



2019 Directed Energy Educational Outreach

The United States Leads the World
in Directed Energy Technology

High Energy Lasers

Optical Technology

Support Systems

High Power Microwaves

Non-Lethal

**DIRECTED ENERGY
IS HERE TODAY!**



Directed Energy to the District of Columbia DE2DC 2019 Educational Exhibits

**Pentagon Exhibit of DE Hardware
April 29th - 1230-1600 - Pentagon Courtyard
April 30th - 0900-1500 - Pentagon Courtyard**

**Congressional Exhibit and Reception of DE Technology
May 2 - 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.

2019 Directed Energy Summit
March 20–21, 2019
Ronald Regan Building and Trade Center



Directed Energy Educational Outreach Campaign Initiated in 2009

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), producing 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) fosters the research, development and transition of directed energy (DE) technologies, including high energy laser (HEL) and high-power microwave (HPM) technologies, for national defense and civil applications through professional communication and education. We are recognized as the premier organization for exchanging information and advocating research, development and application of Directed Energy. Founded in 1999, DEPS is incorporated as a nonprofit corporation in New Mexico, organized and operated exclusively for charitable, scientific, and educational purposes.

Each academic year, DEPS offers individual graduate scholarships of \$10,000. The number of annual scholarship awards depends on available funding, which is provided by grants from the Joint Directed Energy Transition Office and the Office of Naval Research. The traditional academic disciplines involved in DE research include physics, electrical engineering, chemistry, chemical engineering, materials sciences, optical sciences, optical engineering, and aerospace engineering.

DEPS hosts several conferences and workshops 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 that are 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. In addition to the annual symposia, DEPS also sponsors a series of short courses that support continuing DE education and further professional development. Continuing Education Unit (CEU) credits are offered upon completion of such DEPS courses. A listing of DE short course offerings and upcoming events can be found at our website, www.deps.org.

DE2DC provides industry, academia, and government the only opportunity to educate decision makers and warfighters on mature demonstrated DE Systems, technologies and capabilities at one time and place with one voice.



DIRECTED ENERGY OUTREACH CAMPAIGN

NORTHROP GRUMMAN

RADIANCE
TECHNOLOGIES

ATA

Applied Technology Associates

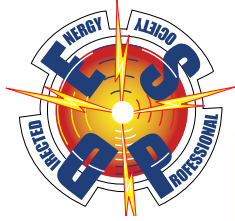


OPTIMAX



Booz | Allen | Hamilton

GENERAL ATOMICS



DSAC



Honeywell
THE POWER OF CONNECTED

Belcan



BOEING



BAE SYSTEMS

II-VI OPTICAL SYSTEMS

leidos



College of Engineering
University of Missouri

LOCKHEED MARTIN

Raytheon

Brashear



Sandia National Laboratories

LASERTEL
a LEONARDO company



Heraeus

National Scope of DE Activities (38 out of 50 States Involved)

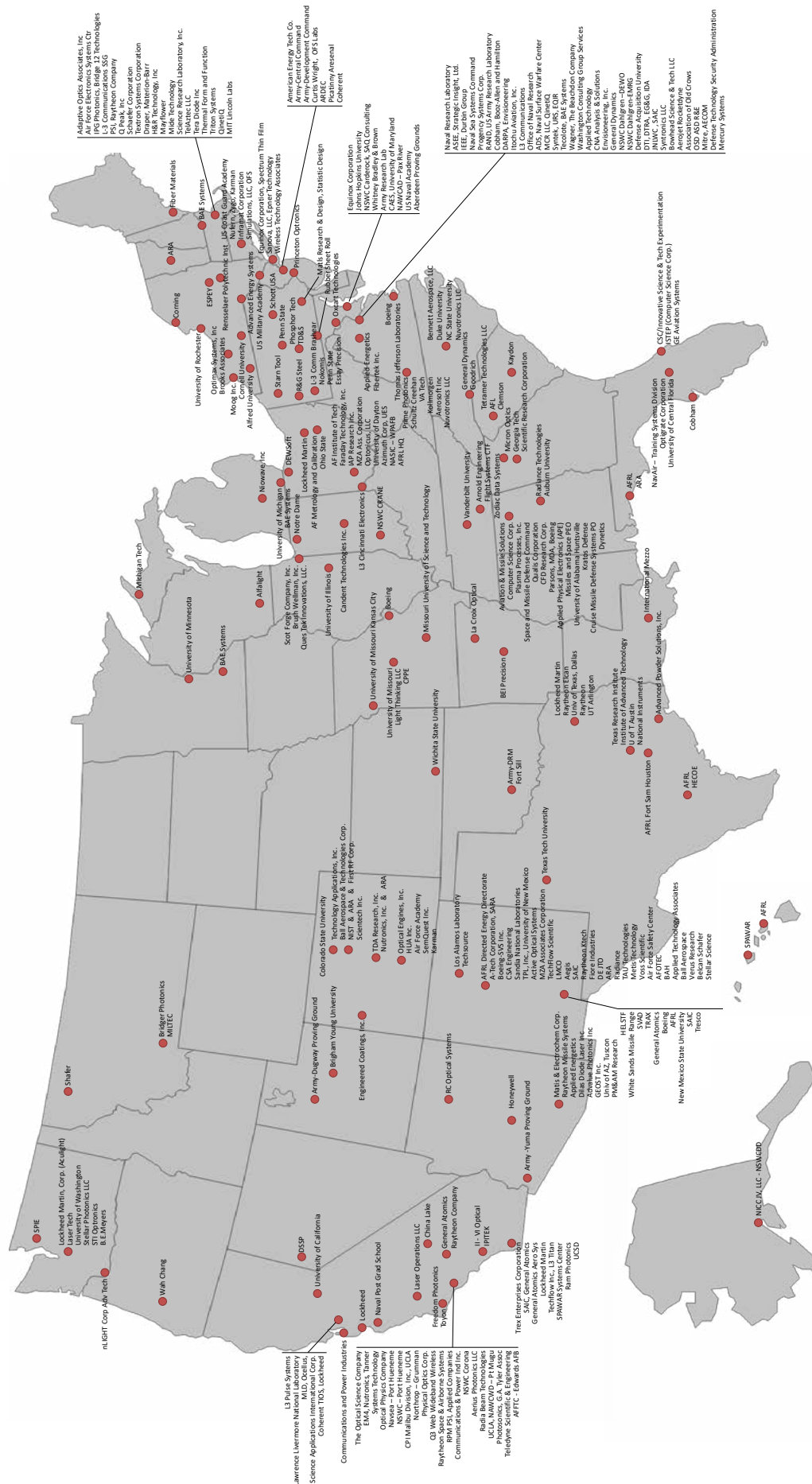


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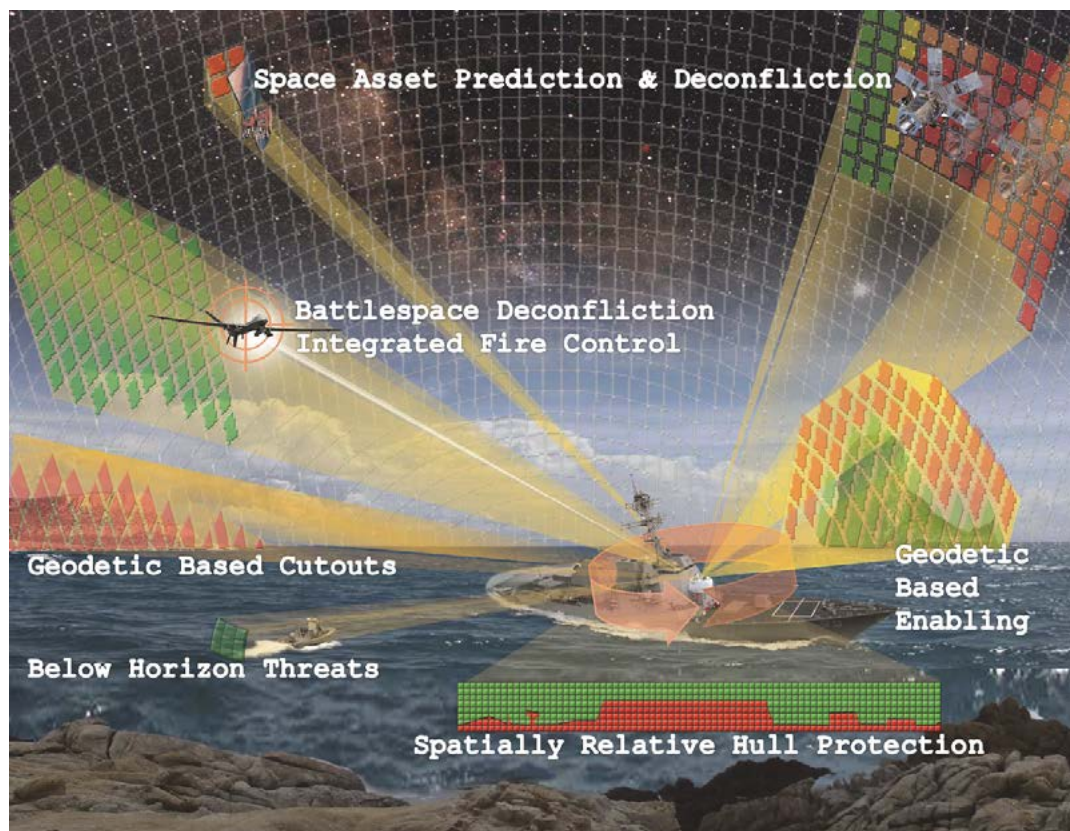
Government Organizations





Joint Laser Deconfliction Safety System (JLDSS)

The Joint Laser Deconfliction Safety System (JLDSS) will provide automated High Energy Laser (HEL) Fire Control (FC) support for Satellite Deconfliction and Battlespace Deconfliction with Command and Control (C2) systems enabling flexible integration of operational HELs in joint environments. National and Department of Defense (DoD) policy recognize that lasers are vital to United States military applications. As laser capacities and applications increase, decision support capabilities, such as JLDSS, are needed to ensure laser illuminations do not impact upon the safe and effective operation of satellites, aircraft, and ground elements in the battlespace. Current DoD laser Satellite Deconfliction (SD) policy places restrictions on laser operators. JLDSS will enable warfighters to determine if specific elements and activities in the battlespace may be inadvertently illuminated; and make informed timely decisions on the safety of laser activities in accordance with policy and Rules of Engagement (ROE). The solution is a multi-service standardized capability that will serve a variety of laser platforms.



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Joint Directed Energy Transition Office (DE JTO)

Establishing the Foundation

for Directed Energy Weapon (DEW) Systems

The DE JTO has four primary functions for the transition of technologies that underlie DE weapon platform development: (1) Acceleration of the development and fielding of DEW capabilities; (2) Advice for exercises and demonstrations; (3) Material/Non-material solution support for development and validation of requirements; and (4) Coordination of the joint DEW portfolio. DE JTO success is critically dependent on other organizations throughout the military departments and defense agencies, consistent funding, and acquisition methods to streamline and accelerate fielding of DEW capabilities to improve the readiness and responsiveness for the Department of Defense.

FY19 BAA Call – Industry

- 31 White Papers; 21 Orals

S&A and FFRDC Call

- 16 White Papers; 11 Orals

MRI Call – Academia*

- *MRIs Call are every three years
- Next MRI call: April 2020



Advocates DE 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 DE technical, policy, & program leaders

The DE JTO utilizes a multi-pronged approach to advance DE technologies through basic and exploratory research working with Universities, DoD Service & Agencies (S&A), and Industry. In addition to advancing the state of the art in DEW for military applications, the DE JTO established an Educational Outreach program to address the issue of limited numbers of US students trained in the various HEL disciplines.



