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Navy Nuclear-Powered Surface Ships: Background, Issues, and Options for Congress

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Summary

Some Members of Congress, particularly on the House Armed Services Committee, have expressed interest in expanding the use of nuclear power to a wider array of Navy surface ships, especially the Navy's planned CG(X) cruiser. The Navy wants to procure the first CG(X) in FY2011, and is currently studying design options for the ship, including the use of nuclear power.

A 2006 Navy study concluded the following, among other things:

- In constant FY2007 dollars, building a Navy surface combatant or amphibious ship with nuclear power rather than conventional power would add roughly $600 million to $800 million to its procurement cost.
- The total life-cycle cost of a medium-size nuclear-powered surface combatant would equal that of a conventionally powered medium-size surface combatant if the cost of crude oil averages $70 per barrel to $225 per barrel over the life of the ship.
- Nuclear-power should be considered for near-term applications for medium-size surface combatants.
- Compared to conventionally powered ships, nuclear-powered ships have advantages in terms of both time needed to surge to a distant theater of operation for a contingency, and in terms of operational presence (time on station) in the theater of operation.

In assessing whether the CG(X) or other future Navy surface ships should be nuclear-powered, Congress may consider a number of issues, including cost, operational effectiveness, ship construction, ship maintenance and repair, crew training, ports calls and forward homeporting, and environmental impact. Potential options for Congress include but are not limited to the following:

- for the CG(X) or other future Navy surface ships, direct the Navy to provide Congress with acquisition plans (including annual funding requirements) for both conventionally powered and nuclear-powered versions, so that Congress can assess both plans;
- direct the Navy to fund the procurement of initial fuel cores for nuclear-powered ships through an appropriation account other than the Shipbuilding and Conversion, Navy (SCN) account;
- direct the Navy to build the CG(X) as a nuclear-powered ship;
- pass permanent legislation, perhaps similar to the so-called Title VIII legislation of the 1970s, requiring future Navy ships of certain kinds to be nuclear-powered;
- provide initial research and development funding to start work on adapting the design of the Ford (CVN-78) class aircraft carrier nuclear power plant for use in the CG(X); and
- direct the Navy to study the option of, or begin the process of, certifying Northrop Grumman Ship Systems and/or General Dynamics' Bath Iron Works to build nuclear-powered ships.

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Introduction and Issue for Congress

Some Members of Congress, particularly on the House Armed Services Committee, have expressed interest in expanding the use of nuclear power to a wider array of Navy surface ships, especially the Navy's planned CG(X) cruiser. The Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee conducted a hearing on the issue on March 1, 2007. The Navy wants to procure the first CG(X) in FY2011, and is currently studying design options for the ship, including the use of nuclear power. Procurement of a nuclear-powered CG(X) in FY2011 would likely involve funding the ship's long-leadtime nuclear-propulsion components in FY2009.

The issue for Congress is whether the CG(X) or other future Navy surface ships should be nuclear-powered. Congress's decisions on this issue could affect, among other things, future Navy capabilities, Navy funding requirements, and the shipbuilding industrial base.

Background

Nuclear and Conventional Power for Ships

Nuclear and Conventional Power in Brief. Most military ships and large commercial ships are conventionally powered, meaning that they burn a petroleum-based fuel, such as marine diesel, to generate power for propulsion and for operating shipboard equipment. Conventionally powered ships are sometimes called fossil fuel ships.

Some military ships are nuclear-powered, meaning that they use an on-board nuclear reactor to generate power for propulsion and shipboard equipment.[1] Nuclear-

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[1] U.S. Navy nuclear-powered ships use pressurized water reactors (PWRs) that are fueled with highly enriched uranium. In a PWR, water flowing through the reactor is heated by the nuclear fuel to a high temperature. The water is pressurized (maintained at a high pressure) so that it does not boil as it heats up. A heat exchanger is then used to transfer heat from the radioactive pressurized water to a separate circuit of non-radioactive water. As the non-radioactive water heats up, it turns into steam that is used to power turbines that drive the ship's propellers and generate power for shipboard equipment.

(continued...)

powered military ships are operated today by the United States, the United Kingdom, France, Russia, and China. Some other countries, such as India, have expressed interest in, or conducted research and development work on, nuclear-powered military ships. A military ship's use of nuclear power is not an indication of whether it carries nuclear weapons — a nuclear-powered military ship can lack nuclear weapons, and a conventionally powered military ship can be armed with nuclear weapons.

Nuclear Power for a Surface Combatant. For a surface combatant like a cruiser, using nuclear power rather than conventional power eliminates the need for the ship to periodically refuel during extended operations at sea. Refueling a ship during a long-distance transit can reduce its average transit speed. Refueling a ship that is located in a theater of operations can temporarily reduce its ability to perform its missions. A nuclear-powered surface combatant can steam at sustained high speeds to a distant theater of operations, commence operations in the theater immediately upon arrival, and continue operating in the theater over time, all without a need for refueling.[2]

In contrast, a conventionally powered surface combatant might need to slow down for at-sea refueling at least once during a high-speed, long-distance transit; might need to refuel again upon arriving at the theater of operations; and might need to refuel periodically while in the theater of operations, particularly if the ship's operations in theater require frequent or continuous movement. **Table 1** shows the unrefueled cruising ranges of the Navy's existing conventionally cruisers and destroyers at a speed of 20 knots, along with transit distances from major U.S. Navy home ports to potential U.S. Navy operating areas. Navy surface combatants have maximum sustained speeds of more than 30 knots. A speed of 20 knots is a moderately fast long-distance transit speed for a Navy surface combatant. For a higher transit speed, such as 25 knots, the unrefueled cruising ranges would be less than those shown in the table, because the amount of fuel needed to travel a certain distance rises with ship speed, particularly as speeds increase above about 15 knots.

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[1] (...continued)
A small number of non-military ships have also been built with nuclear power in recent decades, including the U.S.-built commercial cargo ship NS Savannah, three other commercial cargo ships built in Germany, Japan, and the Soviet Union, and several Soviet/Russian-built nuclear-powered icebreakers. The four cargo ships are no longer in service. More recently, the Center for the Commercial Deployment of Transportation Technologies (CCDoTT) of California State University, Long Beach, has examined the potential cost-effectiveness of building a new generation of nuclear-powered commercial cargo ships.

[2] For an aircraft carrier, the use of nuclear power permits space inside the ship that would have been used for storing ship fuel to be used instead for storing aircraft fuel or other supplies. This lengthens the period of time that a carrier can sustain aircraft operations before needing to take on fuel or other supplies.

