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Navy Shipboard Lasers: Background and Issues for Congress

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Prepared for Members and
Committees of Congress

Summary

This report provides background information and issues for Congress on shipboard solid state lasers (SSLs) that the Navy is developing for surface-ship self-defense. The Navy's proposed FY2025 budget requests continued research and development funding for some of these efforts.

The Navy installed its first prototype SSL capable of countering surface craft and unmanned aerial vehicles (UAVs) on a Navy ship in 2014. The Navy since then has been developing and installing additional SSL prototypes with improved capability for countering surface craft and UAVs. Higher-power SSLs being developed by the Navy could have a capability for countering anti-ship cruise missiles (ASCMs). Current Navy efforts to develop SSLs include

- the Solid State Laser Technology Maturation (SSL-TM) effort;
- the Optical Dazzling Interdictor, Navy (ODIN);
- the Surface Navy Laser Weapon System (SNLWS) Increment 1, also known as the high-energy laser with integrated optical dazzler and surveillance (HELIOS); and
- the High Energy Laser Counter-ASCM Program (HELCAP).

The issue for Congress is whether to modify, reject, or approve the Navy's acquisition strategies and funding requests for shipboard laser development programs. Decisions that Congress makes on this issue could affect Navy capabilities and funding requirements and the defense technology and industrial base.

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This report provides background information and issues for Congress on shipboard solid state lasers (SSLs) that the Navy is developing for surface-ship self-defense. The Navy's proposed FY2025 budget requests continued research and development funding for some of these efforts.

The issue for Congress is whether to modify, reject, or approve the Navy's acquisition strategies and funding requests for shipboard laser development programs. Decisions that Congress makes on this issue could affect Navy capabilities and funding requirements and the defense technology and industrial base.

This CRS report supersedes an earlier CRS report that provided an introduction to potential Navy shipboard lasers.[1]

Earlier Coverage of EMRG and GLGP/HVP Programs

This CRS report previously included coverage of Navy efforts to develop two other potential shipboard weapons—the electromagnetic railgun (EMRG) and the gun-launched guided projectile (GLGP), also known as the hypervelocity projectile (HVP). As part of its FY2022 budget submission, the Navy proposed suspending further work on the EMRG and GLGP programs and requested no research and development funding for them. For background information on the EMRG and GLGP programs, see the April 1, 2022, version or earlier versions of this CRS report.[2]

CRS Reports on Other DOD Efforts to Develop Lasers

SSLs (and other directed energy weapons) are being developed by multiple parts of the Department of Defense (DOD), not just the Navy,[3] and have potential application to military aircraft and ground forces equipment, not just surface ships. Other CRS reports cover some of these other efforts.[4]

[1] CRS Report R41526, *Navy Shipboard Lasers for Surface, Air, and Missile Defense: Background and Issues for Congress*, by Ronald O'Rourke. This earlier CRS report was archived following its final update on June 12, 2015, and remains available as a supplementary reference source on potential Navy shipboard lasers.

[2] The title of the April 1, 2022, version and earlier versions of this report was *Navy Lasers, Railgun, and Gun-Launched Guided Projectile: Background and Issues for Congress*.

[3] For a discussion of Army laser development programs, see CRS Report R45098, *U.S. Army Weapons-Related Directed Energy (DE) Programs: Background and Potential Issues for Congress*, by Andrew Feickert.

[4] See CRS In Focus IF11882, *Defense Primer: Directed-Energy Weapons*, by Kelley M. Sayler; CRS Report R46925, *Department of Defense Directed Energy Weapons: Background and Issues for Congress*, coordinated by Kelley M. Sayler; and CRS Report R45098, *U.S. Army Weapons-Related Directed Energy (DE) Programs: Background and Potential Issues for Congress*, by Andrew Feickert.

Background

Strategic and Budgetary Context

Concern About Survivability of Navy Surface Ships

Although Navy surface ships have a number of means for defending themselves against surface craft, unmanned aerial vehicles (UAVs), and anti-ship missiles,[5] some observers are concerned about the survivability of Navy surface ships in potential combat situations against adversaries, such as China, that are armed with large numbers of UAVs and anti-ship missiles, including advanced models.[6] Concern about this issue has led some observers to conclude that the Navy's surface fleet in coming years might need to avoid operating in waters that are within range of these weapons. Views on whether Navy surface ships can adequately defend themselves against UAVs and anti-ship missiles might influence perspectives on whether it would be cost effective to spend money on the procurement and operation of such ships.

Depth of Magazine and Cost Exchange Ratio

Overview

Two key limitations that Navy surface ships currently have in defending themselves against UAVs and anti-ship missiles are limited depth of magazine and unfavorable cost exchange ratios. Limited depth of magazine refers to the fact that Navy surface ships can use surface-to-air missiles (SAMs) and their Close-in Weapon System (CIWS) Gatling guns to shoot down only a certain number of enemy UAVs and anti-ship missiles before running out of SAMs and CIWS ammunition[7]—a situation (sometimes called "going Winchester") that can require a ship to

[5] These include the following: operating ships in ways that make it hard for others to detect and accurately track Navy ships; jamming or destroying enemy targeting sensors; interfering with the transmission of targeting data from sensors to weapon launchers; attacking missile launchers (which can be land-based launchers, ships, submarines, or aircraft); and countering missiles and UAVs headed toward Navy ships. Navy measures for countering missiles and UAVs headed toward Navy ships include the following: jamming a missile's or UAV's sensor or guidance system; using decoys of various kinds to lure enemy missiles away from Navy ships; and shooting down enemy missiles and UAVs with surface-to-air missiles and the Phalanx Close-In Weapon System (CIWS), which is essentially a radar-controlled Gatling gun. Employing all these measures reflects a long-standing Navy approach of creating a multi-layered defense against enemy missiles, and of attacking the enemy's "kill chain" at multiple points so as to increase the chances of breaking the chain. (The kill chain is the sequence of steps that an enemy must complete to conduct a successful missile attack on a Navy ship. Interfering with any step in the sequence can break the kill chain and thereby prevent or defeat the attack.)