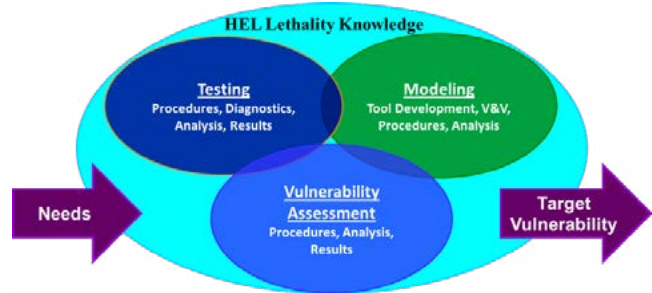
University students and instructors conduct HEL Atmospheric Propagation experiments

Joint Directed Energy Transition Office (DE JTO)
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Albuquerque, NM 87106 Phone: [505] 248-8200
Email: HEL-JTO@jto.hpc.mil

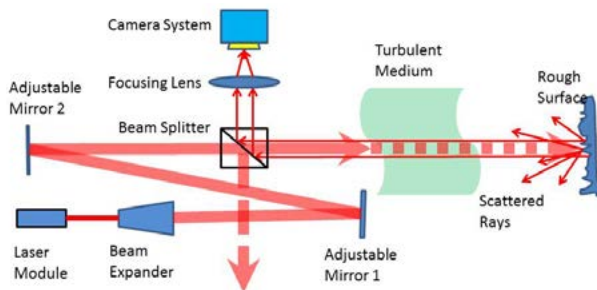


Service Academy cadets and midshipmen are benefactors from the DE JTO Educational Outreach program

DoD S&A subject matter experts, as members of Technical Area Working Groups (TAWGs), represent and advocate for their specific DEW interests.



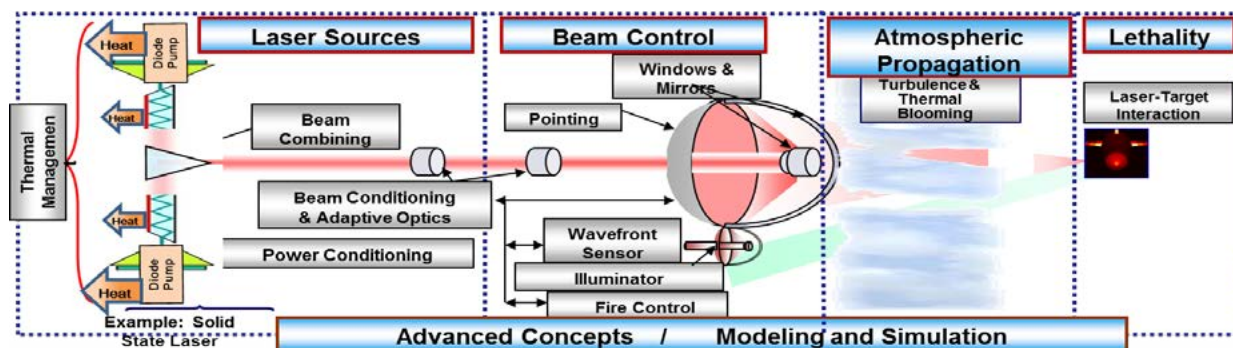
Lethality TAWG: Develops and provides lethality knowledge and expertise in support of DoD projects and activities.



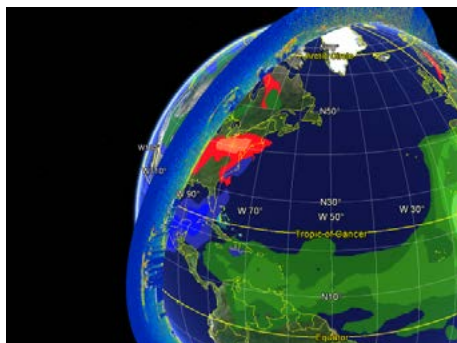
Beam Control (BC) TAWG: Identifies and pursues technologies required for control of laser beams in order to maximize desired effects on targets.



Laser Sources (LS) TAWG: Pursues technologies necessary for mature, rugged, reliable, efficient, and affordable high power lasers sources.



Advanced Concepts (AC) TAWG: Focusses on high- risk, high-payoff basic science/research to advance the state-of-the-art for next generation DEW systems for DoD.



Atmospheric Propagation (AP) TAWG: Develops understanding of the impact of the atmosphere on any HEL anywhere in the world, any time.



Modeling & Simulation (M&S) TAWG: Accurately represents DEW system capabilities in realistic scenarios.



DoD Non-Lethal Weapons Program Directed Energy Capabilities



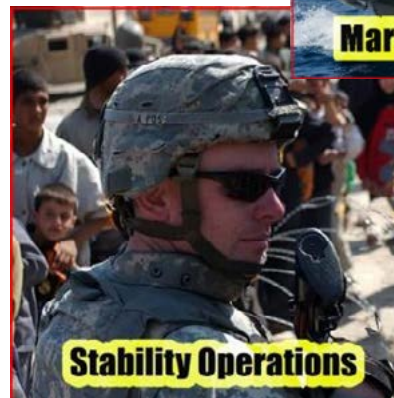
"Our traditional way that we differentiate between peace and war is insufficient to [the dynamic of competition below armed conflict]. We think of being at peace or war-our adversaries don't think that way."

- Gen. Joseph F. Dunford, Jr.; 19th Chairman of the Joint Chiefs of Staff

National Defense Strategy Support. Non-lethal directed energy weapons (NL DEW) help the Joint Force achieve NDS objectives to increase lethality by deterring aggression and sharpening servicemembers' ability to distinguish between friend and foe. This scalable force multiplier facilitates the most efficient use of limited lethal resources while minimizing collateral infrastructure damage and casualties.

Relevant Roles in the Operational Environment. Active denial, high-power microwave vehicle- and vessel-stopping, hail-and-warn, and other NL DEW capabilities developed through the Joint Non-Lethal Weapons Program are non-escalatory options that become more relevant as the complexity of urban and non-traditional battlefield scenarios increases. NL DEW effects deter aggression in scenarios where the use of kinetic weapons is not viable and/or may have unintended political/strategic consequences.

Strategic Value to the DoD and National Interest. The DoD NLW Program's DE portfolio showcased at DE2DC highlights the proven potential of NL DEW to enable U.S. military, interagency, and allied counterparts to advance their influence and interests more effectively. Non-escalatory scalable effects support whole-of-government efforts to counter propaganda, threat or use of military force, and other acts of coercion and subversion in competition short of armed conflict.



Visit: <http://jnlwp.defense.gov> for more information on these and other DoD NLW Program efforts

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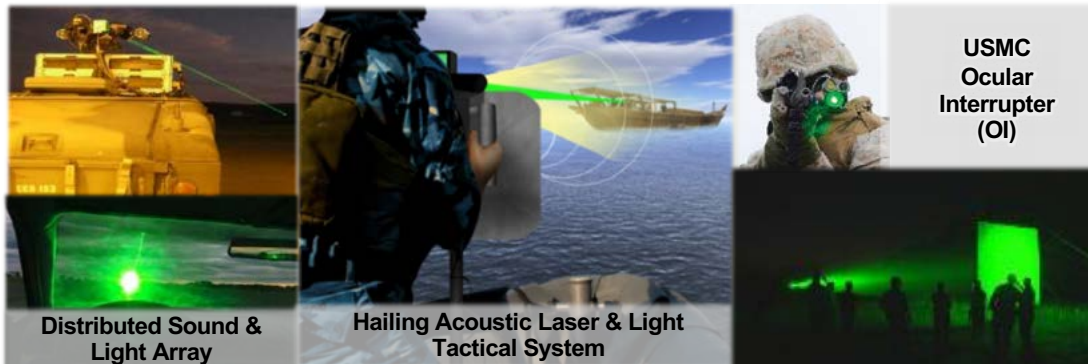
Non-Lethal Directed Energy Weapon (NL DEW) Portfolio:



Active Denial Technology: Non-lethal mmW energy creates an intolerable heating sensation by penetrating a targeted individual's skin to a depth of only 1/64th of an inch - the equivalent of three sheets of paper - compelling them to instinctively move.



RF/HPM NLWs: Emit directed wide- and narrow-band high-power microwave energy to stop advancing vehicles and vessels by temporarily disrupting the platform's control electronics without necessarily harming persons on or near materiel targets.



Long-Range Sound and Light Technology: Low-power lasers and long-range audio devices hail, warn, move, disrupt, and suppress individuals with very low risk of significant injury.

NL DEW SWaP/C² Reduction: NL DEW system, subsystem, & component size, weight, and power consumption with thermal cooling and cost reduction efforts.

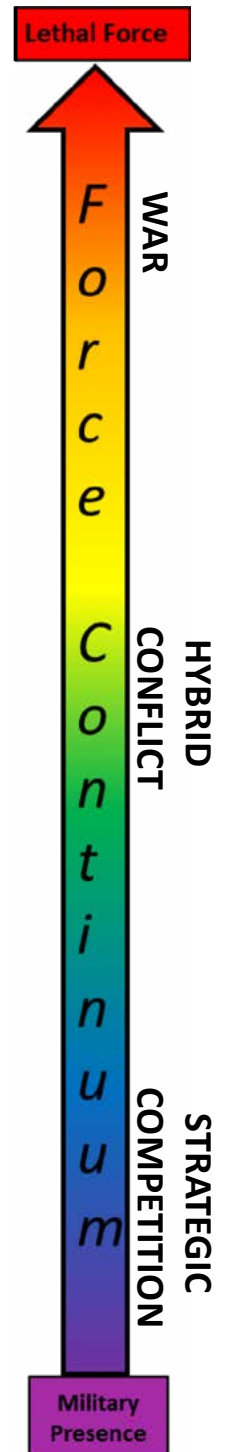
NLW DE Bioeffects Program: The DoD NLW Program has a robust and active NLW DE Bioeffects program in collaboration and partnership with DoD laboratories, industry, and academia. The program's goals include advancing the science and knowledge of DE bioeffects and building predictive Modeling and Simulation (M&S) capabilities to support system design and acquisition. The focus and end state of the M&S capability is to characterize the desired non-lethal effects and risk of injury of DE systems in line with policy outlined in DoD Instruction 3200.19.



Visit: <http://jnlwp.defense.gov> for more information on these and other DoD NLW Program efforts

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AFRL delivers innovative and affordable technologies that give our warfighters an unmatched advantage in the field.

As the scientific arm of the Air Force, AFRL possesses expertise and world-class research facilities in various technology areas.

The Directed Energy Directorate at Kirtland Air Force Base, New Mexico explores high-energy lasers, high power microwaves, and electro-optics for tomorrow's warfighting capabilities.



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Innovative Technologies

Offensive and defensive laser concepts
Non-lethal counter electronics
High power microwaves
Space situational awareness
Weapons modeling, simulation and analysis

Benefits to the Air Force

Speed-of-Light Delivery
Precision Engagement
Controlled/Scalable Effects
Logistical Advantages
Low Cost per Shot

Benefits to the Warfighter

Precision Imaging/Tracking/Engaging
Low Collateral Damage
Scalable & Non-lethal Effects
Deep Magazine

@AFResearchLab



THE AIR FORCE RESEARCH LABORATORY



Innovate
Enable
Protect



Directed Energy Weapons

- Fight and win wars of the future
- New technologies to replace legacy systems
- Provides competitive advantage

DoD's Sole Bioeffects S&T Resource

- Supports force protection for operational use
- Drives counterpersonnel technologies
- Provides bioeffects risk assessment





THE DEFENSE SYSTEMS INFORMATION ANALYSIS CENTER SUPPORTS THE DIRECTED ENERGY COMMUNITY

**FREE
TECHNICAL
INQUIRY
SERVICE**



U.S. 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 repurposing, 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>.



