5-2014

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U.S. Naval Institute Proceedings
May 2014, volume 140, issue 5, pages 30-34
ISSN: 0041-798X

Abstract:
The article discusses how the use of long-range precision strike (LRPS) systems and other technological innovations have the potential to change the way sea wars are conducted. The increasing use of remotely piloted and autonomous air, surface, and sub-surface platforms can also impact sea wars. Advanced information and communications technologies also have an impact on warfare.

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In the hands of adversaries, long-range strike systems could drastically alter the conduct of war at sea
The constant evolution of military technology has driven continuous change in the character of warfare, to the benefit of the militaries that adapt the most successfully. More than 70 years have passed since a major maritime conflict. During that time many new technologies have emerged, with few combat tests to provide reliable guideposts regarding what will prove successful now and in a future conflict.

Over the past few decades, there has been a good deal of thinking about the progress and technological revolution of military affairs. We must reinvigorate discussions about the core of our craft: fighting and winning wars at and from the sea. As we shape the future U.S. Fleet in the next 10 to 15 years, a number of key questions must be addressed: How should we think about naval warfare today, and what do the conditions and concepts that spring from this thinking mean for the Navy in the decades to come? What are the essential technological and warfighting trends for war at sea, and what are the most salient emerging challenges at the high end of the conflict spectrum for naval forces? Have fundamental changes occurred that will require entirely new approaches to preparing for future combat?

The question of cost will underscore this conversation. How specifically should the U.S. Navy recapitalize to remain dominant in any environment given projected budget constraints? Unfortunately, technology and warfighting trends demand major changes in naval warfare and consequent shifts in the purchase of platforms and systems. But new requirements may prove less costly than the current trajectory of naval systems procurement.

Key Trends

Predicting the future is fraught with peril, but a dominant trend emerges from careful war gaming and operations research: the proliferation of long-range precision strike (LRPS) systems.

However, several others should not be ignored:

* The growth of cyber capabilities and their relationship to the electromagnetic (EM) spectrum;
* The increasing use of remotely piloted and autonomous air, surface, and subsurface platforms for a wide range of warfighting tasks; and
* The gradual adoption of new technologies with significant military potential, including directed-energy weapons, rail guns, and others with the potential to change fundamental military balances.

Long-range precision strike systems. LRPS systems have unquestionably impacted the character of naval warfare, and they will continue to do so. (See, for example, the trends in Chinese short- and medium-range ballistic and cruise missiles reported since 2000 in the Department of Defense's annual reports on the military power of the People's Republic of China.) Relying on data derived from a construct of sensors and precision guidance as part of a larger system, these weapons are effective and survivable. ("Effective" means that the weapon can rather reliably hit whatever it is aimed at, regardless of range to target, and put that target out of action. "Survivable" means that the LRPS weapon cannot be destroyed or neutralized in ample numbers or sufficiently quickly, either at the so-called left end [prior to launch] or right end [after launch] of the kill chain.) When envisioning a future war, one must now assume that advanced missiles can reliably penetrate active defenses and destroy or neutralize their objectives.[1]

For LRPS systems to be effective, they must be coupled with well-developed operating procedures and C4ISR (command, control, communications, computers, intelligence, surveillance, and reconnaissance) to provide timely targeting. Increasing numbers of states

(and likely some non-state actors) are developing or acquiring these capabilities. Some technologies, such as accurate mapping, are quite easy to obtain commercially, while others will require capital and know-how.

For two decades, the U.S. Navy has operated virtually anywhere unchallenged. But the appearance of relevant numbers of LRPS systems by the 2000s and their evolving capabilities will threaten our long-held advantage in terms of missile range and accuracy. In the coming decades, adversaries will continue to use them to support anti-access and area-denial strategies that will place our bases, ships, and aircraft at great risk.[2] This is a new and dangerous state of affairs for U.S. naval forces.

The cyber domain and the EM spectrum. Advanced information and communications technologies affect all dimensions of society, including warfare. Recent conflicts suggest that cyber operations will play an increasing role in future wars. Adversaries -- both state and non-state organizations -- will attempt to exploit weaknesses within computers and networks to disrupt and destroy an opponent's military, government, and private capabilities.[3] Mitigating cyber vulnerabilities during all phases, levels, and categories of war, while simultaneously exploiting those of potential adversaries, is essential. But how this develops will depend on how far future opponents move away from a reliance on interconnected networks and how rapidly they acquire and use advanced cyber- and electronic-warfare capabilities.