Table 1. Unrefueled Cruising Ranges and Transit Distances
(in nautical miles)

Unrefueled cruising ranges at 20 knots	
Arleigh Burke (DDG-51) class destroyer	4,400 nm
Ticonderoga (CG-47) class cruiser	6,000 nm
Transit distances	
Pearl Harbor, HI, to area east of Taiwan[a, b]	4,283 nm
San Diego, CA, to area east of Taiwan[a, c]	5,933 nm
Pearl Harbor, HI, to Persian Gulf (via Singapore)	~9,500 nm
San Diego, CA, to Persian Gulf (via Singapore)[c]	~11,300 nm
Norfolk to Persian Gulf (via Suez canal)	~8,300 nm

Sources: For ship unrefueled cruising ranges: Norman Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet*, 18th ed., Annapolis (MD), 2005. For transit distances to area east of Taiwan: Straight line distances calculated by the "how far is it" calculator, available at [http://www.indo.com/distance/]. (Actual transit distances may be greater due to the possible need for ships to depart from a straight-line course so as to avoid land barriers, remain within port-area shipping channels, etc.) For transit distances to Persian Gulf: Defense Mapping Agency, *Distances Between Ports* (Pub. 151), 7th ed., 1993, with distances shown for reaching a position roughly in the center of the Persian Gulf.
a Area east of Taiwan defined as a position in the sea at 24°N, 124°E, which is roughly 130 nautical miles east of Taiwan.
b Distance from Pearl Harbor calculated from Honolulu, which is about 6 nautical miles southeast of Pearl Harbor.
c For transit distances from the Navy home port at Everett, WA, north of Seattle, rather than from San Diego, subtract about 700 nm.

During extended operations at sea, a nuclear-powered surface combatant, like a conventionally powered one, might need to be resupplied with food, weapons (if sufficient numbers are expended in combat), and other supplies. These resupply operations can temporarily reduce the ship's ability to perform its missions.

U.S. Navy Nuclear-Powered Ships

Naval Nuclear Propulsion Program. The Navy's nuclear propulsion program began in 1948. The Navy's first nuclear-powered ship, the submarine Nautilus (SSN-571), was commissioned into service on September 30, 1954, and went to sea for the first time on January 17, 1955. The Navy's first nuclear-powered surface ships, the cruiser Long Beach (CGN-9) and the aircraft carrier Enterprise (CVN-65), were commissioned into service on September 9, 1961, and November 25, 1961, respectively.

The Navy's nuclear propulsion program is overseen and directed by an office called Naval Reactors (NR), which exists simultaneously as a part of both the Navy (where it forms a part of the Naval Sea Systems Command) and the Department of Energy (where it forms a part of the National Nuclear Security Administration). NR has broad, cradle-to-grave responsibility for the Navy's nuclear-propulsion program. This responsibility is set forth in Executive Order 12344 of February 1, 1982, the text of which was effectively incorporated into the U.S. Code (at 50 USC 2511)[3] by Section 1634 of the FY1985 defense authorization act (H.R. 5167/P.L. 98-525 of October 19, 1984) and again by section 3216 of the FY2000 defense authorization act (S. 1059/P.L. 106-65 of October 5, 1999). NR has established a reputation for maintaining very high safety standards for engineering and operating Navy nuclear power plants.

The first director of NR was Admiral Hyman Rickover, who served in the position from 1948 until 1982. Rickover is sometimes referred to as the father of the nuclear Navy. The current director is Admiral Kirkland Donald, who became director in November 2004. He is the fifth person to hold the position.

Current Navy Nuclear-Powered Ships. As of the end of FY2006, the Navy's nuclear-powered fleet included all 73 of its submarines and 10 of its 11 aircraft carriers. The Navy's combat submarine force has been entirely nuclear-powered since 1990.[4] The planned retirement of the Navy's last remaining conventionally powered aircraft carrier in 2008 is to give the Navy an all-nuclear-powered carrier force by 2008.[5]

Earlier Navy Nuclear-Powered Cruisers. In addition to nuclear-powered submarines and nuclear-powered carriers, the Navy in the past built and operated nine nuclear-powered cruisers (CGNs). The nine ships, which are shown in **Table 2**, include three one-of-a-kind designs (CGNs 9, 25, and 35) followed by the two-ship California (CGN-36) class and the four-ship Virginia (CGN-38) class.

The nuclear-powered cruisers shown in **Table 2** were procured to provide nuclear-powered escorts for the Navy's nuclear-powered carriers. Procurement of nuclear-powered cruisers was halted after FY1975 largely due to a desire to constrain the procurement costs of future cruisers. In deciding in the late 1970s on the design for the new cruiser that would carry the Aegis defense system, two nuclear-powered Aegis-equipped options — a 17,200-ton nuclear-powered strike cruiser (CSGN) and a 12,100-ton derivative of the CGN-38 class design — were rejected in favor of a third option of placing the Aegis system onto the smaller, conventionally powered hull originally developed for the Spruance (DD-963) class destroyer. The CSGN was

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[3] See also 42 USC 7158.

[4] The Navy's final three non-nuclear-powered combat submarines were procured in FY1956, entered service in 1959, retired in 1988-1990. A non-nuclear-powered, non-combat auxiliary research submarine, the Dolphin (AGSS-555), was procured in FY1961, entered service in 1968, and retired in January 2007.

[5] The Navy's last remaining conventionally powered carrier is the Kitty Hawk (CV-63), which was procured in FY1956 and entered service in 1961. In 2008, it is scheduled to be retired and replaced by the new aircraft carrier George H. W. Bush (CVN-77), which was procured in 2001. Another conventionally powered aircraft carrier, the John F. Kennedy (CV-67), was decommissioned on March 23, 2007. The Kennedy was the last conventionally powered aircraft carrier procured by the Navy. It was procured in FY1963 and entered service in 1968. For additional discussion of the Kennedy, see CRS Report RL32731, *Navy Aircraft Carriers: Retirement of USS John F. Kennedy — Issues and Options for Congress*, by Ronald O'Rourke.)

estimated to have a procurement cost twice that of the DD-963-based option, while the CGN-42 was estimated to have a procurement cost 30%-50% greater than that of the DD-963-based option. The DD-963-based option became the 9,500-ton Ticonderoga (CG-47) class Aegis cruiser. The first Aegis cruiser was procured in FY1978.