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INFORMATION PAPER ON HIGH ENERGY LASER TACTICAL VEHICLE DEMONSTRATOR

January 2019

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 rockets artillery, and mortars (RAM) threats set
- Compact 100 kW-class fiber laser
- Rugged, agile and stable beam control system
- Modular building block approach
- Speed-of-light engagement of threats with pinpoint precision

2. The HEL TVD's objective is to build and demonstrate 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-RAM at tactical ranges; the system will also be able to defeat Group 1-to-3 unmanned aerial systems. To obtain that



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

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). A TRL 6 demonstration will be conducted in 4th quarter of fiscal year 2022 with technology transition to Program Executive Office Missiles and Space soon thereafter.

3. The High Energy Laser Mobile Test Truck (HELMTT), see Figure 2, is a knowledge point for, and part of, the HEL TVD development effort. Key HELMTT features are:

- Army's first mobile solid-state high energy laser platform
- Rugged, agile, and stable beam control system
- Modular building block approach

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- Speed-of-light engagement of threats with pinpoint precision
- Demonstrated lethal effects on small caliber mortars, unmanned aerial systems (UAS), with a 50 kW-class fiber laser system

4. The HELMTT, as part of the HEL TVD effort, is providing key knowledge on integration and operation of weapon-level HEL systems on tactical platforms. A 50 kW-class fiber laser, the same laser architecture that will be used in the HEL TVD, was integrated into the Heavy



Figure 2. USASMDC/ARSTRAT's High Energy Laser Mobile Test Truck

Expanded Mobility Tactical Truck-based system and began data collection in Fiscal Year 2018 (FY18). The HELMTT is also collecting data to validate/update threat vulnerability modules (VMs) and laser propagation models. The HELMTT will complete the knowledge point in mid-late FY19. The completed knowledge point will include engagements against a select set of rocket, artillery, and mortar threats as well as Group 1 and 2 UAS.

PROPOSED JOINT DIRECTED

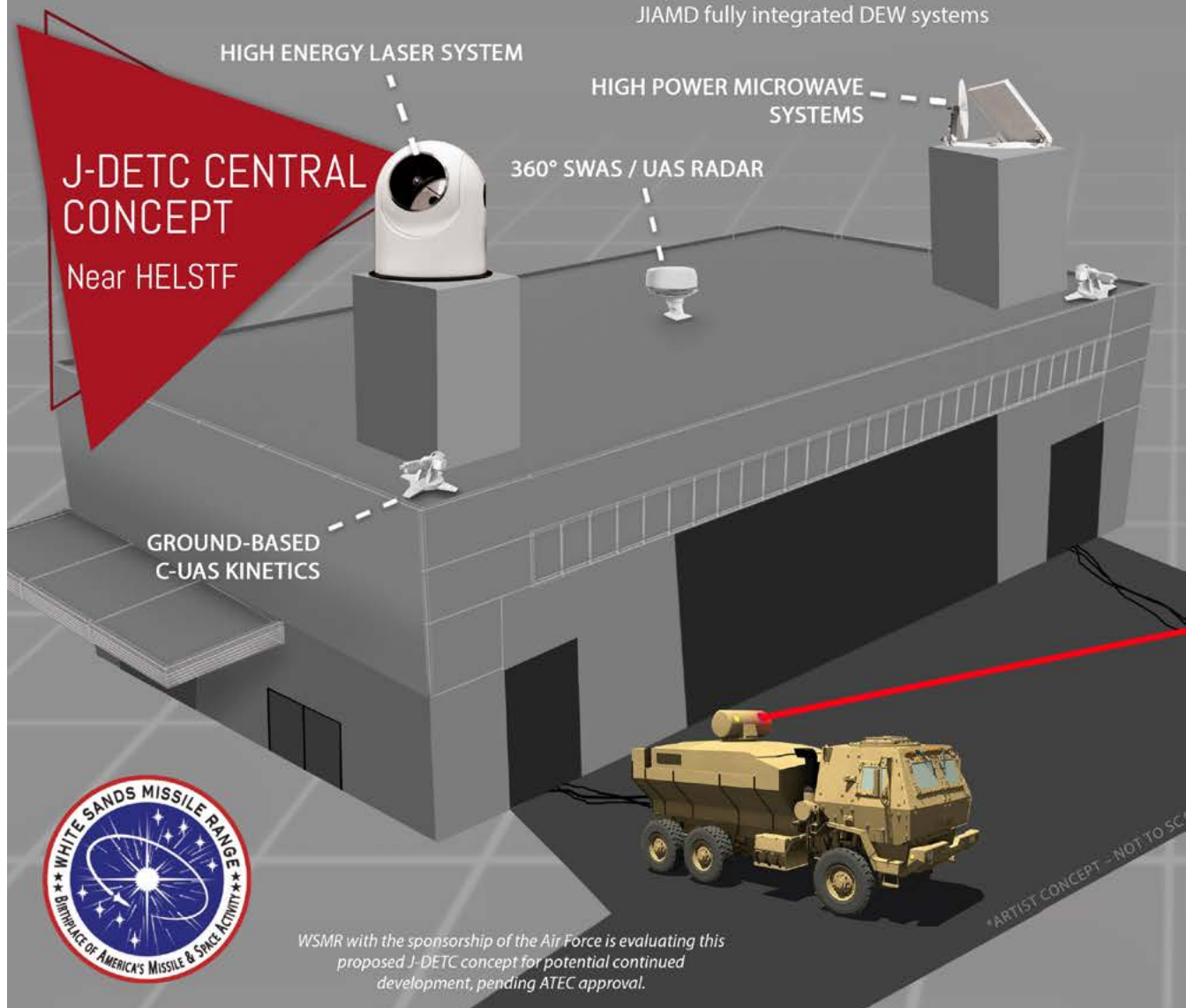
White Sands Missile Range, NM (WSMR)

WSMR CAPABILITY

- WSMR has conducted DE testing for nearly all HEL systems since 1978
- WSMR currently conducts more than 80% of the DEW (HEL & HPM) testing for our nation
- The proposed J-DETC at WSMR will meet the future needs of DEW and C-DEW evaluation
- WSMR stands prepared to support all DEW (HEL & HPM) testing needs

J-DETC PURPOSE

- Directly supports U.S. National Security Strategies to provide overmatch U.S. IAMD to counter peer to near-peer threats and rogue state threats (includes: Ballistic Missiles, CMs, RAM, and Swarming Autonomous Unmanned Systems (SWAS))
- Designed to test complete Joint Integrated (DE, KE, Cyber, EW) Air and Missile Defense (JIAMD) within full kill chain, C2 and sensors network (ground, air, sea, space)
- Supports experimentation, training and certification required for warfighters to operate and maintain JIAMD fully integrated DEW systems

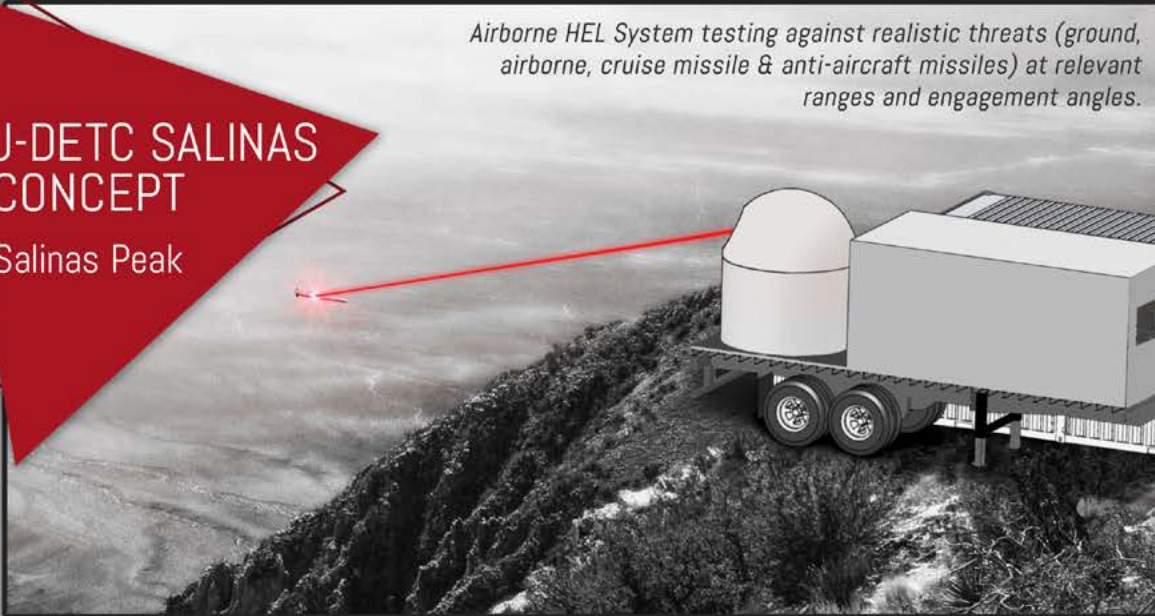


ENERGY TEST CAPABILITY (J-DETC)

J-DETC SALINAS CONCEPT

Salinas Peak

Airborne HEL System testing against realistic threats (ground, airborne, cruise missile & anti-aircraft missiles) at relevant ranges and engagement angles.

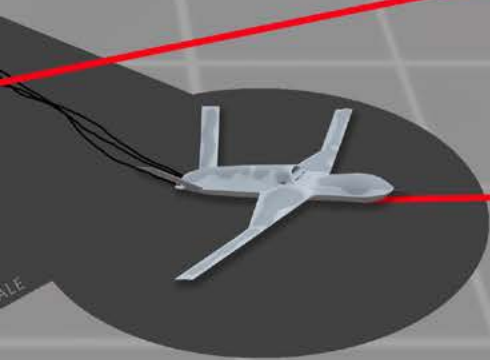


DESIGN OVERVIEW & CHARACTERISTICS

- DEW prototypes to test U.S. systems' ability to counter enemy DEWs
- Supports the rapid transition of DEW systems to the warfighter
- Provides vibration, shock and motion (emulating the movements of ground vehicles, aircraft, or ships) of DEW while engaging threat-representative targets at range
- DoD unrestricted airspace with full command and control authority, ground to space
- J-DETC at White Sands Missile Range with ~3200 sq. miles of instrumented range accommodating large munitions impact and full kill chain integration

CUSTOMERS SUPPORTED

- Department of Defense, Energy & Homeland Security
- Private Sector, US Allies



For more information please contact the WSMR Business Development Office at:



1-866-532-9767



usarmy.wsmr.atec.mbx.team-white-sands@mail.mil

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Labs and Academia



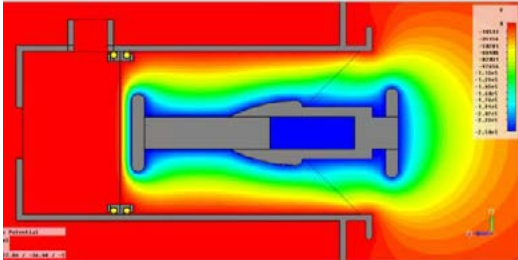


Center for Physical and Power Electronics

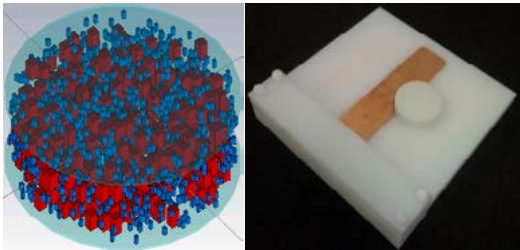
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Directed Energy



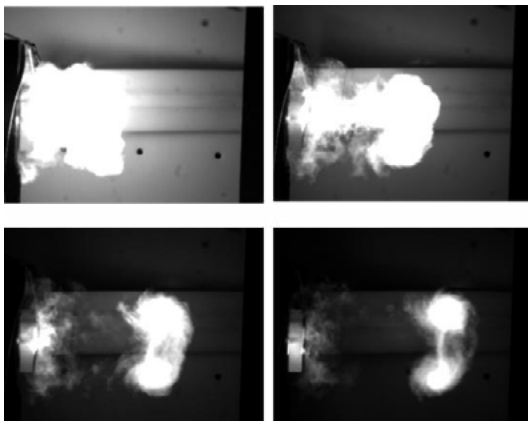
High-voltage materials



High Powered 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. Our approach to problem solving utilizes 3D electromagnetic computations, and the development of prototypes to be tested in our laboratories or the field.



