Some Potential Technology Implications of the Navy’s Future

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Paper prepared for the Committee on Naval Engineering in the 21st Century Transportation Research Board

2011
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Paper for Committee on Naval Engineering in the 21st Century, Transportation Research Board, National Academy of Sciences
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April 30, 2010

Introduction
As requested, this paper briefly surveys some potential technology implications of the Navy’s future. These implications arise from:

• the Navy’s future operating environment,
• the kinds of operations the Navy may conduct in coming years, and
• the Navy’s prospective future resource situation.

Each of these is discussed below. The collection of issues discussed in this paper is not intended to be comprehensive, and the issues are not presented in any particular order.

Potential Implications Arising From Future Operating Environment
Specific features of the Navy’s future operating environment that may have technology implications for the Navy include but are not necessarily limited to the following:

• adversaries with anti-access weapons;
• adversaries with cyberwarfare and ASAT capabilities;
• adversaries with nuclear weapons;
• terrorist and irregular warfare threats to forward-deployed Navy ships;
• limited or uncertain access to, and vulnerability of, overseas land bases;
• diminishment of Arctic sea ice; and
• policymaker focus on energy use and alternative energy.2

Adversaries With Anti-Access Weapons
The Department of Defense (DOD) and other observers believe that a principal feature of the future operating environment for U.S. military forces, including the Navy, will be the possession by potential U.S. adversaries of capable anti-access weapons. DOD’s final report on the 2010 Quadrennial Defense Review (QDR) identifies deterring and defeating aggression in anti-access

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environments as one of six key mission areas, and devotes substantial discussion to the subject.\(^3\) For the U.S. Navy, countries of particular concern in connection with anti-access weapons include China and Iran.

**China**

DOD and other observers believe that an important goal of China’s military modernization effort is to field an anti-access force capable of deterring U.S. intervention in a conflict in the Western Pacific over Taiwan or some other issue, or failing that, delaying the arrival or reducing the effectiveness of responding U.S. military forces, particularly naval and air forces. Key elements of China’s emerging maritime anti-access force include, among other things:

- land-based theater-range ballistic missiles (TBMs), including anti-ship ballistic missiles (ASBMs) capable of hitting moving ships at sea,
- land-attack cruise missiles (LACMs),
- land-based surface-to-air missiles (SAMs),
- land-based aircraft (including some modern Russian-made fighters) armed with anti-ship cruise missiles (ASCMs),
- modern attack submarines (mostly non-nuclear-powered, but some nuclear-powered) armed with ASCMs (including highly capable models such as the Russian-made SS-N-27 Sizzler) and torpedoes (including wake-homing models),
- modern surface combatants armed with ASCMs (including highly capable models such as the Russian made SS-N-22 Sunburn),
- naval mines (including modern models), and
- supporting surveillance and targeting systems.\(^4\)

While most of the above types of platforms and weapons are familiar to the U.S. Navy, the ASBM is a new development – the U.S. Navy has not previously faced a threat from highly accurate ballistic missiles capable of hitting moving ships at sea. On March 23, 2010, Admiral Robert Willard, the Commander of U.S. Pacific Command, testified that China is “developing and testing a conventional anti-ship ballistic missile based on the DF-21/CSS-5 MRBM designed specifically to target aircraft carriers.”\(^5\) Although DOD has previously discussed China’s ASBM development effort,\(^6\) some observers believe Willard’s statement to be the first time that a DOD official has stated publicly that China’s ASBM is not only in development, but has reached the testing stage.\(^7\) Most observers believe that U.S. aircraft carriers would be a primary target of Chinese ASBMs.

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Observers have expressed strong concern about China’s ASBM development effort, in part because the maneuvering reentry vehicles (MaRVs) on the ASBMs would be more difficult to intercept than non-maneuvering ballistic missile reentry vehicles. Some observers, assessing the potential impact of ASBMs on the military balance in the Western Pacific, have characterized the weapon as a potential “game changer.”

Although China’s ASBM development effort has attracted much discussion, other elements of China’s emerging anti-access force – such as its modern submarines, highly-capable ASCMs, wake-homing torpedoes, and mines – can also pose significant challenges to U.S. Navy forces. Prior to the recent focus on China’s ASBMs, the modernization of China’s submarine force and China’s acquisition of highly capable Russian-made ASCMs were subjects of substantial discussion.

To be fully effective, China’s anti-access weapons, particularly those with longer ranges, would need to be supported by maritime surveillance and targeting systems. China is reportedly deploying such systems.

**Iran**

Observers view Iran’s anti-access development effort as aimed at giving Iran an ability in a crisis to impede the ability of U.S. naval forces to enter the Persian Gulf. Iran’s maritime anti-access systems include shore-based ASCMs and SAMs, torpedoes, mines, three non-nuclear-powered submarines, mini-submarines, surface combatants, and small, fast surface craft sometimes called “swarm boats.” Iran used mines in the Persian Gulf in the 1980s during the Iran-Iraq war, in recent years has conducted annual exercises with swarm boats and other assets, and has operated swarm boats in close proximity to U.S. Navy ships operating in the Gulf.

**Potential Technology Implications**

Effectively countering ASBMs and advanced ASCMs may require one or more of the following things, among others:

- shipboard radars that are more capable than Aegis system’s current SPY-1 radar;
- improved networking technologies, including technologies for linking ships with off-board sensors;
- high-power directed energy weapons (DEWs), particularly lasers;
- an improved terminal-phase (endoatmospheric) ballistic missile defense (BMD) interceptor to augment the SM-3 exoatmospheric BMD interceptor; and
- soft-kill options for countering ASBMs; and
- ships with reduced radar cross sections and infrared signatures.

Regarding the first item above (shipboard radars), Navy plans call for starting procurement in FY2016 of a new version of the DDG-51 destroyer, called the Flight III version, that is to be

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9 See, for example, Andrew S. Erickson, “Eyes in the Sky,” *U.S. Naval Institute Proceedings*, April 2010: 36-41.

10 For an article discussing the exercise held in 2010, see Nasser, Karimi, “Iran Begins Strait of Hormuz War Games,” *NavyTimes.com (Associated Press)*, April 22, 1010.

equipped with a scaled-down version of the new Air and Missile Defense Radar (AMDR) that was to be carried by the now-cancelled CG(X) cruiser. Installing this radar on the DDG-51 will require modifying the DDG-51 design to include additional electrical-generating and cooling capacity.

