IMPACTS OF THE ROBOTICS AGE ON NAVAL FORCE DESIGN, EFFECTIVENESS, AND ACQUISITION

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> *It is not in the interest of Britain—possessing as she does so large a navy—to adopt any important change in ships of war . . . until such a course is forced upon her. . . . [T]his time has arrived.*
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> ADMIRAL BALDWIN WALKER, ROYAL NAVY, 1860

The twenty-first century will see the emergence of maritime powers that have the capacity and capability to challenge the U.S. Navy for control of the seas. Unfortunately, the Navy's ability to react to emerging maritime powers' rapid growth and technological advancement is constrained by its own planning, acquisition, and political processes. Introducing our own technology advances is hindered as well. The planning and acquisition system for our overly platform-focused naval force structure is burdened with so many inhibitors to change that we are ill prepared to capitalize on the missile and robotics age of warfare.

Yet by embracing the robotics age, recognizing the fundamental shift it represents in how naval power is conveyed, and refocusing our efforts to emphasize the "right side" of our offensive kill chain—the side that delivers the packages producing kinetic and nonkinetic effects—we may hurdle acquisition challenges and bring cutting-edge technology to contemporary naval warfare.[1] Incorporating robotics technology into the fleet as rapidly, effectively, and efficiently as possible would magnify the fleet's capacity, lethality, and opportunity—all critical to strategic and tactical considerations. Doing so also would recognize the fiscal constraints under which our present force planning cannot be sustained. As Admiral Walker advised above, it is now time to change.[2]

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After addressing the traditional foundations of force structure planning and the inhibitors to change, this article will discuss how focusing on the packages delivered rather than the delivery platforms would allow us better to leverage new technologies in the 2030 time frame. What would a naval force architecture look like if this acquisition strategy were employed? This article will present a force-employment philosophy and a war-fighting strategy based on the tactical offensive that align with this acquisition approach. The article does not present an alternative force structure with actual numbers of ships and platforms, but suggests a force-acquisition strategy and force-design concept that provide a foundational underpinning by which a specific force architecture can be developed. Three strategic force measures—reactivity, robustness, and resilience—will be used subjectively to assess this fleet design compared with our traditional programmed forces.

STRATEGIC FOUNDATIONS OF NAVAL FORCE-STRUCTURE PLANNING AND THE GREAT INHIBITORS

Ideally, a country's naval force structure changes with national strategy, national treasure, technological advancement, and potential adversary capabilities. National strategy provides the rationale for, purpose of, and priority among choices to be made in creating a fleet. National treasure defines the resources and constraints dictating strategic choices. New technologies provide opportunities for increasing fleet effectiveness, yet also may endanger fleet survival should potential adversaries expose and exploit vulnerabilities in these technologies. This is a complex problem even when one takes into account only these four factors; however, U.S. naval acquisition also is challenged by other influences that inhibit capitalization of new technologies.

The most powerful of these inhibitions is inertia. The existing fleet represents a capital-heavy investment by the country, one with long build times and lifetimes. Ships and aircraft cost billions to design, build, and maintain. They require a capital-intensive industry featuring heavy equipment, infrastructure, and a skilled workforce—all generations in the making. As a consequence, annual programming and budgeting decisions are marginal in nature. It is the nature of a large fleet to evolve slowly, as opposed to undergoing revolutionary changes to its composition. This is a reality the Chief of Naval Operations (CNO) faces when considering changes to the naval forces. Each CNO's relatively short tenure restricts the ability to formulate, market, and execute any maritime strategy that would have a comprehensive effect on ship and aircraft procurement.

Since the first six USN frigates were authorized in 1794, national internal political and economic factors have been another major influence on fleet composition. As Ian Toll illustrates well in his *Six Frigates: The Epic History of* *the Founding of the U.S. Navy,* the potential windfalls for local economies when selected to build warships generate powerful political pressures for stabilization once these selections are made.[3] Now just as then, senators and congressmen representing districts that build ships (and aircraft) may be expected to defend existing programs and seek new ones, to the economic benefit of their constituents.

Next, the compartmentalization of fleet planning, budgeting, building, and maintenance caused by large, resource-competing bureaucracies creates a lethargic environment inefficient for change. Multiple oversight agencies and bodies, including Congress, subject every decision that program managers make to often-paralyzing scrutiny. Our agility to implement rapid change is lost when the number of stakeholders exceeds the point at which responsibility and authority can be defined clearly. This is a structural issue common to all capital-heavy investment programs—the space shuttle, large multimission warships, long-range bombers—that require bureaucracies to design and implement them.