CPPE's Anechoic Chamber Wall

Sandia National Laboratories

On the Leading Edge of Directed Energy Research



Sandia has world-class expertise and decades of experience in Directed Energy research, systems development, and assessments for National Security.

We

- Weaponize technology Pathfinders
- Exploit sensors and systems
- Conduct High-Power Microwave (HPM) and RF circuit-to-systems effects testing and assessments
- Develop compact HPM and RF sources, components and systems
- Develop pulsed laser sources and systems
- Research laser-material interaction phenomena
- Model components through systems to engagements
- And more ...

Threat-Informed
Design

DE for
Strike

DE for
Defense

DE Predictive Science

Advanced Modulation

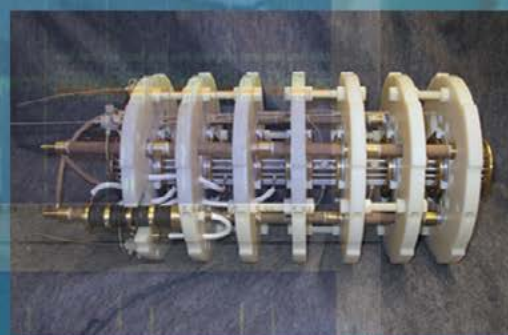
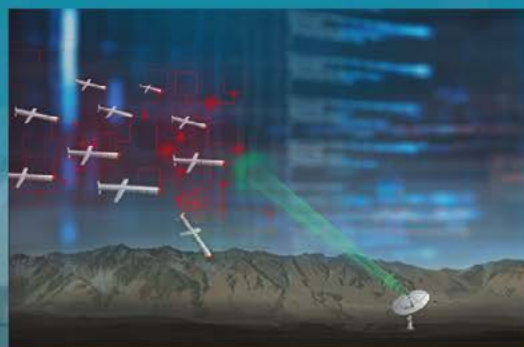
Coherent Beam Combining

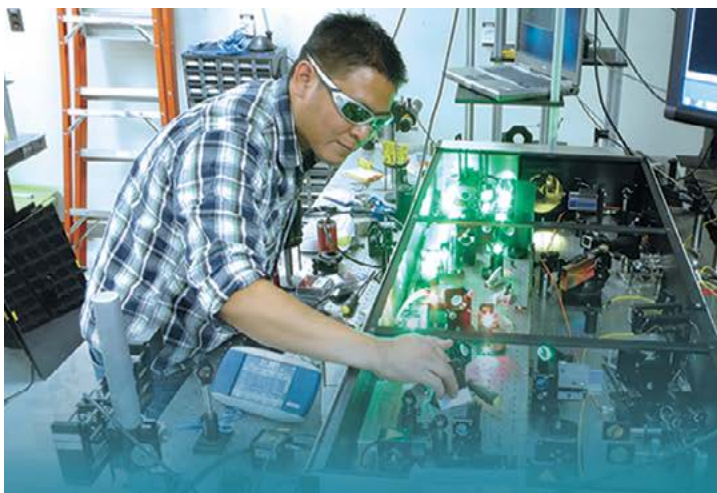
Cooperative EW & Combined Effects

EM Battlespace Management

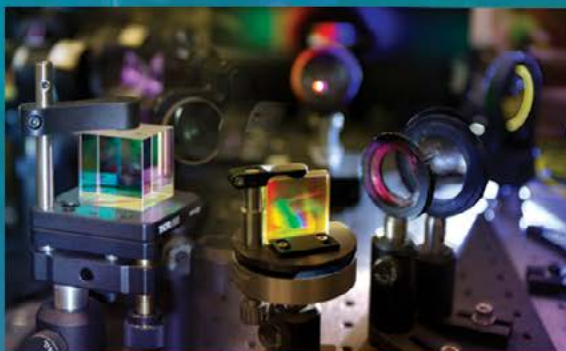


High-Power Microwave Technologies





Pulsed Laser Technologies

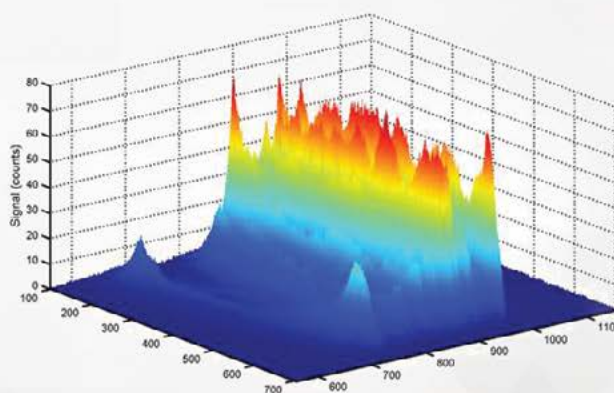


Sandia is a multidisciplinary national laboratory and federally funded research and development center (FFRDC) for the National Nuclear Security Administration.

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.



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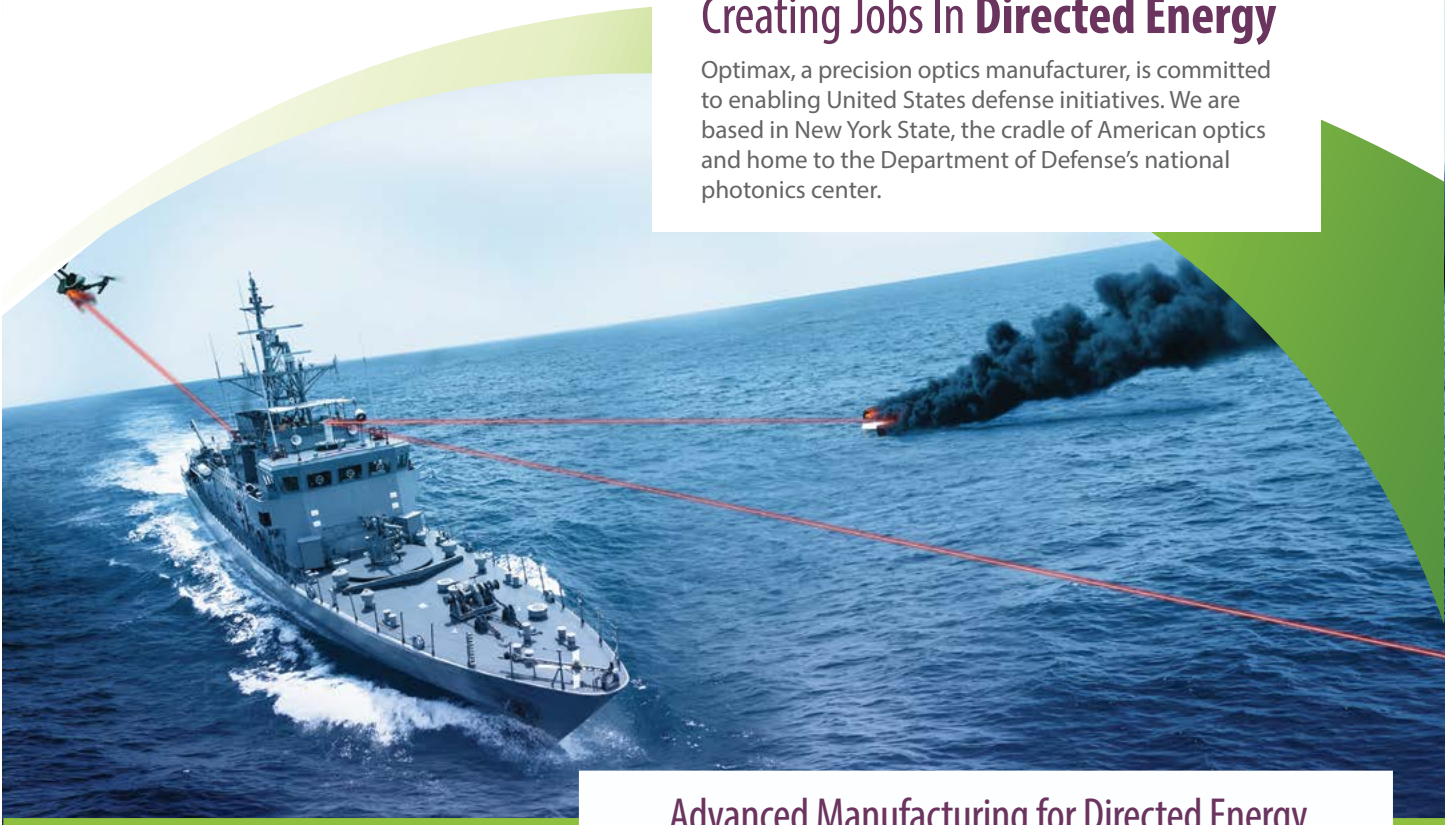
Industry Partners



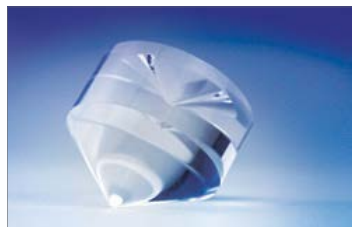


Creating Jobs In Directed Energy

Optimax, a precision optics manufacturer, is committed to enabling United States defense initiatives. We are based in New York State, the cradle of American optics and home to the Department of Defense's national photonics center.



Advanced Manufacturing for Directed Energy



High Power Laser Optics



Research & Development

Initiatives We Support



Directed Energy



C4ISR



National Ignition Facility*



Semiconductor Manufacturing



NASA Mars Rovers

CREATING JOBS IN THE USA

👥 350+ employees +👤 80 new hires in 2018 📈 20% average annual growth 💡 \$1M+ annual training investment

*Image © Lawrence Livermore National Laboratory/ Wikimedia Commons

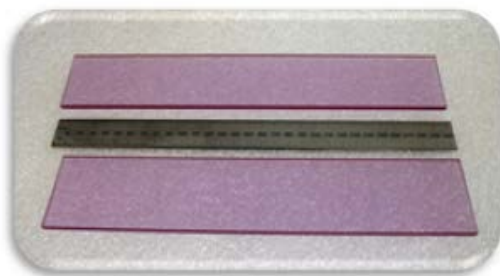
II-VI OPTICAL SYSTEMS

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, manufactures, 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



We are a committed partner in the advancement, development, and research of directed energy technologies. With over 30 years of experience supporting interoperable defense capabilities, our team of engineers combine academic principles with proven engineering skills to further advance the state of Directed Energy, Space Vehicles, and Missile Defense Areas.

