sup>26</sup> In addition, DD(X) destroyer program officials were uncertain about the extent to which programs now in development outside the DD(X) destroyer family of ships will be able to leverage its new technology, citing the costs associated with adapting technology to new platforms that perform different missions. Rather, DD(X) program officials told us that it is imperative for the new ship programs to use human systems integration to inform such decisions.

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### DOD and Navy Offices Have Limited or Unclear Authority to Require Human Systems Integration Activities for Ship Programs

Several offices within DOD and the Navy have an advisory role regarding the implementation of human systems integration, although they lack the authority to require that it be used to optimize crew size and that it be addressed in specific acquisition documents or at each acquisition milestone. The Offices of the Secretary of Defense, Personnel and Readiness, and the Chief of Naval Operations (Acquisition Division) Acquisition and Human Systems Integration Requirements Branch both review new program acquisition documents and provide guidance on human systems integration policy.<sup>27</sup> Additionally, the Office of the Secretary of Defense, Personnel and Readiness, assists in the development of human systems integration policy and addresses policy issues at meetings of defense acquisition executives. The Office of the Assistant Secretary of the Navy (Research, Development, and Acquisition) Chief Engineer, uses human systems integration in its “system of systems” examination of capability above the individual ship level to ensure that systems can function together across various ships to perform the mission.<sup>28</sup>

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<sup>26</sup> Fiscal year 2002 dollars.

<sup>27</sup> The Chief of Naval Operations (Acquisition Division) Acquisition and Human Systems Integration Requirements Branch also encourages manning reductions of up to 20 percent, if possible, for new acquisition programs. It has, however, no authority to require such reductions.

<sup>28</sup> This approach embodies the overarching system requirements for a broad mission need, such as surveillance or missile defense.

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In recognition of the need for an organization within the ship community to “lead the effort to institutionalize humans systems integration...,” the Navy, in October 2002, created the Human Systems Integration Directorate within the Naval Sea Systems Command whose missions include

- establishing human systems integration policy and standards for the Naval Sea Systems Command;
- ensuring the implementation of human systems integration policy, procedures, and best practices;
- assisting program offices in developing and sustaining human systems integration plans; and
- certifying that ships and systems delivered to the fleet optimize ship crewing, personnel, and training and promote personnel safety, survivability, and quality service.<sup>29</sup>

Because of its role as the certifying authority for human systems integration within the Naval Sea Systems Command, the directorate may have more authority than the previously mentioned organizations to ensure that human systems integration is implemented. However, the memorandum establishing the directorate and the instruction specifying its functions do not specify how certification will be accomplished, the acquisition stage at which it will be required, or consequences of noncompliance.

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## Navy Policies and Culture May Impede Introduction of Labor-Saving Technologies and Approaches

Navy acquisition officials also identified the layers of Navy policies, procedures, and instructions that affect ship crew levels and cultural resistance to novel concepts as impediments to optimizing ship crews. They told us that even when human systems integration is used in the early stages of an acquisition program to identify ways to reduce crew size, it is difficult to achieve a consensus among numerous stakeholders within the Navy to change long-standing policies and practices so that labor-saving approaches or technologies can be implemented. To facilitate this process, the DD(X) destroyer program established a forum to evaluate policy barriers to proposed innovations and facilitate needed changes. However, this effort was limited to selected ships. Other programs such as the LHA(R) amphibious assault ship and the JCC(X) command ship had not established a similar forum to resolve the policy barriers to optimize

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<sup>29</sup> Naval Sea Systems Command Notice 5400, “Establishment of the Human Systems Integration (HSI) Directorate (SEA 03),” October 15, 2002.

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## Policy and Cultural Impediments

crewing on these ships. As a result, the Navy currently lacks an ongoing process to facilitate examination of outmoded policies and procedures that may impede optimizing crewing in all new ship acquisition programs.

Navy officials explained that changing policies and procedures is a complex and time-consuming task because the current way of doing business has been incorporated in instructions at all levels in the Navy, ranging from the Secretary of the Navy to commanders of the Atlantic and Pacific Fleets, and across a number of areas, such as recruiting, retention, training, quality of life, and the environment. In addition, new ways of doing business, such as those envisioned for the DD(X) destroyer, will affect and require modifications to Navy doctrine, tactics, and operational requirements. Furthermore, proposed changes must be evaluated for compliance with governing statutes in such areas as compensation, occupational safety and health, and aviation. As such, any change involves numerous stakeholders who must be consulted and grant approval. For example, DD(X) officials told us that it took about 18 months to coordinate with numerous stakeholders to change applicable policies to reduce the number of crewmembers required during flight operations from 48 to 15. Moreover, officials told us that this change is just the beginning since the DD(X) destroyer program has identified numerous Navy policies and procedures across a wide spectrum of topics that need to be changed in order to adopt the innovations proposed by industry to meet the DD(X)'s cost and capability requirements.

Officials with the other programs we examined also viewed Navy policies as a barrier to optimized crewing. JCC(X) command ship program officials reported that current Navy policy and practice would have been a barrier to implementing potential crew size reductions had this program gone forward. Two examples cited by program officials are bridge watchstanding and main propulsion machinery monitoring. At present, Navy practice for bridge watch requires approximately 11 personnel in contrast to commercial practice, which requires 1 person on watch and 1 on stand by. Similarly, Navy practice for machinery monitoring requires personnel in the machinery space at all times to ensure that power is available. This contrasts with commercial practice, which permits putting machinery on automatic and using sensors with alarms routed to a watchstanders' stateroom during certain hours. Officials stated that implementing these commercial practices would have required evaluating their appropriateness for a Navy operating environment and, if approved, would have required modifying existing policies and procedures. Furthermore, the LHA(R) analysis of alternatives concluded that significant changes in organization and procedures are crucial to achieving

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## Navy Lacks a Process to Systematically Address Impediments to Innovation in All New Ship Programs

a substantial reduction in crew size. Cultural change is a particular challenge for the LHA(R) program because the amphibious mission is complex and both Navy and Marine organizations would be involved in developing and implementing changes.

Navy officials stated that current funding practices in which personnel costs are funded from centralized accounts and not out of the operating fleets' budget do not foster an awareness of the true cost of having sailors on board ships and encourage viewing sailors as a "free resource." Additionally, because traditional, time-tested methods and crewing have proven successful in the past, officials told us that Navy commanders have little incentive to assume the risks associated with adopting new ways of accomplishing shipboard tasks with fewer crewmembers, especially when they lack awareness of and accountability for personnel costs.

Because of the magnitude of changes needed to reduce and optimize crewing on the DD(X) destroyer, the program established an effort to identify and resolve policy barriers to implementing labor-saving approaches that conflict with current policy, statutes, or practice. This effort includes (1) reaching out to Navywide personnel development and training organizations and to Atlantic and Pacific Fleet commanders and (2) establishing the DD(X) Policy Clearinghouse Web-based tool to facilitate collaboration with multiple stakeholders and resolve policy impediments to implementing innovations planned for the DD(X) destroyer. The DD(X) clearinghouse was recently transferred to the Naval Sea Systems Command's Human Systems Integration Directorate. However, there are currently no requirements for this forum to address the policy barriers to optimizing crewing encountered in all new ship acquisitions.

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## Conclusions

Given the Navy's recapitalization challenges, efforts to control personnel costs and minimize total ownership costs are becoming increasingly important. Applying human systems integration principles to optimize crew size has the potential to result in a host of cost and operational benefits, including saving billions of dollars by reducing total ownership costs and increasing operational performance and ship maintainability. The experience to date in the DD(X) destroyer program shows that requiring human systems integration from the earliest stages of a program (during concept and technology development) and using the results to establish a crew size reduction goal as a key performance parameter are effective strategies to holding program managers accountable during program reviews for making significant progress toward reducing crew

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size. The DD(X) experience also shows that even when these practices are followed, the program will still face challenges to achieving these goals and encounter pressures to relax the goals as the system design progresses, thereby supporting human systems integration experts' view that human systems integration plans and activities should receive continued review and focus throughout the acquisition process. In contrast, programs such as the JCC(X) and LHA (R) that do not use human systems integration early and do not hold program managers accountable during program reviews for crew size reduction are less likely to achieve the meaningful reduction in crew size. Unless the Navy more consistently applies human systems integration early in the acquisition process and establishes meaningful goals for crew size reduction, the Navy may miss opportunities to lower total ownership costs for new ships, which are determined by decisions made early in the acquisition process.