Finally, the very nature of a fleet's strategic value engenders conservatism in a senior naval leadership faced with the options for change. This is not necessarily an unhealthy view, as loss of the fleet could mean loss of sea lines of communication (SLOCs), and therefore likely a war. Nonetheless, overvaluing what worked in the last major maritime war—which occurred in the 1940s—at the expense of recognizing that missile, robotics, and cyber technology has changed the primary conveyance of naval power may result in a fleet unprepared to combat an enemy that is not so inhibited. A less formally "capable" adversary untethered by allegiance to past precedent may be more flexible and therefore much more dangerous.

Individually, none of these influences on force structure planning can be dismissed. The danger is that in aggregate they result in a harmful escalation of commitment toward obsolete platforms, permitting only marginal changes in force structure amid opportunities for major technological changes. The result today is a brittle U.S. fleet that is susceptible to tactical surprise and slow to react to adversaries' technological initiatives.[4]

The United States is not unique in facing these challenges. Historically, major changes to naval force structure have resulted from war, great technological leaps, or both. Rowing, ramming, and boarding vessels gave way to the naval cannon and sail; sail to steam; armor and rifled guns to aircraft; and aircraft to missiles. Now comes the dawn of a robotics age. Missiles, robots, miniaturization, hypersonic technologies, and artificial intelligence give the advantage to many smaller, faster, and more lethal offense capabilities.[5] Our challenge today is to not allow the restraints on current force structure planning to cede these advantages to potential adversaries.

MISSILES, ROBOTS, AND AN OFFENSIVE TACTICS–ENABLING STRATEGY

Meeting all the desired maritime strategic capabilities—all-domain access, deterrence, sea control, power projection, and maritime security—while constrained by the budget and procurement process will require new thinking in platforms, weapons, and command and control (C2). Embracing the combined capacity of missiles and robotics in this new era creates options for achieving a desired *tactical* end state that enables our operational and strategic goals. Strategists will regard this as a reversal of the traditional hierarchy of the levels of war; yet it is historically accurate. Technology empowers a tactical edge in maritime warfare, providing new operational and strategic choices. For example, the advances in submarine technology during the first half of the twentieth century resulted in a new form of commerce raiding and sea-lane interdiction. The reach of carrier aircraft changed the nature of naval combat in World War II. Advances in nuclear propulsion and ballistic-missile technology in the second half of the twentieth century led to a third way of offering nuclear strategic deterrence: from the sea depths. Parallel examples can be made for missile-carrying aircraft and the guided torpedo.[6]

Today, investing in a very "smart" long-range autonomous offensive missile that can outrange those of our adversary may permit us to build less-expensive, less-well-defended ships from which to launch them, thereby making sea combat more affordable. Shifting emphasis to the weapon's ability and the force's targeting capability, rather than concentrating on the platform itself, changes both the risk and cost calculus.

Take a specific example. Purchasing one fewer *Burke*-class guided-missile destroyer (DDG) would allow the acquisition and operation of thirty-five to forty large autonomous surface vessels (LASVs).[7] If each of the latter were armed with eight antiship cruise missiles, from 280 to 320 offensive missiles could be dispersed in a contested region, as opposed to the eight missiles (canister) or at most ninety (vertical launch systems) that the DDG could bring to one location. Our potential adversaries show an appreciation for this concept by building smaller, missile-capable combatants, establishing a clear missile gap between themselves and U.S. surface forces in contested regions.[8]

The proposal here is not to replace all DDGs with unmanned surface vessels, but to refocus our investments on less expensive "payloads" delivered, kinetic or cyber, not the more expensive delivery platforms.[9] The goal is greater affordability paired with enhanced fleet capacity and employment options, thereby creating uncertainty in our potential adversaries' strategic calculus. A stark example is a weapon that has huge maritime influence—changing our strategic risk calculus—yet has no maritime platform: the Chinese DF-21 antiship ballistic missile.

As important as it is to focus on offensive payloads so as to provide rapid change capacity, doing so yields other benefits as well. It lessens many of the political, economic, and bureaucratic challenges associated with investing in capital-heavy platform programs. Since it is easier to modify weapons than platforms, technological upgrades to weapons systems can be accomplished quicker.[10] The forty-year-old Mk 48 heavyweight torpedo illustrates how an offensive weapon may evolve with new capabilities, even with no major modifications to its platform. There is also less political interest invested in weapon procurement, as these systems do not require the resources associated with a new submarine or aircraft carrier. Fewer stakeholders burden weapon design, procurement, assembly, and modification. These factors enable us to modify offensive capabilities quickly as new technology emerges, or to respond better when an adversary surprises us with a new capability. The ability to test, fail, and quickly change a portion of the fleet that is less capital heavy than our traditional forces is an advantage from any perspective.

