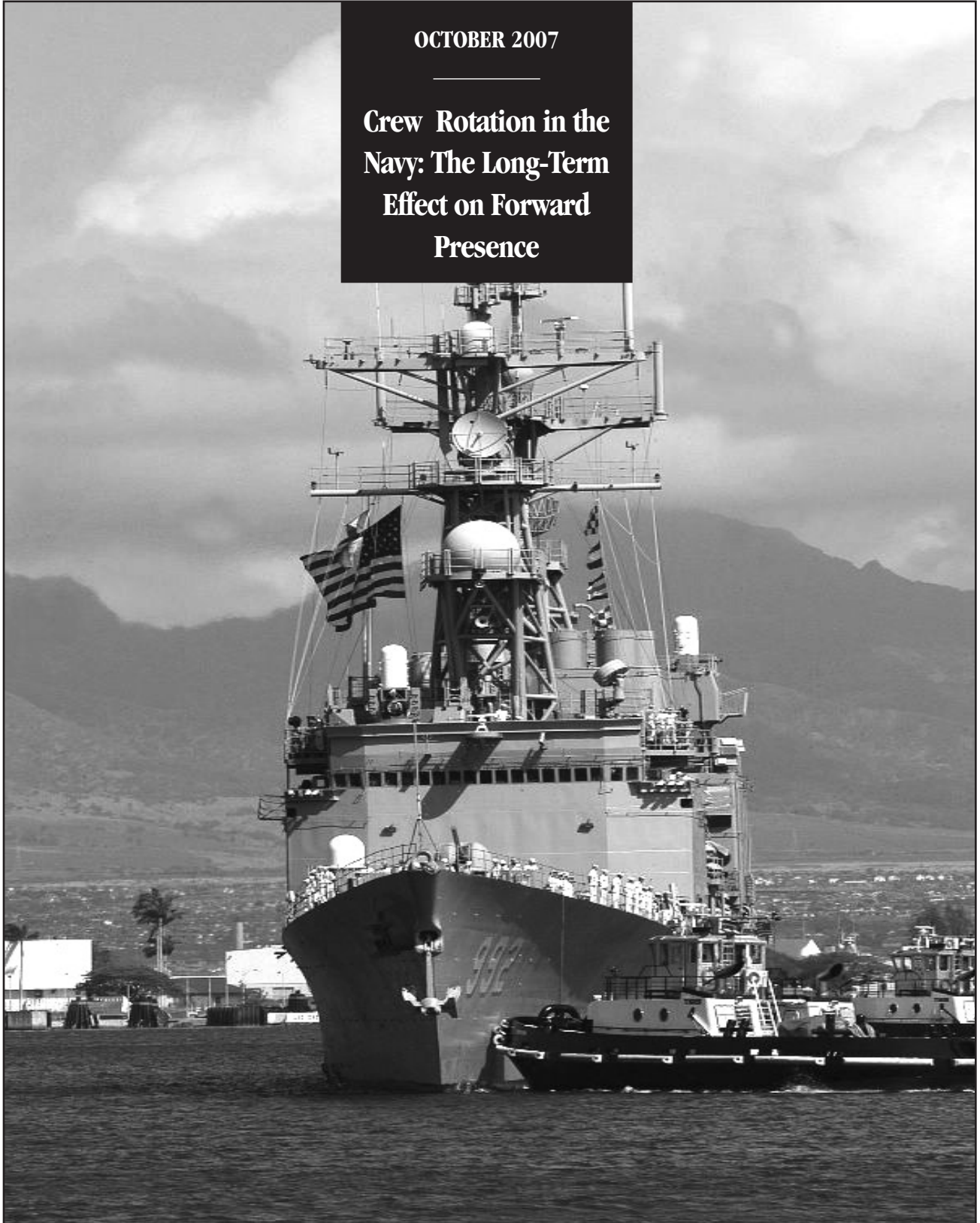


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CBO
PAPER

OCTOBER 2007

**Crew Rotation in the
Navy: The Long-Term
Effect on Forward
Presence**



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Note

The cover shows the Spruance class destroyer *U.S.S. Fletcher* in Pearl Harbor, Hawaii, near the end of the Navy's first Sea Swap experiment in 2004. During that experiment, the *Fletcher* remained deployed overseas for two years while a total of four crews rotated to it at six-month intervals. (Navy photo by Photographer's Mate 2nd Class Dennis C. Cantrell)



Preface

The Navy today deploys most of its ships with single crews. Thus, when a ship goes on deployment, the crew that takes it out of port is the same crew that brings it back, normally six months later. For some ships, however, the Navy employs a variety of dual-crew or multi-crew concepts to increase the amount of time that those ships can spend on-station in their operating areas overseas. In some cases, such as with ballistic missile submarines, crew rotation means that two crews alternate taking a single ship out for relatively short deployments from its home port (usually for less than three months). In other cases, three or more crews successively rotate to a ship while it is deployed overseas so the ship can stay on-station for longer periods and thus provide more “forward presence.” In the past few years, the Navy has experimented with the latter approach by rotating crews to large surface combatants in order to increase the amount of forward presence they provide.

The John Warner National Defense Authorization Act for Fiscal Year 2007 directed the Congressional Budget Office (CBO) to prepare a report examining different approaches to crew rotation, the amount of forward presence that the Navy’s future fleet could provide with and without greater use of crew rotation, and the advantages and disadvantages of such a change. This paper responds to that directive. In keeping with CBO’s mandate to provide objective, impartial analysis, it contains no recommendations.

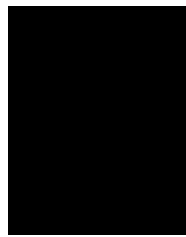
Eric J. Labs of CBO’s National Security Division wrote the report under the general supervision of J. Michael Gilmore. Adebayo Adedeji and Damien Moore of CBO provided helpful comments on various drafts, as did Robert Work of the Center for Strategic and Budgetary Assessments. (The assistance of an external reviewer implies no responsibility for the final product, which rests solely with CBO.)

Christian Howlett edited the paper, and Kate Kelly proofread it. Maureen Costantino designed the cover and prepared the report for publication. Lenny Skutnik produced the printed copies, Linda Schimmel coordinated the print distribution, and Simone Thomas prepared the electronic version for CBO’s Web site (www.cbo.gov).



Peter R. Orszag
Director

October 2007



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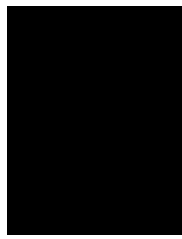
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Summary

Crew rotation—the practice of using more than one crew to operate a single ship—has attracted growing attention in the Navy in recent years. Under conventional crewing concepts, one crew is assigned to each naval vessel and operates it on all deployments and training cruises. (Individual personnel join or leave the crew as part of their normal career rotations.) On a small number of ships, however, the Navy employs rotation systems in which two or more crews take turns manning a particular ship. The purpose of crew rotation is to increase the amount of time that a ship spends operating overseas—providing “forward presence”—compared with conventional single crewing.

The Navy currently uses crew rotation on ballistic missile submarines, mine-countermeasures ships, and coastal patrol craft. According to the service, that approach has worked well. Between 2002 and 2006, the Navy experimented with rotating crews to individual Spruance class or Arleigh Burke class destroyers while those ships were deployed overseas. The Navy concluded that those experiments were a success. Nonetheless, the Navy does not plan to employ crew rotation on large numbers of those types of ships in the foreseeable future because it says it does not need to. The Navy expects to have enough cruisers and destroyers in its inventory over the next 30 years to meet its requirements for forward presence by using single-crewed ships. However, the service plans to use rotating crews on the new class of littoral combat ships (LCSs) that it has begun building, in order to meet the forward-presence requirement that the Department of Defense (DoD) has set for those ships.

This report describes the different approaches to crew rotation that the Navy uses today, has experimented with, or plans to employ. It also analyzes the forward-presence and force-structure implications of using or not using

crew rotation on the Navy’s surface combat ships. That analysis suggests the following conclusions:

- If the Navy employs crew rotation on its planned new classes of cruisers and destroyers, it would probably be able to provide substantially more overseas presence than it can today using single crews.
- If the Navy’s plan to use rotating crews on littoral combat ships does not prove viable, the service will need to buy an additional 30 LCSs to meet DoD’s current forward-presence requirement for those ships.
- If the Navy cannot fully execute its latest long-term shipbuilding plan because of fiscal constraints—resulting in a smaller fleet of cruisers and destroyers—using rotating crews on some of those ships may allow the Navy to meet its current and projected forward-presence requirements for large surface combatants despite having fewer ships.

Crew rotation has several potential drawbacks, however. Depending on the type of rotation scheme used, crews may have less familiarity with the ship they are going to operate and thus a reduced sense of “ownership” about it. Crew rotation is also more complex to administer than single crewing—although the success of rotational crewing on the Navy’s strategic submarines suggests that once the transition to crew rotation is complete, administering the practice becomes routine. Finally, crew proficiency, morale, and retention are not necessarily as high as they would be on single-crewed ships. The extent of those problems may depend on the size of the ship (and thus of the crew), the nature of the ship’s mission, and the amount of time that a particular crew rotation concept has been in use. Long-standing rotation practices work better than more-recent or experimental ones.

In addition, the costs or savings of crew rotation (compared with the costs of equivalent single-crewed ships) vary by type of rotation scheme. Dual-crew concepts, such as those used on ballistic missile submarines—in which two crews take turns operating a single ship—can entail increased one-time and recurring costs. One-time costs can be higher because of the need to spend more on designing and building a class of ships for dual-crew use and the need for more-elaborate training and maintenance facilities. Recurring costs can be higher because there are twice as many personnel per ship and because more maintenance is necessary when ships are at sea for longer periods. In return, dual-crewed ships spend far

more time on-station in their areas of operations than their single-crewed counterparts do.

