CSBA

Center for Strategic and Budgetary Assessments

COMMANDING THE SEAS

THE U.S. NAVY AND THE FUTURE OF SURFACE WARFARE

BRYAN CLARK

COMMANDING THE SEAS

THE U.S. NAVY AND THE FUTURE OF SURFACE WARFARE

BRYAN CLARK

CSBA
Center for Strategic and Budgetary Assessments

2017

ABOUT THE CENTER FOR STRATEGIC AND BUDGETARY ASSESSMENTS (CSBA)

The Center for Strategic and Budgetary Assessments is an independent, nonpartisan policy research institute established to promote innovative thinking and debate about national security strategy and investment options. CSBA's analysis focuses on key questions related to existing and emerging threats to U.S. national security, and its goal is to enable policymakers to make informed decisions on matters of strategy, security policy, and resource allocation.

ABOUT THE AUTHORS

Bryan Clark is a Senior Fellow at the Center for Strategic and Budgetary Assessments (CSBA). Prior to joining CSBA in 2013, Mr. Clark was Special Assistant to the Chief of Naval Operations and director of his Commander's Action Group, where he led development of Navy strategy and implemented new initiatives in electromagnetic spectrum operations, undersea warfare, expeditionary operations, and personnel and readiness management. Mr. Clark served in the Navy headquarters staff from 2004 to 2011, leading studies in the Assessment Division and participating in the 2006 and 2010 Quadrennial Defense Reviews. His areas of emphasis were modeling and simulation, strategic planning, and institutional reform and governance. Prior to retiring from the Navy in 2007, Mr. Clark was an enlisted and officer submariner, serving in afloat and ashore submarine operational and training assignments including tours as chief engineer and operations officer at the Navy's nuclear power training unit.

Mr. Clark holds an M.S. in National Security Studies from the National War College and a B.S. in Chemistry and Philosophy from the University of Idaho. He is the recipient of the Department of the Navy Superior Service Medal and the Legion of Merit.

ACKNOWLEDGMENTS

The author would like to thank the staff at CSBA for their efforts on this study, particularly Jacob Cohn and Ryan Boone, whose research and graphics were essential to completing the project, and Kamilla Gunzinger, for expertly editing and preparing it for publication.

CSBA receives funding from a broad and diverse group of funders, including private foundations, government agencies, and corporations. A complete list of these organizations can be found on our web site at http://csbaonline.org/about/contributors.

This is the revised version of the original study published in November 2014.

Contents

FIGURES

TABLES

Executive Summary

Introduction

The U.S. Navy's surface fleet is at a crossroads. In 2001, the Navy planned a new network-centric approach to surface warfare, supported by a family of new ships: the CG(X) cruiser, DD(X) destroyer, and Littoral Combat Ship (LCS). Each of those ships is now cancelled or truncated, and the approach they supported is in disarray. The U.S. surface fleet must restructure itself around a new central idea of how it will fight. At the same time, it must evolve to address a more challenging security environment characterized by great power competitors that are able to contest the air and sea for hundreds of miles around their territory. The surface fleet—whose missions expanded over the last three decades to include everything from counter-piracy to ballistic missile defense (BMD)—will need to get "back to basics" and focus on sea control to sustain the ability of U.S. forces to project power across increasingly contested waters. And the Navy will have to undertake this evolution at a time of constrained budgets and growing costs to man and maintain its ships and aircraft.

A confluence of events, however, gives the Navy an opportunity to dramatically reshape the surface fleet. In the next year it will:

- Finalize the design for Flight III of the *Arleigh Burke* destroyer (restarted with the truncation of DD[X]);
- Determine the concept and requirements for a new guided missile frigate (FFG) to follow the now-truncated LCS and decide how to modify existing LCSs to be more lethal;
- Implement a plan to sustain its cruiser capacity with the cancellation of CG(X); and
- Decide the characteristics or acquisition approach for several surface fleet weapons and sensors.

Scope

This study and its recommendations are focused on large and small surface combatants. Large surface combatants consist of guided missile cruisers (CG) and guided missile destroyers (DDG); small surface combatants (SSC) include LCSs, FFGs, Patrol Coastal ships (PC), and mine countermeasure ships (MCM). Surface combatants have a distinct role in modern naval warfare from that of other surface ships such as amphibious warships and aircraft carriers. Surface combatants conduct sea control operations to enable the rest of the joint force, including carriers and amphibious ships, to project power. Sea control consists of anti-air warfare (AAW), anti-submarine warfare (ASW), mine warfare (MIW), surface warfare (SUW), and strike warfare against anti-ship threats. Each of these missions has an offensive and defensive aspect.

New Concepts

Offensive sea control is the central concept around which the study's recommendations are based. This idea would refocus large and small surface combatant configuration, payloads, and employment on sustaining the surface force's ability to take and hold areas of ocean by destroying threats to access such as aircraft, ships, and submarines rather than simply defending against their missiles and torpedoes.

Regaining its ability to conduct offensive sea control requires the surface fleet to implement new concepts and approaches to address several significant shortfalls:

- <u>Offensive weapons capacity per ship</u>: Today, CG and DDG vertical launch system (VLS) magazines are filled predominantly with weapons that are only useful for defensive AAW. The Navy needs a new concept for sea-based defensive AAW to free up VLS space for long-range offensive ASW, SUW, and AAW weapons;

- <u>Air defense density and cost</u>: Today, the fleet relies on a layered air defense approach in which the longest-range layers are both most likely to be used and most disadvantageous from a cost and capacity perspective. The Navy should implement a new defensive AAW concept with only one medium-range layer to make more VLS space available for offensive weapons, increase the density of the air defense screen, and improve the cost exchange between U.S. air defenses and enemy anti-ship cruise missiles (ASCMs);

- <u>Offensive weapons capability</u>: Today, the surface fleet lacks weapons with the range to attack aircraft, ships, and submarines outside enemy ASCM range. The Navy should implement a new approach to weapons development that emphasizes multi-mission flexibility and smaller physical size to increase the range of ASW, SUW, and AAW weapons and enable more of them to be carried on each surface combatant;

- Overall surface fleet offensive capacity: The Navy should implement new concepts to expand the number of surface combatants able to participate in offensive sea control operations; and

- SSC capacity: Growing demands for constabulary missions and the current shortfall in SSCs will likely pull CGs and DDGs away from offensive sea control. The Navy should implement new approaches to conduct traditional SSC missions that improve the ability of SSCs to operate without large surface combatant escorts and expand the number of ships in the U.S. National Fleet that can contribute to these missions.

Capability and Program Implications

The study will not propose a new architecture for the surface fleet. Instead, it focuses on modifications to existing ships and new weapons or sensors that can be fielded by 2025. Fiscal constraints likely will preclude the Navy from building a new-design surface combatant until the 2030s, whereas today's Navy and national decision makers can influence capabilities fielded into the mid-2020s.

The study makes recommendations in the following areas:

- Large Surface Combatants: In addition to their planned electronic warfare (EW) systems, the Navy should equip some Flight III *Arleigh Burke*-class DDGs with lasers and high-power radiofrequency (HPRF) weapons for defensive AAW and change the mix of VLS weapons they carry to favor shorter-range defensive weapons such as the Evolved Sea Sparrow Missile (ESSM) and long-range offensive weapons such as SM-6s or Long Range Anti-Ship Missiles (LRASMs). To gain the defensive AAW capacity possible with EMRGs, the Navy should install them on ships such as an expeditionary fast transport (EPF) that have space and weight available for associated power and cooling systems. The Navy should also explore the incorporation of a strike-oriented EMRG on one of the three *Zumwalt*-class DDGs.

- Small Surface Combatants: The Navy should pursue an FFG that is capable of ASW, SUW, and AAW to succeed the LCS. Further, the complexity introduced with modified LCSs and the FFG suggest the Navy should end its rotational crewing concept for LCSs and forward base some of them overseas to achieve similar operational availability. The ability of non-combatant ships such as EPF to conduct some planned LCS missions such as MIW and maritime security suggests the Navy should also separate LCS mission packages from the LCS program, making them independent, stand-alone capability sets that could be carried on a wide range of ships in the National Fleet.

- Surface force weapons: The Navy should pursue modifications with its next generation of weapons such as the LRASM and vertical-launch ASW rocket that ensure surface combatants can engage enemy platforms outside enemy ASCM range while enhancing the offensive capacity of the surface fleet.

Conclusion

The Navy has an uncommon opportunity in the next year to set the course for the future surface fleet. The challenges it faces, however, are daunting. If the Navy doesn't make good choices with regard to the configuration, payloads, and employment of surface combatants, it will fall further behind competitors who will increasingly be able to deny U.S. forces access to their region.

This is the revised version of the original study published in November 2014. Among the revisions, it incorporates the Navy's changes to the LCS program and the new FFG it is pursuing. There is an updated discussion of SM-3 development and added discussion of HPRF and HVP systems based on the increasing interest and potential investment in these programs.

CHAPTER 1:

Introduction

The U.S. Navy's surface fleet is at a crossroads. In 2001, the Navy planned a new approach to surface warfare supported by a family of new ships: the CG(X) missile defense cruiser, DD(X) land attack destroyer, and sea control-focused[1] littoral combat ship. This new family of ships was intended to conduct "network-centric warfare," where the surface fleet would counter growing threats by having each ship specialize in a small set of missions. The fleet would maintain the ability to conduct a wide range of operations by connecting ships via a dense communications network. Each of those 2001 ships is now canceled or its program truncated, leaving the Navy without a coherent surface fleet architecture or a clear central concept for surface warfare.

The United States is now entering a period of significant and perhaps disruptive change that should inform a new central concept for surface warfare. America's security environment is not as benign or stable as it was in 2001, when, a decade after the fall of the Soviet Union, the Navy was without a significant competitor. U.S. surface combatants could take sea control for granted and took on missions such as BMD, counter-piracy, or strike.

Of most concern to the surface fleet, sophisticated long-range sensor and weapon[2] capabilities continue to improve and proliferate from near-peer competitors to other U.S. rivals, threatening U.S. freedom of action and challenging its security assurances to allies and partners. At the same time, instability is spreading with the rise of revisionist states in Eastern Europe, the

1 Sea control is defined by the Navy as "The employment of naval forces, supported by land and air forces as appropriate, in order to achieve military objectives in vital sea areas. Such operations include destruction of enemy naval forces, suppression of enemy sea commerce, protection of vital sea lanes, and establishment of local military superiority in areas of naval operations." See U.S. Navy, *Naval Operations Concept 2010* (Washington, DC: U.S. Navy, 2010), available at http://www.navy.mil/maritime/noc/NOC2010.pdf.

2 For the purposes of this paper, anti-access (A2) capabilities are associated with denying access to major fixed-point targets, especially large forward bases, whereas area-denial (AD) capabilities threaten mobile targets over an area of operations, principally maritime forces, to include beyond the littorals. See Andrew Krepinevich, *Why AirSea Battle?* (Washington, DC: Center for Strategic and Budgetary Assessments, 2010), pp. 8–11.

Middle East, and East Asia as well as failed states in the developing world. And despite the growing challenges to U.S. security, the Navy's budgets are projected to be flat or declining due to legislative caps and growing pressure from nondiscretionary spending. The combination of rising threats and reduced resources places a premium on innovative thinking as the surface fleet works to sustain its ability to help ensure access for U.S. forces and address growing demands for maritime security and training from partners and allies.

Fortunately a confluence of events provides the Navy with a narrow window to adapt the surface fleet to address these challenges. Consider that in the next year the Navy will:

- Identify systems and configuration of the Flight III *Arleigh Burke* destroyer (restarted with the truncation of DD[X]);
- Determine the concept and requirements for a guided missile frigate (FFG) to follow the now-truncated LCS and decide how to upgrade existing LCSs to be more lethal;
- Implement a plan to sustain its cruiser capacity with the cancellation of CG(X); and
- Decide the characteristics or acquisition approach for several surface fleet weapons and sensors.

This study informs these decisions by: highlighting the most relevant trends for surface fleet development; proposing "offensive sea control" as a new central concept for surface warfare (Chapter 2); and identifying the implications of this concept for surface fleet programs and capabilities (Chapter 3).

Scope

This study and its recommendations focus on large and small surface combatants, together referred to as the "surface fleet." Large surface combatants consist of guided missile cruisers (CG) and guided missile destroyers (DDG), whereas small surface combatants (SSC) include LCSs, frigates (FFG), patrol coastal ships (PC), and mine countermeasure ships (MCM). Surface combatants have the distinct role in modern naval warfare of gaining and maintaining control of areas at sea to enable the rest of the joint force to project power. This differentiates them from other surface ships such as amphibious ships and aircraft carriers, whose primary mission is to project power. And while all surface combatants contribute to sea control, traditionally SSCs focus on less-stressing missions such as escort, maritime security, and training for allies and partners.

This study does not propose a new design or architecture for the surface fleet. The likely fiscal constraints will preclude the Navy from fielding a new-design surface combatant until the 2030s. Instead, the study focuses on modifications to existing ships and new weapons or sensors to equip them.

Timeframe

This study focuses on the mid-2020s timeframe. From a practical standpoint, this is far enough in the future to enable new capabilities decided upon in the near term to be fielded,[3] such as those affected by decisions in the coming year. For example:

- The third flight of *Arleigh Burke* DDGs will begin arriving in 2021 to replace today's *Ticonderoga*-class CGs[4] and Flight I *Arleigh Burke*-class DDGs;
- All the Navy's *Ticonderoga*-class CGs will retire by 2029 unless the Navy can continue a phased modernization plan started in FY 2015;[5]
- The first of a new class of FFGs will deliver in 2023, whose concept and specifications will be determined by FY 2020; and
- The Navy will field several next-generation surface fleet weapon and sensor "payloads" in the mid-2020s whose specifications and host platforms will be established in the next two years, including high-energy solid-state lasers, electromagnetic railgun (EMRG), Long-range Anti-ship Missile (LRASM), Surface Electronic Warfare Improvement Program (SEWIP) Block 3, and Air and Missile Defense Radar (AMDR).

Navy Functions and Missions

The Navy's traditional functions, as described in the maritime strategy *A Cooperative Strategy for 21st Century Seapower* and the *Naval Operations Concept*, are deterrence, power projection, sea control, maritime security, and humanitarian assistance and disaster response (HA/DR).[6] The surface fleet contributes to each of these functions, but only surface combatants are capable of conducting the full range of sea control missions. Consequently, when threats to maritime freedom of action emerge, surface combatants are expected to address them.

The missions that comprise the sea control function are surface warfare (SUW), anti-submarine warfare (ASW), anti-air warfare (AAW), mine warfare (MIW), and strike warfare against sea control threats ashore such as anti-ship missile launchers. Each of these missions has an offensive and defensive aspect. In this report, *offensive sea control* refers to operations designed to defeat enemy platforms that can launch anti-ship weapons, as described in the

3 The Navy is developing its FY 2019–2024 Future Year's Defense Plan (FYDP) now, which will establish the fleet of the mid-2020s.

4 The first five *Ticonderoga*-class CGs (CG-47 through CG-51) were decommissioned in 2004–2005; these ships did not have VLS magazines and had material issues such as hull and superstructure cracking that made modernizing them impractical.

5 Under that proposed phased modernization plan, the Navy would retire the oldest eleven CGs by 2026 and the remaining eleven between 2035 and 2043.

6 U.S. Navy, *Naval Operations Concept 2010*.

right-hand column of Table 1. *Defensive sea control* refers to operations designed to defeat enemy anti-ship weapons, as described in the left-hand column of the table. As the table indicates, because anti-ship missiles are the most common sea control weapons today, defensive sea control fundamentally depends on effective defensive AAW.

TABLE 1: SEA CONTROL MISSIONS[7]

Defensive sea control	Mission	Offensive sea control
Defeating surface ship gunfire	Surface warfare (SUW)	Destroying or disabling surface ships
Defeating torpedoes	Anti-submarine warfare (ASW)	Destroying, disabling or rendering ineffective submarines
Defeating airborne anti-ship weapons from aircraft, submarines, ships, and shore launchers	Anti-air warfare (AAW)	Destroying or disabling aircraft
Finding and neutralizing mines	Mine warfare (MIW)	Laying mines
	Strike	Destroying or disabling shore-based anti-ship missile launchers

Large surface combatants such as CGs and DDGs are designed to conduct offensive and defensive AAW, ASW, and SUW. LCSs are equipped with mission packages that enable them to conduct ASW, MCM, or SUW along with their organic capabilities to conduct self-defense against air threats and offensive and defensive SUW.

The Navy de-emphasized sea control in the twenty-five years since the end of the Cold War because U.S. maritime supremacy was essentially unchallenged. The surface fleet prioritized defense against unexpected, small-scale attacks and did not pursue new capabilities for defense against large missile salvos or to conduct the offensive sea control missions described in Table 1. As a result, surface combatants today cannot engage submarines, surface ships, or aircraft from outside enemy anti-ship missile range.

7 Ibid.

Surface Fleet Challenges

The Navy will have to consider three major trends as it develops and implements a new central concept for surface warfare.

State-on-State Threats will Expand as Sensor and Weapons Networks Improve and Proliferate

Over the next decade some of America's rivals are planning to field comprehensive long-range sensors and weapons to prevent U.S. intervention in regional conflicts and deny naval forces access to adjacent seas. Countries such as China and Iran began these efforts ten to fifteen years ago to counter U.S. conventional military superiority by exploiting the diffusion of new military technologies.[8]

The heart of China's sensor and weapon network is a "reconnaissance-strike complex" combining long-range precision-guided weapons such as anti-ship cruise missiles (ASCM) and anti-ship ballistic missiles (ASBM) with long-range targeting systems such as over-the-horizon (OTH) radars and electro-optical/infrared (EO/IR) satellites.[9] Much of this network is in place today and is projected to be fully operational by the 2020s.[10] The overall Chinese strategy appears designed to inflict substantial losses on U.S. forces in a rapid initial attack to demonstrate the United States' inability to defend its allies. In a second phase, "China would assume the strategic defense and confront the United States with the prospect of either paying a very high (and perhaps prohibitive) cost for reversing its gains, or accepting Beijing's fait accompli."[11]

Iran appears to be implementing a similar strategy to counter U.S. operations in the Persian Gulf. It combines improvised weapons such as explosive-laden boats with advanced capabilities such as ASCMs, ASBMs, and midget submarines "to deny or limit the US military's access to close-in bases and restrict its freedom of maneuver through the Strait of Hormuz."[12]

8 Andrew Krepinevich, Barry Watts, and Robert Work, *Meeting the Anti-Access and Area-Denial Challenge*. (Washington, DC: Center for Strategic and Budgetary Assessments, 2003), p. 1.