Given the cost disparity between cyber offense (relatively cheap) versus defense (expensive), and the multiple ways adversaries exploit each others' weaknesses, naval forces can expect that unprotected or non-isolated systems ranging from C4ISR and shipboard systems to logistics chains will be disrupted -- temporarily if not permanently -- during periods of conflict.[4] Naval forces must operate under decentralized command and control (C2) when warranted and maintain tight control of EM emissions to foil LRPS targeting, while fielding computer networks in a simultaneously hardened and resilient manner.[5]

Platform varieties. After witnessing the impact of remotely-piloted systems on recent wars, both allies and potential adversaries are acquiring unmanned systems in bulk.[6] Likewise, the technologies are being applied across the commercial and private sector, resulting in an explosion of affordable, reliable, scalable, and adaptable systems with greater availability. Though these systems are used primarily in permissive or semi-permissive environments, their use and effectiveness in a more demanding environment remains to be seen.

The technology of autonomous systems has the potential to be integrated into all elements of the kill chain, affecting the way C2 systems, sensors and counter-sensors, decoys and deception, persistent surveillance, and weapons are used, protected, denied, and destroyed. These systems are most influential where they offer opportunities that simply did not exist with, or offer distinct advantages over, manned platforms. But the United States is rightly sensitive to the ethical and moral dimensions in adopting autonomous systems for military use.[7] Other nations may be less concerned, which could become a tangible disadvantage in the future.

Emerging but unproven technologies. Directed-energy weapons and the rail gun, as well as improvements in speeds at which kinetic weapons travel above and below the sea, might have larger implications. However, uncertainty still surrounds the ultimate impact of these and other unproven weapons. While determined efforts to bring these technologies forward could arise, given the physics involved, engineering challenges, and steep costs of developing new technologies, it seems unlikely that such systems will fundamentally change the character and execution of war at sea within the timeframe discussed here. Of course, the intelligence community must continually monitor the environment to avoid strategic surprise should a "break-out" system appear.

Implications for High-End Warfare at Sea

Many conditions that planners and strategists have safely assumed about C2 -- our ability to maneuver uncontested, and the security of our supporting systems -- no longer exist. War plans, operations, tactics, and the entire DOTMLPF (doctrine, organization, training, materiel, leadership and education, personnel, and facilities) gamut must adapt to the new circumstances, or we risk putting sailors in grave danger and greatly weakening the contribution the Navy makes to national strategy.

Offensive versus defensive advantage. The fundamental implication of the proliferation of LRPS systems is that states possessing them will be able to hold surface and air forces, as currently configured and employed, at risk far from their shores. Fixed bases, known sanctuaries, and predictably moving platforms are especially vulnerable. As targeting and other capabilities improve, LRPS systems will be able to engage farther into blue water. Depending on geography, they will reach critical bases and operational areas out to hundreds (perhaps thousands) of miles. Fixed assets must rely on sheltering, redundancy, hardening, burial, obscurants, and decoys.

The ability of these systems to threaten mobile targets at a distance is largely dependent on the ability of adversaries to identify and target platforms using emissions from across the EM spectrum. The effective defense of platforms must thus shift from an emphasis on active defense to active deception and passive measures, such as counter-targeting through sensor denial (of radio frequency [RF] and cyber), signature reduction, movement, and dispersal. Integrated air and missile defenses alone are not sufficient to protect individual ships, aggregated forces, or permanent facilities as increasingly effective ballistic or cruise missiles proliferate.

Future wars in which LRPS systems predominate will involve efforts by all sides to find adversary platforms while hiding their own from the enemy's ISR and targeting systems. In the "hider/finder" competition, a mobile platform that can hide in clutter (such as environmental or electromagnetic noise, dense traffic areas, on and under the water, etc.) will likely survive and be capable of offensive

action. This will become the paramount element in contested seas, straits, and littorals. The offensive action of targeting and counter targeting is decisive, and no navy ever triumphed at sea without having the offensive advantage.

No matter how heavily armored they are, ships cannot expect to retain their combat effectiveness after hits from specialized antiship munitions, given the precision and lethality of LRPS systems. However, ships operating with effective emission control procedures that take advantage of clutter from the land and sea may be able to effectively hide and operate. In this mode, larger ships can allow for more offensive striking power, with greater numbers of vertical-launch system tubes and larger magazines. They are also more cost effective.

Smaller ships will allow for dispersal, minimizing the effects of damage to a single platform to the aggregate striking power of the force. In other words, navies would seem likely to adopt fewer numbers of large platforms with big loads of LRPS systems operating back from the battle area (or protected within it, such as submarines), complemented by a larger number of small platforms with shorter-range precision-strike systems operating well forward. These small ISR/strike platforms may be so small that they seemingly contradict the intuitive definition of "platform," being perhaps missile-like in size and other attributes.