This philosophy is particularly exploitable in the electromagnetic (EM) and cyber realm. Inexpensive, disposable unmanned aerial vehicles employing radar reflectors or chirp jamming systems can be more cost-effective delivery platforms for EM packages than a single EF-18 Growler. The introduction of inexpensive, credible, and numerous decoys into the air, on the surface, and undersea also is enhanced by the robotics age's ability to deliver confusing effects with little risk to manned systems. In defense, developing left-of-launch effects against an adversary's surveillance systems—countertargeting—need not be expensive, and, if synchronized with the movement of actual forces, mitigates risk to sailors operating in contested areas.

In other words, when building a fleet for contested environments while operating under real financial constraints, our investments should concentrate on technologies that enhance the right side of our offensive kill chain and enable us to disrupt the left side of an adversary's kill chain prior to his launch. Building kinetic weapons for offense and nonkinetic weapons for defense are more cost-effective options than building multimission, hardened, and therefore expensive platforms. Robotic vehicles for delivering these weapons put the focus of warfare close to the enemy and farther from us.

We are not there yet. If resource allocation is a mirror of strategic choices, in the president's fiscal year 2017 Defense Department budget, of the $183 billion allocated for modernization (which includes procurement and research and development), about 40 percent is allocated for aircraft procurement and shipbuilding, less than 8 percent for munitions.[11] Substantial change, involving Congress and the Navy Department, will be required to move past procuring a platform-centric force to procuring a sensor/weapon-centric force. However, we are beginning to explore the value of naval offense in employing our current fleet, and this, combined with opportunities presented in the robotics age, provides the opportunity to affect positively both fleet architecture and fleet design.

A TAILORED MARITIME OPERATIONAL AND ACQUISITION CONCEPT

Faced with real challenges to sea control by emerging competitors, we are relearning the basic tenet that offense is the most cost-effective form of naval warfare—in both acquisition and employment. Our surface navy is exploring distributed lethality, an offensive operational concept enabled by the missile age, and its principles are being adopted for a distributed fleet, with enhanced lethality and targeting capabilities across the force and across multiple domains. We find that the range of an offensive missile matters, but only if its reconnaissance and targeting system holds the advantage over a potential adversary's reconnaissance and targeting system. As a result, we are reinvigorating EM warfare for surveillance, deception, and countering rival EM systems. Employing some old Cold War tricks enhanced with new technologies, we are considering seriously the use of and training in methods to find, target, and kill in an EM "night" (i.e., when advanced surveillance and targeting systems are available to neither side).[12] These are necessary steps to provide an immediate credible threat, and therefore a deterrent, to potential adversaries' adventurism in regions we hold to be critical to our national interest.

Yet we cannot abandon tactical and operational defense and still maintain use of the oceans. Only in an ideal Mahanian total battle fleet–on–battle fleet engagement, in which all an enemy's sea-command capabilities are defeated in a single massive exchange, can offense achieve sea control. The twentieth century showed this idea to be limited to the age of sail, if it applied even then. Preserving SLOCs and associated logistic-hub availability will require defense against ballistic, hypersonic, and cruise missiles, and torpedoes, mines, and guns. Our countersurveillance, countertargeting, and close-in soft-kill systems become as critical as our hard-kill systems. Dedicated multimission platforms still will be required to defeat an enemy's attacks across our sea and air logistics lines.

For the past forty years, the cost-effective way to provide both offensive and defensive capabilities at sea has been to leverage economies of scale by placing as much multimission capability as possible in a ship hull. Our advanced Aegis *Burke*-class DDGs are the result. Once deployed to, say, the Central Command area of operations, this DDG can conduct counterpiracy activities in the morning, then relocate on short notice to mount theater ballistic-missile defense in the afternoon. It can hunt other surface ships and defend an aircraft carrier from cruise-missile attack. It is versatile, fast, and multifunctional. Operationally, it is limited only by its draft.

But these ships also are limited by their expense. Plus, if a war starts and we begin to lose them, replacement time will be problematic. In a major war at sea, we may find that our cost-effective peacetime strategy of concentrating on economies of scale has created a situation of "too many eggs in one basket." The loss of a DDG while conducting an independent offensive surface action becomes a loss of missile and air defense, antisubmarine warfare (ASW), and escort capacity to the fleet—as well as a highly skilled crew.