9 See Krepinevich, *Why AirSea Battle?*; Jan van Tol, Mark Gunzinger, Andrew Krepinevich, and Jim Thomas, *Air Sea Battle: A Point-of-Departure Operational Concept* (Washington, DC: Center for Strategic and Budgetary Assessments, 2010); and Roger Cliff et al., *Entering the Dragon's Lair: Chinese Anti-access Strategies and Their Implications for the United States* (Santa Monica, CA: RAND, 2007), available at http://www.rand.org/pubs/monographs/2007/RAND_MG524.pdf.

10 The "fully operational A2/AD network" would include fifth-generation strike fighters, communication systems, and undersea surveillance as well. See Jonathan Greenert, "Navy, 2025: Forward Warfighters," *U.S. Naval Institute Proceedings*, December 2011, p. 20, available at http://www.usni.org/magazines/proceedings/2011-12/navy-2025-forward-warfighters; and U.S. Department of Defense (DoD), *China Military Modernization* (Washington, DC: DoD, 2014).

11 Van Tol et al., *Air Sea Battle*, pp. xi–xii.

12 Mark Gunzinger and Chris Dougherty, *Outside In: Operating from Range to Defeat Iran's Anti-Access and Area-Denial Threats* (Washington, DC: Center for Strategic and Budgetary Assessments, 2011), pp. 21–22.

Iran's strategy is not, in itself, a war-winning strategy,[13] but by "significantly raising the costs or extending the timelines of US military intervention [this strategy] may create a window of opportunity for Iran to conduct acts of aggression or coercion."[14]

Other countries will be able to field elements of their own reconnaissance-strike complexes as the systems comprising them become cheaper, more automated, and easier to operate thanks to improved computer processing and incorporation of consumer electronics. Surface combatants will need to continue defending themselves and noncombatants against improving anti-ship weapons while enhancing their ability to destroy weapons-launching platforms on and under the water, in the air, and on the ground.

Instability will Persist as Indirect Conflicts Proliferate

The last quarter-century witnessed a higher incidence of conflict in Europe, the Middle East, and South Asia than occurred in the latter period of the Cold War. The National Intelligence Council predicts this trend will persist through 2030.[15] In particular, the Middle East and South Asia include a large percentage of countries with "lagging economies, ethnic affiliations, intense religious convictions, and youth bulges"[16]—conditions that increase the likelihood of internal conflict.[17]

A growing portion of this instability results from indirect forms of conflict. In the last decade, countries pursuing aggression against their neighbors increasingly shifted from direct military action toward the use of proxy or paramilitary forces and "lawfare." [18] This dynamic is apparent in the recent actions of China and Russia toward its neighbors.

The regions likely to experience increased conflict over the next decade include many U.S. allies and partners and key maritime crossroads such as the Gulf of Aden and Luzon Strait. Calls for U.S. surface combatants will likely increase to defend shipping from criminals and terrorists and to train friendly nations to protect their territory, citizens, resources, and infrastructure.

---

13 Caitlin Talmadge, "Closing Time: Assessing the Iranian Threat to the Strait of Hormuz." *International Security* 33, no. 1, 2008, pp. 82–117.

14 Gunzinger and Dougherty, *Outside In*, pp. 21–22.

15 National Intelligence Council, *Global Trends 2030: Alternative Worlds* (Washington, DC: National Intelligence Council, 2012), p. 70, available at http://www.dni.gov/index.php/about/organization/global-trends-2030.

16 National Intelligence Council 2020 Project, *Mapping the Global Future* (Washington, DC: Government Printing Office, 2004), pp. 97–98, available at http://www.dni.gov/files/documents/Global%20Trends_Mapping%20the%20Global%20Future%202020%20Project.pdf.

17 Ibid.

18 In this paper, lawfare refers to "the strategy of using—or misusing—law as a substitute for traditional military means to achieve an operational objective." See Charles J. Dunlap Jr., "Lawfare Today," *Yale Journal of International Affairs*, Winter 2008, p. 146. Original citation: Nils Petter Gleditsch et al., "Armed Conflict 1946–2001: A New Dataset," *Journal of Peace Research* 39, no. 5, 2002. Latest presentation: Lotta Themnér and Peter Wallensteen, "Armed Conflict, 1946–2013," *Journal of Peace Research* 51, no. 4, 2014.

Budgets are Projected to be Flat or Declining Relative to Inflation

The Navy's resources for improving surface fleet capability or capacity, however, are likely to be constrained. The Budget Control Act of 2011 (BCA) and the Bipartisan Budget Act of 2013 (BBA) cap overall defense budgets through 2021; these caps call for the defense budget to rise at approximately the rate of inflation. The Department of Defense's (DoD) budget constraints appear unlikely to change without the emergence of a significant new national security concern. Further, some analysts assess the budget caps could be a "ceiling" for future defense spending, rather than a temporary constraint, due to continued pressure on federal budgets from nondiscretionary spending such as Medicare and Social Security.[19]

The current budget drawdown is likely to affect recapitalization and modernization to a greater degree than previous drawdowns, placing additional pressure on the Navy's ability to evolve the surface fleet. While the overall percentage reduction imposed by the BCA/BBA budget caps is consistent with previous drawdowns,[20] the amount of the drawdown to be borne by personnel reductions will be much smaller,[21] which will shift more of the budget reduction onto procurement and research and development (R&D) accounts. This will be exacerbated when DoD begins to shift some activities being paid for with supplemental Overseas Contingency Operations (OCO) funding into the Services' base budgets.

The Navy is also not likely to receive a greater portion of a flat or declining DoD budget. Some analysts and former defense officials recommend[22] the Service's slice of the shrinking budget pie increase because naval forces are important to defense priorities such as the Asia-Pacific rebalance and "small footprint" counterterrorism operations described in the 2014 Quadrennial Defense Review (QDR).[23] However, such a shift would be inconsistent with the history of the past seventy years—it happened only once since World War II.[24] Moreover, the president's FY 2015 budget proposal maintains consistent budget shares between the Services through FY 2019.

---

19 Todd Harrison, *Chaos and Uncertainty: The FY 14 Defense Budget and Beyond* (Washington, DC: Center for Strategic and Budgetary Assessments, 2013).

20 Previous drawdowns were after the Korean War (51 percent), Vietnam (25 percent), and the Cold War (35 percent). The drawdown imposed by the BCA/BBA is about 35 percent from a post–Cold War high in 2010. Ibid.

21 In those previous drawdowns, personnel end strength fell 32 percent after the Korean War, 43 percent after the Vietnam War, and 35 percent after the Cold War. The planned personnel reduction in the current drawdown is 7 percent. In particular, Navy end strength will remain nearly constant during this drawdown. Ibid.

22 National Defense Panel, *Ensuring a Strong U.S. Defense for the Future* (Washington, DC: U.S. Institute of Peace, 2014), available at http://www.usip.org/sites/default/files/Ensuring-a-Strong-U.S.-Defense-for-the-Future-NDP-Review-of-the-QDR.pdf, accessed August 11, 2014.

23 DoD, *Quadrennial Defense Review 2014* (Washington, DC: DoD, 2014), available at http://www.defense.gov/pubs/2014_Quadrennial_Defense_Review.pdf.

24 President Eisenhower's "New Look" of the mid-1950s was the only strategy that drove a significant change in Service budget shares during peacetime. Otherwise budget shares only changed during wars when Army funding was increased to support ground operations. After each war, Army's budget share returned roughly to its prewar level. See Harrison, *Chaos and Uncertainty*.

Addressing Competing Interests

The most important of these trends for the Navy to address in a new surface warfare concept is improving and proliferating long-range sensor and weapon networks. Countering these networks and establishing sea control will require better surface fleet weapons and sensors than today and new operating concepts to employ them. But even with these improvements, large surface combatants will not be available to gain and maintain sea control unless the Navy implements new ways to mitigate its SSC shortfall and restore the division of labor between large and small surface combatants. Otherwise, more CGs and DDGs will be pressed into conducting traditional SSC missions of training, maritime security, and security cooperation.

The following chapters describe an overall approach to implement a new central concept for surface warfare and enable the surface fleet to address challenges from anti-access threats, instability, and flat or declining budgets.

CHAPTER 2

Offensive Sea Control: A Central Concept for Surface Warfare

The emerging strategic environment is likely to present U.S. forces with a set of new or intensifying operational challenges during a time of constrained or declining funding. Most importantly, within the next decade the surface fleet will have to adjust from treating sea control as a "given" to having to fight for it in the face of improving long-range sensor and weapon threats. Anti-ship missiles, in particular, will almost certainly continue to improve and be deployed in greater numbers on the ships, aircraft, and submarines of U.S. rivals, as well as on land. To gain sea control in this environment, the surface fleet will need to move from defeating enemy weapons (defensive sea control) to defeating enemy platforms before they can attack (offensive sea control).

Fortunately, a combination of new capabilities—both those we can incorporate over the next ten years as well as those promising major payoffs that we can develop now—and new operational concepts will enable the surface fleet to improve its ability to conduct offensive and defensive sea control. Just as important, they can also better enable the surface fleet to conduct a range of constabulary missions.

This chapter describes how the surface fleet can return to its Cold War focus on offensive sea control and reestablish the division of labor between large and small surface combatants. Capability and programmatic implications of these initiatives are described in Chapter 3. While the recommendations in this and the following chapter would remain largely intact in a broader analysis of the joint force beyond surface combatants, they would likely be adjusted to reflect interdependencies between the surface fleet and other forces.

Enduring Importance of Sea Control

Today's surface fleet missions and division of labor emerged during World War II as the fleet's employment and composition changed to exploit new technologies and counter the improving ability of Axis aircraft and submarines to contest Allied sea control. As the war progressed, battleships were used less for their original mission of SUW and more for AAW to defend the fleet,[25] whereas cruisers shifted from their traditional scouting and commerce raiding missions to become air defense platforms for carrier task forces. Destroyers, used as outer escorts for carrier task forces and to protect merchant convoys, were too few to counter the German submarine threat and lacked the capability to stop Japanese dive-bombers. The Navy responded by building larger destroyers with more AAW guns and augmenting them with smaller ASW and MIW-oriented combatants such as destroyer escorts, minesweepers, corvettes, and frigates. These developments were designed to improve Allied sea control, but they also established a distinction between larger, multi-mission surface combatants such as cruisers and destroyers and smaller, limited-mission combatants such as frigates.

The Cold War further refined this distinction and the surface fleet's mission priorities in the face of a new sea control threat. In the 1970s, the Soviet Union began deploying new SUW capabilities designed to prevent American convoys from reinforcing and resupplying NATO allies and hinder the U.S. fleet's ability to attack the U.S.S.R's northern, southern, and eastern flanks.[26] In particular, Soviet submarine- and surface-launched ASCMs threatened to push U.S. carrier battle groups (CVBG) too far away for naval aircraft to strike targets inside the Soviet Union as prescribed in the U.S. maritime strategy.[27]

The Navy planned to counter the improving Soviet threat by destroying enemy bombers, ships, and submarines before they could launch ASCM attacks, thereby thinning the density of missiles to be within the capacity of the CVBG's defenses. This sea control approach included the "Outer Air Battle" concept in which F-14 fighters guided by E-2C early-warning aircraft would intercept incoming Soviet bombers[28] while P-3C maritime patrol aircraft and submarines would engage Soviet submarines and surface ships outside ASCM range. Because of the severity of the Soviet threat, these operations were the main effort of the carrier air wing, escort submarines, and patrol aircraft until U.S. CVBGs were within striking range of the Soviet Union. The surface fleet planned to complement the Outer Air Battle using a portfolio of new sea control capabilities that would act "up, out, and down" to defeat Soviet missiles,

25 Bernard Brodie, *A Guide to Naval Strategy* (Princeton, NJ: Princeton University Press, 1944).

26 The Soviet Navy deployed the first ASCM capable of submerged launch (SS-N-7) in 1968 and its first supersonic ship/sub-launched ASCM (SS-N-22) in 1970.

27 Joseph Metcalf, "Surface Warfare and Surface Warriors," *U.S. Naval Institute Proceedings*, October 1985, pp. 68–80; and John Hattendorf and Peter Swartz, eds., *U.S. Naval Strategy in the 1980s: Selected Documents*, Naval War College Newport Papers, no. 33 (Newport, RI: Naval War College Press, December 2008).

28 Michael Smith, *Antiair Warfare Defense of Ships at Sea*, professional paper 319 (Alexandria, VA: Center for Naval Analysis, September 1981).

aircraft, surface ships, and submarines that made it past the fleet's outer defenses but before they could reach the CVBG. Specifically:

- "Up"—engage incoming aircraft and missiles using the Aegis combat system, which combined "kinetic" weapons such as the SM-2 interceptor[29] and "non-kinetic" weapons such as the SLQ-32 electronic warfare system;[30]
- "Out"—attack enemy surface ships with Harpoon ASCMs;[31] and
- "Down"—find or drive off submarines using new active helicopter sonars and passive shipboard towed array sonars and attack them with the upgraded Mk-46 Mod 5 lightweight torpedo.[32]

Although portrayed as a vision for the whole surface fleet, this framework applied mainly to large surface combatants—CGs and DDGs. SSCs such as minesweepers, patrol craft, and FFGs would contribute to sea control, but their focus would predominantly be on escort operations and peacetime missions such as maritime security and training allied and partner navies.

Late in the Cold War the surface fleet added another mission with the introduction of the Tomahawk land attack cruise missile (LACM). The Tomahawk gave surface combatants an independent long-range strike capability and presented the Soviets with the threat of attacks from more directions than possible with U.S. carrier-based aircraft alone. This increased Soviet concerns about air defense and drove additional Soviet surface-to-air interceptor investments.

The LACM also began a shift toward power projection that took the surface force away from its previous focus on sea control. The collapse of the Soviet Union in 1991 hastened this shift by ushering in what Robert Work characterizes as a new "Transoceanic Era" for the U.S. military.[33] Rather than emphasizing the garrisoning of its forces overseas to deter and contain Soviet aggression as they had during the Cold War, the United States would adapt its military to become more expeditionary and respond to crises and acts of aggression by deploying from a much smaller number of allied or U.S. bases. In this era, ships and submarines with LACMs became the force of choice for small-scale strikes against terrorists or rogue states because

29 Throughout this study, the term "interceptor" describes a missile used to shoot down another missile or an aircraft. "Missile" denotes all other airborne weapons with propulsion systems.

30 AEGIS Combat Systems Operational Support Group, *AN/SLQ-32(V) Operator's Handbook: Volume 1*, technical document 376 (San Diego, CA: Naval Ocean Systems Center, August 29, 1980), available at http://www.dtic.mil/dtic/tr/fulltext/u2/a090473.pdf.

31 In the 1980s, the Navy also briefly fielded the Tomahawk anti-ship missile (TASM). Because it did not have a seeker (unlike Harpoon), TASM required external guidance to reach the target, which proved problematic at long range in contested environments.

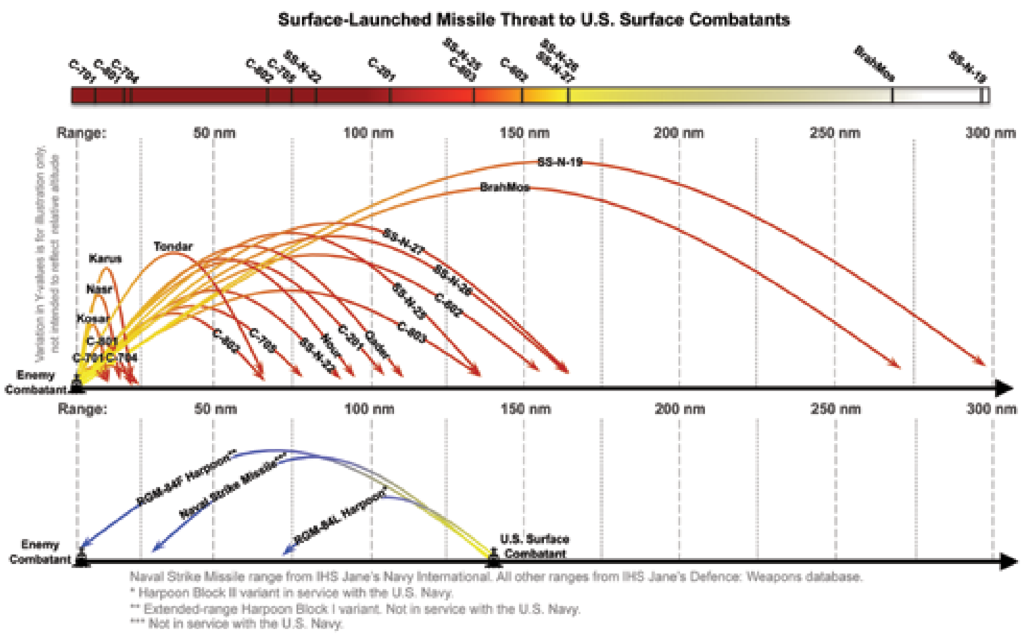
32 Metcalf, "Surface Warfare and Surface Warriors."

33 The original Oceanic Era, noted by Samuel Huntington, began in the 1900s when the U.S. military began conducting operations overseas instead of primarily in North America. See Robert Work and Andrew Krepinevich, *A New Global Defense Posture for the Second Transoceanic Era* (Washington, DC: Center for Strategic and Budgetary Assessments, 2007).

they were already continuously overseas and did not require Washington to secure permission for use or overflight of other states' territory. With no maritime rivals, strike became an increasingly important mission for Navy leaders interested in showing the fleet's relevance.

With new missions to address and a benign maritime threat environment, less investment went into surface fleet ASW and SUW capabilities or next-generation AAW weapons. But sea control threats, particularly ASCMs, continued to advance (see Figure 1). Navy leaders and analysts today assess that the fleet's CGs and DDGs do not have the AAW capacity to defend against modern air and missile threats, such as those posed by China,[34] and lack the reach to defeat submarines and surface ships before they can attack with sophisticated, long-range ASCMs.[35] This leaves them unable to defend themselves, much less defend the joint force or establish sea control in contested waters.

FIGURE 1: U.S. AND POTENTIAL ENEMY ASCM RANGES



34 While Iran does not have the military industrial base and technical capability of Russia or China, it is fielding some ASCM and AAW systems purchased from those countries and can exploit its geography to gain an outsized effect from relatively short-range and unsophisticated systems. For example, at the Strait of Hormuz, it could mass large numbers of relatively simple ASCMs that would be effective against modern air defenses because of their numbers.