The Navy's varied approach to applying human systems integration has occurred partly because Navy guidance allows program managers considerable discretion in determining the extent to which they apply human systems integration principles in developing new systems. In the absence of clear requirements that human systems integration programs will be a key feature of all future acquisition programs, efforts to optimize crew size will continue to vary due to the competing pressures placed on program managers, and the Navy is likely to continue to miss opportunities to reduce personnel requirements for future ships. As a result, the Navy's funding challenges may be exacerbated, and it may not be able to build or support the number of ships it believes are necessary to support the new defense strategy. Although the Navy's recent efforts to establish a focal point for human systems integration policy within the Naval Sea Systems Command is a positive step, the success of this office will depend on its authority to influence acquisition programs in their initial stages. Because the instruction establishing this office does not clearly explain the process this office will use to certify that ships delivered to the fleet will have optimized crews, there is a risk that the office may not have sufficient leverage to influence new programs in their early stages and that this may result in missed opportunities to reduce crew size and achieve long-term cost savings.

Even when the Navy uses a disciplined human systems integration process early in an acquisition program to identify ways to optimize crew size, implementation of new technologies and procedures is often hindered by the Navy's culture and traditions, which are institutionalized in a wide array of policies and procedures affecting personnel levels, maintenance requirements, and training. In recognition of these barriers, the DD(X)

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program and the operational logistics community have established processes to address these barriers for their particular ship or community. However, not all new ship acquisition programs have developed or have access to such a forum to facilitate removing barriers to optimized manning to ensure that costly outdated policies and procedures are systematically reexamined as new innovations are developed.

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## Recommendations for Executive Action

To ensure that the nation's multibillion-dollar investment in Navy ships maximizes military capability and sailor performance at the lowest feasible total ownership cost, we recommend that the Secretary of the Navy develop and implement mandatory policies on human systems integration requirements, standards, and milestones. Specifically, for each new system the Navy plans to acquire, the Secretary of the Navy should require that

- a human systems integration assessment be performed as concepts for the system are developed and alternative concepts are evaluated;
- human systems integration analyses, including trade-off studies of design alternatives, be used to establish an optimized crew size goal that will become a key performance parameter in the program's requirements document; and
- human systems integration assessments be updated prior to all subsequent milestones.

To strengthen the Naval Sea Systems Command's role in promoting the use of human systems integration for new ship systems, we recommend that the Secretary of the Navy require the command to clarify the Human Systems Integration Directorate's role in and process for certifying that ships and systems delivered to the fleet optimize ship crewing.

To facilitate the review of possibly outdated policies and procedures as new labor-saving innovations are identified through human systems integration efforts, we recommend that the Secretary of the Navy require that the Naval Sea Systems Command's Human Systems Integration Directorate establish a process to evaluate or revise existing policies and procedures that may impede innovation in all new ship acquisitions.

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## Agency Comments and Our Evaluation

In commenting on a draft of this report, DOD agreed with our recommendations and indicated that actions were underway or planned to implement them. DOD stated that actions taken in response to our recommendations would only enhance ongoing human systems integration initiatives; ensure more consistent application of human systems integration processes across all ship acquisition programs; and lead to optimized ship crews, increased system performance, and reduced life-cycle costs. The Navy intends to implement our recommendation that it require ship programs to use human systems integration to establish crew size goals and help achieve them, in part, by developing a new program called SEAPRINT (Systems Engineering, Acquisition and PeRsonnel INTeGration), modeled after the Army's MANPRINT program that we cite in our report. The Navy's SEAPRINT program will develop Navywide policy that identifies, mandates, and establishes accountability for human systems integration analyses. This policy will mandate that human systems integration is to be addressed in

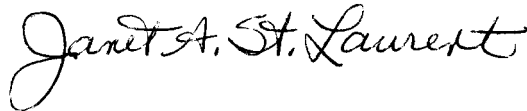
- a specific plan before the acquisition's earliest milestone,
- the initial capabilities document (formerly called the mission needs statement),
- the capabilities development document (formerly called the operational requirements document), and
- assessments performed as part of concept exploration and development and updated prior to all subsequent milestones.

DOD also stated that it endorses a manpower-related key performance parameter for all new ship acquisition programs. In response to our recommendation that the Navy clearly define human systems integration certification standards for new ships, DOD stated that the Navy is developing technical human systems integration criteria and metrics that will be used for measuring and certifying that ships and ship systems meet human systems integration standards. With regard to our recommendation that the Navy formally establish a process to examine and facilitate the adoption of labor-saving technologies and best practices across Navy systems, DOD stated that the Navy has established a new human systems integration clearinghouse, implemented a pilot study using the clearinghouse, and involved stakeholders from across the Navy. DOD also provided technical comments, which we incorporated where appropriate. DOD's comments are included in appendix VI of this report.

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We are sending copies of this report to interested congressional committees; the Secretary of Defense; the Secretary of the Navy; and the Director, Office of Management and Budget. We will make copies available to others upon request. In addition, the report will be available at no charge on the GAO Web site at <http://www.gao.gov>.

If you or your staff have any questions about this report, please call me at (202) 512-4402 or e-mail me at [stlaurentj@gao.gov](mailto:stlaurentj@gao.gov). Key staff members that contributed to this report were Roderick Rodgers, Jacquelyn Randolph, Suzanne Wren, Mary Jo LaCasse, Charles Perdue, and Jane Hunt.

A handwritten signature in black ink that reads "Janet A. St. Laurent". The signature is written in a cursive, flowing style.

Janet A. St. Laurent  
Acting Director, Defense Capabilities  
and Management

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# Appendix I: Scope and Methodology

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To assess the Navy's use of human systems integration principles to optimize crews and goals to reduce crew size on the four new ship programs we were asked to review, we obtained and analyzed key acquisition documents such as mission need statements, analyses of alternatives, and operational requirements documents as well as human systems integration plans and analyses. We also interviewed Naval Sea Systems Command and Military Sealift Command officials who are responsible for the DD(X), T-AKE, JCC(X), and LHA(R) programs to discuss the use of human systems integration and crew size goals. We obtained current ship crewing documents from the Navy's Manpower Analysis Center and the Military Sealift Command and compared the crew size goals for the four ship programs we reviewed to the crew size levels for older ships that perform similar missions. We also obtained data from the Naval Sea Systems Command on the *Arleigh Burke*-class destroyer program on crew sizing and workload to compare with the contractor's crew size estimate for the DD(X). To understand the extent to which the T-AKE's primary mission of underway replenishment affects crew size, we interviewed (1) experts from the Underway Replenishment Department at the Naval Surface Warfare Center (Port Hueneme Division) and the National Steel and Shipbuilding Company (which designed and will build the T-AKE) and (2) a subject matter expert on Navy underway replenishment. To gain an understanding of operational logistics and cargo storage and warehousing, we interviewed officials from the Chief of Naval Operations (Strategic Mobility/Combat Logistics) and St. Onge Company (a subcontractor for the T-AKE ship program) and visited the Defense Distribution Depot Susquehanna, Pennsylvania, one of the Department of Defense's (DOD) largest and most automated distribution centers. To obtain information on the Navy's methods of calculating total ownership costs, we interviewed officials from the Naval Center for Cost Analysis and the Center for Naval Analyses. To calculate the ship crewing cost avoidance potential for the DD(X) and LHA(R) programs, we used data from the Navy's *Cost of a Sailor* study for capturing comprehensive personnel costs and converted the data to fiscal year 2002 dollars.

