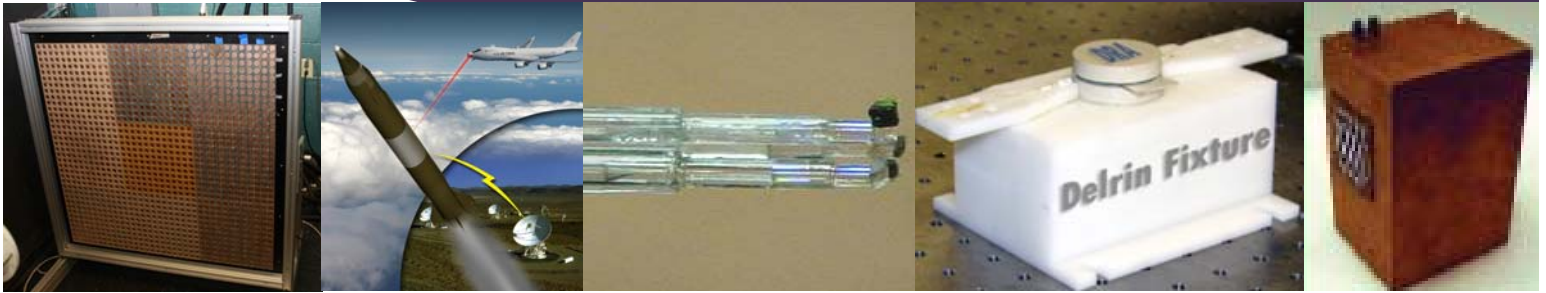




# Directed Energy Test Science and Technology



The Directed Energy Test Science and Technology (DET S&T) Focus Area was initiated at the direction of the Office of the Secretary of Defense (OSD) Test Resource Management Center (TRMC) due to the current inability to conduct required full spectrum test and evaluation (T&E) on emerging directed energy (DE) weapon and threat systems prior to fielding. To support high fidelity T&E of future revolutionary DE weapons, timely S&T investments to fill high priority test shortfalls are required now to develop critical, nascent technologies for utilization by DoD test ranges, facilities, and laboratories. This focus area aims to mature and then transition enabling technologies to reduce the engineering development risk of test capabilities required by test ranges. Successful DET S&T projects produce verified prototypes by advancing high risk, high payoff technologies for transition into a full T&E capability required for effective DE weapon system evaluation.

## DET Focus Area Objectives

The objective of the DET Focus Area is to ensure the required innovative test technology infrastructure (methodologies, instrumentation, data/information, and modeling and simulation tools) is matured for use by DoD test ranges for DE systems T&E. On an annual basis, DET coordinates with the DE T&E community, including Major Range and Test Facility Base (MRTFB) sites, service laboratories, test ranges/facilities, the Directed Energy Test and Evaluation Capability (DETEC) team, and DE program offices to identify DE test shortfall areas requiring S&T investigation. These high risks, high payoff topic areas are developed for inclusion in the annual DET S&T Broad Agency Announcement (BAA) solicitation that Government, industry, and academia partners may respond to. The BAA submissions are reviewed by an all Government, multi-Service T&E/S&T Working Group that provides recommendations to the DET S&T Executing Agent (EA) for contract award prioritization.

## DET Focus Area Description

The DET Focus Area defines DE in terms of high energy laser (HEL) and high power microwave (HPM) domains and identifies DE T&E areas requiring S&T research. The established DET S&T Focus Area process enables smart investment decisions based on verified current and future test requirements. The focus area funds DET S&T projects that address verified DE T&E capability shortfalls by advancing prototype technologies from the laboratory setting into the outdoor operational test range environment. Successful projects may be transitioned directly to other DoD agencies for field T&E use or to other funding sources for follow-on engineering development into a matured T&E capability (such as DETEC) prior to a field agency transfer.

