2017 Directed Energy Educational Outreach

The United States Leads the World in Directed Energy Technology

High Energy Lasers

Optical Technology

Support Systems

High Power Microwaves

High Power Radio Frequency

DIRECTED ENERGY IS HERE TODAY!

Directed Energy to the District of Columbia
DE2DC 2017 Educational Exhibits

Pentagon Exhibit of DE Hardware
March 28th - 0900-1400 - Pentagon Courtyard

Congressional Exhibit and Reception of DE Technology
March 30th - 1300-1900 - Rayburn Building Foyer

What is the purpose of the Directed Energy Educational Outreach Campaign -

The National Directed Energy Outreach Campaign aims to :

(1) promote transition of directed energy technologies into operational use through educational outreach to decision makers and warfighters, and

(2) provide technical expertise to warfighters and decision makers as they incorporate directed energy systems.

Directed Energy Educational Outreach Campaign Initiated in 2010

What is Directed Energy - Directed Energy (DE) technologies encompass a wide range of non-kinetic capabilities that generate beams or fields of electromagnetic energy.

Directed energy weapons (DEWs) propagate this energy to engage a target remotely at the speed of light, including High Energy Lasers (HEL) or High Powered Microwaves (HPM)/High Power Radio Frequency (HPRF) enable precise, scalable effects against multiple targets at a very low cost per shot.

DEWs offer non-lethal warning, escalation of force, ISR and counter-ISR, counter-electronics, counter-munitions, and counter-IED capabilities at a fraction of the cost per engagement compared to traditional, kinetic options. As a complement to existing weapons, DEWs offer the U.S. Military a cost-effective capability enhancement to address evolving threats.

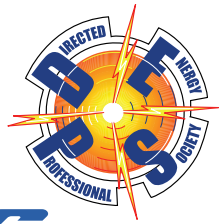
One of the key benefits of DE technologies are scalable effects, i.e., target impacts that range from temporary disruption to permanent damage. With HELs, effects can range from “dazzling,” or blocking visibility only when illuminated, to ablation and damage, usually causing the target to catch fire. With HPM, effects can range from interruption (e.g., shutting off an engine that can later be restarted) to permanent damage to electronics within the target.

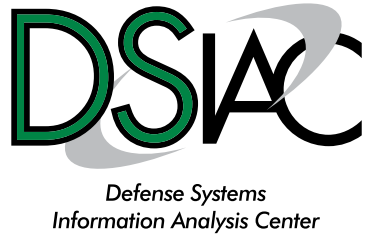
The Directed Energy Professional Society (DEPS) was founded in 1999 to foster research, development and transition of Directed Energy (DE) technology for national defense and civil applications through professional communication and education. We intend to be recognized as the premier organization for exchanging information about and advocating research, development and application of Directed Energy, which includes both high energy lasers (HEL) and high power microwaves (HPM). The Directed Energy Professional Society is incorporated as a nonprofit corporation in New Mexico, organized and operated exclusively for charitable, scientific, and educational purposes.

DEPS offers graduate scholarships of $10,000 for an academic school year. The number of annual scholarship awards depends on available funding, which is provided by grants from the High Energy Laser Joint Technology Office and the Office of Naval Research. The traditional academic disciplines involved in DE research include, but are not limited to, physics, electrical engineering, chemistry, chemical engineering, materials sciences, optical sciences, optical engineering, and aerospace engineering.

DEPS hosts several conference and workshop annually and bi-annually to further information exchange and collaboration amongst the DE community. Unique to DEPS is our ability to host meetings at varying classification levels, from sessions open to the public to those that cover classified research material. DEPS provides each attendee a copy of the respective proceedings from the meeting, based on their individual clearance level. DEPS also sponsors a series of short courses that are associated with the Annual Directed Energy Symposium and other events. Continuing Education Unit (CEU) credits are offered for completion of DEPS courses. A listing of DE courses and events available to the community can be found at our website, www.deps.org.

DIRECTED ENERGY OUTREACH CAMPAIGN





National Scope of DE Activities (37 out of 50 States Involved)

Table of Contents

Government Organizations

High Energy Laser Joint Technology Office

Establishing the Foundation for Laser Weapon Systems

The Department of Defense (DoD) High Energy Laser Joint Technology Office (HEL-JTO) manages a portfolio of science and technology projects in Directed Energy (DE) spanning Academia, Government, and Industry. In addition to advancing the state of the art in High Energy Lasers for military applications, the JTO established an Educational Outreach program to address the issue of limited numbers of US students trained in the various HEL disciplines.

Training the future HEL workforce

The current 2017 Senate bill is proposing acceleration of development and fielding of DE technology and to offset the gains of potential adversaries, as well as a joint DE program office that would expand the HEL JTO. Additionally, the House amendment contains a requirement for designation of a senior official for the development and demonstration of DE weapons for the DoD.

Advocates HEL development & transition

Addresses joint technology requirements

Stimulates inter-service research

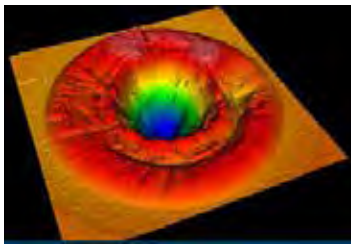
Orchestrates portfolio of R&D projects across government/industry/academia

Establishes community standards & tools

Educates next generation of HEL technical,

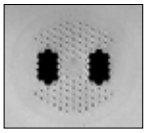
The JTO utilizes a multi-pronged approach to advance HEL technologies through basic and exploratory research, working with Universities, DoD Services & Agencies (S&A), and Industry. Subject matter experts, as members of Technical Area Working Groups, representing DoD organizations, advocate DE interests of their respective S&A, to the JTO to determine the priority of the specific topics to be investigated.

Graduate students at the University of New Mexico

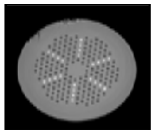


Modeling the effects of HEL on materials at Pennsylvania State University

Multi-Disciplinary Research Initiatives (MRI) support basic research activities at Universities to conceive, explore, and incubate, high risk / high pay-off ideas to improve HEL performance. MRI teams, graduate & undergraduate students, gain research experience in HEL technology while pursuing their academic degrees.



Gain tailored photonic crystal fiber development at Air Force Research



Cladding-pumped Raman gain fibers developed at the Army Research Laboratory

Research topics are selected to complement and/or advance technologies to meet S&A program goals and to further the objectives of these programs, and to keep government laboratory research personnel current on technical developments.

High Energy Laser Joint Technology Office (HEL-JTO)
801 University Blvd. SE Suite 209
Albuquerque, NM 87106

Email: HEL-JTO@jto.hpc.mil
Phone: (505)248-8200

Advanced HEL Deformable Mirror

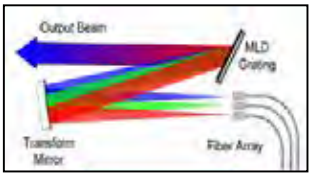
Industry responses to Broad Area Announcements have invariably been excellent; contracts are structured to advance the success of multi-Service DE programs. The technology base has grown due to JTO sponsorship, advancing the state of the art with significant novel technical contributions and providing the foundation for the development of commercialized products by numerous businesses.

2x2 VCSEL Array
2.7x2.7mm / 530W power

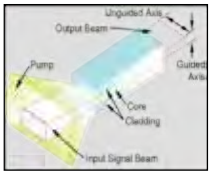
JHPSSL developed by Northrup

Scientific investigations, in a multitude of HEL technologies, have resulted in a number of record breaking achievements. Advancements in solid-state laser technology, prompted the Joint High Power Solid State Laser (JHPSSL) program, directed and managed by the JTO, with the participation and support of the military Services. The JHPSSL program culminated in the first demonstration of a solid-state laser with power output above 100 kW.

Building on this success, the JTO initiated a program to increase laser efficiency and to start addressing "field-ability" of laser devices, the Robust Electric Laser Initiative (RELI). The RELI development program is exploring multiple technologies to achieve improved performance.



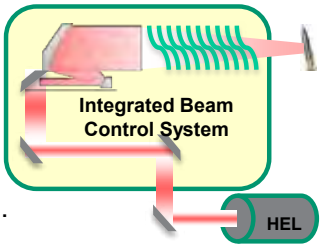
Lockheed Martin's Robust Electric Laser Initiative program uses spectral beam combining.



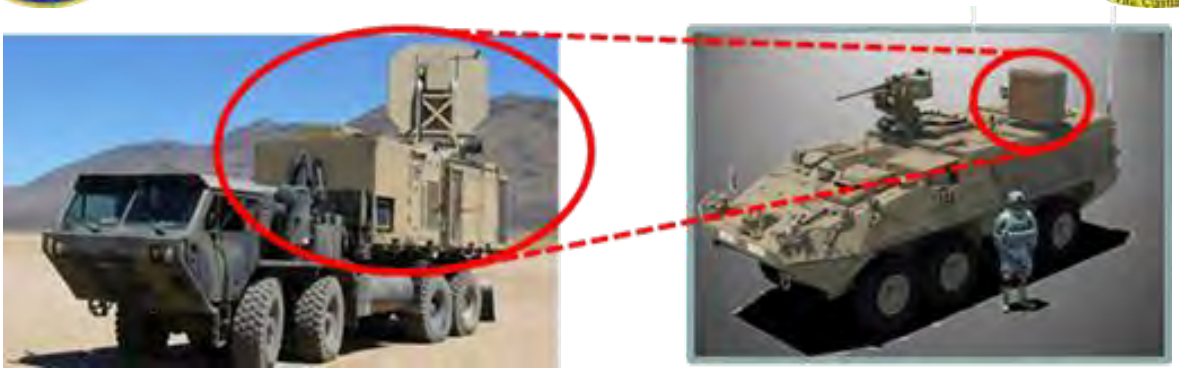
Raytheon's Robust Electric Laser Initiative (RELI) program utilizes Planar Waveguide architecture.

Both slab-based and fiber combined laser concepts have made significant progress, achieving output power and efficiency goals in demonstrations with very good laser beam quality. Services are incorporating RELI developments into their Directed Energy programs. Army chose a fiber-based laser concept as the basis for their HEL Mobile Demonstrator (HEL- MD) Program, the Marine Corps selected a slab-based RELI laser for their Ground Based Air Defense (GBAD) Program, the Navy deployed a fiber-based system, and Air Force is pursuing a fiber laser concept.

With the demonstrated improvements in solid-state laser devices, achieving power goals, exhibiting excellent laser beam quality, increasing efficiency, and progressing toward desired weight and volume necessary for integration onto a military platform, the JTO is concentrating its emphasis on another major part of a laser weapon system, the management and control of the laser beam. This initiative, Advanced Beam control for Locating and Engagement (ABLE) will improve the overall performance of the laser beam control system. The emphasis of the ABLE system is to: 1) maximize the laser throughput; 2) enhance pointing and tracking capabilities; and 3) advance atmospheric compensation through turbulent environments. State of the art components in these areas are being developed for subsystem capability demonstrations. Ultimately, an integrated system demonstration, with a RELI-class laser will be employed to demonstrate the system performance improvements provided by ABLE technologies.



DoD Non-Lethal Weapons Program
Non-Lethal Directed Energy Weapon (NL DEW) Innovation



Solid State Active Denial Technology - Innovations

The DoD's "Third Offset Technology Strategy" is guiding Department-wide effort to identify and invest in innovative means to sustain and advance America's military dominance for the 21st century. Some of DoD's most innovative research is being conducted by the DoD Non-Lethal Weapons (NLW) Program, a leader in directed energy (DE) technology for NL applications.

The DoD NLW Program stimulates and coordinates non-lethal weapons requirements of the U.S. Armed Services and allocates resources to help meet these requirements. The Commandant of the Marine Corps serves as the DoD NLW Program's Executive Agent.

Future non-lethal capabilities will use emerging DE technologies that will provide ranges, additional precision and scalable effects, above and beyond the capacity of current non-lethal weapons.

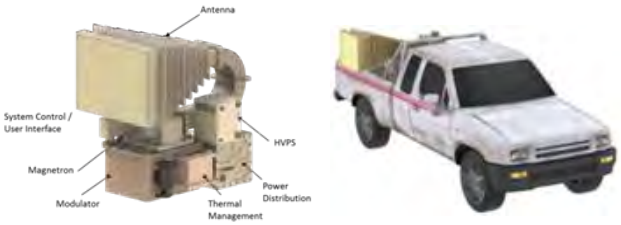
For further information on the DoD Non-Lethal Weapons Program visit:
http://jnlwp.defense.gov

6.8 kW 3300 lb SS-ADT (1W GaN-based MMICs) Skid-Plate Demonstrator with Az/El Gimbal

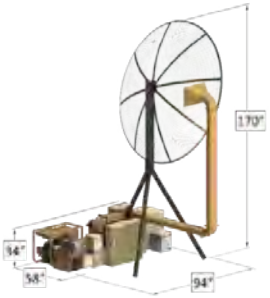
Ongoing research and development projects are making significant progress in size, weight, power, cost and cooling (SWAP-C^2) reduction

Active Denial Technology (ADT) - ADT directs a focused beam of millimeter wave (95 GHz) energy to safely induce an intolerable heating sensation on an adversary's skin, causing an immediate non-lethal counter-personnel "repel" response. The JNLWP and the Army's Armament Research, Development, & Engineering Center (ARDEC) have developed a 100 meter 6.8 kW gimbal mounted solid state (SS-ADT) "skid-plate". This SS-ADT "skid-plate" will be evaluated during the Army's Expeditionary Warrior Experiment from October to December 2017.