Other versions of crew rotation—in which ships are divided into groups of three or four and their crews take turns operating one of the ships, which is kept deployed overseas for a long time—may actually save money, principally from reduced fuel consumption. However, the amount of additional time that such ships spend on-station is much less than under the dual-crew model used for submarines. So far, the Navy has limited such multi-crewing concepts to small surface combatants and its three recent experiments with destroyers.



Crew Rotation in the Navy: The Long-Term Effect on Forward Presence

Crew Rotation in the Navy Today

Although most U.S. naval vessels are operated by a single crew that stays with a ship whether it is in its home port or at sea, the Navy employs crew rotation schemes on some of its ships and submarines. Those rotation systems, which take various forms, have the same goal: to increase the time a ship can spend away from home providing forward presence in its area of operations.

The longest running and most formal crew rotation scheme in the Navy is the dual-crew system that has been used on ballistic missile submarines (SSBNs) since they were first deployed in 1960. The Navy is converting four of its SSBNs to a guided missile configuration; it plans to continue using a dual-crew system on those submarines as well. In recent years, the Navy has begun routinely using multiple, rotating crews on its Cyclone class patrol craft and Avenger class mine-countermeasures ships. In addition, dual crews—modeled on the SSBN system—are used on the Navy's single high-speed ferry ship, the *Swift* (also known as HSV-2).

The Navy has looked into extending crew rotation to parts of its fleet of surface combatants. Between 2002 and 2006, it conducted three experiments that involved rotating crews to forward-deployed destroyers. The Navy also plans to deploy the first of its new littoral combat ships (LCSs)—small vessels designed to operate in coastal waters—with a yet-to-be-defined dual-crewing system, at least initially. (As more LCSs are commissioned, the Navy may use multiple, rotating crews on those ships.) Moreover, when the Navy unveiled its fiscal year 2007 plan for a 313-ship fleet, it told the Congressional Budget Office (CBO) that it would adopt a crew rotation scheme for the new DDG-1000 Zumwalt class destroyers, which it began ordering this year. However, in updating its 313-ship plan for fiscal year 2008, the Navy said in a briefing

to CBO and the Congressional Research Service that it intends to use single crews on those destroyers.

The Blue/Gold System for Ballistic Missile and Guided Missile Submarines

Since the first patrol of the first ballistic missile submarine, the *George Washington*, each SSBN has been assigned two full, alternating crews: the blue crew and the gold crew. The nuclear missiles that those George Washington class submarines carried had relatively short ranges, and to be an effective deterrent, the submarines had to operate relatively close to the Soviet Union. To reduce time spent going back and forth from the continental United States, the SSBNs operated out of forward bases in Holy Loch, Scotland; Rota, Spain; and the Pacific island of Guam. Crew exchanges took place there, as did lower-level maintenance on the submarines (with the support of a submarine tender). More-substantial maintenance work, such as that requiring a dry dock, was performed in the United States.

The purpose of the dual crewing and forward basing was to increase the time that those SSBNs—which were seen as better able to survive attack than any other U.S. system for delivering nuclear weapons—could spend deployed on-station. Those practices allowed more than half of the SSBN force to be at sea and operational at any given time. (The equivalent figure for the Navy's surface combatant force is about one-fifth.)

Changes to Facilitate Dual Crewing on Current-Generation SSBNs.

In the 1970s, when the Navy decided to replace the George Washington class SSBNs, it developed a new generation of ballistic missile submarine (the Ohio class) and a new submarine-launched nuclear ballistic missile (the Trident) specifically with dual crewing in mind. The development program incorporated a number

of features to make maintenance and training easier, thus allowing the submarines to spend less time in port.

First, whereas the early George Washington class SSBNs were attack submarines that had been modified to carry ballistic missiles, the Ohio class submarines were specifically designed and engineered for that role.¹ They include features intended to speed up maintenance, such as an extra-large hatch (called a logistics escape trunk) and removable decks to facilitate the quick replacement of large pieces of equipment. (Removing large items from an attack submarine, by contrast, may require dismantling them onboard the sub, which takes time, or cutting a hole in the hull to remove them.)

Second, the Navy instituted the Trident Planned Equipment Replacement Program for conducting periodic, large-scale equipment changes to ensure that Trident-carrying submarines operate with “like-new” equipment during each deployment. Rather than wait for equipment to fail and be replaced as needed, the Navy replaces equipment on those submarines on a regular schedule. The maintenance facilities at the Trident submarine bases in Kings Bay, Georgia, and Bangor, Washington, include large dry docks, rail-mobile pier-side cranes to quickly remove or insert big pieces of equipment in the submarines, and advanced machine shops. In addition, those facilities are given enough resources to ensure a readily available supply of parts. In those ways, the shore infrastructure for the SSBNs is designed to maximize their availability for deployment.

Third, the Trident Training Facility at each submarine base is more extensive than the training facilities for other Navy ships. Crews that are not on deployment train onshore in facilities that appear virtually identical to those they will use on the submarines at sea.

How the Dual-Crew System Works for Submarines. The Navy operates Trident SSBNs on a 224-day cycle (see Figure 1). One of a submarine’s two crews takes the submarine to sea for 77 days and then returns it to its home port. Both crews then perform maintenance on the

submarine for a 35-day period, after which the second crew takes the submarine to sea for 77 days before returning it to the home port for further maintenance. After that, the cycle begins again.

Because the principal mission of an SSBN is to provide deterrent patrols with strategic weapons, and because the Trident D-5 missile has a range of about 7,000 miles, an SSBN is effectively considered on-station soon after it leaves its home port in the continental United States. As a result, Trident SSBNs spend a majority of their service life at sea on-station, compared with about 20 percent of the time for a single-crewed attack submarine or surface combatant.²

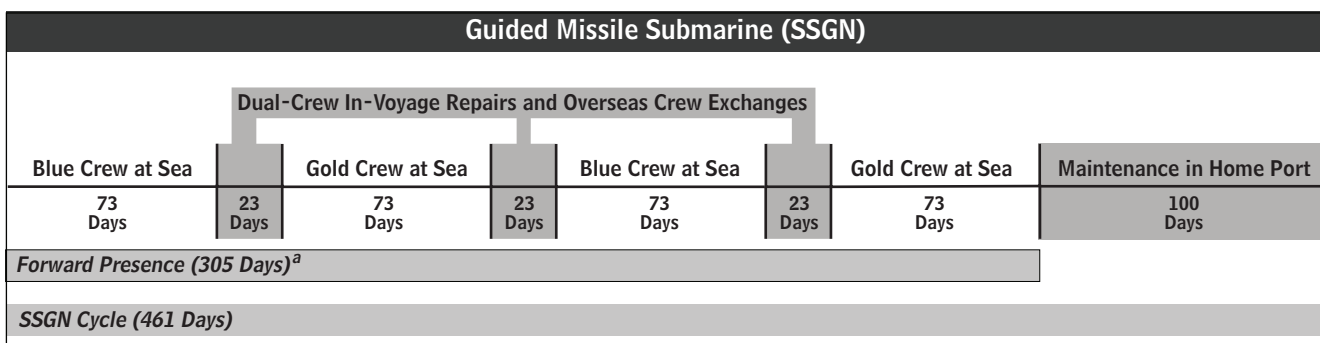
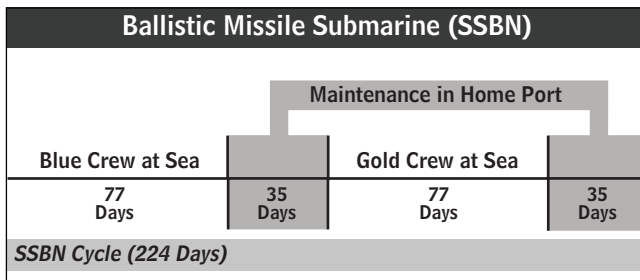
The four SSBNs that the Navy is converting into guided missile submarines (SSGNs) will use a modified blue/gold crewing system that has the same advantages for maintenance and training as the system for SSBNs. However, their different missions and weaponry mean that those guided missile submarines will follow a much longer operating cycle: 461 days (see Figure 1). SSGNs are armed with cruise missiles that have roughly one-seventh the range of Trident D-5 missiles, and they are intended to perform land-attack or special-operations missions (as well as providing forward presence in peacetime). For those reasons, SSGNs need to operate much farther away from the continental United States than ballistic missile submarines do.

In the Navy’s planned deployment cycle for SSGNs, one crew will take a submarine on deployment for 73 days. After that, the SSGN will spend 23 days at an overseas port, during which time the second crew will arrive and both crews will perform maintenance on the submarine, probably with the support of a submarine tender. The first crew will then fly back to the United States—where it will train at onshore facilities—and the second crew will take the SSGN to sea for 73 more days. That part of the cycle is repeated once, and then the submarine returns to the United States for 100 days of maintenance in its home port.

Unlike a ballistic missile submarine, an SSGN is generally not considered on-station for the entire time it is deployed. Of the 361 days it is away from its home port,

1. The Ethan Allen, Benjamin Franklin, James Madison, and Lafayette classes were also designed and constructed specifically as ballistic missile submarines. They, along with the George Washington class, composed the famous “41 for Freedom” ballistic missile submarine force delivered in the 1960s.

2. Attack submarines and surface combatants are not considered on-station until they arrive in their areas of operations overseas.

Figure 1.**Deployment Cycles of Ballistic Missile and Guided Missile Submarines**

Source: Congressional Budget Office based on data from the Navy.

- a. Of the 361 days the SSGN is on deployment, 56 days are used for transit to and from the theater of operations, loading and unloading of equipment, and certifications and inspections following crew exchanges. Those 56 days do not count as forward presence.

56 are spent going to and from the theater of operations, loading and unloading equipment from the submarine's dry-deck shelter, and undergoing the certifications and inspections that are required as part of the crew-exchange process. Consequently, the SSGN provides forward presence for 305 days of its 461-day cycle, or about the same percentage of time that an SSBN spends performing its mission.