35 John Keller, "How Vulnerable are U.S. Navy Vessels to Advanced Anti-Ship Cruise Missiles?" *Military and Aerospace Electronics* (blog), July 9, 2013, available at http://www.militaryaerospace.com/blogs/aerospace-defense-blog/2013/07/how-vulnerable-are-u-s-navy-vessels-to-advanced-anti-ship-cruise-missiles.html; John Patch, "Fortress at Sea? The Carrier Invulnerability Myth," *U.S. Naval Institute Proceedings*, January 1, 2010, available at http://www.usni.org/magazines/proceedings/2010-01/fortress-sea-carrier-invulnerability-myth; and Jonathan Greenert, U.S. Navy Chief of Naval Operations, "Planning for Sequestration in FY2014 and Perspectives of the Military Services on the Strategic Choices and Management Review," Statement before the House Armed Services Committee, September 18, 2013.

Offensive Sea Control: The 21st Century's "Outer Air Battle"

Navy leaders characterize the Service's current role in joint warfighting as initially gaining and sustaining access for the joint force[36] as described in the DoD's Joint Concept for Access and Maneuver in the Global Commons (JAM-GC).[37] This responsibility often falls to naval forces because they can conduct sustained large-scale operations from an offshore sanctuary outside the range of enemy land-based weapons and are often the first element of the joint force to arrive at the conflict area. In comparison, air forces require fixed land bases that may not initially be positioned or prepared to support sustained operations. The surface fleet's main contribution to access is intended to be sea control, as described in the Naval Operations Concept.[38] While ground, air, and other naval forces will likely contribute to sea control in a variety of situations, they also have competing power-projection missions such as amphibious assault, strike, and supporting surveillance and reconnaissance. Only surface combatants will retain sea control as their primary responsibility.

Improvements in the number and capability of anti-access weapons suggest that to achieve sea control in the future, the Navy should return to its Cold War approach of defeating enemy aircraft, ships, submarines, and shore-based missile launchers before they are within weapons range of U.S. forces—but updated for 21st-century challenges. In particular, enemy anti-ship missiles are more capable today than during the Cold War. The latest ASCMs are generally faster and have more sophisticated maneuvers than Soviet missiles, while the range of ASBMs (which did not exist in the Cold War) can reach 800 to 1,000 nm.[39] Warfighting scenarios will also be more stressing on naval forces compared to the Cold War. Against the Soviets, naval forces were expected to open ancillary fronts to the main effort in Central Europe and could devote all their attention to gaining sea control through approaches such as Outer Air Battle. In future scenarios such as against Iran in the Persian Gulf, China in the Western Pacific, and North Korea on the Korean Peninsula, naval forces will provide a significant portion of joint

36 Greenert, "Planning for Sequestration in FY2014"; Christopher Cavas, "China Dominates Naval Strategy Discussion," *Defense News*, June 17, 2014; and John Richardson, "The Future Navy," Navy briefing, May 17, 2017, available at http://www.navy.mil/navydata/people/cno/Richardson/Resource/TheFutureNavy.pdf.

37 Michael E. Hutchens, William D. Dries, Jason C. Perdew, Vincent D. Bryant, and Kerry E. Moores, "Joint Concept for Access and Maneuver in the Global Commons: A new Joint Operational Concept," *Joint Force Quarterly* 84, no. 1, National Defense University, January 27, 2017, p. 134, available at http://ndupress.ndu.edu/JFQ/Joint-Force-Quarterly-84/Article/1038867/joint-concept-for-access-and-maneuver-in-the-global-commons-a-new-joint-operati/.

38 U.S. Navy, *Naval Operations Concept 2010*.

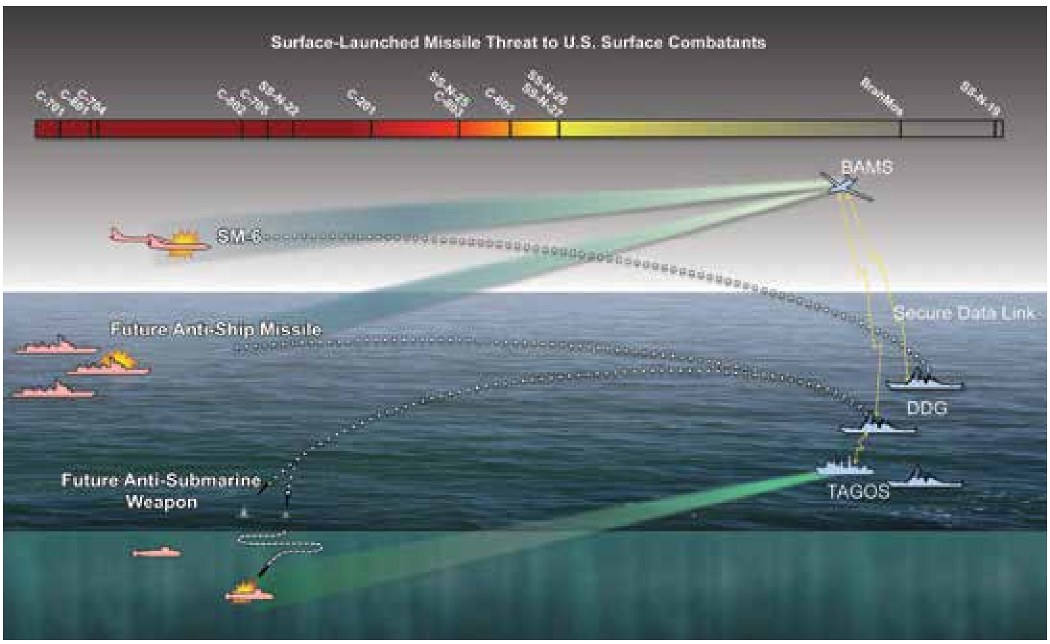
39 At those ranges, however, enemy forces will highly depend on long-range surveillance and communication systems to provide targeting information to missiles. Surface combatants would be more effective in targeting these enablers, rather than planning to attack mobile ASBM launchers themselves from 800–1,000 nm away. For a description of the threat, see DoD, *China Military Modernization*.

force power projection. This will therefore limit the ability of carriers, amphibious ships, and submarines to contribute to sea control.[40]

The 21st-century version of Outer Air Battle is offensive sea control, also called "Distributed Lethality" by Navy surface fleet leaders.[41] This differentiates it from defensive sea control, which consists of defending forces from adversary weapons. It also differentiates the new concept from Outer Air Battle, which focused mainly on defeating enemy aircraft; offensive sea control is intended to defeat the whole range of enemy weapons platforms.

Submarines, amphibious forces, and aircraft carriers are expected to have greater and more immediate power-projection responsibilities in likely future scenarios than in the Cold War. Therefore, in offensive sea control, surface combatants will need to be able to defeat enemy aircraft, submarines, ships, and land-based missile launchers outside enemy ASCM range with minimal support, such as targeting, from other naval forces (See Figure 2).

FIGURE 2: OFFENSIVE SEA CONTROL



40 The limited involvement of naval forces indicates ground forces, in particular, may be able to contribute to sea control to a greater degree than during the Cold War, as they will not be involved in these scenarios in large numbers for the first several weeks of the conflict, or (in the case of Iran and China) perhaps not at all. This study does not address opportunities for ground forces to conduct counter-maritime missions, but other analytic work is underway in this area.

41 Thomas Rowden, "Surface Warfare Must Take the Offensive," *The Diplomat*, June 28, 2014; and Thomas Rowden, Peter Gumataotao, and Peter Fanta, "Distributed Lethality," *Proceedings*, January 2015, available at http://www.usni.org/magazines/proceedings/2015-01/distributed-lethality.

Targeting from other U.S. or allied forces will be essential since enemy ASCMs have ranges of about 150 nm or more, which is beyond the horizon of surface combatant radars and beyond normal sonar detection range. To find enemy submarines outside ASCM range, surface combatants will rely on information from Sound Surveillance System (SOSUS) arrays and deployed sonar arrays on the ocean floor, ocean surveillance (T-AGOS) ships equipped with low-frequency active acoustic (LFAA) sonar, and embarked helicopters with active sonar. The contact information from these sources will not be highly precise, but would be enough to cue other, more precise, sensors or enable long-range attacks intended to suppress the submarine's operations or compel it to evade. Such suppression attacks exploit the three major disadvantages of submarines: they are relatively slow when trying to be stealthy; have no self-defense systems; and lack the sensor range and precision to delay evasion until it is evident that an incoming weapon could hit the submarine. Consequently, once attacked (even unsuccessfully), a submarine generally will need to evade the weapon, clear the area, and reestablish its stealth before continuing with the mission. Suppression will often be enough to achieve the desired effect as part of offensive sea control, but compelling the submarine to evade will also make it more detectable to more precise sensors that may enable a more lethal ASW prosecution. This overall ASW approach was employed successfully in both world wars and the Cold War.[42]

Surface combatants will target enemy surface ships and aircraft in offensive sea control using netted fire control systems such as Cooperative Engagement Capability (CEC) between Aegis ships, Naval Integrated Fire Control-Counter Air (NIFC-CA) between Aegis ships and E-2D early-warning aircraft, and Link-16 between E-2Ds and unmanned air vehicles such as the MQ-4 Triton or Tactical Exploitable Reconnaissance Node (TERN).[43] These systems enable participating ships and aircraft to share sensor data in real time, so a surface combatant can attack a target beyond the range of its own sensors. They can also support unwarned attacks by enabling a platform in the air or forward on the surface to passively locate an enemy platform through its radar or communication emissions and relay target information back to surface combatants that can launch long-range attacks from over the horizon.

Once enemy ships, submarines, aircraft, or shore-based launchers are located, surface combatants can engage them with long-range weapons. These attacks may not need to destroy the enemy platform to be successful. If they simply disrupt enemy SUW operations, these attacks may enable the fleet's freedom of action and stimulate reactions by the enemy that provide improved target information to support a re-attack. And if engagement outside enemy ASCM range is not successful, surface combatants could mount an effective defense against ASCMs using a high-density defensive AAW umbrella (described further below) while continuing to engage enemy strike platforms.

42 John Stillion and Bryan Clark, *What it Takes to Win: Succeeding in 21st Century Battle Network Competitions* (Washington, DC: Center for Strategic and Budgetary Assessments, 2015).

43 Defense Advanced Research Products Agency (DARPA), "Tactical Exploitable Reconnaissance Node (TERN)," available at https://www.darpa.mil/program/tern.

If implemented as designed, offensive sea control will enable every surface combatant to be a potential offensive threat to the enemy as either a sensor or weapons-launch platform. This will make the enemy's targeting problem more challenging by distributing the surface fleet's offensive capacity over many ships. It will also enable a wide range of new surface action group (SAG) configurations that combine large and small surface combatants to conduct offensive sea control operations.

There are several major shortfalls that need to be addressed in order to implement the concept of offensive sea control. These shortfalls imply the need for new surface fleet concepts and capabilities, to include:

- New concepts for sea-based anti-air warfare;
- New approaches to weapons development;
- New concepts to affordably increase surface combatants for offensive sea control; and
- New approaches to defensive and constabulary missions.

New Concept for Sea-based Anti-air Warfare

The first step toward implementing offensive sea control is to enable surface combatants to carry more offensive weapons. The main battery of a CG or DDG is its VLS magazine, which has a finite capacity and currently cannot be reloaded at sea.[44] With a standard peacetime missile loadout, on average only about a third of surface fleet VLS cells are devoted to missiles such as the Tomahawk or SM-6 that could be considered offensive (since they can engage enemy weapon launchers before they are in range to attack). Offensive SUW, AAW, ASW, and strike weapons compete for space in the VLS magazine with defensive AAW weapons, so each cell not needed for air defense could be devoted instead to attacking ships, aircraft, submarines, or launchers and sensors ashore.

War at sea today and in the future will likely include large ASCM salvos from ships, submarines, and aircraft and a smaller number of ASBM attacks from shore. Today's long-range ASCMs cost from $1 million–$3 million,[45] whereas an ASBM costs about $6 million–$10

44 Flight 1 DDG-51s have 90 VLS cells, whereas Flight II and IIa DDG-51s have 96 VLS cells; a CG has 122 cells. There are several potential approaches for at-sea reloading that could be pursued to increase the effective capacity of a large surface combatant.

45 An Indian/Russian BrahMos ASCM is $2 million–$3 million. See "Indian Army Demands More Missile Regiments," *Strategy Page* blog, January 26, 2010, available at: http://www.strategypage.com/htmw/htart/articles/20100126.aspx. A U.S. Tomahawk LACM (comparable in sophistication to many ASCMs) is $1.3 million; see DoD, *Fiscal Year (FY) 15 Budget Estimates: Weapons Procurement, Navy* (Washington, DC: DoD, 2014), available at http://www.finance.hq.navy.mil/fmb/15pres/wpn_book.pdf.

million;[46] an adversary could be expected to launch dozens of them in each attempt to disable or destroy a $1 billion–$2 billion DDG or the $14 billion carrier it defends.

Defeating large ASCM salvos is expected to require many VLS-launched interceptors, but the surface fleet could reduce this air defense "overhead" by adopting a new approach to sea-based AAW. Large surface combatants today employ an integrated, layered AAW approach to protect themselves and their defended ships (carriers, amphibious ships, etc.). This approach is designed to engage enemy aircraft and missiles multiple times starting from long range (from 50 nm to more than 100 nm) through medium range (about 10nm to 30 nm) to short range (less than about 5 nm). Each layer is serviced by a different set of interceptors, with those for the long-range layer (e.g., SM-2 and SM-6) being preferentially used; they are also the largest (taking up the most VLS space) and often the most expensive.[47] The short-range layer is addressed by individual ships' self-defense systems. Electronic warfare jammers and decoys are also used from medium to short range to defeat missile seekers. The new approach presented below calls for separating the missions of the long-range and medium-range AAW layers. It would shift surface combatant long-range AAW capabilities to focus on destroying enemy aircraft as part of offensive AAW and establish a dense, medium-range defensive AAW umbrella designed to defeat enemy missiles.

The current layered defensive AAW approach puts surface combatants on the wrong end of weapon and cost exchanges. Figure 3 shows the number of ASCMs that can be defeated with a hundred ship-based interceptors, which is close to a DDG-51's total VLS capacity of ninety-six cells. As the figure shows, using today's standard shot doctrine of "shoot, shoot, look, shoot"[48] (SS-L-S), fewer than fifty incoming missiles could be engaged regardless of the interceptor's probability of "killing" the missile (also known as Pk for "kill probability" or "probability of kill"). A S-L-S shot doctrine may enable more ASCMs to be engaged, but would increase risk; unless the ASCM is initially engaged at long range using OTH targeting data, it may reach the target before a second engagement can occur. EW systems do not enable the ship to reduce the number of interceptors shot at incoming ASCMs because they cannot defeat the ASCM until the missile breaks the horizon—about 10 nm out for a surface combatant. Instead they are used as a last resort to stop "leakers" from reaching the defended ship. As a result, the complete VLS capacity of a DDG (if all devoted to air defense) would be consumed against fewer than fifty ASCMs—missiles that would cost the enemy about 2 percent the price of a DDG.[49]

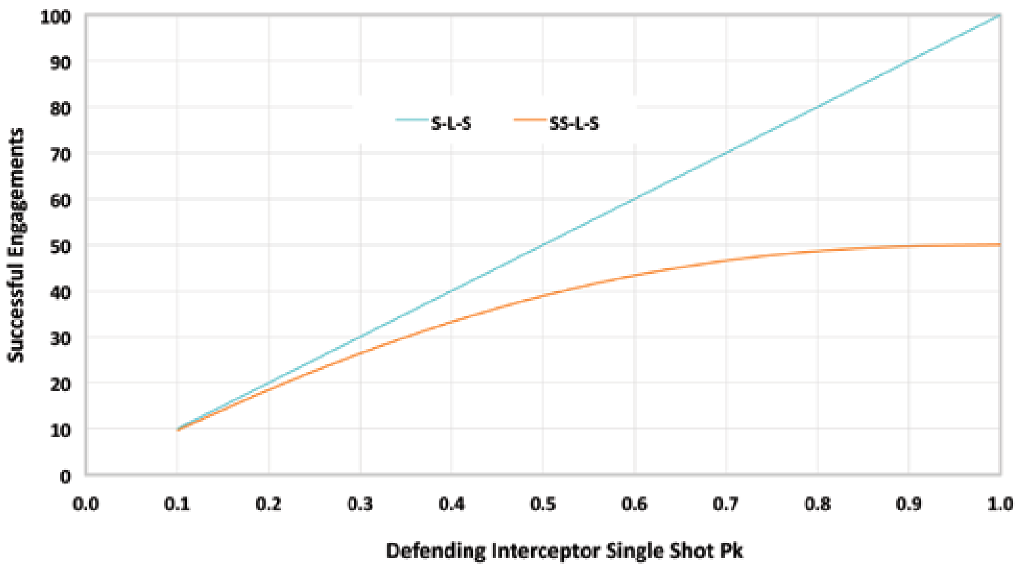
46 Two Chinese analysts, Qiu Zhenwei and Long Haiyan, published this estimate in 2006. See Andrew S. Erickson, "Ballistic Trajectory—China Develops New Anti-Ship Missile," *Jane's Intelligence Review*, 22, January 4, 2010.

47 Navy Air and Missile Defense Command (NAMDC), *The Navy Update and Role in Integrated Air and Missile Defense*, Power Point Presentation (Dahlgren, VA: NAMDC, August 31, 2009), available at http://www2.navalengineers.org/sections/flagship/documents/comrelbrief11aug09part2.ppt.

48 A common U.S. air defense tactic is to shoot two interceptors at an incoming missile, look for successful engagement, and then shoot again if necessary. Therefore, at least two interceptors are expended on every incoming missile.

49 A Flight II or IIa DDG-51 has ninety-six VLS cells. A nominal wartime loadout would be forty-eight SM-2 interceptors, sixteen SM-6 interceptors, thirty-two ESSMs (eight cells), eight ASW rockets, and sixteen Tomahawk LACMs.

FIGURE 3: NUMBER OF ASCMS DEFEATED BY A MAGAZINE OF 100 INTERCEPTORS



Because it would be too risky to adjust air defense shot doctrine, better long-range interceptors will not improve the weapon exchange and only exacerbate the Navy's cost disadvantage. The medium to long-range SM-6 interceptor is faster, longer range, more maneuverable, and has a better seeker than the SM-2. This would likely provide the SM-6 a higher Pk than SM-2 against any given ASCM. But an SM-6 interceptor costs about $4 million, whereas an SM-2 costs about $680,000[50] and a typical advanced ASCM costs about $2 million–$3 million.[51] Given a SS-L-S firing doctrine, each defensive engagement using SM-6s will cost two to four times that of the ASCM it is intended to defeat. Alternatively, four medium-range SM-2 interceptors would cost about the same as the ASCM and would likely be more effective than two SM-6s. This approach would address the cost exchange problem, but would worsen the weapons exchange problem.