Table 2. Earlier Navy Nuclear-Powered Cruisers

Hull number	Name	Builder	Displacement (tons)	Procured	Entered service	Decommissioned
CGN-9	Long Beach	Bethlehem[a]	17,100	FY57	1961	1995
CGN-25	Bainbridge	Bethlehem[a]	8,580	FY59	1962	1996
CGN-35	Truxtun	New York[b]	8,800	FY62	1967	1995
CGN-36	California	NGNN[c]	10,530	FY67	1974	1999
CGN-37	South Carolina	NGNN[c]	10,530	FY68	1975	1999
CGN-38	Virginia	NGNN[c]	11,300	FY70	1976	1994
CGN-39	Texas	NGNN[c]	11,300	FY71	1977	1993
CGN-40	Mississippi	NGNN[c]	11,300	FY72	1978	1997
CGN-41	Arkansas	NGNN[c]	11,300	FY75	1980	1998

Source: Prepared by CRS based on Navy data and Norman Polmar, *The Ships and Aircraft of the U.S. Fleet*.
a. Bethlehem Steel, Quincy, MA.
b. New York Shipbuilding, Camden, NJ.
c. Newport News Shipbuilding, now known as Northrop Grumman Newport News (NGNN).

Initial Fuel Core Included in Procurement Cost. The initial fuel core for a Navy nuclear-powered ship is installed during the construction of the ship. The procurement cost of the fuel core is included in the total procurement cost of the ship, which is funded in the Navy's shipbuilding budget, known formally as the Shipbuilding and Conversion, Navy (SCN) appropriation account. In constant FY2007 dollars, the initial fuel core for a Virginia (SSN-774) class submarine costs about $170 million; the initial fuel cores for an aircraft carrier (which uses two reactors and therefore has two fuel cores) have a combined cost of about $660 million.[6]

The procurement cost of a conventionally powered Navy ship, in contrast, does not include the cost of petroleum-based fuel needed to operate the ship, and this fuel is procured largely through the Operation and Maintenance, Navy (OMN) appropriation account.

[6] Source: Telephone conversation with Naval Reactors, March 8, 2007. Naval Reactor states that the cost figure of about $660 million for an aircraft carrier ($330 million for each of two fuel cores) applies to both existing Nimitz (CVN-68) class carriers and the new Gerald R. Ford (CVN-78) class carrier (also known as the CVN-21 class).

CG(X) Cruiser Program

The Program in General. The CG(X) cruiser is the Navy's planned replacement for its 22 Aegis cruisers, which are projected to reach retirement age between 2021 and 2029. The Navy's planned 313-ship fleet calls for a total of 19 CG(X)s.[7] 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 procuring the third CG(X) in FY2014, two per year during the period FY2015-FY2021, and two final CG(X)s in FY2022 and FY2023.

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. Nuclear power is an option being studied in the AOA. The Navy has stated a preference for basing the CG(X) design on the hull design of the Navy's new DDG-1000 destroyer, which is a conventionally powered ship with a displacement of about 14,500 tons.[8]

The Navy has stated that it wants to equip the CG(X) with a powerful radar capable of supporting ballistic missile defense (BMD) operations.[9] The Navy has testified that this radar is to have a power output of 30 or 31 megawatts, which is several times the power output of the main radar on the Navy's existing cruisers and destroyers.[10] This suggests that in terms of power used for radar operations, the CG(X) might use substantially more energy over the course of its life than the Navy's existing cruisers and destroyers. As discussed later in this report, a ship's life-cycle energy use is a factor in evaluating the economic competitiveness of nuclear power compared to conventional power.

Reactor Plant for a Nuclear-Powered CG(X). The Navy has testified that the reactor plant for a nuclear-powered CG(X) would be based on the reactor plant that the Navy has developed for its new Gerald R. Ford (CVN-78) class aircraft carriers, also called the CVN-21 class.[11] The Ford-class reactor plant, like the reactor plant on the Navy's existing Nimitz (CVN-68) class aircraft carriers, is a twin reactor plant that includes two nuclear reactors. The Navy has said that for a nuclear-

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[7] 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.

[8] For further discussion, see CRS Report RS22559, *Navy CG(X) Cruiser Design Options: Background and Oversight Issues For Congress*, by Ronald O'Rourke.

[9] For more on Navy BMD programs, see CRS Report RL33745, *Sea-Based Ballistic Missile Defense — Background and Issues for Congress*, by Ronald O'Rourke.

[10] Source: Testimony of Navy officials to the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

[11] Source: Testimony of Navy officials to the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007. For more on the CVN-21 program, see CRS Report RS20643, *Navy CVN-21 Aircraft Carrier Program: Background and Issues for Congress*, by Ronald O'Rourke.

powered CG(X), it would seek to use one-half of the Ford-class plant, with a single reactor. Components of the Ford-class plant, the Navy has said, would be modified as needed to adapt it to the CG(X) hull design. This approach, the Navy has testified, would minimize the time and cost of developing a reactor plant for a nuclear-powered CG(X). In the Ford class, the initial nuclear fuel cores in the two reactors are to be sufficient to power the ship for one-half of its expected life of 40 to 50 years. In a nuclear-powered CG(X), the Navy has said, the initial fuel core in the single reactor would be sufficient to power the ship for its entire expected life of 30 to 35 years. Since the two fuel cores for an aircraft carrier cost about $660 million in constant FY2007 dollars (see previous section on initial fuel cores), the cost of a single fuel core for a CG(X) might be about $330 million in constant FY2007 dollars.

Procuring a nuclear-powered CG(X) in FY2011, the Navy has said, would involve funding the ship's long-leadtime nuclear-propulsion components two years earlier, in FY2009. Funding long-leadtime nuclear-propulsion components two years in advance of the year in which the ship is procured would be consistent with the normal process for funding a nuclear-powered submarine.

Construction Shipyards

Nuclear-Capable Shipyards. Two U.S. shipyards are currently certified to build nuclear-powered ships — Northrop Grumman Newport News (NGNN) of Newport News, VA, and General Dynamics' Electric Boat Division (GD/EB) of Groton, CT, and Quonset Point, RI. NGNN can build nuclear-powered surface ships and nuclear-powered submarines. GD/EB can build nuclear-powered submarines. NGNN has built all the Navy's nuclear-powered aircraft carriers. NGNN also built the final six nuclear-powered cruisers shown in **Table 2**. NGNN and GD/EB together have built every Navy nuclear-powered submarine procured since FY1969.

Although NGNN and GD/EB are the only U.S. shipyards that currently build nuclear-powered ships for the Navy, five other U.S. shipyards once did so as well.[12] These five yards built 44 of the 107 nuclear-powered submarines that were procured for the Navy through FY1968. Two of these five yards built the first three nuclear-powered cruisers shown in **Table 2**.