[6] For more on China's anti-ship missiles and UAVs, see CRS Report RL33153, *China Naval Modernization: Implications for U.S. Navy Capabilities—Background and Issues for Congress*, by Ronald O'Rourke. Enemy missiles are not the only reasons that some observers are concerned about the future survivability of U.S. Navy surface ships in combat situations; observers are also concerned about threats to U.S. Navy surface ships posed by small boats, mines, and torpedoes.

[7] Navy cruisers have 122 missile cells; Navy destroyers have 90 or 96 missile cells. Some of these cells are used for storing and launching Tomahawk land attack cruise missiles or anti-submarine rockets. The remainder are available for storing and launching SAMs. A Navy cruiser or destroyer might thus be armed with a few dozen or several dozen SAMs for countering missiles and UAVs. Countering missiles and UAVs with SAMs might sometimes require shooting two SAMs at each enemy missile.

withdraw from battle, spend time travelling to a safe reloading location (which can be hundreds of miles away),[8] and then spend more time traveling back to the battle area.

Unfavorable cost exchange ratios refer to the fact that a SAM used to shoot down a UAV or anti-ship missile can cost the Navy more (perhaps much more) to procure than it cost the adversary to build or acquire the UAV or anti-ship missile. Procurement costs for Navy air-defense missiles range from several hundred thousand dollars to a few million dollars per missile, depending on the type. In combat scenarios against an adversary with a limited number of UAVs or anti-ship missiles, an unfavorable cost exchange ratio can be acceptable because it saves the lives of Navy sailors and prevents very expensive damage to Navy ships. But in combat scenarios (or an ongoing military capabilities competition) against a country such as China that has many UAVs and anti-ship missiles and a capacity for building or acquiring many more, an unfavorable cost exchange ratio can become a very expensive—and potentially unaffordable—approach to defending Navy surface ships against UAVs and anti-ship missiles, particularly in a context of constraints on U.S. defense spending and competing demands for finite U.S. defense funds.

SSLs offer a potential for dramatically improving depth of magazine and the cost exchange ratio:

- **Depth of magazine.** SSLs are electrically powered, drawing their power from the ship's overall electrical supply, and can be fired over and over, indefinitely, as long as the laser continues to work and the ship has fuel to generate electricity.
- **Cost exchange ratio.** Depending on its beam power, an SSL can be fired for an estimated marginal cost of $1 to less than $10 per shot (much of which simply is the cost of the fuel needed to generate the electricity used in the shot).[9]

SSLs that have enough beam power to counter small boats and UAVs, but not enough to counter anti-ship cruise missiles (ASCMs), could nevertheless indirectly improve a ship's ability to counter ASCMs by permitting the ship to use fewer of its SAMs for countering UAVs, and more of them for countering ASCMs.

Navy Operations in Red Sea and Gulf of Aden Since October 2023 Have Spotlighted Depth of Magazine and Cost Exchange Ratio

Operations by U.S. and allied warships ships in the Red Sea and the Gulf of Aden since October 2023 to defend commercial cargo ships (and themselves) from attacks by Houthi forces in Yemen using drones, cruise missiles, and ballistic missiles[10] have spotlighted the above-discussed considerations of depth of magazine and cost exchange ratios, particularly for shooting down substantial numbers of drones, and have drawn attention to the potential ability of lasers (and high-power microwave [HPM] weapons)[11] to counter drones while using fewer of a ship's finite

[8] The missile cells on a Navy cruiser or destroyers are clustered together in an installation called a Vertical Launch System (VLS). VLS cells cannot be reloaded while the ship is underway; a ship needs to return to a port or a calm anchorage to reload its VLS.

[9] Source: Navy information paper on shipboard lasers dated October 20, 2021, provided to CRS by Navy Office of Legislative Affairs on November 17, 2021.

[10] For general background on these attacks, see CRS Insight IN12301, *Houthi Attacks in the Red Sea: Issues for Congress*, by Jeremy M. Sharp.

[11] For more on HPM weapons, see CRS In Focus IF11882, *Defense Primer: Directed-Energy Weapons*, by Kelley M. Sayler; CRS Report R46925, *Department of Defense Directed Energy Weapons: Background and Issues for Congress*, coordinated by Kelley M. Sayler.

number of air-defense missiles and with a more favorable (i.e., more affordable) cost exchange ratio.[12]

On February 13, 2024, the Chief of Naval Operations, Admiral Lisa Franchetti, reportedly stated that as of that date, five Navy destroyers operating in the area had collectively shot down 14 anti-ship ballistic missiles (ASBMs), 7 cruise missiles, and more than 70 drones—a total of more than 91 targets—and that the shootdowns of the ASBMs were the Navy's first in an operational (as opposed to a development or test) setting.[13] Many of these 91-plus shootdowns might have been done with SAMs; some might have involved the use of more than one SAM for an individual target (so as to help ensure that the target would be shot down); and additional SAMs might have been used in engagements other than the 91-plus listed above (i.e., engagements in which the targets were not shot down).