Radio Frequency - High Power Microwaves (RF/HPM) Vehicle & Vessel Stopping - The RF/HPM Vehicle/Vessel Stopper program uses directed high power microwave energy to interfere with engine electronics in order to shut-off vehicle and vessel engines. Two prototype designs are in development: (1) a short range RF/HPM Vehicle/Vessel Stopper prototype which will be employed primarily for force application (e.g., for snap check-point and convoy protection) missions and (2) a long range RF/HPM Vehicle/Vessel Stopper prototype which will be employed for force protection (e.g., entry control point) missions.



Short-Range RF/HPM Vehicle Stopper



Long-Range RF/HPM Vehicle Stopper

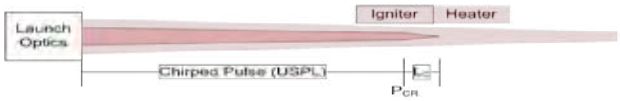
Dazzling Lasers & Non-Lethal Laser Induced Plasma Effects (LIPE) Weapons – These weapons are intended to provide long range hail/warn and non-lethal counter-personnel (e.g., deny, move, and/or suppress) effects. Non-Lethal LIPE weapons may provide long range (~5-6km) hail and warn; high repetition "flash-bang"-like effects; and thermal ablation (counter-personnel and counter-materiel) effects.

Short-Range (Wide-band) Vessel Stopper Prototypes

Long-Range (Narrow-band) Vessel Stopper Prototypes

US Marine Corps Ocular Interruption (OI) Program – Dazzling Lasers

SWAP/C^2 Improvements to NL DEW Systems, Subsystems, and Components – The JNLWP has been working hard to develop "breakthroughs" associated with minimizing DEW SWAP/C^2. This includes research on developing small compact prime power systems, improved thermal management subsystems, and compact lighter weight RF/HPM antenna systems with beam steering capabilities.



NL LIPE Weapon

480 lb - 250 kW Gas-Turbine Prime Power Generator

35 lb Compact S-Band (1.3m dia.) HPM Antenna

For further information on these DoD Non-Lethal Weapons Program efforts visit: **http://jnlwp.defense.gov**


DIRECTED ENERGY
PROFESSIONAL SOCIETY
DEPS

DSIAC

THE DEFENSE SYSTEMS INFORMATION ANALYSIS CENTER

SUPPORTS THE DIRECTED ENERGY COMMUNITY

FREE TECHNICAL INQUIRY SERVICE

Navy

U.S. Air Force

U.S. Marine Corps

In an era of growing global technicalization and improvised tactics, the necessity for a third offset strategy to combat this new paradigm is becoming increasingly evident. To ensure the United States maintains an advantage over our potential adversaries, the Department of Defense (DoD), is concentrating research and development efforts on innovation, such as Directed Energy technology, which holds great promise for maintaining technological superiority in a budget-conscious environment.

Accordingly, the charter of the Defense Systems Information Analysis Center (DSIAC) is to provide an information resource for the DoD, U.S. Government agencies, academia, industry, and other Directed Energy stakeholders to increase the value of government-owned research and development information through re-purposing, reuse, and enhancement.

DSIAC's free technical inquiry service (limited to 4-hours) is available to provide the Directed Energy community with:

- Document retrieval.
- Literature searches.
- Answers to technical questions.
- Technology assessments.
- Modeling & simulation tools.

Other services include;

- Collecting, organizing, and disseminating Directed Energy-related scientific and technical information.
- Fostering and supporting the Directed Energy community with subject matter experts.
- Providing training, conferences, state-of-the-art reports and publishing *DSIAC Journal* articles.

For analysis tasks that exceed the free 4-hr limit, a Core Analysis Task delivery order vehicle is available for DSIAC to perform specialized work under our pre-competed IDIQ contract. For more information on DSIAC or the DoD IACs, visit http://iac.dtic.mil.

DSIAC Defense Systems Information Analysis Center

"Transforming Information into Knowledge"

4695 Millennium Drive, Belcamp, MD 21017-1505

443-360-4600 | www.dsiac.org

Directed Energy Directorate

Speed of Light to the Fight by 2020

AFRL
THE AIR FORCE RESEARCH LABORATORY

About the Directed Energy Directorate

Located at Kirtland Air Force Base, N.M., the Directed Energy Directorate is the Air Force's center of expertise for directed energy and optical technologies. The Directorate focuses on four research areas: Laser Systems, High Power Electromagnetics, Weapons Modeling, Simulation and Analysis, and Directed Energy and Electro-Optics for Space Superiority. The Directorate consists of 700 plus military, civilian, and on-site contractors dedicated to providing the Air Force with game-changing technology.

The Directorate operates on 4,325 acres of land with over 860,000 square feet of laboratory and office space. In addition to the numerous state-of-the-art research laboratories and testing structures at Kirtland AFB, unique facilities on Kirtland include the Starfire Optical Range, the Environmental Laser Test Facility, the High Energy Microwave Laboratory where we do high energy microwave testing inside the anechoic chamber, and the Air Force Maui Optical and Supercomputing site in Hawaii.

Core Technical Competencies (CTC)

There are four technical competencies at the center of all research and development in the Directed Energy Directorate. In each area, the Directorate has world-class personnel, equipment, and facilities that provide directed energy capabilities for the warfighter.

High Power Electromagnetics

- Non-lethal counter-electronics technology (disrupt critical electronic systems)
- Advanced pulsed power components and systems
- High power electromagnetic effects and predictive modeling
- High power microwave (HPM) sources

Laser Systems

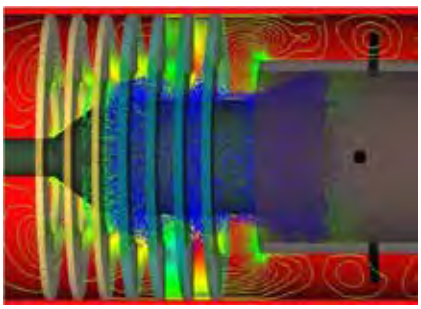
- Future offensive and defensive laser concepts
- Advanced beam control
- Gas, solid-state, and fiber laser sources
- Laser effects and predictive modeling

Directed Energy and Electro-Optics for Space Superiority

- Space Situational Awareness
- Track and image space objects from ground-based telescopes
- Adaptive optic technologies to compensate for atmospheric distortions

Weapons Modeling, Simulation & Analysis

- Concept analysis
- Model synergy of directed energy and kinetic weapons at mission level
- Computer modeling saves time, lowers costs, and provides warfighter with predictive capabilities



The Directorate is organized into divisions by major technology area. Often, research capabilities are drawn from several divisions as well as across the whole of AFRL. The four technology divisions are:

High Power Electromagnetics Division: Research includes High Power Microwave systems that disable electronic infrastructures with little to no collateral damage, research on novel sources, and compact pulsed power.

Laser Division: Research includes advancing high power laser sources, beam control technology, laser modeling and simulation, and laser effects testing, with the goal of integrating and demonstrating laser weapon systems to protect aircraft, airbases, and people.

Space Electro-Optics Division: Research includes improving optical and imaging systems using non-traditional and meter class telescopes to provide increased capability to the nation to view objects in space, as well as atmospheric compensation, optical communications, satellite vulnerabilty analysis, and guidestar technology.

Mission Planning and Support Division: Performs analysis of future concepts and mission and battle level model development to assess the impact of directed energy in Air Force wargaming activities.

Recent Directed Energy Successes

• Accomplished a major step towards 24/7 space situational awareness by collecting the first-ever daytime images of a satellite using a sodium laser guide star adaptive optics system to compensate for atmospheric distortions in real time

• Achieved a significant milestone in the maturation of high power laser weapon system technologies when we conducted the first successful downrange propagation of laser energy from the 150kW-class Demonstrator Laser Weapon System

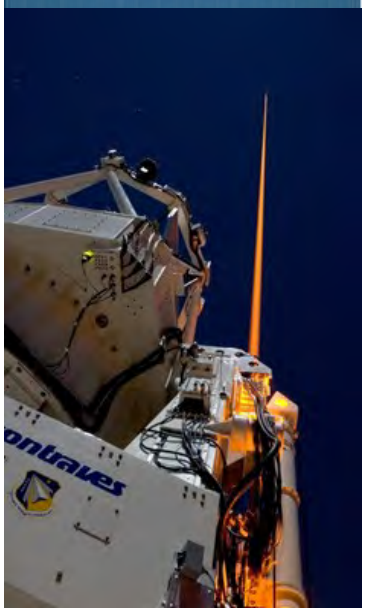
• Completed Phase I of the Hybrid Defense of Restricted Airspace (HyDRA) Study to assess directed energy utility for area/point defense, which resulted in Air Force experimentation activities for counter unmanned aerial vehicle (UAV) threats

• Demonstrated an operationally relevant period of pulse transmission for our CHAMP assets. Two residual CHAMP test articles were used to demonstrate missiles capable of performing counter-electronics missions. The CHAMP missile disables electronic devices without causing collateral damage to facilities or harm to people

Contact 377 ABW Public Affairs for more information: (505) 846-5991DSN 246-5991
Current as of January 2017
http://www.kirtland.af.mil/afrl_rd/index.asp
Approved for Public Release - OPS-16-12831

Directed Energy Directorate

Speed of Light to the Fight by 2020



AFRL THE AIR FORCE RESEARCH LABORATORY

AFRL Directed Energy Directorate

Laser Weapon Systems

Why Laser Weapon Systems

The Department of Defense (DoD) invests research and development (R&D) dollars into directed energy solutions to fill gaps identified by warfighters. Currently, the Air Force is pursuing laser weapons systems (LWS) along with high powered electromagnetics (HPEM) to enable operations in a possible future battlespace involving a technologically advanced adversary with the ability to prevent access to—or deny our ability to operate in—a given area. There is also increased interest in defending against Unmanned Aerial Systems (UAS) and hypersonic weapons.

Laser technology has made significant leaps in both performance and maturity thanks to many years of research. Recent developments in electric solid-state and fiber lasers, designed primarily for tactical engagement, now offer weapons-grade power in a compact system suitable for deployable platforms. For example, the Navy, by virtue of its Laser Weapons System dubbed LaWS, has fielded the DoD's first operational tactical laser on a ship, overcoming many of the policy and legal issues hindering deployment and utilization. Today, laser weapons have finally demonstrated sufficient technical maturity to allow for integration onto air platforms for potential self-defense and offensive missions in the next decade.

Overcoming Challenges

The Air Forces past airborne laser demonstrations pushed the art-of-the-possible, providing an appreciation

both for the unique operational capabilities of an airborne LWS and for the formidable technical challenges that remain to be overcome. Due to the sub- and transonic air speeds of maneuvering tactical aircraft—such as fighter planes—in conjunction with tight packaging constraints, these obstacles are far greater for aerial vehicles than for ground-based systems. Naturally, these mutually interdependent challenges must be addressed concurrently before an LWS can be integrated into an aerial vehicle.

A variety of obstacles impede the utilization of an airborne laser weapon system, several of which have been identified as being most crucial to its success or failure. Most fundamentally, it is essential to maximize laser power while reducing volume and mass, maintaining a size, weight, and power (SWaP) that offers tactical effectiveness. Moreover, beam control systems must be adequately advanced so as to enable precise aiming, tracking, and pointing amidst the aero-mechanical jitter induced by vibrations

during flight. Similarly, system temperature must be controlled via the dissipation of waste heat, and high-speed aerodynamic flow must be mitigated to avoid aero-optical disturbances. Should any of these elements be allowed to dominate, the laser beam can disperse, losing its precision and effectiveness at operational ranges. Finally, it is important to note that a laser system is a complex piece of technology, which must be ruggedized into a compact package capable of surviving a battlefield environment.

In the face of these multiple technical difficulties, AFRL plans to build on past demonstrations and advancements to sponsor a staged approach to address and reduce technology risks. Initially, the focus will be on the development of subsystem technologies, making certain that each component of the greater whole can meet the requirements of the operational Air Force. A flight demonstration with a low-power laser will prove that targets can be tracked at sufficient range and speed to allow for engagement with a laser beam, demonstrating effective mitigation of aerodynamic disturbances. Successful completion of this demonstration will lead to the graduated progression of ground and flight tests for laser weapon systems offering medium-power for tactical operations. The continuing development and eventual deployment of high-power laser systems has the potential to diminish operational risk, create improved warfighting options, and enable new courses of action for military leadership. These airborne demonstrations mark the first AFRL sponsored laser weapon flight program in more than 30 years and are in direct response to the importance placed by senior Air Force leadership on rapidly maturing these systems for operational use.

Laser Source Characteristics

Laser weapons can deliver precise and scalable effects against a wide class of targets near-instantaneously and at a very low cost per shot. For example, the type of gradual effects a 30 kW laser can deliver includes the denial, degradation, disruption, and destruction of a range of targets from UAS to small boats at a range of several kilometers. More powerful lasers have counter-air, counter-ground, and counter-sea applications against a host of hardened military equipment and vehicles at significant range.

Due to the complex logistical chain of chemical lasers, electrically-driven solid-state lasers have become the medium of choice for the modern LWS. These lasers have few moving mechanical parts and consume only electricity, rather than hazardous and caustic chemicals. As such, solid-state lasers are a fraction of the size of chemical lasers, and their weight per power (kg/kW) is about 30 times less, allowing for great savings in space for electric lasers. Beyond considerations of size, solid-state lasers offer a host of advantages.

Electric lasers have a nearly infinite "magazine size" as long as an appropriate power supply is available. As such, the total number of shots they can fire is limited only by the fuel available to drive the electrical power source, provided naturally via the operation of the aircraft. Generally, banks of batteries are employed for this purpose and can be sized to meet the requirements for virtually any laser power and magazine depth. For a 30 kW laser system, the batteries could weigh on the order of 300 pounds and fit within a volume of half of a cubic meter. Since they are constantly powered—"reloaded"—by recharging their electrical power supply, an LWS can engage multiple targets very quickly and is limited for the most part only by its ability to dissipate waste heat. Effective thermal management systems can drastically increase the rate of fire, either through traditional liquid cooling loops or through two-phase cooling, wherein heat is transferred to and melts a solid, the resulting liquid of which is then cooled.