Regarding the second item above (networking technologies), Navy officials have stated that they no longer believe the large version of the AMDR that was to be carried by the CG(X) will be necessary because the Navy has concluded that it will be able to augment data collected by shipboard radars with data collected by off-board sensors.12

Regarding the third item above (high-power DEWs), the marginal cost for the Navy to add interceptors and their launch tubes to the fleet could be considerably greater than the marginal cost for an adversary to field additional ASBMs and ASCMs. If so, the current U.S. approach to AAW and BMD operations could become difficult to afford in a competition against a wealthy and determined adversary. High-powered DEWs, particularly free-electron lasers (FELs) or solid-state lasers (SSLs), offer the potential for reversing such a marginal cost situation by dramatically lowering the cost per shot against an ASBM or ASCM. Accommodating an FEL might require a large interior space on the ship, and supporting a high-power FEL or SSL would require a significant amount of shipboard power – an amount that could require equipping the ship with an integrated electric drive system.13

Regarding the fourth item above (terminal-phase BMD), Navy plans call for replacing the Navy’s current terminal-phase BMD interceptor – the SM-2 Block IV missile – with a new and more-capable terminal-phase BMD interceptor around 2018, as part of the planned 5.2 version of the Aegis BMD system.

Regarding the fifth item above (soft-kill options for ASBMs), Navy leaders have spoken of the need for examining an enemy’s entire kill chain for conducting a cruise or ballistic missile attack against a Navy ship, with an eye toward finding vulnerabilities in that kill chain and developing various options, including non-kinetic options, for exploiting those vulnerabilities. Soft-kill options for countering ASBMs might include measures for confusing the ASBMs’ terminal-guidance sensors.

Regarding the sixth item above (ships with reduced radar cross sections and infrared signatures), a reduced radar cross section and reduced infrared signature could be of value in defeating ASBM

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and ASCM attacks, particularly in terms of defeating the terminal homing sensors in ASBM and ASCMs. Some Navy ships appear to incorporate at least measures for achieving reduced radar cross sections – the DDG-51 can be viewed as an earlier example, the LPD-17 design and the two LCS designs as more recent examples. The DDG-1000 design appears to incorporate a high degree of such measures.

Effectively countering modern submarines may require ships with reduced acoustic signatures, as well as technologies for achieving a distributed, sensor-intensive (as opposed to platform-intensive) approach to ASW. Navy officials in 2004-2005 spoke of their plans for achieving such an architecture. Such an approach might involve the use of networked sensor fields, unmanned vehicles, and standoff weapons. Implementing such an approach to ASW reportedly would require overcoming some technical challenges, particularly for linking together large numbers of distributed sensors, some of which might be sonobuoys as small as soda cans.

Effectively countering wake-homing torpedoes could require completing development work on the anti-torpedo torpedo (ATT) and putting the weapon into procurement. Another question is whether there are any soft-kill options that might be pursued for countering wake homers (other than perhaps ship maneuvers). Technologies for reducing or disrupting a ship’s wake, if any are available, might be one possibility.

Although a number of new mine-countermeasures (MCM) systems are completing development and entering service with the Navy, MCM remains a frequently painstaking, time-consuming task, and MCM in very shallow waters and the surf zone remains a particular challenge. New technologies that would permit MCM operations to proceed more quickly, particularly in very shallow waters and the surf zone, could be of particular operational value. Improved technologies for reducing the magnetic signatures of Navy ships may also be of value in countering mines.

Efforts to counter anti-access weapons notwithstanding, the growing numbers and capabilities of these weapons underscore the importance of continuing to build Navy ships with robust damage-control features. More cost-effective new technologies for deflecting or absorbing warhead detonations, for suppressing shipboard fires, and for controlling flooding, could be important, particularly on ships with reduced-size crews.

Some observers, such as the Center for Strategic and Budgetary Assessments (CSBA), argue that U.S. military forces, including the Navy, should be able to operate with effectiveness outside the ranges of certain anti-access weapons. The Navy has long sought to be able to conduct

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16 CSBA also believes that the Navy must be able to penetrate an enemy’s anti-access capabilities to perform its missions – that to succeed against an enemy fielding an anti-access capability, the Navy must, as part of a joint effort, be able to roll back or neutralize that capability, and that this would ultimately require operating inside the range of the adversary’s anti-access weapons. (Source: Email exchange with Andrew Krepinevich of CSBA, April 21, 2010.) See Andrew F. Krepinevich, Why AirSea Battle?, Center for Strategic and Budgetary Assessments, Washington, 2010, 40 pp.; Robert O. Work, The US Navy[:] Charting a Course for Tomorrow’s Fleet, Washington, Center for Strategic and Budgetary Assessments, 2008, 90 pp.; Andrew Krepinevich, Robert Martinage, and Robert Work, The Challenges to US National Security, Washington, Center for Strategic and Budgetary Assessments, 2008, 59 pp.; Thomas P. Ehrhard and Robert O. Work, Range, Persistence, Stealth, and Networking: The Case for a Carrier-Based Unmanned Combat
operations from outside the range of coastal defense systems. The new development here is that the required stand-off ranges might now be much greater – hundreds of miles, or perhaps a thousand miles or more, depending on the operating ranges of anti-access systems such as ASBMs and nuclear-powered attack submarines.

Potential technology implications of being able to operate outside the ranges of anti-access weapons capable of attacking targets hundreds of miles, or perhaps a thousand miles or more, from shore could include the following:

- developing and acquiring longer-ranged carrier based manned and unmanned aircraft, such as the Navy Unmanned Combat Aircraft System (N-UCAS);
- developing and acquiring longer-ranged weapons, including things such as electromagnetic rail guns and high-speed, long-range strike weapons to complement the subsonic Tomahawk cruise missile; and
- acquiring off-board sensors and networks for conducting surveillance, targeting and damage assessment at very long ranges from the fleet.

Adversaries With Cyberwarfare and ASAT Capabilities

Cyberspace has emerged in recent years as a critical operating domain for U.S. military forces, and is likely to become more important in coming years as both U.S. military use of computer networks and the cyberwarfare capabilities of potential U.S. adversaries continue to grow. DOD’s final report on the 2010 QDR identifies operating effectively in cyberspace as one of six key mission areas, and devotes substantial discussion to the subject.17 The report states:

> Our assessments of conflict scenarios involving state adversaries pointed to the need for improved capabilities to counter threats in cyberspace—a global domain within the information environment that encompasses the interdependent networks of information technology infrastructures, including the Internet and telecommunication networks. Although it is a manmade domain, cyberspace is now as relevant a domain for DoD activities as the naturally occurring domains of land, sea, air, and space. There is no exaggerating our dependence on DoD’s information networks for command and control of our forces, the intelligence and logistics on which they depend, and the weapons technologies we develop and field. In the 21st century, modern armed forces simply cannot conduct high-tempo, effective operations without resilient, reliable information and communication networks and assured access to cyberspace.18

On January 29, 2010, the Navy officially established U.S. Fleet Cyber Command (FCC, aka FLT CYBERCOM), and, as an associated action, also recommissioned the U.S. 10th Fleet. The two organizations are both headquartered at Fort Meade, MD, and are headed by the same vice admiral.19 The Navy earlier that same week stood up another organization, Navy Cyber Forces (CYBERFOR), at Joint Expeditionary Base, Little Creek-Fort Story in Norfolk, VA.20

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In addition to expressing concern over potential adversary capabilities in cyberwarfare, observers have also expressed concern about the current or potential anti-satellite (ASAT) capabilities of potential U.S. adversaries such as China. These concerns were reinforced by China’s successful January 2007 test of an ASAT weapon against an aging Chinese satellite. Given the U.S. military dependence on computers and satellites, computer network attacks and ASAT attacks have the potential for significantly degrading the capabilities of U.S. military forces, including the Navy.