A February 18, 2024, news broadcast stated: "We learned that so far, the Navy has fired more than 100 of their Standard surface-to-air missiles, that can cost as much as $4 million each."[14]

An April 16, 2024, press report states

> The U.S. Navy is nearly $1 billion in the hole after defending Israel from Iranian missiles last weekend and fighting off Houthi attacks on Red Sea shipping since October, the service's secretary said Tuesday [April 16] in a bid to convince House lawmakers to approve $95 billion in supplemental funding.
>
> "I would argue that the President's budget numbers are adequate, but that's also prior to the attacks that we've just had this weekend alone, for example. So we are now closely approaching $1 billion in expenditures for munitions that we need paid back by the

[12] See, for example, Brad Dress, "Houthi Fight Extracts Heavy Cost from Pentagon," *The Hill*, March 2, 2024; Todd South, "Cost Drain and Weapon Stockpile Drawdowns Worry Marine General," *Marine Corps Times*, February 16, 2024; Justin Katz, "Munitions Stockpile Issue Persists 2 Years into Ukraine Conflict: Marine Corps General," *Breaking Defense*, February 14, 2024; Wes Rumbaugh, "Cost and Value in Air and Missile Defense Intercepts," Center for Strategic and International Studies (CSIS), February 13, 2024; Brad Howard, "How Chaos in the Red Sea Is Putting the U.S. Navy to the Test," *CNBC*, January 24 (updated January 25), 2024; Colin Demarest, Megan Eckstein, and Geoff Ziezulewicz, "Amid Red Sea Clashes, Navy Leaders Ask: Where Are Our Ship Lasers?" *Defense News*, January 22, 2024; Geoff Ziezulewicz, "What the Navy Is Learning from Its Fight in the Red Sea," *Military Times*, January 18, 2024; Eugene Gholz, "The US Military Role in the Red Sea—Now Turning Offensive—Is a Bad Deal," Cato Institute, January 12, 2024; Rudy Ruitenberg, "French Navy Defends Use of Million-Euro Missiles to Down Houthi Drones," *Defense News*, January 11, 2024; Rich Abott, "SWO BOSS Wants Accelerated Directed Energy Weapons," *Defense Daily*, January 9, 2024; Sam LaGrone, "New SWOBOSS Wants More Directed Energy Weapons on Warships as Low-Cost Threats Expand," *USNI News*, January 9, 2024; Nick Wilson, "Navy Looks to Field Directed-Energy Weapons to Counter Increasingly Cheap and Prevalent Drones," *Inside Defense*, January 9, 2024; Brad Lendon, "How US Warships Are Shooting Down Houthi Drones in the Red Sea, and What Might Come Next," *CNN*, December 20, 2023; Doug Cameron, "Pentagon Eyes Microwave Weapons to Tackle Drone Threat," *Wall Street Journal*, December 19, 2020; Lara Seligman and Matt Berg, "A $2M Missile vs. a $2,000 Drone: Pentagon Worried over Cost of Houthi Attacks," *Politico*, December 19 (updated December 20), 2023.

[13] Geoff Ziezulewicz, "Why the Navy Says Its Red Sea and Gulf of Aden Battles Are Historic," *Military Times*, February 13, 2024. See also Jonathan Lehrfeld, Diana Stancy, and Geoff Ziezulewicz, "All the Houthi-US Navy Incidents in the Middle East (That We Know Of)," *Military Times*, February 12, 2024. Bernat Armangue and Tara Copp, "On the USS Eisenhower, 4 Months of Combat at Sea Facing Houthi Missiles and a New Sea Threat," Associated Press, February 15, 2024, which states that "as of Wednesday [February 14], the carrier strike group—which includes the cruiser USS Philippine Sea, the destroyers USS Mason and Gravely, and additional U.S. Navy assets in the region, including the destroyers USS Laboon and USS Carney—has conducted more than 95 intercepts of drones, anti-ship ballistic missiles and anti-ship cruise missiles…."

For more on the Navy's ballistic missile defense program, see CRS Report RL33745, *Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress*, by Ronald O'Rourke.

[14] Norah O'Donnell, "Navy Counters Houthi Red Sea Attacks in Its First Major Battle at Sea of the 21st Century," *60 Minutes (CBS News)*, February 18 (updated June 23), 2024. See also Joseph Trevithick, "Navy Has Fired Around 100 Standard Series Missiles At Houthi Drones, Missiles: Report," *The War Zone*, February 19, 2024.

> supplemental," Carlos Del Toro told senators during a Senate Appropriations [Defense] subcommittee hearing.
>
> "We've been firing SM-2s, we've been firing SM-6s, and—just over the weekend—SM-3s to actually counter the ballistic missile threat that's coming from Iran. So we need this supplemental to pass this week," Del Toro said.[15]

An April 25, 2024, press report states

> The price tag for weapons and munitions used to destroy drones must come down, as the costs are "getting too expensive" and uncrewed systems are expected to saturate battlefields, according to the Pentagon's acquisition boss….
>
> Bill LaPlante, the undersecretary of defense for acquisition and sustainment, said April 24 during a conference hosted by the Center for Strategic and International Studies think tank in Washington that "cost curve matters" in counter-drone operations.
>
> The goal is to get the cost down to approximately tens of thousands of dollars per round, he added, noting a price exceeding $100,000 a shot is "getting too expensive."[16]