Functionally, the range of an LWS is dictated by laser power, beam quality, aero-optical and aero-mechanical disturbances, and beam control design. Weather and atmospheric conditions can also serve to limit effective range.

Current Laser Programs

AFRL has two major integration and demonstration programs at the moment: the Self-Protect High Energy Laser Demonstrator (SHiELD) and the Demonstrator Laser Weapon System (DLWS). The former addresses the risk of integrating on LWS onto an aerial platform, while the latter demonstrates the effect of a fully integrated ground-based LWS against representative targets. In addition, several enabling research programs are being conducted to tackle key technical challenges at the subsystem level. In total the Air Force and DARPA are investing more than $500M on these programs. The Army, Navy, the Defense Advanced Research Projects Agency (DARPA), and the Missile Defense Agency (MDA) are also investing in the maturation and integration of solid state laser technology on relevant platforms for their applications. Major aerospace industry partners include General Atomics, Raytheon, Boeing, Northrop Grumman, and Lockheed Martin.

The SHiELD Advanced Technology Demonstration (ATD) is a two-phased effort to showcase the ability of a podded laser system. The program will develop and integrate a more compact, medium-power LWS onto a fighter-compatible pod to demonstrate effectiveness of an LWS in a relevant flight environment for self-defense against ground-to-air and air-to-air weapons. The purpose of the SHiELD ATD is to reduce and retire the risk of an airborne LWS in a calculated and precise fashion, meeting and resolving the aforementioned technical challenges of power-scaling, beam quality, thermal management, and packaging. In its first phase, the flight demonstration is expected to prove that targets can be tracked at sufficient range and speed to subsequently engage with a laser. In the next phase, a moderate-power laser will be incorporated to assess the performance of the LWS in an operationally relevant environment. Flight tests should occur in the FY20 timeframe.

The DLWS program is an effort funded jointly by the Defense Advanced Research Projects Agency (DARPA) and the Air Force. Its purpose is to integrate DARPA's 150 kW-class electric laser (HELLADS—High Energy Liquid Laser Area Defense System) with the Army's beam control system at White Sands Missile Range, addressing the integration challenges for a ground-based LWS. This will demonstrate the lethality of a fully integrated solid-state laser weapons system against representative ground-based and surface-to-air targets of interest to Air Force Special Operations Command (AFSOC) and Air Combat Command

(ACC), respectively. Such targets will include rockets, mortars, and surface-to-air missiles. Key features of the DLWS involve using infrared or optical signals to acquire, track, and hold a precise point on a target, and allowing the laser to deliver sufficient energy to disrupt, disable, or destroy it. AFRL is currently engaged with AFSOC to discuss how existing and planned airborne and ground demonstrations of an LWS could address their requirements. The team is currently integrating the laser with the beam control system, and testing should begin shortly.

AFSOC Interest

The AFSOC commander has recently stated his interest in both defensive and offensive directed energy capabilities in the AC-130 airframe against a varied target set. Performance requirements for the full range of AFSOC missions have yet to be specified, but AFRL assesses that a defensive LWS that weighs less than 5000 lbs. is feasible. Our target weight for a podded solution on a fighter is less than 1500 lbs.

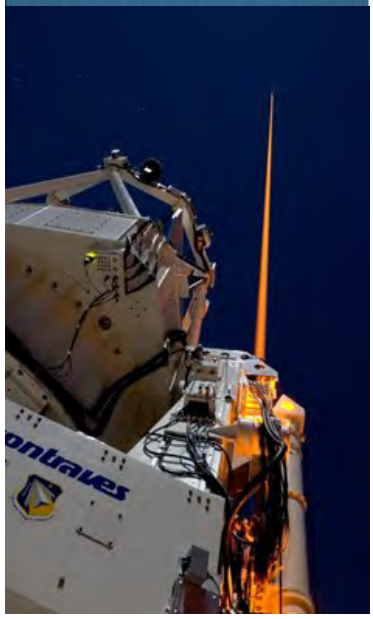
AFRL's laser programs are aiming to achieve a laser weapon system that can operate in all flight regimes against targets that are approaching at supersonic speeds, which must be intercepted at significant ranges. In the process of achieving these goals, the incremental approach described above will address AFSOC requirements. The AC-130 gunship is slower moving with larger volume and weight allowances, and their target sets will likely be at closer range. As such, the laser weapon technology needed to address the AFSOC concept should naturally develop while pursuing the farther-reaching lasers for a tactical platform, though the AFSOC AC-130 gunship laser weapon concept will still require customization to address unique target sets and concepts of employment.

Contact 377 ABW Public Affairs for more information: (505) 846-5991 DSN 246-5991
Reviewed December 2016
http://www.kirtland.af.mil/afrl_rd/index.asp
Approved for Public Release - OPS-15-1038

AFRL
THE AIR FORCE RESEARCH LABORATORY

Directed Energy Directorate

Speed of Light to the Fight by 2020



AFRL Directed Energy Directorate

High Power Electromagnetics

CHAMP System

The Counter-electronics High Power Microwave Advanced Missile Project (CHAMP) is an unmanned system capable of flying into a contested area and disabling an adversary's electronic systems. It employs a high power radio frequency technology, which was developed over the past two decades in the Air Force Research Laboratory and tested through a Joint Capability Technology Demonstration(JCTD) program.

CHAMP offers a proven capability that allows the Air Force to defeat electronic systems in an enemy structure without employing kinetic weapons like bullets or explosives. As such, CHAMP completely avoids damage to infrastructure and danger to life.

The CHAMP system is highly adaptable and can be deployed from a variety of platforms, depending on mission needs.

Possible avenues for a CHAMP acquisition strategy are being considered, though no clear path has been provided. In the meantime, AFRL is continuing its efforts to hone the CHAMP capability, working towards improving the size, weight, and power. Though there are no planned demos of HPM systems in the near future, AFRL is deeply engaged in advancing the technology to enable the next generation of HPM-based weapon systems.

Active Denial System (ADS)

In addition to CHAMP, AFRL matured another non-lethal HPM technology in the last decade—the Active Denial System.

As proven during its Advanced Technology Demonstration program, ADS is a long-range, speed-of-light beam that causes intense pain to targeted individuals without resulting in any temporary or permanent physical damage. AFRL has transitioned this technology to the Joint Non-Lethal Weapons Directorate and showcased it to a host of potential customers, including Homeland Security.

Contact 377 ABW Public Affairs for more information: (505) 846-5991DSN 246-5991
Reviewed December 2016
http://www.kirtland.af.mil/afrl_rd/index.asp
Approved for Public Release - OPS-16-1036

U.S. Army Space and Missile Command

INFORMATION PAPER ON HIGH ENERGY LASER MOBILE TEST TRUCK

1 November 2016

1. The High Energy Laser Mobile Test Truck (HELMTT), see Figure 1, is a data collection asset providing risk reduction for future high energy laser demonstrators and weapon systems. Key HELMTT features are:

- Army's first mobile high energy solid-state laser platform
- Rugged beam control system
- Modular building block approach
- Speed-of-light engagement of threats with pinpoint precision
- Demonstrated lethal effects on small caliber mortars, unmanned aerial systems (UAS), and ground targets, as well as potential intelligence, surveillance, and reconnaissance capability

Figure 1. USASMDC/ARSTRAT's High Energy Laser Mobile Test Truck

2. The HELMTT, formerly the High Energy Laser Mobile Demonstrator, is a technology integration and demonstration effort with a solid state laser system, agile beam control system, and supporting subsystems integrated into a large tactical vehicle. The goal is to integrate and demonstrate maturing technologies to the point where lethal engagements in a relevant environment can be demonstrated. The Heavy Expanded Mobility Tactical Truck-based HEL MD became HELMTT when the Army decided in early fiscal year 2016 to integrate a smaller laser system on a family of medium tactical vehicles. The system was designated the HEL Tactical Vehicle Demonstrator. HELMTT provides risk-reduction for Army high energy laser development.

3. The High Energy Laser Mobile Test Truck efforts support development of future deployed high energy laser systems capable of executing missions such as: force protection, counter-UAS,

and offensive operations, which are critical functional elements at every level of the brigade. The benefit to Warfighters is progress in multiple areas toward a weapon system that will provide: cost effective engagements, reduced manning, significantly reduced logistics burden, and a multi-mission capable platform. The average engagement across the threat set uses approximately 1.5 cups of diesel fuel at a cost of approximately $30; this cost was validated by the Army Materiel Systems Analysis Activity. This low-cost engagement enables the Army to counter mortars, cheap rockets, and small UAS threats at a cost ratio that is advantageous to the U.S.

4. The HELMTT currently consists of a 10 kW laser projected through a precision pointing, high-velocity target tracking beam control system. To support the laser and beam control system, the HELMTT has power and thermal management systems that power and cool all the subsystems. A Battle Management, Communications, Command and Control subsystem receives target cues from radars and points the laser beam to engage the targets.

There are a number of planned upgrades to the HELMTT. Those include: improved container cooling system, upgraded fine track sensor (fiscal year 2016); improved target tracking algorithms (fiscal year 2017); integration with the Integrated Air and Missile Defense System and a 50 kW-class laser integration and demonstration (fiscal year 2018).

The HELMTT's modular architecture enables new subsystems to be added to the system. There are also plans to enable external lasers to propagate into the HELMTT beam control system and out through the 50 cm aperture. These opportunities are available to Department of Defense, government, and U.S. industry partners

Table 1. HELMTT Subsystem Summary

Current System	
Laser	Current: 10 kW modified commercial fiber laser fiscal year 18: 50 kW-class fiber laser
Beam Control System	50 cm aperture retracting telescope, target illuminator, low jitter precision pointing and tracking system
Acquisition and Track Sensors	IR-based wide field-of-view for target acquisition and IR-based narrow field-of-view fine target tracker
Warfighter-Machine Interface	Ruggedized laptop with "X-box"-type controller
BMC3	Modular design with manual/semi-automatic/automatic target acquisition, aim-point selection, and aim-point management
Electrical Power	On-board generator for "house-keeping" load. External generators for laser operations
Thermal Management	Two looped chilled-water system for laser and standard heating, venting and air conditioning for all other subsystems
Platform - HEMTT	500 hp Caterpillar C-15 engine, Allison 4500 SP/5-speed automatic transmission, 8x8 axle, 16 ton payload capacity
Minimum crew	Two person: vehicle operator and laser operator Data collection efforts require additional personnel

5. Before becoming the HELMTT, this system conducted numerous lethal target engagements and data collections. In fiscal year 2014, the system destroyed small caliber mortar projectiles in flight and downed UAS targets. In fiscal year 2014 and fiscal year 2015, the system collected more than 4 TB of data on laser beam propagation in environments ranging from coast to high-

desert including pristine as well as degraded weather conditions. In fiscal year 2016, the HELMTT participated in the Maneuver Center of Excellence sponsored Maneuver Fires Integration Experiment 2016 (MFIX-16). During MFIX-16, military personnel operated the HELMTT laser system to destroy targets. During the course of the event, HELMTT shot down Group 1 UAS rotary-wing and fixed-wing targets. It also destroyed ground targets.

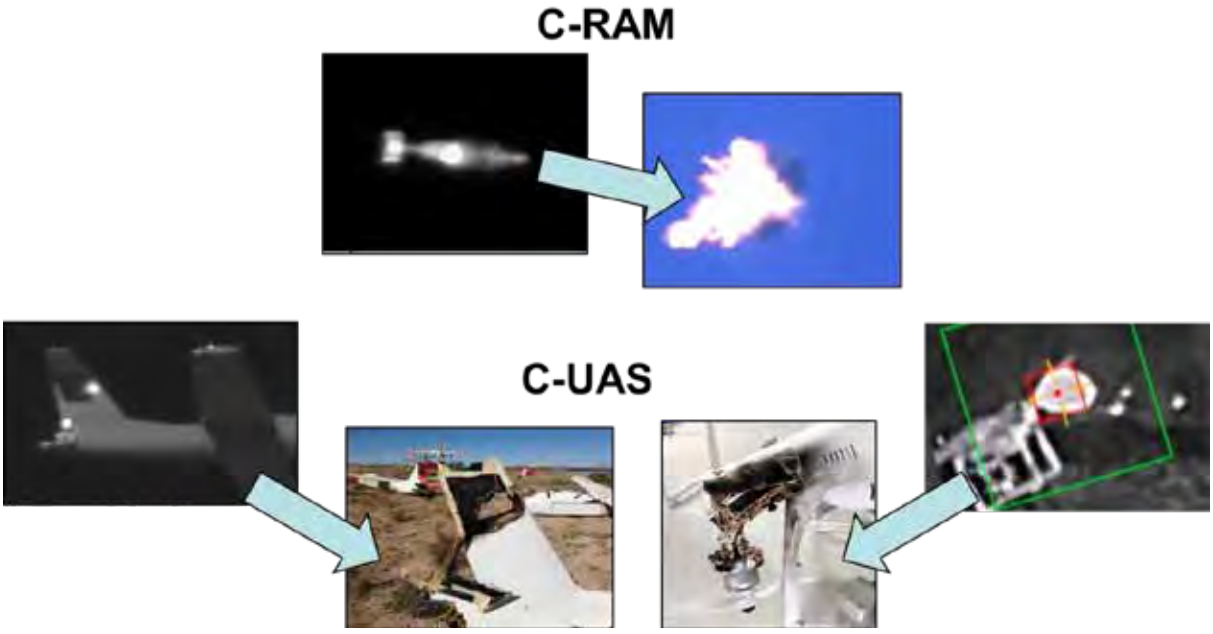


Figure 2. Demonstrated C-mortar and C-UAS Performance

Figure 3. Demonstrated Tactical Mobility

Distribution Statement A. Approved for public release: distribution unlimited, PA #6149

UNCLASSIFIED

U.S. Army Space and Missile Defense Command

INFORMATION PAPER ON HIGH ENERGY LASER TACTICAL VEHICLE DEMONSTRATOR

1 November 2016

1. The High Energy Laser Tactical Vehicle Demonstrator (HEL TVD), see Figure 1, will be a pre-prototype system to address Indirect Fire Protection Capability Increment 2 – Interceptor Block 2 (IFPC 2-I Blk 2) objective requirements. Key HEL TVD features will include:

- System to address IFPC 2-I Blk 2 target set
- Compact 100 kW-class solid state laser
- Rugged beam control system
- Modular building block approach
- Speed-of-light engagement of threats with pinpoint precision

Figure 1. Artist Rendering of High Energy Laser Tactical Vehicle Demonstrator Concept

2. The HEL TVD will be a rugged, mobile, pre-prototype solid state laser weapon system that meets the size, weight, and performance needs of the Army. The effort includes maturing technologies to execute missions to counter-rockets, artillery, and mortars (RAM) at tactical ranges. To obtain that capability, multiple subsystems are under development for integration into the pre-prototype weapon system. These subsystems include: laser subsystem (LSS); beam control subsystem (BCS); electrical power subsystem (EPS); thermal management subsystem (TMS); and Battle Management, Command, Control, Communications and Intelligence (BMC4I) subsystem. These subsystems will be integrated into a modified Family of Medium Tactical Vehicles (FMTV).