To evaluate factors that may impede the Navy's use of human systems integration principles, we obtained and analyzed DOD, Joint Staff, and Navy systems acquisition directives, instructions, and guidance (e.g., the internet-based Defense Acquisition Deskbook and the Program

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Management Community of Practice).<sup>1</sup> We reviewed the interim defense acquisition guidance as it pertains to the acquisition process, human systems integration, and total ownership cost. We did not assess the ship programs' compliance with the several prior versions of DOD and Navy acquisition guidance, but we did evaluate the extent to which human systems integration was applied and whether crew size goals were established. We also obtained and reviewed numerous articles on military and civilian applications of human systems integration. To obtain information on the formulation and oversight of human systems integration policy and guidance, we met with officials from the offices of the Secretary of Defense; the Assistant Secretary of the Navy for Research Development and Acquisition; the Assistant Secretary of the Navy, Chief Engineer; and the Chief of Naval Operations (Acquisition and Human Systems Integration Requirements Branch). To obtain additional information on the benefits of human systems integration and best practices, we interviewed subject matter experts with the Naval Sea Systems Command's Human Systems Integration Directorate, the DD(X) Program Office, the Army's Office of the Deputy Chief of Staff for Personnel, Manpower and Personnel Integration (MANPRINT) Directorate, Carlow International Incorporated, and the Office of Naval Research's Human Systems Science and Technology Department, and we attended the American Society of Naval Engineers Conference on Human Systems Integration. To gain insight on labor-saving technologies and changes to policies and procedures required to implement these innovations, we met with officials from the Naval Sea Systems Command's SMARTSHIP Program Office; met with officials and toured the Office of Naval Research's Afloat Lab in Annapolis, Maryland; and met with officials responsible for the DD(X) Policy Clearinghouse and the Naval Sea Systems Command's Human Systems Integration Directorate. We discussed the funding for human systems integration with the Naval Sea Systems program managers for the four ship programs we reviewed.

We conducted our review from June 2002 through April 2003 in accordance with generally accepted government auditing standards.

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<sup>1</sup> The program management communities of practice include acquisition, systems engineering, total ownership costs, and many other related disciplines. The communities may be accessed at <http://www.pmcop.dau.mil/>.

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# Appendix II: Ships Included in Our Evaluation

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## DD(X) Destroyer

In 1995, the Navy established the 21st Century Surface Combatant program to develop the next generation of surface combatants that would replace retiring destroyers and frigates on a timely basis. In November 2001, the Navy restructured this program from one intended to develop a single ship class of 32 ships into its current form known as the DD(X). The new program aims to develop and acquire three new classes of surface combatants to include the DD(X) as the centerpiece, a cruiser called CG(X), and a smaller littoral combat ship.

The first DD(X) destroyer is to be procured in fiscal year 2005 and enter service in fiscal year 2011. The initial DD(X) is viewed as a “test bed” for the host of new technologies under development. The Navy plans to employ a spiral acquisition strategy for the ship class in which new technology will be phased in over three distinct ship flights.

Plans call for the DD(X) destroyer to have a number of new features and technologies, including

- an advanced electric-drive/integrated power system for propelling the ship that could become the basis for applying electric-drive technology more widely throughout the fleet,
- labor-saving technologies that may permit the ship to be operated with a crew of 125 to 175 people instead of the more than 350 needed to operate current *Arleigh Burke*-class (DDG-51) destroyers,
- a new hull design for reduced detectability,
- two new 155-mm Advanced Gun Systems for supporting Marine forces ashore, and
- 128 vertical-launch tubes for Tomahawk cruise missiles and other weapons.<sup>1</sup>

The Navy is now reevaluating many of the ship’s operational requirements and cost estimates (which were determined and approved under the earlier DD-21 program) and may make substantial changes to the originally envisioned capabilities, including relaxing the crew size and detectability goals, changing the type of gun and amount of munitions carried, and reducing the number of vertical launch tubes.

Previously, the Navy projected the unit procurement cost for the DD-21 destroyer to be not more than \$750 million in fiscal year 1996 dollars

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<sup>1</sup> The number of vertical-launch tubes is being reevaluated.

(the equivalent of about \$795 million in fiscal year 2001 dollars)—somewhat less than the \$950 million unit procurement cost of today’s *Arleigh Burke*-class destroyers.<sup>2</sup> The DD-21 was also envisioned to have an operating and support cost of not more than \$6,000 per hour—about one-third less than that of the *Arleigh Burke*-class, in large part resulting from the smaller crew planned for the future destroyer. In April 2002, the Navy selected Northrop Grumman Ship Systems as the design agent for the DD(X) and the program entered detailed design.

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## T-AKE Cargo Ship

The T-AKE cargo ship is the new combat logistics force ship to be operated by the Military Sealift Command. The ship’s primary mission is to shuttle food, ammunition, repair parts, supplies, and limited quantities of fuel to station ships and combatants. The new ship will replace T-AE 26 *Kilauea*-class ammunition ships and T-AFS 1/8 *Mars*-class and *Sirius*-class combat stores ships in the Military Sealift Command. The ship’s secondary mission is to operate with an oiler (T-AO 187 *Kaiser*-class) to provide logistics support to a carrier battle group. In this capacity, the T-AKE will replace AOE 1 *Sacramento*-class ships.

The ship program initiated development in 1995 and began procurement in October 2001. The Navy has purchased 3 of the 12 planned ships for a total of almost \$1 billion, with delivery expected in fiscal years 2005 and 2006. Current plans are to purchase the 4<sup>th</sup> through 12<sup>th</sup> ships between fiscal year 2003 and 2007 for delivery between fiscal year 2006 and 2010. Once all are purchased and delivered, T-AKE cargo ships will represent 41 percent of the recapitalized combat logistics force fleet (at full operating status).

Military Sealift Command officials mentioned several factors—mission requirements and personnel policies—that explain why, in comparison to the Navy, they are able to operate combat logistics force ships with smaller crews. Logistics ships in the Military Sealift Command have fewer missions and therefore can operate with smaller crews. For example, unlike Navy ships, Military Sealift Command logistics ships do not carry weapons and therefore their crews do not require weapon operators. Military Sealift Command ships also incorporate several other crew reduction practices, including an unattended engine room, minimal bridge watch by use of integrated bridge system technology, self-service laundry

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<sup>2</sup> Cost estimates are for the fifth destroyer built by each shipbuilder involved in the program.

facilities and food service initiatives. Command officials also said that because of their personnel policies, civilian mariners are more experienced than their Navy counterparts. Specifically, because there are no personnel policies requiring job rotation or that individuals leave the service if they are not promoted (“up or out”), civilian mariners are more likely to have been in their current job longer than active-duty Navy personnel. Command officials said that these personnel policies result in a workforce that is more experienced than their Navy counterparts.<sup>3</sup>

The Military Sealift Command’s operating policies also enable it to operate cargo ships with smaller crews than the Navy. For example, command officials said that their policy requires 9 crewmembers per underway replenishment station and that the Navy requires 20 per station. The Military Sealift Command also does not assign a safety officer to each underway replenishment station as the Navy does.

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## JCC(X) Command Ship

In November 1999, the Navy established the Joint Command and Control (Experimental) or JCC(X) program to replace the Navy’s four aging command ships built in the late 1960s and early 1970s. In addition, the JCC(X) was intended to provide an afloat platform for performing joint command and control functions, such as those performed by a joint force commander without the need to obtain permission from host countries to establish a land-based headquarters operation.

