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Navy CG(X) Cruiser Design Options: Background and Oversight Issues For Congress

Ronald O'Rourke
Specialist in National Defense
Foreign Affairs, Defense, and Trade Division

Summary

The Navy would like to use the design of its new DDG-1000 destroyer as the basis for its planned CG(X) cruiser. A CG(X) design based on the DDG-1000 might not be affordable to procure in the numbers the Navy desires. Basing the CG(X) on a smaller hull would produce a CG(X) design that was individually less capable but more affordable. In deciding on a design for the CG(X), policymakers may wish to weigh unit capability against unit affordability. This report will be updated as events warrant.

Introduction

The issue for Congress discussed in this report is: What basic design option should be pursued for the Navy's planned CG(X) cruiser? Congress's decisions on this issue could affect the future size and capabilities of the Navy, the affordability of the Navy's shipbuilding program, and the shipbuilding industrial base. This report focuses on the question of basic CG(X) design options. For a more general discussion of the CG(X) and DDG-1000, see CRS Report RL32109, *Navy DDG-1000 (DD(X)) and CG(X) Ship Acquisition Programs: Oversight Issues and Options for Congress*, by Ronald O'Rourke.

Background

CG(X) Cruiser Program. The CG(X) cruiser is the Navy's planned replacement for its 22 existing Ticonderoga (CG-47) class Aegis-equipped cruisers, which are projected to reach retirement age between 2021 and 2029. The CG-47s are multimission ships with an emphasis on air defense. The Navy wants the CG(X) to be a multimission ship with an emphasis on air defense and ballistic missile defense (BMD).[1] The Navy plans to equip the CG(X) with a powerful new radar capable of supporting BMD

[1] For more on the Navy's role in ballistic missile defense, see CRS Report RL33745, *Sea-Based Ballistic Missile Defense — Background and Issues for Congress*, by Ronald O'Rourke.

operations, perhaps more missile-launch tubes than are on the DDG-1000, and perhaps one 155mm Advanced Gun System (AGS), or none, as opposed to two AGSs on the DDG-1000. The Navy's planned 313-ship fleet calls for a total of 19 CG(X)s.[2] The FY2007-FY2011 Future Years Defense Plan (FYDP) calls for procuring the first CG(X) in FY2011. A 30-year shipbuilding plan that the Navy submitted to Congress in early 2006 calls for building a total of 18 (not 19) CG(X)s between FY2011 and FY2023, including two CG(X)s per year for most of the years between FY2015 and FY2022.

CG(X) Analysis of Alternatives (AOA). The Navy is currently assessing CG(X) design options in a large study called the CG(X) Analysis of Alternatives (AOA), known more formally as the Maritime Air and Missile Defense of Joint Forces (MAMDJF) AOA. The Navy initiated this AOA in FY2006 and plans to complete it in FY2007. Navy plans call for Milestone A review of the CG(X) program in the fourth quarter of FY2007, preliminary design review (PDR) during the first three quarters of FY2010, and Milestone B review of the program in the fourth quarter of FY2011.

Navy Preference for Design Based on DDG-1000 Hull. Although the CG(X) AOA may be examining a wide range of design options for the CG(X), the Navy has publicly stated that it prefers a CG(X) design based on the design of its new 14,500-ton DDG-1000 destroyer. The potential for using the DDG-1000 design for the CG(X) was one of the Navy's arguments for moving ahead with the DDG-1000 program. At an April 5, 2006, hearing, a Navy admiral in charge of shipbuilding programs, when asked what percentage of the CG(X) design would be common to that of the DDG-1000 (previously called the DD(X)), stated the following:

> [W]e haven't defined CG(X) in a way to give you a crisp answer to that question, because there are variations in weapons systems and sensors to go with that. But we're operating under the belief that the hull will fundamentally be — the hull mechanical and electrical piece of CG(X) will be the same, identical as DD(X). So the infrastructure that supports radar and communications gear into the integrated deckhouse would be the same fundamental structure and layout. I believe to accommodate the kinds of technologies CG(X) is thinking about arraying, you'd probably get 60 to 70 percent of the DD(X) hull and integrated (inaudible) common between DD(X) and CG(X), with the variation being in that last 35 percent for weapons and that sort of [thing]....
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> The big difference [between CG(X) and DDG-1000] will likely [be] the size of the arrays for the radars; the numbers of communication apertures in the integrated deckhouse; a little bit of variation in the CIC [Combat Information Center — in other words, the] command and control center; [and] likely some variation in how many launchers of missiles you have versus the guns.[3]

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[2] For more on the Navy's 313-ship plan, see CRS Report RL32665, *Navy Force Structure and Shipbuilding Plans: Background and Issues for Congress*, by Ronald O'Rourke.