## Completed DET S&T HPM Projects

- 1. Directed Energy Data Acquisition Transformation (DEDAT).** The Naval Surface Warfare Center, Dahlgren Division (NWSCDD) in Dahlgren, VA produced the Compact Remote Digitizer for HPM and pulsed power test and measurement.
- 2. Microwave Test Diagnostics (MTD).** L-3 Communications Titan Corporation Applied Technologies/JAYCOR in Albuquerque, NM developed a rugged stand-alone data recording system that enables measurement of key HPM coupling parameters in both laboratory and live-fire tests of dynamic targets.
- 3. Dielectric Field Probes (DEFP).** Integrated Photonics Technology (IPITEK) in Carlsbad, CA and Brigham Young University (BYU) in Provo, UT developed technology consisting of non-intrusive, miniaturized waveguide-based sensors to measure electric fields, polarity, power density, and effects on HPM target electronics at microchip resolution.
- 4. Dielectric Antenna Electro-Optical Sensor (DAEOS).** The University of California, Los Angeles (UCLA) produced a non-intrusive sensor that innovatively embeds an electro-optical microdisk in a dielectric resonator antenna, using whispering gallery mode detection for wide acceptance angle sensing to measure electric fields during HPM narrowband irradiation.
- 5. Compact Three-Axis Sensor (CTAS).** The Naval Research Lab (NRL) in Washington, DC created a prototype for a low cost, compact electro-optical, non-intrusive sensor capable of providing three-axis E-field vector measurements to account for polarization and beam orientation in confined and free-space HPM irradiation test scenarios.

## Completed DET S&T HEL Projects

- 1. Range Profiles of Turbulence (RPOT).** Georgia Tech Research Institute (GTRI) in Atlanta, GA developed the brassboard device that was transitioned to the U.S. Army High Energy Laser System Test Facility. This instrumentation technology enabled remote measurements to characterize the distributed strength of the atmospheric optical turbulence along a HEL beam path as an improvement over prior inaccurate point balloon system measurements. The resulting test measurements can be used to predict the impact of optical turbulence on laser weapon propagation.
- 2. Laser Protected Antenna (LPA).** Science Applications International Corporation (SAIC) in Albuquerque, NM developed novel ways to shield missile termination flight termination system (FTS) antennas from errant HEL beams using material/laser response and thermal performance modeling followed by laser survivability and radio frequency (RF) performance tests.
- 3. Bistatic Optical Imaging Sensor (BOIS).** Photon Research Associates in San Diego, CA produced a 2D hyperspectral imager utilizing a fiber-based integral field sensor to provide spectrally-resolved imagery of airborne targets being engaged by HEL weapons. This imager enhances the Advanced Pointer Tracker at White Sands Missile Range in New Mexico.

## On-Going DET S&T Projects

### *HEL Remote Imagery Sensor Projects*

- **Quantum Well Infrared Photodetectors/Computed Tomographic Imaging Spectrometer (QWIP/CTIS).** The U.S. Army at White Sands Missile Range (WSMR), NM and the Jet Propulsion Lab (JPL) in Pasadena, CA are developing the QWIP/CTIS technology to image near- and mid-infrared (NIR, MWIR) laser beams simultaneously incident on the same target while allowing for separation of multiple laser spots at different wavelengths and intensities for detailed evaluation of HEL system performance.
- **T&E Adaptive Optics System (TAOS).** The U.S. Army and NewTec at WSMR, NM and the Air Force Research Laboratory Starfire Optical Range (SOR) in Albuquerque, NM are developing the TAOS by applying real-time passive adaptive optics and post-processing image reconstruction techniques to compensate for the severe effects of atmospheric distortions on multi-spectral test imagery. This improved spatial resolution and accuracy of remote imagery of airborne targets against HEL weapon systems will enhance evaluation of laser-target interaction.
- **Multiple Waveband Temperature Sensor (MWTS).** The U.S. Army at WSMR, NM and JPL in Pasadena, CA are developing the MWTS. The project will result in a highly stable, monolithically integrated, high resolution infrared

detector array sensor that records registered thermal imagery in four infrared wavebands to infer dynamic temperature profiles on a laser-irradiated ground target.