50 DoD, *Fiscal Year (FY) 15 Budget Estimates: Weapons Procurement, Navy*.

51 This is the cost of the Russia/India codeveloped BrahMos ASCM based on the Russian SS-N-26 Yahkont ASCM. The BrahMos ASCM is being actively marketed to Latin American and Southeast Asian militaries; see "Indian Army Demands More Missile Regiments," 2010; and "BrahMos Missile Can Be Exported to Southeast Asian, Latin American Nations," *Economic Times*, August 3, 2014. For comparison, a Tomahawk costs about $1.3 million; see DoD, *Fiscal Year (FY) 15 Budget Estimates: Weapons Procurement, Navy*.

A defensive AAW scheme centered on medium-range (10–30 nm[52]) interceptors such as the Evolved Sea Sparrow Missile (ESSM) would address both the weapons and cost exchange challenges. ESSM engagements would be cheaper[53] than using the SM-6—even if an extra ESSM is needed to account for them having a lower Pk. Moreover, the ESSM Block 2 that will debut in 2020 will have a fully active seeker similar to the SM-6, and will likely boast a similar Pk against most ASCMs. Against the fastest supersonic ASCMs and future hypersonic ASCMs, SM-2s or SM-6s may be needed for the speed to intercept the incoming missile. Medium-range interceptors such as ESSM are smaller than longer-range interceptors and can be placed in "quad packs" in each VLS cell, quadrupling the ship's defensive AAW capacity or enabling fewer VLS cells to be assigned to defensive AAW weapons. EW jamming, deception, and decoy systems will complement medium-range interceptors from 10–30 nm (depending on the missile's altitude), and EW performance will also improve over the next decade as the Navy continues to field upgrades to the SLQ-32 EW system common to all large surface combatants.

This new AAW concept acknowledges the challenges in obtaining OTH targeting data in an highly contested environment where long-range data links could be jammed. Detecting a sea-skimming ASCM at the SM-6's maximum range would require a surface sensor positioned more than 100 nm forward from the surface combatant or an airborne sensor at more than 10,000 feet of altitude due to the inability of shipboard S or X band air defense radars or passive sensors to see over the horizon. The proposed concept shifts the defensive AAW focus to a range in which a CG or DDG can use its organic (including embarked helicopter) sensors to detect incoming missiles. For example, using onboard sensors, a DDG or CG could detect an incoming sea-skimming ASCM at about 10 nm away. Using its embarked helicopter at a nominal altitude of 800 feet, the ship could detect a sea-skimming ASCM at about 30 nm. Higher-altitude ASCMs and aircraft could be detected at longer ranges.

A medium-range defensive AAW approach will also better enable the surface fleet to integrate new weapons such as lasers, high-power radiofrequency weapons (HPRF), EMRGs, and hypervelocity projectiles (HVP) that will likely be mature in the early to mid-2020s.[54] Because they do not require VLS cells, increasing the use of these systems for defensive AAW

52 An escort will need defensive AAW capabilities that reach a least 20–30 nm to be able to defend nearby ships. For safety, Navy ships normally maintain at least 3–5 nm between ships. An ASCM travelling at Mach 2 will take about forty-five seconds to reach a targeted ship 20 nm away. An escort ship could engage the incoming ASCM with ESSMs at that range from 10 nm on the other side of the targeted ship. These engagements would occur more than 5 nm from the defended ship, after which the defended ship's point defenses—close-in weapon system (CIWS) and Rolling Airframe Missile (RAM)—would be in range to engage "leakers" that are not defeated by the ESSMs.

53 An ESSM costs about $1.3 million; see DoD, *Fiscal Year (FY) 15 Budget Estimates: Weapons Procurement, Navy*.

54 An HPRF weapon uses a high-energy RF pulse to disrupt or damage electronics inside a threat missile. The HVP is an artillery round that can be shot from a gun or EMRG and achieve hypersonic muzzle velocities (more than Mach 5), which would enable it to be shot in front of incoming missiles. The HVP would either directly hit the incoming weapon or (more likely) explode and use shrapnel to damage the missile and send it off course. Ronald O'Rourke, *Navy Lasers, Railgun, and Hypervelocity Projectile: Background and Issues for Congress*, RL 32109 (Washington, DC: Congressional Research Service, June 7, 2017), available at https://fas.org/sgp/crs/weapons/R44175.pdf; and Sydney J. Freedberg Jr., "Lasers vs. Drones: Directed Energy Summit Emphasizes the Achievable," *Breaking Defense*, June 23, 2016, available at http://breakingdefense.com/2016/06/lasers-vs-dronesdirected-energy-summit-emphasizes-the-achievable/.

will enable the Navy to shift additional VLS capacity to offensive weapons.[55] Lasers, HPRF weapons, EMRG, and HVPs are most effective at medium ranges, and thus are consistent with a shift in emphasis toward EW and medium-range interceptors such as ESSM in providing defensive AAW. Lasers and HPRF operate in a straight line from the weapon to the target and thus are limited by the horizon from engaging an incoming sea-skimming ASCM at more than 10–15 nm. Further, the shipboard lasers expected to be mature in the mid-2020s will only have the power to be effective against ASCMs out to a range of about 10 nm.[56]

HVPs from an EMRG or naval gun will have a longer maximum range than lasers, but are also constrained by physics to shorter ranges for defensive AAW. The 32-megajoule (MJ) EMRG the Navy is testing ashore today can launch a projectile at Mach 7 that will travel about 110 nm surface-to-surface and hit a target or burst into fragments. A naval gun is expected to launch an HVP at about Mach 5 and reach 40–70 nm.[57] Since an HVP is unpowered, it travels a generally ballistic path and slows throughout its flight, which will limit its effective range for defensive AAW to much less than its surface-to-surface range. Although an HVP could theoretically engage a low-flying ASCM at close to its maximum range since it is essentially a surface target, the HVP time of flight will be about two minutes. During that time a modern supersonic ASCM is likely to maneuver, and the unpowered projectile cannot correct for significant changes in target position. At an engagement range of about 30 nm for an EMRG or 10 nm for a naval gun, an HVP will reach the incoming missile in about 10–20 seconds, allowing much less time for the missile to maneuver. Unlike the sea-skimming ASCM, an ASBM warhead is likely to be diving toward the ship from high altitude, which will require the HVP to go up to meet it. An HVP will gain altitude for the first 10–30 nm of its travel, enabling it to potentially engage incoming ASBM warheads at that range.

Lasers, HPRF weapons, EMRG, and HVPs, however, will not be able to completely replace interceptors or point defense systems. A laser defeats an incoming ASCM by burning through its casing, causing it to lose aerodynamic stability and veer off course, or damaging its seeker, so the ASCM cannot find its target. HPRF weapons use a high-power RF pulse to damage a missile's electronics. Too much moisture in the air may prevent the laser or HPRF weapon from transmitting enough energy to the ASCM, while clouds, dust, or fog can prevent the electro-optical directors that aim the laser or HPRF weapon from "seeing" the target. The EMRG is not affected by atmospheric effects but will require more electrical power than a

---

55 Lasers and EMRG would also be possible point defense weapons at short (<5 nm) range. This application, however, would not address the shortage of VLS cells on surface combatants.

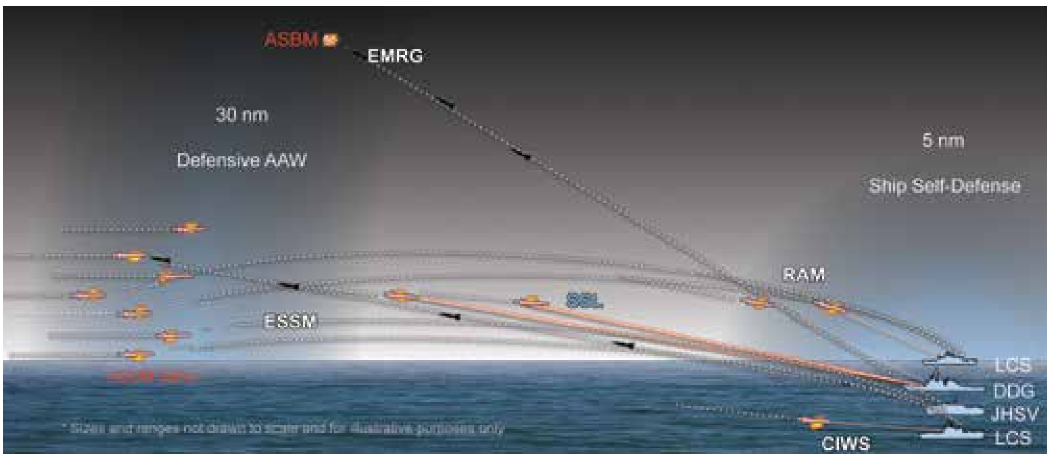
56 Ronald O'Rourke, *Navy Shipboard Lasers for Surface, Air, and Missile Defense: Background and Issues for Congress*, R41526 (Washington, DC: Congressional Research Service, July 31, 2014), available at http://fas.org/sgp/crs/weapons/R41526.pdf. Also, as lasers become more common in defensive AAW, potential adversaries may begin attempting to harden missiles against laser attack.

57 According to BAE Systems, an HVP's surface-to-surface firing range is more than 40 nautical miles when fired from a Mk 45 Mod 2 5-inch gun and more than 70 nautical miles when fired from a 155mm gun on a DDG-1000 class destroyer. See BAE Systems, "Hyper Velocity Projectile (HVP)," factsheet, updated June 2016, available at http://www.baesystems.com/en/product/hyper-velocity-projectile-hvp.

CG or *Arleigh Burke* DDG can generate; it will have to be initially deployed on a separate vessel such as an expeditionary fast transport (EPF) or *Zumwalt* DDG. And even when the required power levels are available, the EMRG or naval gun HVP rate of fire will only be six to ten shots per minute, which will limit the salvo size that can be engaged to between three and five missiles.[58]

The proposed medium-range defensive AAW scheme (see Figure 4) would consist of lasers, HPRF weapons, EMRG, HVPs, interceptors (e.g., ESSM), and EW systems engaging incoming missiles in a dense layer from 10–30 nm. This is far enough away for one surface combatant to protect another or to defend other ships such as a carrier or transport. It is also much more dense than today's layered air defense scheme, since each VLS cell shifted from SM-2s and SM-6s to ESSM provides four times the defensive AAW capacity; EMRG, HPRF weapons, HVPs, and lasers will add even greater capacity. Individual ship point-defense systems would engage "leakers" at 2–5 nm, but this constitutes self-defense rather than a defensive AAW layer.

FIGURE 4: NEW DEFENSIVE AAW SCHEME



Automated decision aids that match defensive AAW systems to incoming missiles will be an essential element of this scheme since multiple systems will be engaging incoming missiles at the same approximate range. These decision aids are inherent in the Aegis combat system but would need to be modestly upgraded to incorporate new systems. EMRG host platforms like EPF would likely need a network such as CEC installed to enable them to participate in the Aegis combat system.

58 For example, a nominal ASCM speed is Mach 3.5 or about 2,500 kts, and EMRG projectiles will average about Mach 5 or about 3,600 kts. The ASCM will travel about 6 nm between EMRG shots if it has a ten-shot/minute firing rate. If the ASCM salvo is initially engaged at 30 nm, the EMRG will be able to shoot five times at the incoming salvo before it arrives at the ship. With a SS-L-S doctrine that enables at most three missiles to be engaged, and with a S-L-S doctrine at most five could be engaged.

A key barrier to implementing this new AAW scheme is cultural. Today's surface combatant commanders prefer defenses that can engage incoming missiles multiple times through multiple layers. This provides a false confidence, however. A layered approach that starts at long ranges (>100 nm) uses larger, more expensive interceptors preferentially and will consume defensive AAW capacity faster than a single medium-range defensive layer without substantially improving air defense effectiveness. The proposed defensive AAW approach will provide rapid engagements with prompt feedback to commanders, who can re-engage an incoming missile multiple times within the short-range layer using multiple systems guided by automated decision aids such as Aegis.

Offensive AAW is the other side of the new sea-based AAW approach. This is where long-range (50 nm to more than 100 nm) interceptors such as SM-6s are better suited. SM-6s, in particular, can engage enemy aircraft outside their ASCM range and are much less expensive than the aircraft they will destroy, producing a more advantageous cost exchange than using SM-6 against enemy ASCMs. Enemy aircraft also generally fly at higher altitudes than ASCMs, enabling them to be detected farther away by shipboard radars whose visibility is limited by the horizon. When available, the engagement range for offensive AAW could be enhanced by OTH targeting information via CEC or NIFC-CA.

This new approach to sea-based AAW would increase the capacity of surface combatants for defensive AAW and enable more of their VLS cells to host offensive AAW, SUW, and ASW missiles—two essential elements to the surface fleet regaining its ability for offensive sea control. The detailed programmatic implications of this change and resulting notional VLS cell allocation are described in Chapter 3.

New Approach to Weapons Development

Implementing offensive sea control fundamentally requires that surface combatants have offensive weapons with longer ranges than the enemy's ASCMs. The surface fleet lacks those weapons today, especially in SUW and ASW. Further, even if surface combatants deploy longer-range offensive weapons, they will be limited by the space available in their main battery, the VLS magazine.

The relevant metric to consider is the number of loaded VLS cells on station that can conduct the needed offensive mission. As the new AAW scheme discussed above is put into place, more VLS cells will become available for offensive weapons, but this may be a relatively small increase until non-VLS defensive AAW systems such as lasers, HPRF weapons, EMRG, and HVPs are widely fielded. To sustain more on-station offensive VLS capacity, the surface fleet should aggressively pursue two initiatives. First, surface combatants should establish the ability to reload missiles at sea. This would enable empty cells to be refilled and enable changing the missiles carried by the ship to comport with changing mission priorities.[59] Second, the surface fleet should work to extract more offensive capacity from each VLS cell by pursuing a new approach to weapons development that prioritizes three attributes:

1. Relevant capability to conduct offensive missions
2. Multi-mission versatility
3. Smaller physical size

The first attribute addresses the minimum capability needed to conduct offensive sea control. The surface fleet's most important shortfall, as noted above, is its current range disadvantage against the anti-ship missiles most likely to be employed against U.S. forces. This range disadvantage means U.S. ships today can conduct only defensive AAW, ASW, and SUW; they will already be inside the ASCM range of the enemy and will be compelled to respond to attacks rather than go on offense and engage the enemy from outside his reach. The Navy is addressing this shortfall as it develops the SM-6 interceptor, LRASM, and Next Generation Land Attack Weapon (NGLAW) to replace, respectively, the Cold War-era SM-2, Harpoon, and Tomahawk. These new weapons are intended to enable offensive operations, but they will not necessarily increase the VLS capacity of surface combatants.

The surface fleet could get more effective capacity out of the VLS magazine by making each VLS weapon applicable to as many missions as possible. The Navy's current and planned VLS weapons are generally dedicated to a single mission. If the mission focus of a surface combatant changes during a deployment, the ship cannot quickly adjust its weapons loadout to maximize capacity for the new mission since at-sea VLS reloading (if and when fielded) would take a ship off the "battle line" for one to two days. If most of its weapons were multi-mission, the ship could have just as much capacity for the new mission as for the previous one.

Further, the surface fleet could expand the actual capacity of the main battery by developing smaller weapons, such as ESSM, that can fit more than one to a VLS cell. Fielding a smaller missile, however, will generally require accepting shorter range, a smaller warhead, or both. Trends in threat weapon systems suggest the Navy should emphasize range at the expense of warhead size. Smaller warheads can be as effective as large ones by achieving "mission kills," where the target is disabled rather than destroyed. The more sophisticated reconnaissance-strike systems being fielded by potential adversaries such as Iran, Russia, and China use sensitive sensors, computer controls, and communication networks that are increasingly vulnerable to even small attacks, making them more susceptible to mission kills.

59 Based on experiments with prototype systems, VLS reloading will take six to eight hours. To be able to reload, the ship would likely need to leave the area in which it would be subject to ASCM attack or engage enemy ships, submarines, or aircraft (the "battle line"). This would nominally be 200 nm (the maximum effective range of most ship and sub-launched ASCMs), which would take about half a day each way at 15–20 kts (a surface combatant's economic speed). See Craig Hooper, "VLS Underway Replenishment: When Will the Navy Get Serious?" *Defense Tech*, June 10, 2010, available at http://defensetech.org/2010/06/10/vls-underway-replenishment-when-will-the-navy-get-serious/.

Some of the surface fleet's current missiles incorporate these attributes. The ESSM and SM-2 interceptors used for defensive AAW today also have surface attack modes not normally employed. The longer-range SM-6 is being modified to incorporate an anti-ship mode and strike.[60] This will make each SM-6 useful for offensive AAW, SUW, or strike missions, providing greater effective capacity from the VLS magazine.[61]

The Navy could also adapt its weapons in development, such as LRASM, to achieve smaller size and multi-mission capability. The exact specifications for the surface-launched version of LRASM are not yet fully defined, but it is intended to be VLS compatible and would likely be based, like the air-launched LRASM, on the Joint Air-to-Surface Standoff Munition-Extended Range (JASSM-ER) missile. The surface-launched LRASM will therefore have a likely range of 300–400 nm[62] and carry a 1,000-pound warhead—twice that of the Harpoon and half the overall weight of the missile. Some analysts have suggested LRASM could be a land-attack missile as well, but question its shorter range compared with the Tomahawk, which has a range of 800–1,000 nm.[63] The Navy could increase LRASM's range to be comparable with Tomahawk's by reducing its warhead from 1,000 pounds to 500 pounds or less, making the missile lighter or enabling it to carry more fuel. This warhead size and LRASM's precision would be sufficient to at least disable a warship and would destroy or disable high-priority systems ashore such as radars and missile launchers. The resulting missile could replace both the Harpoon and Tomahawk, thereby increasing the effective SUW or strike capacity of the VLS magazine.[64]

Anti-submarine warfare is the only offensive sea control mission for which the Navy has no plans to replace its Cold War-era standoff weapons. This creates a capability gap the Navy could address by pursuing the three attributes above (relevant capability, multi-mission versatility, smaller weapons) in developing a replacement weapon. Today, the surface fleet's longest-range ASW weapon is the vertical-launch anti-submarine rocket-propelled torpedo (VL-ASROC or VLA), which consists of a rocket motor topped with an Mk-46 or Mk-54

60 "Navy, Raytheon Ready New Satellite-Guided SM-6 Variant," *Inside Defense*, July 2, 2014 available at http://insidedefense.com/Inside-the-Pentagon/Inside-the-Pentagon-07/03/2014/navy-raytheon-ready-new-satellite-guided-standard-missile-6-variant/menu-id-148.html.

61 Sydney J. Freedberg Jr., "Anti-Aircraft Missile Sinks Ship: Navy SM-6," *Breaking Defense,* March 7, 2016, available at http://breakingdefense.com/2016/03/anti-aircraft-missile-sinks-ship-navy-sm-6/.

