United States Government Accountability Office

GAO

Testimony
Before the Subcommittee on Seapower and Expeditionary Forces, Committee on Armed Services, House of Representatives

For Release on Delivery
Expected at 2:00 p.m. EDT
Tuesday, July 24, 2007

DEFENSE ACQUISITIONS

Realistic Business Cases Needed to Execute Navy Shipbuilding Programs

Statement of Paul L. Francis, Director
Acquisition and Sourcing Management Team

GAO
Accountability * Integrity * Reliability

GAO Accountability·Integrity·Reliability

Highlights

Highlights of GAO-07-943T, a testimony before the Subcommittee on Seapower and Expeditionary Forces, Committee on Armed Services, House of Representatives

July 2007

DEFENSE ACQUISITIONS

Realistic Business Cases Needed to Execute Navy Shipbuilding Programs

Why GAO Did This Study

The Navy is beset with long-standing problems that affect its ability to accomplish ambitious goals for its shipbuilding portfolio. Significant cost growth and long schedule delays are persistent problems. Making headway on these problems is essential in light of the serious budget pressures facing the nation.

This testimony focuses on (1) cost growth in shipbuilding, (2) acquisition approaches in the LPD 17, Littoral Combat Ship, DDG 1000 and CVN 78 programs and (3) steps the Navy can take to improve its acquisition decision-making, particularly the adoption of a knowledge-based framework.

What GAO Recommends

While GAO is making no new recommendations in this testimony, GAO has made numerous recommendations through the years to improve business cases for Navy acquisitions as well as other Department of Defense weapon acquisitions. The Department's acquisition policies largely incorporate these recommendations, but they have not been implemented on actual programs.

www.gao.gov/cgi-bin/getrpt?GAO-07-943T.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Paul L. Francis at (202) 512-4841 or francisp@gao.gov.

What GAO Found

The Navy has exceeded its original budget by more than $4 billion for the 41 ships under construction at the beginning of this fiscal year. And more cost growth is coming. Cost growth is not just a problem for lead ships of a new class but also for follow-on ships. For example, costs for the first two Littoral Combat Ships have more than doubled. Similarly, costs for the first two San Antonio class (LPD 17 and LPD 18) amphibious ships have increased by over $1.3 billion—almost a 77 percent increase above the initial budgets. Cost growth of this magnitude leads to lost opportunities for tomorrow's needs.

These types of problems point to the wisdom of using solid, executable business cases to design and build ships. A business case requires a balance between the concept selected to satisfy warfighter needs and the resources—technologies, design knowledge, funding, time, and management capacity—needed to transform the concept into a product, in this case a ship. Neither LPD 17 nor the Littoral Combat Ship programs was framed around an executable business case; rather, the programs pushed ahead without a stable design and without realistic cost estimates, resulting in higher costs, schedule delays, and quality problems. The Navy has a more thoughtful business case for its next generation aircraft carrier and destroyer programs (CVN 78 and DDG 1000, respectively) before construction, but the programs remain at risk for cost growth partly because of continuing efforts to mature technologies. GAO's work on best practices highlights the need for a disciplined, knowledge-based approach to help shipbuilding, and other defense acquisition programs achieve more successful outcomes. This approach is predicated on certain essentials, including:

- ensuring that technology maturity is proven before a design is considered stable and understanding that production outcomes cannot be guaranteed until a stable design is demonstrated;
- improving cost estimating to develop initial shipbuilding budgets that are realistically achievable; and
- improving cost management through increased use of fixed-price contracting and comprehensive cost surveillance.

A significant challenge to adapting a knowledge-based approach is the lack of a common understanding across programs regarding the definition, timing, and criteria for key knowledge junctures. For example, each shipbuilding program seems to have a different measure as to how much of the design needs to be complete before beginning ship construction. Similarly, there appears to be little criteria across programs regarding how much knowledge—such as the percent of ship units built—is needed at different decision points, including keel lay, fabrication start, and ship launch.

Mr. Chairman and Members of the Subcommittee,

I am pleased to be here today to discuss the Department of the Navy's shipbuilding programs, including its surface combatant programs. The Navy has ambitious goals for its shipbuilding programs. The Navy expects to build more—and often increasingly complex ships—and deliver them to meet warfighter needs, while still achieving reduced acquisition and/or life cycle costs. These are admirable goals, representing the Navy's desire to provide the fleet with the most advanced ships to meet national defense and military strategies. However, there is often tension among the Navy's cost, schedule, industrial base, and capability goals. While this tension is embedded at the beginning of shipbuilding programs, its effects are realized later, during ship construction. Budgets set prior to beginning construction are not realistically achievable and often include optimistic dates for delivery to the fleet. The consequence is often that costs increase after construction has begun, schedule targets slip, and contract scope is reduced. The LPD 17—the lead ship of the San Antonio class amphibious ships—is a case in point. The cost to construct the ship has more than doubled, delivery was delayed by over 3 years, and ship quality ultimately compromised.

Today, I would like to discuss (1) cost growth in shipbuilding programs, (2) acquisition approaches in the LPD 17, Littoral Combat Ship (LCS), the next-generation destroyer and aircraft carrier programs (DDG 1000 and CVN 78, respectively), and (3) steps the Navy can take to improve its acquisition decision making, particularly the adoption of a knowledge-based management framework.

Summary

Cost growth in shipbuilding programs remains a problem. Ships under construction at the beginning of the fiscal year have experienced cumulative cost growth almost $5 billion above their original budgets. Cost growth displaces other ships contemplated in the Navy's 30-year shipbuilding plan and reduces the buying power of the shipbuilding budget.

This cost growth illustrates the problems that arise when programs proceed without a solid business case. A business case requires a balance between the concept selected to satisfy warfighter needs and the resources—technologies, design knowledge, funding, time, and management capacity—needed to transform the concept into a product, in this case a ship. Both the LPD 17 and the LCS programs illustrate the perils of proceeding without a solid, executable business case. Both programs

pushed ahead without stable designs or realistic cost and schedule estimates, resulting in higher costs, schedule delays, and quality problems.

