# TECHNOLOGY MILESTONES

## vol. 14

AIR FORCE RESEARCH LABORATORY

# AFRL Technology Milestones Program

## AFRL's Mission: Creating the Future

The Air Force Research Laboratory (AFRL) is only Air Force organization wholly dedicated to leading the discovery, development and integration of warfighting technologies for our air, space and cyber forces. AFRL creates the Air Force future while maintaining focus on the challenges of today's warfighter needs, providing game-changing technology solutions that alter the face of battle.

## AFRL Technology Milestones Program

The AFRL Technology Milestones Program highlights the achievements of AFRL's workforce of approximately 10,370, more than 60% of whom are scientists and engineers. These Technology Milestones provide context to each accomplishment's significance in addressing urgent warfighter needs, pursuing discovery, and transitioning results to military and commercial interests.

AFRL's expertise spans the full technologic spectrum of Air Force needs, and organizes collaboration and innovation to build on the strength of each individual field of research. These Technology Milestones summarize the Lab's research and development contributions that were started, completed, or gained steady progress in 2011.

For more information on any Technology Milestone item, please visit the AFRL Technology Milestones Program Web site, located at **http://www.wpafb.af.mil/news/index.asp?catid=163**.

WILLIAM N. MCCASLAND
Major General, USAF
Commander

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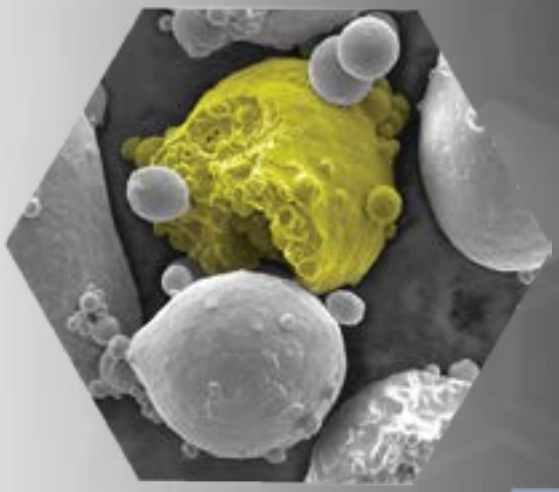
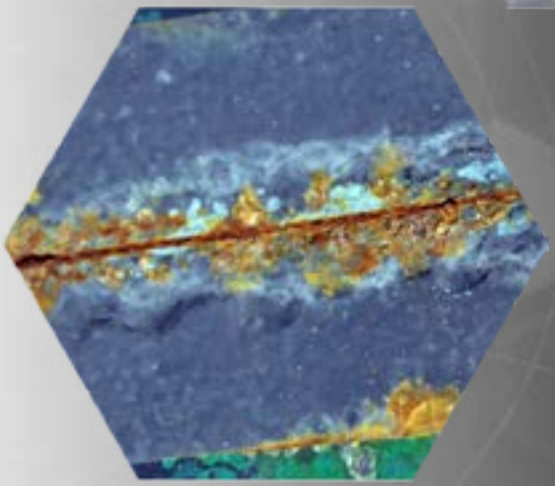




# Introduction

The Air Force Science and Technology Milestones assembled in this book often represent the combined effort of several scientists and engineers, or groups thereof, working as a team. The basic research, applied research, and follow-on technology development efforts described herein are essential to the continued success of the Air Force mission. This book is a compilation of notable Technology Milestones selected from the following categories.

**Response to Needs**

Technology that demonstrates potential for, or has already achieved, application on a developmental or operational Department of Defense system and/or technology that provides "quick-reaction" response to problems or needs of field organizations.