Surface Combatant Shipyards. All cruisers and destroyers procured for the Navy since FY1978 have been built at two shipyards — General Dynamics' Bath Iron Works (GD/BIW) of Bath, ME, and the Ingalls shipyard at Pascagoula, MS, that now forms part of Northrop Grumman Ship Systems (NGSS). GD/BIW has never built nuclear-powered ships. Ingalls is one of the five U.S. yards other than NGNN and GD/EB that once built nuclear-powered ships. Ingalls built 12 nuclear-powered submarines, the last being the Parche (SSN-683), which was procured in FY1968,

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[12] The five yards are the Portsmouth Naval Shipyard of Kittery, ME; the Mare Island Naval Shipyard of Mare Island, CA; the Ingalls shipyard of Pascagoula, MS, that now forms part of Northrop Grumman Ship Systems; Bethehem Steel of Quincy, MA (which became a part of General Dynamics); and New York Shipbuilding of Camden, NJ.

entered service in 1974, and retired in 2005.[13] Ingalls also overhauled or refueled 11 nuclear-powered submarines. Ingalls' nuclear facility was decommissioned in 1980, and NGSS is not certified to build nuclear-powered ships.[14]

Recent Navy Studies for Congress

The Navy has conducted two recent studies for Congress on the potential cost-effectiveness of expanding the use of nuclear power to a wider array of surface ships. These studies are the 2005 Naval Reactors quick look analysis, and the more comprehensive and detailed 2006 Navy alternative propulsion study. Each of these is discussed below.

2005 Naval Reactors Quick Look Analysis. The 2005 NR quick look analysis was conducted at the request of Representative Roscoe Bartlett, who was then chairman of the Projection Forces Subcommittee of the House Armed Services Committee (since renamed the Seapower and Expeditionary Forces Subcommittee). The analysis concluded that the total life-cycle cost (meaning the sum of procurement cost, life-cycle operating and support cost, and post-retirement disposal cost) of a nuclear-powered version of a large-deck (LHA-type) amphibious assault ship would equal that of a conventionally powered version of such a ship if the cost of crude oil over the life of the ship averaged about $70 per barrel. The study concluded that the total life-cycle cost of a nuclear-powered surface combatant would equal that of a conventionally powered version if the cost of crude oil over the life of the ship averaged about $178 per barrel. This kind of calculation is called a life-cycle cost break-even analysis. The study noted but did not attempt to quantify the mobility-related operational advantages of nuclear propulsion for a surface ship.[15]

2006 Navy Alternative Propulsion Study. The more comprehensive and detailed 2006 Navy alternative propulsion study was conducted in response to

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[13] Ingalls built its nuclear-powered submarines at its older East Bank facility. Ingalls' newer West Bank facility has been used for building conventionally powered surface ships, principally surface combatants and large-deck amphibious ships.

[14] In addition to building 12 nuclear-powered submarines, Northrop Grumman states that Ingalls' facilities "allowed Ingalls to participate in submarine overhaul and refueling. By the time the shipyard's nuclear facility was decommissioned in 1980, 11 U.S. Navy attack submarines had been overhauled and/or refueled at Ingalls." Source: Northrop Grumman chronological perspective on Northrop Grumman Ship Systems located on the Internet at [http://www.ss.northropgrumman.com/company/chronological.html]. Accessed by CRS on March 28, 2007.

[15] U.S. Naval Nuclear Propulsion Program, briefing entitled "Nuclear and Fossil Fuel Powered Surface Ships, Quick Look Analysis," presented to CRS on March 22, 2006. The analysis concluded that total life-cycle costs for nuclear-powered versions of large-deck aircraft carriers, LHA-type amphibious assault ships and surface combatants would equal those of conventionally powered versions when the price of diesel fuel marine (DFM) delivered to the Navy reached $55, $80, and $205 per barrel, respectively. Since the cost of DFM delivered to the Navy was calculated to be roughly 15% greater than that of crude oil, these figures corresponded to break-even crude-oil costs of about $48, $70, and $178 per barrel, respectively.

Section 130 of the FY2006 defense authorization act (H.R. 1815, P.L. 109-163 of January 6, 2006), which called for such a study (see **Appendix**). The study reached a number of conclusions, including the following:

- In constant FY2007 dollars, building a Navy surface combatant or amphibious ship with nuclear power rather than conventional power would add roughly $600 million to $800 million to its procurement cost.
  - — For a small surface combatant, the procurement-cost increase was about $600 million.
  - — For a medium-size combatant (defined as a ship with a displacement between 21,000 metric tons and 26,000 metric tons), the increase was about $600 million to about $700 million.
  - — For an amphibious ship, the increase was about $800 million.[16]
- Although nuclear-powered ships have higher procurement costs than conventionally powered ships, they have lower operating and support costs when fuel costs are taken into account.
- A ship's operational tempo and resulting level of energy use significantly influences the life-cycle cost break-even analysis. The higher the operational tempo and resulting level of energy use assumed for the ship, lower the cost of crude oil needed to break even on a life-cycle cost basis, and the more competitive nuclear power becomes in terms of total life-cycle cost.
- The newly calculated life-cycle cost break-even cost-ranges, which supercede the break-even cost figures from the 2005 NR quick look analysis, are as follows:
  - — $210 per barrel to $670 per barrel for a small surface combatant;
  - — $70 per barrel to $225 per barrel for a medium-size surface combatant; and
  - — $210 per barrel to $290 per barrel for an amphibious ship. In each case, the lower dollar figure is for a high ship operating tempo, and the higher dollar figure is for a low ship operating tempo.

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[16] In each case, the cost increase is for the fifth ship in a class being built at two shipyards.

- At a crude oil cost of $74.15 per barrel (which was a market price at certain points in 2006), the life-cycle cost premium of nuclear power is:
  - — 17% to 37% for a small surface combatant;
  - — 0% to 10% for a medium sized surface combatant; and
  - — 7% to 8% for an amphibious ship.
- The life-cycle cost break-even analysis indicates that nuclear-power should be considered for near-term applications for medium-size surface combatants, and that life-cycle cost will not drive the selection of nuclear power for small surface combatants or amphibious ships. A nuclear-powered medium-size surface combatant is the most likely of the three ship types studied to prove economical, depending on the operating tempo that the ship actually experiences over its lifetime.
- Compared to conventionally powered ships, nuclear-powered ships have advantages in terms of both time needed to surge to a distant theater of operation for a contingency, and operational presence (time on station) in the theater of operation.[17]

Potential Issues for Congress

In assessing whether the CG(X) or other future Navy surface ships should be nuclear-powered, Congress may consider a number of issues, including cost, operational effectiveness, ship construction, ship maintenance and repair, crew training, ports calls and forward homeporting, and environmental impact. Each of these is discussed below.

Cost

Development and Design Cost. The cost calculations presented in the 2006 Navy alternative propulsion study do not include the additional up-front design and development costs, if any, for a nuclear-powered surface ship. As discussed in the Background section, the Navy has stated that it would seek to minimize the up-front development cost of the nuclear power plant for a nuclear-powered CG(X) by adapting the design of the new nuclear power plant that has been developed for the Navy's new Ford class carriers.