A May 1, 2024, press report states

> Downing Iranian-supplied missiles and drones with multi-million dollar SM-2 [Standard Missile 2] missiles to protect shipping in the Red Sea and Gulf of Aden is a bad exchange that must change, the vice chairman of the Joint Chiefs of Staff said Wednesday [May 1].
>
> "It has been an air-defense fight" in which the Navy and Air Force, along with allies and partners in Operation Prosperity Guardian, have largely prevailed in demonstrating "how we bring defense in depth," Adm. Christopher Grady said during a U.S. Naval Institute-CSIS Maritime Security Dialogue.
>
> To change the cost-benefit equation, he wants more directed energy systems deployed "where a drop of fuel becomes a weapon" to destroy attacking unmanned systems.[17]

A May 15 2024, press report stated

> The toll of expending expensive surface fleet weapons to take out cheap Houthi drones, anti-ship ballistic and cruise missiles in the Red Sea has pushed the US Navy to speed its exploration of cheaper alternatives and "disruptive capabilities" like Replicator drone swarms that the service hopes could do the job much more cheaply, according to one of the Navy's most senior officials.
>
> The navy "absolutely" needs to invest in cheaper equipment to down drones, said Rear Adm. Fred Pyle, director of surface warfare, during a discussion at the Center for Strategic and International Studies in Washington on Tuesday [May 14].
>
> "We're working towards that end, and we have some solutions that I can't go into, but we are going to get after finding more cost-effective ways to address those lower-end threats,"

[15] Lauren C. Williams, "Mideast Missile Duels Have Cost US Navy Nearly $1B, Secretary Says," *Defense One*, April 16, 2024. See also Svetlana Shkolnikova, "Navy Seeks Urgent Replenishment of $1B in Munitions Spent Countering Iran-Led Attacks in Middle East," *Stars and Stripes*, April 16, 2024; Nick Wilson, "SECNAV: Navy Needs Supplemental to Replace Nearly $1 Billion in Expended Munitions," *Inside Defense*, April 16, 2024.

[16] Colin Demarest, "Drone-Killing Costs Must Come Down, Says Pentagon's Chief Weapons Buyer," *C4ISRNet*, April 25, 2024. See also Nicholas Slayton, "US Needs Cheaper Ways to Shoot Down Drones, Pentagon Acquisition Chief Says," *Task & Purpose*, April 28, 2024.

[17] John Grady, "Navy Air Defense Mission in the Red Sea Makes Case for Directed Energy Weapons, Says VCJCS Grady," *USNI News*, May 1, 2024.

> he explained, later singling out the Pentagon's new, secretive Replicator as one example of an initiative developing that "more cost-effective" technology.[18]

A May 16, 2024, press report stated

> The Navy will increase funding for directed energy solutions, like lasers, to reduce the cost of intercepting enemy missiles, service secretary Carlos Del Toro said Thursday [May 16]—a month after he told lawmakers that shooting down drones and missiles in the Red Sea had cost the service nearly $1 billion. And, Del Toro said, he wants to see "aggressive" deployment in five to 10 years….
>
> In March, U.S. Central Command leader Gen. Erik Kurilla told lawmakers: "I would love to have the Navy produce more directed energy that can shoot down a drone so I don't have to use an expensive missile to shoot it down. But what's worse than not having that expensive missile shoot it down is hitting that $2 billion ship with 300 sailors on it."…
>
> When [Senator Angus] King asked Del Toro [at a hearing before the Senate Armed Services Committee on the Department of the Navy's FY2025 budget] if the Navy could commit to increasing its fund for directed energy research, the Navy secretary said yes, with a caveat.
>
> "To the extent that I have authority to do so in POM 2026,[19] I will absolutely do so…I thought that we needed to invest far more significantly in laser and high directed energy systems. I regret that we haven't done that for the past 30 years or so. We need to do that moving forward. There's no question in my mind to get to a place perhaps five to 10 years from now where we could actually start aggressively employing those capabilities on our ships early."[20]

A July 15, 2024, U.S. Navy news release stated that during combat operations in the Middle East from November 2023 to June 2024, ships from a U.S. Navy aircraft carrier strike group led by the aircraft carrier *Dwight D. Eisenhower* (CVN-69) launched 155 standard missiles (though not all of these were necessarily used for countering missiles or unmanned air, surface, or underwater vehicles), and that carrier-based aircraft from the strike group expended nearly 60 air-to-air missiles.[21]

Navy Shipboard Solid State Lasers (SSLs) in General

Overview

The Navy in recent years has leveraged both significant advancements in industrial SSLs and decades of research and development work on military lasers done by other parts of DOD to make substantial progress toward deploying high-energy lasers (HELs)[22] on Navy surface ships.

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[18] Tim Martin, "High Price of Red Sea Shootdowns Speeds Navy's Pursuit of 'Cost-Effective' Solutions," *Breaking Defense*, May 15, 2024. See also Abby Shepherd, "Cost-Effective Method of Battling Houthis Poses Challenge, Pyle Says," *Inside Defense*, May 14, 2024.

[19] This is a reference to the Program Objective Memorandum 2026—an internal DOD document used for preparing DOD's FY2026 budget submission, which will be submitted to Congress in 2025.

[20] Patrick Tucker, "Navy Secretary Vows More Money for Anti-Drone Lasers," *Defense One*, May 16, 2024.