In the past we addressed economic constraints that prevented our entire fleet from consisting of advanced multimission ships by building a "high-low" mix, incorporating a few special-mission ships to conduct mine countermeasures and logistics. We envisioned the "low" ships in the mix filling the constabulary and escort duties farther from harm's way during times of conflict. But if we consider distributed lethality and the advantage of the offense, combined with advances in unmanned systems, autonomy, and longer-range, smarter missiles, a new opportunity for an economical fleet mix emerges. Its fleet design is the opposite of the traditional high-low mix: we would employ smaller, cheaper offensive platforms to operate forward, and larger sea-control ships to defend against our adversaries' advanced sea-denial capabilities.[13] A fleet employment of such a force results in finding and destroying the enemy with offensive systems that are more numerous, less expensive, and lower manned.[14] They will be the sea-denial force. More-expensive defensive platforms will be deployed in areas of vital interest, or to protect high-value ships and convoys that are within the enemy's reach.[15] This "protection" force will be the sea-control force. The adversary cannot disregard our threat of offensive force to focus on attacking our interests while we have placed the best multimission ships to defend those interests. *This is distributed lethality combined with smart defense*.[16]

As the distributed lethality concept evolves into distributed maritime operations and multidomain concepts, the offsetting of constraining budgets with opportunities in new technologies will nudge us naturally toward this mixed approach. Offensive antiship missiles are becoming smarter and our adversaries have learned to employ them in various ways: from shore, shipping containers, bombers, and missile boats. Our own offensive fleet could be just as versatile, composed of missile corvettes paired with missile-equipped LASVs working in coordination with undersea systems and long-range bombers armed with hypersonic missiles. The objective of the components of this force is to close silently and deceptively; deliver their missiles, torpedoes, mines, or cyber packages; then retire or, if unmanned, stay as a reconnaissance node, if desired.[17] This concept leverages technological advances in missiles, unmanned systems, and countertargeting methods to provide a threat more credible, practical, useful, and economical. (In a calculus of value, a commander is more willing to risk what he or she values less; the more so when its capabilities nonetheless enjoy his or her confidence.) Our traditional fleet primarily will fill the role of the protective force, using strike when necessary to kill threats advancing toward our SLOCs.

This concept is an operational expression of tactics that Arleigh Burke developed during the Solomons campaign. Commodore Burke championed sending the small, maneuverable destroyers ahead of the battle line to conduct coordinated torpedo attacks. Frederick Moosbrugger executed these tactics at Vella Gulf, and Burke did so at Cape Saint George. Burke's fighting doctrine of simplicity, surprise, and delegation of authority also provides the tenets for employing today's offensive force. And, like Burke's skillful employment of radar to provide a tactical edge, the offensive force will be enabled with the latest targeting, countertargeting, and killing technology as it becomes available.[18] A characteristic of light, inexpensive delivery platforms is their ability to be upgraded quickly and cheaply through payload replacement or, if desired, whole-platform change-out.

As the sea-control force evolves through retirement of the top-end multimission platforms, it too will become more tailored by employing the latest technology to counter specific threats, although, by the nature of its purpose, it will remain multimission in character. For example, theater ASW ships still will be required to protect themselves from submarine-launched antiship cruise missiles, and escort duty will require some form of area defense from all threats.

During more-peaceful times, the offensive force can fill peacetime constabulary duties and engagement exercises in forward regions. But dividing a force into offense and protective defense elements is a war strategy, not a peacetime maritime security strategy.[19] Building a portion of the force dedicated to offense, exercising and testing tactics using new technologies in robotics and automation in this force, and engaging allies in its employment signal serious intentions on our part to prepare for actual combat and the willingness to accept some losses. As a result, the new, offensively disposed force provides a stronger deterrence.

The evolution to a tailored fleet from our current force will be more effective and less expensive than simply adding offensive capability to each new ship built in a total multimission force. The tailored fleet will distribute offense to more-numerous platforms, while concentrating defense on areas of vital importance to maintain the true strategic end of our nation's Navy: use of the seas. Such a fleet provides a way to distribute offensive lethality economically and to distribute defense efficiently. Making the offensive force both lethal and sufficiently resilient to ensure its deterrent credibility is addressed next.

