STATEMENT OF

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Chairman Taylor, Ranking Member Bartlett, distinguished members of the subcommittee, thank you for the opportunity to appear before you today to discuss destroyer procurement over the next several years. Press reports indicate that the Navy favors stopping DDG-1000 procurement at two ships and restarting DDG-51 procurement.[1] It has also been reported that the date for procuring the lead CG(X) cruiser may slip from FY2011 to FY2015 or later.[2] As requested, this statement discusses follow-on questions that would arise from a decision to stop DDG-1000 procurement and restart DDG-51 procurement, particularly in the context of a slip in the schedule for procuring the lead CG(X) to FY2015 or later. These questions include but are not limited to the following:

- What should be the design configuration of the DDG-51s that are procured?
- Should the program for modernizing DDG-51s be altered to change the configuration of the modernized ships?
- Should a non-combat ship equipped with a powerful radar be procured as an adjunct platform for improving the fleet's integrated air and missile defense (IAMD) capabilities pending the entry into service of CG(X)s?
- What options, in addition to procuring new DDG-51s, are available for helping to support the shipbuilding industrial base as destroyer production shifts from DDG-1000s back to DDG-51s?

This statement addresses each of these questions. It is based on information in the Navy program of record, past briefings and other information provided by the Navy and industry to CRS on the DDG-51 and DDG-1000 programs,[3] recent industry briefings to CRS that were done at CRS' request, and open-source information, including press reports and recent DOD and Navy letters to Congress that have been made public.

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[1]See, for example, Christopher P. Cavas, "DDG 1000 Program Will End at Two Ships," *DefenseNews.com*, July 22, 2008; Christopher J. Castelli, "Plan To Curtail DDG-1000 Program Advances," *InsideDefense.com*, July 22, 2008; Geoff Fein, "Navy To Buy Eight DDG-51s As It Cancels Further Zumwalt Buys," *Defense Daily*, June 25, 2008.

[2]Christopher P. Cavas, "DDG 1000 Destroyer Program Facing Major Cuts," *DefenseNews.com*, July 14, 2008.

[3]On July 14, 2008, CRS asked the Navy to provide a briefing to CRS on the issue of procuring DDG-1000s or DDG-51s; on July 15, 2008, the Navy replied that it preferred not to provide such a briefing at this time, as the topic related to excursions being done in support of the proposed FY2010 budget to be submitted early next year.

Configuration of New DDG-51s

Although the discussion to date about restarting DDG-51 production has focused on procuring repeat copies of the current Flight IIA DDG-51 design, policymakers may consider the alternative of procuring a modified version of the DDG-51 design. A modified version could have lower annual operating and support (O&S) costs, and could be better aligned with a potential policy goal of using DDG-51 procurement to improve the fleet's capabilities for naval surface fire support (NSFS) or IAMD. (A Navy interest in improving NSFS capabilities helped give rise to the DDG-1000 program, and the Navy had wanted to start improving its IAMD capabilities in FY2011 through procurement of CG(X)s.) In deciding whether destroyer procurement over the next several years should focus on providing improved NSFS capabilities or improved IAMD capabilities, policymakers could consider several factors, including current and potential U.S. Navy operations, the operational requirements for conducting these operations, current and projected threats or challenges associated with these operations, and current or projected Navy or DOD programs (other than destroyer procurement) for countering these threats or overcoming these challenges.[4]

A key system for providing improved NSFS capability is the 155mm Advanced Gun System (AGS) and the associated 155mm Long Range Land Attack Projectile (LRLAP). Key systems for providing improved IAMD capabilities include higher-capability radars and vertical-launch tubes for IAMD interceptors.

The Navy has procured different versions of the DDG-51 design over time. A significant change in the design occurred in FY1994, when the Navy shifted DDG-51 procurement to the Flight IIA version of the ship, which included, among other things, the addition of a helicopter hangar and the repositioning of the ship's aft SPY-1 radar arrays. Prior to implementing the Flight IIA design, the Navy seriously considered a version with even larger-scale changes, called the Flight III design, that would have included, among other things, lengthening the ship's hull to make room for additional mission systems.

Compared to the option of procuring repeat Flight IIA DDG-51s, procuring a modified version of the DDG-51 design would incur additional nonrecurring design and engineering costs, as well as additional recurring production costs due to loss of learning at the shipyard associated with changing the ship's design and (for some of the options discussed below), the enlargement of the ship. Depending on the exact option pursued, the nonrecurring design and engineering costs could total in the hundreds of millions of dollars. Given the number of DDG-51s that may be procured between now and the procurement of a lead CG(X) in FY2015, FY2016, or FY2017, these additional costs might be deemed cost effective in terms of making it possible to procure DDG-51s that have lower O&S costs and are better aligned with a possible policy goal of using DDG-51 procurement to provide the fleet with improved NSFS or IAMD capabilities.

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[4] A July 25, 2008, press article discussed the Navy's preference to stop DDG-1000 procurement at two ships and restart DDG-51 procurement. The article quoted Commander Jeff Davis, a Navy spokesman, as follows: "'DDG-51 is a proven multi-mission ship that better meets our needs, particularly Integrated Air Missile Defense (IAMD), Ballistic Missile Defense (BMD), and Anti-Submarine Warfare (ASW),' Davis said." (Geoff Fein, "Navy To Buy Eight DDG-51s As It Cancels Further Zumwalt Buys," *Defense Daily*, June 25, 2008. In the article as published, this sentence lacked quote marks. CRS on July 28, 2008, confirmed with Defense Daily that this was a direct quote from Davis and that the quote marks were left out by mistake.)