By November 2001, the Navy had received the Office of the Secretary of Defense’s endorsement for an afloat command capability and completed its formal analysis of alternatives. This analysis showed that the assigned Navy crew (the ship’s operators) would account for roughly half the life-cycle cost for a JCC(X). It also showed that a mix of Navy sailors and civilian mariners would be capable of performing the crew functions at

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<sup>3</sup> To confirm whether civilian mariners were more experienced than their Navy peers, we compared the average age and tenure of civilian mariners to active-duty Navy personnel. Relative to Navy personnel, civilian mariners were older (average age is 46 years, Navy average is about 29), although they had similar tenure (average tenure in the Military Sealift Command is about 8 years; the Navy average is almost 9). The Military Sealift Command provided data on civilian mariners. Navy age data was taken from *Population Representation in the Military Services, Fiscal Year 2000*, dated February 2002. Navy tenure data was calculated from *Tabulations of Responses from the 1999 Survey of Active Duty Personnel, Volume 2: Programs and Services, Family, Economic Issues, and Background*, conducted by the Defense Manpower Data Center, dated September 2000.

two-thirds of the personnel cost, saving about \$2 billion for four ships over a 40-year service life. The analysis further estimated that a newly designed ship sized for an embarked command staff of about 800 (these people are in addition to the ship's crew) would cost about \$1 billion for a lead ship in fiscal year 2006 and \$850 million for a follow-on ship if three were built. Subsequent to this analysis, the Navy's draft 2004 budget plan eliminated funding for the JCC(X) and instead directed another ship program, the Maritime Prepositioning Force (Future),<sup>4</sup> to study developing joint command and control modules or variants.

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## LHA(R) Amphibious Assault Ship Replacement

In 2001, the Navy established the Amphibious Assault Ship, General Purpose (Replacement) or LHA(R) program to replace its five aging LHA 1 *Tarawa*-class amphibious assault ships. These ships are primarily designed to move large quantities of Marines, their equipment, and supplies onto any shore during hostilities.

The first LHA ship will be replaced by a *Wasp*-class amphibious assault ship, the LHD-8,<sup>5</sup> in approximately fiscal year 2007, and the remaining ships will be replaced by a modified version of the LHD 8 no later than fiscal year 2024. The modified variant will be made longer and wider to accommodate the larger and heavier aircraft the Marines are developing, the MV-22 Osprey and the Joint Strike Fighter.

The Navy estimates the cost for the first ship to be about \$3 billion with the three successor ships costing about \$2.1 billion each.<sup>6</sup> The ship's annual operating and support cost is estimated to be about \$111 million. The LHA(R) program is currently in the first acquisition phase called concept technology and development.

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<sup>4</sup> The MPF(F) ships will be the Marine Corps' civilian operated forward-deployed floating equipment warehouses. The MPF(F) ships are intended to replace and update the capability currently provided by 13 aging Maritime Prepositioning Ships.

<sup>5</sup> The *Wasp*-class LHD is the Navy's largest amphibious assault ship. This class is an improved follow-on to the five *Tarawa*-class LHA ships. The LHD 8, currently under construction, will incorporate improvements, including a gas-turbine propulsion system and a new electrical auxiliary system that will eliminate steam service.

<sup>6</sup> All LHD cost figures are in constant fiscal year 2003 dollars.

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# Appendix III: Defense Acquisition

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Although its regulatory structure is undergoing change, the Department of Defense's (DOD) complex process to deliver a new ship class to the fleet occurs in three steps. First, the Navy's requirements community establishes requirements for a new system. Second, the Navy's acquisition organizations and contractors design and produce the ship. Finally, after building the ship, the warfighter assumes responsibility for operating and maintaining the ship. DOD's policy is to acquire weapons systems using a disciplined systems engineering process designed to optimize total system performance and minimize total ownership costs.<sup>1</sup> The regulation, requirements, and design aspects of the acquisition process are discussed below.

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## Defense Acquisition Regulatory Structure Is Undergoing Change

Weapons systems acquisition is governed by a complex regulatory structure ranging from public laws to nonmandatory policies, practices, and guidance. Until recently, three major DOD regulatory documents guided the management of Defense acquisition: DOD Directive 5000.1, "The Defense Acquisition System;" DOD Instruction 5000.2, "The Operation of the Defense Acquisition System;" and DOD Regulation 5000.2-R, "Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information Systems (MAIS) Acquisition Programs." On October 30, 2002, the Deputy Secretary of Defense canceled all three documents and by memorandum issued interim guidance. On an interim basis, the DOD 5000.2-R was reissued as a guidebook, *Interim Defense Acquisition Guidebook*, to be used for best practices, lessons learned, and expectations; but its guidance is not mandatory.<sup>2</sup> Additional, supporting, discretionary best practices; lessons learned; and expectations are posted on DOD's internet Web site, *DOD 5000 Series Resource Center*.<sup>3</sup> The interim DOD guidance retains the basic acquisition system structure (i.e., no new phases), emphasizes evolutionary acquisition, modifies the requirements generation documents, and makes several other changes. Policies and procedures for

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<sup>1</sup> Deputy Secretary of Defense Memorandum, *Defense Acquisition, Attachment 1, The Defense Acquisition System*, October 30, 2002.

<sup>2</sup> On May 12, 2003, DOD released a new version of DOD Directive 5000.1 and DOD Instruction 5000.2. A streamlined version of the nonmandatory *Guidebook* is under development. Because this guidance was issued following the completion of our audit work, the description of the acquisition process in this report is based on DOD's interim guidance issued on October 30, 2002.

<sup>3</sup> See <http://dod5000.dau.mil/>. Another internet-based aid, commonly known as "The Acquisition Deskbook," is located at <http://deskbook.dau.mil/jsp/default.jsp>.

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developing and approving requirements for new systems are also under revision.<sup>4</sup>

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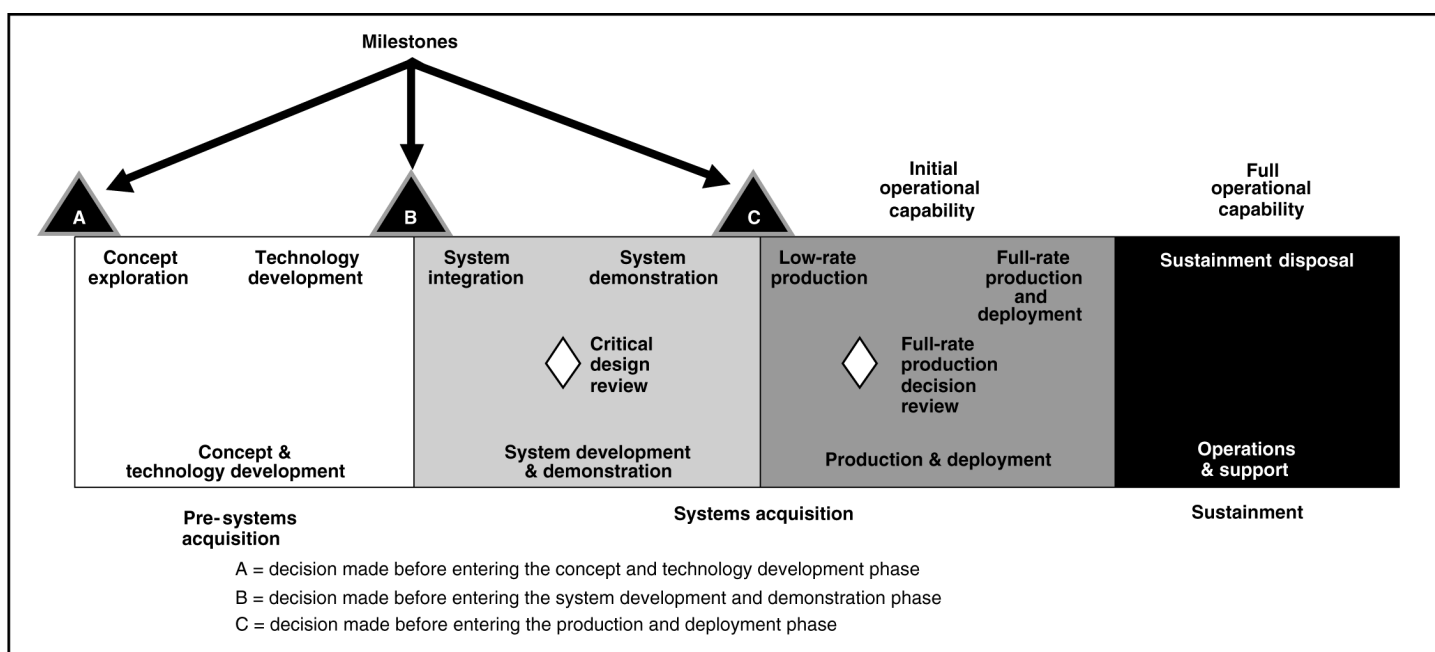
## The Acquisition Process Contains Several Checkpoints for Assessing Progress