[3] Source: Transcript of spoken testimony of Rear Admiral Charles Hamilton II, Program Executive Officer For Ships, Naval Sea Systems Command, before the Projection Forces Subcommittee of House Armed Services Committee, April 5, 2006. The inaudible comment may have been a reference to the DDG-1000's integrated electric-drive propulsion system. Between the two paragraphs quoted above, the questioner (Representative Gene Taylor) asked: "So the big difference [between CG(X) and DDG-1000] will be what?"

Prospective Affordability of CG(X) In Numbers Desired. If the CG(X) is based on the DDG-1000 design, its unit procurement cost will likely be comparable to that of the DDG-1000. The FY2007-FY2011 FYDP includes about $3.25 billion in FY2011 to procure the first CG(X). This compares with $3.29 billion to procure each of the first two DDG-1000s in FY2007-FY2008, and an average of about $2.54 billion each to procure the third, fourth, and fifth planned DDG-1000s in FY2009, FY2010, and FY2011. Some observers, including the Congressional Budget Office (CBO), have expressed concern about the prospective affordability and executibility of the Navy's long-range shipbuilding plan, particularly in FY2011 and subsequent years, when Navy plans call for doubling the attack submarine (SSN) procurement rate to two per year, and for often procuring two CG(X)s per year.[4] Early Navy plans called for procuring two DDG-1000s per year, and a total of 16, 24, or 32 ships. In large part for affordability considerations, planned DDG-1000 procurement was reduced to one ship per year, and a total of 7 ships. If affordability considerations similarly limit CG(X) procurement to one ship per year, total CG(X) procurement might be reduced from 18 or 19 ships to perhaps no more than 12 ships, and possibly as few as seven.[5]

Congressional Interest in Nuclear Propulsion. Some Members of Congress, particularly Representatives Gene Taylor and Roscoe Bartlett of the Projection Forces subcommittee of the House Armed Services Committee, have expressed interest in expanding the use of nuclear propulsion to a wider array of Navy surface ships, including the CG(X).[6]

Potential CG(X) Design Options. If the CG(X) is to be a multimission ship for replacing the CG-47s, basic design options for the CG(X) include (but are not limited to) the following:

- a conventionally powered ship based on the hull design of the 9,200-ton Arleigh Burke (DDG-51) class Aegis destroyer;
- a conventionally powered ship based on a new-design hull that is smaller than the DDG-1000 hull;

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[4] For a discussion, see CRS Report RL326665, op cit, and Congressional Budget Office, *Options for the Navy's Future Fleet*, May 2006.

[5] Twelve ships would result from getting one CG(X) in each of the 12 years (FY2011-FY2023, except FY2012) that the Navy currently plans to procure at least one CG(X). If DDG-1000 procurement is stopped after procurement of the fourth ship in FY2010, so as to make room in the Navy's shipbuilding budget for CG(X)s in FY2011 and subsequent years, then seven CG(X)s combined with four DDG-1000s would make for a combined DDG-1000/CG(X) force of 11 ships. Although the Navy does not base its ship force structure planning on standard, "cookie-cutter" naval formations, an 11-ship DDG-1000/CG(X) force might nevertheless be rationalized as enough to provide one DDG-1000 or CG(X) for each of the Navy's planned 11 carrier strike groups.

[6] See, for example, Dave Ahearn, "Congressman Presses Strategy For Full Destroyer Production Run," *Defense Daily*, July 20, 2006. See also the statements and transcripts of the April 6, 2006, hearing on ship propulsion technologies before the Projection Forces subcommittee of the House Armed Services Committee (not to be confused with the same subcommittee's hearing of April 5, 2006, on Navy shipbuilding programs, quoted earlier), and CRS Report RL33360, *Navy Ship Propulsion Technologies: Options for Reducing Oil Use — Background for Congress*, by Ronald O'Rourke.