[17] Source: Statement of The Honorable Dr. Delores M. Etter, Assistant Secretary of the Navy (Research, Development and Acquisition), et al., Before the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee on Integrated Nuclear Power Systems for Future Naval Surface Combatants, March 1, 2007, pp. 4-5.

Procurement Cost.

For the CG(X). As mentioned in the Background section, the Navy has stated a preference for basing the design of the CG(X) on the design of its new DDG-1000 class destroyer, which is a conventionally powered ship. This approach could result in a conventionally powered CG(X) design with a procurement cost similar to that of the DDG-1000. If a conventionally powered CG(X) were to have a procurement cost equal to that of the DDG-1000 design, then a nuclear-powered CG(X) could cost roughly 32% to 37% more than a conventionally powered CG(X).[18] If a conventionally powered CG(X) were to have a procurement cost greater than that of the DDG-1000, then the percentage procurement cost premium for nuclear power for the CG(X) would be less than 32% to 37%. The 2006 Navy study states that for a medium-size surface combatant that is larger than the DDG-1000, an additional cost of about $600 million to $700 million would equate to a procurement cost increase of about 22%.

If building a Navy surface combatant or amphibious ship with nuclear power rather than conventional power would add roughly $600 million to $800 million to its procurement cost., then procuring one or two nuclear-powered CG(X)s per year, as called for in the Navy's 30-year shipbuilding plan, would cost roughly $600 million to $1,400 million more per year than procuring one or two conventionally powered CG(X)s per year, and procuring a force of 19 nuclear-powered CG(X)s would cost roughly $11.4 billion to $13.3 billion more than procuring a force of 19 conventionally powered CG(X)s. For purposes of comparison, the Navy has requested a total of $13.7 billion for the SCN account for FY2008.

For Submarines and Aircraft Carriers. The Navy estimates that building the CG(X) or other future Navy surface ships with nuclear power could reduce the production cost of nuclear-propulsion components for submarines and aircraft carriers by 5% to 9%, depending on the number of nuclear-powered surface ships that are built.[19] Building one nuclear-powered cruiser every two years, the Navy has testified, might reduce nuclear-propulsion component costs by about 7%. In a steady-state production environment, the Navy testified, the savings might equate to about $115 million for each aircraft carrier, and about $35 million for each submarine. The Navy stated that this "is probably the most optimistic estimate."[20]

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[18] The Navy estimates that follow-on DDG-1000 destroyers will cost an average of about $1.9 billion each to procure in constant FY2007 dollars. (This figure is based on the then-year costs for the third through seventh ships in the DDG-1000 class, which the Navy wants to procure in FY2009-FY2013. These costs were converted into constant FY2007 dollars using a January 2007 Navy shipbuilding deflator. The deflator was provided by the Navy to the Congressional Budget Office, which forwarded it to CRS.) Increasing a ship's procurement cost from about $1.9 billion to $2.5 billion or $2.6 billion (i.e., increasing it by $600 million to $700 million) equates to an increase of 32% to 37%.

[19] Statement of Admiral Kirkland H. Donald, U.S. Navy, Director, Naval Nuclear Propulsion Program, Before the House Armed Services Committee Seapower and Expeditionary Forces Subcommittee on Nuclear Propulsion For Surface Ships, 1 March 2007, p. 13.

[20] Spoken testimony of Admiral Kirkland Donald before the Seapower and Expeditionary
(continued...)

The Navy states that these savings were not included in the cost calculations presented in the 2006 Navy study.

BWXT, a principal maker of nuclear-propulsion components for Navy ships, estimates that increasing Virginia-class submarine procurement from one boat per year to two boats per year would reduce the cost of nuclear propulsion components 9% for submarines and 8% for aircraft carriers, and that "Adding a nuclear[-powered] cruiser or [nuclear-powered] large-deck amphibious ship would significantly drive down nuclear power plant costs across the fleet, even beyond the savings associated with the second Virginia-class [submarine per year]."[21]

Total Life-Cycle Cost. As suggested by the 2006 Navy study, the total-life-cycle cost break-even analysis can be affected by projections of future oil prices and ship operating tempo.

Future Oil Prices. Views on potential future oil prices vary.[22] Some supporters of using nuclear power for the CG(X) and other future Navy surface ships, such as 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, believe that oil in coming decades may become increasingly expensive, or that guaranteed access to oil may become more problematic, and that this is a central reason for making the CG(X) or other future Navy surface ships nuclear-powered.[23]

Ship Operating Tempo. A ship's average lifetime operating tempo can be affected by the number of wars, crises, and other contingency operations that it participates in over its lifetime, because such events can involve operating tempos that are higher than those of "normal" day-to-day operations. Ship operating tempo can also be affected by the size of the Navy. The lower the number of ships in the Navy, for example, the higher the operating tempo each a ship might be required to sustain for the fleet to accomplish a given set of missions.

CG(X) vs. Medium-Size Surface Combatant. If the CG(X) is based on the hull design of the 14,500-ton DDG-1000 destroyer, which is the Navy's stated preference, then the CG(X) may be smaller the 21,000- to 26,000-ton medium-size

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[20] (...continued)
Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

[21] Testimony of Winfred Nash, President, BWXT, Nuclear Operations Division, Before the Subcommittee on Seapower and Expeditionary Forces of the House Armed Service Committee [on Submarine Force Structure and Acquisition Policy], March 8, 2007, pp. 2 and 4.

[22] For a standard U.S. government projection of future oil prices, assuming current policy remains in place, see the Energy Information Administration's Annual Energy Outlook, available on the Internet at [http://www.eia.doe.gov/oiaf/aeo/index.html]. Accessed by CRS on March 28, 2007.

[23] See, for example, the remarks of Representative Taylor at the hearing of the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

surface combatant in the 2006 Navy study. What difference that might create between the CG(X) and the medium-size surface combatant in terms of life-cycle energy use, and thus life-cycle cost break-even range, is not clear. The Navy has testified that the medium sized surface combatant in the 2006 study was modeled with a radar requiring 30 or 31 megawatts of power, like the radar the Navy wants to install on the CG(X).[24]

Operational Effectiveness

Operational Value of Increased Ship Mobility. What is the operational value of increased ship mobility? How much better can a ship perform its missions as a result of this increased mobility? And is there some way to translate the mobility advantages of nuclear power into dollar terms? One potential way to translate the value of increased ship mobility into dollar terms would be to determine how much aggregate capability a force of 19 conventionally powered CG(X)s would have for surging to distant theaters and for maintaining on-station presence in theater, then determine how many nuclear-powered CG(X)s would be required to provide the same aggregate capability, and then compare the total cost of the 19 conventionally powered CG(X)s to the total cost of the nuclear-powered CG(X) force.