[21] U.S. Navy, "Unprecedented: Dwight D. Eisenhower Carrier Strike Group Returns from Combat Deployment," news release dated July 15, 2024, which states: "In total, IKECSG [Eisenhower (aka Ike) Carrier Strike Group] warships launched 155 standard missiles, and 135 TLAMs [Tomahawk land-attack cruise missiles] from their vertical launch system across self-defense and pre-planned strikes. IKECSG aircraft expended nearly 60 air-to-air missiles and released 420 air-to-surface weapons."

[22] In discussions of potential Navy shipboard lasers, a high-energy laser is generally considered to be a laser with a (continued...)

Navy surface ships would use high-energy SSLs initially for jamming or confusing (i.e., "dazzling") intelligence, surveillance, and reconnaissance (ISR) sensors, for countering small boats and UAVs, and potentially in the future for countering enemy anti-ship missiles as well. High-energy SSLs on Navy ships would generally be short-range defensive weapons—they would generally counter targets at ranges of about one mile to perhaps eventually a few miles.

In addition to a low marginal cost per shot and deep magazine, potential advantages of shipboard lasers include fast engagement times, an ability to counter radically maneuvering missiles, an ability to conduct precision engagements, and an ability to use lasers for graduated responses ranging from detecting and monitoring targets to causing disabling damage. Potential limitations of shipboard lasers relate to line of sight; atmospheric absorption, scattering, and turbulence (which prevent shipboard lasers from being all-weather weapons); an effect known as thermal blooming that can reduce laser effectiveness; countering saturation attacks; possible adversary use of hardened targets and countermeasures; and risk of collateral damage, including damage to aircraft and satellites and permanent damage to human eyesight, including blinding. These potential advantages and limitations are discussed in greater detail in the **Appendix**.

Earlier Developments

Earlier developments in the Navy's efforts to develop high-energy SSLs include the following:

- Between 2009 and 2012, the Navy successfully tested a prototype SSL called the Laser Weapon System (LaWS) against UAVs in a series of engagements that took place initially on land and subsequently on a Navy ship at sea. LaWS had a reported beam power of 30 kilowatts (kW).[23]
- Between 2010 and 2011, the Navy tested another prototype SSL called the Maritime Laser Demonstration (MLD) in a series of tests that culminated with an MLD installed on a Navy ship successfully engaging a small boat.
- In August 2014, the Navy installed LaWS on the USS *Ponce* (pronounced pon-SAY)—a converted amphibious ship that operated in the Persian Gulf as an interim Afloat Forward Staging Base (AFSB[I])[24]—to conduct evaluation of shipboard lasers in an operational setting against swarming boats and swarming UAVs (**Figure 1** and **Figure 2**).
- In December 2014, the Navy declared LaWS on the *Ponce* to be an "operational" system.[25] *Ponce* remained in the Persian Gulf until it was relieved in September 2017 by its replacement, the new-construction Expeditionary Sea Base ship *Lewis B. Puller* (ESB-3). *Ponce* returned to the United States and was

beam power of at least 10 kilowatts (kW). In addition to developing SSLs, the Navy has also performed research and development work on a different kind of laser, called the free electron laser (FEL). For background information on the FEL, see CRS Report R41526, *Navy Shipboard Lasers for Surface, Air, and Missile Defense: Background and Issues for Congress*, by Ronald O'Rourke.

[23] See, for example, Mike McCarthy, "Navy Authorized to Use Ship-Based Laser in Battle," *Defense Daily*, December 11, 2014: 3.

[24] As an interim AFSB, *Ponce* operated in the Persian Gulf as a "mother ship" for Navy helicopter and small boat operations. Ships referred to as AFSBs are now referred to as Expeditionary Sea Base ships (ESBs).

[25] Mike McCarthy, "Navy Authorized to Use Ship-Based Laser in Battle," *Defense Daily*, December 11, 2014: 3; Sam LaGrone, "U.S. Navy Allowed to Use Persian Gulf Laser for Defense," *USNI News*, December 10, 2014; Philip Ewing, "Navy Declares Laser Weapon 'Operational,'" *Politico Pro (Pro Defense Report)*, December 10, 2014; Statement of Rear Admiral Mathias W. Winter, United States Navy, Chief of Naval Research, Before the Emerging Threats and Capabilities Subcommittee of the House Armed Services Committee on The Fiscal Year 2017 Budget Request, February 24, 2016, p. 15.

decommissioned in October 2017, at which point LaWS was removed from Ponce. LaWS was to be refurbished to serve as a land-based test asset for the HELIOS effort discussed below.[26]

Figure 1. Laser Weapon System (LaWS) on USS *Ponce*

Source: Navy photograph dated November 16, 2014, accompanying David Smalley, "Historic Leap: Navy Shipboard Laser Operates in Arabian Gulf," *Navy News Service*, December 10, 2014.

Development Roadmap

The Navy is developing SSLs with improved capability for countering surface craft and UAVs, and potentially an eventual capability for countering ASCMs. Navy efforts to develop these more capable lasers have included

- the Solid State Laser Technology Maturation (SSL-TM) effort;
- the Optical Dazzling Interdictor, Navy (ODIN);
- the Surface Navy Laser Weapon System (SNLWS) Increment 1, also known as the high-energy laser with integrated optical dazzler and surveillance (HELIOS); and
- the High Energy Laser Counter-ASCM Program (HELCAP).