Capabilities

- Laser/Optics R&D
- Electro-Optics Tools
- Modeling and Simulation
- Spacecraft Analysis, Testing & Safety Management
- Satellite Engineering
- HEL System Software Design, Development, and Test
- Laboratory & Field Testing
- System Engineering
- Rapid Prototyping
- Material Characterization
- Experimental, Development, and Operational Test & Evaluation
- Logistics/Lab Management
- Additive Manufacturing

Belcan

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Engineering Better Outcomes | belcan.com | Government Services | Engineering Services | Technical Recruiting



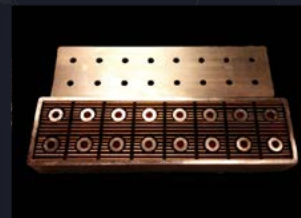
ADVANCED COOLING TECHNOLOGIES

The Thermal Management Experts | www.1-ACT.com

THERMAL TECHNOLOGIES FOR DEFENSE APPLICATIONS

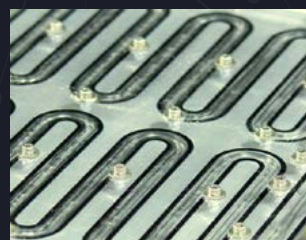
PCM HEAT EXCHANGER

Directed Energy Applications | Pulsed Heat Loads



PCM HEAT SINKS

Thermal Storage | Improved Cooling



PUMPED TWO PHASE COOLING SYSTEMS

Superb Isothermality | High Heat Flux Capable



HIK™ PLATES

Passive Heat Spreading | Improved SWaP-C

No matter where you are in your project, ACT can help.
Contact us for your thermal management needs.

1046 NEW HOLLAND AVENUE
LANCASTER, PENNSYLVANIA 17601, USA
PHONE: 717.295.6061

EMAIL: APPLICATIONS@1-ACT.COM VISIT: WWW.1-ACT.COM

PROVEN THERMAL SOLUTIONS FOR DIRECTED ENERGY WEAPONS

Mission Ready Thermal Solutions for the Military

INTEGRATED THERMAL STORAGE FOR GROUND-BASED AIR DEFENSE SYSTEM

| CASE STUDY: THERMAL STORAGE FOR MILITARY APPLICATION

In support of the Navy's Ground-Based Air Defense Directed Energy On-The-Move (GBAD) program, Advanced Cooling Technologies, Inc. (ACT) developed an efficient, lightweight, compact thermal storage and management subsystem. The system was principally developed for a vehicle mounted air defense laser system to defeat low observable/ low radar

cross section threats to the Marine Corps, specifically Unmanned Aerial Systems. The system removes waste heat from the laser commensurate with available power and other engineering constraints. ACT designed, tested and delivered a full-scale cooling system that can directly integrate with the High Energy Laser.

This is one of several Directed Energy Systems that ACT has developed demonstrating our core strength in heat transfer and thermal management for transient high power applications. For more information on ACT's Military applications, visit www.1-ACT.com/Markets/Military.



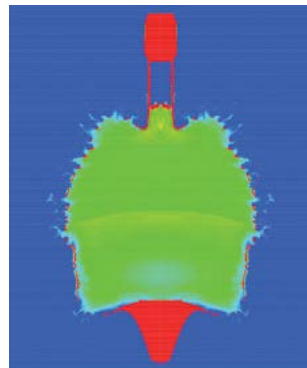
**“GREAT SUPPLIER WITH EXCELLENT MANAGEMENT AND ENGINEERING TEAM.
ACT HAS AN EXCELLENT AND HIGHLY CAPABLE TEAM THAT PROVIDES
OUTSTANDING SERVICE.” - DEFENSE PRIME CUSTOMER**



ADVANCED COOLING TECHNOLOGIES

The Thermal Management Experts | www.1-ACT.com

DIRECTED ENERGY WEAPONS (DEW)



ARA offers advanced directed energy weapons solutions to support our warfighters including:

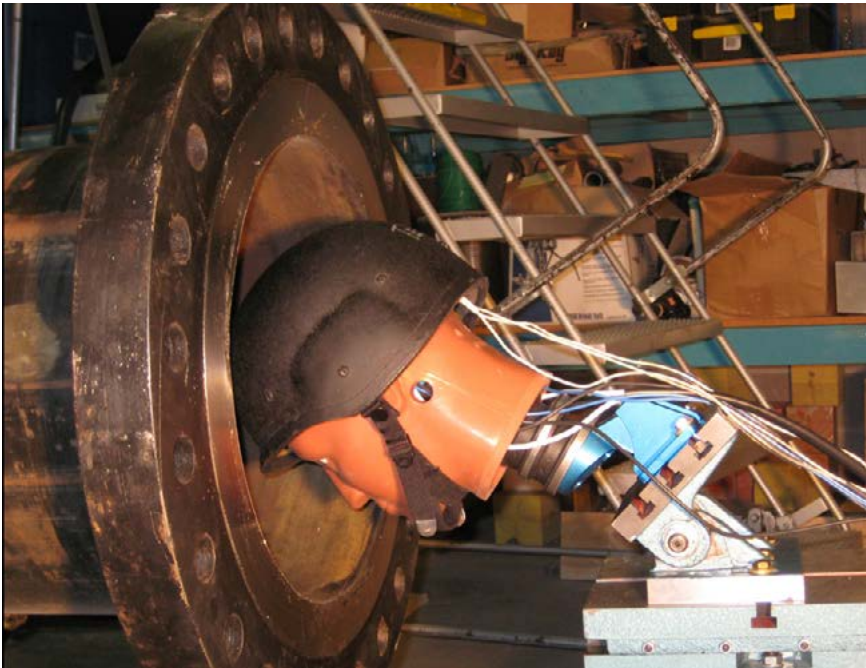
- Small, high power laser weapons creating counter-material, counter-drone and explosive ordnance disposal (EOD) solutions
- System engineering support to advanced laser weapon architectures and system concepts
- Advanced laser technologies and counter high energy laser (HEL) approaches to protect our warfighters
- High power microwave (HPM) system development
- High power, frequency selective surface (FSS) radome technology for HPM weapons
- HPM propagation including atmospherics, structure penetration and coupling effects
- Integrated Weapon Environment for Analysis (IWEA) including DEW tools for mission and lethality analysis
- Human effects from DEW systems including laser and microwave



Applied Research Associates (ARA)

Joseph Paranto • 505-883-3636 • jparanto@ara.com

NON-LETHAL WEAPONS (NLW)



ARA provides research and development support for non-lethal weapons systems including:

- **Electrical Stimulus-Based Disabling Technology**
- **Active Denial Technology**
- **Blunt Impact Technologies**
- **Laser Technology**
- **High Power RF / Microwaves**
- **Sound and Light – Testing our prototype Non-Pyrotechnic Diversionary Devices (NPDD)**
- **Other Counter-Personnel Technologies**
- **Other Counter-Materiel**
- **Human Effects - Investigating health effects from muscular incapacitation (HEMI)**

Currently supporting Joint Non-Lethal Weapons Directorate under contract N00174-17-D-0032. Supporting research and development across a range of capability functional and technology areas.

Applied Research Associates (ARA)


Adam A. Nowinowski • 703-412-9425 • anowinowski@ara.com



Providing key enabling solutions for directed energy systems.



Laser Communications Systems



High Energy Laser Systems

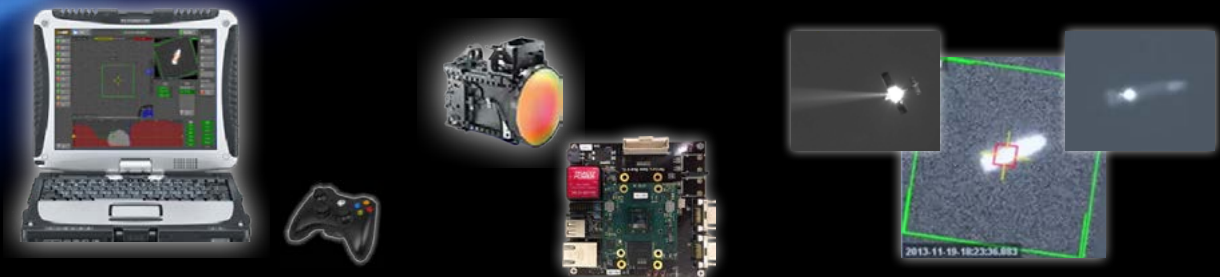
Applied Technology Associates (ATA), in business since 1975, is a precision measurement, sensing, and controls company providing services and products to government and commercial customers. ATA has demonstrated a remarkable ability to transition technology to operational use and commercial products by leveraging internal and government funded research and development. Our products and services span ground, air, and space applications. ATA has 40 years of experience developing innovative technologies and solutions for advanced optical, electro-optical, sensors, lasers, and space flight systems. ATA is at the forefront of line of sight stabilization architectures and component solutions. ATA is a market leader in integrated beam control, pointing control and tracking, image processing systems, and free space optical communications technologies and demonstrations.

LASER WEAPON SYSTEM / FIRE CONTROL



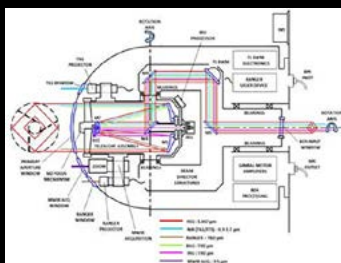
ATA develops highly reliable, modular, low size, weight, and power (SWaP), and low-cost processing electronics and software that process and control the entire suite of high energy laser weapon system components and subsystems, including beam director and beam control, laser device, power and thermal 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, 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, power, and cost, 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 a key provider 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.