Potential Other Operational Advantages of Nuclear Power. Are there operational advantages of nuclear power for a surface ship other than increased ship mobility? One possibility concerns ship detectability. A nuclear-powered ship does not require an exhaust stack as part of its deckhouse, and does not emit hot exhaust gases. Other things held equal, this might make a nuclear-powered surface ship less detectible than a conventionally powered ship, particularly to infrared sensors. This possible advantage for the nuclear-powered ship might be either offset or reinforced by possible differences between the nuclear-powered ship and the conventionally powered ship in other areas, such as the temperature of the engine compartment (which again might affect infrared detectability) or the level of machinery noise (which might affect acoustic detectability).

Some supporters of building future Navy surface ships with nuclear power have argued that an additional operational advantage of nuclear power for surface ships would be to reduce the Navy's dependence on its relatively small force of refueling oilers, and thus the potential impact on fleet operations of an enemy attack on those oilers. The Navy acknowledges that potential attacks on oilers are a concern, but argues that the fleet's vulnerability to such attacks is recognized and that oilers consequently are treated as high-value ships in terms of measures taken to protect them from attack.[25]

Another potential advantage of nuclear power postulated by some observers is that a nuclear-powered ship can use its reactor to provide electrical power for use

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[24] Source: Testimony of Navy officials to the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

[25] Spoken testimony of Vice Admiral Jonathan Greenert before the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

ashore for extended periods of time, particularly to help localities that are experiencing brownouts during peak use periods or whose access to electrical power from the grid has been disrupted by a significant natural disaster or terrorist attack. The Navy has stated that the CG(X) is to have a total power-generating capacity of about 80 megawatts (MW). Some portion of that would be needed to operate the reactor plant itself and other essential equipment aboard the ship. Much of the rest might be available for transfer off the ship. For purposes of comparison, a typical U.S. commercial power plant might have a capacity of 300 MW to 1000 MW. A single megawatt can be enough to meet the needs of several hundred U.S. homes, depending on the region of the country and other factors.[26]

Skeptics of the idea of using nuclear-powered ships to generate electrical power for use ashore could argue that if the local transmission system has been disrupted, the ship's generation capacity may be of limited use in restoring electric power. If the local transmission system is intact, they could argue, onshore infrastructure would be required to transmit the ship's power into the local system. The military or a local utility, they could argue, would likely bear the cost for this infrastructure, which would be used only on a sporadic basis. Skeptics could argue that a Navy ship would be helpful only if the power emergency lasts longer than the time it would take for the ship to reach the connection point. If the nearest available Navy ship is several steaming days away from the connection point when the power emergency occurs, they could argue, the ship might not be able arrive before local power is partially or fully restored. Skeptics could argue that critical facilities in the area of the power emergency, such as hospitals, would likely be equipped with emergency back-up diesel generators to respond to short-term loss of power.[27]

Ship Construction

Shipyards. Another potential issue for Congress to consider in weighing whether the CG(X) or other future Navy surface ships should be nuclear-powered concerns the shipyards that would be used to build the ships. There are at least three potential approaches for building nuclear-powered CG(X)s:

- Build them at NGNN, with GD/EB possibly contributing to the construction of the ships' nuclear portions.
- Certify NGSS and/or GD/BIW to build nuclear-powered ships, and then build the CG(X)s at those yards.

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[26] See, for example, the discussion of the issue available on the Internet at [http://www.utilipoint.com/issuealert/print.asp?id=1728].) Accessed by CRS on March 28, 2007.

[27] For examples of articles discussing the idea of using nuclear-powered ships to generate electrical power for use ashore, see Jose Femenia, "Nuclear Ships Can Help Meet U.S. Electrical Needs," *U.S. Naval Institute Proceedings*, August 2004: 78-80;" and Linda de France, "Using Navy Nuclear Reactors To Help Power California Not Worth Effort," *Aerospace Daily*, May 4, 2001.

- Build the nuclear portions of the CG(X)s at NGNN and/or GD/EB, the non-nuclear portions at NGSS and/or GD/BIW, and perform final assembly, integration, and test work for the ships at either
  - — NGNN and/or GD/EB, or
  - — NGSS and/or GD/BIW.

These options have significant potential implications for workloads and employment levels at each of these shipyards.

On the question of what would be needed to certify NGSS and/or GD/BIW to build nuclear-powered ships, the director of NR testified that

> Just the basics of what it takes to have a nuclear-certified yard, to build one from scratch, or even if one existed once upon a time as it did at Pasacagoula, and we shut it down, first and foremost you have to have the facilities to do that. What that includes, and I have just some notes here, but such things as you have to have the docks and the dry-docks and the pier capability to support nuclear ships, whatever that would entail. You would have to have lifting and handling equipment, cranes, that type of thing; construction facilities to build the special nuclear components, and to store those components and protect them in the way that would be required.
>
> The construction facilities would be necessary for handling fuel and doing the fueling operations that would be necessary on the ship — those types of things. And then the second piece is, and probably the harder piece other than just kind of the brick-and-mortar type, is building the structures, the organizations in place to do that work, for instance, nuclear testing, specialized nuclear engineering, nuclear production work. If you look, for instance, at Northrop Grumman Newport News, right now, just to give you a perspective of the people you are talking about in those departments, it is on the order of 769 people in nuclear engineering; 308 people in the major lines of control department; 225 in nuclear quality assurance; and then almost 2,500 people who do nuclear production work. So all of those would have to be, you would have to find that workforce, certify and qualify them, to be able to do that.[28]

The director of NR testified that NGNN and GD/BIW "have sufficient capacity to accommodate nuclear-powered surface ship construction, and therefore there is no need to make the substantial investment in time and dollars necessary to generate additional excess capacity."[29] In light of this, the Navy testified, only the first and third options above are "viable."[30] The director of NR testified that:

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[28] Spoken testimony of Admiral Kirkland Donald before the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

[29] Statement of Admiral Kirkland H. Donald, U.S. Navy, Director, Naval Nuclear Propulsion Program, Before the House Armed Services Committee Seapower and Expeditionary Forces Subcommittee on Nuclear Propulsion For Surface Ships, 1 March 2007, p. 13.

[30] Source: Statement of The Honorable Dr. Delores M. Etter, Assistant Secretary of the Navy (Research, Development and Acquisition), et al., Before the Seapower and Expeditionary

(continued...)