62 See "AGM-158 JASSM: Lockheed Martin's Family of Stealthy Cruise Missiles," *Defense Industry Daily*, available at http://www.defenseindustrydaily.com/agm-158-jassm-lockheeds-family-of-stealthy-cruise-missiles-014343/, accessed July 10, 2014; Dave Majumdar, "Lockheed LRASM Completes Captive Carry Tests," *The DEW Line* (blog), Flightglobal, July 11, 2013, available at http://www.flightglobal.com/blogs/the-dewline/2013/07/lockheed-lrasm-completes-capti/.

63 "LRASM Missiles: Reaching for a Long-Range Punch," *Defense Industry Daily*, available at http://www.defenseindustrydaily.com/lrasm-missiles-reaching-for-a-long-reach-punch-06752/, accessed July 10, 2014; Adam Kredo, "Obama to Kill Navy's Tomahawk, Hellfire Missile Programs in Budget Decimation," *Washington Times*, March 25, 2014, available at, http://www.washingtontimes.com/news/2014/mar/25/obama-kill-navys-tomahawk-hellfire-missile-program/?page=all.

64 If, for example, a VLS magazine carried twenty LRASMs and twenty Tomahawks, replacing them with forty multimission weapons would provide forty weapons for SUW or strike instead of only twenty for each. This is important because a ship deploys without knowing exactly what missions it will need to conduct over the several months it is at sea. This is in contrast to an aircraft, which flies a mission with a weapon loadout tailored for that mission.

torpedo[65] that is launched from a VLS cell. It has a range of about 12 nm, which is less than one-tenth the range of enemy submarine-launched ASCMs and much less than the range at which U.S. shipboard sonars can detect submarines.

Because of ASROC's short range, surface combatants today rely on helicopters to conduct most of their ASW attacks. But helicopters can only be in one place at a time, carry only two torpedoes, and can only keep station about 30–50 nm from their host ship.[66] As a result, a surface combatant or an external sensor such as SOSUS, deployed sonar arrays, or Surveillance Towed Array Sensor System (SURTASS) may detect submarines within enemy ASCM range that helicopters cannot prosecute because they are out of weapons or out of position. ASW aircraft such as the P-8 *Poseidon* may be able to attack these submarines during large-scale wartime operations, but in smaller operations or in areas away from P-8 orbits (such as during escort missions) surface combatants and their embarked helicopters must be able to promptly engage submarines before they can launch ASCM attacks.

A standoff ASW weapon could be very effective at stopping submarine attacks. Even though its probability of destroying a submarine is only about 20 percent,[67] the ASROC can often achieve a "mission kill," because it takes advantage of a submarine's inherent limitations: they are relatively slow when trying to be quiet; have limited or no self-defense systems; and cannot rapidly determine the location and trajectory of an incoming weapon. Submarines are also generally not designed to survive a successful torpedo attack. As a result, if a submarine detects a torpedo in the water, it generally begins evading immediately, even if the weapon is projected to have only a small chance of success. This takes the submarine away from its mission and out of the fight for hours to days while it repositions and reacquires targeting information. Evasion also makes the submarine more detectable and could enable more precise and lethal re-attacks by ASW forces.

This suggests the surface fleet could greatly enhance its offensive ASW capacity by fielding a longer-range standoff ASW weapon that would complement helicopter-launched torpedoes. And since the ability of ASROC to achieve "mission kills" does not rely on a large warhead, a new standoff weapon could use a smaller warhead to enable longer range, as proposed with LRASM above. One concept for doing this would be to combine the Navy's small Common Very Light-Weight Torpedo (CVLWT) with an SM-2-sized booster. The CVLWT not only has a smaller warhead than Mk-46 or Mk-54 torpedoes, but it also has a sophisticated sonar and processor that enables it to destroy other torpedoes as part of the Navy's torpedo defense

65 The Navy is replacing the torpedo warhead of ASROC with the more effective Mk-54 torpedo, but this does not change the inherent range limitations of the VLA.

66 The MH-60R ASW helicopter has a combat radius of 245 nm; ASW operations involve stopping to dip its sonar to find submarines and then pursue and attack enemy submarines. If the MH-60R travels more than about 50 nm away, it will not have the endurance to search or the range to prosecute detections.

67 This figure is for the ASROC variant employing the older Mk-46 torpedo. A version with the newer Mk-54 torpedo may be higher. Stephen Valerio, *Probability of Kill for an ASROC Torpedo Launch*, M.S. Thesis (Monterey, CA: U.S. Naval Postgraduate School, 2009).

system; it could actually have a higher probability of success than the Mk-46 fielded on ASROC. Alternatively, the Navy could increase its standoff ASW capacity by combining the CVLWT with an ESSM-sized booster, which would not dramatically increase ASROC range but would quadruple the surface combatant's ASW capacity. This could be an effective approach for SSCs pursuing enemy submarines that cannot employ ASCMs due to configuration, size, or a lack of external targeting data.

New Concepts to Affordably Increase Surface Combatants for Offensive Sea Control

As noted above, the offensive weapons capacity per surface combatant will probably continue to be constrained by the VLS capacity needed for defensive AAW interceptors until non-VLS defensive AAW systems such as HVPs, HPRF weapons, EMRGs, or lasers are fully fielded. New approaches are needed to maximize the number of surface combatants that can contribute to offensive missions. There are three fundamental ways the Navy should pursue this objective:

1. Implement a new sustainment concept for CGs so they can be retained longer in active service;

2. Enact new approaches to provide BMD to fixed sites ashore to make more large surface combatants available for sea control; and

3. Pursue new approaches for SSC operations to support CGs and DDGs in offensive sea control.

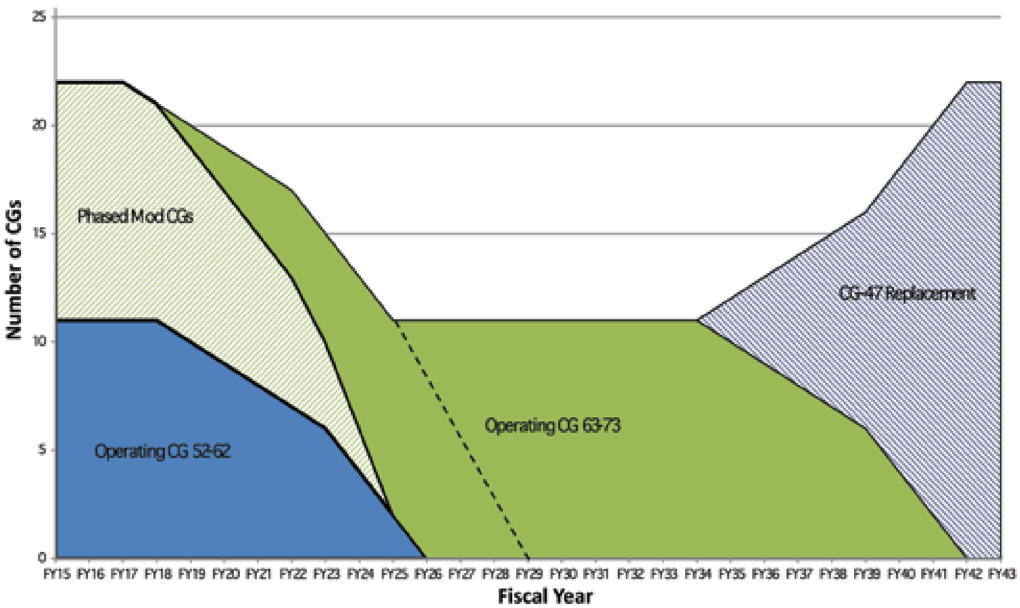
A New Sustainment Concept for CGs

The Navy today has twenty-two *Ticonderoga*-class CGs. To retain more of its current large surface combatant capacity into the late 2030s, the Navy proposed in its FY 2017 budget submission to conduct "phased modernization" of the seven newest, non-modernized, CGs by placing them all in a reduced operating status over the next year. They would be brought back into service over the next decade in conjunction with their mid-life modernization overhauls to replace the oldest eleven CGs on a one-for-one basis as they decommission to maintain the CG fleet at eleven ships. These overhauls would equip the CGs with the latest Aegis combat systems and execute hull, electrical, and mechanical upgrades to extend their lives to forty years. In all, the phased modernization plan would provide the Navy more than a hundred large surface combatant "ship-years" for about $3 billion.[68]

68 Jonathan Greenert, U.S. Navy Chief of Naval Operations, "FY 2015 Department of the Navy Posture," Statement before the House Armed Services Committee, March 12, 2014.

This phased modernization plan would save the Navy money over the next ten years by enabling it to avoid costs associated with operating and manning the seven affected CGs.[69] The plan would also sustain CG force structure to 2038, increasing the capacity of large surface combatants during the years when construction of the SSBN(X) will begin to consume more than one-third the Navy's annual shipbuilding budget (see Figure 5). In terms of offensive sea control, keeping more CGs in the fleet, each with 122 VLS cells, would prevent a significant reduction in the surface force's striking power at a time when potential adversaries' sensor and weapons networks are reaching maturity.[70] Cruisers are also uniquely capable of hosting the Area Air Defense Commander because of their greater personnel capacity, radar redundancy, and larger command and control spaces.[71]

FIGURE 5: CG INVENTORY FROM FY 2015 TO FY 2043[72]



Dotted line shows planned CG inventory without phased modernization.

69 The crewmembers detached from the CGs would go to fill shortfalls elsewhere in the surface fleet, enabling the Navy to avoid the costs of recruiting, training, and compensating new sailors to fill these gaps.

70 DoD, *China Military Modernization*.

71 U.S. Navy, "Cruisers," *Navy Fact File,* January 9, 2017, available at http://www.navy.mil/navydata/fact_display.asp?cid=4200&tid=800&ct=4.

72 Deputy Chief of Naval Operations for Integration of Capabilities and Resources, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2017* (Washington, DC: Office of the Chief of Naval Operations, 2016).

Without this phased modernization plan, the Navy argues it would not be able to sustain CG force structure into the 2030s. The eleven oldest of today's twenty-two CGs will be retired by 2026. Of the newest eleven CGs, several already have material problems that reduced their operational tempo,[73] and the Navy plans to retire them all by 2028 due to a lack of funds unless they undergo the less-expensive phased modernization process.[74]

New approaches for BMD of fixed sites ashore

Sea-based BMD is a relatively new mission that rapidly developed into a significant demand on naval forces. Prior to 2005, no Navy ships were assigned to BMD operations, and force structure requirements did not reflect an allocation for this mission.[75] Today the Navy has thirty-three BMD-capable ships, with plans to increase the number to forty-three ships by 2019.[76] On average, two large surface combatants are continuously deployed in the Mediterranean Sea, Arabian Gulf, and Western Pacific Ocean to provide BMD for partners and allies overseas, which requires at least eighteen CGs or DDGs to support.[77]

BMD-capable large surface combatants are attractive for BMD overseas because they can protect a large area (or "footprint") since the Navy's SM-3 interceptor destroys the ballistic missile in its "midcourse" phase outside the atmosphere. But the CGs and DDGs assigned to BMD missions are largely unavailable for other missions such as offensive sea control. The geometry required to intercept a ballistic missile prevents the BMD ship from maneuvering outside of a relatively small area while the readiness needed to promptly respond to missile launches limits the amount of sensor resources that can be spared for other missions.

The demand for BMD ships will very likely continue to increase. Over the next decade U.S. competitors plan to deploy ballistic missiles with stealthier warheads and "penetration aids" such as decoys or jammers designed to confuse or deceive interceptors. They

73 According to a record of underway employment obtained by the *Navy Times* through a Freedom of Information Act request, the USS *Anzio* (CG-68), USS *Vicksburg* (CG-69), and USS *Port Royal* (CG-73) were all underway less than 15 percent of the time since 2012.

74 Eric Labs, An Analysis Of The Navy's Fiscal Year 2017 Shipbuilding Plan (Washington, DC: Congressional Budget Office, February 2017), p.28.

75 Ronald O'Rourke, *Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress*, RL33745 (Washington, DC: Congressional Research Service, July 31, 2014).

76 Missile Defense Agency, "Aegis Ballistic Missile Defense: Status," available at http://www.mda.mil/system/aegis_status.html, accessed July 2, 2014; O'Rourke, *Navy Aegis Ballistic Missile Defense Program*.

77 This calculation assumes two BMD-capable ships are deployed in the Mediterranean as part of the European Phased Adaptive Approach and in defense of Middle East partners; two are deployed in the Middle East to defend Arabian Gulf partners; and two are deployed in the Western Pacific to defend Japan and South Korea. This level of deployment is consistent with press reports of BMD deployments and Navy leader statements. "Forward Deployed Naval Force" (FDNF) ships based in Rota, Spain, and Yokosuka, Japan, source European and Pacific BMD deployments, respectively. The FDNF operational model requires two ships for each one underway. BMD ships in the Middle East would deploy rotationally from the United States, requiring five ships for each one underway overseas. See Jonathan Greenert, U.S. Navy Chief of Naval Operations, Statement before the House Armed Services Committee, "FY 2014 Department of Navy Posture," April 16, 2013, p. 10; Christopher Cavas, "First U.S. BMD Ship Leaves for Rota," *Defense News*, February 1, 2014.

will also field longer-range ballistic missiles, which are faster and shrink the footprint that can be protected by the interceptors currently deployed on BMD-capable CGs and DDGs.[78] Interceptor and radar upgrades currently planned by the Navy will help BMD-capable ships keep up with improving ballistic missiles,[79] but the footprint defended by each ship will eventually shrink since radar and interceptor size will remain constrained by the size of the ship (e.g., DDG-51) that hosts them. More interceptors and more ships will therefore be required in the future to defend the same area. Unless an alternative method is developed to defend military and civilian targets ashore, an increasing portion of large surface combatants will be consigned to BMD stations overseas and unable to contribute to offensive sea control.

Shore-based BMD capabilities could reduce the demand for BMD ships. Aegis Ashore provides the same large, multiple-country footprint against short and intermediate-range ballistic missiles as a BMD-capable CG or DDG and was deployed in Europe starting in 2015.[80] This system includes the same AN/SPY-1 radar and Aegis BMD version 5.0 software being installed on DDG-51 Flight IIa ships and a twenty-four-cell VLS magazine carrying SM-3 interceptors.

The Navy should pursue replacing today's BMD ship stations in the Middle East and Japan with Aegis Ashore to defend fixed locations against known threats. The cost of an Aegis Ashore system is about $750 million,[81] whereas a Flight IIa DDG-51 costs about $1.6 billion and a Flight III DDG-51 is estimated to cost $1.9 billion.[82] The two to three Aegis Ashore systems that could be purchased for the cost of one DDG would be able to take the place of four to fifteen DDGs, depending on whether the DDGs are forward based. While Aegis Ashore is less mobile than a BMD-capable ship, there is little need for greater mobility because the footprint defended by either system extends for hundreds of miles.

Competitors such as China or Iran can mass large ballistic and cruise missile salvos able to overwhelm the limited capacity of a BMD-capable ship or Aegis Ashore system. For high-value targets that could attract large attacks such as bases and command and control facilities, Aegis Ashore should be complemented by Patriot Advanced Capability upgrade

78 DoD, *China Military Modernization 2014.*

79 Differentiating between actual warheads and decoys requires multiple seekers on interceptors and sea or land-based tracking radars that can apply greater power either because they are more powerful overall or because they can narrow their field of view to concentrate their power on a smaller area. The SM-3 Block 1b missile deployed in 2015 (in conjunction with Aegis BMD version 3.6.X) provided some ability to counter penetration aids with its multiple frequency infrared seeker, while the larger SM-3 Block IIa missile to be deployed in 2018 (with Aegis BMD version 5.1) will also provide greater range and intercept speed to counter faster and longer-range ballistic missiles. The AMDR to be deployed on the DDG-51 Flight III starting in 2021 will provide improved power and differentiation to counter penetration aids as well.

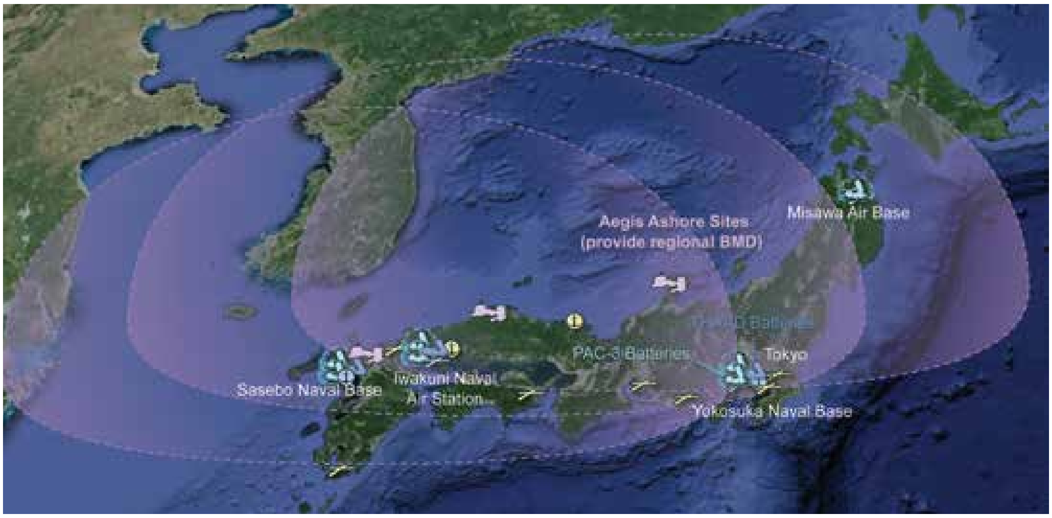
80 Specifically, Aegis Ashore systems will be deployed to Romania in 2015 and to Poland in 2018.

81 "SM-3 BMD, in From the Sea: EPAA & Aegis Ashore," *Defense Industry Daily*, available at http://www.defenseindustrydaily.com/land-based-sm-3s-for-israel-04986/, accessed July 4, 2014.

82 Deputy Chief of Naval Operations, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2017.*

version 3 (PAC-3) and Terminal High-Altitude Air Defense (THAAD) systems. These systems intercept ballistic missiles in their "terminal" phase as they approach the target; this yields a smaller defended "footprint" but enables use of a smaller, less expensive interceptor that can be deployed in greater quantities at the same cost. Figure 6 shows how a combination of shore-based midcourse and terminal-phase missile defenses could be employed in Japan to defend against Chinese and North Korean short- and intermediate-range ballistic missiles.