The Blue/Gold System for the U.S.S. *Swift*

The *Swift* (also known by its designation HSV-2, for high-speed vessel) is a small, fast catamaran that the Navy has leased from a private contractor since 2003. The ship is used to test new technologies and concepts for mine warfare, logistical support, and other missions, as well as to support humanitarian operations and exercises with U.S. allies.

From the time the Navy acquired the *Swift*, it has operated the ship with a blue/gold crewing system modeled on that of ballistic missile submarines. The blue crew is based in Ingleside, Texas, and the gold crew in Little

Creek, Virginia. Each crew operates the ship for about 117 days, with crew exchanges occurring wherever the ship happens to be at the end of that period. (In the past, those exchanges have taken place in the continental United States, Hawaii, Guam, Bahrain, Cyprus, and other locations.) As a result, since the Navy began operating it, the *Swift* has been out of its home port and available for missions more than 80 percent of the time.

Because the *Swift* is leased and is unique in the Navy, its maintenance is handled differently than that of SSBNs. Minor repairs are done by the individual crews, but more-substantial maintenance is performed by a contractor through the Military Sealift Command (the agency that provides, operates, and maintains most of the transport and support ships of the Department of Defense).

The *Swift* is relatively simple to operate, so the Navy does not maintain dedicated training facilities for the shore-based crew. Instead, at the beginning of a crew exchange, the incoming sailors conduct a series of tests and drills to ensure that they are proficient in running the ship.

Table 1.**Navy Ships That Have Used Crew Rotation**

	Displacement When Fully Loaded (Long tons)	Crew Size
Ohio Class Ballistic Missile Submarines	18,400	160
<i>Swift</i> High-Speed Ferry	1,700	40
Cyclone Class Coastal Patrol Ships	331	28
Avenger Class Mine- Countermeasures Ships	1,300	83
Spruance Class Destroyers	9,300	346
Arleigh Burke Class Destroyers	9,200	340

Source: Congressional Budget Office based on Norman Polmar, *The Naval Institute Guide to the Ships and Aircraft of the U.S. Fleet*, 18th ed. (Annapolis, Md.: Naval Institute Press, 2005).

Multicrewing on Coastal Patrol Ships

The Navy's fleet includes eight Cyclone class coastal patrol ships, three of which have their home port in Little Creek, Virginia, and five in Bahrain. Those vessels, which are just one-fifth the size of the *Swift*, are among the smallest ships operated by the Navy (see Table 1). To support them, the Navy uses 13 crews that rotate back and forth from Bahrain. Five crews deploy to the five ships homeported in Bahrain for six months at a time. The other eight crews stay in Virginia with the three remaining patrol ships for eight to nine months, after which they rotate to one of the overseas vessels. Six of those eight crews are assigned to the three Virginia-based Cyclones (two crews per ship) for training. The two crews not assigned to a ship use onshore facilities for additional training courses. During the training phase, crews may change ships, and during the deployment phase, they may return to a different ship than they operated during their previous deployment.

In essence, that system is a hybrid of the Navy's practices of having some ships and crews homeported overseas and having other ships and crews homeported in the United States that then go on routine deployments. Navy ships normally deploy for six months if they are stationed in

the United States. Likewise, Cyclone crews go on six-month deployments, although their ships remain based either in Bahrain or Virginia. That system allows the Navy to count five of the eight patrol ships as being forward deployed 100 percent of the time—resulting in a deployment rate for the force of 62 percent, only slightly less than that of the SSBN force.³ Maintenance on the patrol boats is performed by the crew and contractors in the ships' home ports.

According to the Navy, that multicrewing approach has several advantages. It allows for a high level of forward presence with the five ships stationed in Bahrain, while requiring crew members to be deployed only about 40 percent of the time over a five-year period. In addition, it saves the Navy from having to get the patrol ships overseas, which would be costly if the Cyclones were transported on larger, ship-carrying vessels or would cause wear and tear on the Cyclones if they made the transoceanic voyages themselves.

Dual Crewing and Multicrewing on Mine-Countermeasures Ships

The Navy operates 14 Avenger class ships, which are designed to find and destroy mines at sea. Two of the ships are based in Japan, where they are operated by single crews. Four others are based permanently in Bahrain, and the remaining eight are stationed in Ingleside, Texas. Those 12 ships are operated by 12 crews using a rotation system.

Eight crews, divided into four blue/gold pairs, are assigned to the four ships in Bahrain and to four ships in Texas. While a blue crew is operating its ship in Bahrain, its gold counterpart is operating a ship in Texas and training to go on deployment to relieve the blue crew. Four other crews, designated silver, operate the four remaining Texas-based Avengers. Those crews train on and maintain their own ships and also take custody of other Texas-based ships when a blue or gold crew leaves for a crew exchange in Bahrain.

3. Similarly, the various Navy ships that have their home ports in Japan (which include an aircraft carrier, amphibious ships, surface combatants, and support ships) also count as being forward deployed all of the time, even during maintenance periods. However, the families of Japan-based crews generally live in Japan, whereas the families of Cyclone crews remain in Virginia.

The sailors assigned to the blue or gold crews spend about half of their time deployed (alternating four months in Bahrain with four months in Texas). The silver crews are not part of the overseas deployment rotation; instead, they serve in a logistical and support function for the crews that do deploy. As in the case of Cyclone patrol ships, the families of the Avenger crews remain stationed in Texas.

The advantages of that crewing arrangement are similar to those of the system for coastal patrol craft. The Navy uses three ships to keep one providing overseas presence full time. In addition, as with the Cyclones, the Navy forgoes the wear and tear on the ships' hulls associated with deploying from the United States or the expense involved in transporting the ships overseas. According to the Navy, the crews generally like that schedule because they are not deployed overseas for more than four months at a time. When they are deployed, they maintain a high level of operational availability for the theater commanders who assign them missions.

The Navy's Sea Swap Experiments with Destroyers

Between 2002 and 2006, the Navy conducted three experiments with extending multiple crewing to destroyers, the workhorses of the surface combatant fleet. Those experiments, called Sea Swap, aimed to determine whether the Navy could effectively keep a destroyer overseas longer by rotating crews to the ship, thus providing more forward presence than if the destroyer repeatedly deployed from the United States. The first two experiments were conducted by the Navy's Pacific Fleet Command using Spruance and Arleigh Burke class destroyers. A third experiment was conducted by Fleet Forces Command (FFC)—the Navy's principal entity for organizing, training, and equipping forces for assignment to regional combatant commanders—to refine and improve the Sea Swap concept.

Overall, the Navy was pleased with the results of those experiments. The destroyers that used rotating crews were able to provide significantly more forward presence over a given period than similar ships crewed the traditional way, with few significant negative side-effects for the ships or their crews. The cost implications of using rotational crewing on those ships are not yet clear, however.

The Traditional Single-Crew Concept for Deploying Surface Combatants

Under the Navy's normal crewing concept for surface combatants, one crew operates one ship. The crew spends 12 to 18 months training and performing maintenance on the ship to prepare it for deployment. At the end of that period, the crew takes the ship on a six-month deployment, after which the crew and the ship return to their home port, and the cycle begins again. Most of the Navy's surface combatants are based in San Diego, California, or Norfolk, Virginia—the main naval bases on the West and East Coasts of the United States.

Unlike a Trident submarine, which is on-station almost from the time it leaves its home port, a surface combatant does not arrive on-station until it reaches its area of operations overseas. How long that takes depends on whether the ship is leaving from the East or West Coast and whether it is assigned to European Command, Pacific Command, or Central Command (which has responsibility for the Middle East, the Horn of Africa, Central Asia, and parts of the Indian Ocean). That amount of time also depends on how fast the ship sails and on the number and duration of stops it makes along the way. (An important perk of deploying overseas on a Navy ship is the opportunity to visit "liberty ports" where sailors can go ashore for several days to enjoy the sights, sounds, and foods of other countries.) In a routine deployment, a Navy ship can take between three and six weeks to arrive on-station.⁴

With that traditional single-crewing concept, the Navy needs a force of six surface combatants to keep one on-station at all times in Central Command—or a rotation ratio of 6 to 1. For European Command or Pacific Command, the analogous ratio is 4.5 to 1. The goal of the Sea Swap experiments was to try to reduce those ratios by gaining more forward presence from a given group of ships.

Pacific Command's Sea Swap Experiment with Spruance Class Destroyers

The first experiment began in 2002 and included four Spruance class destroyers: the *Fletcher*, the *Kinkaid*, the *Oldendorf*, and the *Elliott*. All of those ships were slated to

4. In a crisis, that time can be cut considerably by increasing the ship's transit speed and eliminating unnecessary stops along the way.

Figure 2.

Overseas Presence Provided by Sea Swap Experiments Compared with Traditional Ship Deployments

Retiring Ship Class: Spruance Class Destroyer			
Traditional Ship Deployment: Four Ships with Four Crews			
Ship 1	Ship 2	Ship 3	Ship 4
100 Days	100 Days	100 Days	100 Days
<i>Average presence: 100 days per ship per crew</i>			
Sea Swap Experiment: One Ship with Four Rotating Crews			
Crew 1	Crew 2	Crew 3	Crew 4
122 Days	141 Days	141 Days	105 Days
<i>Average presence: 127 days per ship per crew</i>			

Existing Ship Class: Arleigh Burke Class Destroyer			
Traditional Ship Deployment: Four Ships with Four Crews			
Ship 1	Ship 2	Ship 3	Ship 4
124 Days	90 Days	124 Days	90 Days
<i>Average presence: 107 days per ship per crew</i>			
Sea Swap Experiment: One Ship with Three Rotating Crews			
Crew 1	Crew 2	Crew 3	
149 Days	153 Days	151 Days	
<i>Average presence: 151 days per ship per crew</i>			

Source: Congressional Budget Office based on data from the Navy.

Notes: The numbers shown here are for operations in the U.S. Central Command’s area of responsibility (which includes the Indian Ocean, the Persian Gulf, and the Red Sea).

