AFRL

SPEED OF LIGHT TO THE FIGHT

Why Directed Energy Weapon Systems?

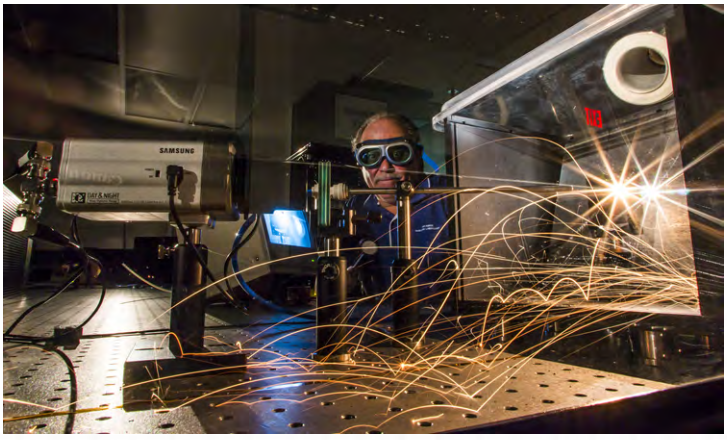
To fill capability gaps identified by warfighters, the Department of Defense (DoD) leads research and development efforts involving directed energy solutions. Two main classes of directed energy weapons (DEW) exist: high energy lasers (HEL) and high power microwave (HPM) systems. For both types of DEW systems, electromagnetic energy creates the desired effect on a target. In contrast, bullets and bombs employ kinetic energy.

For HEL systems, a beam of light creates an effect on the target. For HPM systems, the transmission of a short and extremely high power burst of energy creates the desired effect. Laser technology has made significant leaps in both performance and maturity thanks to years of research. Electric solid-state and fiber lasers now offer weapons-grade power in compact systems suitable for deployable platforms. Since laser weapons have demonstrated the level of technical maturity necessary for air platform integration, they will support potential self-defense and offensive missions in the next decade.

Laser System Capabilities

In general, laser weapons offer warfighters unique opportunities for quick and precise target engagement, mission flexibility, and lighter, more responsive support logistics. The following capabilities make lasers attractive for operational users.

- *Speed-of-light delivery*—Laser weapons engage targets at the speed of light.
- *Multiple target engagements and rapid retargeting*—Laser weapon system engagements typically only last for a few moments which allows for the system to be constantly powered, to move rapidly between targets and be reloaded by recharging the electrical energy storage.



An AFRL Directed Energy Directorate scientist uses his tech demonstrator fiber laser to burn through metal targets. Between year 2000 and 2017, fiber lasers transitioned from a most improbable dark horse candidate to the dominant technology for high energy laser systems. Photo credit: AFRL

- *Deep magazines*—Since lasers are driven by electricity, the number of shots they can fire and sustain is only limited by the system performance and recharge rates as opposed to a specific number of munitions.
- *Low incremental cost per shot*—Since lasers only expend energy, the cost per incremental shot consists of system wear and the cost of the fuel needed to generate the beam.
- *Exceptional accuracy and adjustability*—Laser beams can be focused with great precision, and feature adjustable power levels.
- *Lower logistical support requirements*—Unlike guns or missiles that must be resupplied or replaced, laser weapons only require additional fuel or power to generate the electricity needed to power the weapon.

These attributes of HEL have been recognized for decades. Past Air Force investments in HEL weapon technologies have reached the point where they are ready for operational fielding.

(Continued on page 2)

(Continued from page 1)

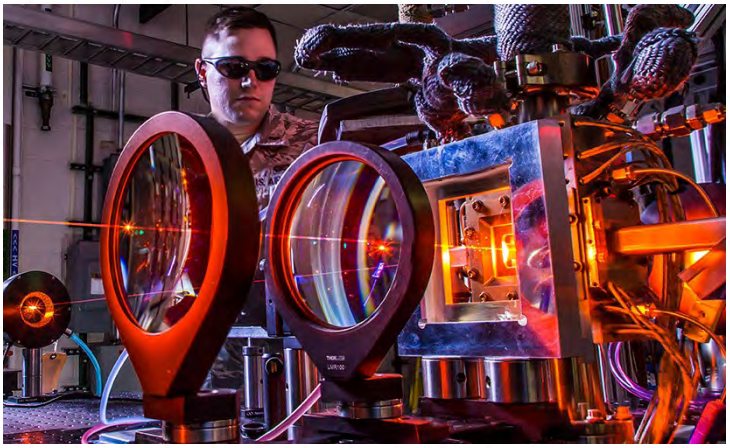
Current Laser Programs

Today, AFRL is working with the Air Force and other DoD partners to bring HEL weapons to warfighters. AFRL is rapidly maturing fiber laser beam combining capabilities, where beams from a larger number of fiber laser amplifiers form a single beam. Significant progress has been made in increasing the output power of individual fiber laser amplifiers. Through beam combining, single amplifier improvements resulted in enormous power scaling. Other strategies to increase power and to generate alternate wavelength lasers are also under investigation. Hollow core fibers are one example. This novel design replaces the glass core of the optical fiber with a gas that generates alternate laser wavelengths, or interacts with the laser signal to shift the laser wavelength. While immature at this time, hollow core fibers (HCF) could significantly expand the applications for laser systems.

AFRL is actively transitioning laser and other key technology elements to strategic DoD entities and prime contractors through Advanced Technology Demonstrations (ATDs). The explosive progress in compact laser design has allowed AFRL to launch major demonstrations such as the Self-defense High Energy Laser Demonstration (SHiELD) ATD, which aims to develop and integrate a compact Laser Weapon System (LWS) into a podded configuration consistent with size, weight, and power available on a fighter-sized platform.

Ultimately, the SHiELD ATD will demonstrate the effectiveness of a LWS in a tactical flight environment for self-defense against incoming threats. The purpose of the this ATD is to reduce and retire the technical risks of an airborne LWS in a calculated and precise fashion, to resolve challenges such as laser power-scaling, packaging, ruggedization, and to overcome the challenges of complex, beam-spoiling aerodynamic effects.

Following the build phase, the first step in testing will be for the system to demonstrate the ability to acquire, track, and point the laser onto a dynamic, non-cooperative target. Flight tests of the fully integrated system in an operationally relevant environment will begin in 2021, during which the SHiELD system will demonstrate its self-protection capabilities with lethal engagement of incoming threats.



An AFRL laser physicist analyzes the output beam from one of the Directed Energy Directorate's advanced laser sources. AFRL scientists continue to investigate novel laser sources that are easily maintained, environmentally friendly, and capable of megawatt-level output. Photo credit: AFRL

To further increase the power beyond the SHiELD design, AFRL awarded four contracts in June 2019 to assess candidate technologies. The Compact High Energy Laser Subsystem Engineering Assessment (CHELSEA), part of the Laser System Development (LSD) program, will identify the most promising technology options to scale laser power by calendar year 2024 as a possible drop-in replacement for the SHiELD laser subsystem, or as part of a new, prototype laser system for airborne applications.

SHiELD and LSD are part of ongoing efforts led by the DoD, the Air Force and its industry and government partners to invest in the maturation and integration of HEL technologies on relevant platforms for a wide range of applications. Various small businesses and a wide variety of major aerospace industry partners are supporting these efforts including General Atomics, Raytheon, Boeing, Northrop Grumman, and Lockheed Martin.

AFRL's laser programs aim to discover, develop, and mature LWS technologies that will allow operation in all flight regimes. AFRL expects to accomplish practical and effective electric laser system demonstrations for tactical airborne applications by 2022.