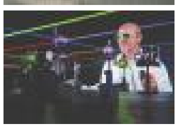
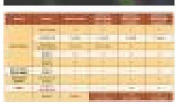
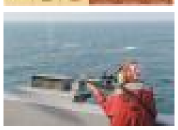
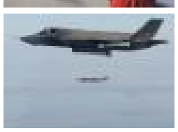
U.S. NAVAL INSTITUTE

Published on *U.S. Naval Institute* (http://www.usni.org)

Home > Magazines > Proceedings Magazine - April 2013 Vol. 139/4/1,322 > The Time for Lasers Is Now

The Time for Lasers Is Now

Print [1]

-  [2]
-  [3]
-  [4]
-  [5]
-  [6]

Proceedings Magazine - April 2013 Vol. 139/4/1,322 [7]
By Bryan G. McGrath and Timothy A. Walton

A new generation of forward-thinkers is needed to bring the power of directed-energy technologies to the Fleet.

Prior to the Civil War, a group of innovative leaders touted the value of steam power for ship propulsion. Facing detractors who claimed steam was redundant to the capabilities of sail, or that the technology would only be suitable for riverine traffic, leaders such as Commodore Matthew Perry and later Rear Admiral Benjamin Isherwood motivated the U.S. Navy to embark on the construction of steam vessels. By the end of the Civil War, the size of the American steam fleet had grown from 28 to 600, and soon thereafter, an increasing number of those were capable of transoceanic travel. [1] By the turn of the century, steam power was essential for a modern naval force.

The U.S. Navy faces a similar situation today, with the technologies of directed energy and electric weapons (DEEW) assuming the place of steam as the disruptive technology. These technologies are rapidly maturing and hold much promise in terms of engagement capability and capacity. Nonetheless, critics view DEEW as redundant to the investments the Navy has made in missile and gun systems, or they assert the technology is not and will not be able to credibly engage advanced threats. The evidence suggests otherwise. DEEW are increasingly capable of engaging much of the spectrum of threats and will greatly add to the Fleet's engagement capability and capacity. Although it is unlikely that DEEW will replace missiles and guns in the foreseeable future, it is clear this new technology can significantly improve a Fleet's defenses and combat potential, diminish adversary advantages, and extend the utility of traditional kinetic weapons systems.

The time is ripe for a new generation of Perrys and Isherwoods to aggressively pursue DEEW technology, define requirements for it, and field it throughout the Fleet.

Austerity is the Mother of Invention

Although we live in a proclaimed age of austerity, now is (paradoxically) precisely the time for the Navy to pursue high-technology DEEW systems. In the years between the World Wars, shrinking budgets forced the Navy to think innovatively. The result was a Fleet that valued experimentation, creativity, and technology insertion—one that was ready intellectually to deal with the challenges of World War II, albeit without the force structure to do so. Faced with shrinking budgets, the Navy must optimize readiness and capabilities development. Where it does look to develop new capabilities, it should focus increased attention and resources on those technologies capable of placing the United States on the advantaged side of cost-exchange ratios.

China, the pacing threat, has developed a sophisticated and deep arsenal of precision-guided munitions that threaten to overwhelm our force's expensive and in-short-supply defenses. DEEW systems such as lasers, electromagnetic railguns (EMRG), and high-powered microwave weapons are counter–anti-access/area-denial (A2/AD) capabilities that would contribute to mitigating, and perhaps reversing, the cost exchange. These new capabilities would improve Fleet defenses, allow the Fleet to increase its time on station (fewer reloads), and dedicate kinetic interceptors to stressing targets and to other mission requirements, such as antisurface warfare, antisubmarine warfare, or strike.

DEEW operate on different physical principals than their gunpowder- and high-explosive-based predecessors. This article focuses on lasers, even though many of the principles and challenges faced by introduction of lasers into the Fleet are common to other DEEW systems. There are a variety of lasers, with the most common, contemporary, developmental systems being chemical lasers, free-electron lasers (FEL), and solid-state lasers. Chemical lasers have been tested for several decades, including on the U.S. Air Force's now-canceled Airborne Laser Test Bed. Chemical lasers use a variety of expensive and corrosive chemicals, which impose significant logistical and safety demands. Free-electron lasers use a relativistic electron beam as the lasing medium. Although they hold tremendous promise of capabilities in the megawatt class, the technology requires comparatively more investment and time to mature when compared with solid-state lasers.