- a conventionally powered ship based on the DDG-1000 hull design (the Navy's preferred approach); and
- nuclear-powered versions of each of these three ships.

To varying degrees, all of these options could:

- start procurement several years from now, if design work were started right away;
- be equipped with a radar powerful enough to support BMD operations, as well as missile-launch tubes large enough for the Kinetic Energy Interceptor (KEI) — a large BMD interceptor currently in development that might be procured for Navy use;
- incorporate an integrated electric-drive propulsion system, like the DDG-1000;
- incorporate other new technologies now being developed for the DDG-1000; and
- be similar to the DDG-1000 in terms of using a reduced-size crew to reduce annual operation and support (O&S) costs.

Ship Based on DDG-51 Hull Design. Basing the CG(X) on the current DDG-51 hull could produce a CG(X) design displacing roughly 9,000 tons. Lengthening the DDG-51 hull with a mid-hull plug might produce a CG(X) design displacing roughly 11,000 tons, which would be about 24% smaller than the 14,500-ton DDG-1000, and roughly as large as the six California (CGN-36) and Virginia (CGN-38) class nuclear-powered cruisers that were procured for the Navy in the 1960s and 1970s. The deck house and lower decks of the DDG-51 hull would need to be redesigned to accommodate a radar capable of supporting BMD operations, an integrated electric-drive propulsion system, other new technologies from the DDG-1000, and KEI-sized missile-launch tubes (if desired). Since the DDG-51 hull was developed in the 1980s, it may include hard-to-change features that prevent it from fully accommodating certain DDG-1000 new technologies, such as, perhaps, those permitting the ship to be operated by a substantially smaller crew.

For ships of a similar type and level of complexity, relative size can be rough proxy for relative unit procurement cost. A 9,000- to 11,000-ton CG(X) would be 62% to 76% as large as a 14,500-ton DDG-1000-based CG(X). However, some shipbuilding costs, such as shipyard fixed overhead costs, do not go down proportionately with ship size. A DDG-51-based CG(X) consequently might cost more than 62% to 76% of what a 14,500-ton CG(X) would cost to procure — perhaps something more like 72% to 86%. Production of a DDG-51-based CG(X) might benefit from residual learning-curve effects of prior production of DDG-51s, the last of which was procured in FY2005. Any limitations in incorporating DDG-1000 technologies for reducing crew size could result in a ship with a larger crew than that of the DDG-1000, and thus higher crew-related life-cycle O&S costs than a DDG-1000-based CG(X).

The DDG-51 hull is a conventional flared hull that slopes outward as it rises up from the waterline. A CG(X) based on the DDG-51 hull consequently would be more detectible by radar than a ship using a tumblehome (inwardly sloping) hull, like that of the DDG-1000. As ship size grows, so does the size of the ship's payload of sensors and weapons. Consequently, larger ships generally have more capability than smaller ones. Indeed, due to certain economies of scale that occur in naval architecture, larger ships can have *proportionately* larger payloads than smaller ones.[7] Thus, a DDG-51-based CG(X) might be *less than* 62% to 76% as capable as a 14,500-ton CG(X).

Ship Based on New-Design Hull. A ship using a new-design hull smaller than the DDG-1000 hull might similarly displace roughly 9,000 to 11,000 tons. (A new-design hull larger than about 11,000 tons might be too close in size to the DDG-1000 hull to produce savings that are worthwhile compared to the option of simply reusing the DDG-1000 hull.) The procurement cost of such a ship might be about equal to that of a DDG-51-based design, or perhaps somewhat less, if the new-design hull incorporates producibility features (i.e., features for ease of manufacturing, such as straighter-running pipeline arrangements) that are more advanced than those of the DDG-51 hull. A new-design hull might be able to take more complete advantage of DDG-1000 technologies than a DDG-51-based design, possibly giving the ship a smaller crew and thus lower personnel-related O&S costs. The new-design hull could be a conventional flared hull, like that of the DDG-51, or a reduced-size version of the DDG-1000's tumblehome hull. The latter option could produce a ship as stealthy as (or perhaps slightly stealthier than) the DDG-1000. Due to the potential greater ability to take advantage of DDG-1000 technologies or other new technologies, a 9,000- to 11,0000-ton ship based on a new-design hull might be somewhat more capable than a DDG-51-based design. A 9,000- to 11,000-ton design would still, however, be substantially less capable than a DDG-1000-based design, and perhaps proportionately less capable.