3. Warfighters face challenges in all aspects of their mission. Soldiers must have weapons that offer precision, controllability, predictability and repeatability to meet the threats of today and the future. A laser weapon system offers these attributes enabling enhanced tactical battlefield operation with a cost per engagement substantially lower than the current Counter Rocket, Artillery, and Mortar system. The HEL TVD will demonstrate target acquisition, tracking, aim-point selection/maintenance and defeat for selected threats.

The first mission is to protect U.S. and allied forces at fixed and semi-fixed bases. HELs will complement conventional offensive and defensive weapons at a significantly lower cost-per-engagement than current systems. The HEL system requires only fuel to complete its mission, there is no ordnance logistics burden as with conventional weapons. The average cost per kill is approximately $30, which shifts the engagement cost equation in favor of U.S. forces. With the entire system on a single tactical vehicle, the site's defense strategy can be quickly adjusted in response to a changing threat environment.

4. The HEL TVD will consist of a 100 kW-class laser projected through a precision pointing, high-velocity target tracking BCS. The BCS will have an aperture of at least 30 cm. To support the laser and BCS, the HEL TVD will have power and thermal management systems that power and cool all the subsystems and provide sufficient magazine to defeat many targets. A Battle Management, Communications, Command and Control (BMC3) subsystem will receive target assignments with appropriate target cues from radars then point the laser beam to engage the targets.

Table 1. HEL TVD Subsystem Summary

Current System	
Laser	100 kW-class fiber laser
Beam Control System	No smaller than 30 cm aperture telescope, target illuminator, adaptive optics, low jitter precision pointing and tracking system
Acquisition and Track Sensors	IR-based wide field-of-view (FOV) for target acquisition and IR-based narrow FOV fine target tracker
Warfighter-Machine Interface	Ruggedized laptop with operator-friendly controller
BMC3	Modular design with manual/semi-automatic automatic target acquisition, aim-point selection, and aim-point management connected to the Army battle management system.
Electrical Power	On-board generator(s) and energy storage
Thermal Management	Laser cooling system and standard heating, venting and air conditioning for all other subsystems
Platform - FMTV	330 hp, 7.2 liter Caterpillar C-7 engine, Allison 3070SP, 7-speed automatic transmission, 6x6 axle, 20,000 lb payload capacity
Crew	Two person: vehicle operator and laser operator

5. The HEL TVD will conduct a demonstration against a variety of targets in fiscal year 2022. Lethal engagements of a variety of targets is planned for this Technology Readiness Level 6 demonstration. In addition, there will be instrumentation there to characterize the 100 kW-class laser beam propagation; the propagation data will be used to help anchor laser models.

The Warfighters' payoff is progress in multiple areas toward a weapon system that will provide: cost effective engagements, reduced manning, significantly reduced logistics burden and a multiple mission

capable platform.

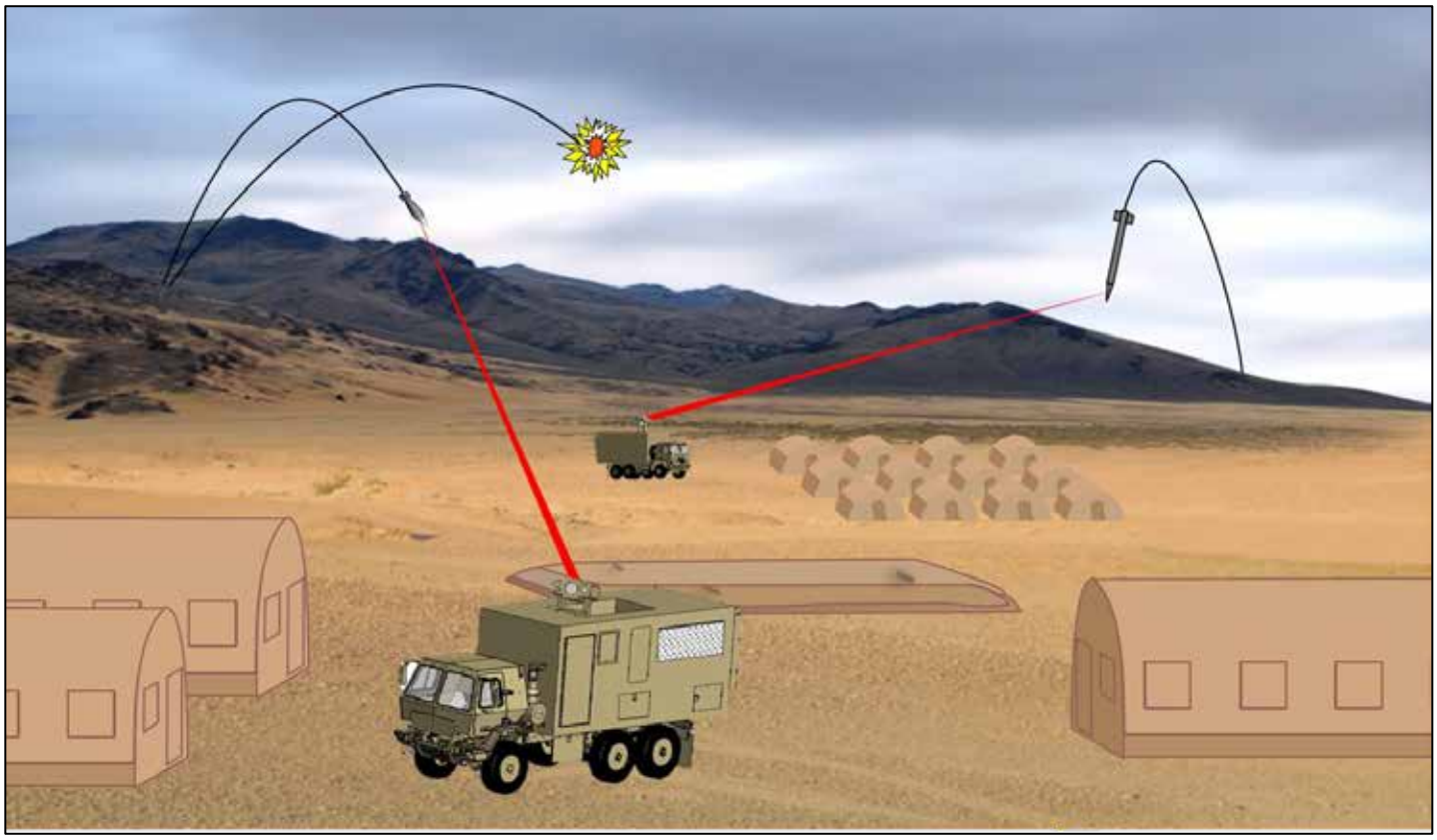


Figure 3. HEL TVD Will Protect Personnel, Equipment, and Facilities

Naval Air Systems Command (NAVAIR)
Naval Air Warfare Center Weapons Division (NAWCWD)
China Lake and Point Mugu, California

Directed Energy Strategic Initiative

Charter. The Naval Air Warfare Center Weapons Division (NAWCWD), China Lake and Point Mugu California, has been designated as active participants in the Directed Energy (DE) Initiative Advanced Technology Enterprise Team, with a specific focus of how DE will impact Naval Aviation. The Division, part of the Naval Air Systems Command (NAVAIR), serves as the technology advocate for high power microwave (HPM) and high energy laser (HEL) weapons with the Office of Naval Research.

NAWCWD – The Place to Test Directed Energy!

With land ranges larger than the state of Rhode Island, the world's largest sea range, 36 major facilities including six uniquely suited for directed energy projects, NAWCWD is the place for directed energy testing.

Directed Energy Projects. Significant HPM and HEL testing has included fiber and pulse lasers, laser architecture support beam control, microwave radiation emitters, and diode pumps.

- **Atmospheric Characterization.** In 2008, NAWCWD began developing the Differential Image Motion Monitor (DIMM) that measures path turbulence. In 2012, a Wide Angle Telescopic Transmissiometer (WATT) was developed that measures path transmission loss using a common optical reference. Ongoing developments with Dahlgren include a new Non-coherent Extended Source Beacon (NESB).
- **New antennas.** Developing new and easier methods to fabricate wideband high-voltage antennas
- **New connectors / modules.** Developed and manufactured a new, custom high-power radio frequency (HPRF) connector that was one-fifth the cost of a commercial unit. Designed and built solid state HPRF modules which outperform magnetrons 100 times larger and heavier.
- **Airborne Direct energy kill sequence.** During one test, a laser system shot down six drone aircraft over the Land Ranges. In another test, a laser weapon system successfully tracked, engaged, and destroyed a drone in flight during a test at San Nicolas Island. In 2009 the Airborne Laser (ABL) conducted numerous milestone tests off of San Nicolas Island, simulating a directed energy kill sequence against an instrumented boosting missile target using three onboard low-power lasers.
- **S&T for Tactical Aviation.** Work includes HEL atmospheric propagation of laser beams, laser source developments in fiber lasers and beam control & aimpoint maintenance.

High Power Authority. NAWCWD has authority to operate up to the highest levels allowed on DoD ranges: 1 MW for HEL and 200 PW for HPRF (frequency dependent). Very few DoD facilities allow HEL weapons to be fired over the horizon including China Lake, Point Mugu, and White Sands. Ranges can maintain an exclusion zone of 19+ miles for aircraft testing over land.

Environmental Requirements in Place. Full documentation now supports HEL and HPRF testing. A certified DON laser safety specialist coordinate with the Laser Clearing House. HPM systems include narrow band, wide band, and ultra wide band.

Unique Facilities Specifically Suited for Directed Energy T&E. Detailed factsheets on the following 6 facilities, as well as all 36 major facilities at NAWCWD can be found on the public site at: navair.navy.mil/nawcwd/

Weapons Survivability Laboratory (WSL). WSL is the largest live fire test and evaluation (LFT&E) facility in the world and serves as the national aviation weapons survivability and lethality location for the US Air Force and US Navy. It is the only facility with three High-Velocity Airflow Systems (HIVASs) generating flight representative airflow to aircraft. Multiple airflow capabilities exist for both kinetic and directed energy T&E. Additional T&E capability includes a hostile fire indicator (HFI) test facility.

Junction Ranch. Due to its remote location, surrounded by mountains, this maximum security facility provides a perfect venue for highly sensitive directed energy T&E. There is a minimum level of spurious electromagnetic interference ensuring the highest data quality possible. Routine testing includes radar cross section and microwave measurement. Features a Look Down facility at over 8,200 MSL with 10 and 17 degree slant angles to test sites.

Thermal Dynamics Test Facility (T-Range). Conducts R&D testing of air-breathing engines, liquid rocket engines, and solid rocket transition to liquid propulsion systems and subcomponents. T-Range has performed many directed energy tests using high-energy lasers to understand and quantify missile component vulnerability.

Missile Engagement Simulation Arena (MESA). This huge facility, secure and highly instrumented, is a perfect indoor venue for DE testing. Measuring 84,190 square feet, 90 feet high by 405 feet long x 150 feet wide it is used to measure the electromagnetic interaction of a sensory system (fuze or guidance) with its intended target. It provides cost-effective, timely, and accurate dynamic missile engagement test data. Missile fuzes are tested against various targets, including full-scale aircraft.

Supersonic Naval Ordnance Research Track (SNORT). Four mile long, dual-rail, precision-alignment track that tests rockets, guided missiles, model and full-scale aircraft, and components under free flight conditions at velocities from subsonic through supersonic. Second longest and fastest sled track in the world. Capable of reaching speeds up to 6,000 feet per second. Frequently used for DE atmospheric characterization/validation testing.

San Nicolas Island (SNI). SNI, 60 miles south of Point Mugu, is regularly used for laser and DE testing. NAWCWD also participates with Port Hueneme who has the Self Defense Test Ship (SDTS) that hosts laser systems and DE testing. The ship provides an at-sea, remotely controlled, T&E platform for conducting advanced combat systems and weapons evaluation. SNI supports a wide variety of T&E and training operations including surface-to-air, surface-to-surface, air-to-air, air-to-surface, missile defense, fleet training, and large-scale complex warfare exercises.