FIGURE 6: A SHORE-BASED APPROACH TO BMD OF ALLIES



New concepts for SSC operations

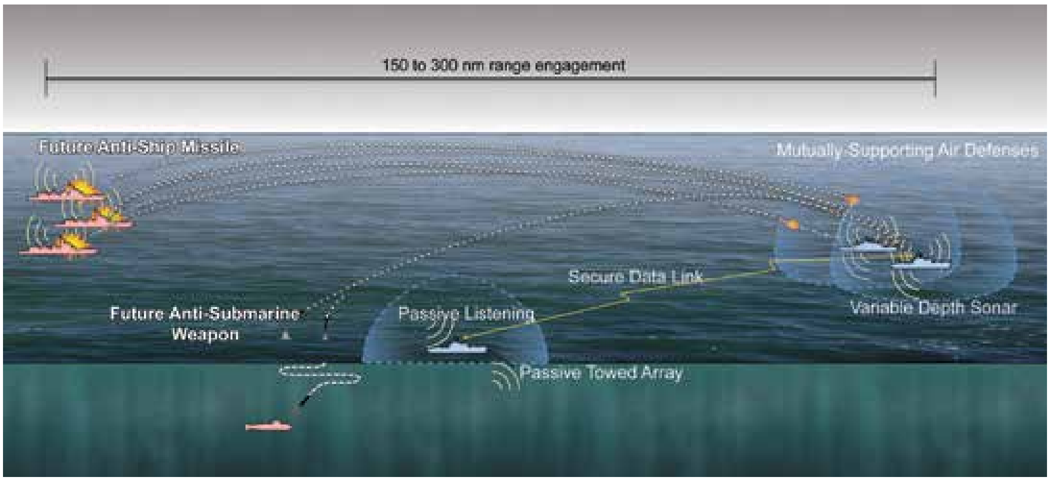
The Navy could use SSCs to add capacity for offensive sea control in less stressing situations. The Navy plans to upgrade its existing LCSs with OTH surface-to-surface missiles such as Harpoon as part of its Distributed Lethality concept and improve their self-defense capability with SEWIP Block II and an additional RAM launcher.[83] The Navy is also pursuing a new FFG to conduct ASW, SUW, and ISR to free CGs and DDGs to focus on offensive sea control operations. The new FFG may also be able to conduct defensive AAW for nearby ships using ESSM or SM-2.

Together, FFGs and LCSs could also conduct offensive sea control missions. Concepts to use FFGs and LCSs for offensive AAW, ASW, SUW, and strike will likely need to employ them as a SAG of three or more ships to provide greater overall defensive AAW capacity and

83 Megan Eckstein, "Navy: Most Offensive, Defensive Upgrades Surface Force Will Be Fielded by 2023," *USNI News*, January 17, 2017, available at https://news.usni.org/2017/01/17/navy-offensive-defensive-upgrades-surface-force-will-fielded-2023; and Patrick Tucker, "Upgrades Will Let the Navy's LCS Operate in More Dangerous Waters," *Defense One*, December 12, 2014, available at http://www.defenseone.com/technology/2014/12/upgrades-will-let-navys-lcs-operate-more-dangerous-waters/101172/.

longer-range targeting than a single SSC.[84] The SAG could be given long-range targeting data from third-party sensors (satellites, other joint force platforms, etc.) or could use a "hunter" ship to find a target with passive or remote sensors and transmit the target's information to "killer" ships farther away. The "killer" ships could then shoot the target from outside the target's sensor or weapons range. Multiple SSCs operating as a SAG would also be able to provide mutual air defense[85] by extending their 30-nm defensive AAW envelopes over each other (see Figure 7).

FIGURE 7: NOTIONAL OFFENSIVE SAG WITH LCS AND DDG



Moreover, FFGs and upgraded LCSs may enable the Navy to also re-evaluate its required number of large surface combatants. If these SSCs can conduct offensive and defensive sea control missions, they may be able to replace CGs and DDGs in some less stressing situations where their smaller capacity is sufficient for the task.

Recent studies by Captain Wayne Hughes, Commander Phillip Pournelle, and others have argued[86] the Navy could gain an advantage in a SUW competition against an adversary such as China by fielding ASCM-equipped SSCs that are smaller than LCSs, such as so-called "fast

84 Longer-range sensors would not be practical since they would take up space and weight needed for defensive AAW weapons to protect the ship and those around it.

85 This assumes the FFG or upgraded LCS would carry an area air defense interceptor such as ESSM so it could protect other ships in company.

86 Phillip Pournelle, "The Rise of the Missile Carriers," *U.S. Naval Institute Proceedings*, May 1, 2013, available at http://www.usni.org/magazines/proceedings/2013-05/rise-missile-carriers.

missile craft."[87] These ships could gain the upper hand in a fight by having enough defensive AAW capacity to require many enemy ASCMs to be launched at each SSC while still being small (and inexpensive) enough to enable the Navy to distribute the surface fleet's offensive capacity over a large number of ships that the enemy would have to hunt down and destroy in detail.

Implementing an offensive SAG concept in the next decade with upgraded LCSs and FFGs would enable the surface fleet to experiment and determine if smaller SSCs such as fast missile craft could improve its ability to conduct offensive sea control.

New Approaches to Defensive and Constabulary Missions

The surface fleet must restore the division of labor between large and small surface combatants to enable CGs and DDGs to focus on offensive sea control. Navy leaders today assess that growing demands on large surface combatants prevent them from being adequately trained and maintained.[88] This situation will likely get worse unless it is promptly addressed as outlined below. With the retirement of the last *Oliver Hazard Perry*-class FFGs in 2015, the fleet has only half the Navy's required number of SSCs (see Figure 8).[89] Large surface combatants therefore bear an increasing share of missions normally done by SSCs including convoy and logistics escort, maritime security, and partner training.

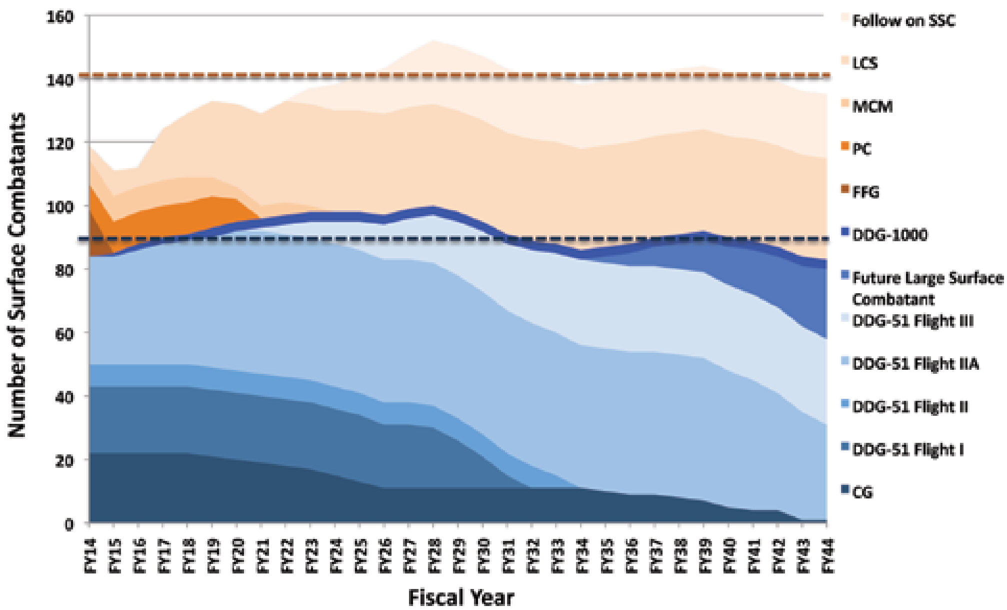
Although Figure 8 implies the number of SSCs will return to the required number by FY 2024, this chart assumes DoD receives a higher level of funding than allowed by current legislative budget caps. It is therefore likely that Navy shipbuilding will be negatively impacted if these caps are not adjusted. Further, the new FFG being pursued by the Navy will be more capable and therefore likely cost more than the LCS it will replace. This could reduce the number of SSCs the Navy is able to build in the next decade.

87 The *Ambassador*-class FMC is built in the United States and is equipped with Harpoon ASCMs, point-defense RAM interceptors, and a CIWS gun. It costs about $200 million, so purchasing even a three-ship SAG of FMCs would take a meaningful portion of the already-tight shipbuilding budget. See Luke Tarbi, "U.S. Navy Needs Fast Missile Craft—and LCS—in Persian Gulf," *Breaking Defense*, April 14, 2014, available at http://breakingdefense.com/2014/04/us-navy-needs-fast-missile-craft-and-lcs-in-persian-gulf/.

88 Richard Sisk, "Navy Struggles to Meet Demands," *DoD Buzz*, January 16, 2013, available at http://www.dodbuzz.com/2013/01/16/navy-struggles-to-meet-demands/; Sam Fellman, "CNO: Stressed Fleet Can't Sustain Op Tempo," *Navy Times*, May 3, 2012, available at http://www.navytimes.com/article/20120503/NEWS/205030317/CNO-Stressed-fleet-can-t-sustain-op-tempo; and Greenert, "FY 2014 Department of Navy Posture," p. 15.

89 OPNAV N8, *Navy Combatant Vessel Force Structure Requirement*, report to Congress (Washington, DC: OPNAV N8, January, 2013); Deputy Chief of Naval Operations, *Report to Congress on the Annual Long -Range Plan for Construction of Naval Vessels for FY2015*.

FIGURE 8: U.S. NAVY SURFACE FLEET COMPOSITION[90]



The dotted lines show the required number of large surface combatants (blue) and SSCs (brown).

In peacetime, CGs and DDGs can conduct maritime security and training missions during their regular deployments as part of a carrier strike group (CSG). Each CSG notionally includes five large surface combatant escorts,[91] and threats in peacetime are modest enough that most of these escorts can disaggregate hundreds of miles away without significant risk to the carrier. In wartime, however, these ships would need to reaggregate with the carrier to gain and sustain access for it and the Joint Force in contested environments. If they have spent their time conducting other missions, CSG escorts may not have the proficiency or combat system readiness to conduct offensive sea control missions effectively in a conflict's early stages.[92] Moreover, some CSG escorts may not be able to return to the carrier because some constabulary missions may need to continue in wartime, such as maritime security operations to prevent clandestine resupply of the enemy.

90 Deputy Chief of Naval Operations, *Report to Congress on the Annual Long -Range Plan for Construction of Naval Vessels for FY2017*.

91 U.S. Navy, Chief of Naval Operations, *Policy for Baseline Composition and Basic Mission Capabilities for Major Afloat Navy and Naval Groups*, OPNAVINST 3501.316B (Washington, DC: U.S. Navy, October 21, 2010), available at http://doni.documentservices.dla.mil/Directives/03000%20Naval%20Operations%20and%20Readiness/03-500%20Training%20and%20Readiness%20Services/3501.316B.pdf.

92 Thomas Copeman, *Vision for the 2026 Surface Fleet* (Washington, DC: U.S. Navy, 2014); Daisy Khalifa, "Gortney's Readiness: Predictable, Adaptable for Sailors," *Seapower Magazine*, April 8, 2014, available at http://www.seapowermagazine.org/sas/stories/20140408-gortney-redefines-readiness.html.

Large surface combatants will also need to take on wartime convoy and logistic ship escort missions that would traditionally have been done by SSCs. According to its FY 2017 shipbuilding plan, all the Navy's SSCs will be LCSs by 2024, as indicated in Figure 8. The LCS will not be able to conduct escort missions, however, since it has only a self-defense AAW system and cannot simultaneously embark and operate its SUW and ASW mission packages to defend noncombatant ships against submarines and enemy surface combatants.

The Navy should pursue new approaches to conduct maritime security, training, and escort missions. This will enable large surface combatant crews more time to train and maintain their ships in peacetime and make more CGs and DDGs available for offensive sea control in wartime. Specifically, the Navy should:

- Field more small surface combatants able to defend themselves and others
- Empower the "National Fleet" to conduct less-stressing SSC missions

Field More Small Surface Combatants Able to Defend Themselves and Others

As adversary sensor and ASCM capabilities proliferate and improve, small surface combatants will need better defenses while noncombatant logistics ships and civilian convoys will need to be protected from enemy aircraft, surface ships, and submarines in more places and situations.[93] Today CGs and DDGs would have to provide this protection since both variants of LCS (Figure 8) have only a limited self-defense AAW capability. Their twenty-one RIM-116 Rolling Airframe Missiles (RAM) have a maximum range of only 5 nm, preventing effective defense of escorted ships, while their capacity is too small to enable even self-defense in a high-threat environment.[94]

93 These three capabilities were needed in escorts used in World Wars I and II and in the "Tanker War" between Iran and Iraq in 1987–88. See Brodie, *A Guide to Naval Strategy*; Lee Allen Zatarain, *Tanker War: America's First Conflict with Iran, 1987–1988* (Havertown, PA: Casemate Publishers, 2009); and William Sims and Burton Hendrick, *The Victory at Sea: The Allied Campaign Against U-Boats in the Atlantic 1917–18* (UK: Leonaur Publishing, 2012).

94 Given short-range missiles on an LCS, a defended ship would have to operate too close to the LCS to permit effective maneuvering, and the LCS would have to be positioned between the incoming missile and the escorted ship or directly in front of or behind the escorted ship. To ensure the incoming ASCM is intercepted, two RAM would likely be shot at each incoming ASCM. This would result in the LCS magazine of RAMs being exhausted after ten ASCM attacks. In the littoral operating environment envisioned for the LCS, more ASCM attacks would likely occur before the ship could reload its RAM magazine.

FIGURE 9: THE USS *FREEDOM* (LCS-1) AND USS *INDEPENDENCE* (LCS-2) VARIANTS OF LCS[95]

The Navy recently announced a plan that would address this capability shortfall by truncating the LCS program at thirty-two ships and developing an FFG with organic AAW, ASW, and SUW capabilities similar to those originally inherent in the *Oliver Hazard Perry*-class FFG.[96] The *Perry*-class was designed to escort amphibious, logistics, and merchant ships. With similar capabilities, the FFG could reduce the demand on large surface combatants for this mission.

While the modified LCS is among the options being considered for the FFG, the new ship will likely cost more than the LCS since it will incorporate additional capabilities. An LCS consists of a "sea frame" with a deck gun and self-defense interceptors; it normally embarks a mission package focused on a specific capability area. Currently, the Navy is developing mission packages for ASW, SUW, and MCM. Upgrading the LCS to have equivalent capabilities to a *Perry*-class FFG would require, for example, that it carry the ASW mission package full-time and incorporate longer-range AAW capabilities. An LCS with the ASW mission package costs about $515 million,[97] and a new AAW system would add to that cost. For comparison, the *Perry*-class FFGs (last built in 1989) would cost about $774 million in FY 2014 dollars.

95 The *Freedom*-class (LCS-1, 3, 5, etc.) is a planning monohull ship, whereas the *Independence*-class (LCS-2, 4, 6, etc.) is a planning trimaran. Both have about 3,300 tons and are 378 feet and 418 feet long, respectively.

96 Based on direction from the Chief of Naval Operations (CNO) to the SSC Task Force and the Task Force's Request for Information (RFI) from industry; see Chief of Naval Operations, *Small Surface Combatant Task Force*, Joint Letter (Washington, DC: U.S. Navy, March 13, 2014), available at http://blogs.defensenews.com/saxotech-access/pdfs/Letter140313.pdf; and U.S. Navy, Naval Sea Systems Command, *Request for Information (RFI) for Market Information Pertinent to the Navy's Future Small Surface Combatant* (Washington, DC: U.S. Navy, April 9, 2014), available at https://www.fbo.gov/index?s=opportunity&mode=form&id=4672fccc30bde30cb8c1cff475c95cf5&tab=core&_cview=1.

97 This is based on $475.7 million for an LCS sea frame, $20.9 million for the ASW mission package, and $14.8 million for common mission package equipment. This combination most closely approximates the capabilities of the original FFG outside of its AAW capability. The other mission packages are Mine Countermeasures ($97.7 million) and surface warfare ($32.6 million). See Ronald O'Rourke, *Navy Littoral Combat Ship (LCS) Program: Background and Issues for Congress*, RL33741 (Washington, DC: Congressional Research Service, August 2014) available at http://fas.org/sgp/crs/weapons/RL33741.pdf.

For a similar cost, the Navy could pursue an FFG based on an existing U.S. or foreign design instead of attempting to upgrade the LCS. The LCS, even with additional AAW capabilities, will not have the size to carry the fuel and personnel needed for sustained operations. An FFG derived from the National Security Cutter or Italian-French FREMM frigate would be a better option to support escort operations and conduct independent operations. The argument for not upgrading the LCS is detailed further in Chapter 3.

Empower the National Fleet to Conduct Less-Stressing SSC Missions

The Navy will need to expand the number of ships able to conduct less-stressing missions such as maritime security, noncombatant evacuation, mine clearing, and partner training. These missions are normally conducted by SSCs, but the projected shortfall in SSCs until the mid-2020s will mean more of them will need to be conducted by large surface combatants, taking them away from offensive sea control operations. In the long term, the shortfall is not likely to be alleviated, as the Navy is unlikely to reach its requirement of fifty-two small combatants due to continued fiscal constraints and the higher costs of FFGs.

The U.S. National Fleet has a wide selection of noncombatant ships that could augment SSCs in low- to moderate-threat environments. The National Fleet formally consists of the U.S. Navy and U.S. Coast Guard, which together have 370 ships.[98] In the U.S. Navy's Battle Force there are about sixty support and logistics ships, including up to eleven EPFs and up to five expeditionary support docks (ESD) designed to host an array of unmanned systems, helicopters, and small boats. The U.S. Coast Guard's ninety cutters are also capable of carrying these payloads. The National Fleet can also be considered to include the Maritime Sealift Command's (MSC's) twenty-six prepositioning ships and the Department of Transportation's 117 National Defense Reserve Fleet (NDRF) ships, forty-six of which form the U.S. Navy's Ready Reserve Fleet.[99]

The Navy originally planned to equip LCSs with modular MCM, ASW, and SUW mission packages that could shift between open sea frames. Although the Navy decided in 2017 to permanently equip LCSs with the ASW or SUW mission package and some of the SUW

98 The National Fleet is described in U.S. Navy, Office of the Chief of Naval Operations and United States Coast Guard, Office of the Commandant, *National Fleet Plan* (Washington, DC: U.S. Navy and U.S. Coast Guard, March 2014), and it consists of 290 Navy Battle Force Ships and ninety USCG cutters as of August 3, 2014. See Ronald O'Rourke, *Coast Guard Cutter Procurement: Background and Issues for Congress*, R42567 (Washington, DC: Congressional Research Service, 2014), available at http://fas.org/sgp/crs/weapons/R42567.pdf.