[26] Source: Navy briefing to CRS and the Congressional Budget Office (CBO) on SNLWS program, April 27, 2018. For additional discussion of LaWS, see U.S. Navy, *U.S. Navy Program Guide 2017*, pp. 180-181, which refers to LaWS as the SSL-QRC (solid state laser—quick reaction capability).

Figure 2. Laser Weapon System (LaWS) on USS *Ponce*

Source: Navy photograph dated November 17, 2014, accompanying David Smalley, "Historic Leap: Navy Shipboard Laser Operates in Arabian Gulf," *Navy News Service*, December 10, 2014.

Figure 3 shows the Navy's approach for developing shipboard high-energy lasers as of May 16, 2024. As shown in **Figure 3**, first three efforts above are included in what the Navy calls the Navy Laser Family of Systems (NFLoS). (The fourth NFLoS effort shown in **Figure 3**, the Ruggedized High Energy Laser [RHEL] effort, is now completed.) **Figure 4** shows the Navy's approach for developing shipboard high-energy lasers as of August 17, 2022. Compared with the older **Figure 4** from August 2022, the newer **Figure 3** from May 2024 does not show SNLWS Increment 2 and SNLWS Increment 3 as future development efforts, and does not show an ASCM defense capability and a subsequent improved ASCM defense capability as future fleet capabilities.

Current and Recent Navy SSL Development Efforts

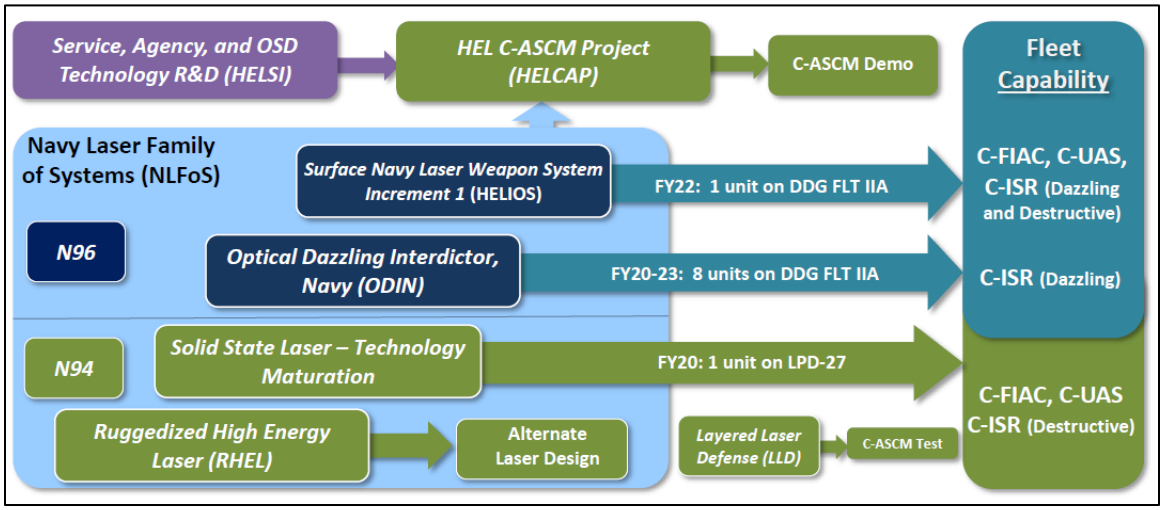
SSL-TM

The SSL Technology Maturation (SSL-TM) program developed a prototype shipboard laser called the Laser Weapons System Demonstrator (LWSD) "to address known capability gaps against asymmetric threats (UAS [unmanned aerial systems], small boats, and ISR sensors) and will inform future acquisition strategies, system designs, integration architectures, and fielding plans for laser weapon systems."[27] Industry teams led by BAE Systems, Northrop Grumman, and Raytheon, among others, competed to develop an LWSD with a beam power of up to 150 kW. On

[27] Department of Defense, *Fiscal Year (FY) 2024 Budget Estimates, Navy, Justification Book Volume 2 of 5, Research, Development, Test & Evaluation, Navy*, March 2023, p. 182 (PDF page 250 of 1568).

October 22, 2015, DOD announced that it had selected Northrop Grumman as the winner of the SSL-TM competition.[28]

Figure 3. Navy Laser Weapon Development Approach as of May 16, 2024



Source: Navy briefing slide provided by Navy Office of Legislative Affairs to CRS on May 16, 2024. N96 is the Surface Warfare Division of the Office of Chief of Naval Operations. N94 is the Innovation, Technology Missions, and Test and Evaluation Division.

The Navy announced in January 2018 that it intended to install LWSD on the amphibious ship *Portland* (LPD-27).[29] The system reportedly was installed on the ship in the fall of 2019.[30] On May 22, 2020, the Navy announced that *Portland* had used its LWSD to successfully disable a UAV in an at-sea test that was conducted on May 16, 2020.[31]

Figure 5 is an Office of Naval Research (ONR) graphic illustration of the SSL-TM system and its components if it had been installed on the Navy's Self Defense Test Ship (the ex-USS *Paul F. Foster* [DD-964], an old Spruance [DD-963] class destroyer). **Figure 6** is a Navy graphic illustration of the SSL-TM system on *Portland*. An October 18, 2019, blog post included photographs (**Figure 7**, **Figure 8**, and **Figure 9**) of a device the blog post identified as the SSL-TM laser being transported from Redondo Beach to San Diego for installation on *Portland*.[32]

[28] DOD contract award announcements for October 22, 2015. See also "US Navy Selects Northrop Grumman to Design and Produce Shipboard Laser Weapon System Demonstrator," December 22, 2015. See also Richard Scott, "Northrop Grumman to Build on MLD for SSL Demonstrator," *IHS Jane's International Defence Review*, February 2016: 5; Michael Fabey and Kris Osborn, "Navy to Fire 150Kw Ship Laser Weapon from Destroyers, Carriers," *Scout Warrior*, January 23, 2017.

