United States Government Accountability Office

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Report to the Chairman, Subcommittee on Projection Forces, Committee on Armed Services, House of Representatives

September 2004

DEFENSE ACQUISITIONS

Challenges Facing the DD(X) Destroyer Program

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GAO-04-973

Highlights

Highlights of GAO-04-973, a report to the Chairman of the Subcommittee on Projection Forces, Committee on Armed Services, House of Representatives

Why GAO Did This Study

The DD(X) destroyer—a surface ship intended to expand the Navy's littoral warfare capabilities—depends on the development of a number of new technologies to meet its requirements. The Navy intends to authorize detailed design and construction of the first ship in March 2005.

GAO's past work has shown that developing advanced systems that rely heavily on new technologies requires a disciplined, knowledge-based approach to ensure cost, schedule, and performance targets are met. Best practices show, for example, that a program should not be launched before critical technologies are sufficiently matured—that is, the technology has been demonstrated in its intended environment—and that a design should be stabilized by the critical design review.

Given the complexity of the DD(X) system and the number of new technologies involved, GAO was asked to describe the Navy's acquisition strategy for DD(X) and how it relates to best practices, and how efforts to mature critical technologies are proceeding.

What GAO Recommends

GAO is not making recommendations in this report. Program officials agreed with our assessment of DD(X) program risks, but believe these risks can be mitigated.

www.gao.gov/cgi-bin/getrpt?GAO-04-973.

To view the full product, including the scope and methodology, click on the link above. For more information, contact Paul L. Francis at (202) 512-2811 or francisp@gao.gov.

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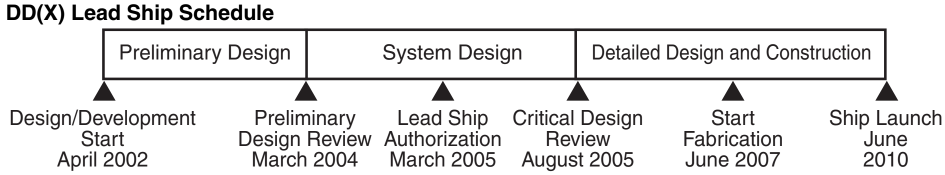
DEFENSE ACQUISITIONS

Challenges Facing the DD(X) Destroyer Program

What GAO Found

To reduce program risk, the Navy plans to build and test 10 developmental subsystems, or engineering development models, that comprise DD(X)'s critical technologies. While using these models represents a structured and disciplined approach, the program's schedule does not provide for the engineering development models to generate sufficient knowledge before key decisions are made. None of the technologies in the 10 engineering development models was proven to be mature when system design began, as best practices advocates. Moreover, the Navy does not plan to demonstrate DD(X) technology maturity and design stability until after the decision to authorize construction of the lead ship, creating risk that cost, schedule, and performance objectives will not be met. With many of the tests to demonstrate technology maturity occurring around the time of critical design review in late fiscal year 2005, there is the risk that additional time and money will be needed to address issues discovered in testing.

DD(X) Lead Ship Schedule



Source: GAO analysis of Department of Defense information.

Some of the technologies are progressing according to the Navy's plans, while others have experienced challenges. Four of the 10 engineering development models—the total ship computing environment, the peripheral vertical launch system, the hull form, and the infrared mockups—are progressing as planned toward demonstrating complete subsystems. However, four other models—the integrated power system, the autonomic fire suppression system, the dual band radar, and the integrated deckhouse—have encountered some problems. At this point, the most serious appear to be the schedule delay in the dual band radar resulting from the Navy's decision to change one radar type and the additional weight of the integrated power system. The two remaining engineering development models—the integrated undersea warfare system and the advanced gun system—are progressing as planned, but will not culminate in the demonstration of complete subsystems before being installed on the first ship. While the Navy has fallback technologies for the hull form and the integrated power system, it does not have such plans for the other eight engineering development models.

Contents

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United States Government Accountability Office
Washington, D.C. 20548

September 3, 2004

The Honorable Roscoe G. Bartlett
Chairman
Subcommittee on Projection Forces
Committee on Armed Services
House of Representatives

The DD(X) destroyer is a surface ship intended to expand the Navy's land attack and littoral warfare capabilities. The program is currently in the system design phase and the Navy plans to authorize detailed design and construction of the lead ship in March 2005. A number of technology advancements are necessary for the DD(X) to meet its requirements. The Navy plans to demonstrate the technologies by building and testing 10 developmental subsystems, referred to as engineering development models.

In response to your February 26, 2004, request, we assessed the DD(X) program's acquisition strategy and technology maturation efforts, and briefed your staff on May 18, 2004. As agreed in that meeting, we have prepared this report, which updates and further explains the information briefed. This letter addresses: (1) the program's strategy for maturing technologies and how it compares to best practices and (2) how efforts to mature critical technologies are proceeding.

To assess the program's strategy for maturing technologies, we reviewed the program's acquisition strategy, test and evaluation master plan, and other relevant documents and information. We also drew on our prior work on best practices in developing complex systems. To address the progress of technology development efforts, we analyzed reviews of current test activities and design assessments, cost performance reports, and other program information. We also met with program officials including those leading each of the engineering development models. In addition, we met with officials of companies under contract to design DD(X), including the prime contractor, Northrop Grumman Ship Systems, and several of its subcontractors. We compared data obtained from various documents and program officials against each other to ensure data reliability. We conducted our work from April 2004 to July 2004 in accordance with generally accepted government auditing standards.

Results in Brief

The engineering development models used by the program to mature technologies and reduce risk represent a structured and disciplined approach. The models generally call for designing, developing, and testing the DD(X) subsystems that house the key technologies before ship construction begins. Formal risk assessments and risk reduction strategies are an element of each model. However, the program's schedule does not provide for the models to demonstrate high levels of maturity when needed. Best practices call for demonstrating technologies before entering system design and stability of system design before proceeding with production. None of the 10 engineering development models were demonstrated when system design began. DD(X) technology maturity and design stability will not be demonstrated before the decision to authorize construction of the lead ship, creating risks for establishing and meeting realistic cost, schedule, and performance objectives. With many of the tests to demonstrate technology maturity occurring around the time of critical design review in late fiscal year 2005, there is a risk that additional time and money will be necessary to address issues discovered in testing. Program officials acknowledge the risks associated with the advanced technologies, but believe that taking such risks is warranted to ensure that DD(X) technologies are not obsolete and that they have taken adequate steps to mitigate the risks before ship construction begins.