DDG-51 configuration options that may be procured in coming years include but are not limited to the following:

- the current Flight IIA design;
- a modified version with additional features for reducing O&S costs;
- a modified version with additional features for reducing O&S costs and an AGS;
- a modified version with additional features for reducing O&S costs and additional vertical-launch tubes;
- a modified version with additional features for reducing O&S costs and an improved radar; and
- a modified version with additional features for reducing O&S costs, additional vertical-launch tubes, and an improved radar.

Each of these options is discussed below. The first of these options might be ready for implementation sooner than the others. If so, and if procurement of a modified DDG-51 design were desired, procurement of DDG-51s over the next several years could begin with procurement of the current Flight IIA design and then shift to the modified design when the modified design was ready for procurement.

Although the option of procuring the current Flight IIA DDG-51 design might be ready for implementation sooner than the other options, the Navy and other observers have cautioned that the time line for restarting procurement of the current Flight IIA design could be extended by the need to restart or reestablish vendors for certain key DDG-51 components, such as the reduction gear.

Current Flight IIA Design

This option, which might be considered the baseline option, has the lowest nonrecurring design and engineering costs and the lowest recurring production costs of all the options presented here. It would maximize the number of DDG-51s that could be procured for a given amount of procurement funding. It would also pose the lowest amount of technical, schedule, and cost risk. It would have higher life-cycle O&S costs then the next option discussed below, and perhaps higher O&S costs than some of the other options discussed below as well. Procuring the current Flight IIA design would provide more of the same capabilities that DDG-51s currently provide for the fleet, but the ships might not be considered particularly well-aligned if a possible policy goal was to use DDG-51 procurement to provide improved (as opposed to additional) capabilities for NSFS or IAMD. As mentioned above, the current Flight IIA design could be procured as a bridge to procurement of one of the modified designs discussed below.

Version With Features for Reducing O&S Costs

This option would procure Flight IIA ships that were modified to include features for reducing the ships' annual O&S costs. Potential features of this kind include but are not limited to the following:

- adding automated equipment and making other changes to reduce crew size;
- adding some electric-drive equipment for interconnecting parts of the ship's mechanical-drive propulsion system so as to permit the system to operate more like an integrated electric drive system; and
- installing a near-surface bow bulb above the existing sonar dome to improve hydrodynamic efficiency.

The discussion below of how these three features could reduce DDG-51 O&S costs uses as its starting point the table below on annual DDG-1000 and DDG-51 O&S costs, which is reprinted from Admiral Gary Roughead's May 7, 2008, letter to Senator Kennedy on the DDG-1000 and DDG-51.[5]

(FY$M)	DDG 1000	DDG 51
Operating (steaming)	$18.5	$15.7
Maintenance	$10.3	$5.6
Manpower	$8.5	$19.9
Total	$37.3	$41.2
Crew Size	[Total 120] 14 officers 106 enlisted	[Total 296] 24 Officers 272 Enlisted

Source: Letter dated May 7, 2008, from Admiral G. Roughead to the Honorable Edward M. Kennedy, p. 2. The figures shown in brackets for total crew size were added to the table by CRS.

Reducing Crew Size. Admiral Roughead's letter states that the above table "does not include personnel reduction savings expected from the DDG Modernization program." The Navy informed CRS on July 25, 2008, that the DDG-51 modernization is not expected to reduce DDG-51 crew size, but that the size of the DDG-51 crew has, for other reasons, been reduced recently from the figure of 296 shown in the table to 278, a reduction of 18 people.[6]

Additional actions might permit a further reduction in DDG-51 crew size: A 2003 industry briefing to CRS on DDG-51 modernization for reduced manning discussed various steps for reducing crew size by about 100.[7] The House Armed Services Committee's report (H.Rept. 108-491 of May 14, 2004) on the FY2005 defense authorization bill (H.R. 4200) similarly stated:

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[5]Source: Letter dated May 7, 2008, from Admiral G. Roughead to the Honorable Edward M. Kennedy, posted on the Internet at InsideDefense.com (subscription required) on May 30, 2008.

[6]Source: Navy information provided to CRS by telephone, July 25, 2008.

[7]Source: Industry briefing to CRS on DDG-51 modernization for reduced manning, August 8, 2003.

> The committee notes that the Navy is scheduled to commence a DDG-51 modernization plan in fiscal year 2005 with new construction and subsequently extend modernization to in-service destroyers. The committee is aware that the foundations for DDG-51 modernization are: increased warfighting capability, leverage of the DDG–51 shipbuilding program, reduction of total ship ownership costs, and use of open architecture. In addition to those factors, the committee believes that reduction in crew size from the present approximately 300 to an objective of 200 personnel should also be part of the foundation of an even more aggressive modernization program.
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> According to the Navy, a DDG-51 class ship costs $25.0 million per year to operate, including $13.0 million for the crew. The Navy estimate is that its present modernization plan could reduce the crew cost per ship by $2.7 million per year. A larger reduction in crew size would clearly appear to result in significant savings over the estimated 18 years of remaining normal service life, especially noting that per capita personnel costs may be expected to increase during that period.[8]

Using the figures in the table from Admiral Roughead's May 7 letter, if additional steps can reduce ship crew size by another 32 people, for a total reduction of 50 — one-half the figure of 100 mentioned in the 2003 industry briefing and the 2004 committee report — then annual manpower costs for the DDG-51 could be reduced from the figure of $19.9 million shown in the table to about $16.5 million, a reduction of about 17%.