A paradigm shift is needed for shipbuilding programs. Technology maturity must be proved before a design can be considered stable, and production outcomes cannot be guaranteed until a stable design is demonstrated. The Navy also needs to

- define and align knowledge points more consistently across programs to optimize resource allocation and improve performance;
- ensure initial shipbuilding budgets are realistic by improving cost estimating, and
- improve cost management through increased use of fixed-price contracting and comprehensive cost surveillance.

Cost Growth Remains a Problem in Navy Shipbuilding Programs—and May Threaten Future Success

Cost growth is a persistent problem for shipbuilding programs as it is for other weapon systems. Over 40 ships were under construction at the beginning of this fiscal year. If the performance of future shipbuilding programs continues at the same rate as current programs, the Navy will be forced to fund cost growth in future budget years at the expense of other ships in the Navy's shipbuilding plan.

Funding for the 41 ships under construction is over $56 billion, almost $4.6 billion above initial budget requests.[a] Congress has already appropriated additional funds to cover most of these cost increases (see table 1).

[a]Based on the fiscal year 2008 President's budget request and over $513 million in fiscal year 2007 funding transfers from other Navy programs.

Table 1: Cost Growth in Program Budgets for Ships under Construction in Fiscal Year 2007

Dollars in millions

Ship		Initial budget	Fiscal year 2008 or latest President's budget	Total cost growth	Cost growth as a percent of initial budget
CVN 77		$4,975	$5,822	$847	17%
DDG 100–112		14,309	14,679	370	3
LCS 1-LCS 2[a]	 	472	1,075	603	128
LHD 8		1,893	2,196	303	16
LPD 18-23[b]		6,194	7,742	1,548	25
SSN 775-783[c]		20,744	21,678	934	5
T-AKE 1-9		3,354	3,386	32	1
Total: 41 ships		**$51,941**	**$56,578**	**$4,637**	

Source: GAO analysis of Navy data.

[a]Includes about $484 million in reprogrammed funding requested by the Navy through June 2007. A small amount of these funds may be designated for certain LCS research and development activities.

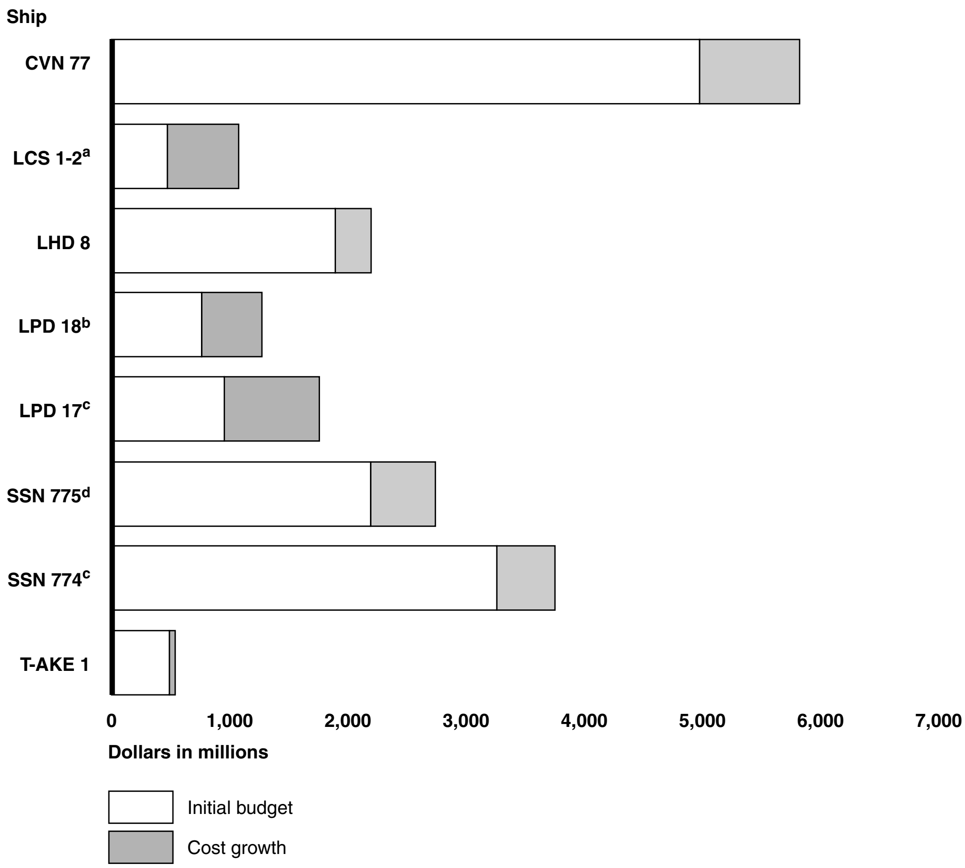
[b]Includes $29.3 million in reprogrammed funding requested by the Navy in 2007 to complete LPD 18 and LPD 20.

[c]The Navy has transferred $25.5 million in funding from SSN 776 to cover the costs of completing SSN 775 after delivery—and believes that additional unfunded shortfalls may still exist.

Note: For ships constructed on the Gulf Coast, cost growth can be attributed in part to the effects of Hurricanes Katrina and Rita. The Navy has already received over $1.1 billion in funding, and an additional $1.3 billion has also been appropriated for hurricane-related damages, but it has not yet been allocated to individual programs.

Breaking these costs down further reveals the dynamics of shipbuilding cost growth and the challenges it presents for the 30 year shipbuilding plan. For example, cost growth in mature programs, like the Arleigh Burke class destroyers (DDG 100-112) is low because most cost growth has already been captured in earlier ships. Cost growth in the Virginia class submarines (SSN 775-783) and the Lewis and Clark class auxiliary ships (T-AKE 1-9) is also low because they include several ships early in construction—before cost growth tends to occur. On the other hand, cost growth is particularly high on lead ships of a new class (see fig. 1).