Of the 10 engineering development models, four are progressing as planned toward demonstrating complete subsystems, including the total ship computing environment, the peripheral vertical launch system, the hull form, and the infrared mockups. Four models have encountered some problems, including the integrated power system, the autonomic fire suppression system, the dual band radar, and the integrated deckhouse. At this point, the most serious appear to be the schedule delay in the radar resulting from the Navy's decision to change one radar type and the additional weight of the integrated power system. The two remaining engineering development models–the integrated undersea warfare system and the advanced gun system–are progressing as planned, but will not culminate in the demonstration of complete subsystems before being installed on the first ship. The Navy does have backup approaches as a contingency for the hull form and the integrated power system, but not for the other engineering development models.

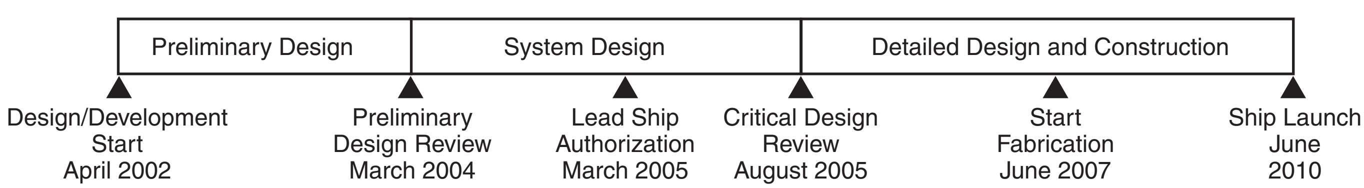
Background

The DD(X) destroyer is a multimission surface ship designed to provide advanced land attack capability in support of forces ashore and contribute to U.S. military dominance in littoral operations. Among its planned features is the ability to engage land targets from long ranges using its 155-millimeter guns and Tomahawk land attack cruise missiles. The ship will also feature reduced radar, acoustic, and heat signatures to increase survivability in the littorals. In November 2001, the Navy restructured the program to focus on developing and maturing a number of transformational technologies. These technologies will provide a baseline to support development of a range of future surface ships such as the future cruiser and the Littoral Combat Ship.

The DD(X) program is managing risk by designing, developing, and testing 10 engineering development models for the program's critical technologies. Each of the 10 engineering development models represents an experimental subsystem of DD(X) and may incorporate more than one transformational technology.

The key events in the DD(X) schedule are shown in figure 1.

Figure 1: DD(X) Lead Ship Schedule of Events



Source: GAO analysis of Department of Defense information.

The program completed its system-level preliminary design review March 2004 and is currently in system design. The next major event occurs in March 2005, when the Navy will seek authority to commit research, development, test and evaluation funds for detailed design and construction of the lead ship. The program's system-level critical design review will be held late in fiscal year 2005 after the lead ship authorization and will assess design maturity. The current contract for design and development of DD(X) ends in September 2005. Further design and development activities, including detailed design and construction, will take place under a new contract to be awarded in March 2005.

The Conference Report to the fiscal year 2005 Defense Appropriations Act states that the funds appropriated for DD(X) in the act are limited to design and advanced procurement requirements for the first two ships. The Conference Report further directs that no funds are available for the procurement of materials dependent upon delivery of key DD(X) technologies unless those technologies have undergone testing. The Conference Report also states that the Navy should complete land-based testing of the advanced gun system and integrated power system prior to the completion of the critical design review.[1]

Program Strategy Has Good Features but Demonstrates Technologies after Key Commitments

The Navy is developing 12 technologies for DD(X) using 10 engineering development models. Engineering development models seek to demonstrate key DD(X) subsystems and may involve more than one critical technology (see table 1).

[1] H.R. CONF. REP. NO. 108-622, at 188 and 310 (2004).

Table 1: Description of Engineering Development Models

Engineering development models	Description
Advanced Gun System	Will provide long-range fire support for forces ashore through the use of unmanned operations and the long-range land attack projectile.
Autonomic Fire Suppression System	Intended to reduce crew size by providing a fully automated response to fires.
Dual Band Radar	Horizon and volume search improved for performance in adverse environments.
Hull Form	Designed to significantly reduce radar cross section.
Infrared Mockup	Seeks to reduce ship's heat signature in multiple areas.
Integrated Deckhouse and Apertures	A composite structure that integrates apertures of radar and communications systems.
Integrated Power System	Power system that integrates power generation, propulsion, and power distribution and management.
Integrated Undersea Warfare System	System for mine avoidance and submarine warfare with automated software to reduce workload.
Peripheral Vertical Launch System	Multipurpose missile launch system located on the periphery of the ship to reduce damage to ship systems.[a]
Total Ship Computing Environment	Provides single computing environment for all ship systems to speed command while reducing manning.

Source: DD(X) program office and contractors.

[a]The Navy refers to both the enclosure for the launcher and the full subsystem as the Peripheral Vertical Launch System.

The engineering development models are the most significant aspect of the program's risk reduction strategy. To demonstrate technologies, each DD(X) development model follows a structured approach for design, development, and testing. Initially, requirements for each of the development models are defined and recorded in a common database. The risk of not meeting these requirements is assessed and strategies are formulated to reduce these risks. Once designs are formulated, components are tested to build knowledge about a subsystem's viability. In testing, the performance of engineering development models is confirmed. It is these tests that provide confidence in a technology's ability to operate as intended. Once the technology is demonstrated, the subsystem can be integrated into the ship's system design.

Our reviews of commercial and Department of Defense acquisition programs have identified a number of specific practices that ensure that high levels of knowledge are achieved at key junctures in development and used to make investment decisions.[2] The most important practice is achieving a high level of technology maturity at the start of system development. A technology reaches full maturity when its performance is successfully demonstrated in its intended environment. Maturing a technology to this level before including it into system design and development can reduce risk by creating confidence that a technology will work as expected and allows the developer to focus on integrating mature technologies into the ship design. This improves the ability to establish realistic cost, schedule, and performance objectives as well as the ability to meet them. Including the technologies in system development before reaching maturity raises the risk of discovering problems late that can increase the cost and time needed to complete design and fabrication.