WEB FIRES, FOOTBALL, AND ACCELERATED CUMULATIVE WARFARE

In a 2016 report to the CNO, Strategic Studies Group (SSG) 35 identified the next "capital ship" as the network of machines and humans.[20] It recognized that emerging technology enables a multitudinous, disaggregated force of manned and unmanned systems to challenge adversary situational awareness and targeting. It is the end vision of a sensor/weapon-centric force and describes a way to employ the offensive fleet. But, in this model, what now is a *capital ship*? Under the traditional definition, it is the most heavily armed and powerful warship, one of the first rank in size and armament.[21] The capital ship is the main conveyance of naval power. The SSG implicitly selected the "main conveyance of combat power" definition to describe its network of systems and concept of employment. However, if the main conveyance of naval power is defeated, so is the Navy. Capital ships can be viewed as a naval center of gravity. In a network of manned and unmanned systems, the network becomes the naval center of gravity—and therefore a target of interest to an adversary.

Like the SSG's network, the maturing "web fires" or "netted fires" concept is a vision of netted sensors, shooters, and communications linked together to provide multiple options in executing detect-to-engage sequences across an area of operations. Information will be ubiquitous and accessible to all sensor and weapon operators via a web construct, linked through various methods of mesh networks, burst transmissions, and traditional communication channels resistant to enemy jamming and interference.[22] The mesh network "capital ship" is designed to survive against interference and intrusion, just as the battleship was armored to survive against rifled rounds. It will enable distributed operations or massing of fires across all domains, including the human domain. It provides the surveillance and information advantage needed to employ long-range weapons before an adversary does. This web fires concept will be enriched by the use of unmanned systems, smart weaponry, and autonomy. It is the natural technological evolution of the Soviets' reconnaissance-strike complex.[23] It is the realization of the third offset, as envisioned by Deputy Secretary of Defense Robert Work.[24] It is the implementation of the SSG network of machines and humans.

Then the fighting starts. How battle resilient the web fires and distributed forces will be depends on the technology that enables them; on the C2 and intelligence, surveillance, and reconnaissance systems and tactical philosophy envisioned when the elements are built; and on the sailors who operate them. The United States cannot be assured of technological superiority in the future, so our Navy must retain war-fighting methods that do not assume assurance of continuous information to all elements of the force. It must create a force design—defined as the way we fight—to leverage the greatest advantage of American forces: individual command initiative and innovation in the face of adversity.

Web fires and a distributed force to be used as the offensive or sea-denial force should be built from the bottom up, not from the top down, meaning that, if necessary, every manned node in the web can act independently as a scout, commander, and shooter within its own area of responsibility. This decentralized execution is not a new concept for U.S. naval forces (every submariner will recognize the C2 concept), but unless the web is built with self-reliant, capable nodes from the start, we may not be able to implement fully a command philosophy of distributed decision making, particularly if we must fight in the electromagnetic night. "Offboard" information provided by the web, or subelements of the web, is then viewed as an enhancer, but not necessary to employ weapons. The offensive force will be network enabled, not network dependent.

Employing the offensive fleet as a distributed force comprising self-sufficient weapons-launch platforms, augmented by web fires' off-platform information when available, achieves a highly resilient force structure. In a fight, the force network leverages a strategy of accelerated cumulative warfare, relying on individual engagements to create the desired emerging operational and strategic effects.[25] It confounds an adversary by offering a multidomain, independent, dispersed, and offensively oriented challenge to defeat. This foundational philosophy turns the focus to tactical offense, reorients acquisition from platforms to weapons (kinetic and nonkinetic), and accelerates employment of technologies in missiles and robotics. It leads to a more numerous force composed of smaller platforms, as John Arquilla envisioned in his 2010 *Foreign Policy* article "The New Rules of War."[26]

In execution, such an offensive force resembles an offensive football squad. After a play is called, each player proceeds to his assigned area, with full knowledge of his role in the called play. No communication is required after the ball is hiked. Although everyone has a role, each, if necessary, also can carry the football, run for a touchdown, or tackle. If the quarterback views new information after the play is called, a short audible at the line may change the play. Employment of the offensive fleet in a distributed force is similar. Pairs of delivery systems may move into position on the basis of commander's intent and up-to-date intelligence; no communication is required. If an audible is called, it can be communicated through brief signals in code along short-burst, mesh-network paths.[27] And each player, if necessary, can target and shoot independently within his or her area of responsibility.

The emergent effect of this cumulative strategy is sea denial close to the enemy's objectives, with or without a continuous C2 network. This achieves the intent of both the web fires and manned-and-unmanned network concepts without dependency on an actual network, thereby eliminating a possible single-point vulnerability for the enemy's attention. This enhances force resiliency and increases each unit's survivability.