Proven experience with HEL and HPRF T&E – Land & Sea Environments

- **HEL T&E:** Airborne Laser lab / high energy laser damage effects ● Above-horizon laser engagement capability ● Black Dart Demonstration ● Laser Weapon System (LaWS) demonstrations
- **HPRF T&E:** RF weapon survivability testing ● GPS jamming testing since the early 1990s ● Commercial infrastructure and OSD testing ● Active denial and pulsed RF emitter systems ● Tested 10TW ultra HPM system in 2011 ● Spectral topographical range mapping to characterize containment of RF energy ● Tested 1.1kW 30MHz system ● Demonstrated HPM non-linear transmission line (NTLT) system

High-Energy Lasers (HEL). HEL weapons are intended to damage or destroy enemy systems. These weapons may be integrated onto land, aircraft, and ship platforms and will be used to enhance area defense, aircraft self-protection, strategic and tactical missile defense, and precision strike. HEL weapons remain focused over a great distance, thus providing significantly more energy on a target. Types of HEL systems anticipated for testing at NAWCWD include solid state, fiber, and carbon dioxide (CO_2). Power levels are expected up to and including megawatt class, and wavelengths will range from nanometers to micrometers.

High-Power Microwave (HPM). These counter-electronics systems, which operate across a broad range of the microwave frequencies, are typically characterized as having a short, intense energy pulse that can yield relatively high voltage surges in targeted electronics.

Testing Non-lethal HPM Systems. NAWCWD is testing systems that operate at relatively high frequencies causing discomfort, but the effects are non-lethal. HPM weapons may be integrated onto land, aircraft, and ship platforms and will be used to enhance both counter-electronic and non-lethal anti-personnel capabilities. Types of HPM systems anticipated for testing at NAWCWD include, but are not limited to, narrowband, wideband, and ultra wideband.

Operational Characteristics of Directed Energy Systems. Testing of DE systems will support the ongoing development of non-kinetic weapons in response to theater requirements. HEL and HPM testing would include air-to-air, air-to-ground, surface-to-air, surface-to-surface, and electromagnetic scenarios as well as static tests. HEL and HPM safety protocols are in place.

NAWCWD Specific Projects and Initiatives 2015-2016

Weapons
- Compact 2.5 Billion Watt Man-Portable HPRF Vehicle Stopper
- HPRF Vessel Stopping Bomb Demonstrator
- UAS Hosted HPRF Electronic Attack Demonstrator

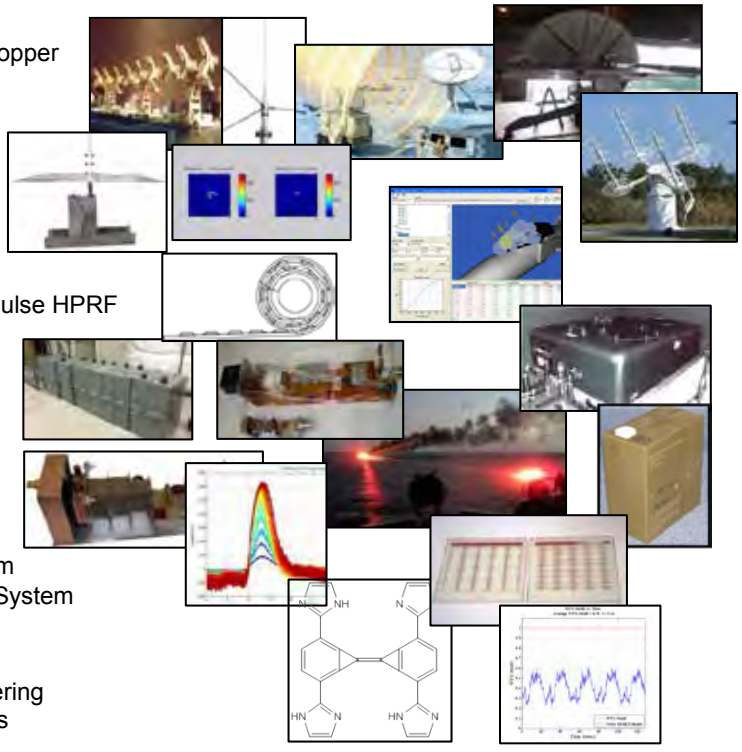
Weapon Systems Simulators
- Weapon-Class Laser Weapon Simulator
- Passive Wavefront Sensing for HEL application

Antenna Development
- Half-parabolic Impulse Radiating Antenna (HIRA)
- Wideband Monopole Antenna with Reflector Dish for Impulse HPRF
- Helical Antenna Design for HPRF System
- Compact, Conformal, Collapsible Antennas

Analysis, Modeling and Simulation
- High Energy Laser Mission Utility Assessment Modeling

Systems, Components
- 100+ MW High Power Radio Frequency (HPRF) Module
- Compact HPRF Power Combiner
- Temperature Stabilization for Man-Portable HPRF System
- Battery Powered Power Supply for Man-Portable HPRF System
- Higher Frequency Power Semiconductors

Counter Directed Energy
- Polymers: Multi-functional Reflective Coatings for Countering High Power Microwave (HPM)-Directed Energy Weapons
- Disposable Electric Field Intensity Indicator



Contacts	• Dr. Phil Peters, NAWCWD Directed Energy Team: phil.peters@navy.mil 760-939-1569 • DeAnne Bell, Business Development Office: deanne.m.bell@navy.mil 760-939-0707

Labs and Academia

Sandia Labs – On the Leading Edge of DE Research

Sandia is a multidisciplinary national laboratory and federally funded research and development center (FFRDC) for the National Nuclear Security Administration. Sandia also supports the warfighter by accelerating the development of innovative systems, sensors, and technologies for the national security community. We provide technical solutions for global security; engineering and integrating advanced science and technology to help defend and protect the United States. We partner with the DoD, other federal agencies, and highly qualified industry and university partners to accomplish our missions.

Sandia National Laboratories is a world leader in pulsed power science and technology. Sandia has decades of experience in directed energy research for National Security with expertise in Compact Pulsed Power System Design, High Power Electromagnetics, Modeling and Simulation, Semiconductor RF/Optoelectronic and Microelectronic Circuit Design, Effects Testing, Laser Applications, Materials Development and Characterization, Microsystems & Engineering Sciences Applications, and Sensor & Systems Exploitation.

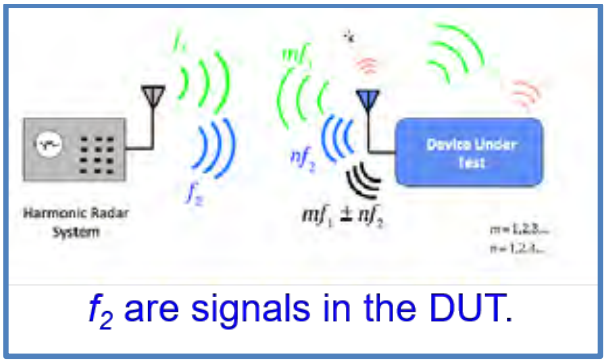
Important Accomplishments in 2016

Electromagnetic Launch Technology

- *Development, assessment and selection of materials.*
- *Development of advanced instrumentation.*
- *M&S of aerothermal protection, high-speed sliding electrical interface, armature and rail geometries, and projectile effects.*

Harmonic Radar for UAV Detection and Operational State Determination

- *Demonstrated ability to detect and measure the nonlinear response of electronics.*
- *Validated that measurements include information that corresponds to specific operational states.*
- *Technique supports detection of targets in cluttered environment.*



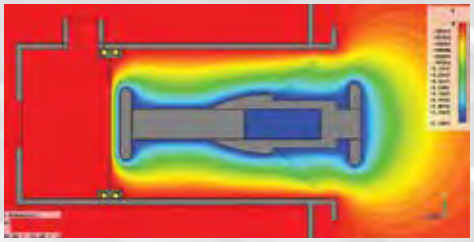
Sandia National Laboratories is a multi-mission laboratory managed and operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin Corporation, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

Center for Physical Electronics & Power Electronics

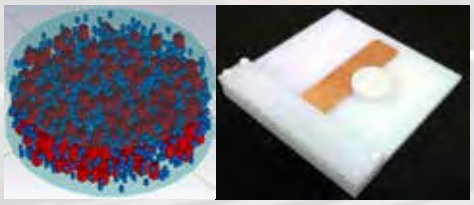
University of Missouri

Contact:
Randy Curry, Ph.D.
311 Naka Hall
Columbia, MO 65211
CurryRD@missouri.edu
573-882-3017

Directed Energy

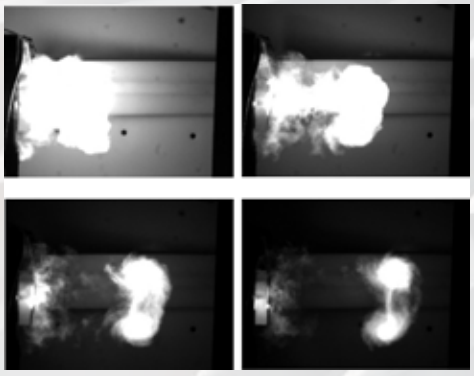


High-voltage Materials



High-Power Antennas and Applied Electromagnetics

Plasmas



Laser and Nuclear Pumped Applications

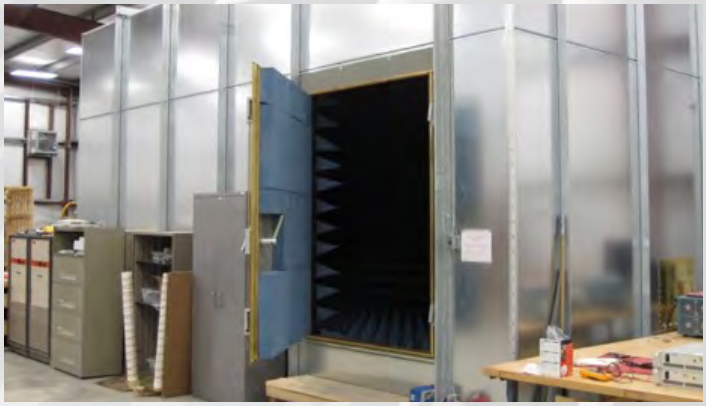
The Center for Physical and Power Electronics strategically solves complex problems in the areas of directed energy, high-voltage materials, plasmas, laser applications, high power antennas, applied electromagnetics and translational medicine. Our focus is rapid development of solutions for our customers and demonstration of prototypes.

Our team consists of former industrial, Department of Defense, Department of Energy and aerospace engineers, as well as academic teams of engineers, physicists, chemists, material scientists, doctors and veterinarians.

We are an integrated team that can deliver solutions to complex problems.

In academia, we are recognized as one of the top two leaders in the research and development of directed energy applications, new high-voltage materials, compact high power antennas, and plasmas.

With more than 17,500 square feet of high-bay test area, radiation rooms and anechoic chambers, we can rapidly test solutions. We optimize using 3D electromagnetic computations, then develop prototypes and test them in our laboratories or in the field.



BACKGROUND IMAGE OF CPPE'S ANECHOIC CHAMBER WALL

Industry Partners


DIRECTED ENERGY
PROFESSIONAL SOCIETY
DEPS

II-VI OPTICAL SYSTEMS

Materials That Matter

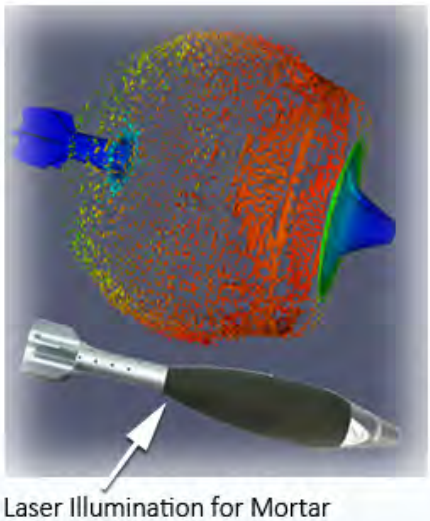
II-VI Optical Systems (II-VI OS) produces Materials, Optical Assemblies and Laser Sub-assemblies to support Laser, EO and IR requirements. II-VI OS designs, manu-factures, coats, integrates and tests precision laser sub-assemblies, optical systems and components. Our products support all of the DoD Prime Contractors and are deployed with these customers' products on military platforms for all branches of the DoD.

II-VI Optical Systems has grown over the years from a producer of specialty optical materials including Sapphire and Diamond Windows to a full service provider of engineered solutions including optical sub-assemblies such as SiC Beam Expander Telescopes. We have a Laser Materials Foundry producing YAG and YLF and we have a Ceramic YAG facility producing Ceramic YAG components. We established a DoD laser diode manufacturing capability in California to address our customers' emerging needs domestically. We are tailoring laser diodes for the unique needs of military solid state lasers that are matched to high performance gain media and coatings used inside HEL laser systems.

Regardless of the type of laser or optical system, II-VI Optical Systems stands ready to support customer requirements through all TRL levels and into production. Hard-ware: Laser Diode Stacks, SiC Beam Expanders, Sapphire and Diamond Windows, YAG, YLF, Ceramic YAG HEL Coatings.