DOD's acquisition process, as outlined in its interim guidance issued October 30, 2002, provides an ordered structure of tasks and activities to bring a program to the next major checkpoint. These checkpoints, called milestones, are the points at which a recommendation is made and approval sought regarding starting or continuing an acquisition program into one of three phases: concept and technology development, system development and demonstration, and production and deployment (see fig. 2). The phases are intended to provide a logical means of progressively translating broadly stated mission needs into well defined system-specific requirements and ultimately into effective systems. A fourth phase, operations and support, follows the system acquisition. This phase represents the ownership period of the system when a unit, in this case a ship, is fielded and operated by sailors for a period of 30 to 50 years. A program's progress toward established program goals, or key performance parameters, is assessed at milestones.

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<sup>4</sup> Chairman of the Joint Chiefs of Staff Instruction 3170.01B, *Requirements Generation System*, Apr. 15, 2001. The new CJCSI 3170.01C and CJCSM 3170.01 are expected to be reissued in mid-2003.

Figure 2: The DOD Acquisition System Process, Phases, Milestones, and Key Activities



Source: DOD.

The concept and technology development phase has two major efforts: concept exploration and technology development. This phase begins with a milestone A decision to enter concept and technology development. Entrance into this phase depends upon a validated and approved initial capability document [mission need statement]. Concept exploration typically consists of competitive, parallel, short-term concept studies guided by the initial capability document (mission need statement). The focus of these studies is to refine and evaluate the feasibility of alternative solutions to the initial concept and to provide a basis for assessing the relative merits of these solutions. Analyses of alternatives are used to facilitate comparisons. A project may enter technology development when a solution for the needed capability has been identified. This effort intends to reduce technology risk and to determine the appropriate set of technologies. A project exits technology development when an affordable increment of militarily-useful capability has been identified, the technology for that increment has been demonstrated in a relevant environment, and a system can be developed for production within a short time frame (normally less than 5 years). During technology development, the user is required to prepare the capability development document [operational requirements document] to support subsequent program initiation. An affordability determination is made in the process of

addressing cost as a military requirement and included in the capability development document [operational requirements document], using life-cycle cost or, if available, total ownership cost.

The purpose of the system development and demonstration phase is to develop a system. This phase has two major efforts: system integration and system demonstration. The entrance point is milestone B, which is also the initiation of an acquisition program. The system integration effort intends to integrate subsystems and reduce system-level risk. The system can enter system integration when the program manager has a technical solution for the system, but has not yet integrated the subsystems into a complete system. The critical design review during system development and demonstration provides an opportunity for mid-phase assessment of design maturity. The system demonstration effort intends to demonstrate the ability of the system to operate in a useful way consistent with the validated key performance parameters. The program can enter system demonstration when the program manager has demonstrated the system with prototypes. This work effort ends when a system demonstrates its capabilities in its intended environment using engineering development models or integrated commercial items (in addition to several other criteria).

The purpose of the production and deployment phase is to achieve an operational capability that satisfies mission needs. The decision to commit DOD to low-rate initial production takes place at milestone C. Continuation into full-rate production results from a successful full-rate production decision review. During this effort, units shall attain initial operational capability.

Operations and support has two major efforts: sustainment and disposal. The objectives of this activity are the execution of a support program that meets operational support performance requirements and sustainment of systems in the most cost-effective manner for the life cycle of the system. When the system has reached the end of its useful life, it must be disposed of in an appropriate manner.

# Appendix IV: Summary of DD(X) Destroyer Gold Team Trade Studies

Trade studies are required to support decisions throughout the systems engineering process. During a requirements analysis, requirements are balanced against other requirements or constraints, including cost. Requirements analysis trade studies examine and analyze alternative performance and functional requirements to resolve conflicts and satisfy customer needs. As part of the design competition for the DD(X) destroyer, the competing contractors conducted trade studies and analyses on their system concept designs and the related systems requirements. Table 1 highlights some of the 23 trade studies conducted by the winning design agent, Northrop Grumman Ingalls Shipyard and Raytheon.

**Table 1: Selected DD(X) Destroyer Trade Studies Conducted by Northrop Grumman Ingalls Shipyard and Raytheon, from 1998-2002**

Study topic	Scope of analysis
Command center design	Incorporated analytic processes from Westinghouse Electric commercial nuclear power plant design efforts.
Operator crewing—propulsion, electrical, and auxiliary plant	Studied processes and toured U.S.N.S. <i>Red Cloud</i> , <sup>a</sup> operated by Maersk Line Limited, Inc., <sup>b</sup> to gain insight into civilian crewing of noncombat portions of ship operations.
Food service	Investigated commercial advanced food service program used by many hotel chains.
Damage control	Investigated chemical plant firefighting methods, particularly telerobotics, for inclusion in the automated fire suppression system engineering development model.
Cognitive work analysis	This process, which was the foundation of the human systems integration effort, was developed in the Netherlands.
Training concepts	Investigated Ford Motor Company distance learning and “Just-in-Time” training system for their maintenance and service department personnel.
Remote equipment monitoring	Received briefings on the Delta Airlines and Boeing Corporation remote monitoring capability of in-flight data from their commercial airline fleet.
Facility maintenance/cleaning	Reviewed design requirements and practices of Maersk Line, Ltd., for reductions in the work required for common area cleaning and maintenance.
Self-service laundry	Reviewed Maersk Line, Ltd., use of self-service laundry on its United States Naval Ship contract ships. Reviewed both reliability of the equipment and crew satisfaction.
Ashore administrative, personnel, and disbursing service	Reviewed program provided by Northrop Grumman Information Technology to the Navy at the precommissioning sites.
Reduced bridge watchstanders	Investigated United States Naval Ship and commercial operations with Maersk Line, Ltd., as well as Navy Smart Ship and Sperry Integrated Bridge System programs.
Portable computing	Investigated wearable computers developed by Boeing in Seattle, Washington, and the Massachusetts Institute of Technology Media Lab at Cambridge, Massachusetts.

Source: Navy.

<sup>a</sup>U.S.N.S. *Red Cloud* is a *Watson*-class large, medium speed, roll-on/roll-off sealift ship. The ship is operated by the Military Sealift Command and crewed by contract civilian mariners.

<sup>b</sup>Maersk Sealand is one of the largest liner shipping companies in the world, serving customers all over the globe.

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# Appendix V: Comparison of DDG 51 and DD(X) Crew Sizes

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Plans for the DD(X) destroyer envision significant reductions when compared to previous destroyer ships in the number of crewmembers required to man watches, provide support functions, and perform special evolutions. For example, DD(X) plans call for 20 watchstations, requiring 60 billets,<sup>1</sup> a significant reduction from the DDG 51 destroyer, which has 61 watchstations requiring 163 billets. Similarly, DD(X) ship crew sizing studies project that 833 hours will be required per week for own unit support functions such as administration, messing, and supply while the DDG 51 requires 5,500 for the same functions. To achieve these proposed reductions, the DD(X) plans to employ a new operational crewing concept, human-centered design and reasoning systems, advances in ship cleaning and preservation, a new maintenance strategy, an automated damage control system, and “reach back” technologies and distance support. Officials emphasized that the DD(X) plans will continue to evolve as the program matures. In addition, changes to the DD(X) destroyer’s operational requirements, which are currently being reevaluated, will likely further affect these estimates.