The Navy's use of engineering development models to mature DD(X) technologies represents a disciplined process for generating the information needed for development, and corresponds with portions of the best practices approach. In using engineering development models, the Navy seeks to achieve high levels of technology maturity by first defining the requirements and risks of a developmental technology and then executing a series of tests to reduce these risks and prove the utility of a technology in its intended environment. The progress of technology maturity is recorded and communicated clearly through the use of established metrics, affording the program manager and others readily available information for use in decision making.

The program's schedule, however, does not allow most engineering development models to generate sufficient knowledge before key decisions are made. None of the DD(X) technologies included in the 10 engineering development models were mature at the start of system design and none are expected to be mature at the March 2005 decision to authorize detailed design and construction of the lead ship. Under the current schedule, 7 of the 10 subsystems will not be demonstrated until the end of program's critical design review in August 2005 or beyond. The decision to authorize

[2] For more information see GAO, *Best Practices: Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO/NSIAD-99-162 (Washington, D.C.: July 30, 1999) and *Best Practices: Capturing Design Manufacturing Knowledge Early Improves Acquisition Outcomes*, GAO-02-701 (Washington, D.C.: July 15, 2002).

award of the contract for detail design and construction of the lead ship will thus be made before the technologies are proven and the design is stable. By the end of the critical design review, only three subsystems are expected to have completed testing: the autonomic fire suppression system, the hull form, and the infrared mockups. The integrated power system, peripheral vertical launch system, and total ship computing environment complete testing just after the critical design review. The remaining four subsystems complete testing well after critical design review or are not tested as fully integrated systems until after installation on the first ship. The Navy is aware of the risks presented by its schedule but stated that exit criteria have been established for milestone decisions which ensure requirements will be met. Program officials further stated that, according to the Department of Defense acquisition policy, technologies for ships do not have to be mature until shipboard installation.

Our reviews of commercial best practices identified a second critical practice that increases a program's chances of success: achieving design stability by the system-level critical design review. For a stable design, subsystems are integrated into a product that meets the requirements of the user. Design stability requires detailed knowledge of the form, fit, and function of all technologies as well as the integration of individual, fully matured subsystems. Stability of design allows for testing to prove system reliability and leads into production planning.

Most of the testing of the engineering development models will take place in the months immediately before and after critical design review and beyond. Even if the models proceed with complete success, they will not be done in time to achieve design stability at the critical design review. If problems are found in testing–as has been the case with other programs–they could result in changes in the design, delays in product delivery, and increases in product cost.[3] Detailed knowledge about subsystems and their component technologies is necessary for developing the system design. If this information is not available and assumptions about operating characteristics have to be made, redesign may be necessary when reliable information becomes available. This can increase the schedule and the costs of system design. Unstable system design could also affect

[3] See GAO, *Defense Acquisitions: The Army's Future Combat Systems' Features, Risks, and Alternatives*, GAO-04-635T (Washington, D.C.: Apr. 1, 2004).

construction. Higher construction costs are likely to be incurred if work is done inefficiently or if changes result in rework.

One example of the consequences of technology and design immaturity already apparent in the DD(X) program is the development of the dual band radar and its impact on the integrated deckhouse. The dual band radar consists of two separate radar technologies and will not complete testing until fiscal year 2008. Due to this lengthy period of testing, the dual band radar may not be installed until the first ship is afloat. Contractors have stated that this schedule has led to the need for increased funding. Because the dual band radar will not be fully tested by critical design review, program officials have had to make some assumptions about where in the deckhouse it will be placed. If the weight of the radar increases or if other technical factors cause it to be relocated, a redesign effort may be needed to assure that requirements are met. As the deckhouse forms a significant portion of the DD(X), redesign could have an impact on the ship as a whole.

Other shipbuilding programs have developed strategies that call for maturing critical technologies while still providing decision makers with relatively high levels of knowledge at key decision points. For example, the CVN-21 future aircraft carrier program has a risk reduction strategy that defines a timeline for making decisions about a technology's maturity. The majority of these decisions are made early in the system design phase prior to the system critical design review. This should allow the system design to proceed in integrating technologies with the assurance that they will work in their intended environment. Lead ship authorization occurs after critical design review so that the maturity of the design can be demonstrated before a decision is made.

Some DD(X) Development Models Progressing as Planned by the Navy; Others Are Experiencing Challenges

The DD(X) program entered its system design phase without the majority of its technologies completing their design or component testing stage. These activities include events like design reviews for the integrated power system and damage testing on components of the peripheral vertical launch system. The only development model beyond these initial stages is the hull form, which has completed its initial tests and simulations and is now entering a second design and test phase.

Testing subsystems to demonstrate whether they will work in their intended environment is scheduled to begin for most development models in fiscal year 2005 and will continue, in some cases, beyond fiscal year 2006, as shown in table 2.

Table 2: Engineering Development Model Test Schedule

Engineering development model	Begin testing	End testing
Advanced Gun System		
Advanced Gun System	June 2005	August 2005
Long Range Land Attack Projectile	September 2004	September 2005
Integrated System[a]	—	—
Autonomic Fire Suppression System	January 2005	August 2005
Dual Band Radar		
Multi-Function Radar	October 2004	April 2006
Volume Search Radar	September 2006	June 2007
Integrated System	August 2007	January 2008
Hull Form	August 2003	July 2004
Infrared Mockup	March 2005	July 2005
Integrated Deckhouse and Apertures	February 2005	June 2005[b]
Integrated Power System	July 2005	September 2005
Integrated Undersea Warfare System	[c]	[c]
Peripheral Vertical Launch System		
Advanced Vertical Launch System (Launcher)	May 2005	September 2005
Peripheral Vertical Launch System (Enclosure)	March 2005	May 2005
Integrated System	May 2005	May 2005
Total Ship Computing Environment	August 2005	September 2005

Source: DD(X) program office and contractors.

[a]Tests using both the gun system and projectile are not performed until after ship installation.

[b]Tests with volume search portion of dual band radar are not performed under the current contract.

[c]Tests of the undersea warfare system to demonstrate components will occur between May 2004 and December 2005 the full system will not be demonstrated until after ship installation.