**Potential Technology Implications**

The emergence of cyberspace as a critical operating domain for U.S. military forces raises a question as to what kinds of defensive and offensive cyberwarfare capabilities U.S. Navy ships should be equipped with that would be in addition to Navy and DOD cyberwarfare capabilities resident at centralized locations ashore. More generally, the potential for computer network attacks and ASAT attacks suggests a need for measures to ensure the fleet’s resilience in the face of such attacks. Such measures could include redundancy in computers and networking links, an ability to rapidly reconstitute computer networks and satellite capabilities, and an ability for ships to continue operating effectively in a stand-alone mode when support from off-board systems is reduced or not available due to attacks on computer networks or satellites.

**Adversaries With Nuclear Weapons**

Observers have identified nuclear-armed states and the potential for proliferation of nuclear weapons to non-state actors as another key feature of the future operating environment. DOD’s final report on the 2010 QDR mentions the issue at multiple points and states that:

> Because of their extreme lethality and long-term effects, nuclear weapons are a source of special concern, both for the United States and for its allies and partners in regions where adversary states possess or seek such weapons. If regional adversaries succeed in fielding even small arsenals of nuclear weapons, the security dynamics of key regions could be severely complicated. Even as we strive to prevent proliferation, we must take steps to hedge against its possibility. Accordingly, DoD will continue to enhance U.S. capabilities for deterring and preventing the use of nuclear weapons and their means of delivery.\(^\text{21}\)

The report also states: “The range of plausible future challenges is significant; DoD requirements to deal with such challenges include the following:... Defeating aggression by adversary states, including states armed with advanced anti-access capabilities and/or nuclear weapons...”\(^\text{22}\)

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22 Department of Defense, *Quadrennial Defense Review Report*, February 2010, p. 15. The Center for Strategic and Budgetary Assessments (CSBA) similarly states that:

> Although the United States remains the world’s leading power, it finds itself confronting three major, enduring, and very different strategic challenges:

> - Containing and if possible defeating violent Islamist terrorists...
> - Hedging against the rise of a hostile China... and
> - Preparing for a world where nuclear weapons have spread to a number of additional states and possibly to non-state actors, which would increase the likelihood of a direct conflict with a nuclear-armed opponent, the collapse of a nuclear-weapon state, or a nuclear terrorist attack.

Potential Technology Implications

For the U.S. Navy, the possession by adversaries of nuclear weapons could raise the possibility of nuclear weapons being used during a conflict against or in the vicinity of U.S. Navy ships. This possibility was a concern during the Cold War, but receded during the initial years of the post-Cold War era. Renewed concern about this possibility could renew or underscore a requirement for building U.S. Navy ships with features for withstanding the effects of nuclear weapon, including overpressure, thermal effects, electromagnetic pulse (EMP), and contamination by radioactive fallout.

The Navy’s most-numerous surface combatant, the Arleigh Burke (DDG-51) class destroyer, was designed during the Cold War and includes such features. The ship, for example, can withstand a certain amount of overpressure, and incorporates a protected interior area, or citadel, in which crew members can seek temporary shelter. Navy ships have also been equipped with washdown systems that can wash away radioactive fallout. The Navy in March 2010 reportedly reactivated its EMP Assessment Group after a roughly 10-year period of reduced activity to develop new strategies for protecting the fleet against EMP.23

Terrorist and Irregular Warfare Threats to Forward-Deployed Navy Ships

Navy concerns over terrorist and irregular threats to forward-deployed Navy ships were significantly heightened by the October 12, 2000, boat-bomb attack on the Navy destroyer Cole (DDG-67) in the harbor of Aden, Yemen. They were further reinforced by the September 11, 2001, terrorist attacks in New York and Washington, the October 6, 2002, boat-bomb attack on the French oil tanker Limburg, the August 19, 2005, rocket attack against the Navy amphibious ships Ashland (LSD-48) and Kearsarge (LHD-3) in the port of Aqaba, Jordan, and the Hezbollah organization’s July 14, 2006, attack on the Israeli corvette Hanit using shore-based ASCMs (reportedly Chinese-made C-802s).24

In January 2010, it was reported that terrorists or would-be terrorists in the Middle East were asking online readers for help in collecting information on the names, missions, movements, and other characteristics of U.S. Navy ships, apparently to support potential attacks on those ships.25 On March 10, 2010, the Office of Naval Intelligence (ONI) reposted on its web site a March 9, 2010, advisory from the U.S. Maritime Administration (MARAD) warning ships operating in waters near Yemen about possible terrorist attacks.26

24 The Navy has cited proliferation of ASCMs, including proliferation to non-state actors as Hezbollah, as one reason for its decision to alter its destroyer-procurement plans by stopping procurement of DDG-1000 destroyers and restarting DDG-51 procurement. (Source: Transcript of spoken testimony by Vice Admiral Barry McCullough before the Seapower subcommittee of the House Armed Services Committee on July 31, 2008.)
26 The ONI posting, which was accessed on the Internet on April 16, 2010 at http://www.nmic.navy.mil/Intelligence_Community/piracy/pdf/special_advisory_20100310.pdf, stated:

To ensure maximum dissemination to the maritime industry and/or community, ONI invites your attention to the following US DOT MARAD advisory. Please note, this advisory is not piracy-specific. This advisory regards terrorism and is being disseminated in an effort to promote security for those operating within the maritime domain.

US DOT MARAD Advisory

Information suggests that al-Qaida remains interested in maritime attacks in the Bab-al-Mandeb Strait, Red Sea, and the Gulf of Aden along the coast of Yemen. Although it is unclear how they
Potential Technology Implications

A focus on terrorist and irregular warfare threats to forward-deployed Navy ships would suggest a need for continuing U.S. Navy initiatives begun after the attack on the Cole to develop improved means of defending Navy ships against such threats. This could include, in addition to technologies for defeating ASCMs, things such as:

- sensors, barriers, unmanned vehicles, and lethal and non-lethal weapons for countering small boats, mini-submarines, and swimmers;
- sensors and weapons for cost-effectively countering rockets and mortars; and
- topside equipment that can withstand attacks by rockets and mortars.  