Addition of Some Electric-Drive Equipment. As discussed in two CRS reports,[9] one maker of electric-drive propulsion equipment has proposed increasing the planned scope of the Navy's program for modernizing its DDG-51s to include adding some electric-drive propulsion equipment to the ships' existing mechanical-drive propulsion plants. The option could also be applied to new-construction DDG-51s. The added equipment would more fully interconnect the mechanical-drive components on each ship, producing what the firm refers to as a hybrid propulsion plant. The firm estimates that the addition of this equipment would reduce DDG-51 fuel use by about 16%. This option, the firm estimates, would have a non-recurring engineering cost of $17.1 million and a recurring cost (including both equipment cost and installation cost) of $8.8 million per ship.[10]

Using the figures in the table from Admiral Roughead's May 7 letter, reducing DDG-51 fuel use by 16% would reduce the ship's annual operating (steaming) cost from the figure of $15.7 million shown in the table to about $13.2 million — a reduction of about $2.5 million. The Navy has informed CRS that the operating (steaming) cost figures in the May 7 letter are based on fuel costs as of February 2008 and reflect a crude oil cost of $112.14 per barrel.[11] If crude oil in coming years costs more than $112.14 per barrel, the dollar savings associated with a 3.9% reduction in fuel

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[8] H.Rept. 108-491, pp. 122-123.

[9] CRS Report RL33360, *Navy Ship Propulsion Technologies: Options for Reducing Oil Use — Background for Congress*, by Ronald O'Rourke, and CRS Report RS22595, *Navy Aegis Cruiser and Destroyer Modernization: Background and Issues for Congress*, by Ronald O'Rourke.

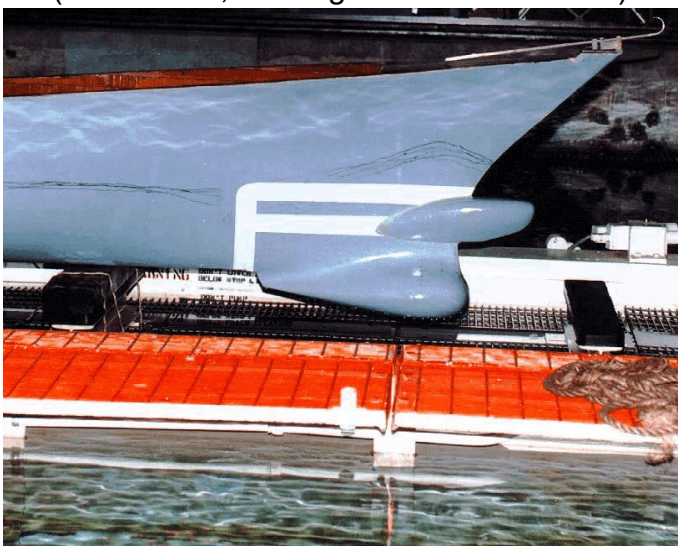
[10] Source: Briefing by the firm DRS dated December 19, 2007, with estimated percentage fuel-savings and cost figures reconfirmed by telephone call with CRS on July 17, 2008. DRS also stated in the phone call that one Navy official had stated that the reduction in fuel use could be greater than DRS estimates because the commanders of ships with this equipment would likely adjust ship speeds to operate the ship more often at the hybrid system's most-efficient speed points (i.e., the system's "sweet spots").

[11] Source: Navy information provided to CRS by telephone, July 25, 2008.

use would be greater than $2.5 million per year. The obverse would be true if crude oil in coming years costs less than $112.14 per barrel.

Adding a Near-Surface Bow Bulb. As discussed in a CRS report,[12] a study by the Navy's David Taylor Model Basin estimated that fitting a near-surface bow bulb — essentially a shaped piece of steel — onto a DDG-51class destroyer could reduce its fuel use by 3.9%.[13]

Figure 1. Near-Surface Bow Bulb Design for DDG-51
(bulb above, existing sonar dome below)



A document from the hydromechanics department of the Naval Surface Warfare Center Carderock Directorate summarizing efforts by that department through 1999 to improve the

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[12]CRS Report RL33360, *Navy Ship Propulsion Technologies: Options for Reducing Oil Use — Background for Congress*, by Ronald O'Rourke.

[13]Dominic S. Cusanelli, "Stern Flaps and Bow Bulbs for Existing Vessels, Reducing Shipboard Fuel Consumption and Emissions," available online at: [http://www.unep.fr/ozonaction/events/military/proceedings/Presentation%20Material/24%20-%20Cusanelli%20-%20SternFlaps.doc]. The study is undated but refers to a test that was "recently completed in Dec. 2000." As also stated in CRS Report RL33360, an earlier (1994) study by the same organization estimated that 79 existing Navy cruisers and destroyers could be fitted with bow bulbs for a total development and installation cost of less than $30 million, and that the constant-dollar life-cycle fuel savings of the 79 ships would be $250 million. (Dominic S. Cusanelli, "Development of a Bow for a Naval Surface Combatant which Combines a Hydrodynamic Bulb and a Sonar Dome," paper presented at the American Society of Naval Engineers Technical Innovation Symposium, September 1994, available online at [http://www50.dt.navy.mil/reports/hydrobulb/].) DOD stated in 2000 that fitting bulbous bows onto 50 DDG-51s (a total of 62 DDG-51s have been procured) could save $200 million in life-cycle fuel costs. (U.S. Department of Defense, *Climate Change, Energy Efficiency, and Ozone Protection, Protecting National Security and the Environment*. Washington, 2000. (Office of the Deputy Under Secretary of Defense (Environmental Security), November 2000) p. 5. Available online at [https://www.denix.osd.mil/denix/Public/Library/Air/Climate_Change/dodclimatechange.pdf].)