II-VI Optical Systems
Murrieta, California - Tustin, California - Port Richey, Florida - Philadelphia, Pennsylvania
www.opticalsystems.com - Dennis Lehan (978) 509-5001 or dennis.lehan@ii-vi.com

Integrated Weaponeering Solutions



Laser Illumination for Mortar Detonation

- Vulnerability / Lethality Analysis Architectures
- Weapon Effectiveness
- Mission / Campaign Level Simulations
- Wargaming Support
- Mission Performance
- Trades & Analysis

Directed Energy System Analysis & Design

- Weapon Aimpoint, Lethality & Debris Understanding
- Advanced Electro-Optic & Ladar Tracking
- Simple, Cost-Effective Hardware Solutions
- System Engineering Support

Integrated Weapons Environment for Analysis (IWEA)

- ARA produces a common modeling, simulation and analysis (MS&A) infrastructure for Directed Engergy/Kinetic Energy weapon effectiveness
- Supports comprehensive weapons science & technology strategy
- Quantifies the trades & synergies of directed energy (DE) and kinetic energy (KE) weapons optimized for desired mission
- Considers human effects and sensor data and is extendable to cyber and space domains
- Incorporates higher fidelity methodologies into engagement and mission level analysis
- Provides feedback to model developers

Non-Lethal Weapon System Development

- Non-lethal deterrence through auditory techniques & electrical stimulation
- Reusable non-pyrotechnic diversionary devices
- Human physiology modeling & simulation
- Assessment & prediction of human injury
- Advanced test facilities & equipment

ARA

www.ara.com

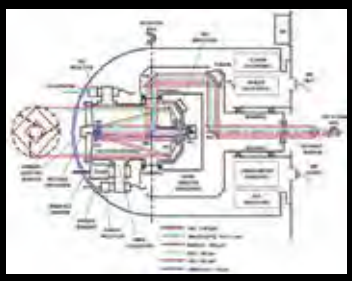
LASER WEAPON SYSTEM / FIRE CONTROL

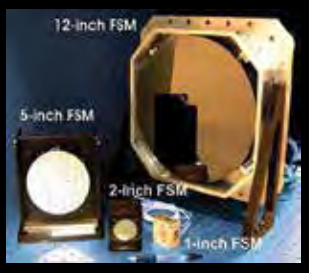
ATA develops highly reliable, modular, low-SWaP, and low-cost processing electronics and software that process and control the entire suite of high-energy laser weapon system (HELWS) components and subsystems, including beam director and beam control, laser device, power and thermal management, fire control and target tracking. In addition to small SWaP, we achieve key improvements in modularity, diagnostics, and distributed safety.

TRACKING AND AIMPOINT MAINTENANCE

ATA develops field-proven target tracking systems that achieve real-time acquisition and fine tracking and aimpoint maintenance with lower tracking jitter, reduced aimpoint drift, and longer operating range than current systems. Our architecture offers reductions in size, weight, and power, and cost (SWaP-C) and the hardware and software are modular, enabling reuse across different laser weapon programs and services.

BEAM CONTROL SOLUTIONS





Beam stabilization technology forms the backbone of a beam control system, and ATA is at the forefront of stabilization architectures and component technologies. ATA supports the full range of beam stabilization architectures and is an innovator, designing and manufacturing the enabling inertial sensors, optical inertial reference units, and fast steering mirrors for directed energy systems.

www.atacorp.com

ATA *Applied Technology Associates*


DIRECTED ENERGY
PROFESSIONAL SOCIETY
DEPS

BOEING

High Energy Laser Weapons
Precision Engagement for the Warfighter

Stryker Mobile Expeditionary High Energy Laser

HELMTT
High Energy Laser Mobile Test Truck

Compact Laser Weapon System
portable configuration

Legacy of Expertise

For more than 20 years, Boeing and its legacy companies have extensively developed directed energy technologies, creating solutions ranging from Compact and Tactical Laser Weapon Systems, to Strategic Laser Systems for missile defense. Directed Energy systems deny and defeat threats with precision. With a low cost-per-shot and an infinite magazine, Directed Energy systems are effective over land, air, and sea.

Boeing has expertise in a wide range of directed energy-related technologies, including:

- Beam control and scalable beam directors
- Lethal and non-lethal weapons
- Acquisition, tracking and pointing
- Space surveillance
- Relay systems
- Advanced sensing
- Real-time processing
- Electro-optical processing

Compact Laser Weapon System

The Compact Laser Weapon System (CLWS) is a modular, high energy laser (HEL) weapon system that can be operated as a stand-alone system, integrated on combat vehicles, or mounted onto a Containerized Weapon System. The CLWS can accommodate from 2 to 10 kW lasers and is ideal for the counter-UAS mission, in addition to C-ISR, special event and force protection. The Stryker MEHEL is a real-life example pairing a DE weapon with a tactical vehicle. Successful integration and demonstration on that vehicle in 2016 performing the C-UAS and C-ISR missions proved that lasers are an effective, low-cost solution to countering the growing UAS threat.

Tactical Laser Weapon Modules

Boeing has proven HEL weapon systems integration experience on programs such as the Airborne Tactical Laser (ATL) and the U.S. Army's High Energy Laser Mobile Test Truck (HELMTT) – which has tracked and destroyed mortar rounds and unmanned aerial vehicles. Our Tactical Laser Weapons Modules can be integrated with 10 to 150 kW lasers for ground, maritime and airborne missions.

Strategic Systems

Boeing has done pioneering work in Strategic Laser Systems, demonstrating the viability of directed energy against missile threats on the Airborne Laser Test Bed. Boeing is committed to partnering with the Missile Defense Agency to advance the state-of-the-art in directed energy to keep allied forces secure against such threats.

YOUR ESSENTIAL PARTNER

Booz Allen Hamilton offers a broad range of engineering capabilities, combining our deep understanding of our clients' missions and operating environments with an innovative mix of engineering skills, tools, facilities, and best-in-class technologies. Our directed energy (DE) team draws from Booz Allen's 3,000 well-rounded engineers and scientists, who are not only accomplished in their fields but also strong in other disciplines, including policy, business, and leadership. Booz Allen delivers high-quality services and solutions tailored to client objectives. Across technical areas and applications, our innovative approaches offer comprehensive capabilities throughout the development and deployment process to advance DE systems from concept to reality.

To find out more about how our people can help you drive your purpose and passion, visit **BoozAllen.com**.

Use of DoD image does not constitute or imply endorsement.

COMMITTED TO ADVANCING DIRECTED ENERGY SOLUTIONS

Booz Allen has established itself as an authoritative source for analysis, expertise, and solutions to accelerate the development, validation, fielding, and sustainment of operational directed energy (DE) systems. We are united with our clients in a relentless pursuit to address our nation's toughest problems with innovative and holistic solutions.

Booz Allen has been performing technical work in DE for 20 years, providing our science, engineering, and analytic expertise across the DE research and development lifecycle for both high-energy laser (HEL) and high-power microwave (HPM) technologies.

DE FUNCTIONAL AND DOMAIN EXPERTISE

HPM Prototyping and Demonstration
Design, development, test, and evaluation of sources, supporting subsystems, and prototype weapons

HEL Development and Deployment
Performing subsystem selection; integration; deployment; and operational test, evaluation, and support

DE System and Target Modeling and Simulation
Modeling DE systems and engagements from the component to mission level

Source Characterization and Effects Testing
Identifying, characterizing, and evaluating DE sources and targets to guide technology maturation and system design

DE Systems Engineering, Integration, and Mission Analysis
Managing and incorporating requirements, interfaces, interoperability, operational utility, and documentation

Stakeholder Engagement and Thought Leadership
Fostering collaboration across stakeholders in government, industry, and academia to advance DE

Use of DoD image does not constitute or imply endorsement.

About Booz Allen

Booz Allen Hamilton has been at the forefront of strategy, technology, and engineering for more than 100 years. Booz Allen partners with private and public sector clients to solve their most difficult challenges. To learn more, visit BoozAllen.com. (NYSE: BAH)

For more information, contact

HENRY A. "TREY" OBERING III
Executive Vice President
obering_henry@bah.com

JOE SHEPHERD
Director
shepherd_joe@bah.com

LEADING & INNOVATING TOGETHER

Broadest range of products.
Superior customer service.
Comprehensive solutions.

COHERENT | DILAS COHERENT | NUFERN

Learn more at together.coherent.com.

L-3 High Energy Laser Systems

For more than 20 years, L-3 Brashear has been a premier provider of beam director assemblies for High Energy Laser (HEL), laser weapon components and controls for all branches of the U.S. Department of Defense (DoD). In the air, on land or at sea, L-3 is proud to support the defense and protection of our warfighters. Our laser weapon systems have supported successful and extended demonstrations, including U.S. Navy deployment of the sailor-operated LaWS system in the Persian Gulf area.

The beam director is the "gun" that shoots the laser "bullet." It is the ruggedized telescope that points and stabilizes the laser beam and keeps it on the moving target. While exposed to all environments, the beam director guides and focuses the lethal laser energy from the large laser source and projects it onto the target.

Within the past year, L-3 Brashear has supported several HEL programs that are advancing the state-of-the-art for precision engagement weapon systems on multiple platforms:

- **LaWS** (Laser Weapon System) – Deployed; operated by sailors.
- **SSL-TM / LWSD** (Solid State Laser Technology Maturation – Laser Weapon System Demonstrator) – L-3 Brashear, partnered with Northrop Grumman, under contracts awarded by the ONR will design, develop and manufacture an innovative beam director; suitable for integration with and testing of a Solid State Laser (SSL) weapon demonstrator.
- **GBAD** (Ground Based Air Defense) – Performing with ONR and NSWCDD to develop a small, agile, vehicle-mounted laser weapon system to deploy with U.S. Marines in the field.
- **LWBD** (Light Weight Beam Director) – Assisting U.S. Army SMDC to develop new and advanced beam director technologies for improving lethality and dynamic performance.
- **Endurance** – Working with DARPA and Northrop Grumman to develop a small, very high performance beam director for use on aircraft.
- **HELMD** (High Energy Laser Mobile Demonstrator) – Collaborating with U.S. Army SMDC to advance the capabilities of the HELMD system.
- **ABLE** (Advanced Beam Control for Locating and Engagement) – Supporting the HEL-JTO (Joint Technology Office) on advancing critical enabling technologies for HEL weapon systems.
- **THEL** (Tactical High Energy Laser) – Working with U.S. Army SMDC to upgrade the capabilities of this system which have been successfully operating since 1998.
- **International project(s)**

L-3 Brashear has been advancing the state-of-the-art in beam director technology by combining time-tested optical designs with new materials and optical processes that increase the effectiveness, range and power-on-target of the laser weapon. In addition to optical improvements, L-3 Brashear has been setting new standards for the speed and precision of the beam director, enabling the system to engage swarms of UASs and volleys of mortars. The ability to quickly and precisely project this lethal energy onto maneuvering and fast-moving targets that are difficult to engage with conventional munitions is a critical advantage of laser weapon systems. Other key factors are low cost per shot and high number of target engagements that can be completed before refueling.

These new and ongoing projects continue to push the bounds of HEL weapon technologies and capabilities, preparing them for integration into the DoD's weapons inventory and battlefield tactics. Building on the expertise gained over 20 years of Directed Energy system development and 130 years of experience with optical and tracking systems, L-3 plays a valuable role in national security by ensuring that our men and women in uniform are equipped with the most innovative solutions available. They are the reason we come to work, and we honor their service and sacrifices by doing our best every day.

Previously completed programs have demonstrated success against targets such as:

- Mortars
- Artillery
- Rockets / missiles
- Long range rockets
- Small boats
- UASs
- Unexploded ordnance
- IEDs

THE PREMIER PROVIDER OF HIGH ENERGY LASER CONTROL SYSTEMS AND COMPONENTS:

- Beam directors
- Stabilized gimbals
- Ruggedized optical systems
- Beam expander telescopes
- Fast steering mirrors

SETTING NEW BENCHMARKS IN:

- Integrated control systems
- Kilowatt to megawatt power class
- Fast precision pointing / tracking
- Stable, low-jitter tracking
- High Energy Laser optics
- Beam stabilization
- Sensor integration
- EMI/RFI hardened