Four of the 10 engineering development models—the total ship computing environment, the peripheral vertical launch system, the hull form, and the infrared mockups—are progressing as planned toward demonstrating complete subsystems. However, challenges have arisen with other development models. The impact of some of these challenges has been mitigated with minimal change to the program, but others remain unresolved or have resulted in rescheduling and cost growth. Only two of the engineering development models, the hullform and the integrated power system, have fallback technologies that could be used if current technologies do not meet requirements. All other engineering development models could necessitate system level redesign if they fail to mature technologies to meet requirements. We have already noted the challenges with the dual band radar and its impact on the integrated deckhouse. Other challenges are highlighted below. Program officials agreed with our assessment of DD(X) program risks, but believe these risks can be mitigated through use of fallback technologies and design budgeting. Design budgeting refers to the practice of building in extra margins, such as weight and space, to accommodate growth as the design matures. Appendix I provides details on the status of all 10 engineering development models.

The integrated power system is currently exceeding its weight allowances by a significant amount and has used up its entire additional design margin for weight. This means that any further increases in weight could affect other systems or result in an unplanned and unbudgeted weight reduction program. The power system has also experienced some software compliance issues with the total ship computing environment. Program officials have defined the software issue and are working toward a solution. In addition, the testing schedule for the power system has been altered due to changes to the dual band radar. Program officials had planned to test the two subsystems together in at-sea tests on a surrogate vessel. When the delays in testing for dual band radar occurred, at-sea tests for the power system were cancelled. To compensate for the loss of knowledge that was to be gained by this testing, the program office plans for increased fidelity in land based testing. Plans for the integrated power system do include the use of a fallback technology. Use of the technology would require some trade-offs in performance, weight, and noise requirements. In their comments on this report, the Department of Defense stated that the Navy has allocated additional margin from the total ship design to account for weight growth in the integrated power system. While this adjustment in overall ship margin does not directly impact the overall ship design, it may leave less space for future growth in other systems.

While the early tests of the autonomic fire suppression system exceeded expectations, by sustaining significant damage and still controlling the fire, some challenges have arisen that delayed later testing. Like the power system, the fire suppression system experienced compatibility issues with the total ship computing environment. These issues have been recognized and the program office has identified solutions to resolve them. These software compatibility issues caused a delay in the system tests that pushed their completion beyond the system-level critical design review.

The current testing plans for the integrated undersea warfare system include testing of the dual frequency sonar array for internal interference, the ability of the high frequency portion of this array to detect mines, and the software necessary to integrate all functions and reduce the sailor's workload. Though these tests may prove the functionality of components and technologies within the undersea warfare system, they do not demonstrate the system as a whole. As a result, when the current series of testing concludes in May 2005, the undersea warfare system will not have demonstrated operations in the intended environment.

While development of the advanced gun system is proceeding as planned and has even overcome early challenges in design and development, the current plans do not include fully demonstrating the maturity of the subsystem. Land based testing of the gun system, including the automated mount and magazine, is planned for the summer of 2005 and flight tests for the munition are set to complete in September of 2005. However, the two technologies will not be tested together until after ship installation. Program officials cited lack of adequate test facilities as the reason for the separate tests.

Agency Comments

In commenting on a draft of this report, DOD stated that it is appropriate to undertake a reasonable amount of risk in the DD(X) lead ship, given the long production lead time in shipbuilding. It noted that the DD(X) risk mitigation approach represents the management of finite resources to achieve innovation and to implement a cost effective test plan designed to address those risks. DOD stated that the DD(X) schedule supports readiness of all the engineering development models in time for ship installation, which for shipbuilding programs, is the most relevant point of reference for technology maturity as DOD policy indicates technologies for ships do not have to be mature until that time. DOD concluded that the DD(X) engineering development models are on track to support a milestone B decision in March 2005 to authorize the lead ship and to achieve maturity prior to installation. DOD pointed out that it had selected exit criteria for that decision to provide for assessments of critical technologies and that results of all required tests will be available for the decision. DOD made specific comments on individual engineering development models, which we address elsewhere in the report.

As noted in the draft report, we believe the approach the Navy has taken to demonstrate DD(X) technologies through the engineering development models is both structured and disciplined. However, the short amount of time between lead ship authorization and ship launch (5 years and 3 months), together with the fact that virtually every major subsystem on the ship depends on a new technology or novel use of existing technologies, frame a challenge that involves significant risk. While tests on some key subsystems are scheduled to be conducted by the milestone B decision, these tests are to demonstrate the functionality of components but not the subsystems. Thus, the full demonstration of technology maturity and the resolution of unknowns will continue beyond the milestone decision. Our past work on best practices has shown that technological unknowns discovered later in product development lead to cost increases and schedule delays. Two key factors that can mitigate the effect of such risks—time in the schedule to address problems and the availability of backup technologies—are largely unavailable for the DD(X) program. While DOD policy allows for technologies to mature up to the point of ship installation, it does not necessarily follow that this is a best practice. In fact, DD(X) will proceed from the start of development to initial capability in about the same time as other non-shipbuilding systems for which DOD does call for demonstration of technology maturity before development start.[4]

We plan to provide copies of this report to the Senate Armed Services Committee; the Senate Committee on Appropriations, Subcommittee on Defense; and the House Committee on Appropriations, Subcommittee on Defense. We also will provide copies to the Director, Office of Management and Budget; the Secretary of Defense; and the Secretary of the Navy. We will make copies available to others upon request.

[4] Examples include the F/A-22 Raptor (14.5 years), the Joint Strike Fighter (10 years 5 months to 11 years 5 months), and the Expeditionary Fighting Vehicle (7 years 9 months). DD(X) will take 8 years and 2 months.

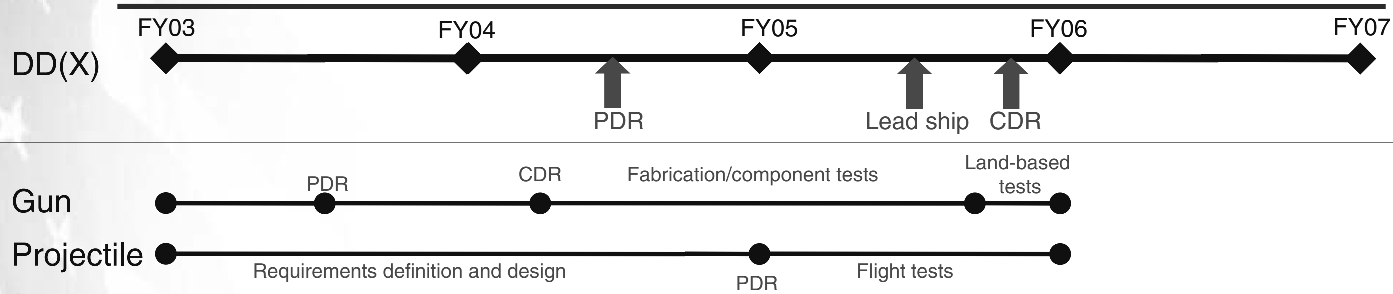
If you or your staff have any questions concerning this report, please contact me on (202) 512-4841; or Karen Zuckerstein, Assistant Director, on (202) 512-6785. Major contributors to this report are J. Kristopher Keener, Angela D. Thomas, and Karen Sloan.