hydrodynamic and operational performance of the DDG-51 similarly states that in tests of this proposal:

> Ship performance improvement was projected for the entire ship speed range across all sea states tested, resulting in significant annual fuel savings.
>
> Analysis of seakeeping data and extreme sea wave load tests indicate that the bow bulb had no significant impact on ship motions or hull girder loads. Acoustic transfer function tests data from a vibracoustic model concluded that the bow bulb should have little noticeable impact on the sonar self-noise levels.[14]

Using the figures in the table from Admiral Roughead's May 7 letter, reducing DDG-51 use by an additional 3.9% would reduce the ship's annual operating (steaming) cost from the figure of $15.7 million shown in the table to about $12.7 million — a reduction of $3.0 million. This savings figure is again based on a crude oil cost of $112.14 per barrel.

Summary of Potential O&S Cost Reductions. **Table 1** below summarizes the potential reductions in annual DDG-51 O&S costs from the three options discussed above. The total figure of $34.8 million shown in the final column of the table is about 15% less than the figure of $41.2 million from the table in Admiral Roughead's May 7 letter. These figures would need to be adjusted for the options discussed later in this statement to take into account the configuration changes of those options.

Table 1. DDG-1000 and DDG-51 Annual O&S Costs

(FY$M)	DDG 1000	DDG 51	DDG 51 with potential O&S cost reductions
Operating (steaming)	$18.5	$15.7	$12.7
Maintenance	$10.3	$5.6	$5.6
Manpower	$8.5	$19.9	$16.5
Total	$37.3	$41.2	$34.8
Crew Size	120 Total (14 officers 106 enlisted)	296 Total (24 Officers 272 Enlisted)	246 Total

Source: Letter dated May 7, 2008, from Admiral G. Roughead to the Honorable Edward M. Kennedy, p. 2 (first two data columns) and CRS review of Navy and industry data (third data column).

[14]Document entitled "Recent Design Programs, DDG 51," available online at: [http://www.nswccd.navy.mil/hyd/mul-gal/doc-gal-1/documents/DDG51.pdf].

Version With Reduced O&S Costs and An AGS

This version of the DDG-51 design would include an AGS as well as features for reducing O&S costs. The purpose in procuring this version would be to provide the fleet with improved NSFS capabilities. Under this option, the Flight IIA design would be modified by removing the 5-inch gun and perhaps also the forward 32-cell vertical launch system (VLS) battery, lengthening the ship forward of the deckhouse through the insertion of a hull plug, and installing an AGS with a magazine capable of storing as many LRLAP rounds as can be fitted, with a goal of 300.

Some of the sources that CRS consulted expressed doubts or concerns about the technical feasibility or engineering difficulty of this option. Other sources expressed fewer concerns along these lines. A redesign of the AGS's ammunition storage and handling space would be needed to accommodate the AGS in the DDG-51 hull.

The Navy informed CRS in 2005 that it might be possible to fit the existing DDG-51 hull with one AGS, that doing so would likely require the removal of 5-inch gun and the forward 32-cell VLS battery, and that in this configuration, the DDG-51 might carry about 120 LRLAPs.[15]

At a March 14, 2008, hearing on shipbuilding issues before this subcommittee, Vice Admiral Barry McCullough was asked what platforms other than the DDG-1000 might be equipped with an AGS. He replied:

> Well, sir, I will tell you we looked at [whether] could you put the Advanced Gun System in an Arleigh Burke [DDG-51] hull. And without doing a detailed shock analysis on it, I will tell you physically it fits. We'd have to do some arrangement changes in it. But you can put the gun in there. And my concern is the magazine capacity. Outside of that, we haven't looked at putting it in any other hull form. So I'll get back to you on that.[16]

This comment, like the information that the Navy provided to CRS in 2005, appears to relate to an installation that does not involve lengthening the DDG-51 hull. Lengthening the DDG-51 hull forward of the deckhouse could provide additional space and weight-carrying capacity for additional LRLAP rounds, and perhaps also permit the retention of the forward 32-cell VLS battery. The Navy and industry in the past have studied options for lengthening the DDG-51 hull by various lengths to accommodate various capability upgrades, such as additional VLS cells;[17] the maximum possible

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[15]Source: Navy briefing to CRS on DDG-1000 and DDG-51 capabilities, June 10, 2005.

[16]Source: Transcript of hearing. The idea of backfitting an AGS onto an existing Spruance (DD-963) class destroyer, so that the ship could be used as a risk-reduction platform for the DDG-1000, was explored by a group of three Navy lieutenants in a 2003 study done while at the Massachusetts Institute of Technology. The study's preferred installation option, which involved the removal of the ship's aft 5-inch gun but no hull extension, resulted in a magazine with an estimated capacity of 304 LRLAP rounds. (Julie Higgins, Jason Rhoads, and Michael Roach, *Advanced Gun System (AGS) Backfit, DD-988 Naval Gunfire Support Ship Conversion*, Massachusetts Institute of Technology, 13.413, Project in Naval Ship Construction, Spring 2003, 30 pp.)