**Discovery**

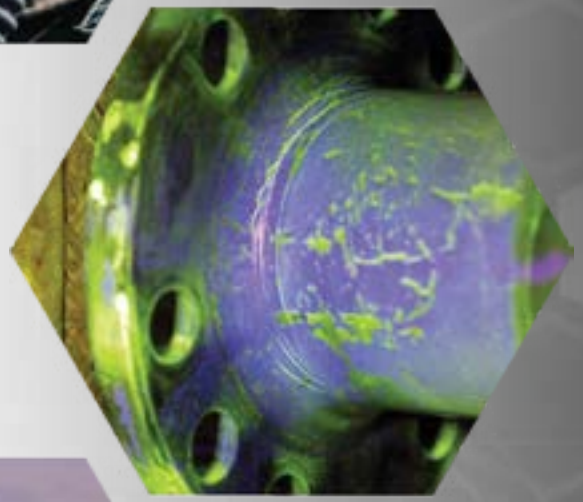
Major innovative technological advancements that offer significant potential for existing and future Air Force systems

**Tech Transition/Transfer**

Technology that has transferred from the laboratory to the private sector, to include industry, academia, and state and local governments.

**Awards and Recognition**

Acknowledgment of AFRL contributions within the science and engineering community at large, concerning technology advancements in the areas of technology transition, technology transfer, or technical achievement.



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# AFRL Technologies

**711th Human Performance Wing (711 HPW)**

*Mission Statement:* The 711th Human Performance Wing's advances human performance in air, space, and cyberspace through research, education, and consultation and supports the most critical Air Force resource – our operational military forces. The Wing's primary focus areas are aerospace medicine, human effectiveness science and technology, and human systems integration. In conjunction with the Navy Aerospace Medical Research Laboratory and surrounding universities and medical institutions, the 711 HPW functions as a Joint Department of Defense Center of Excellence for human performance sustainment and readiness, optimization, and enhancement.

- Human Effectiveness Directorate
  - Forecasting
  - Decision Making
  - Bioeffects
  - Training
- Human Performance Integration
  - Human Performance Optimization
  - Human Performance Sustainment
- USAF School of Aerospace Medicine
  - Office of the Dean
  - Aerospace Medicine
  - International and Expeditionary Education and Training
  - Occupational and Environmental Health
  - Preventive Medicine and Public Health
  - Aeromedical Research
  - Military Training

**Air Force Office of Scientific Research (AFOSR)**

*Mission Statement:* As a vital component of AFRL, AFOSR's mission is to support Air Force goals of control and maximum utilization of air, space, and cyberspace. AFOSR accomplishes its mission by investing in basic research efforts that support the Air Force mission in relevant scientific areas. Central to AFOSR's strategy is the identification of long-range technology options for national defense, as well as the timely transfer of related scientific knowledge to industry, the academic community, and government laboratories that foster developmental research leading to revolutionary technologies for the Air Force.

- Aerospace, Chemical, and Material Sciences
  - Mechanics of Multifunctional Materials and Microsystems
  - Surface and Interfacial Science
  - Organic Materials Chemistry
  - Molecular Dynamics
  - Theoretical Chemistry
  - Molecular Design and Synthesis
  - High-Temperature Aerospace Materials
  - Low-Density Materials
  - Hypersonics and Turbulence
  - Flow Control and Aeroelasticity
  - Space Power and Propulsion
  - Combustion and Diagnostics
  - Multi-Scale Structural Mechanics and Prognosis
- Physics and Electronics
  - Atomic and Molecular Physics
  - Information Processing and Storage
  - Multi-Scale Modeling
  - Plasma and Electro-Energetic Physics
  - Electromagnetics
  - Laser and Optical Physics
  - Remote Sensing and Imaging Physics
  - Space Sciences
  - Quantum Electronic Solids
  - Adaptive Multimode Sensing and Ultra-High-Speed Electronics
  - Optoelectronics: Components, Integration, and Information Processing and Storage
  - Sensing, Surveillance, and Navigation
- Mathematics, Information, and Life Sciences
  - Complex Networks
  - Bioenergy
  - Robust Computational Intelligence
  - Systems and Software
  - Information Operations and Security
  - Sensory Information Systems
  - Computational Mathematics
  - Information Fusion
  - Dynamics and Control