Adding Defensive Flexibility

There are two types of solid-state lasers. Solid-state fiber lasers combine the beams from multiple diodes to create a uniform laser beam. By combining the output of thousands of fibers, high-energy outputs can be achieved. However, due to increased loss in beam quality, they face the limitation that their potential power output is inferior to the other type of solid-state laser: solid-state slab lasers. Solid-state slab lasers, such as diode-pumped solid-state lasers, operate by using a laser diode to "pump" a solid medium. Combining the outputs of multiple slabs is the primary means of achieving higher energy levels. Solid-state slab lasers have achieved a relatively high level of technological readiness (approximately Technology Readiness Level 5–6) and are capable of being increased in power from their current levels, which are capable of engaging subsonic air targets, to levels capable of engaging significant numbers of supersonic ones. In examining its program, the Navy should divide its efforts into the continued long-term research of FEL and the near- and mid-term development and deployment of solid-state lasers.

As a result of their physical properties, solid-state lasers can produce a number of useful effects. Laser optics can be employed for high-resolution target identification and tracking. At low power settings and with coloration, lasers themselves can be used to warn targets at-range. Additionally, lasers could damage certain target electro-optical sensors in order to counter enemy surveillance or to blind missile or unmanned system seekers. Lastly, and most importantly, lasers are capable of destroying targets. Lasers able to deliver adequate irradiance to a target (determined by laser "brightness" or power, beam quality, and stability) for an appropriate period of time can destroy missiles, aircraft, and surface vehicles.

Single ships such as DDG-51 Flight II and III destroyers, aircraft carriers, amphibious-assault ships, and DDG-1000 destroyers armed with lasers could effectively employ them for self-defense against unmanned aerial systems (UAS), boats, and lower-end missiles. Sailing on board appropriate battle-group formations, though, lasers could enable powerful, close-in area defense of groups of ships against advanced threats. Evolved Sea-Sparrow missiles or SeaRAM would likely be required for certain threat geometries during large missile raids; however, lasers would be able to economically engage many if not most of the azimuths of threats. Linked by an in-situ, networked battlemanagement capability, lasers would "deepen" battle groups' magazines of kinetic missiles. Consequently, lasers would add flexibility to a ship's defense. Commanders would have the option of conserving missiles and engaging threats with lasers, which would save long-range missiles for "archers," advanced threats, and challenging geometries.

Lasers would also add resilience to Fleet defenses with a more capable inner-layer area defense. This would:

• Increase ship survivability, particularly in saturation raids

• Allow engagement of late detects (or guided weapons that quickly pop-up in the littorals)

• Reduce communications or track challenges faced by missiles against saturation raids.

Moreover, lasers would facilitate the rebalancing or optimization of ship magazines. Without lasers, a notional guided-missile destroyer is heavily weighted toward an SM-2/6 loadout, with much less SM-3 and Tomahawk land-attack missile capability. Adding lasers allows a ship to carry a more even distribution that can maximize time on station, ballistic-missile defense, antisurface, antisubmarine, or strike capability. Again, DEEW should not be seen as a replacement for missiles, so much as a means to extend their effectiveness.

Lasers: *Not* Star Wars

DEEW such as lasers are oftentimes viewed as fantastic "Star Wars" capabilities that, despite repeated promises, have not reached technological maturity and will not emerge for quite some time. Historically, an inhibiting factor for the transition of lasers into the Fleet has been the dilemma that, due to the technological immaturity of the systems, the "conceptual designs of laser weapons that are scaled for combat effectiveness are too large to be appealing to users; conversely, weapons that are sized for platform convenience generally lack convincing lethality." [2] It is a growing consensus of experts, though, that solid-state laser technology has greatly matured and is now ready for fielding of systems with appropriate platform convenience and lethality in the near term.

Representative of developments, in 2010 the Office of Naval Research (ONR) tested its laser weapon system by engaging four UAS targets flying over water. Guided by Phalanx Close-In Weapon System sensors, the system demonstrated the integration of existing technologies with new ones and showed the real promise of lasers. Shortly thereafter, in 2011 the ONR tested its Maritime Laser Demonstration (MLD) program, consisting of a 15-kilowatt solid-state slab laser. The more powerful MLD achieved demonstrated material kills at moving targets from an underway decommissioned *Spruance* -class destroyer. MLD most importantly has the ability to "chain" together different solid-state slabs with relative ease, producing a weapon capable of destroying realistic threats.

Another criticism of lasers is that they will perform poorly at sea because of environmental effects (such as heavy rain or fog) on lasers. Certain laser prototypes have demonstrated great resilience in maritime environments. For example, MLD withstood actual sea conditions, including 8-foot waves, 25-knot winds, and rain and fog. Furthermore, DEEW would be part of an ensemble approach to Fleet weaponry. Consequently, missiles, electronic countermeasures, and appropriate tactics, techniques, and procedures would be employed when lasers might be less effective.