Sincerely yours,

Paul L. Francis
Director, Acquisition and Sourcing Management

DD(X) Engineering Development Models

Advanced Gun System



- Gun system to fulfill requirements for long-range land attack and precision volume fire for forces ashore, development models includes technologies for both the unmanned magazine and the long-range land attack munition
- Gun system requires automated magazine for unmanned operations, including loading and launch of long-range munitions
- Modifications to ship size led to change in gun system design
- Understanding of gun design gained through 3-D modeling—manufacturing of physical components began April 2004
- Early “fly-off” competition for projectile provided proof of concepts
- Lead ship authorization supported by:
  - Component testing for gun—land based tests planned for June 2005
  - 5 of 15 flight tests for projectile—flight tests set to end September 2005
- Gun and projectile will not be demonstrated together before installation on first ship

PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

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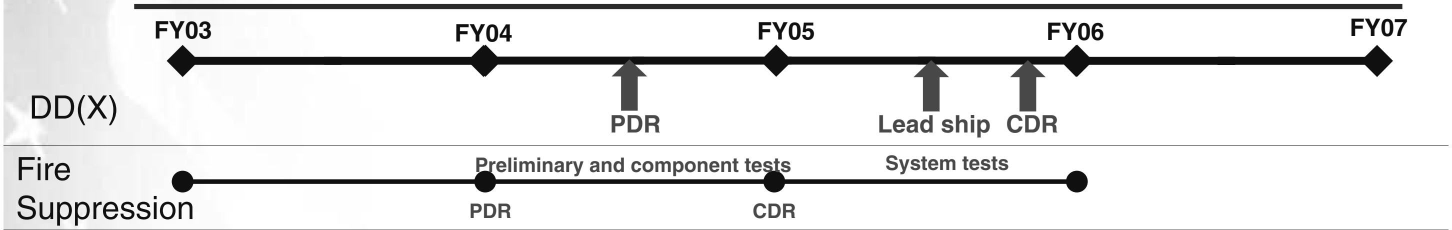
Autonomic Fire Suppression System

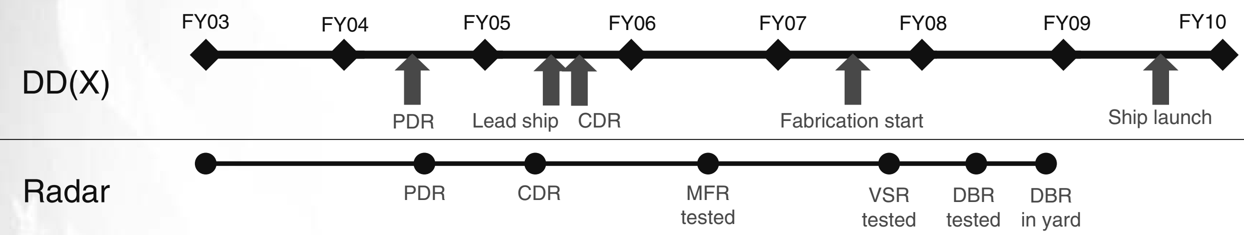


- Fire Suppression System utilizes new technologies such as smart valves, flexible hosing, nozzles, sensors, and autonomic operations to reduce crew and time needed for damage control
- Proof of concept tests exceeded expectations
  - Tested smart valves, flexible hosing, nozzles, and some autonomic operations
- Software compatibility issues with computing environment acknowledged and solutions identified
- Possible system integration issues include:
  - Effect of water mist on power system
  - Fire suppression capabilities needed in deckhouse under discussion
- Completion of system tests delayed beyond lead ship authorization due to software issues – expected to complete tests in August 2005

PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

Dual Band Radar

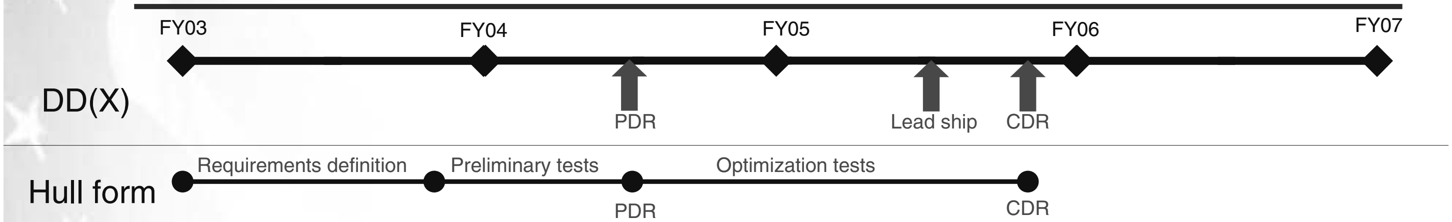


- Dual Band Radar consists of an X-Band multi-function radar and an S-Band volume search radar
  - Multi-function radar provides information for land attack and defense against threats from aircraft, surface vessels, and submarines: prototype is currently in testing
  - Volume search radar cues the multi-function radar, provides information on long-range aerial targets, and assists with air control, currently in design
- In July 2003 the Navy revisited the frequency of the volume search radar and changed path (L-Band to S-Band)
  - Change required modification to contract
  - Volume search radar testing delayed until detailed design and construction phase
- New schedule has impact on ship design and construction
  - Contractor indicated that installation may occur with ship in the water
- Design of deckhouse is tied to dual band radar
- Lead ship authorization supported by critical design review and land based tests of multi-function radar—dual band radar testing not complete until mid-FY08

- PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review
MFR—Multi-function radar; VSR—Volume search radar; DBR—Dual band radar

Source: GAO analysis of Navy information.