[17]For example, the Navy in 1988 studied design options for a Flight III version of the DDG-51 design that included hull extensions, in various locations along the hull, of 30 feet, 40 feet, and 46 feet. The CNO gave initial approval to a Flight III design concept incorporating a 40-foot extension (12 feet forward and 28 feet

(continued...)

hull extension might be 55 or 56 feet.[18] An extension of 55 or 56 feet might permit a magazine of more than 300 rounds, or alternatively might permit the retention of at least some of the ship's forward VLS cells.

Because the AGS requires much more electrical power to operate than the DDG-51's current 5-inch gun, equipping the DDG-51 with an AGS might require the installation of an additional electrical generator. The best location for such a generator might be in one of the ship's two helicopter hangar spots, which would reduce the ship's helicopter hangar capacity from two helicopters to one.

Version With Reduced O&S Costs and Additional Vertical-Launch Tubes

This version of the DDG-51 design would include additional vertical-launch tubes as well as features for reducing O&S costs. The purpose in procuring this version would be to provide the fleet with improved IAMD capabilities.

Additional vertical-launch tubes could be installed by lengthening the ship's hull forward of the deckhouse. A 1994 CRS report discussed, on the basis of Navy information, how a 12-foot extension could permit the installation of 32 additional VLS cells.[19] In 1997, to support research that CRS was conducting into possible alternatives to the Navy's proposed Arsenal Ship,[20] the Navy provided CRS with information on how lengthening the DDG-51 hull so as to install additional VLS tubes might change the ship's procurement cost. The information is summarized in **Table 2** below. The estimated changes in procurement cost were parametric, rough order of magnitude (ROM) estimates only, subject to further engineering evaluation, and did not include detail design or nonrecurring engineering costs. Although the table shows variants equipped with Mk 41 VLS tubes (the kind currently used on Navy surface ships), adding vertical launch tubes of a newer design may also be possible.

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[17](...continued)
aft), and the design was intended to begin procurement in FY1994. (Source: Donald Ewing, Randall Fortune, Brian Rochon, and Robert Scott, *DDG 51 Flight III Design Development*, Presented at the Meeting of the Chesapeake Section of The Society of Naval Architects and Marine Engineers, December 12, 1989.) The Flight III design was canceled in late-1990/early-1991. Subsequent studies led to the current Flight IIA design, which does not include a hull extension. A 1994 CRS report discussed the option of lengthening the DDG-51 design by about 12 feet to increase the forward VLS battery from 32 cells to 64 cells. (See CRS Report 94-343 F, *Navy DDG-51 Destroyer Procurement Rate: Issues and Options for Congress*, by Ronald O'Rourke [April 25, 1994; out of print and available directly from the author]), pp. CRS-27 to CRS-28.

[18]Sources: Recent discussions with industry officials and Navy information provided to CRS in 1997.

[19]See CRS Report 94-343 F, *Navy DDG-51 Destroyer Procurement Rate: Issues and Options for Congress*, by Ronald O'Rourke [April 25, 1994; out of print and available directly from the author]), pp. CRS-27 to CRS-28.

[20]The Arsenal Ship program was aimed at acquiring a small number of relatively simple and inexpensive surface ships, each armed with about 512 VLS tubes. The program was cancelled in 1997. For more on the program, see CRS Report 97-455 F, *Navy/DARPA Arsenal Ship Program: Issues and Options for Congress*, by Ronald O'Rourke, and CRS Report 97-1004 F, *Navy/DARPA Maritime Fire Support Demonstrator (Arsenal Ship) Program: Issues Arising From Its Termination*, by Ronald O'Rourke.

Table 2. 1997 Navy Information on DDG-51 Variants With Additional VLS Tubes

Variant	Number of Mk 41 VLS tubes (% change relative to Flight IIA)	Number of 5-inch guns	Hull extension (in feet)	Rough recurring procurement cost (relative to Flight IIA)
Current Flight IIA design	96	1	0	1.00
Option 1	128 (+ 33%)	1	12[a]	<1.05
Option 2	160 (+ 67%)	1	30	<1.10
Option 3	192 (+100%)	1	<56	<1.15
Option 4	256 (+167%)	1	56	<1.20

Source: U.S. Navy data provided to CRS on April 9, 1997, except for the figure of 12 feet shown for the variant with 32 additional VLS cells, which is U.S. Navy data provided for CRS Report 94-343 F, *Navy DDG-51 Destroyer Procurement Rate: Issues and Options for Congress*, by Ronald O'Rourke [April 25, 1994; out of print and available directly from the author]). The cost figures in the table are rough order of magnitude (ROM) estimates and do not reflect any detailed design or engineering costs typically reflected in a lead-ship cost. The cost estimates provided by the Navy to CRS, though ROM estimates, were more precise than shown here, and were labeled business sensitive. They have been rendered more approximate by CRS for presentation in this table. The costs of the options as estimated by the Navy did not differ from one another in exact increments of 5%. See also Figure 6 on page 131 from Dean A. Rains, "Methods For Ship Military Effectiveness Analysis," *Naval Engineers Journal*, March 1994: 126-135; and Table 3 on page 26 from Dean A. Rains, "Naval Ship Affordability," *Naval Engineers Journal*, July 1996: 19-30.