ASSESSING THE CONCEPT

For a comprehensive quantitative assessment of a future naval force, we would need a complete force architecture with specific numbers of ships, aircraft, submarines, weapons, unmanned platforms, facilities, and basing locations. We also would need a concept of employment, operations, doctrine, and tactics for the force architecture—a force design. These types of studies are conducted cyclically, with the most recent set requested by Congress and delivered to it in 2017.[28]

The intent of this article, however, is to present a foundational precept on which to build both a fleet architecture and a fleet design: seeking to increase the fleet's offensive power and ability to adapt by leveraging the robotics age's emerging technologies in kinetic and nonkinetic warheads, missiles, and platforms to deliver them. In lieu of a detailed quantitative assessment, a subjective overview of the concepts will be discussed using more-strategic metrics. Although many metrics could be selected to assess alternative future naval force structures, as its strategic litmus tests this analysis will use reactivity, robustness, and resilience. For this purpose they are defined as follows:

- *Reactivity* is a fleet's ability to capitalize quickly on new technology advancements and react to a "capability surprise" from a potential adversary.
- *Robustness* is a fleet's ability to be relevant across a variety of futures that differ in national priorities, geopolitical and geoeconomic conditions, maritime strategies, and conflict scenarios.
- *Resilience* is a fleet's ability to sustain damage in a particular future and conflict scenario while still accomplishing national objectives. Resilience is a subset of robustness, and is similar to the concepts addressed in current Navy staff analyses conducted to assess programmed fleet capabilities.

Reactivity

Much of the foregoing highlights the characteristics necessary for a payload-focused force to be more adaptable than the current acquisition program's expensive, long-lived, multimission ships and aircraft. By increasing the proportion in the mix of smaller (whether unmanned or manned single-mission) delivery platforms, we increase a fleet's reactivity. Missile seekers, sensors, software, and unmanned systems can be replaced or modified, tested, corrected, retested, and introduced into the fleet with fewer challenges than a multimission destroyer.

The former lend themselves to advantages in maintenance and repair as well, with less nonavailability time fleet-wide. For example, when a DDG is in dry dock availability, the fleet loses all its mission areas. This is an aspect of the "too many eggs in one basket" finding in our previous wartime example. In contrast, when a single-mission platform is undergoing maintenance, the fleet loses only that one mission. In addition, numerous smaller platforms allow a greater portion of the fleet to be forward deployed while the remaining force is being updated in rear areas.

Robustness

Although the ability to perform the enduring missions of strategic deterrence, protecting SLOCs (sea control), denying adversary sea communications (sea denial), and projecting power from the sea is desirable in naval forces, the capabilities and capacities of a nation's navy to exercise these missions are influenced by the political will, economic resources, and global power aspirations of its people. These can change faster than the capital-intensive, long-lived, multimission ships and submarines of our programmed force. A comprehensive assessment of a fleet architecture's robustness or utility across several international political and economic environments—with various competing national strategies and possible conflicts—will involve extensive future scenario planning to assess strategic risk. For brevity, only general observations are made here.

Our current programmed force is heavily invested in complex multimission platforms that employ advanced technologies, mainly in defense. It seeks to optimize the fleet's influence in a future that is a projection of our current fiscal and political environment, with operational concepts born during World War II. Although any robust U.S. fleet will have some of these platforms, allocating too large a share consumes and locks in future fiscal resources for maintenance, manning, training, and operations. In addition, if the fleet is successful in deterring the very-high-end conflicts for which these platforms are built, those platforms may find themselves conducting missions for which they are not well suited, such as when cruisers conduct counterpiracy operations. Worse, if fiscal constraints become onerous, the expense of operating these platforms may become prohibitive, so the only affordable strategy becomes to employ them as a "fleet in being"—tied to the pier. Adding to the mix more smaller platforms, both manned and unmanned, is a cost-effective way to provide policy makers with design options for fleet employment, reconfiguration, and basing. A core portion of the fleet comprising long-lived, multimission ships remains dedicated to exercising sea control, while the offensive sea-denial force composed of smaller, less expensive systems may grow or diminish as the national strategy and available national treasure vary.

Resilience (or Toughness)

As mentioned, fleet resilience is a subset of fleet robustness. The ability of the fleet to sustain damage yet continue to operate in a contested environment against an adversary may be achieved in two major ways: build in a vigorous damage-containment design through redundancy and compartmentation in individual platforms, or have many platforms.

Advanced weaponry's ability to inflict a mission kill makes building individual ship resilience challenging and costly. Having many ships in a fleet also imposes costs, but can be achieved if the fleet, not individual ships, is built with a redundancy of smaller, mission-specific platforms organized into task groups that are dispersed while in contested waters.