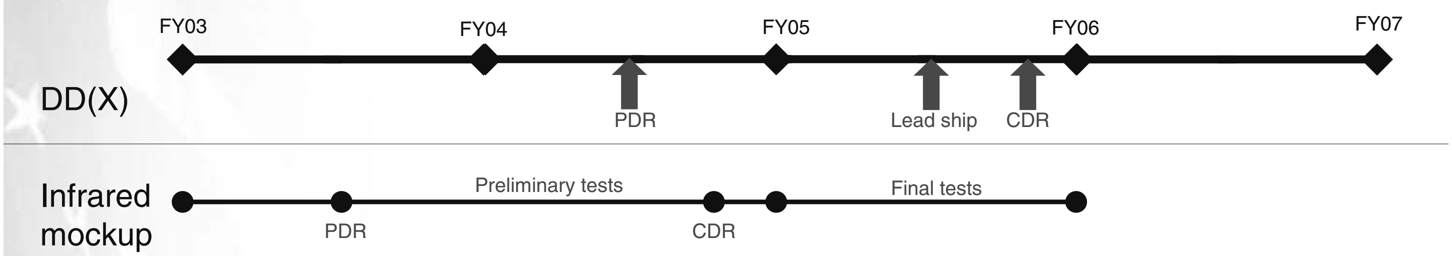
Hull Form



- DD(X) will introduce radically new hull design that widens as it approaches the waterline
- June 2003 modifications to ship size led to changes in hull form design
- Hull form had fallback design—decision made at preliminary design review that fallback no longer necessary
- Program is assessing the applicability of models and simulations for traditional hull forms for use with new hull form
- Propeller currently in design—original 7 bladed design changed to 6 or 5 bladed design
- System tests to demonstrate new propeller design and refine hull form design will not be complete before lead ship authorization—test set to end in July 2005
- PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

Infrared Mockup

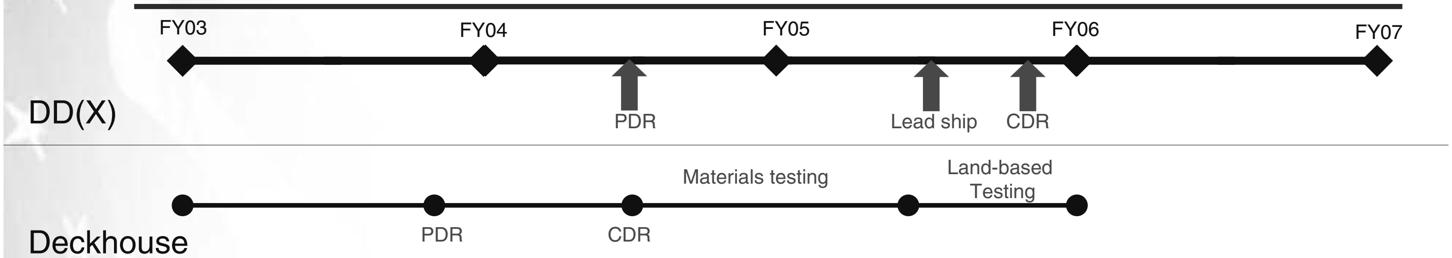


- Infrared suppression seeks to reduce heat signature of the ship using sheeting water system on hull, material treatments to deckhouse, and passive air cooling for exhaust
- Preliminary tests include at-sea testing of materials as well as land-based testing of exhaust suppression with surrogate components
- Final tests include further materials testing for signature and environmental factors, hull water system mock ups, as well as scale model and full scale testing of exhaust suppression
- Two of three comprehensive environmental tests, hull water system mockups, and scale model exhaust tests support lead ship authorization—third comprehensive environmental test set for April 2005, full scale exhaust suppression tests set for 3rd quarter FY05

PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

Integrated Deckhouse and Apertures

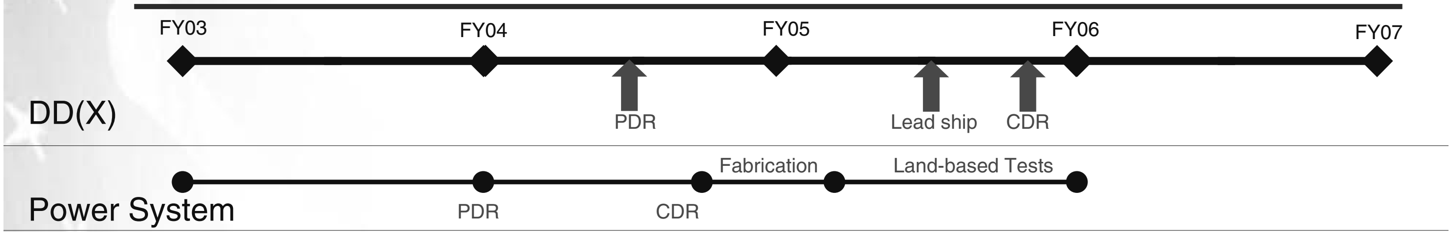


- Deckhouse makes up a large portion of the ship and is formed of composite components to reduce weight, also integrates apertures of radars and communications systems
- Weight and design affected by July 2003 change to volume search radar
  - Test schedule affected—deckhouse effort being rebaselined
- Impact of volume search radar on deckhouse not tested in this phase of development—may cause changes to deckhouse
- Lead ship authorization supported by testing for corrosion, shock, and damage—testing of full scale sections for shock, fire, radar cross signature and aperture integration planned for 3rd quarter 2005

PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

Integrated Power System

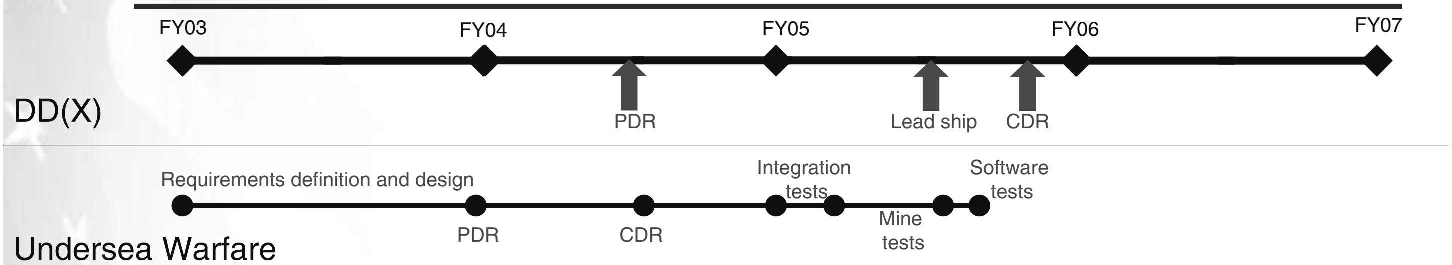


- Power system includes development of an integrated shipwide power generation and distribution system as well as development of a permanent magnet motor for propulsion
- A backup technology for the magnet motor exists but has higher weight, more noise, and reduced efficiency – final decision on which technology to include will be made no later than critical design review
- Power system is currently exceeding weight allowance by significant margin which includes the system's entire design budget for weight, any further increases in weight could impact other systems or result in an unplanned weight reduction program
- Software compliance issues with computing environment acknowledged and mitigation solutions identified
- At-sea testing will no longer take place
  - Fidelity of land-based tests increased
- Lead ship authorization supported by component testing of magnet motor and power generation—land-based testing of prototype planned for 4th quarter 2005

PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

Integrated Undersea Warfare

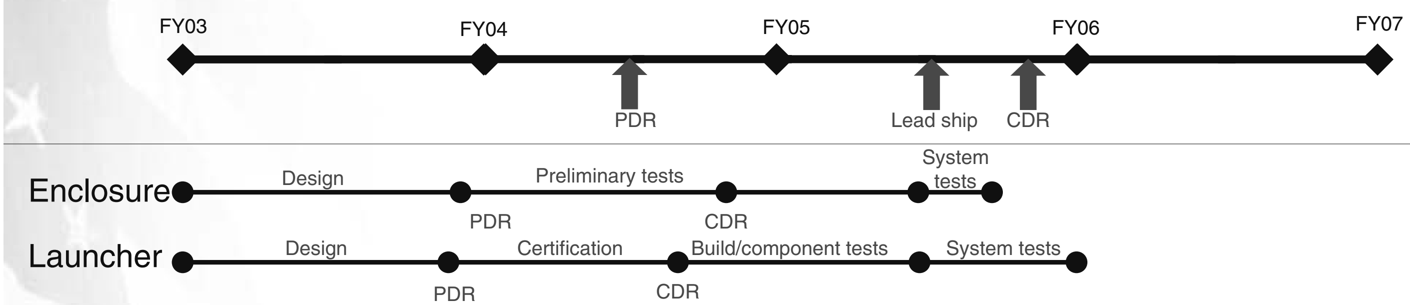


- Undersea warfare system designed to detect mines and submarines in the littorals and is composed of medium and high frequency arrays, towed arrays, and decision-making software to reduce the workload of the sailor
- All arrays based on existing technologies, but the integration of two different frequencies in one array is a challenge
- Tests performed only prove functionality of components and not system as a whole
- Component testing completes after lead ship authorization—software testing scheduled to end in May 2005

PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

Peripheral Vertical Launch System

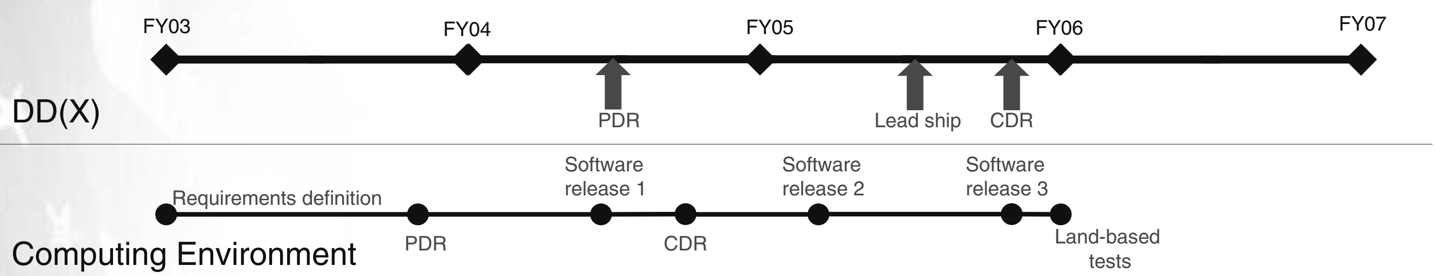


- Peripheral vertical launch system consists of the missile launcher and the enclosure for the launcher—system will be placed on the perimeter of the ship, not centrally
- Launcher development based on existing systems
    - Includes design margins and open architecture electronics that will allow for future munitions
- Multiple damage tests completed on enclosure before lead ship authorization
- Tests for system will not be completed by lead ship authorization:
    - Only component testing complete on launcher—system testing set to end third quarter 2005
    - Testing on enclosure set to end in third quarter 2005

PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

Total Ship Computing Environment



- Provides single computing environment for all ship systems to speed command while reducing manning
- Computing environment consists of seven software releases ending in 3rd quarter FY09
- Computing environment development plans include many of the GAO software best practices (GAO-04-393)
  - Developing software in an evolutionary environment
  - Following disciplined development process
  - Using meaningful metrics to measure progress
- Engineering development model includes three of seven software releases and tests with data from other engineering development models
- Lead ship authorization supported by two of three software releases—land-based system testing of functionality scheduled to occur fourth quarter 2005

PDR—Preliminary design review; Lead ship—Lead ship authorization; CDR—Critical design review

Source: GAO analysis of Navy information.

Comments from the Department of Defense

Note: GAO comments supplementing those in the report text appear at the end of this appendix.

OFFICE OF THE UNDER SECRETARY OF DEFENSE

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WASHINGTON, DC 20301-3000

ACQUISITION, TECHNOLOGY AND LOGISTICS

AUG 2 0 2004

Mr. Paul L. Francis
Director, Acquisition and Sourcing Management
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Francis:

This is the Department of Defense (DoD) response to the GAO draft report, "DEFENSE ACQUISITIONS: Challenges Facing the DD(X) Destroyer Program," dated August 2004 (GAO Code 120321/GAO-04-973).

The GAO offered no recommendations; however, the Department would like to provide technical corrections and additional information (enclosure).

The Department appreciates the opportunity to comment on the draft report.

Sincerely,

Glenn F. Lamartin
Director
Defense Systems

Enclosure:
As stated

GAO DRAFT REPORT – DATED AUGUST 2004
GAO CODE 120321/GAO-04-973

"DEFENSE ACQUISITIONS: Challenges Facing the DD(X) Destroyer Program" (GAO Code 120321)"

DEPARTMENT OF DEFENSE RESPONSE

Comments regarding the content of the report follow.

See comment 1.

1 - Page 3: The report identifies "Ship Launch" as September 2009. The correct date is June 2010.