The Return of Command at Sea

Planners and warfighters have heretofore presumed that operational units have unconstrained access to an increasingly clear, detailed, and real-time picture of the battle space -- an advantage the United States could sustain indefinitely.[8] This may no longer be a safe assumption. Recent conflicts suggest that cyber weapons can and no doubt will be used before, during, and after kinetic operations. C2 systems are especially at risk, and information-assurance dominance can no longer be assumed.

More challenging still, LRPS systems may be able to destroy vulnerable C2 nodes far from the fight. Rapid and focused kinetic attacks, combined with cyber and EW activities, take advantage of our reliance on the electromagnetic spectrum and make rapid reconstitution more problematic. Adversaries already recognize that it may be easier to disable, blind, or kill C2 within the battle space, not to mention between higher and lower echelons, than to find, fix, and finish weapon platforms.

Given the proliferation of LRPS and over-the-horizon targeting systems, strict emission control must become the normal mode of operations for all naval forces, with emissions and/or system power levels limited to only what is absolutely necessary. Those who do not will be at a severe disadvantage in future conflicts, as forces emitting significant signals of any type may be found and destroyed. Consequently, expectations regarding connectivity need to be modified, and training must be relentless with allowances for the attendant increased risks such as collisions, groundings, and accidents during peacetime.

Military strategies and doctrines predicated on the instantaneous exchange of high-volume data anywhere in the world and in real time will not apply in the next high-intensity conflict. It is crucial to learn how to continue to fight without networking and massive data exchange. Commanders at all levels will have less information, and frontline commanding officers will likely require more freedom of initiative and responsibility than thought possible for many years. Moreover, our independent, expeditionary Navy culture, seeded in the 19th and early 20th centuries but diminished over the past quarter-century, requires greater emphasis in this environment. We must build on this heritage.

New Approach to Logistics

For decades, U.S. military forces have benefited from superb logistical support provided from forward bases. For an expeditionary navy, logistics and sustainment pose significant constraints and liabilities. In recognition of the increasing danger to American staging areas, regional powers are developing missile forces that can reliably threaten those air bases and ports. Mobile and temporary nodes are necessary to counter this. Cyber weapons will also increasingly target and degrade computer and communications systems required by supply chains. Because military supply chains did not face this vulnerability during the Persian Gulf, Iraq, and Afghanistan wars, strategists and planners have come to expect logistics advantages to continue. We must question such assumptions and plan accordingly.

Although ordnance expenditure rates will certainly be far less than they were during wars prior to the widespread proliferation of LRPS systems, it is questionable whether our relatively small stockpiles of precision munitions will prove sufficient to sustain a prolonged conflict. The ability to surge LRPS production might be one of the most critical factors in future battlefield success. Yet the demand for advanced logistics is not limited to reloads for shipboard magazines. For the immediate future, the availability of petroleum, oil, and lubricants remains a limiting factor for Navy forces. A transition to smaller vessels staged forward might reduce fuel-flow requirements to forward areas relative to the current force, but constant maneuver and high-speed operations will still impose demands for large quantities of heavy bulk fuel. Sustained maritime operations at long distances, therefore, require ships with sufficient sea-keeping ability, endurance, and magazine depth, sustained by a robust seaborne logistics force.

This observation raises another dimension of the future logistics challenge: High-end missiles and torpedoes are expensive. Stockpiles are not limitless, and an opponent who has greater reserves or the ability to rapidly replenish them will have a distinct advantage in anything other than a short, decisive war. A low ordnance stockpile requires exquisite targeting and use -- an especially challenging environment characterized by effective C4ISR denial. Thus, opponents with the sufficient arsenal depth to "classify targets by destruction" -- that is, to kill anything that might be a target -- have the advantage here. After two decades of assuming that conflict will not escalate beyond our control (again, the enemy has a vote) or that high-end conflicts will end quickly and decisively, we must

pay more attention to the issue of the sustained wartime production of sophisticated ordnance and counter-targeting expendables such as decoys and obscurants.

Relevant Forces for the Future

Thinking about the future of warfighting is not merely an academic exercise; it's a deadly serious business with profound implications. Billions of dollars and perhaps thousands of lives are at stake in the decisions we make today about how the Navy configures itself to fight in the future. Moreover, the extent to which the United States continues to field a dominant naval force will have a direct impact on its strategic position throughout the 21st century. This author's thoughts are not the final word, but a provocation to reconsider our investments in equipment and human capital. How these trends and their resultant systems merge will have impacts that cannot be clearly imagined.