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



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

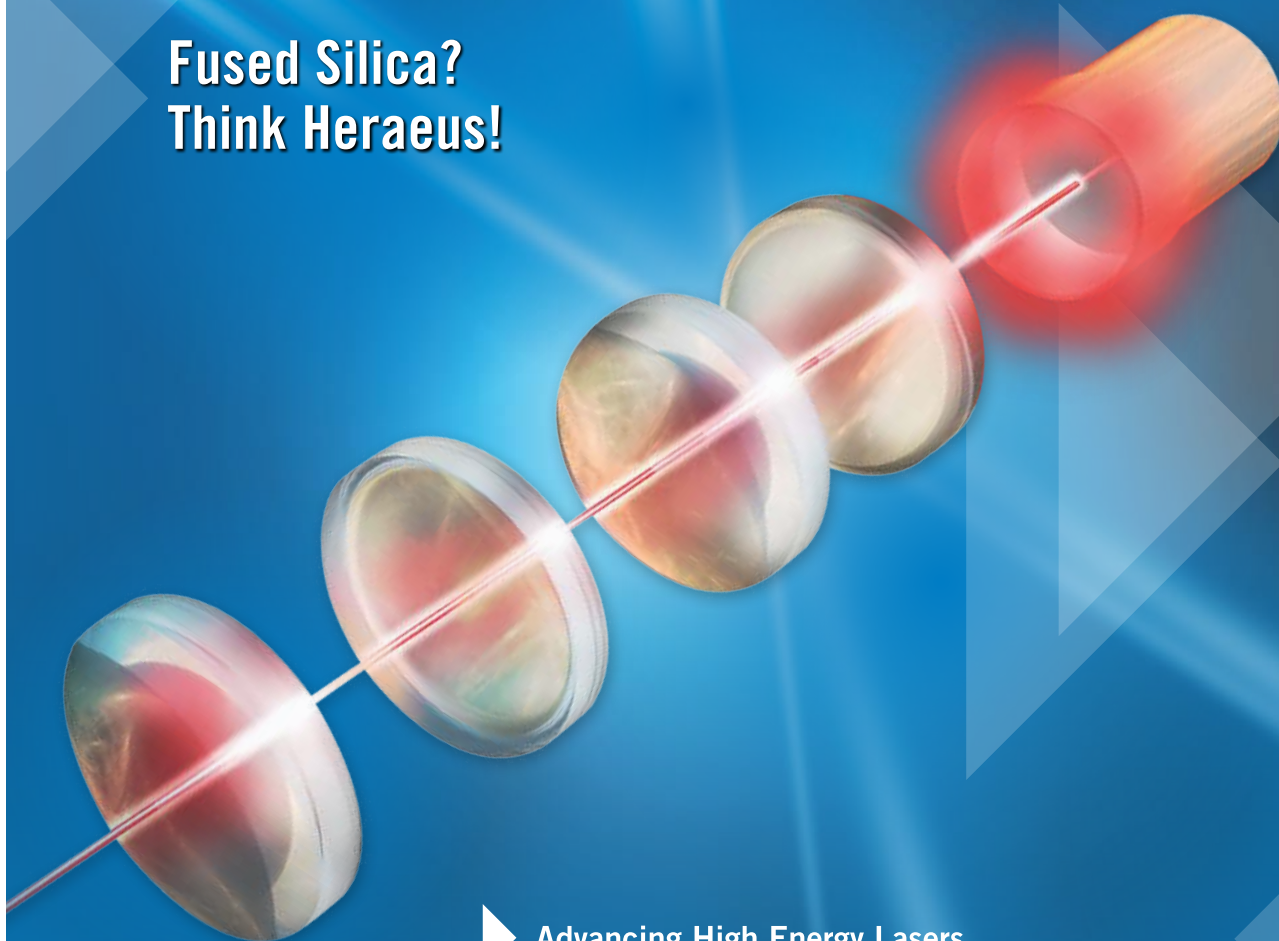
Executive Vice President
obering_henry@bah.com

JIM POTTER

Directed Energy Services Lead
potter_patrick@bah.com

Heraeus

Fused Silica? Think Heraeus!



Advancing High Energy Lasers

Your reliable partner with commercial off-the-shelf high-volume fused silica production

High power lasers:

- optimized fused silica from UV to near IR
- laser transmission fiber
- active laser fibers

Highest power NIR Laser Optics:

- low absorption
- large size homogeneous fused silica



www.herae.us/deps

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sales.hqs.optics.us@heraeus.com

Specialty Fiber USA
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30518 Buford, Georgia
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Power for Next-Generation Weapon Systems

As the electrical demands of high-energy lasers and microwave systems increase, Honeywell will be there to power these weapon systems. We're enabling the future with power and thermal technologies for air, land and sea platforms.

Honeywell
THE POWER OF **CONNECTED**

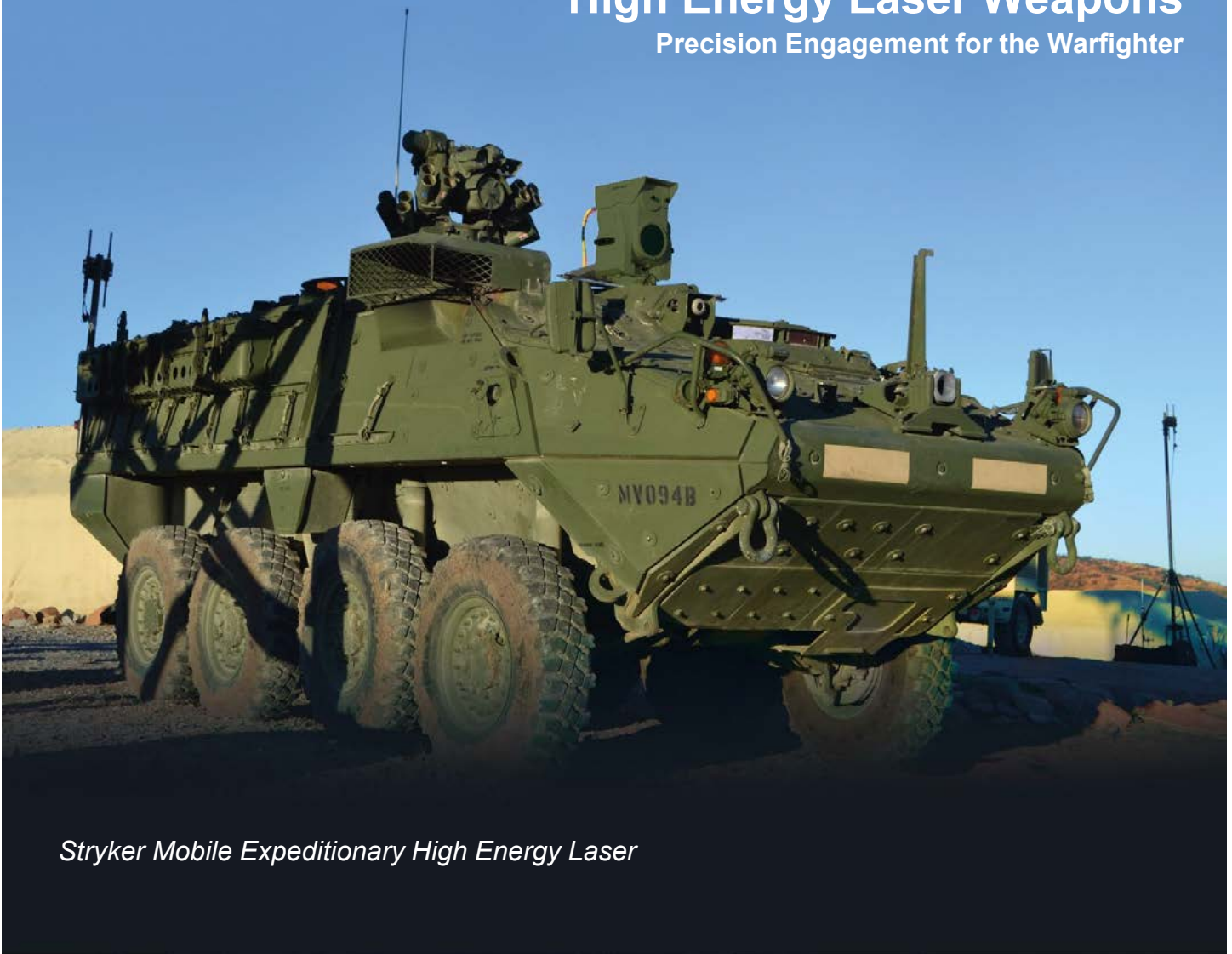
For more information, please visit
aerospace.honeywell.com.

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High Energy Laser Weapons

Precision Engagement for the Warfighter



Stryker Mobile Expeditionary High Energy Laser



High Energy Laser Mobile Test Truck



Compact Laser Weapon System

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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 a near 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 integrated into a container. The CLWS can accommodate 2 to 10 kW lasers and is ideal for the counter-UAS mission, in addition to counter-ISR, special event and force protection. The Stryker Mobile Expeditionary High-Energy Laser (MEHEL) demonstrates the pairing of a DE weapon with a tactical vehicle. Successful vehicle integration and demonstration from 2016 through 2018 performing C-UAS and C-ISR missions, proved 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), tracking and destroying 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 is a pioneer 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 directed energy efforts to keep allied forces secure against such threats.



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LEADING & INNOVATING TO ENABLE DIRECTED ENERGY

Whether scaling systems to a higher power or developing lightweight beam delivery systems, Coherent has robust photonic solutions for theater-ready, real-world directed energy weapon applications.

From **Laser Diodes** to **Fiber Amplifiers**, **Custom Optics** to **Specialty Gain Mediums** and **Q-Switching Crystals**—Coherent delivers superior components for your directed energy system—coherent.com/directed-energy



COMPONENTS FOR YOUR DIRECTED ENERGY SYSTEM

Laser Diodes

Complete range of high-power, high efficiency pump diodes optimized for fiber, solid-state, and DPAL pumping. SWaP-optimized for Directed Energy applications.

Manufactured in Tucson, AZ

Fiber Amplifiers

Industry-leading fiber laser amplifiers with high power, high efficiency, narrow linewidth, while simultaneously SWaP optimized. Standard products, and customized configurations available, along with supporting accessories such as seed lasers, polarization controllers, and linewidth broadeners.

Manufactured in East Granby, CT

Custom Optics

Large format optics for both tracking systems, and beam directors. Space-flight heritage for low-SWaP and high reliability applications. Custom coating capabilities.

Manufactured in Richmond, CA

Specialty Gain

Doped fiber and custom crystals optimized for beam quality and high energy applications. Custom configurations and coatings available.

Manufactured in East Granby, CT and E. Hanover, NJ

Q-Switching & Harmonic Crystals

Optimized for pulsed lasers and harmonic generation, for dazzlers, BIL's, and TIL's.

Manufactured in E. Hanover, NJ





DIRECTED ENERGY. WHERE IT COUNTS.

General Atomics Electromagnetic Systems is transforming innovative concepts into breakthrough electric weapon systems to support the future warfighting force.

From flexible High Energy Laser weapon systems and High Power Microwave technologies, to electromagnetic railgun systems, our portfolio of multi-mission directed energy solutions provide the precision, range, speed, and power to efficiently and effectively defend against a growing range of complex threats from the land, sea, and air.

Learn more at www.ga.com/ems



ADVANCING INNOVATIONS IN ELECTRIC WEAPON SYSTEMS

General Atomics Electromagnetic Systems' (GA-EMS) technologies are designed to arm the future force with capabilities to counter existing and emerging threats.

HIGH ENERGY LASER WEAPON SYSTEMS

GA-EMS' advanced solid state High Energy Laser (HEL) weapon system provides proven laser technologies to enable the detection and defeat of an expanding range of targets, including unmanned vehicles, missile threats, ISR systems, rockets, artillery, and mortars. GA-EMS' HEL weapon system offers significant power-on-target enabling shortened engagements and rapid retargeting. The system's modular, scalable design also offers significant reductions in size, weight, and power consumption to suit air, land, and sea-based platforms.



Compact Hemispherical
Beam Director

- 100 kW-class laser scalable to 300 kW and larger
- Lightweight, efficient thermal management
- Greater performance at reduced lifecycle cost
- Shorter dwell times and rapid retargeting
- Extended target engagement ranges
- Integrated ultra-high power density battery system

MULTI-MISSION RAILGUN WEAPON SYSTEMS

GA-EMS is advancing the development of electromagnetic railgun weapon systems to support integrated air and missile defense, counter battery fire, and precision indirect fire, providing greater flexibility for future Navy and Army applications. GA-EMS railgun weapon systems integrate high energy density pulsed power, a launcher, and a weapon fire control system to launch projectiles at a high muzzle velocity, leading to shortened engagement times, rapid defeat of threats, and longer range.