- Mathematical Modeling of Cognition and Decision
- Natural Materials and Systems
- Optimization and Discrete Mathematics
- Collective Behavior and Socio, -Cultural Modeling

**Air Vehicles Directorate**

*Mission Statement:* The Air Vehicles Directorate (RB) plans, formulates, and directs US science and technology development (research, exploratory, and advanced) for military air vehicles; orchestrates and executes technology developments in aeronautical/control sciences and aerospace structures; integrates air vehicle technologies across all AFRL technology directorates at the systems level; and orchestrates this technology development with Department of Defense and national labs, industry and academia, the National Aeronautics and Space Administration and Federal Aviation Administration, the North Atlantic Treaty Organization, and other foreign research agencies. *(*See footnote.)*

- Propulsion Integration
- Weapons Integration
- Experimental Aeronautical Sciences
- Flow Control/Flow Physics
- Plasma Physics
- Low-Speed Aerodynamic Configurations
- High-Speed Aerodynamic Configurations
- Multidisciplinary Computational Research
- High-Speed Computational Research
- Applied Computational Science
- Control Systems and Theory
- Unmanned Air Vehicle Cooperative Control
- Space Access and Hypersonics Guidance and Control
- Flow Control, Mechanization, and Automation
- Simulation-Based Research and Development
- Multifunctional Structures
- Hybrid Structures
- Composite Structures
- Metallic Structures
- Thermal Structures
- Adaptive Structures
- Structural Health Assessment
- Computational/Analytical Certification
- Combined Environments (Structures)
- Multidisciplinary Design and Demonstration
- Aeroelasticity Analysis Methods
- Structural Integrity
- Structural Dynamics
- Experimental Structures
- Air-Space Operations
- Photonic Flight Control
- Adaptive Control
- Software Verification and Validation
- Systems Engineering "Lite"
- Thermal Systems

**Directed Energy Directorate**

*Mission Statement:* Lead the discovery, development, and delivery of directed energy science and technology for national security.

- High Power Electromagnetics (HPEM): Dominate the battlespace with advanced adaptive electromagnetic weaponry that defeats adversary capabilities
  - HPM Sources
  - Pulsed Power
  - High Energy Beam & Plasma Physics
  - HPM System Integration
  - HPM Effects, Modeling & Simulation
- Laser Systems (LS): To engage and rapidly negate, through laser projection from airborne platforms, any target, offensively and defensively, from the ground to the edge of space
  - Lasers
  - Beam Control
  - Laser Systems Integration Technologies
  - Laser Effects, Modeling & Simulation
  - Laser Systems Demonstrations
- Directed Energy and Electro-0ptics for Space Superiority (DEEOSS): Ground-based electro-optic-derived knowledge is a highly-valued and integral part of our Nation's critical Space Situational Awareness capabilities
  - Atmospheric Compensation and Imaging
  - Electro-Optical Phenomenology and Signatures
  - Data Integration and Directed Energy Effects
- Weapons Modeling and Simulation (WM&S): Develop accurate physics & effects based models to predict and characterize impacts of directed energy and kinetic systems across all domains
  - Systems and Missions Modeling and Simulation



** While AFRL combined RB and RZ to form a single entity—Aerospace Systems (RQ)—in July 1, 2012, the Technology Milestones captured herein occurred prior to this merger and are thus presented as such. Please note, however, that the contact information for all RB and RZ items does reflect details as updated for RQ.*

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## Information Directorate

*Mission Statement:* The Information Directorate leads the discovery, development, and integration of affordable warfighting information technologies for the nation's air, space, and cyberspace forces.