Limited or Uncertain Access To, and Vulnerability of, Overseas Land Bases

Prior to the current deployment of large numbers of U.S. military forces to Iraq, Afghanistan, and neighboring countries, advocates of naval forces argued that sea-based forces in coming years could become more important for defending U.S. interests because U.S. access to overseas land bases in coming years could become more limited or uncertain. As U.S. forces eventually withdraw from Iraq, Afghanistan, and neighboring countries, this argument may reemerge.

Advocates of naval forces have also argued that land bases in coming years could become increasingly vulnerable to attack by weapons such as theater-range ballistic missiles. The vulnerability of land bases to attack was a principal reason for Marine Corps and Navy interest in

would proceed, it may be similar in nature to the attacks against the USS COLE in October 2000 and the M/V LIMBURG in October 2002 where a small to mid-size boat laden with explosives was detonated. Other more sophisticated methods of attack could include missiles or projectiles.

Although the time and location of such an attack are unknown, ships in the Red Sea, Bab-al-Mandeb Strait, and the Gulf of Aden along the coast of Yemen are at the greatest risk of becoming targets of such an attack.

All vessels transiting the waters in the vicinity of Yemen are urged to operate at a heightened state of readiness, maintain strict 24-hour visual and radar watches, and regularly report their position, course and speed to the UKMTO.

Vessels are at greatest risk in areas of restricted maneuverability, and while in/near port or at anchor. Merchant vessels are requested to report any suspicious activity to the UKMTO Dubai.

The original MARAD advisory (2010-03 of March 9, 2010) is available on the Internet at: [http://www.marad.dot.gov/news_room_landing_page/maritime_advisories/advisory/advisory2010-03.htm].


building a new squadron of next-generation maritime prepositioning ships called the Maritime Prepositioning Force of the Future, or MPF(F). The MPF(F) squadron was to enable a new concept for operating from maritime prepositioning ships that would involve at-sea arrival and assembly of Marine forces and the launching of Marine operations ashore directly from the MPF(F) ships, without need for establishing or seizing control of an intermediary land base. Although the Navy’s proposed FY2011 budget sets aside the plan for building the MPF(F) squadron in favor of a less-expensive effort to build a few ships to augment the Navy’s existing maritime prepositioning ships, the concern over the vulnerability of land bases that led to the MPF(F) concept remains.

**Potential Technology Implications**

Limited or uncertain access to overseas bases or the vulnerability of such bases to attack might lead policymakers to view naval forces as a more important for defending U.S. interests, but it could also have some technology implications for the Navy, because the Navy today makes use of overseas facilities to support its forward-deployed operations. Reducing the Navy’s reliance on these facilities for obtaining fuel and supplies, and for repairing battle damage, might entail things such as:

- ships with increased on-board storage for fuel and supplies;
- ships that use fuel more efficiently (which could include equipping ships with integrated electric drive technology);
- ships with smaller crews (and therefore less need for food and other personnel-related consumables);
- nuclear power not just for aircraft carriers and submarines, but for other ships as well; and
- ships with greater survivability or more capability to repair their own battle damage at sea.

**Diminishment of Arctic Sea Ice**

The diminishment of Arctic sea ice is leading to increased human activities in the Arctic, and is opening up a potential new operating area for Navy and Coast Guard surface ships. On January 12, 2009, the George W. Bush Administration released a presidential directive establishing a new U.S. policy for the Arctic region. The directive, dated January 9, 2009, was issued as National Security Presidential Directive 66/Homeland Security Presidential Directive 25 (NSPD 66/HSPD 25). The directive states, among other things, that U.S. national security interests in the Arctic include “such matters as missile defense and early warning; deployment of sea and air systems for strategic sealift, strategic deterrence, maritime presence, and maritime security operations; and ensuring freedom of navigation and overflight.”

DOD’s final report on the 2010 QDR states:

> The effect of changing climate on the Department’s operating environment is evident in the maritime commons of the Arctic. The opening of the Arctic waters in the decades ahead[,] which will permit seasonal commerce and transit[,] presents a unique opportunity to work collaboratively in multilateral forums to promote a balanced approach to improving human and environmental security in the region. In that effort, DoD must work with the Coast Guard and the Department of Homeland Security to address gaps in Arctic communications, domain awareness, search and rescue, and environmental observation and forecasting capabilities to support both current and future

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28 NSPD 66/HSPD 25, Section III B.

The report also states:

The Department of Defense and its interagency partners must be able to more comprehensively monitor the air, land, maritime, space, and cyber domains for potential direct threats to the United States. Such monitoring provides the U.S. homeland with an extended, layered in depth defense. This effort includes enhanced coordination with Canada for the defense of North America as well as assisting Mexico and Caribbean partners in developing air and maritime domain awareness capacities. Special attention is required to develop domain awareness tools for the Arctic approaches as well. In coordination with domestic and international partners, DoD will explore technologies that have the potential to detect, track, and identify threats in these spheres to ensure that capabilities can be deployed to counter them in a timely fashion.  

The Navy and Coast Guard are exploring the potential implications that increased surface ship and aircraft operations in the Arctic may have for required numbers of ships and aircraft, ship and aircraft characteristics, new or enlarged Arctic bases, and supporting systems, such as navigation and communication systems. The Navy and Coast Guard have sponsored or participated in studies and conferences to explore these implications, the Coast Guard has deployed boats and aircraft into the region to better understand the implications of operating such units there, and Navy sailors in 2009 rode on Canadian Navy ships deploying to Arctic waters for similar reasons. The Coast Guard is coordinating with the North Atlantic and North Pacific coast guard forums to plan exercises in the Arctic in the summer of 2010.

The Navy examined issues and concerns relating to climate change at a May 15, 2009, meeting of the Chief of Naval Operations (CNO) Executive Board. Following this meeting, the Navy decided to establish a Navy group led by the Oceanographer of the Navy called Task Force Climate Change (TFCC), and to develop Navy roadmaps first for the Arctic, and later for more general responses to global climate change.

The Navy issued its Arctic roadmap on November 10, 2009. The document, which is dated October 2009 and co-sponsored by TFCC and the Oceanographer of the Navy, is intended to guide the service’s activities regarding the Arctic for the period FY2010-FY2014. The November 10 cover memo states that the document is to remain in effect until the completion of the report on the FY2014 Quadrennial Defense Review (QDR), at which time it will be reviewed and revised to incorporate guidance from that QDR.