The most immediately pressing question is which Navy forces in place now -- and in the intermediate future -- will be more relevant in the years ahead? Based on the preceding analysis, it appears that the most significant forces for future warfare at sea include:

* Platforms employing standoff ordnance that penetrate high-end defenses;
* Platforms with an emphasis on offensive firepower to prevail at sea;
* Mobile and low-observable platforms and logistics, readily dispersed, and heavily protected or hidden by decoys, obscurants, RF jammers, and signature control; and
* Forces minimally reliant on RF networks to be employed against high-end opponents using pre-planned responses and low-data-rate, secure, and sporadic communications.

Conversely, less relevant forces of the future will include:

* Those dependent on fixed bases;
* Platforms within enemy missile ranges that have large signatures and are thus readily targetable;
* Systems dependent upon long-distance, high-data-rate RF networks;
* Platforms that must penetrate high-end defenses to deliver ordnance; and
* Platforms whose primary means of survival rests on active defense (i.**e**. shooting missiles with missiles).

As Chief of Naval Operations Admiral Jonathan Greenert has predicted, payloads will indeed become more important than platforms -- with an emphasis on long-range strike systems and inherently passive defenses that will prove far less costly than efforts to provide active defense of large and expensive ships. All of the requirements for effective counter-targeting -- emission control, RF obscurants, sensor jammers, and decoys -- will cost only a fraction of a single high-end ballistic-missile defense interceptor, and can likely be employed by the current force without a wholesale scrapping of extant ships and aircraft. Likewise, a future shift to lower-signature platforms that are essentially weapons and sensor trucks -- and are inherently offensive rather than predominantly defensive -- will provide much more bang for the buck.

The trends identified here, their implications, and the potential platforms and payloads that follow should stimulate further war gaming, operations research, and traditional scholarship. We must re-invigorate our critical thinking and our actions if we are to meet the challenges of future warfare at sea. It is essential to embrace the opportunities afforded by LRPS systems to field a Navy that can deliver resolute offensive power to discourage would-be adversaries and prevail in a fight should deterrence fail. Given the remarkable assets, analytic expertise, talent, and energy of the Fleet, we have all the means necessary to stay ahead of these challenges to remain the premier global navy. Now is the time to put on our thinking caps, roll up our sleeves, and look beyond our bow, not in our wake.

The guided missile destroyer USS Preble (DDG-88) fires a tomahawk missile in a training area off the coast of California. But the United States and its allies aren't the only entities with advanced long-range precision strike (LRPS) technology. "In the coming decades, adversaries will continue to use [LRPS systems] to support anti-access and area-denial strategies that will place American bases, ships, and aircraft at great risk," the author warns.

This artist rendering depicts the Office of Naval Research-funded electromagnetic railgun, a long-range projectile-launching weapon that uses electricity instead of chemical propellants, installed on board the USNS Millinocket (JHSV-3). Although emerging technologies have the potential to influence how the U.S. Navy responds to threats, "uncertainty still surrounds the ultimate impact of [the railgun] and other unproven weapons."

Information Systems Technician 2nd Class Brian Raines reviews the emission-control status on board the USS John C. Stennis (CVN-74) in February 2013. "No matter how heavily armored they are, ships cannot expect to retain their combat effectiveness after hits from specialized antiship munitions," the author stresses. "However, ships operating with effective emission control procedures that take advantage of clutter—may be able to effectively hide and operate."

On 2 March, Cryptologic Technician Seaman Allen Stevenson loads antiship missile-defense chaff rounds in a decoy-launcher system on board the USS Balaan (LHD-5). As the author notes, all of the requirements for effective counter-targeting -- including decoys -- "will cost only a fraction of a single high-end ballistic-missile defense interceptor."

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2. See for instance, Ian Easton, China's Evolving Reconnaissance-Strike Capabilities: Implications for the U.S.-Japan Alliance, Project 2049, The Japan Institute of International Affairs, February 2014.
3. See for instance, Department of Defense Science Board, Task Force Report: Resilient Military Systems and the Advanced Cyber Threat, Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, Washington, DC, January 2013.
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5. Peter Dombrowski and Chris Demchak, "Cyber War, Cybered-Conflict and the Maritime Domain," Naval War College Review, Spring 2014.
6. Kimberly Hsu, R. Craig Murray, Jeremy Coo, and Amanda Feld, "China's Military Unmanned Aerial Vehicle Industry," U.S. China Economic and Security Review Commission Staff Research Backgrounder, 20 June 2013, http://www.uscc.gov/sites/default/files/Research/China%27s%20Military%20UAV%20lndustry%5F14%20June%202013.pdf.
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