A fleet with numerous offensive sea-denial forces, as in the fleet mix proposed here, would enjoy greater resilience than the current programmed force. The latter relies more on active defense and individual platform survivability to sustain the fleet in a contested environment, but in the missile and robotics age this will remain difficult and expensive to achieve and maintain.

We are in the missile age and at the dawn of the robotics age. Cyber warfare already has arrived in peacetime and will affect combat operations in wartime. Emerging technologies give us new ways to convey naval power and may allow us to overcome the inhibitors to changing a capital-intensive, long-lived, platform-centric fleet.

We would begin this journey by tailoring the fleet into offensive sea-denial forces and protective/defensive sea-control forces. The offensive force would be built using manned and unmanned systems, in all domains, in relatively large numbers, to deliver kinetic and nonkinetic effects. This would be a "package"-centric force, with short testing, learning, and upgrading cycles. It would be employed under a netted-web-fires and distributed-fleet concept, but from the bottom up, with each manned node capable of independent weapon employment. The manned systems, such as missile corvettes, would be built in sufficient numbers to conduct the mainstay peacetime presence and constabulary duties, in cooperation with allies.

Our traditional fleet, with its advanced multimission capabilities, would have the more difficult defensive or sea-control role. It too could be upgraded with lessons learned from the offensive force and to counter new enemy technologies. With constraining budgets, our traditional fleet would have to be somewhat smaller to fund the less expensive offensive fleet, but it no longer would have to meet the presence requirements that drove up its force numbers.

This fast-evolving wartime fleet concept will challenge potential adversaries with a close-in, lethal, yet resilient threat, while providing robust defense to our nation and our own SLOCs. A fleet architecture founded on leveraging the missile and robotics age in this manner will increase its capability to be reactive, robust, and resilient.

NOTES

1. Various "kill chain" models exist to describe a tactical engagement. In one the steps are finding the enemy forces, fixing their location, tracking their movements, targeting with a weapon system, engaging them with that weapon, and assessing the damage after the attack. By advocating focusing on the "right side" of this kill chain, I mean we need to invest considerable time in maximizing our weapon's autonomy and its other capabilities during the engagement phase, with less concern about which platform launches it. Later in this article, when we discuss attacking the "left side" of the adversary's kill chain, we mean countering their fixing and targeting capabilities.
2. Admiral Walker was referring to building a warship completely of iron. Quoted in Arthur Herman, *To Rule the Waves: How the British Navy Shaped the Modern World* (New York: HarperCollins, 2004), p. 452.
3. Ian W. Toll, *Six Frigates: The Epic History of the Founding of the U.S. Navy* (New York: W. W. Norton, 2006).
4. See National Research Council, *Responding to Capability Surprise: A Strategy for U.S. Naval Forces* (Washington, DC: National Academies Press, 2013).
5. John Arquilla, "The New Rules of War," *Foreign Policy* 2, no. 22 (March/April 2010), available at www.foreignpolicy.com/.
6. For a more detailed discussion on how technology impacts naval combat, see Phillips Payson O'Brien, ed., *Technology and Naval Combat in the Twentieth Century and Beyond* (Abingdon, U.K.: Routledge, 2001).
7. The DDG vs. LASV cost trade-off range comes from comparing a DDG procurement cost estimate of $1.5 billion with an antisubmarine warfare (ASW) continuous trail unmanned vehicle (ACTUV) procurement cost of $25 million. For the DDG, see Pat Towell and Lynn M. Williams, *Defense: FY17 Budget Request, Authorization, and Appropriations,* CRS Report 7-5700 (Washington, DC: Congressional Research Service, April 12, 2016); information for the LASV relies on Scott Littlefield, program manager, interview by author, February 14, 2017. The more bounding constraint is a daily operating cost for the DDG of seven hundred thousand dollars compared with an estimated twenty-thousand-dollar daily operating cost for the ACTUV. Littlefield interview.
8. Alan Cummings, "A Thousand Splendid Guns: Chinese ASCMs in Competitive Control," *Naval War College Review* 69, no. 4 (Autumn 2016), pp. 79–92.
9. The concept of packages over payloads was introduced by Adm. Jonathan W. Greenert, USN, in "Payloads over Platforms: Charting a New Course," U.S. Naval Institute *Proceedings* 138/7/1,313 (July 2012), pp. 16, 23. The present article highlights the importance of this concept to leveraging fully the missile and robotics age, and provides a venue to engender more-rapid change.
10. The foremost example of the "two-stage" system approach was the aircraft carrier. Beginning in the 1930s, the U.S. Navy kept its carrier fleet viable by upgrading carrier air wings, and later by upgrading the missiles under the wings of the aircraft. The nuclear-powered carrier and carrier air wing are now a "three-stage" system.
11. U.S. Defense Dept., *United States Department of Defense Fiscal Year 2017 Budget Request: Program Acquisition Cost by Weapon System* (Washington, DC: Office of the Under Secretary of Defense [Comptroller] / Chief

Financial Officer, February 2017), p. 3, available at comptroller.defense.gov/.