The Spruance class experiment was conducted by Pacific Command and thus used only Pacific Fleet destroyers for the comparison group. The Arleigh Burke class experiment was conducted by Fleet Forces Command and used a mix of Pacific Fleet and Atlantic Fleet destroyers for the comparison group.

The entire deployment for any destroyer or (in the case of the Sea Swap experiments) destroyer crew was 180 days. The difference between that figure and the number of days of forward presence a ship actually provided reflects time spent sailing to and from the theater of operations. Some additional time may have been spent at a liberty port outside the theater of operations.

be retired within two years. The *Fletcher* deployed to the western Pacific and Indian Ocean areas of operation in August 2002 and remained on-station for almost two years, with a crew from one of the other three ships rotating to it every six months. Those other destroyers remained in the United States, where their crews performed the usual routine of training and preparing to deploy with their ships. But when a crew’s turn came to

rotate to the *Fletcher*, its regular ship was decommissioned. Crew exchanges took place in Australia, Singapore, and the United Arab Emirates. At the end of the *Fletcher*’s two-year deployment, the last crew brought her back to the United States and the ship was retired.

That crewing experiment produced a significant increase in the amount of forward presence provided by the Sea

Swap ships compared with an equivalent number of traditionally deployed ships (see Figure 2). A single-crewed Spruance class destroyer deploying from the West Coast to the western Pacific would provide 100 days of forward presence per 180-day deployment (with the rest of the time spent in transit, at liberty ports, or in training). Thus, four of those ships would provide a total of 400 days of presence. In comparison, the four ships and crews involved in the first Sea Swap experiment provided 509 days of forward presence, or an average of 127 days per ship—a 27 percent improvement over traditional deployments.

Beginning in late 2002, Pacific Command conducted a second Sea Swap trial using Arleigh Burke class destroyers. That experiment is not discussed here, however, because it was similar in concept and results to the third Sea Swap test (by Fleet Forces Command using Arleigh Burke class destroyers), which is described in detail below. In addition, the Navy collected much more data for the FFC experiment than it did for the Pacific Command experiments.

What Pacific Command wanted from its Sea Swap tests was to prove that more presence could be provided by rotating crews to a forward-deployed ship. On that basis, Pacific Command deemed Sea Swap a success. Because of that emphasis, the data that the Navy collected in the experiment focused on how the crew exchanges worked, the readiness of the crews when the exchanges took place, and what shore-based infrastructure was needed to support crew rotation. The Navy did not collect data on the costs of the experiment or compare the material condition of the multicrewed ships with that of traditionally operating ships.

From the Navy's perspective, a principal advantage of the Spruance class experiment (aside from providing more forward presence) was that the Navy did not have to spend as much money on ship maintenance. The Navy aims to send its ships overseas in very good material condition. However, since the *Kinkaid*, the *Oldendorf*, and the *Elliott* were being decommissioned rather than deployed, the Navy did not provide the normal amount of maintenance needed to send those ships overseas. For that reason, the Navy concluded that rotational crewing works especially well with classes of ships that are being retired.⁵ However, the Navy did not document how much it might save in maintenance costs because of crew rotation because it already planned to retire the ships

used in that experiment and thus did not evaluate them to determine how much maintenance they would have needed to be fit for deployment.

In a report released in late 2004, the Government Accountability Office (GAO) criticized the first two Sea Swap experiments as insufficiently rigorous and lacking in appropriate oversight and guidance from the Navy.⁶ Specifically, GAO stated that the lack of an analytic framework—which would have included formal measurable goals, objectives, and metrics to determine the effects of crew rotation on operational requirements, costs, ship condition, and crew morale—prevented the Navy from effectively evaluating the Sea Swap concept. The Navy did not provide guidance for crew-exchange procedures or for documenting a ship's condition when an exchange took place. In particular, the Navy did not collect enough information to properly evaluate the effect that such a long deployment had on the amount of maintenance that the ship needed overseas or on its return home. Although the Navy intended to retire the *Fletcher*, failure to evaluate whether it was in worse condition as a result of its long deployment prevented a proper cost-effectiveness analysis of Sea Swap, according to GAO.⁷

Partly in response to GAO's criticisms, the Navy conducted a third Sea Swap experiment, this time carried out by Fleet Forces Command. The trial focused on providing a more rigorous experiment and collecting more data, particularly about costs and maintenance.

FFC's Sea Swap Experiment with Arleigh Burke Class Destroyers

The third Sea Swap experiment began in early 2005 and employed three Arleigh Burke class destroyers: the

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5. See Secretary of the Navy Donald C. Winter, *Report on Navy Surface Ship Rotational Crew Programs in Compliance with Section 342 of Fiscal Year 2007 National Defense Authorization Act* (February 15, 2007), p. 15. That document is an interim report. The Navy's final report was expected in June 2007, although as of this writing, it had not yet been issued.
 6. Government Accountability Office, *Force Structure: Navy Needs to Fully Evaluate Options and Provide Standard Guidance for Implementing Surface Ship Rotational Crewing*, GAO-05-10 (November 2004).
 7. That criticism also applied to Pacific Command's experiment with Arleigh Burke class destroyers. The Navy did not compare the condition of the multicrewed ship in that experiment with the conditions of similar ships after their deployments.

Gonzalez, the *Laboon*, and the *Stout*. The *Gonzalez* deployed to Central Command's area of responsibility for 18 months, three times longer than the traditional deployment of a surface combatant with a single crew. Every six months, the crew of one of the other two destroyers rotated to the *Gonzalez*, with the exchanges taking place in Bahrain. Shore personnel in Norfolk, Virginia—where the three destroyers are based—acted as caretakers for the other ships while the crew exchanges were occurring. During the course of its deployment, the *Gonzalez* operated with five expeditionary strike groups (task forces that comprise three amphibious ships and three surface combatants), three of which deployed from the Atlantic Fleet and two from the Pacific Fleet.

This crew rotation experiment provided much more forward presence than either traditional ship deployments or the test with Spruance class destroyers (see Figure 2 on page 6). The control group in the experiment consisted of four Arleigh Burke class destroyers with single crews on six-month deployments: two from the Pacific Fleet and two from the Atlantic Fleet. The Atlantic Fleet ships each provided 124 days of forward presence (with the balance of time spent in transit or in port calls outside their area of operations). The Pacific Fleet ships provided 90 days of presence each, reflecting the longer sailing times from the West Coast to the Indian Ocean. In all, that control group of four crews and four ships provided 428 days of presence over an 18-month period, or an average of 107 days per ship per crew. Over the same period, the *Gonzalez* provided more forward presence—453 days—using three crews (and, in effect, three ships), for an average of 151 days per ship per crew. That figure represents an improvement of 40 percent over the traditional single-crew method and 19 percent over the results of the Sea Swap test with Spruance class destroyers.

The increase in forward presence in the third Sea Swap experiment suggests that if the Navy normally needs 100 surface combatants to provide a given level of presence, the same capability could be provided with 72 surface combatants using this variant of rotational crewing. Thus, rather than needing a rotation ratio of 5 to 1 for single-crewed surface combatants, the Navy could reduce that ratio to about 3.5 to 1 with Sea Swap.⁸

8. That 5-to-1 rotation ratio is CBO's estimate of a rough fleetwide average, based on the 6-to-1 ratio used by Central Command and the 4.5-to-1 ratio used by European and Pacific Commands.

The Navy's Conclusions About Sea Swap and Future Policy

The Navy reported that the results of the FFC Sea Swap experiment were positive, for the most part. Rotational crewing saved fuel costs by requiring fewer transits of the Pacific Ocean. The material condition of the *Gonzalez* at the end of its deployment was not substantially different from that of ships that deployed with single crews—although the Navy is awaiting a final evaluation of the ship's condition after its regular shipyard overhaul.⁹ Crew morale and readiness were about the same among the rotating crews and those on single-crewed ships. Crew retention, however, was somewhat lower than on other ships. Overall, the Navy concluded that the Sea Swap concept works but that it requires increased oversight on the part of Navy staff to execute and increased effort and coordination on the part of crew members to ensure smooth transitions between crews.

According to the Navy's report, rotational crewing has several other advantages. From the combatant commander's perspective, the rotationally crewed ship in the FFC experiment remained in-theater for nearly the full 18 months, with none of the gaps in coverage that can occur if a relief ship arrives late. In addition, allied and friendly navies appreciated the familiarity of working with the same U.S. ship, even though the crew and command of the ship changed. From the Navy's perspective, rotational crewing generally eliminated the possibility that a ship's—and thus its crew's—deployment could be extended beyond the normal six months.¹⁰ Because the ship remained in the theater of operations, crews could be swapped out every six months. But with a traditionally crewed ship, if its relief ship was not available and forward presence absolutely had to be maintained, the ship could have its tour of duty extended.

9. The Navy states in its interim report: "Using the *Gonzalez* post deployment Critical System Assessment . . . in October 2006 as a reference point, the material condition of the Experiment and the Control Group ships were similar. However, the full assessment of *Gonzalez* material condition will include review and assessment of her post deployment maintenance availability scheduled to begin March 2007. These results will be included in the final report." See Winter, *Report on Navy Surface Ship Rotational Crew Programs*, p. 13. (The final report has not yet been released.)

10. The last crew in the rotation could have its deployment extended, however, unless the Navy was prepared to conduct another crew exchange, which was not part of the Sea Swap experiment.

The Navy's report also identified several drawbacks of the third Sea Swap experiment. First, because rotational crewing was not "business as usual," it required some adjustment by the different crews, in that they would not be deploying with the ships on which they had trained. Some shore infrastructure and logistical coordination were required, particularly during crew exchanges, when ships being left in the United States needed personnel to support them. Thus, a large-scale use of Sea Swap could require an increase in shore-based infrastructure and personnel in order to provide enough sailors to take care of several ships whose crews had left for overseas exchanges at the same time. The Navy has not estimated how many additional personnel might be needed or at what cost.