Figure 1: Cost Growth in Lead Ships and Significant Follow-ons (Dollars in Millions)



Source: GAO analysis of Navy data.

[a]LCS 1 and 2 include about $484 million in reprogrammed funding requested by the Navy through June 2007. A small amount of these funds may be designated for certain LCS research and development activities.

[b]Includes $20.6 million in reprogrammed funding requested by the Navy in 2007 to complete LPD 18.

[c]SSN 774 and LPD 17 were delivered in October 2004 and January 2005, respectively.

[d]The Navy has transferred $25.5 million in funding from SSN 776 to cover the costs of completing SSN 775 after delivery—and believes that additional unfunded shortfalls may still exist.

Cost growth for recent lead ships has been on the order of 27 percent.[b] The Navy is developing two lead ships in the LCS program—each with a unique

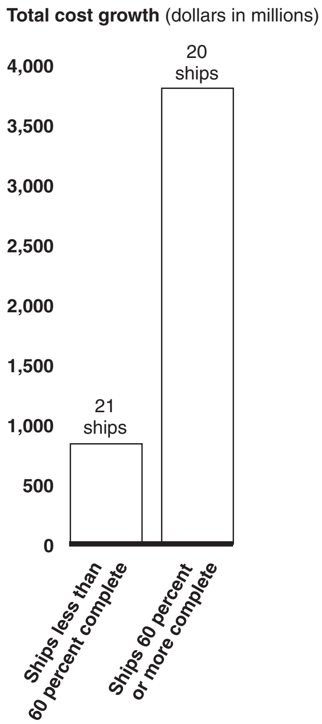
[b]Based on the initial and most recent President's budget request for all lead ships authorized between fiscal year 1996 and fiscal year 2006, including the second ship when the hull is constructed at a different shipyard than the first ship of the class.

design. These ships have already experienced a 128 percent cost growth. Cost increases are also significant if the second ship is assembled at a different shipyard than the first ship. This is the case with SSN 775, which has had cost growth of well over $500 million. Although the ship has been delivered, the Navy continues to incur costs for unfinished work.

Follow-on ships in many cases are also experiencing significant cost increases in construction. Although LPD 18 is the second ship of the class, construction costs grew by over $500 million—a more than 90 percent increase over its initial budget for construction. LPD 18 has recently been delivered, but the Navy requested an additional $20.6 million in reprogrammed funding in 2007 to complete the ship. Cost growth is particularly prevalent where major changes were made to an existing ship design. For example, CVN 77 is the final aircraft carrier of the Nimitz class and is based on the design of previous carriers, but it included over 3,500 design changes. CVN 77 has experienced cost growth in construction of over $847 million—a 17 percent increase over the initial budget.

Besides lead and mature ships, a number of ships under construction may not have realized the full extent of cost growth—which tends to lag behind the initial budget request by several years. In fact, the magnitude of cost growth occurs in later phases of construction—after ships are 60 percent or more complete (see fig. 2).

Figure 2 Cost Growth in Ships by Percent of Construction Completed



Source: GAO analysis of Navy data.

The current budgets for many ships have already proven inadequate to cover the likely costs to complete construction. Funding has been transferred from other Navy programs, obtained through prior year completion requests or shifted away from future build plans. The most prominent example is the LCS program. The Navy has already reprogrammed almost $485 million to fund cost increases for the first two LCS and deleted three Flight 0 ships from its budgets. The Navy transferred about $62 million in funding from future T-AKE ships to cover cost increases on the first two ships under construction. In the Virginia-class program, the Navy estimates about $130 million shortfall and plans to cover the shortfall from transfers from within the program. In December 2006, the Navy believed that about $67 million would be needed to complete LPD 20 and LPD 21. However, Navy officials stated that these estimates are too conservative because they represent cost growth against the current contract baseline for LPD ships under construction. The Navy anticipates increasing the baseline for the LPD 17 ships—resulting in even higher completion costs.

If current patterns of performance continue in the future, the Navy's shipbuilding plan will be in jeopardy. The Navy outlined its strategy for achieving a 313-ship force in its updated long-range shipbuilding plan. Over the next 5 years, the Navy plans to significantly increase the rate of construction and introduce nine new classes of ships, including the Ford-class aircraft carrier (CVN 78) and the Zumwalt-class destroyer (DDG 1000). To support the plan, the Navy will require shipbuilding funding significantly above current levels—on the order of $5 billion more by fiscal year 2013. The Navy recognizes that the success of the plan will depend on its ability to realistically estimate and control shipbuilding costs. Over the next year the Navy will begin construction of CVN 78, DDG 1000, and LHA 6 amphibious assault ship. The Navy estimates that these ships alone will require nearly $20 billion in construction funding, representing the Navy's most costly lead ships. Even a small percentage of cost growth on the big ships could lead to the need for hundreds of millions of dollars in additional funding.

Shipbuilding Programs Often Have Unexecutable Business Cases

Navy shipbuilding programs are often framed around an unexecutable business case, whereby ship designs seek to accommodate immature technologies, design stability is not achieved until late in production, and both cost and schedule estimates are unrealistically low. This situation has recently been evidenced in the LPD 17 and LCS programs, which have required costly out-of-sequence work during construction. The DDG 1000 and CVN 78 programs are at risk because of lingering technology immaturity, coupled with cost and schedule estimates with little margin for error.

Elements of a Business Case

We have frequently reported on the wisdom of using a solid, executable business case before committing resources to a new product development effort. In its simplest form, a business case requires a balance between the concept selected to satisfy warfighter needs and the resources—technologies, design knowledge, funding, time, and management capacity—needed to transform the concept into a product, in this case a ship. At the heart of a business case is a knowledge-based approach that requires that managers demonstrate high levels of knowledge as the program proceeds from technology development to system development and, finally, production. Adapting this approach to shipbuilding is a challenge, as I will discuss later. Ideally, in such an approach, key technologies are demonstrated before development begins. The design is stabilized before the building of prototypes or, in the case of ships, construction begins. At each decision point, the balance among time, money, and capacity is validated. In essence, knowledge supplants risk over time.