Ship Based on DDG-1000 Hull Design. The procurement cost of this option, the Navy's preferred choice, would be substantially greater than those of the previous two options, but perhaps less so than a simple size comparison would suggest, due to shipbuilding costs that are fixed or relatively insensitive to ship size. Production of the ship would benefit from learning-curve effects of producing DDG-1000s. Hull-design and system-integration costs would be minimized through reuse of the DDG-1000 hull and elements of the DDG-1000 combat system, and could be substantially lower than those of the previous two options. The ship would be substantially more capable than the previous two options, and perhaps proportionately more capable, due to economies of scale in naval architecture. Thus, although this ship would be substantially more expensive to procure, it would likely offer more capability per dollar than the previous two designs.

Nuclear-Powered Versions Of These Three Ships. Adding a nuclear propulsion plant to any of the above three options would likely increase its unit procurement cost by several hundred million dollars. The nuclear plant would include a an initial nuclear fuel core sufficient to power the ship for much or all of its expected 35-year service life. If oil prices in coming years are high, much of the increase in unit procurement cost could be offset over the ship's service life by avoided fossil-fuel costs.[8] Designing a nuclear propulsion plant for the ship would likely cost hundreds of millions of dollars, and possibly make the ship ready for procurement one or more years later than

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[7] For example, due to sources of hull drag and its effect on ship speed, as ship size grows, the size of the propulsion plant needed to push the ship through the water at a given speed does not need to grow as quickly. Larger ships consequently can have proportionately smaller propulsion plans, leaving proportionately larger amounts of room sensors and weapons.

[8] For a discussion of this issue, see CRS Report RL33360, op cit.

a conventionally powered version. The ship would be more capable than the corresponding conventionally powered version because of the mobility advantages of nuclear propulsion, which include, for example, the ability to make long-distance transits at high speeds in response to distant contingencies without need for refueling. Unlike a conventionally powered ship, which could be built entirely at Northrop Grumman Ship Systems (NGSS) of Pascagoula, MS, and New Orleans, LA, or at General Dynamics Bath Iron Works (GD/BIW) of Bath, ME, at least the nuclear portion of a nuclear-powered ship might need to be built at Northrop Grumman Newport News of Newport News, VA, the country's only shipyard currently capable of building nuclear-powered surface ships (unless NGSS or GD/BIW were licensed for nuclear ship construction).

Assessing These Options. The basic CG(X) design options presented above can be assessed in terms of development cost and risk, procurement cost, annual O&S cost, and unit capability, all in the context of operational requirements or desires, the potential operational risks of not fulfilling those requirements or desires due to insufficient unit capability or insufficient ship quantities, and potential implications for the shipbuilding industrial base. The question of whether to procure a potentially smaller number of individually more expensive and more capable ships, or a potentially larger number of individually less expensive and less capable ships, is a classic ship-design and force-planning issue that the Navy, the Department of Defense, and Congress have faced many times in the past. The advantage that larger ships have in terms of unit capability and capability per dollar is one reason why the Navy has often preferred larger and more capable designs in recent decades. This advantage has been counterbalanced by the issue of unit procurement affordability, because procuring an insufficient quantity raises the risk of not having a ship in service in the right location when it is needed.

Potential Oversight Issues for Congress

Potential oversight questions for Congress include the following:

- How much consideration is the Navy giving in the CG(X) AOA to design options other than those based on the DDG-1000? Are other basic options being treated in the AOA simply as straw men?
- How do the costs and capabilities of 9,000- to 11,000-ton CG(X) designs compare to those of a DDG-1000-based CG(X)? Under potential future budget conditions, how many units of these designs might be procured? In light of potential procurement rates and procurement totals, what are the potential operational risks and industrial-base implications of these designs?
- In assessing basic CG(X) design options, is the Navy assigning too much value, not enough value, or about the right amount of value to the sunk costs of designing the DDG-1000 hull and to CG(X) production economies that can result from moving down the DDG-1000 learning curve?