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## DD(X) Operational Crew Size Concept

The approach to operational crewing on the DD(X) destroyer will differ markedly from that employed on legacy ships. The older ship classes tend to have legacy systems and watchstations that are “stovepiped,” meaning that they maintain separate stations and databases for such things as sensors, weapon systems, and logistics, which are not linked together and which require people to be specially trained on these systems. This results in an inflexible work environment in which commanders are unable to level workload across watchstanders because they are trained in separate disciplines. It requires extra people, with little increase in capability. The DD(X) concept is to have watchstanders trained functionally across warfare areas who can be flexibly employed as the situation demands. This approach results in a more compact, flexible watch team, which requires fewer augmentations and which is designed to flexibly respond to a variety of tactical situations. Underpinning this concept is a strategy in which crewmembers will be highly trained across multiple warfare areas or maintenance tasks and advanced skills will apply across multiple disciplines with specialized skills only being used periodically.

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<sup>1</sup> Watchstations are manned in three sections, or 8-hour shifts, over the course of a day.

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## Human-Centered Design and Reasoning Systems

The DD(X) destroyer envisions reducing underway watchstanding through greater use of human-centered design and reasoning systems such as

- integrated bridge system technologies demonstrated in CG 47 *Ticonderoga*-class “smart ship” and many commercial ships that provide computer-based navigation, planning and monitoring, automated radar plotting, and automated ship control;<sup>2</sup>
- the integrated command environment that provides reduced combat information center crewing by using “multi-modal watchstation” type displays, the ability to monitor more than one watchstation at each console, and the use of decision support systems to facilitate instantaneous situational awareness;
- computerized engineering control systems that are extensively used in the commercial shipping industry and machinery space design that permits zero underway crewing by using remote monitors and sensors; and
- a flexible watch team-type organization.

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## Advances in Cleaning and Preservation

The DD(X) destroyer plans to use advances in ship cleaning and preservation to free sailors from traditional maintenance and preservation duties and privatizing the preservation work that cannot be engineered away. Reliability-centered maintenance<sup>3</sup> and condition-based maintenance<sup>4</sup> concepts will be employed on the DD(X) instead of the traditional planned maintenance system currently used on DDG 51 destroyers. This change is expected to reduce noncorrective type maintenance and significantly reduce corrective maintenance induced by the planned maintenance

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<sup>2</sup> According to the *Smart Ship Assessment Report*, the experiment aboard a *Ticonderoga*-class guided missile cruiser has reduced workload and ship crewing requirements while enhancing combat readiness and improving the crew’s quality of life. The experiment validated the use of cost-effective commercial technology and policy changes to allow sailors to focus on their war fighting and professional skills by freeing them from repetitive tasks.

<sup>3</sup> Reliability-centered maintenance is a maintenance scheme based on the reliability of the various components of the system or product in question. It requires extensive knowledge about the reliability and maintainability of the system and all of its subsequent components, including the mean time to repair and failure rates of the product or system. Implementing this kind of preventative maintenance program can greatly reduce the cost of ownership.

<sup>4</sup> The objective of condition-based maintenance is to accurately detect the current state of mechanical systems and accurately predict systems’ remaining useful lives. This enables organizations to perform maintenance only when needed to prevent operational deficiencies or failures, essentially eliminating costly periodic maintenance and greatly reducing the likelihood of machinery failures.

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system. In addition, routine maintenance on the DD(X) is projected to be reduced by increased equipment reliability and a strategy of replacing failed components on board instead of repairing them at sea. Lastly, cleaning is expected to be reduced by better ship design that capitalizes on commercial shipping industry best practices such as cornerless spaces and maintenance-free deck coverings.

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## DD(X) Maintenance Strategy

The DD(X) destroyer maintenance strategy focuses on allowing sailors to concentrate on war-fighting tasks and skills rather than on ship maintenance and preservation (i.e., “rust busting” skills). The DD(X) maintenance strategy envisions no organizational level repair conducted on the ship. As such, many repair watches have been eliminated. Three key elements of the DD(X) maintenance strategy include

- reducing maintenance requirements through improved system reliability and redundancy and to leverage labor-saving advances in corrosion control materials and technology,
- improving maintenance work efficiency by conducting condition-based maintenance instead of scheduled maintenance, and
- using reach back and remote monitoring support while deployed.

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## Automated Damage Control System

The DD(X) destroyer will employ extensive automated damage control systems, integrated with an optimally manned damage control organization to quickly suppress and extinguish fires and control their spread.

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## Use of Reach Back Technologies and Distance Support

The DD(X) destroyer plans to use “reach back” technologies and distance support to reduce crew workload. “Tele-systems” initiatives are being studied for ship crew reduction in the areas of medicine, personnel, pay, training, and maintenance. DD(X) also envisions having real-time collaboration between the ship and shore, and between ships. Ships would access expertise from the systems commands, industry, and other deployed ships on a year round, around the clock basis.

Table 2 compares the workload and crew composition for the DDG 51 Flight IIA and those proposed for the DD(X).

**Table 2: Comparison of Watchstations for the DDG 51 Flight II A and the DD(X)**

DDG51 Flight II A watchstations		DD(X) watchstations <sup>a</sup>		Potential workload reduction enablers
Position(s)	No.	Position	No.	
Tactical action officer	1	Tactical action officer	1	No change anticipated
Combat systems coordinator	8	Command center warfare officer	1	<ul style="list-style-type: none"> <li>• DD(X) maintenance strategy (increase reliability and replace instead of repair) will eliminate need for on-station repairmen</li> <li>• Automated damage control system</li> </ul>
Own ship display controller				
Combat systems office of the watch/combat system maintenance supervisor				
Fire control supervisor				
Radar repairman				
Computer repairman				
Display repairman				
Electronics support supervisor				
Combat information center supervisor	1	Watch supervisor cross warfare area advanced	1	No change anticipated
Engineering officer of the watch	9	Engineering officer of the watch	1	<ul style="list-style-type: none"> <li>• Use of condition-based maintenance philosophy and reliability-centered maintenance instead of planned maintenance system</li> <li>• Increased systems reliability</li> <li>• Use of monitors and sensors</li> <li>• System redundancy</li> <li>• Speedy “plug &amp; play” repairs</li> <li>• Automated damage control system</li> </ul>
Propulsion/auxiliary control console operator				
Electrical plant control console operator				
Engine room operator				
Auxiliary system monitor				
Engine room operator				
Propulsion system monitor				
Damage control/integrated survivability management system operator				
Sounding and security watch				
Tactical information coordinator	2	Information dominance advanced	1	Human-centered design and reasoning systems with integrated information displays
Local area network manager				
Intelligence console operator	3	Cross warfare area basic (intelligence)	1	Human-centered design and reasoning systems with integrated information displays <sup>b</sup>
Intelligence console operator				
Tactical intelligence operator				
Communications supervisor	3	Cross warfare area basic communications	1	Human-centered design and reasoning systems with integrated information displays
Communication systems manager				
Communications systems operator No. 1				
Electronic warfare supervisor	4	Information dominance advanced	1	<ul style="list-style-type: none"> <li>• DDG 51 workload involves electronic warfare “soft kill” signatures management. Improved signatures on the DD(X) will negate the need for countermeasures and chaff operators.</li> <li>• Human-centered design and reasoning systems with integrated information displays</li> <li>• Automated damage control system</li> </ul>
Damage control console operator				
Super rapid blooming off-board chaff operator				
Identification supervisor				