As shown in the table, all these options retain the DDG-51's 5-inch gun. If the gun is considered not critical for the ship's intended concept of operations, it could be eliminated from the design, which would reduce the design's procurement cost. Supporters of eliminating the 5-inch gun might argue that the gun is not critical because it does not contribute to a goal of providing improved IAMD capabilities, and because the Navy already has 106 5-inch guns on 22 existing Aegis cruisers (two guns each) and 62 DDG-51s already in service or under construction (one gun each). Opponents of eliminating the 5-inch gun could argue that the absence of a gun would reduce the mission flexibility of the ship.

Version With Reduced O&S Costs and An Improved Radar

This version of the DDG-51 design would include an improved radar in the place of the DDG-51's current SPY-1 radar, as well as features for reducing O&S costs. The purpose in procuring this version would be to provide the fleet with improved IAMD capabilities.

The improved radar would use active-array radar technology, as opposed to the older passive-array technology used in the SPY-1. The active-array technology would be similar to that used, for example, in the DDG-1000 dual band radar. Multiple industry sources have briefed CRS on their proposals for modifying the DDG-51 design to include an active-array radar with greater capability than the SPY-1.

If the DDG-51 hull is not lengthened, then modifying the DDG-51 design to include an improved radar would require removing the 5-inch gun to make space and weight available for additional equipment needed to support operations with the improved radar. Lengthening the hull might provide enough additional space and weight capacity to permit the 5-inch gun to be retained.[21] Supporting equipment to be installed would include an additional electrical generator and additional cooling equipment.[22] The best location for the generator might be in one of the ship's two helicopter hangar spots, which would reduce the ship's helicopter hangar capacity from two helicopters to one.

Due to the higher cost of the improved radar compared to the SPY-1 and the cost for the additional generator and cooling equipment, modifying the DDG-51 design to this configuration would increase the recurring procurement cost of the ship. Information provided to CRS by industry suggests that if the hull is not lengthened, the increase might be in the general range of $100 million, or perhaps or more. If the hull were lengthened, the cost increase would be greater.

Version With Reduced O&S, Additional Tubes, and An Improved Radar

This version of the DDG-51 design would include both additional vertical-launch tubes and an improved radar, as well as features for reducing O&S costs. The purpose in procuring this version would be to provide the fleet with improved IAMD capabilities. This option would require the hull to be lengthened. The resulting ship would be more expensive in all respects (nonrecurring design and engineering costs, procurement costs, and annual O&S costs) and more capable than the other options discussed here.[23] If the ship's hull were lengthened by 55 or 56 feet, the resulting ship might be roughly 25% more expensive to procure than the current Flight IIA design, or perhaps more than that.

DDG-51 Modernization Program

In the context of a decision to stop DDG-1000 procurement and restart DDG-51 procurement, policymakers may consider the option of altering the current program for modernizing existing DDG-51s so as to produce modernized ships with configurations similar to the modified configurations discussed above for new-construction DDG-51s. Each of the modified configurations discussed above might be achievable through modernizations of existing DDG-51s.

Altering the DDG-51 modernization program to include such changes to the ship configuration would:

- increase the cost of the modernization program;

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[21]Some sources consulted by CRS believe that the 5-inch gun could be retained, even if the hull is not lengthened.

[22]Some sources consulted by CRS believe that an additional electrical generator might not be needed.

[23]Depending on the amount of reduction in annual O&S costs, it is possible that this ship might be comparable to, or less expensive than, a baseline DDG-51 Flight IIA in terms of annual O&S costs.

- increase the amount of shipyard work associated with each modernization, which could have implications for supporting the shipbuilding industrial base (see discussion below);

- produce ships with lower O&S costs than currently planned;

- produce ships that are aligned more closely with a possible policy goal of providing the fleet with improved NSFS or IAMD capabilities; and

- permit the modernization effort to produce ships with improved NSFS capabilities while the new-construction effort produces ships with improved IAMD capabilities, or vice versa, thus pursuing both of these potential policy goals.

Non-Combat Adjunct Ship With Powerful Radar

If DDG-51s are procured or modernized with an eye toward providing improved IAMD capabilities, another option that policymakers may consider would be to procure a non-combat ship equipped with a powerful radar to act as an adjunct platform for missile defense operations and perhaps also air defense operations. The radar on the ship would be a large, active-array radar that would be considerably more powerful than the improved radar that could be installed on a modified DDG-51. The presence in the fleet of such a radar could significantly improve the fleet's IAMD capabilities. The ship might be similar to the Cobra Judy Replacement ship currently under construction. A few or several such adjunct ships might be procured, depending on the number of theaters to be covered, requirements for maintaining forward deployments of such ships, and their homeporting arrangements. The ships would have little or no self-defense capability and would need to be protected in threat situations by other Navy ships.

Supporting the Shipbuilding Industrial Base

Policymakers have expressed concern about the potential impact on the shipbuilding industrial base over the next several years of a decision to stop DDG-1000 procurement and restart DDG-51 procurement. Particular concern has been expressed about General Dynamics' Bath Iron Works (GD/BIW) of Bath, ME, since construction of surface combatants is that yard's primary source of work.