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34 Memorandum for Distribution dated November 10, 2009, from Admiral J. W. Greenert, Vice Chief of Naval Operations, on the subject of the Navy Arctic Roadmap. The document was posted on *InsideDefense.com* (subscription required).
**Potential Technology Implications**

Potential technology implications, particularly for surface ships, of increased Navy operations in the Arctic include a potential need for one or more of the following:

- ice-strengthened hulls,
- underside features, including propellers, shafts, rudders, and intakes, that are designed for operations in ice-infested waters;
- topside systems capable of operating in extreme cold, as well as technologies for eliminating or resisting ice buildup on topside surfaces;
- fuels and lubricants formulated for operations in extreme cold;
- technologies to support search-and-rescue operations in ice-infested waters;
- communication and navigation systems for operations in high latitudes; and
- improved models and analytical tools for predicting environmental conditions in the Arctic.

**Policymaker Focus on Energy Use and Alternative Energy**

Policymakers, including Navy leaders, have begun to focus more strongly on energy use and alternative energy as a factor in evaluating DOD systems and operations. Their interest in the issue derives from a desire to reduce one or more of the following:

- fuel expenditures (to reduce pressures on service budgets),
- the fuel-related logistics tail for sustaining military operations in forward locations (to reduce budget pressures and also make forces more expeditionary and agile),
- DOD’s dependence on petroleum (so as to reduce DOD’s vulnerability to a disruption in oil imports), and
- DOD’s greenhouse gas emissions (to mitigate DOD’s contribution to climate change and perhaps set an example for other organizations) without reducing military effectiveness.\(^{36}\)

The Department of the Navy in recent years has instituted a range of initiatives to reduce ship and aircraft fuel use, make its installations more energy efficient, and increase the use of alternative energy. Many of the ship-related initiatives (including things such as stern flaps and hull coatings, to name just two frequently mentioned examples) are pursued under the Navy’s Energy

Conservation (ENCON) program, which is led by the Naval Sea Systems Command (NAVSEA).[^37]

On October 14, 2009, Secretary of the Navy Ray Mabus announced a series of five new energy-related goals for the Department of the Navy, stating:

What the Navy and Marine Corps are doing now is great, but I am here to encourage you and us to go farther – to dream what might be rather than to simply accept what is…. I’m here to commit the Navy and Marine Corps to meet bold and ambitious goals in energy. I mean this about being bold and ambitious, and so I’m going to announce five energy targets today that the department will meet over the course of the next decade.

First: we are going to change the way the Navy and Marine Corps awards contracts. The lifetime energy cost of a building or a system, and the fully burdened cost of fuel in powering those, will be a mandatory evaluation factor used when awarding contracts. We are going to hold industry contractually accountable for meeting energy targets and system efficiency requirements. And we’re going to do more. We will also use the overall energy efficiency and the energy footprint of a competing company as an additional factor in acquisition decisions. We want industry to partner with us and take steps not just to provide us with more energy efficient products, but to produce those products in energy efficient ways.

Second: The Navy will demonstrate in local operations by 2012 a Green Strike Group composed of nuclear vessels and ships powered by biofuel. And by 2016, we will sail that Strike Group as a Great Green Fleet composed of nuclear ships, surface combatants equipped with hybrid electric alternative power systems running biofuel, and aircraft flying only biofuels – and we will deploy it.

Third: the Department of the Navy will by 2015 reduce petroleum use in our 50,000 strong commercial fleet in half - by 50 percent. We’ll do this by replacing our current fleet, as they go out of service, with a new composite fleet of flex fuel vehicles, hybrid electric vehicles, and neighborhood electric vehicles. Moving to biofuels and electric vehicles will benefit the local communities where our bases are located and will spur adoption of similar vehicles in those neighborhoods.

Fourth: the Department of the Navy will by 2020 produce at least half of our shore-based energy requirements on our installations from alternative sources. We will boost our usage of renewable energy and in some cases we will supply power to the grid from solar, wind, ocean, or geothermal sources generated by the base. We’re already doing this at China Lake, where our on-base systems generate 20 times the load of the base.

Lastly, and maybe most importantly, I am asking all of us to meet a very ambitious goal. Today, about 17 percent of our total energy consumption comes from alternative sources. By 2020, half of our total energy consumption for ships, aircraft, tanks, vehicles, and shore installations will come from alternative sources. Right now I’m told 40 percent is a more realistic goal and even that remains difficult because of the cost and logistics.^[38]


Potential Technology Implications

Potential technology implications of an increased focus on energy use and alternative energy, particularly for ships, could include things such as:

- shipboard equipment that is more energy-efficient than existing models;
- new technologies, and wider application of existing technologies (e.g., stern flaps and hull coatings, including environmentally friendly coatings), for improving the hydrodynamic performance of ships;
- wider application of hybrid-drive and integrated electric drive technology;
- higher-efficiency gas turbines;
- fuel cells;
- biofuels, particularly those whose production does not displace food production, and the certification of ship and aircraft engines to operate on biofuels;
- nuclear-power not only for aircraft carriers and submarines, but other ships as well; and
- kite-assisted propulsion.

Potential Implications Arising From Future Navy Operations

The Navy in coming years will likely conduct many of the same kinds of operations that it has conducted in past years, ranging from peacetime presence and engagement for deterrence, reassurance, and regional stabilization, to major combat operations intended to influence events ashore, including strike operations, amphibious landings, and support of Marines or other friendly ground forces ashore. This section focuses on recently added, expanded, or renewed kinds of operations that are in addition to more established kinds of Navy operations, including the following:

- BMD operations;
- counterterrorism and irregular warfare operations;
- anti-piracy operations;
- partner capacity-building operations; and
- humanitarian assistance and disaster response (HADR) operations.

BMD Operations

As a consequence of the proliferation of theater-range ballistic missiles, the emergence of China’s ASBM, and the Administration’s September 2009 decision to use Navy Aegis ships for European BMD operations, observers expect Navy BMD operations to expand significantly in scope in coming years. Indeed, there is a concern that demands from regional U.S. combatant commanders for BMD-capable Aegis ships are growing faster than the supply of such ships, and BMD-capable Aegis ships consequently will experience a high tempo of operations for at least the next few years, until the two planned Aegis Ashore sites are established in Europe.

Reflecting expected future demands for BMD-capable Aegis ships, Navy plans now call for at least 10 of 22 Aegis cruisers, and all Aegis destroyers, to eventually be equipped for BMD operations. The Navy is currently examining options for how to maintain forward deployments of
BMD-capable Aegis ships in Europe while keeping adequate numbers of Aegis ships available for other missions. Possibilities include forward-homeporting BMD-capable Aegis ships in Europe, multiple crewing, and Sea Swap (i.e., extended-duration deployments with crew rotation).