12. *Electromagnetic night* signifies a contested environment in which the EM spectrum is challenging and the use of global positioning systems, long-range communications, and national technical means is not assured.

13. For a discussion on single-mission ships' value in the littorals, see Wayne P. Hughes Jr. [Capt., USN (Ret.)], "Single-Purpose Warships for the Littorals," U.S. Naval Institute *Proceedings* 140/6/1,336 (June 2014).

14. Wayne P. Hughes Jr. [Capt., USN (Ret.)], "The New Navy Fighting Machine: A Study of the Connections between Contemporary Policy, Strategy, Sea Power, Naval Operations, and the Composition of the United States Fleet" (Naval Postgraduate School study prepared for the Office of Net Assessment, Office of the Secretary of Defense, 2009). Limited distribution.

15. Bryan Clark et al., "Alternative Future Fleet Architecture Study" (Center for Strategic and Budgetary Assessments study prepared for the Navy Department, 2016). This study presents a very similar concept, dividing forces into deterrence forces (forward tailored by region) and maneuver forces (conducting traditional fleet moves where needed).

16. Jeffrey E. Kline and Wayne P. Hughes Jr., "A Flotilla to Support a Strategy of Offshore Control," NPS Technical Report OR-13-0001R (2013). Limited distribution.

17. Jeffrey E. Kline and Wayne P. Hughes Jr., "Between Peace and the Air-Sea Battle: A War at Sea Strategy," *Naval War College Review* 65, no. 4 (Autumn 2012), pp. 35–40.

18. Several good books cover destroyer operations and tactical doctrine in the Pacific theater, including Theodore Roscoe, Thomas L. Wattles, and Fred Freeman, *Destroyer Operations in World War II* (Annapolis, MD: Naval Institute Press, 1953). However, for a concise summary of Burke's tactical doctrine and integration of radar into C2 philosophy, see the description in a Naval War College paper of the battle at Empress Augusta Bay in William H. Kimball [Cdr., USN], "Command & Control 'Little Beavers' Style: Arleigh Burke in the Solomon Islands Campaign" (1994), available at www.dtic.mil/.

19. This is not to say that engagement activities are less important. For a good discussion on their foundational importance, see Robert C. Rubel, "Posture versus Presence: The Relationship between Global Naval Engagement and Naval War-Fighting Posture," *Naval War College Review* 69, no. 4 (Autumn 2016), pp. 19–29.

20. "The Network of Humans and Machines as the Next Capital Ship," CNO Strategic Studies Group 35 Final Report (July 31, 2016). Limited distribution.

21. *Webster's New Collegiate Dictionary,* 1977, s.v. "capital ship."

22. Alexander Bordetsky, Stephen Benson, and Wayne P. Hughes Jr., "Hiding Comms in Plain Sight: Mesh Networking Effects Can Conceal C2 Efforts in Congested Littoral Environments," *Signal* (June 1, 2016), pp. 42–44.

23. Barry D. Watts, *The Maturing Revolution in Military Affairs* (Washington, DC: Center for Strategic and Budgetary Assessments, 2011).

24. Robert O. Work [Deputy Secretary of Defense], "The Third U.S. Offset Strategy and Its Implications for Partners and Allies" (speech delivered to a meeting of the Center for a New American Security, the Willard Hotel, Washington, DC, January 28, 2015).

25. For an early vision of joint accelerated cumulative warfare, see Jeffrey E. Kline, *Joint Vision 2010: Accelerated Cumulative Warfare* (Washington, DC: National Defense Univ. Press, 1997).

26. Arquilla, "The New Rules of War."

27. In his upcoming third edition of *Fleet Tactics* (Naval Institute Press), Wayne Hughes calls for a new "signal" book that can convey tactical information in brief, agreed-upon signals.

28. Justin Doubleday, "Navy Delivers Fleet Architecture Studies to Congress," *Inside Defense,* February 14, 2017, insidedefense.com/.