The Navy concluded its interim report by stating, "No additional Sea Swap Initiatives are currently planned. However, the Sea Swap multi-crewing concept is executable and works extremely well for ships with high demand but low numbers and most especially in the case of 'sun-setting' a particular class of ships."¹¹ As noted above, when the Navy is planning to retire a ship class, it can avoid a substantial amount of maintenance to make old ships ready for their last deployments if it can simply rotate those ships' crews to a vessel that is already deployed overseas.

Ships with "high demand but low numbers"—such as coastal patrol ships or mine-countermeasures ships—are ones for which there are many more potential missions than vessels available to perform them. The Navy appears to have concluded from the Sea Swap experiments that it can get more use from high-demand ships by rotating crews to them instead of, for example, building more of those ships to meet the demand.

Logically, however, the effectiveness of multicrewing should depend on the characteristics of ships rather than on their numbers or the demand for them. The Navy's statement that multicrewing works well on ships with high demand and low numbers means, in effect, that crew rotation would work well on similar ships regardless of their numbers or demand. (Whether rotational crewing would be necessary on such ships is another matter.) In communications with CBO after releasing its interim report, the Navy recognized that there is no distinction in the viability of Sea Swap between ships that are in high

demand but have low numbers and other ships that cannot be characterized that way. Thus, although the Navy currently has no plans to employ Sea Swap on large surface combatants, if it needs to provide more forward presence with those ships in the future than is feasible under traditional crewing procedures, and if it is unwilling or unable to expand its force of those ships, using Sea Swap could be a viable option to fill the gap.¹²

CBO's Analysis of the Potential Effects of Expanding Crew Rotation

In recent years, the Navy has begun issuing annual reports that detail its plans for ship construction over the next three decades. The defense authorization act for 2007 directed CBO to examine how much forward presence could be provided under the Navy's long-term shipbuilding plan with the widespread use of crew rotation. The remainder of this paper looks at the amount of presence that the Navy's surface combatant force might be able to provide in the future under various types of crew rotation and the potential costs of such a change.

Requirements for Forward Presence and Plans for Multiple Crewing Under the Navy's Long-Term Shipbuilding Plan

The latest long-term shipbuilding report envisions expanding the Navy's battle-force fleet from its current size of about 280 ships to 313 ships by 2020.¹³ The surface combatant force—which today comprises 74 cruisers and destroyers and 30 frigates—would consist of 94 cruisers and destroyers and 55 littoral combat ships by 2020 (see Figure 3). Under that plan, by 2040, the Navy will have finished purchasing seven DDG-1000 guided missile destroyers and 19 CG(X) guided missile cruisers and will be replacing the Arleigh Burke class destroyers with a new anti-air guided missile destroyer, the DDG(X).

Based on its analysis of wartime needs—which stresses the importance of forward-deployed and early-arriving forces—the Navy has set its long-term requirement for

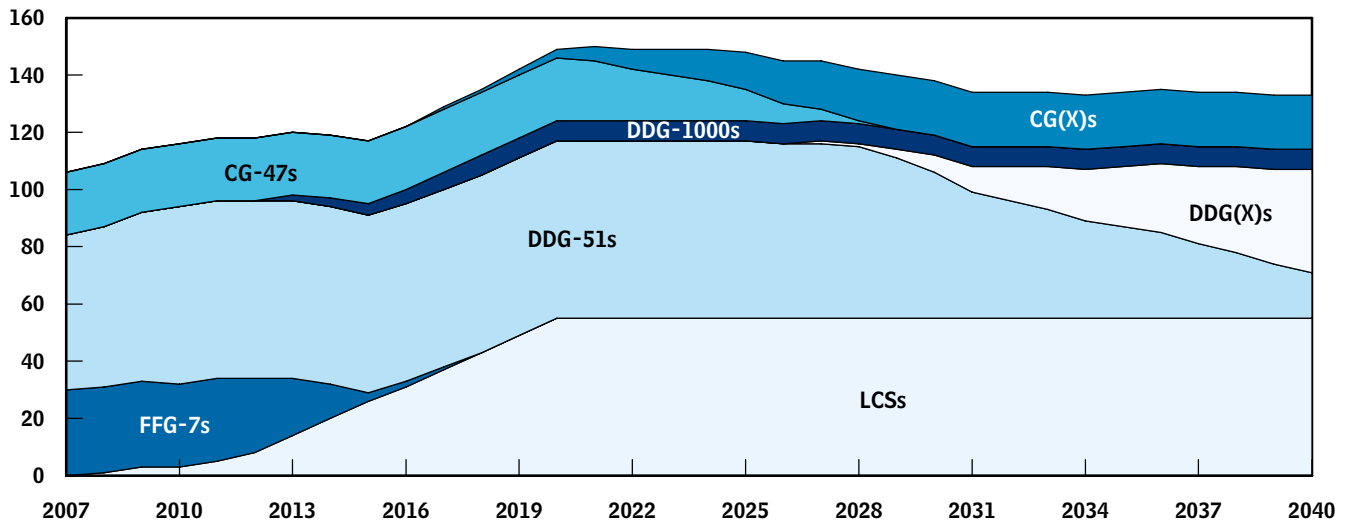
11. Winter, *Report on Navy Surface Ship Rotational Crew Programs*, p. 15.

12. However, section 342(b) of the John Warner National Defense Authorization Act for Fiscal Year 2007 (P.L. 109-364; 120 Stat. 2154) prohibits the Navy from implementing any new crew rotation experiment or program on surface ships until October 1, 2009.

13. See Department of the Navy, *Report to Congress on Annual Long-Range Plan for Construction of Naval Vessels for FY2008* (February 2007).

Figure 3.

The Navy's Inventory of Surface Combatants Under Its Long-Term Shipbuilding Plan



Source: Congressional Budget Office based on data from the Navy.

Notes: CG-47s = Ticonderoga class cruisers; CG(X)s = future guided missile cruisers; DDG-1000s = Zumwalt class guided missile destroyers; DDG-51s = Arleigh Burke class destroyers; DDG(X)s = future anti-air guided missile destroyers; FFG-7s = Oliver Hazard Perry class guided missile frigates; LCSs = littoral combat ships.

CBO adjusted its assumptions about LCS purchases to reflect changes in that program since the publication of the Navy's 2008 shipbuilding plan. CBO assumed future purchases and retirements would occur at levels intended to keep the LCS force steady at 55 ships.

large surface combatants at 88 cruisers and destroyers.¹⁴ Of that number, 21 are supposed to be forward deployed at any given time (including ships on routine deployment from the United States and those based in Japan). Similarly, analysis of the need for littoral combat ships in future conflicts and for other missions that may occur at the same time—such as maritime interception or counterterrorism operations—suggests to the Navy that it must have an average of 23 LCSs overseas at any given time. The Navy believes it can achieve that level of presence with a fleet of 55 LCSs. From 2020 through the succeeding 20 years, the Navy's shipbuilding plan would acquire enough small and large surface combatants to meet both of those forward-presence requirements (see the top panel of Figure 4).

14. The 313 ships in the long-term plan (including the 88 cruisers and destroyers) are the requirement that the Navy has set for its fleet, which it says it needs to meet by 2020. Under the current schedule for commissioning and decommissioning ships, however, the Navy would have more than 88 large surface combatants until 2028.

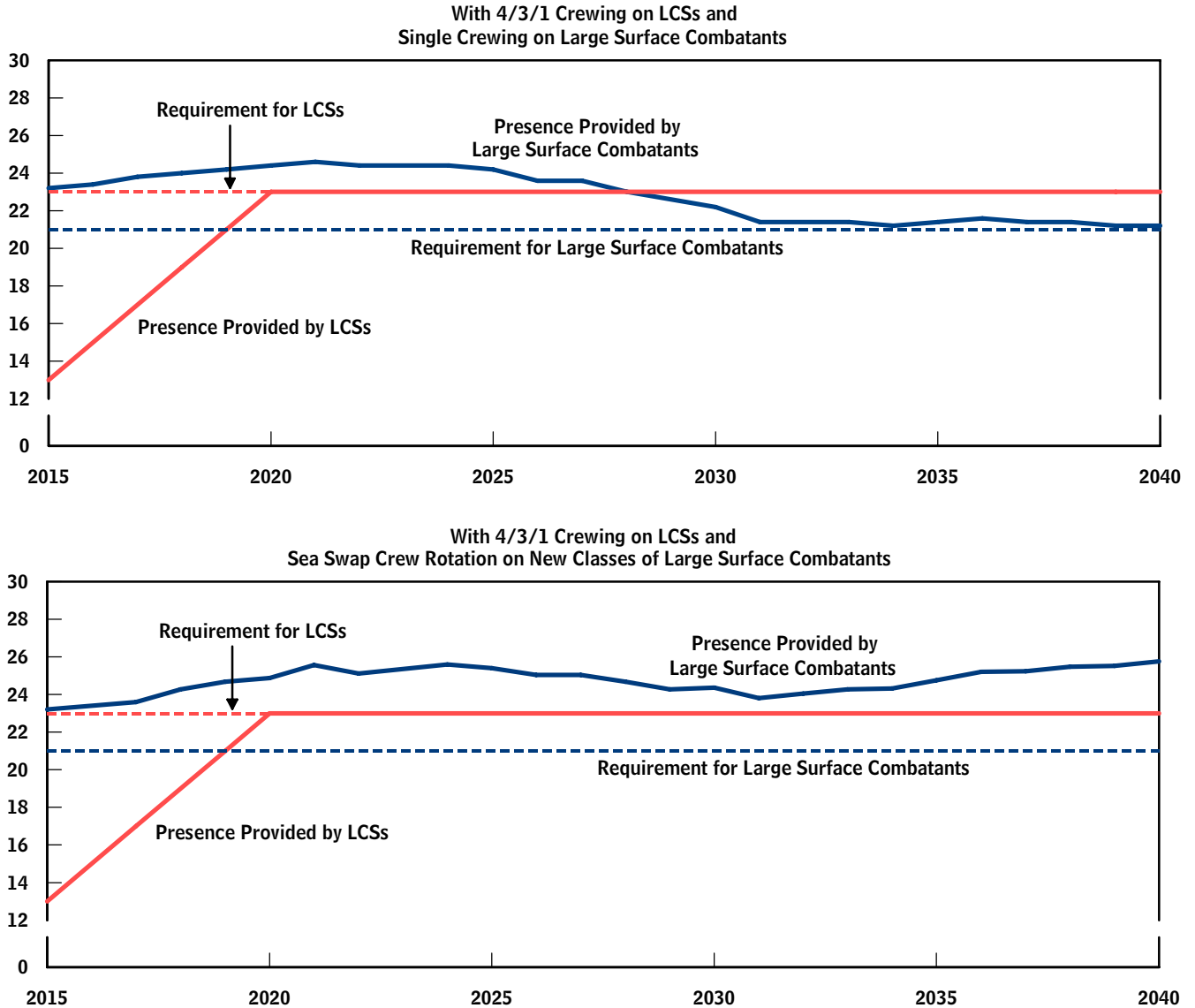
The expected rotation ratio for littoral combat ships is smaller than the ratio for large surface combatants because the Navy's plan anticipates using a rotational crewing concept for LCSs that is similar to the one now employed on Cyclone class coastal patrol boats. Specifically, the Navy envisions using four crews to operate three LCSs based in the continental United States, of which one ship would be forward deployed at any given time. That approach is often abbreviated as the 4/3/1 crewing concept. However, the first two LCSs (which are now under construction) will use a blue/gold dual-crew system—perhaps similar to that of mine-warfare ships—until enough LCSs have been commissioned into the fleet to allow for multiple crewing.