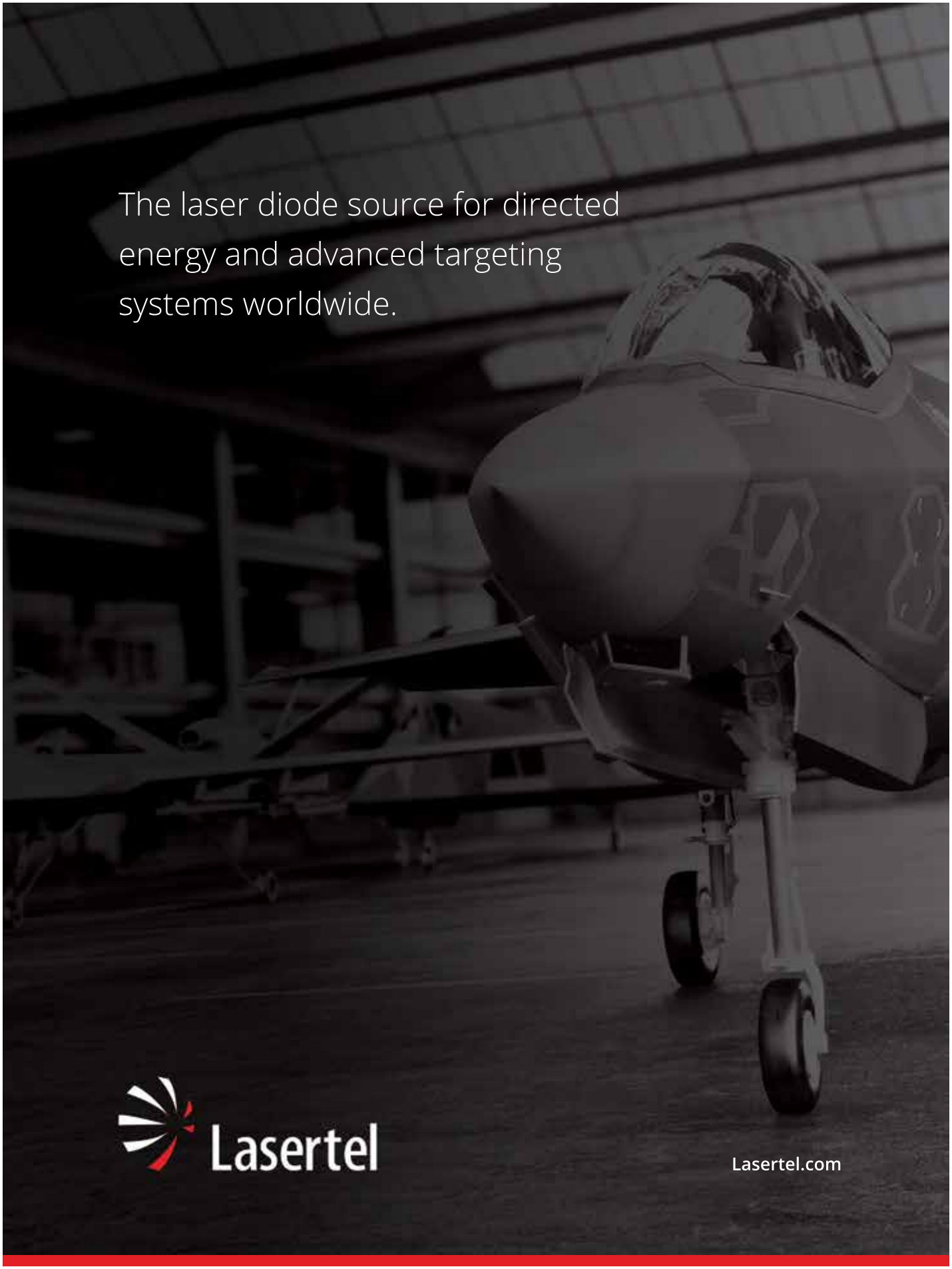
L-3 Brashear

Tel: 412.967.7700

Email: Sales.Brashear@L-3com.com

L-3com.com/Brashear


DIRECTED ENERGY
PROFESSIONAL SOCIETY
DEPS


The laser diode source for directed energy and advanced targeting systems worldwide.
Lasertel
Lasertel.com

leidos

Applied Technology, Advanced Solutions

At Leidos, we have a history of performance excellence built on a culture of innovation. Our diverse and talented employees turn information into insight, delivering answers to our customers that help protect and enrich lives around the world. Looking beyond the limitations of today, we deliver innovative solutions and services that matter most for tomorrow.

Key Stats

Reston, Virginia
Headquarters

33,000+/-
employees worldwide

$10B
annual revenue

27% Intelligence & Homeland Security

30% Defense

27% Civil

16% Health

TECHNICAL CORE COMPETENCIES


C4ISR


CYBER


SYSTEMS ENGINEERING

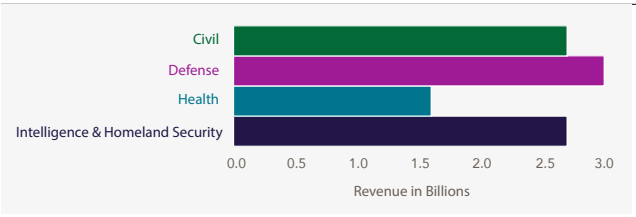

LARGE-SCALE AGILE SOFTWARE DEVELOPMENT


DATA ANALYTICS


ENTERPRISE IT MODERNIZATION


OPERATIONS & SUSTAINMENT

THE MARKETS WE SERVE



ADVANCED SOLUTIONS

Conducts research and development across all markets to unlock potential scientific discoveries or improvements in technology, supporting C4ISR and data analytic requirements for our customers.

CIVIL

Performs work related to energy and the environment, utilities, manufacturing and industrial, federal infrastructure, and air traffic management.

DEFENSE

Delivers technology, services, and IT solutions to military services, the U.S. Department of Defense, and allied nations around the world.

HEALTH

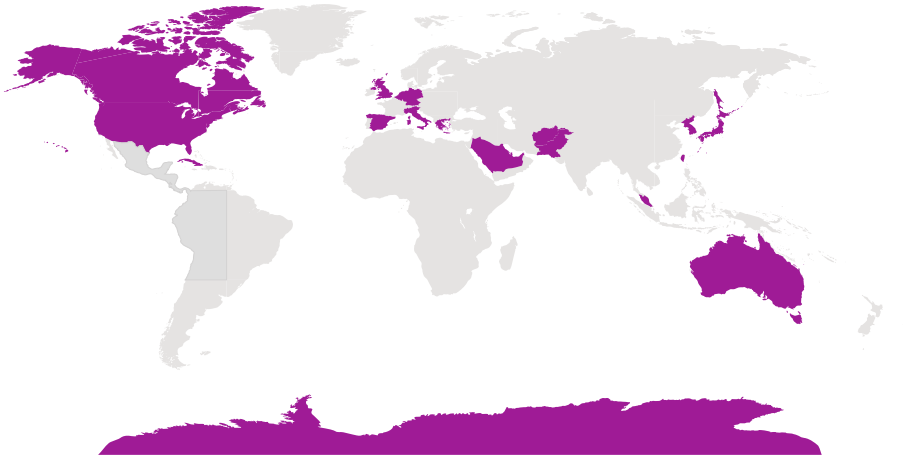
Offers services and solutions to federal and commercial clients, including IT services, population health risk management, case management, health analytics, life sciences, and public health.

INTELLIGENCE & HOMELAND SECURITY

Provides complex services, technology, and solutions to the Intelligence Community & Homeland Security agencies.

EXPANDED GLOBAL FOOTPRINT

Leidos is well positioned for growth, with subject matter experts currently operating in 410 locations around the world, including more than 2,000 employees in international locations.

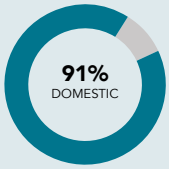


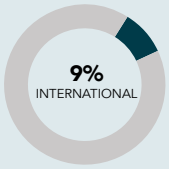
KEY LOCATIONS

Baltimore, MD
Bethesda, MD
Columbia, MD
Frederick, MD
Gaithersburg, MD
Houston, TX
Orlando, FL
Reston, VA
Rockville, MD
San Diego, CA
Washington, DC

Afghanistan
Antarctica
Australia
Canada
Germany
Japan
Korea
Kuwait
Italy
United Arab Emirates
United Kingdom

GLOBAL FOOTPRINT





60% employees working at **Customer Sites**

1,100 employees with **PhDs**

6,900 employees with **Master's Degrees**

50% employees with **STEM Degrees**

CLEARED PROFESSIONALS

71% Top Secret and Above

13,000 Cleared Employees

29% Secret

YEARS OF SERVICE

20% employees are **Military Veterans**

Roger A. Krone

CHIEF EXECUTIVE OFFICER

Roger A. Krone is Chairman and Chief Executive Officer of Leidos. For Krone, the future of Leidos is one with a laser focus on its customers, shareholders, and employees. Under his strategic vision, the organization remains committed to investing in critical internal and customer research and development efforts. He is the driving force behind the company's culture of innovation, the environment shaped to inspire employees to create innovative technology solutions that respond to clients challenges today and tomorrow.

John Fratamico
PRESIDENT, ADVANCED SOLUTIONS GROUP

Angie Heise
PRESIDENT, CIVIL GROUP

Mike Leiter
PRESIDENT, DEFENSE GROUP

John Scholl
PRESIDENT, HEALTH GROUP

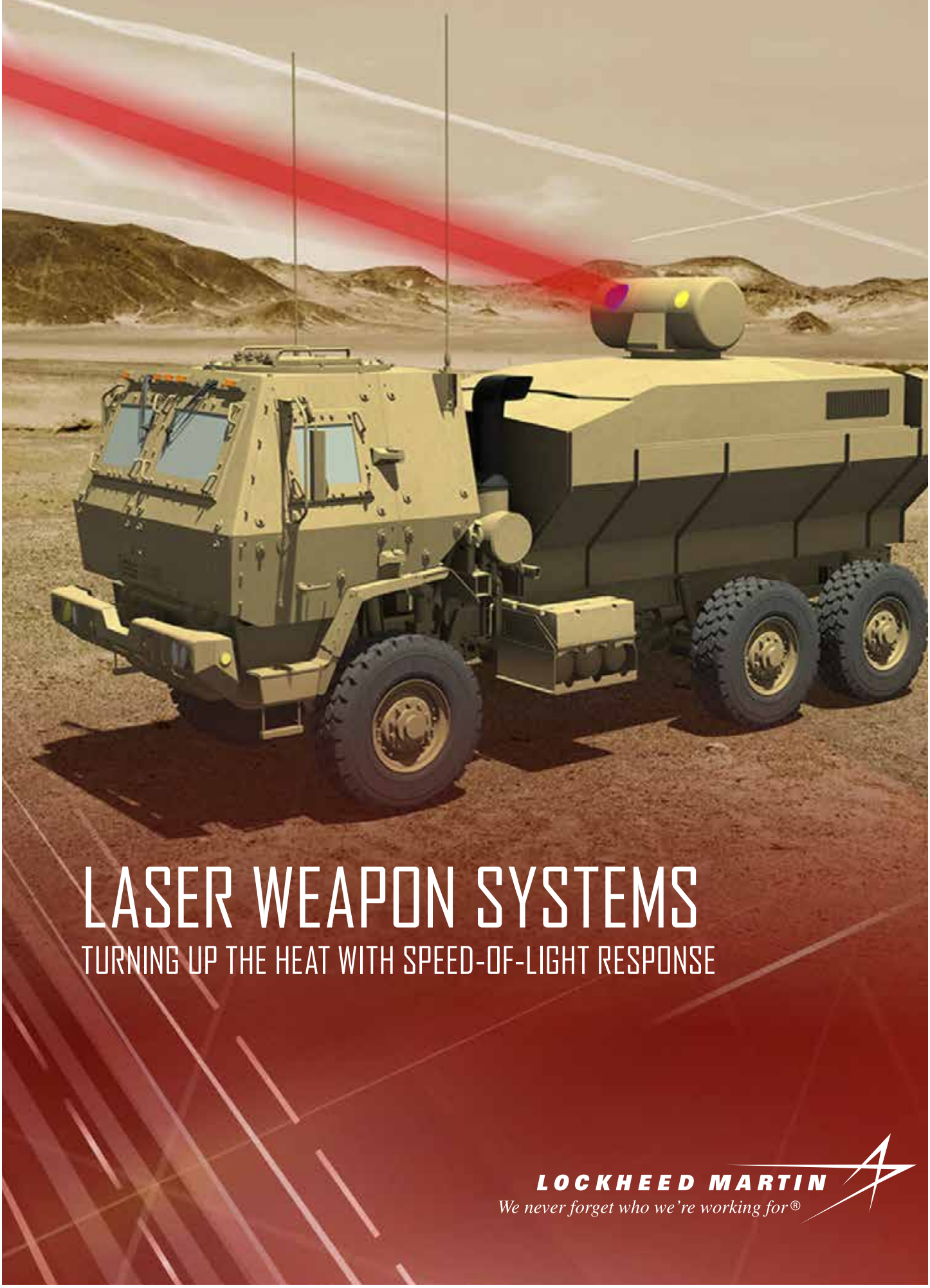
Tim Reardon
PRESIDENT, INTELLIGENCE & HOMELAND SECURITY GROUP

LinkedIn: Leidos
YouTube: Leidosinc
Facebook: Leidosinc
Twitter: @Leidosinc

leidos

ANY FEEDBACK FOR US?

We always want to hear from our customers and teammates
Contact Us Today **leidos.com/contact**


LASER WEAPON SYSTEMS
TURNING UP THE HEAT WITH SPEED-OF-LIGHT RESPONSE
LOCKHEED MARTIN
We never forget who we're working for®

LASER WEAPON SYSTEMS

Lockheed Martin has specialized in laser weapon system development for 40 years, with advancements in areas such as precision pointing and control, line-of-sight stabilization and adaptive optics – essential functions in harnessing and directing the power of a laser beam – and in compact, robust, spectrally beam-combined fiber laser devices that provide unmatched performance.

Lockheed Martin's directed energy (DE) laser program draws upon our proven expertise across a broad range of capabilities, as well as our spirit of innovation. Our experience includes:

- The beam-control/fire-control system for a megawatt-class laser that destroyed a ballistic missile in flight
- High-power spectrally beam-combined fiber lasers that provide the most efficient conversion of platform prime power into lethal power on target
- Unique SWIR component capabilities that significantly extend the ISR (intelligence, surveillance, and reconnaissance) range of the DE laser system
- Widespread weapons-system and platform integration experience across all DoD services

REVOLUTIONARY TECHNOLOGY

Laser weapons are a revolutionary technology because of the advantages of speed, flexibility, precision and low cost per engagement that are only possible with lasers.

These advantages apply to stand-alone DE laser systems as well as to weapon systems that combine DE and kinetic energy capabilities. In these cases, DE operates as a force multiplier, enabling the warfighter to counter a growing range of emerging threats.

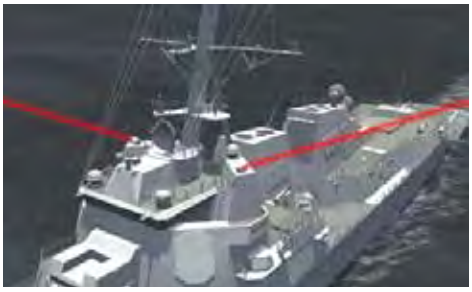
DE weapons are characterized by:

- Very deep magazine
- Extremely low cost per engagement
- Speed of light delivery

These strengths mean that they are well-suited to countering large numbers of inexpensive, highly maneuverable threats that might otherwise exhaust the magazines of our current defensive kinetic energy (KE) weapons. By using DE and KE weapons together, the warfighter will be able to neutralize emerging swarming threats while reserving our most capable kinetic weapons to defend against our adversaries' largest and most hardened threats. DE weapon systems support multi-mission scenarios, and can be readily augmented by communications functions, as well as unprecedented intelligence, surveillance and reconnaissance range, and precision.