- High firing rates enable engagements of simultaneous multiple threats
- Compact form factor enables mobile IAMD warfare
- Electromagnetic launch eliminates explosives and propellants
- High capacity (deep magazine) and low engagement cost
- Scalable pulsed power technology to reduce overall system footprint

HIGH POWER MICROWAVE TECHNOLOGIES

GA-EMS is developing High Power Microwave (HPM) components, subsystems, and systems to prove the viability of HPM weaponry on the modern battlefield. Our capacitors and pulsed power components are being used by Department of Defense customers in several HPM system prototypes. GA-EMS is also designing airborne test and prototype capabilities to demonstrate HPM components and systems in operationally-relevant environments. Leveraging decades of experience, GA-EMS is leading the design of recoverable HPM airborne test and prototype systems to hasten the transition of HPM weaponry to support the future warfighter.



Learn more at www.ga.com/ems





INNOVATION & LEADERSHIP IN HIGH ENERGY LASER BEAM CONTROL AND ADAPTIVE OPTICS SYSTEMS



MZA Associates Corporation

4900 Lang Ave NE, Suite 100
Albuquerque, NM 87109
P: (505) 245-9970
F: (505) 245-9971

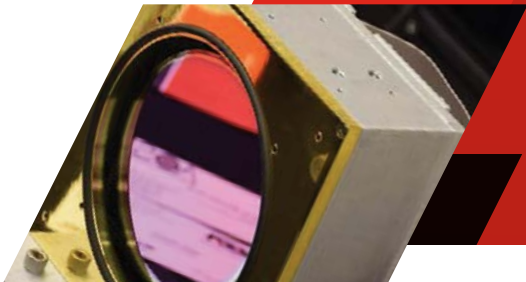
1360 Technology Court, Suite 200
Dayton, OH 45430
P: (937) 684-4100
F: (505) 245-9971

MZA.com

MZA analyzes, designs, builds, and tests precision beam control systems for High Energy Laser and compensated imaging systems.

- Laser Weapon Effectiveness Predictive Modeling
- Lightweight & Compact Beam Control Systems
- Deformable Mirrors and Adaptive Optics Systems
- Target Acquisition, Tracking, & Pointing (ATP) Systems
- Characterization and Compensation of Atmospheric Turbulence
- Characterization and Compensation of Aero-Optical Effects
- Free-space Laser Communications
- WaveTrain Wave-optics Analysis and System Modeling

Directing Our Energy to Directed Energy



MZA is a leading innovator and manufacturer of high power deformable mirrors and closed-loop adaptive optics systems.

The next generation of precision strike weapons is being built with technologies developed by MZA.

An Employee-Owned Company

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:

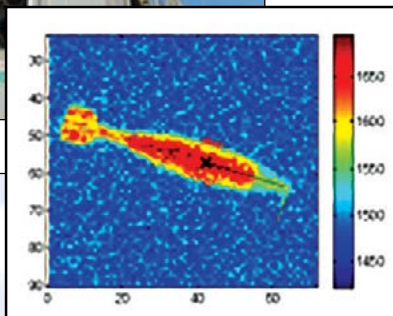
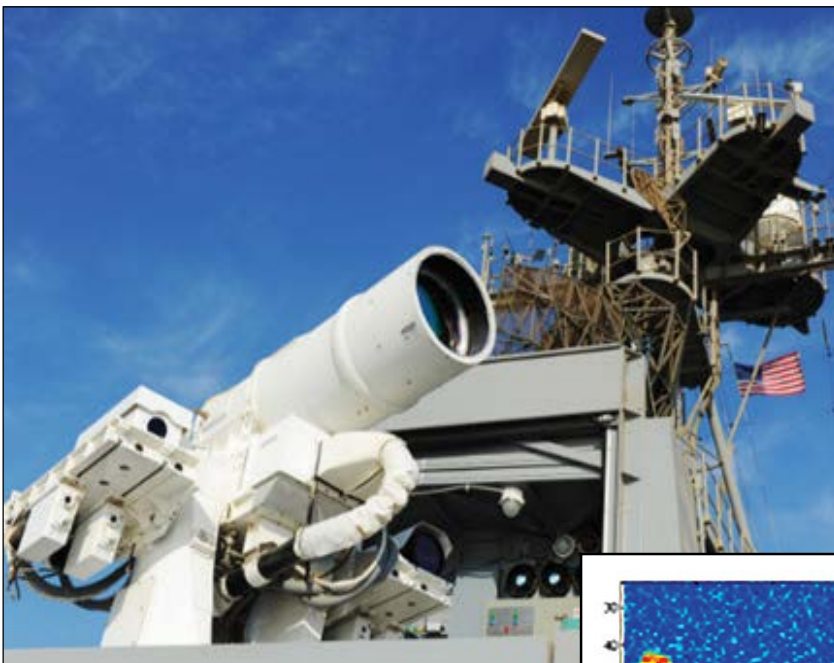
Richard Happel

rbhappel@nanoelectromagnetics.com

314-565-0029



Brashear



L3 Brashear is the 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 and at sea, L3 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 in the Persian Gulf area.

The beam director is the “gun” that shoots the laser “bullet.” It is the ruggedized optical system

that stabilizes the laser beam and keeps it on the moving target, significantly reducing down time and increasing lethality. Within the past year, L3 Brashear supports several HEL programs that are advancing the state-of-the-art for precision engagement weapon systems on multiple platforms up-to megawatt class lasers.

Scan /Detect

ID

Laser Beam Directors

Protection for our Warfighters



Protecting our warfighters and critical assets from inbound threats:

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



For more info:
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615 Epsilon Drive
Pittsburgh, PA 15238
412.967.7700
Sales.Brashear@L3T.com

Engage

Defeat

2108 DEPS program

High Energy Laser Systems for Directed Energy & Emerging Applications

Directed Energy Potential

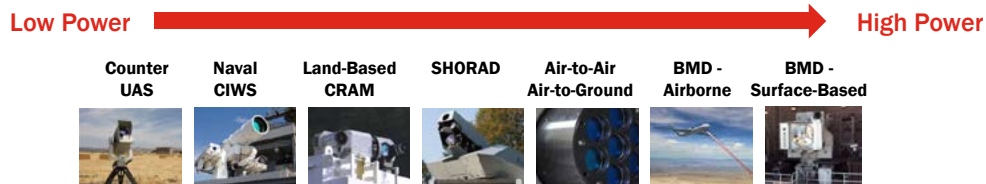
“Light speed” weaponry is a key component of the Department of Defense’s Third Offset Strategy, which seeks to develop long-range methods to counter adversarial threats. Laser-based systems are ideal for countering modern-day threats, as they offer very low consumable costs while also offering greater speed and range compared to conventional ballistic weapons.

Specifically, laser systems:

- Provide virtually instant target engagement
- Have low cost per shot
- Achieve highly focused damage on specific areas of a target for precision targeting

The successful integration of the Laser Weapon System (LaWS) aboard the USS Ponce has proven that directed energy is a viable defensive technology. The depth of applications for laser-based directed energy systems is extensive and includes anti-UAV, small ship deterrent, and missile defense. Each application and platform represents unique challenges and a wide range of performance requirements. The optical output power demanded can range from 10’s of kilowatts for counter-UAV applications to megawatts of power for intercontinental ballistic missile defense kill lasers.

Several laser technologies are being studied for scalability and deployability in the multitude of platforms that might serve as a home for directed energy weapons. Fiber lasers, solid state and hybrid (DPAL) lasers, among others, are being researched and developed by defense and industry partners. All of these lasers have one commonality: they use semiconductor laser diodes as pump sources.



Power scaling is not the only technical challenge in directed energy lasers. Weight and volume restrictions are of paramount importance for airborne applications such as the F-35 Joint Strike Fighter, AC-130 gunship, and lasers mounted on unmanned aerial vehicles. The US Department of Defense and DARPA are actively researching methods to drastically decrease the current weight/power ratio and volume of pump diodes for directed energy lasers.

Diode Pump Sources for Directed Energy Lasers

Due to the thousands of pump diodes required for directed energy laser systems, it is essential to develop and optimize the laser diode pump sources. Pump sources are the single largest contributors to the size, weight and costs of these systems.

The performance challenges on the diode pump sources are significant. In addition to power scaling, designers are under significant pressure to miniaturize and reduce the weight of these diodes as well as greatly increase their brightness and efficiency.

Key laser diode performance parameters include:

- Operation at temperatures ranging from -40°C to +80°C and beyond
- Maintaining brightness of the pump diodes as laser systems scale up in power
- Physical size and weight reduction
- Improving optical conversion efficiency
- Reducing complexity of optical systems
- Minimizing demands on the external power supply

Lasertel has been working tirelessly to meet and exceed these performance metrics.

Laser Diode Bars

With wavelengths available from 760nm to 1700nm, the semiconductor laser diode bar (1cm) is the most basic element of the system. A variety of cavity lengths and fill factors can be chosen to optimize for performance. Typically, electrical-to-optical efficiencies >60% can be achieved. Both high average power and high peak power laser diode bars are available.

Laser Packaging

Lasertel's T6 package is a heat sink building block used to deliver very high power to the laser diode bars while also efficiently maintaining operation temperature. The T6 uses high performance heat sink materials that are expansion matched to minimize thermally induced mechanical stress. Up to 50 individual diode bars can be mounted on each T6. The small form factor and back-mounted mechanical and cooling fluid interfaces allow for multiple devices to be stacked in very close proximity, enabling megawatt-level scalability while maintain brightness. This package has been qualified for harsh MIL environments including airborne qualified systems.

Beam Shaping and Collimation

A high degree of beam collimation is needed to focus and shape the light into the desired form factor needed for pumping or direct diode illumination. To minimize the physical footprint and weight of the device, it is advantageous to perform this collimation at a micro optic level. The T6 package allows for the addition of fast and slow-axis lenses, as well as more advanced optics that correct for smile and pointing errors, all of which can be attached directly to the laser diode package. These optics are attached using a proprietary process that provides extreme physical ruggedness and maintains alignment over large temperature ranges. Additional beam shaping and focusing can be added to provide a well-conditioned, homogenized output beam. Designs have been developed for coupling the light into a delivery fiber, direct coupling into a solid state rod or slab or directly on target.

Scalability

Scaling power is essential for directed energy systems. Lasertel manufactures systems capable of megawatts of power with a common coolant and electrical manifold. These laser diode systems have provided brightness over 11kW/cm² and total powers over 1 Megawatt per unit.



T6

Fluid Cooled Laser Diode Array

- Scalable building block
- Reliable in harsh environments
- Advanced beam conditioning



Megawatt

Collaborative research with LLNL proves T6 scalable density.



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

32,000+/-

employees worldwide

\$10B

annual revenue

\$3.9B

Defense &
Intelligence

\$1.2B

Advanced
Solutions

\$3.6B

Civil

\$1.7B

Health

TECHNICAL CORE COMPETENCIES



SENSORS,
COLLECTION, AND
PHENOMENOLOGY



CYBER



SYSTEMS
ENGINEERING AND
INTEGRATION



SOFTWARE
DEVELOPMENT



DATA SCIENCE



ENTERPRISE IT
MODERNIZATION



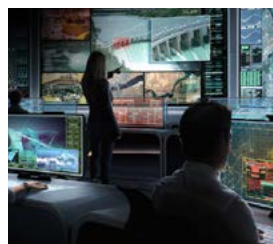
OPERATIONS
AND LOGISTICS

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.



DEFENSE & INTELLIGENCE

Provides a diverse portfolio of systems, solutions, and services covering air, land, sea, space, and cyberspace for Defense and Intelligence customers worldwide.



CIVIL

Delivers a range of aviation systems and integration, complex logistics and infrastructure support, cybersecurity and analytics, facility and campus management and operations, energy engineering, environmental management, IT infrastructure modernization and transportation security solutions.