The assumption that the Navy will use 4/3/1 crewing for LCSs once they enter the fleet in large numbers may not hold true, however. When CBO asked how many LCSs would be needed to start implementing the 4/3/1 concept, the Navy stated that it "is reviewing future manning options, and the use of a 4:3 crewing concept is among

Figure 4.

Forward Presence Provided by Surface Combatants Under the Navy’s Long-Term Shipbuilding Plan

(Number of ships forward deployed)



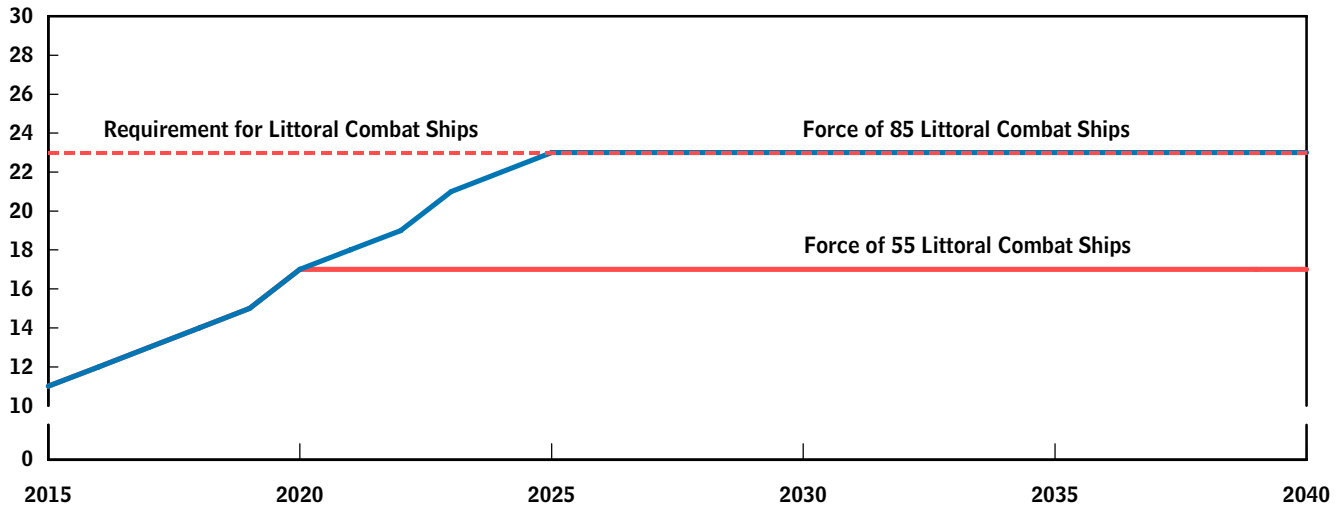
Source: Congressional Budget Office.

Notes: Under 4/3/1 crewing, four crews would operate three ships, one of which would be forward deployed at any given time.

CBO adjusted its assumptions about purchases of littoral combat ships (LCSs) to reflect changes in that program since the publication of the Navy’s 2008 shipbuilding plan. CBO assumed that future purchases and retirements would occur at levels intended to keep the LCS force steady at 55 ships.

Figure 5.**Forward Presence Provided by Single-Crewed Littoral Combat Ships**

(Number of ships forward deployed)



Source: Congressional Budget Office.

the options being considered.”¹⁵ A decision not to employ that crewing concept could have implications for the amount of forward presence that LCSs could provide. For example, if the Navy determined that rotational crewing was not feasible for littoral combat ships and used a conventional single-crewing approach instead, the planned force of 55 LCSs would be able to keep only about 17 ships forward deployed at one time, rather than the stated requirement of 23 ships. To meet that forward-presence requirement with single-crewed LCSs, the Navy would have to build 85 ships instead of 55 (see Figure 5).

Effects of Widespread Crew Rotation Under the Navy’s 313-Ship Plan

To analyze the possible impact of crew rotation on the fleet envisioned in the Navy’s long-term shipbuilding plan, CBO had to make various assumptions. For example, CBO defined the phrase “widespread use of crew rotation” from the 2007 defense authorization act to mean continuing crew rotation for ship classes that use it now, employing the 4/3/1 concept on littoral combat ships, and applying the Sea Swap rotation concept to all future classes of large surface combatants. (The Navy has not analyzed or conducted crew rotation experiments on other types of ships, such as amphibious ships or aircraft

carriers.)¹⁶ CBO chose to limit its analysis to future classes of large surface combatants because, in theory, introducing widespread crew rotation to new classes would allow the Navy to plan for and design the ships in ways to facilitate crew rotation.

Specifically, CBO assumed that the planned DDG-1000 guided missile destroyers, CG(X) future cruisers, and DDG(X) future guided missile destroyers (replacements for Arleigh Burke class destroyers) would employ the Sea Swap approach. Ships would be divided into groups of three, with one ship deploying for 18 months and the crews of the other two ships rotating to it every 6 months. At the end of 18 months, the deployed ship would return to its home port in the United States, and one of the other two ships in the group would deploy for an 18-month period, with the cycle of 6-month crew rotations continuing (see Figure 6).

In general, CBO assumed that crew rotation would not begin with a class of ships until at least a year after the

15. Department of Defense information paper on LCS crewing furnished to the Congressional Budget Office on June 29, 2007.

16. In 2003, the Navy considered experimenting with crew rotation on an amphibious ship. It abandoned that effort, however, when its preliminary analysis determined that crew rotation would be too complex and difficult to execute on such a ship, particularly in conjunction with the Marine Corps, whose units would be aboard the Navy ship and would need to rotate along with the ship’s crew.

Figure 6.

Notional Three-Ship Crew Rotation for Future Large Surface Combatants on 18-Month Deployments

Surface Combatant A								
On Deployment			In Home Port			In Home Port		
Crew 1	Crew 2	Crew 3	Crew 2	Crew 3	Crew 1	Crew 3	Crew 1	Crew 2
180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days

Surface Combatant B								
In Home Port			On Deployment			In Home Port		
Crew 3	Crew 1	Crew 2	Crew 1	Crew 2	Crew 3	Crew 2	Crew 3	Crew 1
180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days

Surface Combatant C								
In Home Port			In Home Port			On Deployment		
Crew 2	Crew 3	Crew 1	Crew 3	Crew 1	Crew 2	Crew 1	Crew 2	Crew 3
180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days	180 Days

Source: Congressional Budget Office.

third ship of the class had been commissioned. (Typically, a newly commissioned ship needs about a year to be made ready for regular, routine deployments.) Given that assumption and the shipbuilding schedules in the Navy’s long-term plan, crew rotation on large surface combatants would not begin for about 10 years. The Navy would employ Sea Swap on DDG-1000 class destroyers starting in 2018. (Because that class of ships is limited to seven, CBO assumed that crew rotation would begin once all of the ships had been commissioned.)¹⁷ The first CG(X)s would employ crew rotation beginning in 2021, and the first DDG(X)s starting in 2030.

Overall, using the Sea Swap approach on those ships would enable the Navy to provide much more overseas presence with large surface combatants that its requirement calls for (see the bottom panel of Figure 4 on page 11). Today, the Navy maintains an average of about

23 large surface combatants overseas at any given time, and it says that it requires at least 21 over the long term. Under the widespread use of crew rotation, that number would rise to 25 ships by 2020 (when 6 destroyers would be using Sea Swap) and to 26 ships by 2040 (when 57 cruisers and destroyers would have rotating crews).

CBO did not attempt to estimate in detail the potential costs or savings to the Navy of using the Sea Swap concept on a widespread basis. Such estimates are uncertain and would be determined by, among other things, the cost of fuel 20 to 40 years in the future and the potential schedule of ship deployments. The Navy has told CBO that existing shore personnel can support at least one crew rotation at any given time and, therefore, that using Sea Swap does not entail any additional personnel costs.¹⁸ But if 57 ships were using crew rotation, then presumably 18 to 20 exchanges would be taking place every six months involving crews from San Diego or

17. CBO assumed that one of the seven planned DDG-1000s would be based in Japan with a single crew. The others would be divided into two groups of three and would use rotational crewing as outlined above.