A sound business case would establish and resource a knowledge-based approach at the outset of a program. We would define such a business case as firm requirements, mature technologies, and an acquisition strategy that provides sufficient time and money for design activities before construction start. The business case is the essential first step in any acquisition program that sets the stage for the remaining stages of a program, namely the business or contracting arrangements and actual execution or performance. If the business case is not sound, the contract will not correct the problem and execution will be subpar. This does not mean that all potential problems can be eliminated and perfection achieved, but rather that sound business cases can get the Navy better shipbuilding outcomes and better return on investment. If any one element of the business case is weak, problems can be expected in construction. The need to meet schedule is one of the main reasons why programs cannot execute their business cases. This pattern was clearly evident in both the LPD 17 and LCS programs. In both cases, the program pushed ahead with production even when design problems arose or key equipment was not available when needed. Short cuts, such as doing technology development concurrently with design and construction, are taken to meet schedule. In the end, problems occur that cannot be resolved within compressed, optimistic schedules. Ultimately, when a schedule is set that cannot accommodate program scope, delivering an initial capability is delayed and higher costs are incurred.

In shipbuilding programs, the consequences of moving forward with immature technologies or an unstable design become clear once ship construction begins. Ships are designed and constructed with an optimal sequence—that is, the most cost-efficient sequence to construct the ship. This includes designing and building the ship from the bottom up and maximizing the units completed in shipyard shops and installed in the dry dock while minimizing tasks performed when the ship is already in the water, which tend to be costlier than tasks on land. Once units are installed access to lower decks of the ship becomes more difficult. If equipment is not ready in time for installation, the shipbuilder will have to work around the missing equipment. Additional labor hours may be needed because spaces will be less accessible and equipment may require more time for installation.

Business Cases Deteriorated with Construction of LPD 17 and Littoral Combat Ships

What happens when the elements of a solid business case are not present? Unfortunately, the results have been all too visible in the LPD 17 and the LCS. Ship construction in these programs has been hampered throughout by design instability and program management challenges that can be traced back to flawed business cases. The Navy moved forward with ambitious schedules for constructing LPD 17 and LCS despite significant challenges in stabilizing the designs for these ships. As a result, construction work has been performed out of sequence and significant rework has been required, disrupting the optimal construction sequence and application of lessons learned for follow-on vessels in these programs.

In the LPD 17 program, the Navy's reliance on an immature design tool led to problems that affected all aspects of the lead ship's design. Without a stable design, work was often delayed from early in the building cycle to later, during integration of the hull. Shipbuilders stated that doing the work at this stage could cost up to five times the original cost. The lead ship in the LPD class was delivered to the warfighter incomplete and with numerous mechanical failures, resulting in a lower than promised level of capability. These problems continue today—2 years after the Navy accepted delivery of LPD 17. Recent sea trials of the ship revealed problems with LPD 17's steering system, reverse osmosis units, shipwide area computing network, and electrical system, among other deficiencies. Navy inspectors noted that 138 of 943 ship spaces remained unfinished and identified a number of safety concerns related to personnel, equipment, ammunition, navigation, and flight activities. To date, the Navy has invested over $1.75 billion constructing LPD 17.

In the LCS program, design instability resulted from a flawed business case as well as changes to Navy requirements. From the outset, the Navy sought to concurrently design and construct two lead ships in the LCS program in an effort to rapidly meet pressing needs in the mine countermeasures, antisubmarine warfare, and surface warfare mission areas. The Navy believed it could manage this approach, even with little margin for error, because it considered each LCS to be an adaptation of an existing high-speed ferry design. It has since been realized that transforming a high-speed ferry into a capable, networked, survivable warship was quite a complex venture. Implementation of new Naval Vessel Rules (design guidelines) further complicated the Navy's concurrent design-build strategy for LCS. These rules required program officials to redesign major elements of each LCS design to meet enhanced survivability requirements, even after construction had begun on the first ship. While these requirements changes improved the robustness of LCS designs, they contributed to out of sequence work and rework on the lead ships. The Navy failed to fully account for these changes when establishing its $220 million cost target and 2-year construction cycle for the lead ships.

Complicating LCS construction was a compressed and aggressive schedule. When design standards were clarified with the issuance of Naval Vessel Rules and major equipment deliveries were delayed (e.g., main reduction gears), adjustments to the schedule were not made. Instead, with the first LCS, the Navy and shipbuilder continued to focus on achieving the planned schedule, accepting the higher costs associated with out of sequence work and rework. This approach enabled the Navy to achieve its planned launch date for the first Littoral Combat Ship, but required it to sacrifice its desired level of outfitting. Program officials report that schedule pressures also drove low outfitting levels on the second Littoral Combat Ship design as well, although rework requirements have been less intensive to date. However, because remaining work on the first two ships will now have to be completed out-of-sequence, the initial schedule gains most likely will be offset by increased labor hours to finish these ships.

The difficulties and costs discussed above relate to the LCS seaframe only. This program is unique in that the ship's mission equipment is being developed and funded separately from the seaframe. The Navy faces additional challenges integrating mission packages with the ships, which could further increase costs and delay delivery of new antisubmarine warfare, mine countermeasures, and surface warfare capabilities to the fleet. These mission packages are required to meet a weight requirement of 180 metric tons or less and require 35 personnel or less to operate them.[c] However, the Navy estimates that the mine countermeasures mission package may require an additional 13 metric tons of weight and 7 more operator personnel in order to deploy the full level of promised capability. Because neither of the competing ship designs can accommodate these increases, the Navy may be forced to reevaluate its planned capabilities for LCS.

[c]LCS mission packages include combat systems, support equipment, computing environment, and mission crew. The mission package weight requirement of 180 metric tons or less also includes aviation fuel, and the manning requirement of 35 or less includes personnel comprising an aviation detachment.