Now on p. 9.
See comment 2.

2 - Table 2, page 7: The report's EDM Test Schedule, identifies "IPS EDM Begin Testing" date as September 2005. The correct date is February 2005.

3 - "GAO Highlights": The ability of DD(X) to deliver revolutionary capabilities to the fleet with reduced crew necessitates some element of development and production risk. Given the long production lead time in shipbuilding, the Navy believes it is appropriate to undertake a reasonable amount of risk in the DD(X) lead ship, in order to deliver technological benefits to the rest of the class. The DD(X) risk mitigation approach represents the management of finite resources to achieve innovation and to implement a cost effective test plan designed to address those risks with the greatest potential to challenge the ship's ability to conduct its mission. The concerns expressed by GAO regarding that approach, as it relates to the DD(X) schedule and the execution of the EDMs are discussed below. The DD(X) schedule supports readiness of all of the DD(X) EDMs in time for ship installation, which for shipbuilding programs, is the most relevant point of reference for technology maturity. In the case of DD(X), lead ship contract award (FY05) precedes scheduled system installations by as much as four years (FY09), thus allowing additional time for system development and test. As the GAO notes, DOD acquisition policy indicates that technologies for ships do not have to be mature until shipboard installation. In conclusion, the DD(X) EDMs are on track to support a Milestone B decision and to achieve maturity prior to ship installation.

Now on p. 2.

4 - Page 1: The GAO states that the DD(X) schedule "does not provide for the models to demonstrate high levels of maturity when needed." The DD(X) program is on track to support the demonstration of certain fundamental capabilities at Milestone B (prior to lead ship contract award), to complete necessary testing by ship Critical Design Review (CDR), and to mature systems in time for ship installation.

Now on p. 6.

5 - Page 5: The Department selected the exit criteria for DD(X) Milestone B to provide assessments of critical technologies prior to the contract award. Results of all tests required in support of Milestone B including Long Range Land Attack Projectile guided

1

flights, and testing of the Advanced Gun System, Multi-Function Radar, and Integrated Power System, will be available in time to support the review in March 2005, prior to the Phase IV contract award. Following Milestone B and lead ship contract award, the Navy will complete additional testing to provide data necessary to feed into the CDR, which will be a series of events stretching across the summer of 2005.

Now on p. 10.

See comment 3.

6 - Page 8: Integrated Power System (IPS). The GAO notes that IPS has exceeded its weight allowance and consumed the additional design margin for weight, as well. While IPS has exceeded its original weight allocation, the Navy allocated additional margin from the total ship margin without impact to the overall ship design. As such, the Navy does not consider IPS weight status to be indicative of significant risk. GAO also concludes that the Navy altered at-sea test plans for IPS due to changes in the schedule for the Dual Band Radar EDM. However, the decision to eliminate at-sea testing for IPS reflected the determination that it is possible to get the same information at the land based test site in a more controlled and cost effective manner by utilizing a dynamic load machine that simulates propeller loading and not ship motions. The cancellation of at-sea testing for IPS allowed the Navy to instead focus resources on IPS integration, which the Navy has identified as an area of technical risk.

Now on p. 11.

7 - Page 9: Advanced Gun System (AGS). The GAO expresses concern that the Navy will not test the AGS and Long Range Land Attack Projectile (LRLAP) together until after ship installation and cites the lack of adequate test facilities as the reason. Although the Navy will not test the AGS and LRLAP together prior to ship installation, the current test program incorporates overlapping interfaces to mitigate that risk. Gun and magazine testing at Army Proving Grounds, Dugway, Utah, incorporates LRLAP-like slugs and actual tactical propellant charges. Similarly, the projectile testing at Naval Air Warfare Center/Weapons Division, Point Mugu, California, utilizes an AGS barrel. Lastly, Navy decided to forego the testing based on an assessment that the investment required to test AGS and LRLAP together would not be cost effective in terms of the additional risk mitigation achieved.

Now on p. 8.
See comment 4.

8 - Page 6: Dual Band Radar (DBR). The GAO cites the development of the DBR as "one example of the consequences of technology and design immaturity already apparent in the DD(X) program." In fact, the changes to the DBR development schedule were the result of a deliberate Navy decision to change the Volume Search Radar (VSR) frequency from L-band to S-band, not of issues with the technical approach. The Navy's investment decision was intended to leverage development resources for a scalable radar for possible use on the next generation cruiser, CG(X).

Now on p. 8.

9 - Page 6: Integrated Deck House and Apertures (IDHA). The GAO expresses concern that redesign of the integrated deck house, which is currently on schedule to support CDR, could be required if the weight of the DBR changes or if other technical factors cause it to be relocated. In order to mitigate that risk, the Navy sized the DBR array

2

design to support potential future improvements and to allow the system to absorb design adjustments without impact to the IDHA. Similarly, the IDHA design incorporates sufficient power and cooling margins to address changes resulting from the S-band testing. VSR interface commonality with the Multi-Function Radar portion of DBR is expected to serve as an effective risk reducer for integration.

Now on p. 10.

10 - Page 8: Autonomic Fire Suppression System (AFSS). The GAO references AFSS compatibility issues with the Total Ship Computing Environment and notes that, as a result, Navy delayed tests beyond the system CDR. It is important to understand that the tests rescheduled are for supervisory software, which the Navy does not consider a significant system risk. The AFSS EDM has demonstrated its ability to extinguish fire and to successfully reconfigure. Therefore, the Navy has addressed key risks before the CDR.

Now on p. 11.

11 - Page 8: Integrated Undersea Warfare (IUSW). The GAO indicates that the IUSW system will not demonstrate operations in the intended environment. The Navy is testing the components of the IUSW system, vice the entire system, in a relevant environment to mitigate that risk. For IUSW, the Navy decided to focus resources on key performance technologies of the EDM with higher perceived risk.

3

GAO Comments

The following are GAO's comments on the Department of Defense's letter dated August 20, 2004.

1. Change to the ship schedule incorporated into the body of the report.

2. The period from February to July includes only testing of the permanent magnet motor, one component of the integrated power system. The date in the report was changed to July 2005 to reflect the beginning of full system testing of the integrated power system.

3. This is not a GAO conclusion. The statement is based on statements provided by the Navy as well as industry contractors.

4. Our discussion of the technology and design maturity of the dual band radar and the integrated deckhouse deals with the impact of the Navy's decision to change radar frequency, not the reason for the decision.

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