18. Department of Defense information paper furnished to the Congressional Budget Office on April 2, 2007.

Norfolk (the main U.S. naval bases for the Pacific and Atlantic Fleets). Depending on ship schedules, two or three crew exchanges could occur in a given month, which would require as many as 42 additional personnel at each of those bases to serve as caretaker crews for the ships left vacant during the exchanges. However, the costs of those additional personnel would be offset by the savings on fuel from making fewer transoceanic trips.

Effects of Widespread Crew Rotation with a Smaller Fleet

In previous analyses, CBO concluded that implementing the Navy's current long-term shipbuilding plan would probably be more expensive than the Navy anticipates.¹⁹ Building a fleet of 313 ships would cost an average of \$17.3 billion per year (in 2008 dollars) between 2008 and 2037, the Navy estimates. CBO estimates that shipbuilding costs would average \$22.7 billion a year over that period. Both figures are significantly higher than the annual average of \$11.5 billion that the Navy has spent on ship programs since 2002.

Over the past 17 years, whenever budget constraints have forced the Navy to scale back its fleet, it has reduced the major components of the fleet (aircraft carriers, submarines, surface combatants, and amphibious ships) by roughly equal proportions. If funding constraints prevented the Navy from meeting its 313-ship goal and the service responded with across-the-board cuts, it could end up with a fleet of about 210 battle-force ships by 2040—including 54 large surface combatants and 40 LCSs (reductions of about 40 percent and 30 percent, respectively, from currently planned levels).²⁰ Such a fiscally constrained fleet would require annual spending for shipbuilding of \$14.5 billion per year, CBO estimates—

about the same as the amount the Navy has requested for 2008. The surface combatant force would consist of five DDG-1000 Zumwalt class destroyers rather than seven, 11 CG(X) cruisers instead of 19, and 38 anti-air guided missile destroyers (intended primarily for fleet air defense) rather than 62 (see Figure 7).

Under the Navy's current plan to use single crews on large surface combatants and rotating crews on LCSs, that smaller surface combatant force would not meet the Navy's requirements for forward presence (see the top panel of Figure 8). By the late 2020s, Arleigh Burke class destroyers would be retiring in greater numbers than they were being replaced. With the fiscally constrained fleet described above, the Navy would be able to keep only 16 large surface combatants forward deployed in 2040, compared with the requirement of 21, and only 18 littoral combat ships, compared with the requirement of 23.

If such a scenario unfolded, the Navy could close the gaps in forward presence by using a blue/gold dual-crew rotation—similar to that planned for guided missile submarines—on some of its new large surface combatants and LCSs. With that crewing system (shown in Figure 1 on page 3), the Navy expects that its four SSGNs will be enough to keep two submarines forward deployed at all times and a third forward deployed almost five months of the year. That approach results in a rotation ratio of 1.67 to 1, compared with 5 to 1 for single-crewed surface combatants or 3 to 1 for LCSs under the 4/3/1 concept.

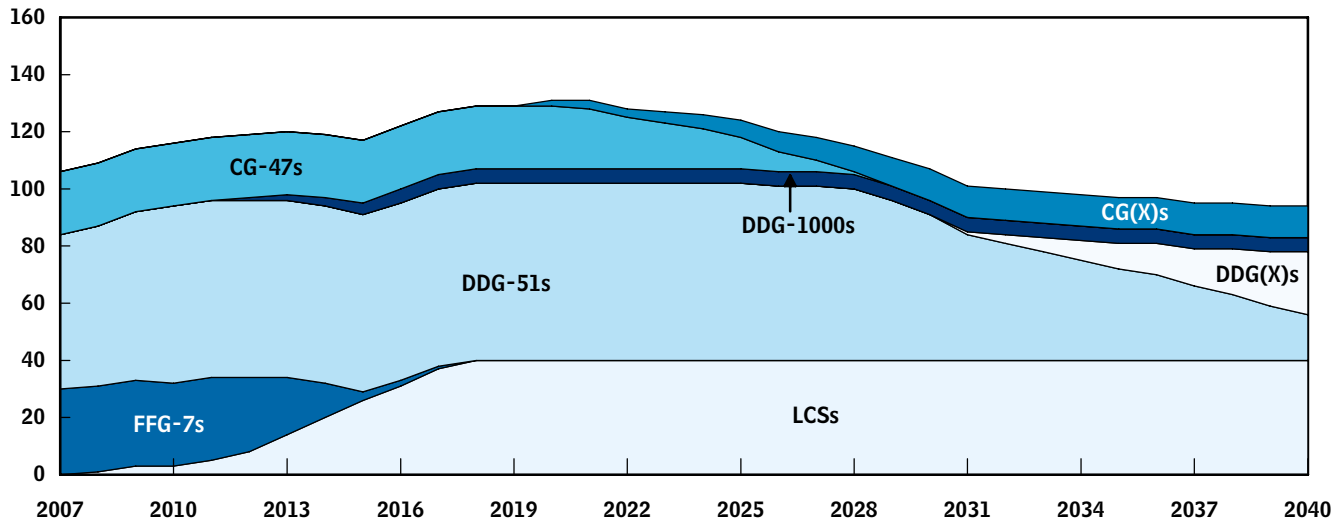
If nine of the Navy's CG(X)s and three of its DDG(X)s employed a blue/gold system and the rest used single crews, the 54 large surface combatants in the fiscally constrained fleet would be able to keep at least 21 forward deployed at any given time through 2040 (see the bottom panel of Figure 8). That result includes seven single-crewed cruisers and destroyers based in Japan, a number that CBO assumed would remain constant through 2040. In addition, if 23 of the 40 LCSs in the smaller fleet used a blue/gold crewing system, they would be able to maintain an overseas presence of 23 ships, including those based in Japan. That approach would have the advantage of meeting the Navy's presence requirement for LCSs in 2018, two years earlier than under the Navy's plan. It should be noted, however, that a fleet with fewer ships could be less flexible in responding to crises and less able to recover from losses suffered in combat.

19. See the statement of J. Michael Gilmore, Assistant Director for National Security, and Eric J. Labs, Senior Analyst, Congressional Budget Office, *The Navy's 2008 Shipbuilding Plan and Key Ship Programs*, before the Subcommittee on Seapower and Expeditionary Forces of the House Armed Services Committee, July 24, 2007. That testimony updated the analysis in Congressional Budget Office, *Options for the Navy's Future Fleet* (May 2006).

20. For a detailed discussion of alternatives for smaller fleets, see Congressional Budget Office, *Options for the Navy's Future Fleet*, Chapter 3. That analysis looked at five options for the Navy if total spending for ship and aircraft operations and procurement was constrained to \$43 billion per year. (For example, money saved on aircraft procurement and operating costs could be applied to ship procurement.) The fiscally constrained fleet discussed here is the same as Alternative 1 in that report.

Figure 7.

The Navy’s Inventory of Surface Combatants Under a Fiscally Constrained Fleet



Source: Congressional Budget Office.

Note: CG-47s = Ticonderoga class cruisers; CG(X)s = future guided missile cruisers; DDG-1000s = Zumwalt class guided missile destroyers; DDG-51s = Arleigh Burke class destroyers; DDG(X)s = future anti-air guided missile destroyers; FFG-7s = Oliver Hazard Perry class guided missile frigates; LCSs = littoral combat ships.

With an SSGN-type blue/gold crewing scheme, there would be twice as many crews as ships, and nondeploying crews would conduct their training onshore rather than on ships. Whether such a concept would work with large surface combatants and LCSs is difficult to evaluate because it has not been tried. Other than the limited Sea Swap experiments, the Navy has no experience with rotational crewing on large surface combatants. Adapting the SSGN crewing concept to cruisers and destroyers would be a much more ambitious project that would require planning and experimentation as well as investment in training and maintenance facilities. (Issues related to the cost of such a change are addressed in the next section.)

Previous CBO analyses concluded that probably the most important factor in making a blue/gold crewing system work—especially one as ambitious as the SSGN model—is rigorous configuration control in the design and construction of the class of ships, including some redundancy in key systems.²¹ Neither the CG(X) future cruisers nor the DDG(X) future destroyers have been designed yet. The Navy is currently studying what capabilities the CG(X) should have; after that analysis is complete, the Navy will begin designing the ship, with the first one due to be authorized in 2011. The DDG(X) is even further

off, with the first ship expected to be authorized in 2022. Thus, the Navy can still design its future large surface combatants to operate with dual crews, should that prove necessary in the 2020s. Other elements needed to support a blue/gold system, such as more-extensive training and maintenance infrastructure, could also be developed by the 2020s.