- **Absolute Irradiance Imaging System (I2S).** Optical Physics Company in Calabasas, CA is developing a remote imaging sensor system that employs a target illuminator probe beam at wavelengths close to the HEL beam and aerosol backscatter to characterize HEL irradiance on target.

#### *HEL Non-Intrusive Beam Profiling Projects*

- **HEL Target Board (HTB).** Georgia Tech Research Institute is developing HTB, a large scale prototype scattering diffuser target board based on photo-thermal refractive (PTR) glass that has low absorption, ruggedness, and survivability for HEL beam diagnosis during simultaneous lethality tests.
- **Temperature and Irradiance Sensor Matrix (TISM).** AEgis Technologies in Huntsville, AL is developing a low profile, conformal matrix of photoconductive detectors non-intrusively adhered to missile target surfaces to telemeter accurate incident spatial irradiance and target surface temperature maps.
- **Beam Irradiance on Target System (BITS).** SemQuest Inc. in Colorado Springs, CO is developing a survivable optical collector array to HEL irradiance that can be mounted on the outside of a flight target/target board and couple to internal shielded detectors, then measure and transmit HEL irradiance with user-selectable location accuracy with minimal interference on HEL-target lethality, target dynamics, and target optical signature.

#### *HEL Target Surface Temperature Measurement Projects*

- **Precision Radiometric Surface Temperature Sensor (PRST).** Bodkin Design & Engineering in Newton, MA is developing a 2D hyperspectral imager using 60 wavebands from NIR-MWIR, producing 3D radiometric data-cubes, and applying algorithms based on temperature-emissivity separation to generate both radiometrically correct surface temperature and emissivity maps.
- **Surface Temperature Estimation Tool (STET).** Northrop Grumman Corporation in San Antonio, TX is employing Constrained Non-Linear Least-Square minimization algorithm and extensions to estimate surface temperature and time-dependent temperature maps without knowledge of the emissivity of the material.

#### *HEL Rear Surface Temperature Sensor Projects*

- **Heat Flux Sensor Array (HFSA).** University of Missouri, Columbia is developing the HFSA that comprises an array of micro-heat flux sensors embedded on the rear surface target surface to determine dynamic front surface temperature profiles using 3D inverse heat conduction codes.
- **Inversion-derived Resistive Temperature Sensors (IRTS).** AEgis Technologies in Huntsville, AL is responsible for the IRTS project, which aims to produce ink-jet printable conformal sensor arrays applied to rear target surfaces to determine dynamic front surface temperature maps with physics-based heat models.

#### *HEL Projects to Enable Open Air Range Tests*

- **Integrated Atmospheric Characterization System (IACS).** Georgia Tech Research Institute in Atlanta, GA is leading the design, development, and testing of the IACS project that fabricates a prototype light detection and ranging (LIDAR)-based system to characterize water vapor, atmospheric turbulence, and aerosol content at long distance HEL slant beam paths.

#### *HPM Non-intrusive Electric Field Sensor Projects*

- **Advanced Polymer Optical Sensors (APOS).** IPITEK of Carlsbad, CA is furthering all-dielectric, non-intrusive channel waveguide, polymer-in fiber, and slab-coupled configured electro-optical sensors that utilize highly sensitive and reliable polymers to map HPM irradiation at microchip resolution.

#### *HPM Non-intrusive Magnetic Field Sensor (or both EO/MO) Projects*

- **Magneto-Optical Field Sensors (MOFS).** Opteos in Ann Arbor, MI is developing prototype fiber-coupled, magneto-optical sensors for polarimetric field detection using the Faraday Effect during HPM irradiation at microchip resolution.