**Potential Technology Implications**

Potential technology implications of countering ASBMs were discussed earlier in the initial section discussing anti-access weapons. Additional potential technology implications, particularly given the plan for using BMD-capable Aegis ships for European BMD operations, include:

- integrating the Aegis BMD system with other elements of the planned European BMD architecture;
- adapting the Aegis BMD system into an Aegis Ashore configuration;
- developing the SM-3 Block IIB missile that is to be used at the Aegis Ashore sites; and
- developing shipboard technologies for facilitating the use of multiple crewing or Sea Swap on BMD-capable Aegis ships.

**Counterterrorism and Irregular Warfare Operations**

DOD’s report on the 2010 QDR identifies succeeding in counterinsurgency, stability, and counterterrorism operations as one of six key mission areas, and devotes substantial discussion to the subject.\(^{39}\) Counterterrorism and irregular warfare operations have been a Navy focus since the October 12, 2000, boat-bomb attack on the Navy destroyer Cole (DDG-67), the September 11, 2001, terrorist attacks in New York and Washington, and the initiation of U.S. combat operations in Iraq and Afghanistan. The Navy is currently supporting U.S. operations in Iraq and Afghanistan in a variety of areas, in part through the assignment ashore of thousands of Individual Augmentee (IA) sailors. The Navy in recent years has taken a number of organizational steps to improve its capabilities for conducting irregular warfare operations, including establishing the Navy Irregular Warfare Office, the Naval Expeditionary Combat Command (NECC), riverine squadrons, a Navy Foreign Area Officer (FAO) program, and a naval civil reserve affairs battalion. Although the scale of U.S. military operations in Iraq and Afghanistan is expected to decline over time, some observers believe that counterterrorism and irregular warfare operations will likely continue to form a part of Navy operations in coming years.

**Potential Technology Implications**

Potential technology implications of a continued focus on counterterrorism and irregular warfare operations include the following:

- developing and acquiring improved ship-based ISR capabilities, including UAVs, particularly those capable of conducting persistent ISR operations;
- developing improved capabilities for expeditionary electronic warfare, signals intelligence, counter-IED, explosive ordnance disposal (EOD), and riverine capabilities;

\(^{39}\) Department of Defense, *Quadrennial Defense Review Report*, February 2010, pp. 17 and 20-26. In an apparent shift in DOD terminology, the main text of the report does not use the term irregular warfare and instead refers to counterinsurgency and stability operations. The term irregular warfare appears once in the report, in the Chairman of the Joint Chiefs of Staff assessment of the 2010 QDR (see the final word on page 102 and the first word on page 103).
• fast-to-target, low-collateral-damage strike weapons; and
• improved capabilities for covertly inserting and recovering Navy special operations forces (i.e., SEALs), including developing and acquiring a follow-on to the Advanced Swimmer Delivery System (ASDS).

Anti-Piracy Operations

The U.S. Navy is one of several navies currently engaged in anti-piracy operations in waters of Somalia. Although these operations have helped reduce the number of successful pirate attacks in these waters, numerous observers believe that piracy in this area will not subside completely until an effective government is established in Somalia, which may not occur for some time. Although anti-piracy operations are valuable in terms of contributing to the safety and security of commercial ships, including U.S.-flag ships, maintaining deployments of Navy ships to these waters incurs a financial and opportunity cost for the Navy.

Potential Technology Implications

Potential technology implications of continued anti-piracy operations include technologies that might permit these operations to be performed more cost-effectively. This could include improved ISR technologies, particularly UAVs for conducting persistent ISR, technologies for discriminating pirates from legitimate fisherman, and non-lethal weapons for Navy ships or ship-based manned and unmanned aircraft.

Partner Capacity-Building Operations

DOD’s report on the 2010 QDR identifies building the security capacity of partner states as one of six key mission areas, and devotes substantial discussion to the subject. Consistent with this, the Navy is conducting partner capacity-building operations in which Navy forces engage with navies and coast guards of other countries to help improve their capacities for conducting maritime-security operations. Such capacity-building operations are one means of implementing the Navy’s Global Maritime Partnerships (GMP) initiative, under which navies work cooperatively to pursue goals of common interest, particularly in the area of maritime security. The Cooperative Strategy for 21st Century Seapower – the joint Navy-Marine Corps-Coast Guard maritime strategy document released by the three services in October 2007 – discusses working with partners at several points.  

41 The Secretary of the Navy testified in February 2010 that:
Both the Navy and Marine Corps routinely conduct training exercises and multi-lateral operations with nations all around the world to solidify our relationships with traditional allies and forge partnerships with new friends. Global Partnership Stations in Africa, South America, and the Pacific are training hundreds of Sailors, Marines, and Coast Guardsmen from dozens of nations…. (Statement of the Honorable Ray Mabus, Secretary of the Navy, Before the House Armed Services Committee on 24 February 2010, pp. 4-5.)
42 The document, for example, states that:
Expanded cooperative relationships with other nations will contribute to the security and stability of the maritime domain for the benefit of all. Although our forces can surge when necessary to respond to crises, trust and cooperation cannot be surged. They must be built over time so that the strategic interests of the participants are continuously considered while mutual understanding and respect are promoted.
A key to fostering such relationships is development of sufficient cultural, historical, and linguistic expertise among our Sailors, Marines and Coast Guardsmen to nurture effective interaction with
Potential Technology Implications

Potential technology implications of a continued emphasis on partner capacity-building operations could include things such as improved education and training facilities that are either built into ships or are available in the form of portable modules that can be set up aboard ships or moved ashore.

Humanitarian Assistance and Disaster Response (HADR) Operations

The Navy is also now placing considerable emphasis on humanitarian assistance and disaster response (HADR) operations. In addition to their humanitarian value, such operations can strengthen U.S. relationships with the assisted countries and improve foreign public opinion of the United States. High-profile Navy HADR operations outside the United States in recent years include operations in Indonesia in response to the Indian Ocean tsunami of December 26, 2004, and, most recently, operations in Haiti in response to the earthquake there on January 12, 2010. HADR operations can involve various ship types, including hospital ships, amphibious ships, surface combatants, and aircraft carriers, as well as aircraft (particularly helicopters).

Potential Technology Implications

Potential technology implications of a continued emphasis on HADR operations could include:

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diverse international partners. Building and reinvigorating these relationships through Theater Security Cooperation requires an increased focus on capacity-building, humanitarian assistance, regional frameworks for improving maritime governance, and cooperation in enforcing the rule of law in the maritime domain.

Additionally, the Sea Services must become adept at forging international partnerships in coordination with the other U.S. services and government departments. To this end, the Global Maritime Partnerships initiative seeks a cooperative approach to maritime security, promoting the rule of law by countering piracy, terrorism, weapons proliferation, drug trafficking, and other illicit activities.