In addition, Lockheed Martin's directed energy weapons bring some important and unique advantages to the warfighter:

- A robust and highly-maintainable laser architecture that is designed to minimize life-cycle cost and to maximize up-time
- Output laser power that can be rapidly adjusted between low and maximum power to support disrupt, disable, and destroy capabilities
- Highly parallel laser architecture that supports graceful degradation by eliminating almost all single points of failure



- Highest system efficiency demonstrated in any DE laser system; minimizing size weight and power requirements for DE platforms such as Army and Marine Corps ground vehicles, Navy DDG and LCS ships, and SOCOM AC-130
- Highest lethality laser to minimize engagement time

LOCKHEED MARTIN IS ADVANCING AND DEMONSTRATING A RANGE OF LASER WEAPON SYSTEM TECHNOLOGIES:

ADAM (Area Defense Anti-Munitions)

- Autonomous operations for rocket threats; accepts external sensor cue when required; capable of continuous operation
- Successfully engaged constrained and free-flying rockets, an unmanned aircraft systems (UAS) target in flight, and a small boat
- Affordable commercial-off-the-shelf (COTS) based system with very low cost-per-kill; deep magazine; scalable precision effects
- Capable of close-in defense (1-4 km)

ALADIN (Accelerated Laser Demonstration Initiative)

- 30-kilowatt laser made by combining many fiber lasers into a single, near-perfect-quality beam of light
- Uses approximately 50 percent less electricity than alternative solid-state laser technologies
- Spectral Beam Combining sends beams from multiple fiber laser modules, each with a unique wavelength, into a combiner that forms a single, powerful, high-quality beam

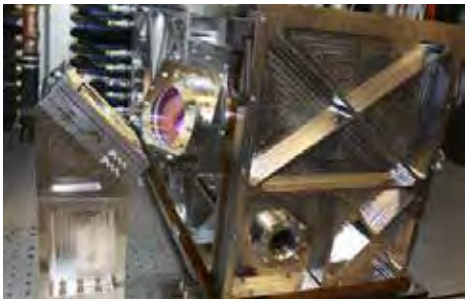
ATHENA (Advanced Test High Energy Asset)

- Represents highest power level documented by a laser weapon system of this type, while retaining excellent beam quality and electrical efficiency
- First field testing of an integrated 30-kilowatt single-mode fiber laser weapon system prototype
- Uses the proven high-energy laser weapon system architecture from our ADAM system, and incorporates the 30-kilowatt ALADIN laser

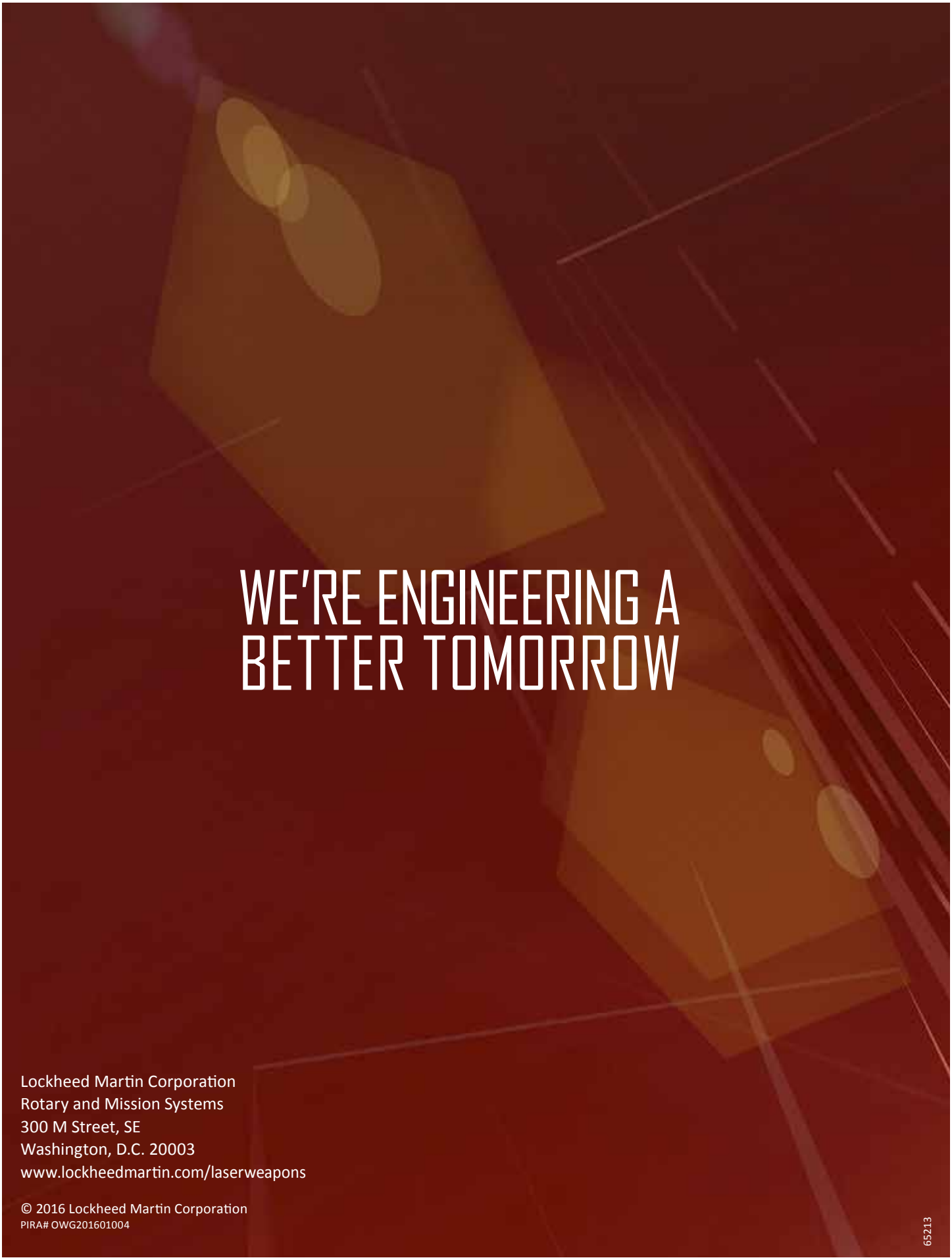
ABC Turret (Aero-adaptive Aero-optic Beam Control)

- Prototype turret with the ability to fire in any direction mounted on tactical aircraft
- First turret to demonstrate a 360-degree field of regard for laser weapon systems on an aircraft flying near the speed of sound
- Validated performance with nearly 60 flight tests conducted in 2014 and 2015 using a business jet as a low-cost flying test bed

RELI (Robust Electric Laser Initiative) for Army HELMTT (High Energy Laser Mobile Test Truck) Demonstrator



- Modular 60-kW laser in development for the U.S. Army
- Proven affordable weapon architecture that supports size, weight and power constraints for air, sea and land platforms
- Scalable design combines multiple kilowatt lasers to attain various weapon power levels
- Modularity results in a reliable and low maintenance laser system that minimizes single points of failure




DIRECTED ENERGY
PROFESSIONAL SOCIETY
DEPS

NanoElectromagnetics LLC

NanoEM - An Emerging Leader in Compact HPRF

From components to systems, NanoEM offers complete solutions

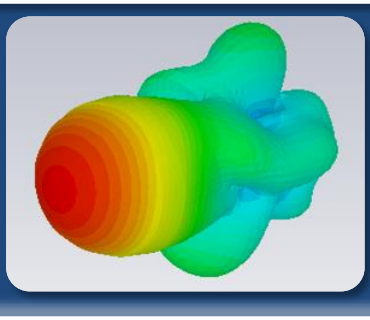
NanoElectromagnetics LLC (NanoEM) specializes in the custom development and production of compact high power antennas, high voltage capacitors, and integrated high power sources. By incorporating proprietary composite materials engineered at the nanoscale, NanoEM's components and systems provide significant advantages in performance, size, and weight in military directed energy systems.

HPRF Antennas

- Compact helical antenna arrays
  - Demonstrated order-of-magnitude reduction of volume and weight
- Dielectric-loaded waveguide feeds
- Low-profile dielectric resonators

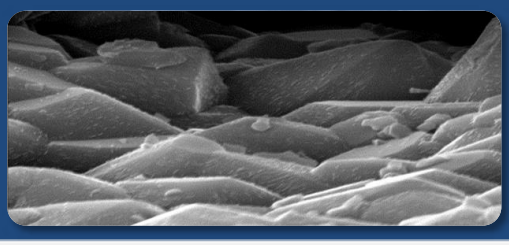
HPRF Sources

- High power RF capacitors
- High energy density capacitors
  - 10x energy density of HV ceramics
  - Custom shapes for tight packing
- High power solid-state switches
- Innovative RF synthesis



NanoEM provides a unique combination of DE development capabilities

NanoEM's dedicated research laboratory for high voltage materials and advanced EM modeling and simulation capabilities provide groundbreaking innovations in compact high power RF systems. NanoEM has the expertise and resources to rapidly design, model, prototype, and test the components and systems that will enable compact mobile DE systems to be fielded by the modern military.



Materials Development

- Patented composite materials
- Tunable properties for each application
- High voltage material characterization

3D Modeling and Simulation

- CST Studio Suite
  - Reduced development cost and risk
  - Fast transition to hardware validation

Start a conversation by contacting us:
Kevin O'Connor
OConnorKA@nanoelectromagnetics.com
573-882-3824

Maritime Laser Weapon Systems

Naval Defense at the Speed of Light

Current and advanced threats create increasing operational challenges for the U.S. Navy and conventional defense systems. Traditional and irregular warfare threats – including swarming small boats, UAVs, enemy aircraft and anti-ship cruise missiles – are proliferating and growing more difficult to detect, track, engage, disable or destroy. To counter these threats, the fleet requires affordable countermeasures with operational flexibility and military superiority. Northrop Grumman high-energy laser systems have demonstrated their speed-of-light weapons capabilities and can provide the solutions warfighters need.

Maritime Laser Weapon System

The Maritime Laser Weapon Systems (MLWS) concept leverages solid state laser technology from years of research and proven laboratory demonstrations to create a near-term operational laser weapon with substantial payoff for the warfighter.

Northrop Grumman's solid state laser architecture allows for power levels scaling to the 100 kilowatt class, preserving good beam quality to defend ships from a wide variety of threats.

MLWS is a cost-effective weapon when compared with more traditional munitions, providing the combatant commander the option of using a low-cost- per-engagement laser weapon instead of expensive missiles with limited magazine against low-value targets.

Additionally, high resolution images provided by the stabilized, optical pointing and tracking system yield an extremely effective, multi-mission capability for situational awareness and intelligence, surveillance and reconnaissance missions at long ranges.

Northrop Grumman's recent record-breaking performance of concurrent electric laser power levels, beam quality, and run-time, combined with new compact, modular and rugged designs, solidify the technological readiness of solid-state laser weapons. With low cost per shot, deep magazine, and ultra-precision, Northrop Grumman high-energy lasers will help the U.S. Navy address current and future threats.

Laser weapon ship integration analyses have been performed to determine potential beam director and subsystem locations for DDG 51.

MLWS can be configured to defend against anti-ship missiles providing an ultra-precise, low cost-per-shot solution for U.S. Navy threats.

Northrop Grumman Laser Systems:
Defense at the Speed of Light

THE VALUE OF *PERFORMANCE.*

NORTHROP GRUMMAN

www.northropgrumman.com

SCHAFER CORPORATION

Since 1972 Schafer has conducted research and development of directed energy systems and laser weapons for the Department of Defense (DoD). Our scientists and engineers have experience in high energy laser (HEL) systems, beam control (BC) theory and applications, optical and mechanical systems design, hardware development, target tracking and adaptive-optics system development, physics-based modeling and simulation, systems engineering, systems integration, ground and flight experiment planning, and lab and field testing of Directed Energy (DE) systems.

The scientists and engineers at Schafer are some of this country's most notable and experienced technologists in DE systems development. Schafer personnel have been involved in every weapons class DE system developed by industry or the DoD including the SDIO Space Based Laser (SBL), the MDA Airborne Laser (ABL); the Army's Tactical High-energy Laser (THEL); Navy's LaWS, Free-electron Laser (FEL), and MIRACL/SeaLite programs; Air Force/DARPA HELLADs; Army/AF Joint High Power Solid State Laser (JHPSSL), Counter Surveillance & Reconnaissance System (CSRS); Multi-mission Deployable Optical System (MDOS), Pacific Sail, Denali, and the HEL JTO RELI program. On the low energy side, Schafer has supported the development of tracking and beacon illuminators as well as applications for LIDAR, LADAR, and laser communications. Schafer also has a long heritage and current state-of-the-art capabilities in conducting laser vulnerability analysis of optical sensor systems supporting numerous customers. Schafer currently supports AFRL/RD, High Energy Laser/Joint Technology Office (HEL JTO), Army Research Laboratory, DARPA, the Office of Naval Research, and the Naval Surface Warfare Center.

High-bay for satellite integration & optical experiments

CONTACT INFORMATION

Mark Neice
DEPS Executive Director
7770 Jefferson NE, Suite 440
Albuquerque, NM 87109
505-998-4910
mark@deps.org

Cynthia Kaiser, DE Outreach
HEL JTO / DEPS Coordinator
7770 Jefferson NE, Suite 440
Albuquerque, NM 87109
505-249-9117
cynthia@stsincalb.com