DDG 1000 and CVN 78 Have More Thoughtful Business Cases, but Significant Technical Risks Remain

Elements of a successful business case are present in the Navy's next-generation shipbuilding programs—CVN 78 and DDG 1000. The Navy's plans for these programs call for a better understanding of the designs of these ships prior to beginning construction, thereby reducing the risk of costly design changes after steel has been bent and bulkheads built. Yet some elements of their business cases put execution within budgeted resources at risk. While the Navy has recognized the need to mature each ship's design before beginning construction, CVN 78 and DDG 1000 remain at risk of cost growth due to continuing efforts to mature technologies. Success in these programs depends on on-time delivery and installation of fully mature and operational technologies in order to manage construction costs. Budgets and schedules for each ship leave little if any margin for error.

DDG 1000

The DDG 1000 development has been framed by challenging multi-mission requirements, resultant numerous technologies and a tight construction schedule driven by industrial base needs. In the DDG 1000 program, the Navy estimates that approximately 75 percent of detail design will be completed prior to the start of lead ship construction in July 2008. Successfully meeting this target, however, depends on maturing 12 technologies as planned. Currently, three of these technologies are fully mature. Two DDG 1000 technologies—the volume search radar and total ship computing environment—have only completed component-level demonstrations and subsequently remain at lower levels of maturity. Schedule constraints have also forced the Navy to modify its test plans for the integrated power system and external communication systems.

The volume search radar, one of two radars in the dual band radar system, will not have demonstrated the power output needed to meet requirements even after integrated land-based testing of the prototype radar system is completed in 2009. Production of the radars, however, is scheduled to begin in 2008, introducing additional risk if problems are discovered during testing. According to Navy officials, in the event the volume search radar experiences delay in testing, it will not be integrated as part of the dual band radar into the DDG 1000 deckhouse units that will be delivered to the shipbuilders. Instead, the Navy will have to task the shipbuilder with installing the volume search radar into the deckhouse, which program officials report will require more labor hours than currently allocated. The DDG 1000 program's experience with the dual band radar has added significance as the same radar will be used on CVN 78.

In the case of the DDG 1000 total ship computing environment, the Navy is developing hardware infrastructure and writing and releasing six blocks of software code. Although development of the first three software blocks progressed in line with cost and schedule estimates, the Navy has been forced to defer some of the functionalities planned in software release four to software blocks five and six due to changes in availability of key subsystems developed external to the program, introduction of non development items, and changes in program integration and test needs. The Navy now plans to fully mature the integrated system following ship construction start—an approach that increases program exposure to cost and schedule risk in production.

The DDG 1000 program also faces challenges completing testing for its integrated power system and external communications systems. Currently, shipbuilder-required equipment delivery dates for these systems do not permit time for system-level land-based integration testing prior to delivery. As a result, the Navy has requested funds in fiscal year 2008 for the third shipset of this equipment so that testing can be completed without interrupting the planned construction schedules of the first two ships. However, in the event problems are discovered, DDG 1000 construction plans and costs could be at risk.

CVN 78

The Navy has completed the basic design of CVN 78, and the shipbuilder is currently developing the carrier's more detailed design. According to the shipbuilder, about 70 percent of CVN 78's design is complete, with almost all of the very low decks of the ship completely designed. Progress in designing CVN 78 is partially the result of a longer preparation period that has enabled the shipbuilder to design more of the ship prior to construction than was the case on previous carriers. However, the Navy may face challenges in maintaining its design schedule because of delays in the development of the ship's critical technologies. Such delays could impede the completion of the ship's design and interfere with the construction of the ship.

CVN 78 will feature an array of advanced technologies such as a new nuclear propulsion and electric plant, an electromagnetic aircraft launch system (EMALS) and an improved aircraft arresting system. These technologies, along with an expanded and improved flight deck, are designed to significantly improve performance that the Navy believes will simultaneously reduce acquisition and life cycle costs compared to previous carriers. The Navy has focused much attention on developing technologies and has retired much risk. Yet risk remains. The schedule for installing CVN 78's technologies takes advantage of construction efficiencies. The shipbuilder has identified key dates when technologies need to be delivered to the yard in order to meet its optimal construction schedule. A number of CVN 78's technologies have an increased potential to affect this schedule because they are (1) located low in the ship and needed early in construction or (2) highly integrated or embedded in the ship's design. The dual band radar is integrated into the design of the carrier's island and is critical to the smaller island design. EMALS crosses 48 of the ship's 423 zones (or separate units that make up the ship's design). For example, problems with EMALS could have a cascading effect on other areas of the ship.

While the Navy has mitigated the risk posed by some technologies, like the nuclear propulsion and electric plant, key systems, in particular, EMALS, the advanced arresting gear, and the dual band radar have encountered difficulties during development that will likely prevent timely delivery to the shipyard. Challenges include the following:

- **EMALS** encountered technical difficulties developing the prototype generator and meeting detailed Navy requirements, which led to increased program costs and an over 15-month schedule delay. To meet shipyard dates for delivering equipment, the contractor eliminated all schedule margin, normally reserved for addressing unknown issues. Yet, significant challenges lay ahead—the Navy will begin testing a production representative system in 2008, and the shipboard system will be manufactured in a new facility inexperienced with production. If problems occur in testing or production, the contractor will not be able to meet its delivery date to the shipyard, causing work to be done out of sequence.
- The **advanced arresting gear** program faced difficulties delivering drawings to the Navy, leading to program delays. Schedule delays have slipped the production decision and delivery to CVN 78 by 6 months. In an effort to maintain shipyard delivery dates, the Navy has consolidated upcoming test events—increasing test cycles and eliminating schedule margin. However, by compressing test events, the Navy will have little time to address any problems prior to production start. Late delivery of the advanced arresting gear will require installation after the flight deck has been laid. The shipbuilder will expend additional labor to lower the system into place through a hole cut in the flight deck.
- The **dual band radar** presents the most immediate risk to the DDG 1000 program, but delays in production could cascade down to CVN 78—affecting delivery to the shipyard. Moreover, upcoming land-based testing will not include certain demonstrations of carrier-specific performance. In particular, the Navy has not yet scheduled tests to

verify the radar's air traffic control capability, but expects such demonstrations will occur by the end of fiscal year 2012. This leaves little to no time to make any necessary changes before the radar's 2012 in-yard date.