- Information Dominance (ground, air, and space systems,)
- Information Exploitation
- Information Fusion
- Communications and Networking
- Information Management
- Advanced Computing Architectures
- Information Exploitation
- Information Fusion
- Information Understanding
- Signal Processing
- High-Performance and Adaptive Computing
- Collaborative Environments
- Advanced Displays and Intelligent Interfaces
- Modeling and Simulation
- Information Assurance
- Intelligent Information Systems (including intelligent agents, planning/scheduling and decision aids, knowledge bases, and access)
- Analytics
- Cyber Resilience
- Neuromorphic computing
- Trusted computing architectures
- SA across air, space, & cyberspace
- Cyber agility
- Resilient cyber systems
- Trusted hardware and software
- Mission-focused autonomy
- Contested environments
- Quantum Computing
- Decision making technologies

## Munitions Directorate

*Mission Statement:* The Munitions Directorate leads the discovery, development, integration, and transition of affordable precision engagement technologies for our air, space, and cyberspace force.

- Munitions Energetic Materials:
  - Energetic Material Formulation
  - Energetic Material Processing
  - Computational Energetics
  - Energetic Material Characterization & Phenomenology
- Damage Mechanisms Science:
  - Material Science
  - Computational Multiphase Flow
  - Computational Solid Mechanics
  - Energy Conversion
  - Energy Coupling
  - Non-Traditional Defeat Mechanisms
- Fuze Technology:
  - Fuze Energetic Initiation Science & Technology
  - Hard Target Defeat Fuzing Technology
  - High-G Shock and Vibration Simulation & Modeling
  - Feature Extraction for Fuze Aimpoint Detection & Selection
  - Fuze End Game Sensing Technology
- Terminal Seeker Sciences
  - Target Re-Acquisition and Recognition Theory
  - Radio Frequency (RF) Seekers
  - Electro-Optic (EO)/Infrared (IR) Seekers
  - Bio-Inspired, Multispectral, Multi-Aperture Seekers
- Munitions Aerodynamics, Guidance, Navigation and Control
  - Navigation
  - Control
  - Guidance & Avionics
  - Munitions Aerodynamics Sciences
- Munition System Effects Sciences
  - Weapon Target Interaction
  - Virtual Environment Simulation
  - Physical Effects Simulators/Stimulators
  - Applied Munitions System Simulation Sciences
  - Seekers & Guidance
  - Navigation
  - Control Algorithms
  - Airframe
  - Inertial sensors

- Fuzes
- Warhead & Explosive

• Critical Technical Functions
- Propulsion
- Data link
- Power
- Carriage & Release
- Human-in-the-loop
- Expertise in the areas of all Calibers of guns

**Materials and Manufacturing Directorate**

*Mission Statement:* Plan and execute the USAF program on materials and manufacturing in the areas of basic research, exploratory development, advanced development and industrial preparedness. Provide responsive support to Air Force product centers, logistics centers, and operating commands to solve system and deployment related problems and to transfer expertise.

• Advanced Materials for Thermal Protection Systems & Structures
• AESA Radar Producibility
• Agile Protection (Sensors/Personnel)
• Air Base Security Technology
• Advanced Propulsion Manufacturing
• Biotechnology
• Datalink Component Affordability
• Electromagnetic Hardening Materials
• Electronic Fault Detection
• Energy Harvesting Materials and Devices
• Engine Systems Prognosis
• High Energy Laser (HEL) Source Materials
• Integrated Defense
• Liquid Rocket Engine Materials
• Manufacturing Readiness Assessments
• Material State Awareness (Structures/Propulsion)
• Materials for Hypersonic Glide Vehicles
• Microbiology and Applied Biochemistry
• Nanomaterials Technology
• Optical Technology
• Persistent Air ISR
• Proactive Threat Defeat - Laser Source Materials
• Quick Turn Warm Structures
• Root Cause Analysis & Solutions for Material Failures (Electronic/Structural)
• Sensor Hardening (Space/Airborne)
• Solid State Beam Steering Materials
• Spacecraft Propulsion Materials
• Structural Hardening Assessment
• Turbine Engine Rotor and Blade Life Prediction/Extension S&T

**Sensors Directorate**

*Mission Statement:* "To lead the discovery, development, and integration of affordable sensor and countermeasure technologies for our warfighters."

