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

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

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Summary

The Navy has stated that it would like to use the design of its new DDG-1000 destroyer as the basis for its planned CG(X) cruiser. Ships based on other hull designs are possible. Nuclear propulsion is an option being studied for the CG(X). For a more general discussion of both 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. This report on basic CG(X) design options will be updated as events warrant.

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 large and powerful new radar capable of supporting BMD operations. The CG(X) may also have more missile-launch tubes than are on the DDG-1000, and 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 FY2008-FY2013 Future Years Defense Plan (FYDP) calls for procuring the first CG(X) in FY2011 and the second in FY2013. The Navy's 30-year (FY2008-FY2037) shipbuilding plan calls for building 17 more CG(X)s between FY2014 and FY2023, including two CG(X)s per year for the seven-year period FY2015-FY2021.

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[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.

[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.

CG(X) Analysis of Alternatives (AOA). The Navy is currently assessing CG(X) design options in a 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 the second quarter of FY2006 and plans to complete it by mid-September 2007. Navy plans call for Milestone A review of the CG(X) program in the first quarter of FY2008, preliminary design review (PDR) in the third quarter of FY2010, critical design review (CDR) in the third quarter of FY2011, and Milestone B review in the fourth quarter of FY2011.

Navy Preference for Design Based on DDG-1000 Hull. Although the CG(X) AOA is examining a wide range of design options for the CG(X), the Navy has publicly stated on several occasions that would like to use the design of its new DDG-1000 destroyer as the basis for the CG(X). (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, for example, a Navy admiral then 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]

Prospective Affordability of CG(X) in Numbers Desired. If the CG(X) is based on the DDG-1000 design, its unit procurement cost might be comparable to that of the DDG-1000. The FY2008-FY2013 FYDP includes notional "placeholder" figures of about $3.2 billion in FY2011 to procure the first CG(X) and about $3.1 billion in FY2013 to procure the second CG(X). This compares with about $3.2 billion to procure each of the first two DDG-1000s in FY2007-FY2008. 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

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[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?"

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 19 ships to perhaps no more than 12 ships, and possibly as few as eight.[4] 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.[5]

Congressional Interest in Nuclear Propulsion. Some Members of Congress, particularly Representatives Gene Taylor and Roscoe Bartlett, the chairman and ranking member, respectively, of the Seapower and Expeditionary Forces subcommittee of the House Armed Services Committee, strongly support expanding the use of nuclear propulsion to a wider array of Navy surface ships, beginning with the CG(X).[6] Nuclear propulsion is an option being studied in the CG(X) AOA.

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, or on a variation of that hull design;
- a conventionally powered ship based on a new-design hull that is smaller than the DDG-1000 hull;
- a conventionally powered ship based on the DDG-1000 hull design or on a variation of that hull design (the Navy's stated preferred approach);
- a conventionally powered ship based on a new-design hull that is larger than the DDG-1000 hull; and
- nuclear-powered versions of each of these four ships.

Ship Based on DDG-51 Hull or Variation of That Hull. 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

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[4] 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 eight CG(X)s combined with four DDG-1000s would make for a combined DDG-1000/CG(X) force of 12 ships. Although the Navy does not base its ship force structure planning on standard, "cookie-cutter" naval formations, a 12-ship CG(X) force (or a combined 12-ship DDG-1000/CG(X) force) might nevertheless be rationalized as enough to provide one ship for each of the Navy's planned eventual total of 12 carrier strike groups.

[5] For a discussion, see CRS Report RL32665, op. cit., and Congressional Budget Office, *Options for the Navy's Future Fleet*, May 2006.