**Appendix V: Comparison of DDG 51 and  
DD(X) Crew Sizes**

DDG51 Flight II A watchstations		DD(X) watchstations <sup>a</sup>		Potential workload reduction enablers
Position(s)	No.	Position	No.	
Anti-air warfare coordinator Missile system supervisor Radar system controller	3	Cross warfare area advanced (Anti-air warfare)	1	<ul style="list-style-type: none"> <li>• Multifunction radar provides improved capability and reduced human anti-air warfare workload</li> <li>• Human-centered design and reasoning systems with integrated information displays</li> </ul>
Land attack warfare coordinator <sup>c</sup>	1	Land attack warfare specialist	1	No change anticipated
Gun fire control system console operator Tomahawk weapons system supervisor	2	Cross warfare area basic (land attack warfare)	1	Human-centered design and reasoning systems with integrated information displays
Tomahawk weapons system operator Tomahawk weapons system operators (+3) <sup>d</sup>	2	Cross warfare area advanced	1	Human-centered design and reasoning systems with integrated information displays
Quarter master of the watch Boatswain mate of the watch ship control	3	Assistant officer of the deck	1	Human-centered design and reasoning systems with integrated information displays
Junior officer of the deck	1	Junior officer of the deck	1	No change anticipated
Officer of the deck Messenger Surface detector tracker Lookout starboard Lookout port Lookout aft Signal watch Supervisor/operator recorder	8	Officer of the deck	1	<ul style="list-style-type: none"> <li>• Change to current Navy policy and procedures for bridge crewing</li> <li>• Use of cameras</li> <li>• Electronic log keeping</li> <li>• Improved communications</li> <li>• Integrated bridge system</li> </ul>
Surface/subsurface/engagement control officer warfare coordinator Surface/subsurface warfare supervisor	2	Cross warfare area basic integrated air/surface dominance	1	Human-centered design and reasoning systems with integrated information displays
Undersea warfare coordinator sonar supervisor	2	Cross warfare area basic undersea warfare	1	Human-centered design and reasoning systems with integrated information displays
Undersea warfare console operator Undersea warfare console operator Undersea warfare console operator	3	Undersea warfare specialist	1	Human-centered design and reasoning systems with integrated information displays
Air intercept controller Antisubmarine/surface tactical air controller Unmanned aerial vehicle controller <sup>e</sup>	3	Antisubmarine/surface tactical air controller	1	Human-centered design and reasoning systems with integrated information displays

**Appendix V: Comparison of DDG 51 and DD(X) Crew Sizes**

DDG51 Flight II A watchstations		DD(X) watchstations <sup>a</sup>		Potential workload reduction enablers
Position(s)	No.	Position	No.	
		Flex watchstation cross warfare area <sup>f</sup>	1	
<b>Total (163 watch billets over a 3 section watch)<sup>g</sup></b>	<b>61</b>	<b>Total (60 watch billets over a 3 section watch)</b>	<b>20</b>	

Source: Navy

<sup>a</sup>This table was created by us based on data provided by Naval Sea Systems Command (PMS 500). Watchstation numbers for the DDG 51 Flight II A destroyer are from the ship's *Preliminary Ship Manning Document*, dated October 5, 2002, version for Flight IIA. Watchstation numbers for the DD(X) destroyer are from the design agent's (Gold Team) Phase III working document dated September 26, 2002, which reflects a summary of the design agent's Phase II crewing studies. Officials stated that this is the closest comparison possible from the DDG 51 to the DD(X). They noted that not all responsibilities clearly map to the new system. Officials also stated that these numbers will continue to evolve as the program matures. This table has been reviewed by PMS 500 officials for accuracy and includes official comments provided to us on November 18, 2002.

<sup>b</sup>Officials noted that intelligence system requirements will be dictated to DD(X) and that achieving reductions in this area relies heavily on successful software development efforts. The DD(X) design agent is currently working on this area.

<sup>c</sup>This is one of six DDG 51 watchstations for land attack.

<sup>d</sup>This is three of six DDG 51 watchstations for land attack.

<sup>e</sup>This is one of six DDG 51 watchstations for land attack.

<sup>f</sup>This position provides flexibility in the event of workload surges.

<sup>g</sup>Total does not equal 3 times 61 due to the fact that some watches are not always manned.

In addition to the daily shipboard routine of standing watches in the various ship's departments, designated crewmembers also have collateral duties to support special events, referred to as special evolutions. These evolutions involve activities such as underway replenishment of fuel, food and ammunition transferred from either helicopters or other ships, flight operations, small boat operations, and anchoring. The number of people required and the estimated labor hours per week for these special evolutions are other indicators of ship workload. Table 3 compares the number of billets and weekly workload required for selected special evolutions on the *Arleigh Burke*-class destroyer with those estimated for the DD(X) destroyer. Table 3 compares the billets and labor hours required per week for special evolutions on the DDG 51 Flight IIA and those proposed for the DD(X).

Appendix V: Comparison of DDG 51 and  
DD(X) Crew Sizes

**Table 3: Comparison of Crew Size for Selected Special Evolutions on DDG 51 Flight IIA and DD(X) Destroyers**

Evolution	DDG 51 Flight IIA		DD(X) Gold Team Phase II		Change in billets	Percent change in labor hours
	Billets	Labor hours per week	Billets	Labor hours per week		
Fueling at sea	57	228	9	11.61	48	-95
Connected replenishment	38	19	12	6.12	26	-68
Vertical replenishment	32	7.8	11	5.61	21	-28
Boat operations	15	8.4	6	5.67	9	-33
Flight operations	41	351	16	87.50	25	-75
Restricted navigation operations	12	12.2	3	.93	9	-92
Towing/towed	41	5.9	7	3.13	34	-47

Source: Navy.

# Appendix VI: Comments from the Department of Defense

Note: A GAO comment supplementing those in the report text appears at the end of this appendix.



PERSONNEL AND  
READINESS

OFFICE OF THE UNDER SECRETARY OF DEFENSE  
4000 DEFENSE PENTAGON  
WASHINGTON, D.C. 20301-4000



12 MAY 2003

Ms. Janet St. Laurent  
Acting Director, Defense Capabilities and Management  
U.S. General Accounting Office  
Washington, DC 20548

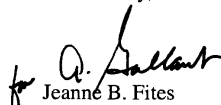
Dear Ms. St. Laurent:

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report (GAO-03-520), "MILITARY PERSONNEL: Navy Actions Needed to Optimize Ship Crew Size and Reduce Total Ownership Costs," dated April 17, 2003 (GAO Code 350269/350132).

The Department acknowledges receipt of the draft report and generally concurs with the report. Specific comments related to each recommendation are enclosed. The Department appreciates the opportunity to review and comment on the draft report.

My point of contact is Lieutenant Colonel Spencer Rutledge III. He can be reached at 703-693-1214 or via e-mail at [spencer.rutledge@osd.mil](mailto:spencer.rutledge@osd.mil).

Sincerely,

  
for Jeanne B. Fites  
Deputy Under Secretary of Defense  
(Program Integration)

Enclosure  
As stated



GAO DRAFT REPORT DATED APRIL 17, 2003  
GAO-03-520 (GAO CODE 350269/350132)

“MILITARY PERSONNEL: Navy Actions Needed to Optimize Ship Crew Size and  
Reduce Total Ownership Costs”

**General Comments:**

It is the Department’s belief that actions taken in response to GAO’s proposed recommendations would only enhance ongoing Human Systems Integration (HSI) initiatives, ensure more consistent application of HSI processes across all ship acquisition programs, and lead to optimized ship crews, increased system performance and reduced life cycle costs. DoD concurs with all recommendations.