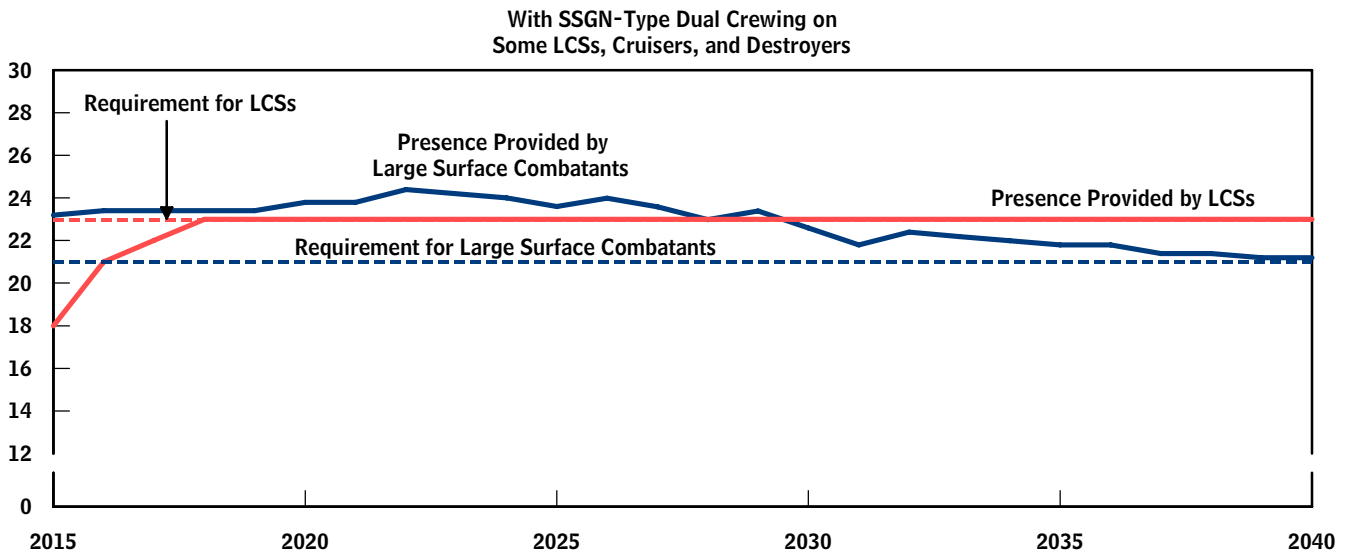
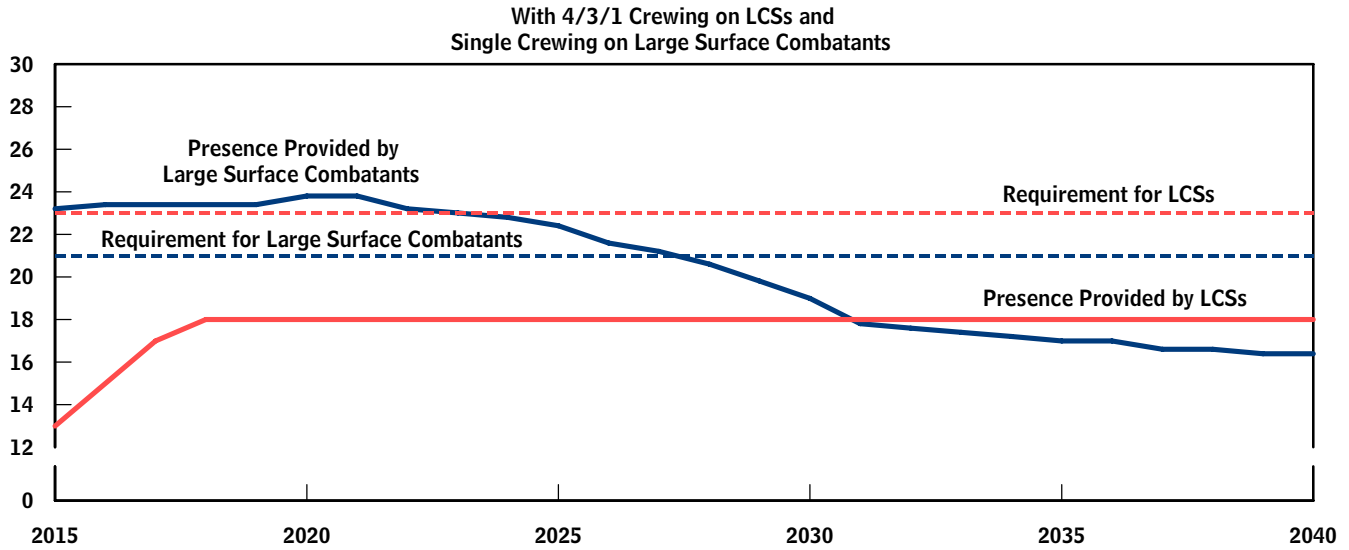
The Navy has not yet commissioned the first LCSs, so it has no practical experience of how a blue/gold or 4/3/1 crewing concept would work for that class. In addition, the Navy has officially told CBO that it does not yet know how many LCSs will be based in Japan and how many will be assigned to the Atlantic or Pacific Fleet. The

21. See Congressional Budget Office, *Increasing the Mission Capability of the Attack Submarine Force* (March 2002), and *Transforming the Navy's Surface Combatant Force* (March 2003). During the decade or more that it can take to build a class of ships, electronics and other systems are frequently updated, which means that the last ships in a production run may have very different systems than their earlier counterparts. Configuration controls would be intended to ensure that the ships of a class were as similar to each other as possible so that they all resembled the onshore training systems used by nondeploying crews and so that individual crew members could fill in on a ship other than their own, if necessary, with minimal retraining.

Figure 8.

Forward Presence Provided by Surface Combatants Under a Fiscally Constrained Fleet

(Number of ships forward deployed)



Source: Congressional Budget Office.

Notes: These scenarios assume that funding constraints cause the Navy to reduce its fleet to about 210 ships over the long term, rather than the 313 ships envisioned in its latest shipbuilding plan.

Under 4/3/1 crewing, four crews would operate three ships, one of which would be forward deployed at any given time.

LCSs = littoral combat ships; SSGN = guided missile submarine.

final determination of those issues will affect what form of, and to what extent, alternative crewing methods would be used for the LCS if the Navy could not afford to buy all 55 planned ships of that class. The service's current experience with rotational crewing on small ships, such as coastal patrol ships and mine-countermeasures ships, suggests that it would be possible to adapt dual crewing to the LCSs.

Alternatively, the Navy could choose a more mixed solution to address shortfalls in forward presence with a fiscally constrained fleet. For example, if the Navy based 8 large surface combatants in Japan (up from 7 today) and used the Sea Swap three-crew version of crew rotation on all 46 remaining cruisers and destroyers, it could keep 21 large surface combatants forward deployed at a time. However, it is not clear that employing Sea Swap on 46 ships is a lesser challenge than adapting a blue/gold crewing system to 12 cruisers and destroyers. Similarly, if the Navy based 15 littoral combat ships overseas and used its 4/3/1 crewing concept on the other 25, it could maintain a forward presence of 23 ships. Finding countries in various regions willing to base 15 LCSs, however, would require negotiating with their governments, with no certainty about the outcome.

Cost Implications of Rotational Crewing

The costs or savings from rotational crewing—both one-time and recurring costs or savings—vary depending on the particular crewing concept. The type of rotational crewing with the highest relative costs (compared with those of the same or a similar ship operated by a single crew) is the blue/gold system for ballistic missile and guided missile submarines.

One-time costs for that form of dual crewing include designing and building the ships with rigorous configuration controls to facilitate the use of alternating crews and with more-redundant and more-rugged systems to withstand the longer times that dual-crewed ships spend at sea. Other one-time costs include more-extensive training and maintenance infrastructures. For example, the Navy keeps a larger supply of spare parts on hand (valued at more than \$1 billion) for dual-crewed Trident submarines than for single-crewed attack submarines (whose inventory is valued at less than \$200 million). The dedicated Trident training and maintenance facilities themselves would cost a total of about \$1 billion to replace at both Trident submarine bases.

The Trident blue/gold model also incurs higher recurring costs for routine operations. A Trident submarine costs about one-third more to operate than a single-crewed attack submarine. That difference mainly occurs because of the higher personnel costs of having two crews per submarine, but part of the difference reflects higher maintenance costs for Trident submarines. (Excluding personnel costs, operating costs for a dual-crewed ballistic missile submarine are \$46 million per year, compared with \$32 million per year for a single-crewed attack submarine.) Some of the difference may also be attributable to the different sizes of the ships: SSBNs weigh more than 18,000 tons, whereas Los Angeles class attack submarines weigh about 7,000 tons.

The Sea Swap crew rotation experiments, by contrast, involved no one-time start-up costs and produced savings in operating costs, according to the Navy's report on the experiments. Having fewer transoceanic trips saved fuel costs, although those savings were partially offset by the costs of flying the crews overseas and putting them up in hotels during crew exchanges, among other expenses. Overall, the Navy's analysis concluded that the 18-month Sea Swap deployment of the *Gonzalez* cost about \$10 million less than three 6-month deployments of single-crewed Arleigh Burke class destroyers. As noted above, using Sea Swap on all of the Navy's new surface combatants (a total of 57 ships by 2040) might require increasing the number of shore-based personnel in Norfolk and San Diego by 42 people each to facilitate crew exchanges. The costs of those additional personnel, however, would be more than offset by the savings generated from the widespread use of Sea Swap under the Navy's 313-ship plan.

Employing an SSGN-type blue/gold crewing system on large surface combatants and littoral combat ships under the fiscally constrained fleet could entail substantial start-up costs as well as higher operating costs for those ships compared with single-crewed versions. The Trident experience suggests that the Navy would need to build dedicated training and maintenance facilities and keep a large supply of spare parts readily available. Designing the ships from the outset specifically to use a blue/gold system would also be necessary.

With respect to future large surface combatants, constructing a single class of 12 ships for a blue/gold system—rather than 9 ships of one class and 3 of another—would reduce the need to build separate training

facilities and spare-parts pools.²² Thus, in a fiscally constrained fleet, rather than purchase 11 CG(X)s, the Navy could buy 12 and not plan to base any of them in Japan. It could use dual crews on the entire class, which would eliminate the need for dual crews on DDG(X)s. The same concept would apply to the LCSs; at least 23 of those ships would need to be of the same design. (The Navy is currently building two versions of the LCS and is not expected to settle on a single design until 2010.)

With those changes, total operating costs for large surface combatants and littoral combat ships in the fiscally

constrained fleet would still be less than under the Navy's plan. The 88 large surface combatants and 55 LCSs envisioned in the Navy's plan would require 88 and 73 crews, respectively. The 54 large surface combatants and 40 LCSs in the fiscally constrained fleet would require 66 and 63 crews, respectively. The dual-crewed ships would have higher maintenance costs than single-crewed versions. But whatever costs were associated with dual-crew systems would be exceeded by the savings from not buying 34 large surface combatants and 15 LCSs included in the Navy's plan.²³

22. The Trident submarine fleet consists of 14 ships, so a class of 12 dual-crewed surface combatants would not be unprecedented in terms of the size of the force.

23. For more details about the costs of specific ship classes, see Congressional Budget Office, *Options for the Navy's Future Fleet*.