(A Cooperative Strategy for 21st Century Seapower, October 2007, section entitled “Foster and sustain cooperative relationships with more international partners.” Italics as in original.)

The Navy’s FY2011 budget overview document similarly states:

There is no one nation that can provide a solution to maritime security problems alone. A global maritime partnership is required that unites maritime forces, port operators, commercial shippers, and international, governmental and nongovernmental agencies to address our mutual concerns. This partnership increases all of our maritime capabilities, such as response time, agility and adaptability, and is purely voluntary, with no legal or encumbering ties. It is a free-form, self-organizing network of maritime partners – good neighbors interested in using the power of the sea to unite, rather than to divide.

(Department of the Navy, Highlights of the Department of the Navy FY 2011 Budget, February 2010, p. 1-5.)

43 The Cooperative Strategy for 21st Century Seapower states that:

Building on relationships forged in times of calm, we will continue to mitigate human suffering as the vanguard of interagency and multinational efforts, both in a deliberate, proactive fashion and in response to crises. Human suffering moves us to act, and the expeditionary character of maritime forces uniquely positions them to provide assistance. Our ability to conduct rapid and sustained non-combatant evacuation operations is critical to relieving the plight of our citizens and others when their safety is in jeopardy.

technologies (including airborne sensors) permitting rapid detailed surveys and assessments of damaged areas, and the rapid dissemination of that information to personnel in the field;

• technologies for improved ship-to-shore transfer of relief supplies and equipment, particularly in cases where sea ports and airports are damaged or not available;

• technologies for rapidly repairing damaged sea ports and airports;

• technologies for portable power-generation, water purification, and medical-care modules that can be quickly installed on ships that are responding to a disaster, or quickly moved from ships to shore locations in the disaster area;

• technologies that may assist in the rapid reestablishment of a basic level of local communications and civil governance; and

• technologies permitting personnel in the field to reach back to distantly located medical or other specialists for advice and information.

Potential Implications Arising From Future Resource Situation

The Navy, like all the services, faces a challenging situation regarding the balance between available resources and program desires. Many observers, including Navy leaders, expect the Navy’s budget to experience little or no real growth in coming years. Given the increase in projected federal budget deficits that has occurred since the late-2008 financial crisis, a real decline in Navy funding levels in coming years is a possibility. Within the Navy’s budget, year-to-year increases in real per capital military personnel (MilPer) costs and real per capita operations and maintenance (O&M) costs have offset Navy efforts to achieve savings through end strength reductions, and put continued pressure on Navy investment accounts. The affordability and executability of the Navy’s long-range shipbuilding plan in particular has become an annual topic of debate. Navy leaders for years have been making often-difficult budget choices between funding current operations and readiness and funding investments in future force structure and capabilities. Observers expect coming years to be just as difficult for Navy leaders in this regard, if not more difficult. Some aspects of the Navy’s resource situation that may have technology implications for the Navy’s future include but are not limited to the following:

• increases in ship and aircraft unit procurement costs;

• reduced ship and aircraft procurement rates;

• operation and support (O&S) costs crowding out funding for procurement;

• limited numbers of new ship and aircraft designs.

Each of these is discussed below.

Increases in Ship and Aircraft Unit Procurement Costs

Increases in Navy ship and aircraft unit procurement costs make it more difficult for the Navy to procure ships and aircraft in desired quantities within available resources. Several shipbuilding programs, such as the Littoral Combat Ship (LCS), have experienced significant cost growth in recent years, and the F-35 Joint Strike (Fighter) – including the B and C versions intended for the

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44 A recent news article, for example, quoted Secretary of the Navy Ray Mabus as saying, “We are looking at a no substantial growth and realistically no growth at all, in terms of the amount of money we are allocated to spend.” (Geoff Fein, “Diminishing Budgets Forcing Navy To Closely Examine Contracts, Navy Secretary Says,” Defense Daily, April 22, 2010: 4-5.)
Marine Corps and Navy, respectively – currently appears to be experiencing substantial cost growth.

**Potential Technology Implications**

To reduce unit procurement cost growth, the Navy is taking various actions, including actions that have potential technology implications. Currently planned or potential actions of this kind include:

- making greater use of common hulls, airframes, systems, and components;
- increasing the use of modularity in ship design and construction;
- incorporating into ship and aircraft designs improved design-for-producibility features, and in general making better use of production engineering in developing new designs;
- incorporating into ship and aircraft designs new materials that are less expensive to shape and install than those they replace;
- developing technologies for reducing the size, weight, and cost of shipboard systems, such as radars and electric-drive equipment;
- incorporating technologies for reducing ship crew size, including technologies for automated damage control; and
- developing improved construction processes and methods, such as those developed by the National Shipbuilding Research Program (NSRP).

**Reduced Ship and Aircraft Procurement Rates**

In spite of actions such as those above, constraints on Navy resources suggest that procurement rates of Navy ships and aircraft, which have been relatively low since the early 1990s, are likely to remain constrained in coming years. With regard to shipbuilding, the advent of programs for procuring significant quantities of relatively inexpensive ships, such as the LCS and the Joint High Speed Vessel (JHSV) programs, will make it somewhat easier for the next few years for the Navy to attain an annual rate of ship procurement somewhat higher than the rates attained in recent years. The Navy’s five-year (FY2011-FY2015) shipbuilding plan includes a total of 50 ships (of which 25 are LCSs and JHSVs), or an average of 10 per year, as opposed to the single-digit ship quantities achieved during the period FY1993-FY2009.

Beyond FY2015, as the LCS and JHSV programs run their course, and as the Navy enters the period for procuring the SSBN(X) next-generation ballistic missile submarine, the challenge of shipbuilding affordability will become more difficult. The Navy currently estimates the unit procurement cost of the SSBN(X) at $6 billion to $7 billion in today’s dollars, which is roughly equivalent to half of the Navy’s annual shipbuilding budget.

The Navy’s report on its 30-year (FY2011-FY2040) shipbuilding plan projects that the Navy will have limited resources for procuring other kinds of ships during the years in which it procures SSBN(X)s. The report projects that implementing the 30-year shipbuilding plan would result in...

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45 Additional information on the NSRP is available online at: [http://www.nsrp.org/].

46 The Navy’s report on its 30-year (FY2011-FY2030) shipbuilding plan states:

  Recapitalizing the SSBN force will impact the Navy in the mid-term as significant resources are allocated to the SSBN(X) recapitalization program ... these ships require significant resource commitment and they will impact the Navy’s ability to procure other shipbuilding requirements during the period when they are being procured....