- **Spectrographic Magnetic Field Sensor (SMFS).** Ktech Corporation's SMFS effort produces an innovative, truly non-intrusive magnetic optical field sensor that employs magnetic moment coupling materials with spectroscopic infrared detection techniques to quantify HPM magnetic fields within confined test targets.
- **Integrated Electro-Magneto-Optic Sensor (IEMS).** Naval Research Laboratory, Washington, D.C. is developing a prototype fiber-coupled 3-axis sensor that measures both the electric and magnetic fields simultaneously from the same location using 50 meter long optical fibers from a laser diode probe beam.

#### *HPM Projects to Support Threat Systems*

- **Microwave Rotary Attenuator (MRA).** Ktech Corporation in Albuquerque, NM is developing the prototype MRA device that enables continuous and dynamic power variation irradiated out of the DETEC HPM Narrowband Threat Systems Capability. MRA includes a rotary joint with resistive cards that vary HPM attenuation, a significant improvement over fixed, frequency-dependent foam sheets.
- **Dual Oscillator for Microwave Generation (DOMG).** ITT is advancing the balanced dual oscillator pulser technology utilizing a single high voltage spark gap switch with a parabolic antenna to generate wideband HPM irradiation above 2 GHz.

#### *HPM Projects to Support Emerging Test Gaps*

- **Scanning Target Board (STB).** Scientific Applications and Research Associates, Inc. (SARA) in Cypress, CA is developing STB, a W-band HPM target board that will use an array of compact, multi-layered wideband patch antennas to directly measure and map the power spectrum emitted from a W-band HPM source.
- **Cine Radiography Imagery Measurement (CRIM).** L3 Communications in San Leandro, CA is developing the prototype CRIM instrumentation device that permits the rapid, successive x-ray imaging of short duration explosive-driven HPM sources for performance evaluation.
- **Skin Heating/Electric Field Strength Measurement Sensor Network (SHEF).** Research Triangle Institute (RTI) International in Research Triangle Park, NC is developing prototype co-located fluorescent temperature & wearable W-band patch antenna arrays with data acquisition systems to provide subject-under-test skin diagnostics.
- **Terahertz Imaging Profiler Array (TIPA).** Aegis Technologies in Huntsville, AL is developing a prototype 0.2-1.4 THz-band detector array and optical beam steering subsystem to quantify beam profiles of new THz sources.

### DET S&T Program Status

DET S&T is an on-going TRMC focus area to mature critical T&E technology required for the full spectrum DE testing and to create viable transitions for test range field applications. Annually, DET identifies high priority DE test technology shortfalls, releases them in a Broad Agency Announcement (BAA), and awards selected innovative high risk, high payoff solutions based on available funding.

### DET S&T Broad Agency Announcement Opportunities

The BAA is released yearly in March-April timeframe with selected projects awarded between October-December. Additional information regarding BAA solicitation for interested bidders may be viewed at both FedBizOpps (FBO) and Army Single Face to Industry (ASFI) links below:

**FBO Link:** [https://www.fbo.gov/indexes=opportunity&mode=form&id=c5d77301912cfa27917026077e2b0e02&tab=core&\\_cview=1](https://www.fbo.gov/indexes=opportunity&mode=form&id=c5d77301912cfa27917026077e2b0e02&tab=core&_cview=1)

**ASFI Link:** [https://acquisition.army.mil/asfi/solicitation\\_view.cfm?psolicitationnbr=W900KK08R0012](https://acquisition.army.mil/asfi/solicitation_view.cfm?psolicitationnbr=W900KK08R0012)

*For more information about the DET S&T Program, please contact :*

*Mr. Minh Vuong, DET S&T Executing Agent, U.S. Army PEO STRI*

*12350 Research Parkway, Orlando, FL 32826*

*Tel: 407-384-5238 • Email: [minh.vuong@us.army.mil](mailto:minh.vuong@us.army.mil)*