The CVN 78 business case also faces risks in the area of cost because the estimate that underpins the budget is optimistic. For example, the Navy estimates that fewer labor hours will be needed to construct CVN 78 than the previous two carriers—even though it is a lead ship that includes cutting edge technologies and a new design. Although the Navy is working with the shipbuilder now to reduce costs prior to the award of a construction contract (scheduled for early next year) through such measures as subsidizing capital expenditures to gain greater shipyard efficiency, costs will likely exceed budget if technologies or other materials are delivered late or labor hour efficiencies are not realized.

A Disciplined, Knowledge-Based Process Is Key to Better Outcomes

How can the Navy achieve better outcomes in its shipbuilding programs? Our work on best practices highlights the need for a disciplined, knowledge-based approach so that programs proceed with a high probability of success. This means technology maturity must be proven before a design can be considered stable, and production outcomes cannot be guaranteed until a stable design is demonstrated. The challenge in adapting such an approach to shipbuilding is determining when these levels of knowledge should be reached in shipbuilding programs and what standards should serve as criteria for demonstrating this knowledge. It seems that no two shipbuilding programs are run the same way. For example, it can be agreed that key aspects of a ship's detail design must be completed before construction begins. However, what those aspects are or how they should be measured is not defined. What may be acceptable in one shipbuilding program is not acceptable in another. In our reviews of ship programs, the definition of phases, strategies, and decision points varies from program to program. In addition to defining key junctures of knowledge, standards, and corresponding decision points for shipbuilding programs, there are other steps the Navy could take that would better inform its acquisition decision making in shipbuilding programs. These include:

- ensuring that initial shipbuilding budgets are realistically achievable by improving cost estimating, and
- improving cost management through increased use of fixed-price contracting and comprehensive cost surveillance.

Aligning Knowledge and Decision Points Consistently across Shipbuilding Programs

Each shipbuilding program seems to embody its own strategy for making decisions. In programs other than shipbuilding, the Milestone B decision represents the commitment to design and develop a system, at which time requirements should be firm and critical technologies mature. Milestone B means different things in different shipbuilding programs. The CVN 21 program held its Milestone B review shortly before a preliminary design review, and 3 years before the planned approval for the construction contract. The Milestone B review for DDG 1000—called DD(X) at the time--occurred over 1 year after the preliminary design review and shortly after the critical design review—it was used to authorize negotiation of a construction contract. The LCS program has received authorization for construction of six ships—it has yet to hold a Milestone B review.

The need for a common understanding of what Milestone B represents is all the more important given the requirements for certification at Milestone B enacted by Congress in 2006.[d] These provisions require the decision authority to certify that, among other things,

- the technology has been demonstrated in a relevant environment,
- requirements have been approved by the Joint Requirements Oversight Council,
- the program is affordable, and
- the program demonstrates a high likelihood of accomplishing its intended mission.

We believe that the certification for all shipbuilding programs should take place at the same point. The uniqueness of individual program strategies leads to similar challenges in trying to establish what level of knowledge is needed at subsequent critical junctures in shipbuilding programs. Each shipbuilding program seems to have a different measure as to how much of the design needs to be complete—and what constitutes design readiness—prior to beginning ship construction. It seems to us that there should be clear metrics for what the Navy expects at key junctures across all shipbuilding programs. Further, there appears to be few criteria across shipbuilding programs regarding how much knowledge—such as the percentage of ship units built—is needed at different decision points, including keel lay, fabrication start, and ship launch. A clearer understanding of the key knowledge junctures and corresponding criteria

[d]National Defense Authorization Act for Fiscal Year 2006, Pub. L. No. 109-163, § 801; 10 U.S.C. § 2366a.

across shipbuilding programs would help establish a better basis for cost and schedule estimates.

Establishing Executable Program Budgets through Improved Cost Estimating

As we have seen, the Navy's track record for achieving its initial budgets for shipbuilding programs has not been good. If we expect programs to be executed within budget, programs need to begin with realistic budgets. Since ship construction is generally budgeted in 1 fiscal year—or in the case of CVN 78 and DDG 1000—over 2 years, it is essential that the Navy understand and plan for the likely costs of the ship when construction is authorized. A ship's initial budget will, in large part, determine whether and how much cost growth will occur and require funding in later years.

The foundation of an executable budget is a realistic cost estimate that takes into account the true risk and uncertainty in a program. Realistic cost estimates are important not only because they are used to establish program budgets, but also because they help enable the Navy to determine priorities, including whether to proceed with a program. Our past work has shown that the Navy tends to underestimate the costs needed to construct ships—resulting in unrealistic budgets and large cost increases after ship construction has begun. Initial estimates of LPD 17 and LCS 1 assumed significant savings based on efficiencies that did not materialize as expected. Future ships like CVN 78 make similar assumptions.

One way to improve the cost-estimating process is to present a confidence level for each estimate, based on risk and uncertainty analyses. By conducting an uncertainty analysis that measures the probability of cost growth, the Navy can identify a level of confidence for its estimates and determine whether program costs are realistically achievable. Navy cost analysts told us that they used quantitative risk analyses to test the validity of cost estimates of CVN 78 and DDG 1000. We believe that the Navy and the Department of Defense (DOD) should take this a step further—requiring a high confidence level threshold when making program commitments and budget requests. The Defense Acquisition Performance Assessment Panel recommended an 80 percent confidence level, meaning that a program has an 80 percent chance of achieving its estimated costs.[e] Whether this is the right level warrants thoughtful discussion, but it is worth noting that analyses for CVN 78 and DDG 1000 were well below an

[e]Defense Acquisition Performance Assessment Panel, *Defense Acquisition Performance Assessment Report* (Washington, D.C., January 2006).