• Radio Frequency (RF) Sensing
• Electro-Optical (EO) Sensing
• Net-Centric Spectrum Warfare
• EO Electronic Warfare
• Layered Sensing Exploitation
• Enabling Sensor Devices/Components

**Propulsion Directorate**

*Mission Statement:* The Propulsion Directorate (RZ) plans and executes the Air Force's basic research, exploratory development, and advanced development programs for flight vehicle propulsion and power technology; conducts in-house research and development to exploit new opportunities, maintain technical expertise, and verify contractor findings; provides technical and management assistance in support of studies, analyses, development planning activities, acquisition, test, evaluation, modification, and operation of air, space, and weapons systems and related equipment; provides the principal Air Force interface with scientific, industrial, educational, and other government agencies; and serves as the Air Force Materiel Command focal point in these technical areas. *(*See footnote.)*

• Turbine Engines
• Rocket Engine Test Facilities
• Turbine Engine Augmentors
• Solid-Fueled Ramjets
• Turbine Engine Bearings
• Solid Propellants
• Combined-Cycle Engines
• Solid Rocket Boosters
• Subsonic and Supersonic Combustion
• Solid Rocket Service Life
• Compressors
• Solid Rocket Motors



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- Turbine Engine Controls
- Carbon Fibers and Composites
- Turbine Engine Diagnostics
- Ceramic Processing
- Endothermic Fuels
- Computational Chemistry
- Engine Starting Systems
- Electric Propulsion
- Engine Health Monitoring Systems
- High-Energy-Density Matter
- Exhaust Nozzles
- Injectors and Spray Measurements
- Fans
- Laser Propulsion
- Fuel Pumps and Fuel Systems
- Liquid Rockets and Combustion
- Gas Generators
- Micropropulsion
- Gears
- Monopropellants
- High-Cycle Fatigue (and its mitigation)
- Nontoxic Propellants
- Ignition Prognostics
- Plume Phenomenology
- Lubrication Systems
- Power Conditioning Equipment
- Oil Specifications, Diagnostics, and Analysis
- Propulsion Fluid Dynamics
- Oil Monitors
- Rocket Materials
- Optical Diagnostics
- Rocket-Based Combined-Cycle Engines
- Pressure-Sensitive Paints
- Solar Propulsion
- Pulsed-Detonation Engines
- Thermal Management
- Scramjets (supersonic combustion ramjets)
- Thermionics
- Seals
- Auxiliary Power Units
- Turboramjets
- Batteries and Fuel Cells
- Turboshaft Engines
- Capacitors
- Very Short Takeoff and Landing Propulsion
- Circuit Breakers
- Air Turborockets
- Converters/Inverters
- Hybrid Rockets
- Electric Motors
- Intercontinental Ballistic Missile Propulsion
- Conventional and Superconducting
- Liquid-Fueled Ramjets
- Generators

## Space Vehicles Directorate

*Mission Statement:* The Space Vehicles Directorate develops and transitions innovative high-payoff space technologies supporting the warfighter, while leveraging commercial, civil, and other government space capabilities to ensure America's advantage.

- Space Environment Impacts and Mitigation
  - Solar, solar wind, radiation belt/interplanetary, ionospheric effects; thermosphere and satellite drag; reentry environment; plasma physics and chemistry
- Space Electro-Optics/Infrared Technologies
  - Hyperspectral, hypertemporal, polarimetric imaging; space-based imaging; focal plane technologies; cryocoolers; nuclear explosion monitoring
- Space Platforms and Operations Technologies
  - Vibration isolation; deployable structures; lightweight structures; structural dynamics; space power; responsive acquisition and mission planning; guidance, navigation, control and autonomy; ballistic missile technology
- Space Electronics
  - Microelectronic foundations, components, integrated microsystems
- Space Experiments
  - Space system/payload development, integration, test, and flight; modeling and simulation; space system engineering.