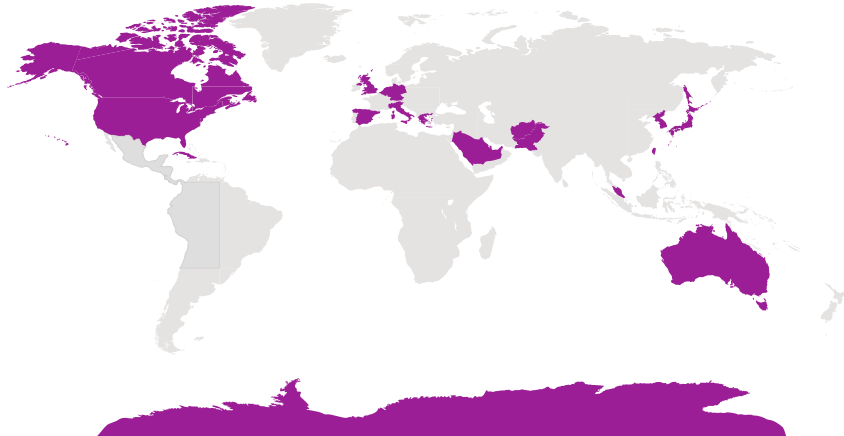


HEALTH

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.

EXPANDED GLOBAL FOOTPRINT

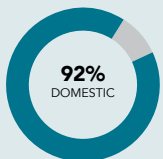
Leidos is well positioned for growth, with subject matter experts currently operating in 410 locations around the world, including more than 2,000 employees in international locations.



KEY LOCATIONS

Baltimore, MD	Afghanistan
Bethesda, MD	Antarctica
Columbia, MD	Australia
Frederick, MD	Canada
Gaithersburg, MD	Germany
Houston, TX	Japan
Orlando, FL	Korea
Reston, VA	Kuwait
Rockville, MD	Italy
San Diego, CA	United Arab Emirates
Washington, DC	United Kingdom

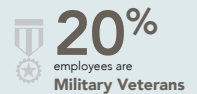
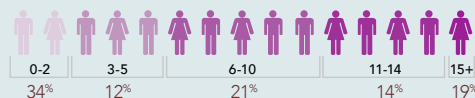
GLOBAL FOOTPRINT



CLEARED PROFESSIONALS



YEARS OF SERVICE



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.



Mike Chagnon
PRESIDENT,
ADVANCED SOLUTIONS
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Angie Heise
PRESIDENT,
CIVIL GROUP



Tim Reardon
PRESIDENT,
DEFENSE &
INTELLIGENCE GROUP



Jon Scholl
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ANY FEEDBACK FOR US?

We always want to hear from our customers and teammates
Contact Us Today [leidos.com/contact](https://www.leidos.com/contact)



Laser Weapon Systems

Innovative Warfighting Solutions For The Services

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.

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

ATHENA (ADVANCED TEST HIGH ENERGY ASSET)



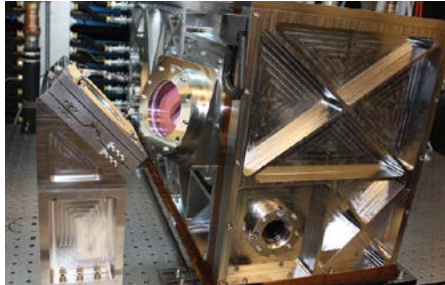
- A LM-designed and integrated ground-based, transportable laser weapon system
- At 30 kW represents the first and highest fiber laser power level highest power level documented by a laser weapon system of this type, while retaining excellent beam quality and electrical efficiency providing an advanced adaptive optics beam control system to enhance lethality and range
- An affordable, integrated system that has demonstrated capability of addressing multiple threats, including UAS, rockets, mortars, and small boats

HELIOS (HIGH ENERGY LASER AND INTEGRATED OPTICAL-DAZZLER WITH SURVEILLANCE)



- The high-energy fiber laser will be designed to counter unmanned aerial systems and small boats
- HELIOS sensors will be part of an integrated weapon system, designed to provide decision-makers with maximum access to information. HELIOS data will be available on the Lockheed Martin-led Aegis Combat System.
- The HELIOS dazzler will be designed to obscure adversarial UAS-based ISR capabilities.

RELI (ROBUST ELECTRIC LASER INITIATIVE) FOR ARMY HIGH ENERGY LASER MOBILE TEST TRUCK (**HELMTT**)



- 60 kW class laser currently integrated into the Army's HELMTT vehicle
- Currently undergoing testing in relevant tactical environments against targets such as rockets, mortars, and UASs
- Scalable architecture that demonstrates enhanced laser supportability and graceful degradation
- Highly reliable solid state laser architecture with >8 hrs of operation at high power, and >5,000 laser shots

LANCE (LASER ADVANCEMENT FOR NEXT GENERATION COMPACT ENVIRONMENT)



- Air Force's SHIELD (Self-Protect High Energy Laser Demonstrator) Laser Weapon System will demonstrate aircraft self-defense capability during subsonic-supersonic flight demonstration
- SHIELD LANCE advances spectral beam combined (SBC) fiber laser packaging to provide high beam quality 50-kilowatt class HEL in aircraft pod

HEL TVD (HIGH ENERGY LASER TACTICAL VEHICLE DEMONSTRATOR)



- Army demonstrator addresses Indirect Fires Protection Capability (IFFC) missions
- Mobile 100 kW-class laser weapon system to counter rocket, mortar, and UAS threats for fixed site protection
- Compact, efficient Spectrally Beam Combined fiber laser with high Power in the Bucket efficiency (PIBE)
- Advanced adaptive optics improves system performance, even in harsh weather conditions
- Low jitter, agile beam director for enhanced lethality

LPLD (LOW POWER LASER DEMONSTRATOR)



- Missile Defense Agency (MDA) laser beam control program designed to demonstrate applicability of DE to boost-phase kill by propagating a lethal high-power laser beam over a very long-range from a high-altitude airborne platform
- Developing technology and system design under MDA contract
- Leverages expertise in laser system architectures, ballistic missile defense system integration, platform integration, optics and beam control



Maritime Laser Weapon Systems

Proven, capable, affordable

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN



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

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**HELMTT - High Energy Laser
Mobile Test Truck**



Concepts to Capabilities

Radiance Technologies Inc. is a premier, employee-owned small business providing engineering, integration, testing, operational support, and technology and prototype development for military and intelligence communities.

Our business is organized into five groups which focus on Intelligence Analysis, Cyber Research, Technology Development, Operational Support, and Engineering Services where Radiance has built a strong capability in the High-Energy Laser (HEL) domain.

We provide analysis, design, test, verification, and integration for HEL weapon system development. We can model, simulate, and analyze the end-to-end HEL engagement from beam generation, through the beam train and atmosphere, and finally to the target, including target effects.

Radiance takes great pride in our successful track record of support to the DoD, armed services, intelligence agencies, and other government organizations and is proud to be a key member of the Army's HEL development efforts.

Distribution Statement A: Cleared for public release. PAO8181

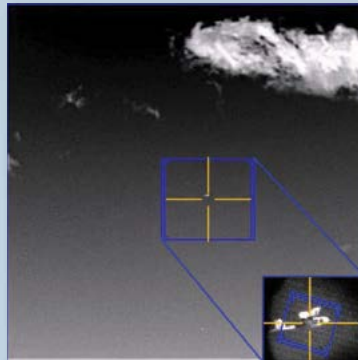
350 Wynn Drive | Huntsville, AL 35805 • (256) 704-3400

High-Energy Laser Technology Development



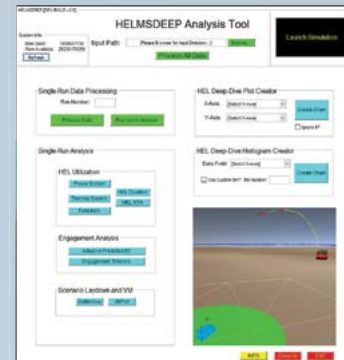
HEL SIL - High Energy Laser System Integration Lab

- Develop and operate U.S. Army Space and Missile Defense Command/Army Forces Strategic Command's High Energy Laser (HEL) System Integration Lab (SIL)
- Functions include the ability to Prototype, Analyze, Verify, and Validate HEL weapon systems and related emerging technologies



ATHELA - Advance Technologies for High Energy Laser Applications

- ATHELA's primary focus is improved performance and increased technology readiness levels for laser and beam control technologies
- Technology focuses include Enhanced Tracking Research, Adaptive Optics and High Energy Laser Concepts (Direct Diode and Fiber Lasers)



HELMSDEEP - High Energy Laser Modeling Suite for the Development of Enhanced Expeditionary Products

- Provides user capability to perform system and subsystem analyses of high energy laser (HEL) systems
- Models propagation and target damage, and provides analyses of HEL weapon target assignment strategies



SEMSS-RD - Systems Engineering and Modeling and Simulation for AFRL RD

- SEMSS-RD delivers systems engineering support for development of directed energy systems, specifically trade studies, schedules, program plans, and test strategies
- SEMSS-RD currently supports the Self-Protect High Energy Laser Demonstrator (SHIELD) program with integrating a HEL system onto a tactical aircraft



SSLT - Solid State Laser Testbed

- Premiere HEL Facility for HEL Lethality Testing and Full Scale Dynamic Engagements
- Designed to investigate the military application of SSLs in realistic test conditions



HELMTT - High Energy Laser Mobile Test Truck

- Integration, test, and verification of new and emerging technologies in support of high energy laser development
- Demonstration and data collection support to verify effectiveness of HEL in operational environments with the purpose of anchoring model development

RT18-0100

HIGH-ENERGY LASERS

BLAZING

AHEAD

Arming today's warfighters with tomorrow's weapons, Raytheon delivers high-energy lasers and combat-proven sensors in a single package. Now you can neutralize the most agile of threats with the most advanced laser defense system.



[Raytheon.com/lasers](https://www.raytheon.com/lasers)



Raytheon

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RAYTHEON LASER SOLUTIONS

Raytheon is defining the future for high-energy laser weapon systems (HEL), target designators and next-generation Light Detection and Ranging (LIDAR) devices. Our combat-proven sensors and ready-now technology bring trusted, innovative and adaptable solutions that dominate the battlefield.

ACCELERATING TOMORROW

High-energy lasers are no longer the stuff of tomorrow. Right now, Raytheon is field testing mature, fully integrated systems designed to counter the evolving threat.

In May 2017, Raytheon completed the world's first successful HEL weapon engagement from a rotary-wing aircraft. In a series of follow-on ground demonstrations, the company integrated its HEL weapon system onto a Polaris MRZR™ all-terrain vehicle and downed over 90 UAVs in multiple DoD exercises.

Raytheon's rugged and modular weapon system is designed to detect, identify, track, and defend against enemy missiles, mortars, swarming boat attacks and other asymmetric threats.

At the system's core is an advanced variant of Raytheon's widely deployed Multi-Spectral Targeting System.™ It provides unmatched Intelligence, Surveillance and Reconnaissance (ISR) capabilities while also delivering precision accuracy as a HEL beam director.

In addition to weapon systems, Raytheon continues to break new ground on rugged, high-power laser devices, including Raytheon's proprietary planar waveguide technology.

BENEFITS:

- High survivability, rugged design with straightforward scalability to higher output power
- Single-screen user interface with gamer-style controller
- Compact and lightweight
- Efficient heat removal and thermal management
- Modular, low-maintenance design
- Automated queuing from the full spectrum of EO/IR sensors
- Proven manufacturing experience



Raytheon



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