Additionally, a single-weapon solution would fail to provide adaptability to multiple scenarios or changing last-move dynamics. Instead, lasers should be viewed as a powerful new capability that, like any emerging class of weapons, will be gradually integrated into various platforms over time. As such they will coexist for decades—using novel hybrid operational concepts— with existing weapon technology, including missiles, which are essential for beyond-the-horizon engagement of threats.

The Path to the Fleet

There is increasing recognition within the U.S. Navy that DEEW systems are beginning to reach maturity and that it is time to begin to field them in the Fleet. Sensing the trend, former Chief of Naval Operations Admiral Gary Roughhead tasked the Strategic Studies Group to examine a topic titled "Maritime Operations in the Age of Hypersonic and Directed-Energy Weapons." In April 2012, the Center for Strategic and Budgetary Assessments released a report highlighting the value of directed energy weapons. [3] And the ONR has requested from industry a technical-maturation program to build one to two prototype laser weapons that can achieve 100-kilowatt output and go to sea for up to six months by 2016. [4] This decision, taken with the support of senior Navy leadership, clearly affirms the Navy's interest in rapidly fielding these technologies.

In order to succeed, the Navy needs a lucid and aggressive path for the deployment of DEEW. Such a path should involve three main lines of effort:

• Defining requirements for DEEW through rigorous analysis

• Improving DEEW experimentation and technical maturation

• Optimizing Navy organizations for DEEW.

For DEEW to flourish, the Department of Defense must first define an operational requirement that realistically creates space for a DEEW option to fill. As Distinguished Engineer for Directed Energy and NAVSEA Technical Warrant for Directed Energy and Electric Weapon Systems Dr. David Stoudt contends:

> The continuing problem is matching those unique capabilities to vetted operational requirements. The DE technical community has made great strides in helping the operational community understand the capabilities of DE weapons and their potential military effects on targets. The lack of formal requirements, however, has yielded more of a technology push—rather than an operational pull—of various DE capabilities. [5]

This lack of a formal requirement continues even though there clearly are capability, capacity, and affordability challenges for U.S. naval forces. For example, even though it is common knowledge that in a counter-A2/AD campaign, ships would lack magazine depth for extended operations, current requirements analyze the situation per individual engagement, not at the campaign level. Hence, in a perversion of the requirements process, there is no "gap" to trigger material development, even though there are major existing gaps against both individual threat types and campaign-level aggregations of threats. Definition of these requirements through Navy analysis and the contribution of relevant combatant-command inputs on gaps is an important first step for fielding DEEW.

Decision Time

Subsequently, the Navy should pursue making a material-development decision (MDD) to address current capability and capacity gaps. An MDD would, based on the maturity of the technology, identify the capability gap lasers would address and recommend the use of an acquisition process to address it. Such a decision would not commit the Navy to fund a laser, or bind it to any specific time lines. However, it would allow Navy offices to investigate material-solution options through an analysis of alternatives (AoA).This would:

• Determine what type of weapon, kinetic or DEEW—and if DEEW, what power and brightness—is best suited to address challenging gaps

• Would allow technology development to continue

• Allow program planning to take place.

A second line of effort for fielding solid-state lasers to the Fleet is furthering experimentation and technical maturation. Both virtual and physical experimentation is needed to refine operating concepts and to refine system-engineering inputs such as lethality and atmospherics. Considering virtual experimentation, modeling experts observe that "conventional air-to-air warfare (AAW) models . . . are not well suited for showcasing current or near-term laser-weapon capabilities" that must engage a target for a period of time, rather than "instantly" destroying it as with a missile. [6]

With regard to physical experimentation, the Navy has faced delays testing lasers, oftentimes due to difficulty reserving adequate range facilities. Accordingly, in order to save cost and speed up testing, the Navy should designate a primary site for experimentation efforts. The Pacific Missile Range (PMRF) in Hawaii provides the perfect location. With high test availability, it allows live fire against all relevant threat types with ready integration with representative radar and combat-system assets. Additionally, PMRF has the space necessary for ready storage of government and industry demonstrators and test equipment. This concentration of advantages would improve efficiency in experimentation and design work and avoid duplications of effort that currently take place.

Since the ONR's laser prototypes will not be ready until 2016, the Navy could obtain preliminary test data using the Army's 105-kilowatt solid-state laser at White Sands Missile Range.

Organizational Inroads

Lastly, the Navy must examine the organizational structures currently in place to field DEEW into the Fleet. A renewal of Navy interest in DEEW has been manifested in the establishment of a number of organizations and positions: the Surface Navy Directed Energy and Electric Weapons Program Office, executive positions and a technical-authority warrant for directed energy, and the Naval Directed Energy Advisory and Oversight Group. These are all very positive steps to leverage DOD's exceptional military and civilian leadership.