# DynaMan Puts RPA Operators Back in the Pilot's Seat

*Bob Shaw, a retired AF Reserve pilot and subject matter expert for the 711th Human Performance Wing's Human Effectiveness Directorate, Warfighter Interface Division, Supervisory Control Interfaces Branch, evaluates the symbology and flight dynamic algorithms used in a DynaMan synthetic world.*

Remotely Piloted Aircraft pilots will fly like they're airborne thanks to a system that provides an enhanced ability to dynamically maneuver the plane. The AFRL is developing the system, logically named the Dynamic Maneuvering operator interface and informally known as "DynaMan."

Many Air Force (AF) missions require quick responses from pilots and maximum performance from aircraft. In the case of traditionally piloted aircraft, pilots move the stick and throttle and receive immediate feedback from the aircraft and environment. For Remotely Piloted Aircraft, the control loop is not as direct. During operations beyond the line of sight, there is currently a delay of about 1.8 sec between the pilot's control input and system feedback — the operator does not see the result of control input for nearly 2.0 sec.

Two of the most important pieces of information used by pilots in flight are the state of the aircraft (a plane's orientation and energy, such as altitude, airspeed and course), and the frame of reference (the horizon or direction of motion). This 1.8 sec lag inhibits a pilot's ability to perform precise maneuvers at a moment's notice.

With DynaMan, the pilot enters the desired control inputs using the familiar stick and throttle. The control station sends these inputs to the aircraft and to the simulations, and both destinations execute the control inputs upon receipt. The simulation displays the instantaneous response of the simulated aircraft and the virtual world, allowing for smoother control of the vehicle. The aircraft response is received 2.0 sec later and is compared to the simulation response. Any differences are applied to the simulation, bringing it in line with what actually happened.

In manned aircraft, the real world acts as the frame of reference for pilots. The RPA frame of reference is currently displayed as a narrow field of view of the real world – like looking through a straw. Addressing this impairment, DynaMan incorporates offboard datalink information that tells the pilot about objects surrounding the aircraft in airspace, such as clouds and other aircraft, providing pilots with a 360° view. The datalink information is currently simulated, but there are plans to begin feeding live datalink information into the system for evaluation.





*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# LASIK Shown to be Safe at Longer Exposure to Higher Altitudes

The AFRL's USAF School of Aerospace Medicine successfully completed the first high-altitude operational tests of vision following LASIK (laser-assisted in situ keratomileusis) eye surgery. The study demonstrated that LASIK recipients met the 20/20 vision standard under operational conditions up to altitudes of 35,000 ft. Previous studies were limited to 25,000 ft and were not conducted under hypobaric conditions. LASIK has been approved for Air Force aircrews since 2007.

There have been several published reports of temporary myopic (nearsighted) shifts among some individuals at prolonged high altitude exposure following LASIK. The magnitude of the shifts seems to be dependent on the altitude to which a person is exposed as well as the length of exposure. The altitude-induced myopic shifts result in temporary blurring of vision that recovers after descending from high altitude.

Previous studies examined visual stability after LASIK using nitrogen-filled goggles to induce corneal hypoxia simulating altitudes up to 25,000 ft. However, altitude exposure produces both hypoxic and hypobaric conditions at the surface of the cornea. Further, the USAF operational limit for exposure is 35,000 ft, significantly higher than previous studies. Using an AFRL altitude chamber, evaluation of refractive error and visual acuity among study volunteers following LASIK eye surgery was safely conducted at the 35,000 ft operational limit.