The Navy informed CRS on March 11, 2008, that a DDG-1000 would require, by Navy estimates, about 2.5 times as much shipyard labor to build as would be required to build a DDG-51.[24] On April 10, 2008, the Navy clarified that this ratio was based on the number of labor hours that the Navy estimates will be needed to build the first two DDG-1000s, and that subsequent DDG-1000s would require smaller amounts of shipyard labor, reducing the ratio for subsequent ships to something less than 2.5 to 1.[25] (The DDG-51 design, in contrast, is already well down its learning curve and would not decline by a substantial additional amount through additional production.)

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[24]Source: Navy Office of Legislative Affairs telephone call to CRS on March 11, 2008.

[25]Source: Navy briefing to CRS and CBO on April 10, 2008.

Assuming a rate of learning in the DDG-1000 production process that might be typical for a complex combatant ship, and taking into account the shared production arrangement for the DDG-1000, a seventh DDG-1000 might require roughly 1.7 to 1.9 times as much shipyard labor to build as a baseline Flight IIA DDG-51. Other calculations based on these factors include the following:

- ships 3 through 7 in a 7-ship DDG-1000 program might provide the equivalent of roughly 9.3 to 10.3 baseline Flight IIA DDG-51s' worth of shipyard labor hours;

- the shipyard that was the primary yard for building ships 3, 5, and 7 in a 7-ship DDG-1000 program would receive a total of roughly 5.1 to 5.7 baseline Flight IIA DDG-51s' worth of shipyard hours for its role in building ships 3 through 7 in a 7-ship DDG-1000 program; and

- the shipyard that was the primary yard for building ships 4 and 6 in a 7-ship DDG-1000 program would receive a total of roughly 4.2 to 4.6 baseline Flight IIA DDG-51s' worth of shipyard labor hours for its role in building ships 3 through 7 in a 7-ship DDG-1000 program.[26]

These figures suggest that if policymakers desire to fully replace the shipyard labor hours that would have been provided by ships 3 through 7 in a 7-ship DDG-1000 program, and if procurement of DDG-51s of some kind through FY2013 (the year in which the seventh DDG-1000 was scheduled for procurement) provides less than the equivalent of roughly 9.3 to 10.3 baseline Flight IIA DDG-51s' worth of shipyard labor hours, then one or more of the options listed below for supplementing DDG-51 construction work with other forms of work might be considered.

In addition to total shipyard hours, another factor to consider for maintaining the shipyards is whether the mix of work being pursued preserves critical ship-construction skills, including outfitting skills and combat system integration skills. The options listed below for supplementing DDG-51 construction work would support such skills to varying degrees.

There are multiple options for supplementing DDG-51 construction work so as to support the shipbuilding industrial base over the next several years, including but not limited to the following:

- assigning DDG-51 modernizations to the two yards that built the ships — GD/BIW and the Ingalls yard at Pascagoula, MS, that forms part of Northrop Grumman Shipbuilding (NGSB);

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[26]Source: CRS calculation based on a CRS assumption of:
— a smooth learning curve of 85% to 90% for the DDG-1000 program;
— a unified learning curve for the portions of every DDG-1000 that are to be built by only one single firm; and
— a split learning curve for the portion of each DDG-1000 that is to be built by the yard performing the final-assembly work on the ship.
For a discussion of shipbuilding learning curves, see CRS Report 96-785 F, *Navy Major Shipbuilding Programs and Shipbuilders: Issues and Options for Congress*, by Ronald O'Rourke, pp. 95-110. [out of print and available directly from the author]

- assigning Aegis cruiser (i.e., CG-47 class) modernizations to the two yards that built the ships (again, GD/BIW and the Ingalls yard);

- procuring adjunct non-combat radar ships as described earlier in this statement and assigning the construction of those ships to GD/BIW and/or NGSB;

- having GD/BIW participate in the construction of Littoral Combat Ships that are built to the General Dynamics LCS design;

- procuring one or more LPD-17s beyond those in the Navy's shipbuilding plan, and perhaps have GD/BIW build parts of those ships (similar to how GD/BIW is currently building parts of LPD-24 for NGSB);[27]

- procuring additional LHA-type amphibious assault ships, and perhaps have GD/BIW build parts of those ships;[28]

- procuring AGS-armed versions of the basic LPD-17 class hull — another option that has been suggested for improving the fleet's NSFS capabilities (see **Appendix A** to this statement) — and perhaps have GD/BIW builds parts of those ships;

- procuring a third and final DDG-1000;[29]

- procuring two new polar icebreakers for the Coast Guard, and assigning construction of those ships to NGSB and/or GD/BIW;[30] and

- accelerating the procurement of National Security Cutters (NSCs) for the Coast Guard (NSCs are built at NGSB).

Some of these options would be available for implementation sooner than others. Those available the soonest might be of the most use for bridging a work gap between the winding down of DDG-1000 production and the restart of DDG-51 production. As mentioned earlier, the Navy and

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[27]GD/BIW was originally slated to build 4 of a then-planned class of 12 LPD-17s, and is currently building parts of LPD-24, the eighth ship in the class. NGSB has subcontracted parts of other LPD-17s to a shipyard in Texas.

[28]For additional discussion of the amphibious lift goal and the numbers of amphibious ships that might be procured to support that goal, see CRS Report RL34476, *Navy LPD-17 Amphibious Ship Procurement: Background, Issues, and Options for Congress*, by Ronald O'Rourke.