99 The forty-six RRF ships consist of thirty-five roll-on/roll off (RO/RO) vessels (which includes eight Fast Sealift Support vessels, FSS), two heavy-lift or barge carrying ships, six auxiliary crane ships, one tanker, and two aviation repair vessels. See Department of Transportation, "National Defense Reserve Fleet," available at http://www.marad.dot.gov/ships_shipping_landing_page/national_security/ship_operations/national_defense_reserve_fleet/national_defense_reserve_fleet.htm, accessed August 3, 2014. That the national fleet could include MSC and NDRF ships was argued most prominently by now-Deputy Defense Secretary Robert Work in a 2008 paper: Robert Work, *The U.S. Navy: Charting a Course for Tomorrow's Fleet* (Washington, DC: Center for Strategic and Budgetary Assessments, 2008).

mission package capabilities,[100] the LCS mission package concept could provide a way for noncombatant ships to contribute to SSC missions.

The mission package concept leverages advances in unmanned systems. In mine warfare and maritime security, for example, noncombatant ships could act as a "mother ship," deploying off-board systems that conduct the mission, rather than as a tactical platform that directly conducts the mission like a minesweeper or patrol craft. Mines are hunted today with autonomous vehicles such as the Mk-18 Mod 2 unmanned underwater vehicle (UUV) and neutralized with remotely operated systems including the SLQ-60 UUV. Similarly, pirates or traffickers are typically located using helicopters or unmanned vehicles such as the MQ-8C vertical takeoff UAV (VTUAV) and intercepted by rigid-hull inflatable boats (RHIB). These systems could also be hosted and deployed from a logistics ship, EPF, or expeditionary support base (ESB). In a low-to-moderate threat environment, these noncombatant ships may need to be protected, which could be done by an FFG while still increasing the overall capability of the fleet.

Using noncombatant ships for military missions such as mine clearing or maritime security will require augmenting the ships' civilian crew with military personnel and establishing legal arrangements to enable the ship to use force to defend itself and other ships during military operations. These arrangements have already been made with the Afloat Forward Staging Base-Interim (AFSB-I) USS *Ponce,* which conducts mine clearing and partner training today as a noncombatant ship in the Arabian Gulf.

Expand the mission package concept beyond the LCS

The mission package concept should be expanded and separated from only being associated with the LCS program. This would enable more of the U.S. National Fleet to contribute to day-to-day operations and enable noncombatant ships to do SSC missions that otherwise would fall to large surface combatants. The self-contained combination of operators and equipment associated with mission packages enables these capabilities to be deployed on other Navy, Coast Guard, and Department of Transportation ships.

Some elements of the planned LCS mission packages will not be practical to integrate or use on support ships due to performance limitations or because the ships lack appropriate communication or command and control systems. For example, the ASW mission package's specialized handling equipment and command and control requirements make it difficult to integrate onto a ship such as an EPF or ESB. Other mission packages or parts of packages, however, can be used on other ships with little modification. Systems like mine hunting and clearing UUVs can be operated independently from a wide range of ships and their data uploaded to command and control systems later. The SUW mission package's RHIBs and helicopters can operate from a wide range of support ships. EPFs and ESBs in particular will be

100 Christopher Cavas, "LCS Crewing, Operating, Basing Schemes Are Changing," *Defense News*, September 11, 2016, available at https://www.defensenews.com/naval/2016/09/12/lcs-crewing-operating-basing-schemes-are-changing/.

equipped with communications and command and control systems to enable the ship to coordinate maritime security operations with other ships.

Going forward, the Navy should evaluate other mission packages that could be modularized and employed by LCSs and noncombatant ships such as disaster response, preventive medical care, signals intelligence, airborne surveillance, counter-illicit trafficking, and electronic warfare.

CHAPTER 3

Capability and Program Implications

This chapter summarizes high-priority initiatives and investments needed in the near to midterm (i.e., one to two FYDPs, or to 2028) to implement the new concepts and approaches described in Chapter 2. These recommendations focus on how the surface fleet equips and configures ships, rather than proposing new-design surface combatants. The Navy needs to improve its ability to conduct sea control in the next decade, but fiscal constraints will likely preclude new-design ships until the 2030s. Although the recommendations below focus on "payloads," they are grouped by the platform to which they pertain. Weapons recommendations that are independent of combatant type are described separately. Within each section, recommendations are associated with a concept or approach from Chapter 2.

Large Surface Combatants

Large surface combatants (CG and DDG) and aircraft carriers are the only U.S. Navy ships with the weapons capacity and combat systems to conduct the full range of sea control missions in a stressing threat environment. As described in Chapter 2, several aspects of today's large surface combatant configuration and employment constrain their ability to conduct offensive sea control missions such as AAW, ASW, SUW, and strike against coastal threats.

A New Approach to Sea-Based AAW

Chapter 2 recommended the surface fleet adopt a new approach to AAW that separates longer-range offensive AAW against aircraft from medium-range defensive AAW against incoming ASCMs or ASBMs. This will provide more VLS space for offensive weapons. Automated battle management and deeper magazines will be needed to provide commanders confidence in this new air defense concept despite improving anti-ship threats. The Aegis combat system already has automated fire control, which should be modified to conduct defensive AAW in the 10- to 30-nm range and incorporate new defensive AAW systems. Along with smaller interceptors such as ESSM, lasers, HPRF weapons, EMRGs, and HVPs will provide greater magazine depth to surface combatants. The technology for these new capabilities will be mature in the early 2020s; given projected threats, the fleet cannot wait to field them until a new surface combatant is built in the 2030s.

Lasers and HPRF weapons

Directed energy weapons are entering the fleet and could contribute to defensive AAW in the next decade. The Navy deployed a laser in summer 2014 aboard the AFSB-I USS *Ponce* in the Arabian Gulf for experimentation and to develop concepts of operation (Figure 10).[101] This 33-kilowatt (kW) solid-state laser uses fiber-optic cable as the lasing medium and will only be able to defeat small UAVs, small boats, and EO/IR sensors. The Navy's Solid State Laser Technology Maturation (SSL-TM) program plans to deliver a 100- to 150-kW laser capable of defeating larger UAVs and fast attack craft (FAC).[102] Further, the Navy anticipates fielding a 300- to 500-kW solid-state laser in the early 2020s that would be capable of defeating ASCMs at about 10 nm.[103] The Air Force demonstrated an HPRF weapon in 2014 and is pursuing upgraded versions today that could be repurposed for AAW.[104]

101 Eric Beidel, "All Systems Go, Navy's Laser Weapon Ready for Summer Deployment," Office of Naval Research, press release, April 7, 2014, available at http://www.onr.navy.mil/Media-Center/Press-Releases/2014/Laser-Weapon-Ready-For-Deployment.aspx.

102 Matthew L. Klunder, United States Navy Chief of Naval Research, Statement Before the Intelligence, Emerging Threats and Capabilities Subcommittee of the House Armed Services Committee, "The Fiscal Year 2015 Budget Request," March 26, 2014, available at http://www.acq.osd.mil/chieftechnologist/publications/docs/FY2015_Testimonyonr_klunderusnm_20140326.pdf.

103 O'Rourke, *Navy Shipboard Lasers for Surface, Air, and Missile Defense*.

104 Katherine Owens, "Air Force Electronic Weapons to Get an Electromagnetic Power Boost," *Defense Systems*, May 15, 2017, available at https://defensesystems.com/articles/2017/05/15/electromagnetic.aspx.

FIGURE 10: LASER WEAPONS SYSTEM DEPLOYED ON USS *PONCE*

As described in Chapter 2, lasers in the 300- to 500-kW range and HPRF weapons could contribute to a new medium-range approach to defensive AAW and enable more VLS cells to be used for offensive sea control. Within the surface fleet, the electrical power needed to continuously fire a 300- to 500-kW laser (about 1,500–2,000 kW) exceeds the reserve electrical capacity of today's CGs and Flight IIa DDG-51s but is within the planned capacity of the Flight III DDG-51. An HPRF weapon would take much less electrical power.[105]

Recommendation**:** When the Navy's solid-state laser is mature at a power level of 300–500 kW, install one on several new construction Flight III DDG-51s to enable experimentation and concept development. HPRF systems should be fielded more quickly on some DDG Flight II or Flight III ships.

Electromagnetic Railgun and Hypervelocity Projectiles

The Navy plans to have an EMRG ready for operational use in the next decade (Figure 11). This culminates a decade of research on this capability and several years of demonstrating it ashore against a variety of targets at the Naval Surface Warfare Center in Dahlgren, Virginia.[106]

105 A Flight IIa DDG-51 has only about 245 kW of spare generating capacity, whereas a Flight III DDG-51 is projected to have about 2,100 kW of reserve electrical capacity and sufficient extra cooling for a 300- to 500-kW laser; the required power for a laser could be attained with a smaller demand on the ship's power supply using power storage devices such as capacitors or fuel cells. This would limit the overall rate of fire but could enable installation of a laser on a ship with less reserve power capacity such as a Flight IIa DDG, LCS, or FFG. See Mark Vandroff, *DDG 51 Program*, Power Point Presentation (Washington, DC: U.S. Navy, January 14, 2014), available at http://www.navsea.navy.mil/Media/SNA2014/1-14-1--Vandroff.pdf; and O'Rourke, *Navy Shipboard Lasers for Surface, Air, and Missile Defense*.

106 An EMRG accelerates a GPS-guided ferromagnetic projectile to hypersonic (Mach 6–7) speeds using a series of magnets positioned along a rail, similar to a magnetic levitation (MAGLEV) train. See O'Rourke, *Navy Lasers, Railgun, and Hypervelocity Projectile*, p 15.

The Navy projects an EMRG will be operationally useful and able to be integrated on a surface combatant in the mid-2020s, but it does not yet have a plan to do so.[107]

FIGURE 11: THE 32-MJ EMRG BARREL ON USNS *MILLINOCKET* (T-EPF 3)

More promising is the HVP that EMRGs and naval guns would fire. It is about 24 pounds and 18–24 inches long by 3 inches wide, making it less than half the size of 5"/62 gun cartridges and about a tenth the size of missile interceptors such as the SM-2. Ships will be able to carry many more HVPs than missiles or cartridges and store them in a wide variety of locations since the projectiles are inert. Like some artillery rounds, the HVP can maneuver in flight using small canards or other control surfaces, and it use GPS guidance to reach fixed points; like some air defense interceptors it can be guided to an incoming threat missile.

The artillery-launched HVP will be able to deploy faster and on more ships than an EMRG. HVPs could be employed by the 5-inch or 6-inch guns on all Navy DDGs and CGs, but the surface force's current large and small combatants (with one exception, noted below) will not be able to host an EMRG unless their electrical generation capacity is significantly augmented. The 32-MJ EMRG the Navy plans to mature by the early 2020s requires 15–30 megawatts (MW) of electrical power to fire at its maximum projected rate of six to ten times per

107 "Operationally useful" according to the Navy is being able to fire six to ten rounds a minute and shoot several hundred rounds from an EMRG barrel before it must be replaced. See Kelsey Atherton, "The Navy Wants to Fire Its Ridiculously Strong Railgun from the Ocean," *Popular Science*, April 8, 2014, available at http://www.popsci.com/article/technology/navy-wants-fire-its-ridiculously-strong-railgun-ocean.

minute.[108] This is more than the total electric output of the planned Flight III DDG-51 (12 MW) and current Flight IIa DDG-51s or CGs (both 9 MW).

A smaller EMRG powered via storage devices such as capacitors may be supportable by these ships' electrical systems but would have a limited number of shots before needing to be recharged, limiting its utility in a sustained engagement. It may also be unable to engage the full spectrum of air threats. If the Navy is going to make the investment to place an EMRG on all its ships, those ships should be capable of ASBM defense, which would likely require a 32-MJ EMRG. It has a range of 110 nm surface-to-surface and gains altitude for about the first 20–30 nm; this enables it to hit high-altitude missiles such as ASBM warheads at that range. A smaller EMRG than 32 MJ may not be able to engage ASBMs in the 10- to 30-nm defensive AAW scheme outlined in Chapter 2.

HVPs fired by naval guns will have similar flight characteristics as one fired from an EMRG. The muzzle velocity will be less—about Mach 4 or 5—and the range will be shorter at 40–70 nm.[109] A gun-fired HVP may not be able to engage ASBM warheads or future hypersonic ASCMs in the 10–30 nm range because it may not have the speed to achieve an intercept and will only gain altitude for about the first 10–20 nm. It would, however, be effective against subsonic and some supersonic ASCMs, depending on the engagement geometry.

HVPs from either EMRGs or naval guns will need to be guided to their targets. They may be unable to carry an on-board seeker because the shock associated with their launch may damage a seeker, and the heat generated by their high speeds may preclude using an infrared sensor. An HVP could carry a GPS sensor to get close to the expected intercept point, then rely on a high-fidelity shipboard sensor such as an interferometric radar or EO sensor to guide it to intercept the incoming missile or warhead. To prevent it from having to exactly hit the incoming weapon, the HVP could carry a warhead of flechettes or ball bearings that it would detonate in front of the ASCM or ASBM warhead.

To support ASCM defense, the Navy could deploy HVPs and associated targeting sensors on each CG and DDG. For ASCM and ASBM defense, the Navy could integrate a 32-MJ EMRG for defensive AAW on ships that are able to deploy with CSGs or Amphibious Ready Groups (ARG) and have a sufficient weight and space margin for the EMRG and associated electrical generation and cooling systems. Ideally an EMRG would be incorporated into a new large surface combatant to provide for defensive AAW and long-range surface fires, but that will not happen until the 2030s, ten years after EMRGs will likely be ready to enter the fleet. In the 2020s, ships such as EPFs could host the 32-MJ EMRG by bringing onboard additional power and cooling capacity. This would make defensive AAW those particular ships' primary

108 Kris Osborn, "Navy Plans to Test Fire Railgun at Sea in 2016," *Military.com*, April 7, 2014, available at http://www.military.com/daily-news/2014/04/07/navy-plans-to-test-fire-railgun-at-sea-in-2016.html; "Electromagnetic Rail Gun (EMRG)," *Global Security.org*, updated May 19, 2014, available at http://www.globalsecurity.org/military/systems/ship/systems/emrg.htm.

109 BAE Systems, "Hyper Velocity Projectile (HVP)."

mission, and the ship would be reassigned to operate in concert with large surface combatants to protect CSGs or ARGs. Alternatively, amphibious ships or carriers could be equipped with the power and cooling capacity to host an EMRG, but its rate of fire (six to ten shots/minute) would not provide adequate self-defense or substantially relieve the defensive AAW burden on large surface combatants.[110]

EMRGs larger than 32 MJ would be effective for AAW and SUW. The *Zumwalt*-class destroyers (DDG-1000) would be good platforms for surface attack EMRGs.[111] The DDG-1000 uses electric power for all ship systems—including propulsion—and is thus able to apportion its 78.6-MW generating capacity to engines, sensors, or weapons. Because the class is small (three ships) only one DDG-1000 is likely to be deployed at a time.[112] Equipping DDG-1000s with EMRGs will therefore not significantly improve the defensive AAW capacity of large surface combatants.[113] Instead, the DDG-1000 should host a large (64-MJ) EMRG optimized for land attack, which would require about 50–60 MW of electrical power for sustained fires. This would enable precision attacks at one-half to one-third the range of a LACM but with greater capacity and a higher probability of circumventing enemy defenses since the EMRG projectile is small and traveling at high-supersonic speed on arrival. This integration effort would also provide a valuable starting point for incorporating an EMRG on the Navy's next large surface combatant in the 2030s.

Recommendations:

1. The Navy should equip three to five existing EPFs with 32-MJ EMRGs and related support systems in the early 2020s. These ships would employ rotating military or composite military/civilian crews to enable the ship to operate continuously overseas with periodic overhauls in CONUS. The ships would be assigned to a geographic theater and report to the CSG or ARG commander in that theater as one of the group's escorts.

2. The Navy should equip the EPFs hosting EMRGs with CEC so they can receive fire control information from the Aegis combat system on CGs and DDGs. This will enable the EMRG to participate in the Navy's air defense networks. The Navy will also need to incorporate into Aegis the algorithms needed to guide EMRG projectiles to the correct intercept points for ASCMs or ASBMs.

110 To defend another ship, a ship must generally employ interceptors that can go up and over the defended ship in the event it is between the defender and the incoming missile. To defend another ship with a line-of-sight weapon such as lasers or EMRG, the carrier or amphibious ship would have to position itself between the incoming missile and the target, which puts the higher-value ship at risk and may preclude placing the carrier or amphibious ship on an advantageous course for flight operations.

111 Matt Cox, "Railguns Remain in Navy's Future Plans," *Defense Tech*, April 10, 2013, available at http://defensetech.org/2013/04/10/railguns-remain-in-navys-future-plans/.

112 Current large surface combat operating cycles range from 27–36 months long with 7–8 months of deployed time per cycle. Therefore each surface combatant provides about 0.22 to 0.25 of a deployed ship.

113 Deputy Chief of Naval Operations, *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for FY2017*.

3. To exploit the power capacity of DDG-1000, the Navy should explore integration of a 64-MJ EMRG on a DDG-1000 once the larger EMRG is developed and achieves a rate and number of sustained fires adequate for strike missions.

4. To bring gun-based AAW capability to more ships, the Navy should accelerate development of HVP and deploy it and associated sensors on as many CGs and DDGs as possible.

Shift BMD Missions to Other Systems

As sensor and weapon threats proliferate and improve, an increasing number of large surface combatants will be taken up in BMD deployments unless other means are fielded to address this mission. Because of the positioning and combat system readiness needed for BMD operations these ships are essentially lost to fleet commanders as offensive sea control assets.

CGs and DDGs should continue to have BMD capability to protect the joint force at sea and augment the defense of civilian and military targets ashore during times of heightened threat. They should not, however, be the primary means of providing day-to-day protection for fixed locations against surprise ballistic missile attack. Aegis Ashore and other land-based systems should instead be used for these applications.

Recommendation: The Navy should consider "trading" procurement of one Flight III DDG-51 for procurement of two Aegis Ashore systems that could be fielded in the Middle East or East Asia. The idea of trading a ship for something that is not a ship is normally anathema to Navy leaders, but every ship consigned to a BMD station is essentially lost to offensive sea control operations. This trade would return four (if the Aegis Ashore systems replace forward-based DDGs in Japan) to ten (if the Aegis Ashore systems replace rotationally deployed DDGs in the Middle East) DDGs to offensive sea control.