> my view of this is we have some additional capacity at both Electric Boat and at Northrop Grumman Newport News. My primary concern is if we are serious about building another nuclear-powered warship, a new class of warship, cost is obviously going to be some degree of concern, and certainly this additional costs, which would be — and I don't have a number to give you right now, but I think you can see it would be substantial to do it even if you could. It probably doesn't help our case to move down the path toward building another nuclear-powered case, when we have the capability existing already in those existing yards.[31]

With regard to the third option of building the nuclear portions of the ships at NGNN and/or GD/EB, and the non-nuclear portions at NGSS and/or GD/BIW, the Navy testified that the "Location of final ship erection would require additional analysis." One Navy official, however, expressed a potential preference for performing final assembly, integration, and test work at NGNN or GD/EB, stating that:

> we are building warships in modular sections now. So if we were going to [ask], "Could you assemble this [ship], could you build modules of this ship in different yards and put it together in a nuclear-certified yard?", the answer is yes, definitely, and we do that today with the Virginia Class [submarine program]. As you know, we are barging modules of [that type of] submarine up and down the coast.
>
> What I would want is, and sort of following along with what [NR director] Admiral [Kirkland] Donald said, you would want the delivering yard to be the yard where the reactor plant was built, tooled, and tested, because they have the expertise to run through all of that nuclear work and test and certify the ship and take it out on sea trials.
>
> But the modules of the non-reactor plant, which is the rest of the ship, could be built theoretically at other yards and barged or transported in other fashion to the delivering shipyard. If I had to do it ideally, that is where I would probably start talking to my industry partners, because although we have six [large] shipyards [for building large navy ships], it is really two corporations [that own them], and those two corporations each own what is now a surface combatant shipyard and they each own a nuclear-capable shipyard. I would say if we were going to go do this, we would sit down with them and say, you know, from a corporation standpoint, what would be the best work flow? What would be the best place to construct modules? And how would you do the final assembly and testing of a nuclear-powered warship?[32]

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[30] (...continued)
Forces Subcommittee of the House Armed Services Committee on Integrated Nuclear Power Systems for Future Naval Surface Combatants, March 1, 2007, p. 7.

[31] Spoken testimony of Admiral Kirkland Donald before the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

[32] Spoken testimony of Vice Admiral Paul E. Sullivan, Commander, Naval Sea Systems Command, to the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

Nuclear-Propulsion Component Manufacturers. A related issue that Congress may consider in weighing whether the CG(X) or other future Navy surface ships should be nuclear-powered is whether there is sufficient capacity at the firms that make nuclear-propulsion components to accommodate the increase in production volume that would result from building the CG(X) or other future Navy surface ships with nuclear power. On this question, the Navy has testified:

> Right now, as I look across the industrial base that provides [for nuclear-powered ships], let's just talk about the components, for instance, and I just look across that base, because we have been asserting earlier that we were going to go to [a procurement rate of two Virginia-class submarines per year] earlier [than the currently planned year of FY2012], we had facilitized and have sustained an over-capacity in those facilities to support construction of those additional components. So right now, it depends on the vendor and which one is doing what, the capacity is running right now at probably about 65 percent of what it could be doing, on the order of that. Again, it varies depending on the vendor specifically.
>
> So there is additional capacity in there, and even with the addition of a second Virginia-class submarine, there is still a margin in there, if you are talking about a single cruiser in the early phases of design, we still have margin in there that I believe we can sustain that work in addition to the submarine work within the industrial base.
>
> We would have to look at that in more detail once we determine what the design looks like and the degree to which we can use existing components. If you had to design new components, that would add a little bit more complexity to it, but that is a rough estimate of what I would provide for you now.[33]

Ship Maintenance and Repair

Building CG(X)s or other future Navy surface ships with nuclear power could affect the future distribution of Navy ship maintenance and repair work, because only certain U.S. shipyards are qualified for performing certain kinds of work on nuclear-powered ships. Much of the maintenance and repair work done on nuclear-powered ships is done at the country's four government-operated naval shipyards (NSYs) — Portsmouth NSY at Kittery, ME, Norfolk NSY at Norfolk, VA; Puget Sound NSY at Bremerton, WA; and Pearl Harbor NSY at Pearl Harbor, HI. NGNN and GD/EB also perform some maintenance and repair work on nuclear-powered ships.

Crew Training

Would the Navy have the capacity to train the additional nuclear-qualified sailors that would be needed to crew additional nuclear-powered ships? On this question, the director of NR testified that: "My training pipeline does have the capacity without further infrastructure investment to produce the additional personnel required by future classes of [nuclear-powered] ships." He also stated:

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[33] Spoken testimony of Admiral Kirkland Donald before the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

> We, in looking at the training pipeline, there are a couple of dynamics that are in work right now. First off, the [nuclear-powered aircraft carrier] Enterprise is going to be going away [in 2013], and that is a pretty significant training load just to keep that crew operating.[34] And also, there as the CVN-21 [carrier class] comes on, [that is, as] the Ford-class carriers come on, and the [Nimitz-class nuclear-powered carriers] start to go away, [the number of people required to crew carriers will decrease, because with the] Ford class, we are targeting a 50 percent reduction in the reactor department sizing over there [compared to the Nimitz class].
>
> So for the foreseeable future, the training infrastructure that we have right now will meet the needs to sustain this [additional] class [of nuclear-powered ship], if you choose to do it.[35]

Port Calls and Forward Homeporting

A nuclear-powered ship might be less welcome than a conventionally powered ship in the ports of countries with strong anti-nuclear sentiments. The Navy works to minimize this issue in connection with its nuclear-powered submarines and aircraft carriers, and states that "U.S. nuclear-powered warships are welcome today in over 150 ports in more than 50 countries worldwide, thus allowing our warships to carry out their mission without constraint."[36]

Some Navy ships are forward-homeported, meaning that they are homeported in foreign countries that are close to potential U.S. Navy operating areas overseas. Forward-homeported Navy ships have occasional need for access to maintenance facilities near their home ports, and foreign shipyards are not qualified to perform certain kinds of maintenance work on nuclear-powered Navy ships. Building CG(X)s or other future Navy surface ships with nuclear power might thus affect the number of potentially suitable locations for forward-homeporting the ships, should the Navy decide that forward homeporting them would be desirable for purposes of shortening transit times to and from potential operating areas.

Environmental Impact

Conventionally powered ships exhaust greenhouse gases and other pollutants that are created through combustion of petroleum-based fuel. They can also leak fuel into the water, particularly if they are damaged in an accident (such as a collision) or by enemy attack. Other environmental impacts of conventionally powered ships include those associated with extracting oil from the ground, transporting it to a refinery, refining it into fuel, and transporting that fuel to the ship. Most of these activities produce additional greenhouse gases and other pollutants.