80 percent confidence level (in the case of DDG 1000 at around 45 percent)—increasing the likelihood that costs will grow above budget.

Timing is also an important element for achieving realism in budgets. In the past, the Navy has generally requested approval for detail design and construction of the lead ship at the same time. As a result, construction budgets did not benefit from the knowledge gained in system design or early stages of detail design. An alternative approach is to separate the decision to fund detail design from the decision to fund construction. The benefits of this approach are evident in the funding of DDG 1000. The Navy first requested funding for detail design and construction of the lead ship in its fiscal year 2005 budget request, estimating these costs to total $2.7 billion. Congress did not fund construction of the lead ship, but instead funded detail design and purchase of some materials in the fiscal years 2005 and 2006 budgets. In March 2005, the Navy completed a life-cycle cost estimate for the ship that placed the cost of DDG 1000 at $3.3 billion. DOD independent cost analysts estimated even higher costs. The budget request for fiscal years 2007 and 2008 included $3.3 billion for each of the two lead ships, reflecting an improved understanding of budget requirements compared to the initial fiscal year 2005 request.

Better Management of Costs through Fixed-Price Contracting and Comprehensive Cost Surveillance

The Navy can take other steps to improve the outcomes of its shipbuilding programs by strengthening its cost management capability, including

- greater use of fixed-price contracting and
- enhanced and comprehensive cost surveillance

Fixed-priced Contracting for Construction

In an effort to improve cost management, the Navy is promoting fixed-priced contracts for ship construction. In a fixed-price incentive contract, costs above a target are shared with the contractor, up to a ceiling price. Both the target cost and price ceiling are negotiated at the outset. The contractor is responsible for costs above the ceiling price, limiting the government's cost risk. In shipbuilding, lead ships are commonly done under cost-plus-incentive-fee contracts as are some follow-on ships. Under these contracts, the government is responsible for paying allowable costs incurred and the fee will be adjusted according to a negotiated formula. The first five LPD 17 ships use cost-plus-incentive-fee contracts and the first two LCS are being built under cost-type contracts. The Navy typically uses fixed-priced incentive contracts for ships that are later in the class, including DDG 51 class destroyers and CVN 77, and for all ships in the T-AKE class of auxiliary ships, a less complex ship.

We are encouraged by the Navy's efforts to move to fixed-price contracts. Fixed-price contracts limit the government's risk of cost growth while encouraging realism in negotiating contract prices and careful cost management. However, the move to fixed-price contracting is feasible only if risks can be understood and managed. If the Navy is to use fixed-price contracts for the second or third ship in the class—or even the lead ship—it must supplant risk with knowledge. We are convinced that a move to fixed-price contracting will only succeed if the Navy adopts a more disciplined process, one that ensures that the elements of an executable business case exist as the development effort begins. If technologies are still being demonstrated, the delivery of critical systems when needed cannot be assured. Nor can designs be finalized. Increased used of fixed-price contracting requires that technologies be demonstrated early, the design stabilized before construction begins, and realistic estimates for cost and schedule made.

Cost Surveillance

Given the risk of cost growth in shipbuilding, it is equally important that the Navy strengthen its oversight of shipyard cost performance. Our work has shown that the Navy may not have adequate management tools necessary to identify and react to early signs of cost growth. In particular, in the CVN 78 program the Navy has not effectively used earned value management data captured in cost performance reports submitted by the contractor. Earned value management is a tool that provides the government and contractors with insight into technical, cost, and schedule progress on their contracts. Although the shipbuilder is designing much of CVN 78 prior to the award of the construction contract, we found that contractor cost performance reports do not provide an objective measure of program schedule and costs incurred. While the Navy expects that future cost performance reports will better reflect shipyard performance after the construction contract is awarded and significant construction work is under way, it has missed an opportunity to gain insight into current costs—and gauge future shipyard performance. Moreover, the Navy may not require the shipbuilder to submit monthly cost performance reports that include variance analyses, which describe the reasons for cost and schedule variances. Without monthly contractor performance reports that include variance analyses, the Navy will miss timely information regarding root causes for cost and schedule problems and mitigation efforts—making it more difficult to identify risk and take corrective action.

But timely and complete cost performance reports are not enough. The Navy must leverage this information to better manage shipbuilder performance. In particular, the Navy's Supervisor of Shipbuilding

(SUPSHIP) is not engaged in evaluating shipbuilder cost performance for all shipbuilding programs. SUPSHIP provides the Navy with unique insight into program performance because it is located at the shipyard, providing on-site program surveillance, including independent analysis of shipbuilder cost and schedule performance. However, SUPSHIP does not currently have the capability to conduct independent cost surveillance of the CVN 78 program. We believe that this capability is necessary to effectively analyze shipbuilder cost data and verify that the data depict actual conditions and trends.

Cost surveillance at the shipyard is just one element of the management capacity needed to plan and execute shipbuilding programs. There has also been considerable discussion of the need to have a workforce with the right skills in the right numbers. It has been more difficult to arrive at a firm definition of the size and composition of the workforce needed, and the appropriate balance between government and contractor personnel. Sharp declines in the size of the acquisition workforce have occurred over the last several years. The Navy's numbers are a case in point. The Navy reports that staffing at Naval Sea Systems Command headquarters has decreased by almost 50 percent since 1991, from 4,871 to 2,331 personnel.

Mr. Chairman, that concludes my statement. I would be pleased to answer any questions.

Objectives, Scope, and Methodology

To develop information on the status of Navy shipbuilding programs and practices that can improve the process for acquiring ships, we relied largely on our prior reporting on shipbuilding programs and updates to this work, as well as work under way for the committee on the CVN 78 program. In the course of this work, we analyzed program documents, including program baselines, contractor performance reports, cost estimates, budget documents and other program assessments, as well as policy guidance. We also interviewed government, shipbuilding, and other contractor officials associated with a number of shipbuilding programs, including CVN 77 and 78, LPD 17, DDG 1000, LCS, and Virginia-class Submarines.