Nonetheless, further changes are necessary. To date, no resource sponsor from the Office of the Chief of Naval Operations has been assigned *primary* responsibility for DEEW. A resource sponsor could elevate the prominence of the technology and resolve bureaucratic contention that might arise. Although lasers have important communications and counterintelligence/surveillance/reconnaissance capabilities, which may suggest a home for them under the Deputy Chief of Naval Operations for Information Dominance, the true scope of their capabilities is more closely aligned with engagement of threats. Consequently, the Director of Surface Warfare should be assigned responsibility for DEEW. Furthermore, if the Navy's AoA suggests a DEEW is the optimal solution for the stated gaps, then an office under the Program Executive Office for Integrated Warfare Systems should logically be formally established to manage the weapon-system acquisition planning and preparation.

These proposed changes in organization are not merely academic. The rapid advancement of DEEW technology over the last few decades, both in the United States and abroad, hints at a shift in the calculus of warfare similar to that which occurred in the interwar period in the early part of the 20th century. Armored warfare, close-air support, carrier strike warfare, and submarine warfare were all made possible by technological advances, but in each case, the countries that made the greatest strides in those new types of warfare were not the originators of the technological advances. Other countries, in particular China, are aggressively pursuing DEEW and may have systems similar in capability to the United States. Hence, we must expect DEEW will threaten its own forces in the future. Additionally, less mature or less bureaucratic militaries may best be able to maximize the impact of novel capabilities by forming new organizations and tactics around them. With several other countries actively pursuing DEEW technology, the U.S. military may be at risk of suffering technological surprise from the very technologies it originally developed.

The Navy today needs a new generation of Perrys and Isherwoods to aggressively pursue DEEW technology, define the requirements for it, and field it throughout the Fleet. Regardless of the age, the Navy's great leaders faced technical, financial, and bureaucratic obstacles that they surmounted. Today's leaders face many of the same challenges with the added rigors of a complex and lengthy requirements-and-acquisition process that forces them to start laying the foundation for a future system long in advance of production. In these times of fiscal austerity, bold Navy leaders must develop those disruptive, game-changing technologies that will win the competitions of the future. As it will take approximately six years from the point of an MDD until the first low-rate initial production system, if the Navy would like to have a capable laser before the end of the decade, and possibly on the first DDG-51 Flight IIIs, the time to act is now.

---

1. Frank M. Bennett, *The Steam Navy of the United States: A History of the Growth of the Steam Vessel of War in the U.S. Navy, and of the Naval Engineer Corps* (Pittsburgh: W. T. Nicholson Press, 1896).

2. Naval Studies Board, National Research Council, *Technology for the United States Navy and Marine Corps 2000–2035: Becoming a 21st-Century Force* , vol. 5 (Weapons), chapt. 6, "Navy and Marine Corps Applications for Laser Weapons" (Washington, DC: National Academies Press, 1997).

3. Mark Gunzinger, "Changing the Game: The Promise of Directed Energy Weapons" (Washington, DC: Center for Strategic and Budgetary Assessments, April 2012), www.csbaonline.org/publications/2012/04/changing-the-game-the-promise-of... [8] .

4. Spencer Ackerman, "Navy: We're 4 Years Away From Laser Guns on Ships," *Wired: Danger Room* , 30 March 2012, www.wired.com/dangerroom/2012/03/navy-lasers-four-years/#more-76978 [9] .

5. David C. Stoudt. “Naval Directed-Energy Weapons—No Longer a Future Weapon Concept,” *Leading Edge* , vol. 7, no. 4 (2012), www.navsea.navy.mil/nswc/dahlgren/Leading%20Edge/Directed%20Energy/files... [10] .

6. Robin Staton and Robert Pawlak, “Laser Weapon System (LaWS) Adjunct to the Close-In Weapon System (CIWS),” *Leading Edge* , vol. 7, no. 4 (2012), www.navsea.navy.mil/nswc/dahlgren/Leading%20Edge/Directed%20Energy/files... [10] .

Bryan McGrath is the founding director of Delex Consulting, Studies, and Analysis. A retired surface-warfare officer, he commanded the USS *Bulkeley* (DDG-84) from 2004 to 2006; he also led the team that produced the 2007 maritime strategy, *A Cooperative Strategy for 21st-Century Seapower* , and was its primary author.

Timothy Walton is an associate of Delex Consulting, Studies, and Analysis specializing in Sino-American reciprocal-force dynamics. He previously served at the Center for Strategic and International Studies' Defense-Industrial Initiatives Group, the Federation of American Scientists' Nuclear Information Project, and as a Carroll Fellow of Georgetown University.

Source URL: http://www.usni.org/magazines/proceedings/2013-04/time-lasers-now