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[34] The Enterprise has a one-of-a-kind, eight-reactor nuclear power plant that creates training demands unique to that ship.

[35] Spoken testimony of Admiral Kirkland Donald before the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

[36] Spoken testimony of Admiral Kirkland Donald before the Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee, March 1, 2007.

Nuclear-powered ships do not exhaust greenhouse gases and other pollutants created through conventional combustion. The environmental impacts of nuclear-powered ships include those associated with mining and processing uranium to fuel reactors, and with storing and disposing of spent nuclear fuel cores, radioactive waste water from reactors, and the reactors and other radioactive components of retired nuclear-powered ships. As mentioned in the Background section, NR has established a reputation for maintaining very high safety standards for engineering and operating Navy nuclear power plants. In addition, Navy combat ships are built to withstand significant shock and battle damage. It is possible, however, that a very serious accident involving a nuclear-powered Navy ship (such as a major collision) or a major enemy attack on a nuclear-powered Navy ship might damage the ship's hull and reactor compartment enough to cause a release of radioactivity, which may have adverse effects on the environment.

Potential Options for Congress

Potential options for Congress regarding the issue of whether the CG(X) or other future Navy surface ships should be nuclear-powered include but are not limited to the following, some of which might be combined:

- for the CG(X) or other future Navy surface ships, direct the Navy to provide Congress with acquisition plans (including annual funding requirements) for both conventionally powered and nuclear-powered versions, so that Congress can assess both plans;

- to equalize the treatment of petroleum-based and nuclear fuel in Navy ship procurement costs, direct the Navy to exclude the cost of initial fuel cores for nuclear-powered ships from the total procurement cost of those ships, and to fund the procurement of those cores through an appropriation account other than the Shipbuilding and Conversion, Navy (SCN) account;

- direct the Navy to build the CG(X) as a nuclear-powered ship;

- pass permanent legislation, perhaps similar to the so-called Title VIII legislation of the 1970s, requiring future Navy ships of certain kinds to be nuclear-powered;[37]

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[37] The Title VIII legislation comprised Sections 801-804 of the FY1975 defense authorization act (H.R. 14592/P.L. 93-365, August 5, 1974, 88 Stat. 408-409). The legislation was codified at 10 USC 7291. Section 801 made it U.S. policy "to modernize the strike forces of the United States Navy by the construction of nuclear-powered major combatant vessels and to provide for an adequate industrial base for the research, development, design, construction, operation, and maintenance for such vessels." Section 801 also stated: "New construction major combatant vessels for the strike forces of the United States Navy authorized subsequent to the date of enactment of this Act becomes law [sic] shall be nuclear powered, except as provided in this title." Section 802 defined the term "major combatant vessels for the strike forces of the United States Navy." Section 803

(continued...)

- provide initial research and development funding to start work on adapting the design of the Ford-class aircraft carrier nuclear power plant for use in the CG(X); and

- direct the Navy to study the option of, or begin the process of, certifying NGSS and/or GD/BIW to build nuclear-powered ships.

Legislative Activity in 2007

The Seapower and Expeditionary Forces Subcommittee of the House Armed Services Committee conducted a hearing on March 1, 2007, on the issue of whether to make the CG(X) or other future Navy surface ships nuclear-powered.

[37] (...continued)
required the Secretary of Defense to submit a report to Congress each year, along with the annual budget request, on the application of nuclear power to such ships. Section 804 stated that "All requests for authorizations or appropriations from Congress" for such ships shall be for construction of nuclear-powered versions of such ships "unless and until the President has fully advised the Congress that construction of nuclear powered vessels for such purpose is not in the national interest," in which case the President is to provide, for Congress' consideration, an alternate program of nuclear-powered ships, with appropriate design, cost, and schedule information.

Title VIII was repealed by Section 810 of the FY1979 defense authorization act (S. 3486/P.L. 95-485, October 20, 1978, 92 Stat. 1623). Section 810 of that act replaced the Title VIII legislation with a policy statement on Navy shipbuilding policy that did not mandate the use of nuclear power for any Navy ships. Section 810, like the Title VIII legislation, was codified at 10 USC 7291. It was subsequently recodified at 10 USC 7310, pursuant to a law (H.R. 4623/P.L. 97-295 of October 12, 1982) that amended titles 10, 14, 37, and 38 to codify recent law. 10 USC 7310 was then repealed by Section 824(a)(8) of the FY1994 defense authorization act (H.R. 2401/P.L. 103-160 of November 30, 1993).

Appendix. Section 130 of P.L. 109-163

Section 130 of the conference report (H.Rept. 109-360 of December 18, 2005) on the FY2006 defense authorization act (H.R. 1815, P.L. 109-163 of January 6, 2006) required the Navy to submit a report by November 1, 2006, on alternative propulsion methods for surface combatants and amphibious warfare ships. The Navy submitted the report to Congress in January 2007. Section 130 states:

SEC. 130. REPORT ON ALTERNATIVE PROPULSION METHODS FOR SURFACE COMBATANTS AND AMPHIBIOUS WARFARE SHIPS.

(a) ANALYSIS OF ALTERNATIVES. — The Secretary of the Navy shall conduct an analysis of alternative propulsion methods for surface combatant vessels and amphibious warfare ships of the Navy.

(b) REPORT. — The Secretary shall submit to the congressional defense committees a report on the analysis of alternative propulsion systems carried out under subsection (a). The report shall be submitted not later than November 1, 2006.

(c) MATTERS TO BE INCLUDED. — The report under subsection (b) shall include the following:

(1) The key assumptions used in carrying out the analysis under subsection (a).

(2) The methodology and techniques used in conducting the analysis.

(3) A description of current and future technology relating to propulsion that has been incorporated in recently-designed surface combatant vessels and amphibious warfare ships or that is expected to be available for those types of vessels within the next 10-to-20 years.

(4) A description of each propulsion alternative for surface combatant vessels and amphibious warfare ships that was considered under the study and an analysis and evaluation of each such alternative from an operational and cost-effectiveness standpoint.

(5) A comparison of the life-cycle costs of each propulsion alternative.

(6) For each nuclear propulsion alternative, an analysis of when that nuclear propulsion alternative becomes cost effective as the price of a barrel of crude oil increases for each type of ship.

(7) The conclusions and recommendations of the study, including those conclusions and recommendations that could impact the design of future ships or lead to modifications of existing ships.

(8) The Secretary's intended actions, if any, for implementation of the conclusions and recommendations of the study.

(d) LIFE-CYCLE COSTS. — For purposes of this section, the term "life-cycle costs" includes those elements of cost that would be considered for a life-cycle cost analysis for a major defense acquisition program.