  The SSBN(X) procurments will be concurrent with wholesale end-of-service-life retirements of
a fleet that grows from 284 ships in FY2011 to 315 ships in FY2020, reaches a peak of 320 ships in FY2024, drops below 313 ships in FY2027, declines to 288 ships in FY2032-FY2033, and then increases to 301 ships in FY2039-FY2040. The report projects that the attack submarine and cruiser-destroyer forces will drop substantially below required levels in the latter years of the 30-year plan.47

With regard to aircraft procurement, the Navy and Marine Corps are facing a projected shortfall in strike fighters. The size of this projected shortfall is a matter of debate, but other things held equal, cost increases in the F-35 program could make the shortfall larger by reducing the number of F-35Bs and Cs that can be procured each year within available resources.

**Potential Technology Implications**

One possible response to reduced ship and aircraft procurement rates would be to extend ship and aircraft service lives, so that desired force levels can be maintained with lower rates of procurement of new units. Potential technology implications of extending ship and aircraft service lives could include:

- building ships and aircraft with more-rugged or more-durable materials;
- building ships and aircraft with greater growth margins;
- building ships and aircraft with open-architecture combat systems and physical open-architecture features to facilitate modernization over long ship and aircraft lives;
- improved technologies for corrosion control; and
- developing improved technologies and models for monitoring, inspecting and assessing the condition of in-service ships and aircraft and estimating their remaining service lives.

A second possible response to reduced ship procurement rates would be to increase the percentage of ship life spent on deployment, so that desired numbers of forward-deployed ships can be maintained with a smaller overall number of ships. Potential technology implications of increasing percentage of ship life spent on station could include:

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SSN 688 submarines, CG 47 class guided missile cruisers, DDG 51 class guided missile destroyers, and LSD 41/49 class dock landing ships. While the SSBN(X) is being procured, the Navy will be limited in its ability to procure other ship classes. This slowdown in procurement will occur when the Navy needs to be procuring at least 10 ships per year to maintain its force level against the anticipated ship retirements from the 1980s and 1990s.

The report also states:

Because of the high expected costs for these important national assets, yearly shipbuilding expenditures during the mid-term planning period [FY2021-FY2030] will average about $17.9B (FY2010S) [$17.9 billion in constant FY2010 dollars] per year, or about $2B more than the steady-state 30-year average. Even at this elevated funding level, however, the total number of ships built per year will inevitably fall because of the percentage of the shipbuilding account which must be allocated for the procurement of the SSBN. In the far-term planning period, average shipbuilding expenditures fall back to a more sustainable level of about $15.3B (FY2010S) average per year. Moreover, after the production run of SSBN(X)s comes to an end in FY 2033, the average number of ships built per year begins to rebound.


47 The projected number of attack submarines drops below the required level of 48 boats in FY2022, reaches a minimum of 39 boats in FY2030, and remains below 48 boats through FY2040. The projected number of cruisers and destroyers drops below the required level of 88 ships in 2027, reaches a minimum of 67 ships in FY2034, and remains below 88 ships through FY2040.
building ships and aircraft with more-rugged or more-durable materials;
building ships with more-reliable systems, redundant systems, and increased onboard capacity for repairing equipment; and
building ships with technologies for facilitating the use of multiple crewing or Sea Swap.

A third possible response to reduced ship procurement rates would be to increase the use of unmanned vehicles (UV) in lieu of, or to extend the capabilities of, Navy ships and aircraft. This could have technology implications not only for the UVs themselves, but also for their parent platforms. It might, for example, suggest a need for ships that can embark and operate a greater number of UVs than can be embarked and operated by today’s ships.

Operation and Support (O&S) Costs Crowding Out Funding for Procurement

As one means of addressing the problem of O&S costs within the Navy’s budget crowding out funding for procurement programs, Navy leaders are placing an increasing emphasis on total ownership cost (TOC) in the design and evaluation of new ships and aircraft. The Navy’s new Gerald R. Ford (CVN-78) class aircraft carriers, for example, are to have a life-cycle O&S cost several billion dollars less than that of the Nimitz (CVN-68) class design. Life-cycle O&S costs have been a factor in discussions of the relative merits of the DDG-51 and DDG-1000 destroyer designs, and, most recently, in discussions by some observers of the relative merits of the two LCS designs.

Potential Technology Implications

Potential technology implications of a continued concern for reducing (or at least constraining) annual ship and aircraft O&S costs could include a need for some or all of the following:

- increased use of UVs as substitutes for manned ships and aircraft;
- ships with automation and other technologies permitting reduced-sized crews;
- technologies (such as those discussed earlier in the section on energy use and alternative energy) for reducing fuel use;
- ships and aircraft built with systems, components and materials that are more reliable and have reduced life-cycle maintenance costs;
- improved technologies for corrosion control;
- improved technologies and models for monitoring, inspecting and assessing the condition of in-service ships and aircraft; and
- ships and aircraft with open-architecture combat systems and physical open-architecture features to reduce-life-cycle modernization costs.

Limited Numbers of New Ship and Aircraft Designs

As one means of living within projected funding levels, Navy leaders in coming years may reduce ship- and aircraft-design costs by developing fewer new ship and aircraft designs. A reduced number of new ship designs could also be viewed as consistent with moving toward a greater use of common hull designs. Near-term Navy programs for designing new complex combatants appear limited to the LSD(X) amphibious ship and the SSBN(X) ballistic missile submarine, whose lead ships are to be procured in FY2017 and FY2019, respectively. The Navy’s proposal to cancel the CG(X) cruiser and instead procure a Flight III version of the DDG-51 destroyer from
FY2016 through FY2031 suggests that the next effort to design a new cruiser- or destroyer-type ship might not begin until the mid-2020s.⁴⁸

**Potential Technology Implications**

A reduced number of new ship and aircraft designs suggests a potential need for strategies for introducing new technologies into the fleet more through modifications to existing ship designs than through designing new ships. This could involve, among other things:

- improved design tools for working with existing ship designs; and
- roadmaps for introducing into the cruiser-destroyer fleet, through modifications to the DDG-51 design, technologies (such as integrated electric drive and composite structures) that were previously planned for widespread introduction into the cruiser-destroyer fleet through acquisition of significant numbers of DDG-1000s and CG(X)s.

Regarding the second item above, the Navy in February 2010 began a technical study and cost analysis on options for modifying the DDG-51 design to achieve goals of improved integrated air and missile defense (IAMD), manpower reductions, energy efficiency and improved power generation, improved effectiveness in warfare areas in addition to IAMD, and total ownership cost reduction.⁴⁹

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⁴⁸ Other near-term opportunities for designing new ships include the Mobile Landing Platform (MLP) maritime prepositioning ship, the TAT(F) fleet tug, TAO(X) oiler, and the TAGOS(X) ocean-surveillance ship, and the TARS(X) salvage ship, whose lead ships are to be procured in FY2011, FY2015, FY2017, FY2020, and FY2020, respectively.