[29] Megan Eckstein, "LPD Portland Will Host ONR Laser Weapon Demonstrator, Serve as RIMPAC 2018 Flagship," *USNI News*, January 10, 2018; Richard Abott, "Next Navy Amphib Will Feature Laser Weapon Demo, Chosen as Flagship for RIMPAC 2018," *Defense Daily*, January 11, 2018.

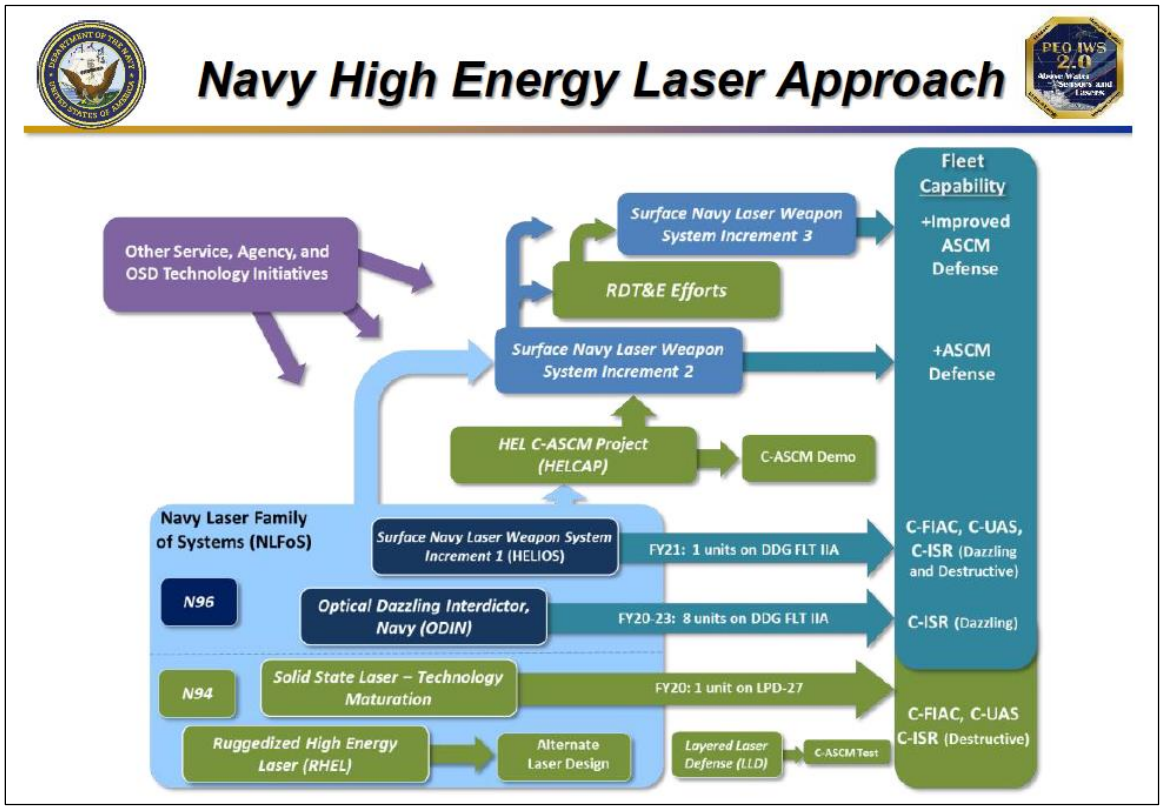
[30] Christopher P. Cavas, "Lasers Sprout in San Diego," *Defense & Aerospace Report*, March 1, 2020.

[31] Commander, U.S. Pacific Fleet Public Affairs, "USS Portland Conducts Laser Weapon System Demonstrator Test," *Navy News Service*, May 22, 2020. See also Megan Eckstein, "VIDEO: USS Portland Fires Laser Weapon, Downs Drone in First At-Sea Test," *USNI News*, May 22, 2020; Paul McLeary, "US Warship Fries Drone with Powerful New Laser," *Breaking Defense*, May 22, 2020; Geoff Ziezulewicz, "Watch This Ship-Mounted Navy Laser Shoot Down a Drone," *Navy Times*, May 26, 2020.

[32] Tyler Rogoway, "Mysterious Object Northrop Is Barging from Redondo Beach Is a High-Power Naval Laser," *The Drive*, October 18, 2019.

The Navy's FY2025 budget submission states that SSL-TM deinstallation, final report, program closeout, and hardware disposition began in the second quarter of FY2023 and are scheduled to be completed in the fourth quarter of FY2024.[33]

Figure 4. Navy Laser Weapon Development Approach as of August 17, 2022



Source: Navy briefing slide provided by Navy Office of Legislative Affairs to CRS on August 17, 2022. N96 is the Surface Warfare Division of the Office of Chief of Naval Operations. N94 is the Innovation, Technology Missions, and Test and Evaluation Division.