[29]Procurement of a third and final DDG-1000 could be viewed as somewhat analogous to the procurement of the third and final Seawolf (SSN-21) class submarine, which was procured in part to help maintain the submarine construction industrial base while the successor Virginia (SSN-774) class design was being readied for procurement.

[30]For a discussion of the option of procuring new polar icebreakers for the Coast Guard, see CRS Report RL34391, *Coast Guard Polar Icebreaker Modernization: Background, Issues, and Options for Congress*, by Ronald O'Rourke. The procurement of the Coast Guard's newest polar icebreaker, Healy (WAGB-20), was funded in FY1990 through the Navy's shipbuilding budget (the Shipbuilding and Conversion, Navy [SCN] appropriation account).

other observers have cautioned that the time line for restarting procurement of the current Flight IIA design could be extended by the need to restart or reestablish vendors for certain key DDG-51 components.

Increasing the scope of work to be performed in the DDG-51 modernization program to include configuration changes like those discussed earlier in this statement could increase the amount of work that would be provided by the first option above. Similarly, increasing the scope of work to be performed in the CG-47 modernization program to include the installation of an improved radar (an option discussed in **Appendix B** to this statement) could increase the amount of work that would be provided by the second option above.

Procuring additional ships to be built at NGSB could help support GD/BIW, even if GD/BIW does not share in their production, by permitting a greater share of DDG-51 construction work to be assigned to GD/BIW while still adequately supporting NGSB.

Mr. Chairman, distinguished members of the subcommittee, this concludes my testimony. Thank you again for the opportunity to appear before you to discuss these issues. I will be pleased to respond to any questions you might have.

Appendix A. Non-DDG-51 Options for Improved NSFS or IAMD Capabilities

This appendix presents a brief summary of some non-DDG-51 ship procurement and modernization options for improving the fleet's NSFS or IAMD capabilities.

Non-DDG-51 Options For Improved NSFS

Non-DDG-51 options for providing improved NSFS capabilities include but are not necessarily limited to the following:

- **Procuring the current DDG-1000 design.** The current DDG-1000 design was developed to provide improved capabilities for NSFS and therefore does not need to be modified to be aligned with such a goal. The DDG-100 design includes, among other features, two AGSs, each with a magazine capable of 300 LRLAP rounds, for a total of 600 rounds. The DDG-1000 is also designed to take on additional LRLAP rounds while it is firing LRLAPs, creating what has been called an "infinite magazine."

- **Procuring a modified LPD-17 hull equipped with two AGSs.** Procuring a modified LPD-17 hull equipped with two AGSs has been suggested by both the Congressional Budget Office (CBO) and the Center for Strategic and Budgetary Assessments (CSBA) as a potential alternative to procuring DDG-1000s. The two guns and their magazines would be installed in the aft part of the ship, which would degrade or eliminate the LPD-17 design's well deck and aviation capabilities. CBO estimated in 2006 that an initial AGS-armed LPD-17 might cost about $1.9 billion, including $400 million detailed design and nonrecurring engineering costs, and that subsequent ships might cost about $1.5 billion each.[31]

Non-DDG-51 Options For Improved IAMD

Non-DDG-51 options for providing improved IAMD capabilities include but are not necessarily limited to the following:

- **Procuring a modified DDG-1000 design that includes additional vertical launch tubes rather than AGSs, perhaps in conjunction with procuring an adjunct non-combat radar ship.** This option would involve removing the ship's two AGSs and their magazines and using the freed-up space for additional vertical launch tubes, so as to more closely align the DDG-1000 design with the goal of providing improved IAMD capabilities. This option could significantly increase the number of vertical-launch capacity of the ship. This option could also involve procuring, as an adjunct platform, a non-combat ship equipped with a powerful radar for supporting improved missile defense operations and perhaps also improved air defense operations. This adjunct ship was discussed in the main part of this statement.

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[31] See Congressional Budget Office, *Options for the Navy's Future Fleet*, May 2006, pp. 56-57 (Box 3-1).

- **Procuring a modified DDG-1000 design that includes additional vertical launch tubes rather than AGSs, and also a higher-capability radar, perhaps in conjunction with procuring an adjunct non-combat radar ship.** This option is similar to the previous option, except that the DDG-1000 would also be equipped with a radar with more capability than the radar in the current DDG-1000 design. (The higher-capability radar would use active-array technology, like the current DDG-1000 radar, but would use that technology in a radar with more fully populated arrays.) A radar with a certain amount of additional capability could be accommodated without redesigning the DDG-1000 deck house; a radar with a greater amount of additional capability could be accommodated through a partial redesign of the deckhouse (i.e., a redesign that would affect the deckhouse but not require a change to the ship's basic hull design). Due to the space needed for the additional cooling units that would be needed to support a higher-capability radar, this option might result in a smaller number of additional vertical launch tubes than the previous option. This option, like the previous option, could also involve procuring an adjunct non-combat ship equipped with a powerful radar, particularly if the higher-capability radar on the DDG-1000 is the one that does not require redesigning the deckhouse.

- **Modifying existing CG-47s to include an improved radar.** This option would involve replacing the SPY-1 radar on existing CG-47s with an improved radar using active-array technology similar to the technology used in the current DDG-1000 radar. This option would require the removal of one of the CG-47's two 5-inch guns, as well as the removal of some other mission equipment. It would also require replacing the ship's electrical generators and cooling equipment with more capable models, and replacing the ship's electrical distribution system. This option could also involve procuring an adjunct non-combat ship equipped with a powerful radar.