[6] For additional discussion, see CRS Report RL33946, *Navy Nuclear-Powered Surface Ships: Background, Issues, and Options for Congress*, by Ronald O'Rourke.

propulsion system, other new technologies from the DDG-1000, and (if desired) missile-launch tubes large enough to accommodate a BMD interceptor now in development called the Kinetic Energy Interceptor (BMD). Since the DDG-51 hull design was originally 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. In addition, as ship size grows, so does the size of the ship's weapon and sensor payload. 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. Thus, a DDG-51-based CG(X) might be *less than* 62% to 76% as capable as a 14,500-ton CG(X). Due to the space, weight, and energy requirements of the large and powerful BMD-capable radar to be carried by the CG(X), accommodating such a radar in a DDG-51-based CG(X) design might require steep reductions in other ship capabilities.

Ship Based on New-Design Hull Smaller Than DDG-1000 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 unit 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 11,000-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. As with the previous option, due to the space, weight, and energy requirements of the large and powerful BMD-capable radar to be carried by the CG(X), accommodating such a radar in a 9,000- to 11,000-ton CG(X) based on a new-design hull design might require steep reductions in other ship capabilities.

Ship Based on DDG-1000 Hull or Variation of That Hull. This option, which is the Navy's stated preferred approach, could produce a ship about as large as the 14,500-ton DDG-1000, or (if the DDG-1000's hull is expanded) somewhat larger than the DDG-1000 (i.e., upwards of 20,000 tons). The unit procurement cost of this option 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.

Ship Based on New-Design Hull Larger Than DDG-1000 Hull. This option could produce a ship of more than 20,000 tons. In at least some respects, this option would be more capable than the previous option, and perhaps proportionately more capable. The unit procurement cost of this option would be greater than that of the previous option, but perhaps less so than a simple size comparison would suggest. Production might benefit less than would the previous option from the DDG-1000 learning curve, and hull-design and system-integration costs might be higher than those of the previous option due to less reuse of DDG-1000 hull design features and the DDG-1000 combat system.

Nuclear-Powered Versions of These Four Ships. A Navy report submitted to Congress in January 2007 suggests that adding a nuclear propulsion plant to a to any of the above four options would likely increase its unit procurement cost by $600 million to $700 million in constant FY2007 dollars. If oil prices in coming years are high, much or all of the increase in unit procurement cost could be offset over the ship's service life by avoided fossil-fuel costs.

Due to its larger size, the fourth option above would most easily accommodate a modified version of one-half of the new nuclear propulsion plant that has been developed and designed for the Navy's new Gerald R. Ford (CVN-78) class aircraft carriers.[7] The third option above might also accommodate a modified version of one-half of a Ford-class propulsion plant, but perhaps less easily and with more modifications. The first two options above would likely require the design of a new nuclear propulsion plant. Designing a new nuclear propulsion plant would likely cost hundreds of millions of dollars; modifying the Ford-class plant would cost substantially less.

[7] For more on the CVN-78 program, see CRS Report RS20643, *Navy Ford (CVN-78) Class (CVN-21) Aircraft Carrier Program: Background and Issues for Congress*, by Ronald O'Rourke.

A nuclear-powered ship would be more capable than a 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. Building the CG(X) as a nuclear-powered ship might mean that at least part of the ship would not be built at two shipyards that have built the Navy's cruisers and destroyers in recent years, because neither of these yards are certified to build nuclear-powered ships.[8]

Assessing These Options. The basic CG(X) design options presented above can be assessed in terms of development cost and risk, unit 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?
- What are the relative costs and capabilities of the options discussed above? What is the potential tradeoff between unit capability (and unit procurement cost) on the one hand, and potential numbers procured on the other?
- 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 the DDG-1000 learning curve?

Legislative Activity for FY2008

Section 1012 of the House-reported version of the FY2008 defense authorization bill (H.R. 1585) would make it U.S. policy to build cruisers and certain other large Navy ships with nuclear power unless the Secretary of Defense notifies Congress that nuclear power for a given class of ship would not be in the national interest. The provision is discussed on page 387 of the House Armed Services Committee's report on H.R. 1585 (H.Rept. 110-146 of May 11, 2007).

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[8] For a discussion of this issue, see CRS Report RL33946, op. cit.