[33] *Department of Defense, Fiscal Year (FY) 2025 Budget Estimates, Navy, Justification Book Volume 2 of 5, Research, Development, Test & Evaluation, Navy, Budget Activity 4*, March 2024, pp. 180, 185, 186 (PDF pages 256, 261, 262 of 1520).

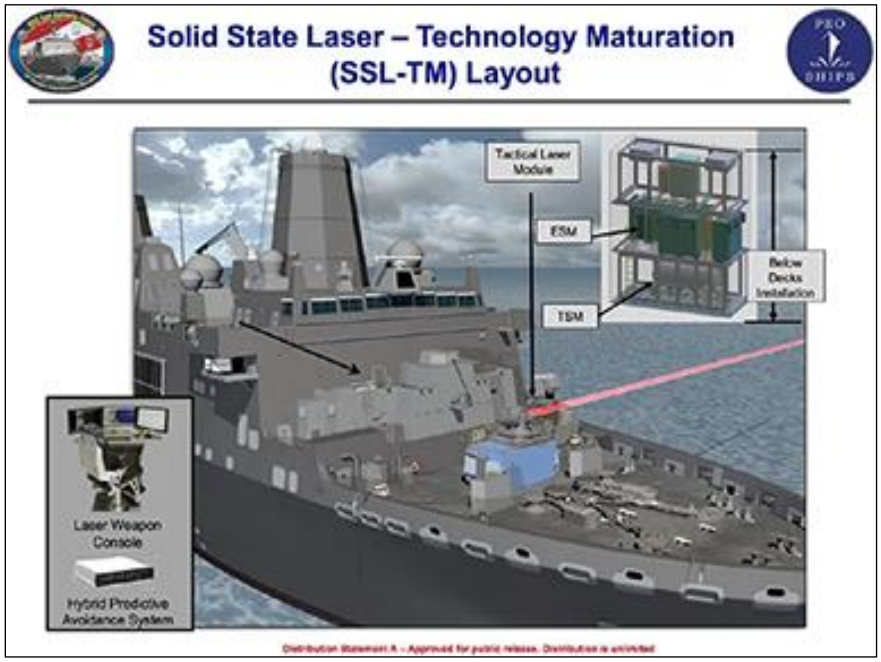
Figure 5. ONR Graphic of SSL-TM Laser System

Artist's rendering of installation on Navy's Self Defense Test Ship

Source: Slide from February 2016 ONR briefing to CRS on SSL-TM program, received from Navy Office of Legislative Affairs February 26, 2016.

Figure 6. Navy Graphic of SSL-TM Laser System

Artist's rendering of installation on USS *Portland*



Source: Navy briefing slide accompanying Tyler Rogoway, "Mysterious Object Northrop Is Barging from Redondo Beach Is a High-Power Naval Laser," *The Drive*, October 18, 2019. The blog post credits the slide to the Navy and describes it as a "recent slide."

Figure 7. Reported SSL-TM Laser Being Transported

Source: Photograph accompanying Tyler Rogoway, "Mysterious Object Northrop Is Barging from Redondo Beach Is a High-Power Naval Laser," *The Drive*, October 18, 2019. The photograph is a cropped version of a photograph printed in full elsewhere in the blog post. The uncropped version is credited to "Matt Hartman/ShoreAloneFilms.com."

Figure 8. Reported SSL-TM Laser Being Transported

Source: Photograph accompanying Tyler Rogoway, "Mysterious Object Northrop Is Barging from Redondo Beach Is a High-Power Naval Laser," *The Drive*, October 18, 2019. The photograph is credited to "KABC CH7 Screencap."

Figure 9. Reported SSL-TM Laser Being Transported

Source: Photograph accompanying Tyler Rogoway, "Mysterious Object Northrop Is Barging from Redondo Beach Is a High-Power Naval Laser," *The Drive*, October 18, 2019. The photograph is credited to "Matt Hartman/ShoreAloneFilms.com."

ODIN

Overview

Optical Dazzler Interdictor Navy (ODIN) systems have been installed on eight Arleigh Burke (DDG-51) class destroyers. **Figure 10** and **Figure 11** reportedly show an ODIN system. The first ODIN installation reportedly was done on the destroyer *Dewey* (DDG-105) in 2019.[34]

The Navy's FY2025 budget submission states

> Optical Dazzler Interdictor Navy (ODIN) development provides directed energy, shipboard Counter-Intelligence, Surveillance, and Reconnaissance (C-ISR) capabilities to the Fleet to dazzle Unmanned Aerial Systems (UASs) and other platforms that address the Urgent Operational Needs (UONs) statement provided by the Fleet. ODIN, as a non-Program of Record, was developed and fielded with RDT&E,N funding and was initially envisioned as a Non-Permanent Change (NPC). FY 2018 was the first year of funding which supported the design, development, procurement, and installation of 8 ODIN

[34] Hope Hodge Seck, "The Navy Has Installed the First Drone-Stopping Laser on a Destroyer," *Military.com*, February 21, 2020; Justin Katz, "Navy Installs Laser on Destroyer to Counter Unmanned Intelligence Drones," *Inside Defense*, February 21, 2020; Christopher P. Cavas, "Lasers Sprout in San Diego," *Defense & Aerospace Report*, March 1, 2020; Kris Osborn, "New Destroyer-Fired Laser Weapons Might Stop Hypersonic Missile Attacks," *Warrior Maven*, March 1, 2020, which was republished as Kris Osborn, "Could Naval Lasers Be the Solution to China's Hypersonic Missile Threat?" *National Interest*, March 7, 2020.