Small Surface Combatants

The Navy needs improved SSC capacity and capability to restore the "division of labor" between large and small surface combatants. The growing SSC shortfall will increasingly require that CGs and DDGs conduct traditional SSC missions such as counter-piracy while the lack of air defense systems on LCSs will result in CGs and DDGs having to protect noncombatant ships in areas of conflict. As described in Chapter 2, there are three main approaches by which the Navy can use SSCs to enhance the surface fleet to regain its ability to conduct offensive sea control missions in the face of improving anti-ship threats:

1. Field more small surface combatants able to defend themselves and others

2. Augment large surface combatants with SSC SAGs for offensive sea control

3. Empower the National Fleet to conduct less-stressing missions

The first two approaches are interrelated in that the program and capability changes needed to make SSCs more able to defend themselves also enable them to contribute to offensive sea control. Therefore, the capability and program implications that follow focus on approaches 1 and 3 above.

Field More Small Surface Combatants Able to Defend Themselves and Others

Develop the FFG

The Navy is currently evaluating requirements for an FFG that will succeed the LCS as its primary small surface combatant. The request for information (RFI) recently issued by the Navy for industry input sets a low bar for the minimum capabilities needed in the new ship.[114] Although the RFI allows for a wide range of possible FFG proposals, it establishes a capability hierarchy that could support development of a less expensive and less capable ship that does not meet the Navy's needs.

The FFG RFI designates capabilities for SUW and self-defense as the highest priorities and ASW systems as a secondary priority. Capabilities for AAW, such as a VLS, are not a priority. However, respondents to the RFI are asked to address whether a VLS magazine could be included in the FFG, and of what size. This approach leaves open the question of whether the FFG will be able to host VLS-launched weapons such as the SM-2 and SM-6 multi-mission interceptors or Tomahawk Land Attack Missiles (TLAM).

The future FFG, however, will need capabilities to conduct ASW and AAW. The Navy's stated requirement of 104 large surface combatants is based on requirements for CSG protection and BMD stations.[115] This leaves no CGs or DDGs for other operations such as escorting logistics or noncombatant ships. Moreover, the Navy's shipbuilding plan, shown in Figure 8, will fall short of the required number of large surface combatants.[116] Small combatants such as FFGs will need to support escort missions for logistics and noncombatant ships, or even of CSGs in some situations. To be effective escorts, they will need to protect against submarine, ship, and air attack with similar endurance as large surface combatants.

114 U.S. Navy, "RFI: FFG(X)—US Navy Guided Missile Frigate Replacement Program," *FedBizOps*, July 10, 2017, available at https://www.fbo.gov/index?s=opportunity&mode=form&id=cdf24447b8015337e910d330a87518c6&tab=core&_cview=0.

115 Sixty large surface combatants are needed to protect the Navy's required twelve CSGs based on five large surface combatants per CSG as recommended in U.S. Navy, "Policy For Baseline Composition and Basic Mission Capabilities of Major Afloat Navy and Naval Groups," OPNAV Instruction 3501.316B, October 21, 2010, available at https://doni.daps.dla.mil/Directives/03000%20Naval%20Operations%20and%20Readiness/03-500%20Training%20and%20Readiness%20Services/3501.316B.pdf. Assuming the Optimized Fleet Response Plan (OFRP) of one 7-month deployment per 36-month cycle, five large surface combatants are needed for each CG or DDG on a BMD station. The Navy maintains 10–15 BMD stations at any given time in the Mediterranean, Persian Gulf, and Western Pacific supported by a combination of forward-based and CONUS-based ships. With two forward-based ships or five CONUS-based ships needed to support each station, between 40 and 75 large surface combatants could be required for BMD operations.

116 Chief of Naval Operations (CNO), *Report to Congress on the Annual Long-Range Plan for Construction of Naval Vessels for Fiscal Year 2017* (Washington, DC: U.S. Navy, July 2016), p. 7.

Consider eliminating LCS rotating crews

The truncation of the LCS program, development of the new FFG, and upgrades to Flight 0 LCSs call into the question the Navy's planned LCS crewing concept. In this concept, an LCS deploys for up to 16 months and is operated by two crews on four-month-long rotations from their homeport in San Diego, CA or Mayport, FL. There are two significant reasons the Navy should shift from this approach to instead have a single dedicated crew for each LCS sea frame:

- **Forward basing opportunities for Flight 0 LCS.** With thirty-two Flight 0 LCSs, the Navy's planned crewing model would maintain sixteen ships forward, manned by sixty-four rotating crews. They would replace today's forward-based SSCs and operate out of Bahrain (eight), Singapore (four), and Sasebo in Japan (four), but not be based there.[117] The Navy could keep the same number of ships overseas with only thirty-two crews by manning each ship with one dedicated crew and basing them in these three ports. In Bahrain and Sasebo, this would continue the current forward-basing arrangement of today's PCs and MCMs, whereas in Singapore new arrangements would be needed for crews (perhaps unaccompanied at first) to live at the U.S. facility there. The remaining sixteen LCSs would be based in CONUS. As with other surface combatants, ships based overseas would swap with CONUS-based ships every five-to-eight years to conduct major maintenance actions such as overhauls. Mission packages would continue to have their own crews that rotate to the host platform.
- **More organic capabilities and increased variation in upgraded LCSs and FFGs.** Between FFGs, two variants of Flight 0 LCSs, and upgraded LCSs, there will be at least five different configurations of SSCs. Each will require different personnel skills and qualifications, making it increasingly difficult to move crews between ships. The resulting family of SSCs should shift to dedicated crews to enable them to better learn the capabilities of their particular ship.

<u>Recommendations</u>:

1. The Navy should pursue an FFG capable of defending another ship to succeed the LCS, starting design work in FY 2018 and construction in FY 2020 to minimize the duration of the shortfall in SSC inventory. To facilitate rapid design, the FFG should be based on an existing foreign FFG or a similar ship, such as the National Security Cutter.
2. The FFG should incorporate the following systems or equivalents:
    - The current ASW mission package consisting of the MH-60R, VTUAV, Multifunction Towed Array (MFTA), VDS, and SQQ-89(V)15 processor (adds 115 tons);

117 Greenert, "Planning for Sequestration in FY2014."

- An existing digital 3D phased array radar such as the Enterprise Air Surveillance Radar; and
- Three eight-cell Mk-41 tactical length[118] VLS modules (loaded with a combination of ESSMs and SM-2s) and an existing compatible fire control system such as the COMBATTs-21.

3. The Navy should pursue modular capabilities for non-kinetic LCS defensive AAW based on the SLQ-32 SEWIP Block 3 system being installed on DDGs.[119] This digital system uses a versatile electronically scanned array that can detect, classify, jam, deceive, and gather intelligence on enemy electromagnetic sensors and communication systems across a wide range of frequencies. It can conduct more missions than the planned LCS EW system and engage more incoming missiles to expand LCS defensive AAW capacity without requiring more interceptors.
4. The Navy should eliminate the current rotational crewing concept for the LCS and instead man each ship with a dedicated crew. Further, the Navy should forward base LCSs overseas rather than only operate them from overseas ports. Forward basing should start in those locations where SSCs are based or operate from today (Bahrain, Sasebo, and Singapore), but should expand to include additional partner and ally bases.

Empower the National Fleet to Conduct Less-Stressing Missions

As indicated in Figure 8, the shortfall in SSCs between now and the mid-2020s will result in more large surface combatants being pulled away from offensive sea control missions to perform maritime security, training, and other constabulary missions. The Navy could use modular systems and equipment, such as those developed for the LCS, to empower a larger pool of government-owned ships for these security cooperation and training missions in low-threat environments.

Recommendations:

1. The Navy should establish mission packages as a set of programs independent of the LCS and evolve existing LCS mission packages to be able to operate as stand-alone systems. This would enable whole mission packages or components of mission packages to be used on logistic, support, and other noncombatant ships. This may require mission package sensors to collect raw data for later processing and analysis or to transmit raw sensor data to another ship such as an LCS for processing. Weapons systems will need to be able to fire using a local controller (as opposed to the LCS combat system) and find

118 These are long enough to accommodate SM-2, ESSM, ASROC, and Naval Strike Missile, but not long enough for Tomahawk. See United Defense, Armament Systems Division, *Vertical Launching System (VLS) Mk 41—Tactical-Length Module*.

119 Jonathan Greenert, U.S. Navy Chief of Naval Operations, "FY 2014 Department of Navy Posture," Statement before the Senate Subcommittee on Defense, Committee on Appropriations, April 24, 2013.

the target with an organic seeker. The Navy should make the following mission package systems capable of stand-alone operation:

- The entire MCM mission package. Several of the remotely operated and autonomous UUVs of this package were operated from RHIBs, the USS *Ponce*, and foreign ships during International Mine Countermeasure Exercises in 2012 and 2013. Other MCM mission package systems such as the Airborne Laser Mine Detection System can be mounted on helicopters and small boats operating from ships other than an LCS. Data from sensor systems could be collected and passed physically or via communication networks to a mine-clearing command and control vessel.

- The entire SUW mission package. The helicopters, Hellfire missile, and RHIBs of this package can be readily made into stand-alone systems. The Mk-46 30-mm gun will be more difficult to incorporate into some ships because of its size and shape, but could be modified to operate as a stand-alone system.

- Some systems from the ASW mission package. The lightweight tow and torpedo decoy system would be useful on support and logistic ships as a self-defense measure, while the MH-60R ASW helicopter can be hosted on a wide range of platforms. The other main ASW mission package systems (MFTA and variable depth sonars, SQQ-89[V]15 processor) require specialized handling equipment and fittings on the host platform and therefore may not be practical as stand-alone systems.

2. The Navy should consider building additional civilian-crewed ships such as EPFs to mitigate the near-term SSC shortfall. This would also provide additional inexpensive capacity to support a future EMRG deployment and serve as a hedge against future reductions in SSC procurement due to fiscal constraints as discussed in Chapter 1. For example, an EPF costs about $180 million,[120] or about one-third the cost of an LCS.[121] During years in which there isn't enough funding to buy the third LCS or FFG, the Navy could buy an additional EPF.

3. The Navy should develop additional mission packages for security cooperation, training, humanitarian assistance, etc., to enable U.S. and partner noncombatant ships to more easily contribute to these missions.

120 U.S. Navy, Office of Budget, *Highlights of the Department of the Navy FY 2013 Budget* (Washington, DC: U.S. Navy, 2012), available at http://www.finance.hq.navy.mil/FMB/13pres/Highlights_book.pdf.

121 O'Rourke, *Navy Littoral Combat Ship Program*.

Surface Fleet Weapons

A New Approach to Weapons Development

Between now and 2025, the surface fleet can substantially improve its offensive sea control capability and capacity through changes to its weapons portfolio. Weapons were not an area of emphasis in the post-Cold War era and now U.S. forces find themselves at the wrong end of range, salvo, and cost competitions with potential adversaries equipped with Chinese and Russian-made long-range precision weapons.

As described in Chapter 2, the Navy should prioritize relevant capability, multi-mission versatility, and smaller size in its next generation of weapons. This will enable surface combatants to conduct offensive sea control and increase the real and effective capacity of the VLS magazine—the ship's main battery.

Recommendations: The Navy should pursue the following weapons capabilities:

1. A multi-mission, long-range ASCM/LACM: The Navy should consider a smaller warhead when developing the surface launch LRASM variant to enable a range comparable to a Tomahawk (>800 nm) that could make it an effective anti-ship or land-attack weapon.

2. A long-range ASW missile: A follow-on to ASROC based on a long-range weapon such as SM-2, SM-6, or LRASM would enable surface ships to directly engage enemy submarines outside enemy ASCM range and complement the weapons capacity of their embarked helicopters. Surface combatants would be able to attack submarines at the limit of their organic sensors or based on cueing from external sensors such as SOSUS or SURTASS. The Navy should also investigate a smaller standoff ASW weapon that can be carried in larger numbers to engage submarines at more than 15 nm but less than enemy ASCM range.

3. A small, fully active defensive AAW interceptor: The development of ESSM Block 2 should be accelerated. Its small size and active seeker will enable large and small surface combatants to engage more incoming ASCMs than a larger semi-active missile that takes an entire VLS cell and requires the radar to illuminate the target.

With these changes, a notional DDG-51 VLS loadout could change, as indicated in Table 2.

TABLE 2: EVOLVED VLS LOADOUT WITH PROPOSED WEAPONS CHANGES

Mission	Current Missile	Number	Future Missile	Number
Offensive AAW	SM-6	34	SM-6	42
Defensive AAW	ESSM	32 (8 cells)	ESSM Blk II	96 (24 cells)
	SM-2	32		
BMD	SM-3	6	SM-3	4
Strike	Tomahawk	4	LRASM	18
SUW	see note below	see note below	LRASM/ SM-series	18/42
ASW	VLA	4	New ASW missile	8

Note: Flight 1 DDG-51s have 8 Harpoon ASCMs in a deck-mounted non-VLS launcher.

Summary

These recommendations intentionally focus on the “payloads” a ship carries such as sensors, weapons, and other combat systems, rather than proposing new-design surface combatants. This acknowledges the significant fiscal constraints facing the Navy as it pursues a new central concept for the surface fleet. These constraints will likely prevent the Navy from building a new-design ship until the mid-2030s.

Focusing on payloads also allows these recommendations to deliver improvements in the near to midterm (one to two FYDPs) and address the continued improvement and proliferation of anti-ship threats. Reconnaissance-strike networks such as China’s already have a range and capacity advantage over U.S. surface combatants, which will grow as their capabilities improve. These recommendations will enable the surface fleet to begin to regain an advantage in the salvo and cost competition with capable adversaries in the next ten years.

Finally, a focus on payloads enables these recommendations to be more “actionable” by a budget process that is increasingly unstable as a result of ongoing budget caps and resistance by the Congress and the White House to agree on long-term defense spending levels. It is easier in this environment to start or protect funding for modifications to existing ships and new weapons or sensors than to sustain the resources necessary for a major new construction program.

CHAPTER 4

Conclusion

The U.S. military must regain its ability to control the sea against improving sensor and weapon threats. While this is often considered a job for the Navy alone, DoD should explore options to improve the ability of other parts of the joint force to contribute to sea control. For example, U.S. Army or Marine Corps units could employ anti-ship missiles from shore, or U.S. Air Force bombers could regain their proficiency in maritime strike. The fight for maritime access will need to become more "joint" as it becomes increasingly contested in strategically significant areas such as the Persian Gulf, Western Pacific, and Indian Ocean.

The surface fleet, however, will remain the only element of the joint force dedicated to sea control. To regain their maritime superiority, surface combatants will need to be able to destroy threats to sea control before the enemy can attack, rather than simply have an improved ability to defend against weapons after they are launched. Defensive sea control, which the surface fleet fell into largely through neglect of weapons development, will only exacerbate today's growing weapons and cost exchange disadvantages. Only by returning to an offensive approach, as with the Cold War's Outer Air Battle, can the surface fleet position itself to fire fewer weapons than the enemy and do so without draining resources from other parts of the fleet.

In pursuing offensive sea control, the surface fleet must contend with persistent and growing demands for maritime security, training, and cooperation missions. Without sufficient SSCs and noncombatant ships to perform these missions, the division of labor in the surface fleet will break down, and large surface combatants—the fleet's mainstay for offensive sea control—will become consumed in constabulary operations.

The Navy's approach to these challenges cannot be a future vision targeted for decades from today. It must be an executable plan incorporating realistic resource and time constraints that enables the surface force to gain the advantage against improving adversaries as soon as practical. This study provides the framework of such an approach for the surface fleet to restore its command of the sea.

LIST OF ACRONYMS

A2/AD	anti-access/area denial
AAW	anti-air warfare
AFSB	Afloat Forward Staging Base
AFSB-I	Afloat Forward Staging Base - Interim
AMDR	Air and Missile Defense Radar
ARG	Amphibious Ready Group
ASBM	anti-ship ballistic missile
ASCM	anti-ship cruise missile
ASROC	anti-submarine rocket-propelled torpedo
ASW	anti-submarine warfare
BBA	Bipartisan Budget Act of 2013
BCA	Budget Control Act of 2011
BMD	ballistic missile defense
CEC	Cooperative Engagement Capability
CG	guided-missile cruiser
CIWS	close-in weapons system
CONUS	continental United States
CSBA	the Center for Strategic and Budgetary Assessments
CSG	carrier strike group
CVBG	carrier battle group
CVLWT	Common Very Light-Weight Torpedo
DDG	guided-missile destroyer
DoD	Department of Defense
EM	electromagnetic
EMRG	electromagnetic railgun
EO	electro-optical
ESSM	Evolved Sea Sparrow Missile
FAC	fast attack craft
FFG	frigate
FSS	Fast Sealift Support
FY	fiscal year
FYDP	Future Years Defense Program
GPS	Global Positioning System
IR	infrared

LIST OF ACRONYMS

JASSM-ER	Joint Air-to-Surface Standoff Munition-Extended Range
JHSV	joint high speed vessel
LACM	land-attack cruise missile
LCS	Littoral Combat Ship
LFAA	low-frequency active acoustic
LPD	amphibious transport dock
LRASM	Long Range Anti-Ship Missile
MAGLEV	magnetic levitation
MCM	mine countermeasures ship
MFTA	Multifunction Towed Array
MIW	mine warfare
MSC	Military Sealift Command
NATO	North Atlantic Treaty Organization
NDRF	National Defense Reserve Fleet
NGLAW	Next Generation Land Attack Weapon
NIFC-CA	Naval Integrated Fire Control-Counter Air
OCO	Overseas Contingency Operations
OTH	over-the-horizon
PAC-3	Patriot Advanced Capability upgrade version 3
PC	patrol craft
Pk	probability of kill
QDR	Quadrennial Defense Review
R&D	research and development
RAM	Rolling Airframe Missile
RHIB	rigid-hull inflatable boat
SS-L-S	shoot-shoot-look-shoot
S-L-S	shoot-look-shoot
SAG	surface action group
SSL	solid-state laser
SOSUS	Sound Surveillance System
SSBN(X)	Ohio-class ballistic missile submarine replacement
SSC	small surface combatant
SSDS	Ship Self-Defense System
SSL-TM	Solid-State Laser Technology Maturation

LIST OF ACRONYMS

SSN	nuclear attack submarine
SURTASS	Surveillance Towed Array Sensor System
SUW	surface warfare
THAAD	Terminal High Altitude Area Defense
TLAM	Tomahawk Land Attack Missile
UAV	unmanned aerial vehicle
USNS	United States Naval Ship
USS	United States Ship
USSR	Union of Soviet Social Republics
UUV	unmanned underwater vehicle
VDS	variable depth sonar
VLA	vertical launch ASROC
VL-ASROC	vertical launch anti-submarine rocket-propelled torpedo
VLS	vertical launch system
VTUAV	vertical takeoff unmanned aerial vehicle

CSBA

Center for Strategic and Budgetary Assessments

1667 K Street, NW, Suite 900
Washington, DC 20006
Tel. 202-331-7990 • Fax 202-331-8019
www.csbaonline.org