While providing well-deserved recognition of the DD(X) program’s extensive HSI efforts, the Department echoes the Navy’s concerns that the general tone of the report implies a lack of interest or desire to pursue aggressive manpower reductions and HSI goals by other ship acquisition programs. A number of the observed differences between the DD(X) HSI efforts and those of the other ship acquisition programs studied (i.e., LHA(R), T-AKE and JCC(X)) are directly related to factors outside the control of the Program Manager (PM), and even the Naval Sea Systems Command (NAVSEASYS COM). For example, LHA(R) is not able to implement as aggressive an HSI program as DD(X) because it was not resourced to do so. This lack of funding applies not only to the HSI analyses required to determine appropriate ship crew optimizations, but also to the research and development (R&D) required to pursue advanced technology that enables these workload and manpower reductions. External influences and PM constraints on a program’s ability to implement aggressive HSI analyses are not limited to funding shortfalls. Joint command staff manpower requirements for JCC(X) were the purview of the DoD Joint Staff (JS), not the JCC(X) PM, NAVSEASYS COM, or even OPNAV. Optimization of these manpower requirements can only be done in cooperation with the JS.

Any actions taken to ensure HSI is more consistently applied early in the acquisition process and establishes meaningful goals for crew size reduction must be sensitive to multiple perspectives and external influences, yet broad and bold enough to address not only HSI processes, but larger capability definition, acquisition and resourcing/funding issues.

**Comments on specific GAO Recommendations:**

**RECOMMENDATION 1:** The GAO recommended that the Secretary of the Navy, develop and implement mandatory policies on human systems integration requirements, standards and milestones. (p. 37/GAO Draft Report)

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See comment 1.

**DOD RESPONSE: Concur with comment.**

The Navy is pursuing a program to address these concerns. Systems Engineering, Acquisition and Personnel INTeграtion (SEAPRINT) is: (a) a philosophy based on the premise that manpower and human performance are design drivers, not design consequences; (b) a technical approach that integrates analyses among the domains of HSI, and between HSI analyses and the systems engineering and acquisition processes, and (c) an emerging set of tools that will enable PMs to execute the required HSI activities in a resource effective manner. SEAPRINT will provide the mechanism whereby programs can perform HSI assessments as concepts for programs are developed and alternatives are evaluated. It will determine appropriate and achievable HSI requirements, identify those that should be KPPs, and track their progress throughout system development and trade-offs.

A cornerstone of the SEAPRINT program is development of Navy-wide HSI policy that identifies, mandates and holds responsible authorities accountable for HSI analyses, requirements and results. The policy is expected to be similar to the Army's AR 602-2, *MANPRINT in the System Acquisition Process*. It will be consistent with (i.e., flow down from) DoD- and DoN-level HSI policy and guidance. Navy had strong representation and influence in the development of these higher-level policies. Therefore, even though these policies are still in flux, Navy will be able to develop HSI policy and guidance that accommodates the future requirements determination and acquisition environments. This policy will mandate that (among other things), an HSI Plan (HSIP) be in place before the acquisition program's earliest milestone; a Target Audience Description (TAD) be developed during concept exploration; HSI implications and constraints be included in the Initial Capabilities Document (ICD); well-defined, capability-based, testable HSI requirements be included in the Capabilities Development Document (CDD) and refined in the Capabilities Production Document (CPD); test and evaluation activities be based on human-in-the-loop modeling and simulation techniques, and HSI assessments be performed as part of concept exploration and development, and be updated prior to all subsequent milestones. This Navy-wide policy will apply to all Navy organizations and is intended to facilitate coordination, cooperation and increased partnership between the SYSCOMs. This cross functional teaming is vitally important as we embark on even greater "born joint" concepts, and continue to develop integrated shipboard, aviation and C4ISR system/family-of-systems. CNO N12 (Director Total Force Programming and Manpower), who is the Navy-wide office/sponsor for HSI policy and processes, is executing the \$1.05M Congressional plus up to investigate and develop a MANPRINT-like HSI program for Navy. Work on this program began in January 2003. Initial efforts, including the Navy-wide HSI policy, will be completed by September 2003.

Navy will be considering additional policy to address HSI in architectures. The new draft DoD architecture Framework Document includes significant HSI, but is currently a guidance document, not policy. Once the content of this document (in total) has been validated, Navy will consider recommending the language for a DoN or DoD policy.

Enclosure 1

While concurring with this recommendation, Navy wishes to stress that without appropriate emphasis on the HSI assessments early in the process, manpower-related key performance parameters (KPPs) may be developed without using the principles of Top Down Functional Analysis (TDFA), and may not address all capability, acquisition and funding/resource implications and constraints. Without this analysis, manpower-related KPPs may be arbitrary and ultimately a detriment to the program's ultimate success relative to life cycle and total ownership cost. Also, Navy recognizes that not *all* programs should have a manpower-related KPP. Authority to set manpower KPPs should reside with the manpower requirements office (DCNO (Manpower and Personnel) (CNO N1)), who will coordinate with the warfare sponsor and PM. Navy does endorse a manpower-related KPP for all new ship acquisition programs. Manpower-related KPPs will be identified on an ongoing basis.

**RECOMMENDATION 2:** The GAO recommended that the Secretary of the Navy, require the *Naval Sea Systems* Command to clarify the Human Systems Integration Directorate's role in and process for certifying that ships and systems delivered to the fleet optimize ship crewing. (p. 38/Draft Report)

**DOD RESPONSE:** Concur with comment.

The Naval Sea Systems Command (NAVSEASYS COM) Human Systems Integration Directorate (SEA 03) is developing acquisition, and technical Human Performance criteria and metrics for ship system acquisition programs. In developing these metrics and conducting the assessments, SEA 03 has involved many of the Navy HSI stakeholders. When this work is completed, the proposed metrics will be shared with all appropriate Navy entities. Once approved, SEA 03 will also recommend incorporating these metrics into the DoN Acquisition process. Approved metrics will be used to measure and certify that ship and ship systems meet human performance criteria as part of the total ship/system performance and certification process. As part of this process, SEA 03 is currently reviewing all NAVSEA acquisition programs with respect to HSI effectiveness. Expected completion date is December 2003.

**RECOMMENDATION 3:** The GAO recommended that the Secretary of the Navy, require that the Naval Sea Systems Command Human Systems Integration Directorate establish a process to evaluate or revise existing policies and procedures that may impede innovation in all new ship acquisitions. (p. 38/Draft Report)

**DOD RESPONSE:** Concur with comment.

As the GAO stated in its report, the DD(X) program started the Policy Clearinghouse (PCH) to address policies and procedures. NAVSEA's HSI Directorate (SEA 03) has taken over the DD(X) PCH, and has expanded the application to all ships and submarines. When SEA 03 expanded the PCH, it broadened the scope to include issues

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beyond policies and procedures. The program is now called the HSI Clearinghouse for Issues and Policies (CLIP). A pilot study using CLIP is being developed in conjunction with the Commander Surface Forces, Pacific reduced manning experiment aboard DDG 51 and CG 47 class ships. Also, the DD(X) Design Agent has developed issues and is preparing to post them in CLIP. Because some policies and procedures are outside of NAVSEA's authority, successful execution of the CLIP requires participation from across the Navy stakeholders. NAVSEA will work with these stakeholders to require and identify the necessary means (i.e., resources) for policy and procedure owners to participate in CLIP as required. Overall expected completion date is June 2004.

Enclosure 1

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The following is GAO's comment on the Department of Defense's letter dated May 12, 2003.

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## GAO's Comment

1. We disagree that the tone of our report implies a lack of interest or desire on the part of program managers to pursue manpower reductions. Rather, our report notes that a number of factors, including funding issues, create barriers that make it more difficult for program managers to pursue manpower reductions and develop robust human systems integration programs. Moreover, we agree that resourcing human systems integration and supporting analyses at the earliest stages of the program is a responsibility that does not wholly reside with the program manager but is shared by the Navy staff. As our report clearly points out, given the existing barriers and an absence of specific requirements to implement a comprehensive human systems integration approach, the JCC(X) and LHA(R) programs did not identify or request resources for performing human systems integration and related analyses to support the research and development required to pursue advanced technology that could have enabled workload and manpower reductions.

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