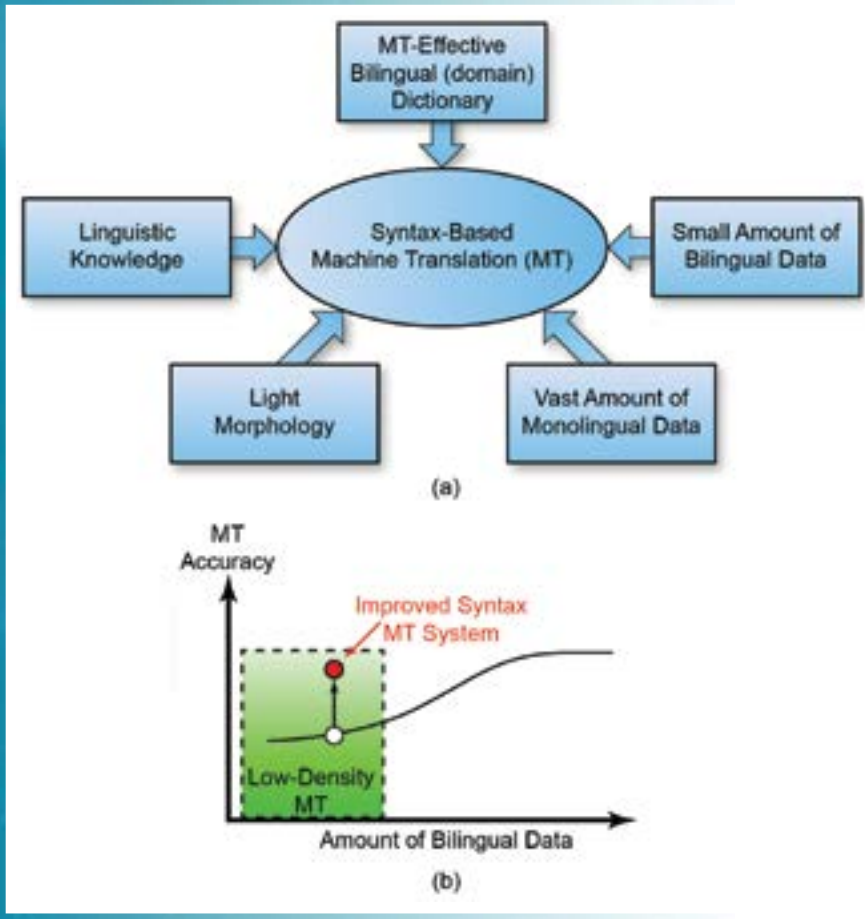
The present study demonstrated that LASIK study volunteers exposed to 35,000 ft for 30 min experienced no significant changes in refractive error or visual acuity. Thus, aircrew treated with LASIK are expected to function safely and effectively when exposed to these operational conditions.

*Chamber activities at USAF School of Medicine, studying the effect of LASIK surgery at higher altitudes.*



*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# Innovative Techniques Add Speed, Value to Language Technologies




*Further improvements to SDL Language Weaver's Syntax-based Machine Translation framework including the components listed in (a) resulted in additional Machine Translation Accuracy as seen in (b).*

Department of Defense (DoD) personnel operate all over the world, fighting in the Global War on Terror, bringing humanitarian relief, and working with coalition operations. Much of the information needed to effectively operate is in foreign speech and text; however, there is a critical lack of linguists to translate these sources. To address this problem, the DoD has funded the development of translators for both speech and text.

Currently, the development process has been slow and costly as the standard method to improve performance has been to collect, transcribe, and translate ever larger amounts of training data. While this involves low technical risk, it will not be able to address rapid turnaround requirements in new languages and domains of interest to the DoD. What's needed are innovative techniques that can perform at least on par with standard techniques but that do not require substantial new training data when being adapted for use in a new language and/or domain. SDL Language Weaver, a Small Business Innovation Research (SBIR) project, produced data-efficient learning techniques that significantly reduce development costs of high-accuracy machine translation systems, particularly for translating from and into morphologically rich, data-poor languages and domains. Morphologically rich languages use a large number of prefixes and/or suffixes that attach to word stems to affect meaning. Many such languages are of importance to the DoD.

The technologies developed by SDL Language Weaver consist of the SDL Language Weaver syntax-based machine translation (MT) approach; the construction of better, MT-effective dictionaries; the exploitation of smart, effective morphology analysis; and the integration of large-scale language models. These technologies led to accurate syntax-based machine translation products.

Rather than using the phrase-based machine translation approach that relies heavily on lexicalized translational phrase pairs, this project uses the SDL Language Weaver syntax-based approach that translates with syntax translation rules. A translation rule can either capture lexical translation information or encode abstract (or generalized) syntactic translation knowledge.