Contact and Staff Acknowledgments

For future questions about this statement, please contact me at (202) 512-4841. Individuals making key contributions to this statement include Lisa L. Berardi, Noah B. Bleicher, Gwyneth M. Blevins, Lily J. Chin, Todd Dice, Christopher R. Durbin, Jennifer Echard, Diana Moldafsky, Moshe Schwartz, and Karen Zuckerstein.

Related GAO Products

Defense Acquisitions: Progress and Challenges Facing the DD(X) Surface Combatant Program. GAO-05-924T, Washington, D.C.: July 19, 2005.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-07-406SP, Washington, D.C.: March 30, 2007.

Defense Acquisitions: Challenges Associated with the Navy's Long-Range Shipbuilding Plan. GAO-06-587T, Washington, D.C.: March 30, 2006.

Defense Acquisitions: Challenges Remain in Developing Capabilities in Naval Surface Fire Support. GAO-07-115, Washington, D.C.: November 30, 2006.

Defense Acquisitions: Improved Management Practices Could Help Minimize Cost Growth in Navy Shipbuilding Programs. GAO-05-183, Washington, D.C.: Feb. 28, 2005.

Defense Acquisitions: Plans Need to Allow Enough Time to Demonstrate Capability of First Littoral Combat Ships. GAO-05-255, Washington, D.C.: March 1, 2005.

Appendix I: Cost Growth for Individual Ships

Table 2: Cost Growth in Program Budgets

Dollars in millions (figures may not add due to rounding)

Ship	Initial Budget	Fiscal year 2008 President's budget[a]	Total cost growth	Cost growth due to construction	Cost growth due to Navy-furnished equipment	Cost growth as a percent of initial budget
CVN 77	$4,975	$5,822	$847	$771	$76	17%
DDG 100	938	1,066	128	142	(13)	14
DDG 101	935	984	49	62	(13)	5
DDG 102	1,016	1,097	80	126	(46)	8
DDG 103	1,107	1,117	10	56	(46)	1
DDG 104	1,062	1,113	51	97	(46)	5
DDG 105	1,184	1,207	23	42	(20)	2
DDG 106	1,233	1,240	7	27	(20)	1
DDG 107	1,089	1,093	4	21	(17)	0
DDG 108	1,102	1,103	1	18	(17)	0
DDG 109	1,138	1,142	4	21	(17)	0
DDG 110-112	3,505	3,517	12	29	(17)	0
LCS 1-2	472	1,075[b]	603	NA	NA	128
LHD 8	1,893	2,196	303	320	(17)	16
LPD 18	762	1,272	510	531	(22)	67
LPD 19	1,064	1,286	222	228	(6)	21
LPD 20	890	1,137	247	311	(64)	28
LPD 21	1,113	1,287	173	283	(110)	16
LPD 22	1,256	1,403	147	287	(140)	12
LPD 23	1,108	1,357	249	337	(88)	22
SSN 775	2,192	2,740	548	546	1	25
SSN 776	2,020	2,183	164	154	9	8
SSN 777	2,276	2,332	56	65	(9)	2
SSN 778	2,192	2,242	50	246	(196)	2
SSN 779	2,152	2,255	102	283	(180)	5
SSN 780	2,245	2,289	44	41	3	2
SSN 781	2,402	2,378	(24)	(24)	(0)	-1
SSN 782	2,612	2,604	(7)	(7)	0	0
SSN 783	2,654	2,654	-	-	-	0
T-AKE 1	489	538	49	44	6	10
T-AKE 2	358	370	12	9	3	3
T-AKE 3	361	335	(26)	(25)	(1)	-7

Ship	Initial Budget	Fiscal year 2008 President's budget[a]	Total cost growth	Cost growth due to construction	Cost growth due to Navy-furnished equipment	Cost growth as a percent of initial budget
T-AKE 4	370	342	(28)	(32)	4	-8
T-AKE 5/6	683	702	19	20	(1)	3
T-AKE 7/8	713	712	(1)	4	(4)	0
T-AKE 9	380	386	6	9	(3)	2
Total	**$ 51,941**	**$ 56,578**	**$ 4,637**			

Source: GAO analysis of Navy data.

[a]Includes reprogramming actions and requests through June 2007.

[b]A small amount of these funds may be designated for certain LCS research and development activities.

GAO's Mission

The Government Accountability Office, the audit, evaluation and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through GAO's Web site (www.gao.gov). Each weekday, GAO posts newly released reports, testimony, and correspondence on its Web site. To have GAO e-mail you a list of newly posted products every afternoon, go to www.gao.gov and select "Subscribe to Updates."

Order by Mail or Phone

The first copy of each printed report is free. Additional copies are $2 each. A check or money order should be made out to the Superintendent of Documents. GAO also accepts VISA and Mastercard. Orders for 100 or more copies mailed to a single address are discounted 25 percent. Orders should be sent to:

U.S. Government Accountability Office
441 G Street NW, Room LM
Washington, D.C. 20548

To order by Phone:	Voice:	(202) 512-6000
	TDD:	(202) 512-2537
	Fax:	(202) 512-6061

To Report Fraud, Waste, and Abuse in Federal Programs

Contact:

Web site: www.gao.gov/fraudnet/fraudnet.htm
E-mail: fraudnet@gao.gov
Automated answering system: (800) 424-5454 or (202) 512-7470

Congressional Relations

Gloria Jarmon, Managing Director, JarmonG@gao.gov (202) 512-4400
U.S. Government Accountability Office, 441 G Street NW, Room 7125
Washington, D.C. 20548

Public Affairs

Paul Anderson, Managing Director, AndersonP1@gao.gov (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, D.C. 20548

PRINTED ON RECYCLED PAPER