By leveraging additional data sources, and developing training techniques specific to handling the challenges of morphology rich languages, SDL Language Weaver can apply this knowledge to additional languages and domains.

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# AFRL Takes Up the SWORD to Assist Warfighters and Pararescuers

Researchers at the AFRL are transitioning to a new program to assist joint terminal air controllers (JTACs) and pararescue jumpers (PJs).

For several years, AFRL's 711th Human Performance Wing's Human Effectiveness Directorate enhanced (711 HPW/RH) technology for the Battlefield Air Targeting Man-Aided kNowledge (BATMAN) project. The BATMAN project is designed to reduce weight, integrate components, enhance ergonomics and improve operator interfaces – thus increasing warfighters' efficiency in the field. The BATMAN concluded at the end of Fiscal Year 2011 and is being replaced with the Specialized Warfighter Operations Research and Development (SWORD) program.

Under SWORD, the program will expand research to include the PJs, who perform rescue and recovery missions involving people and equipment behind enemy lines. They are part of the Guardian Angel Weapon System, which also includes combat rescue officers, and survival, evasion, resistance and escape specialists. So that AFRL's scientists and engineers could better understand the work of the Guardian Angel Weapon System, PJs from the 123rd Special Tactics Squadron Air National Guard Unit, Louisville, Kentucky, staged a rescue demonstration in the parking lot of the Tec^Edge Innovation and Collaboration Center in Dayton, Ohio.

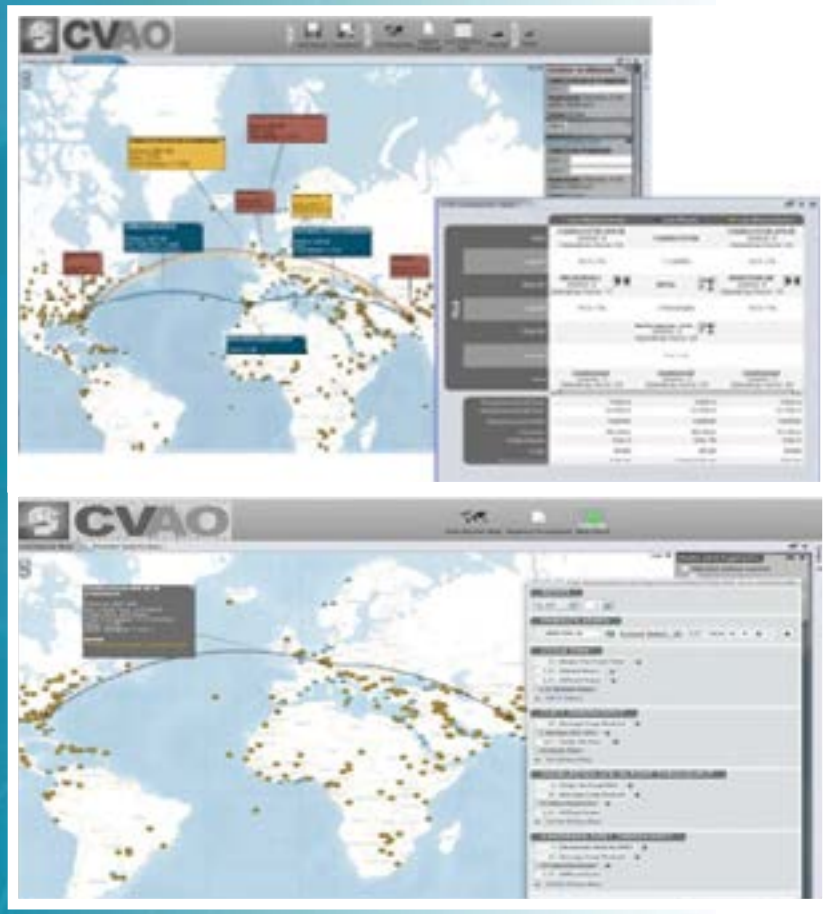
Using a junk car to represent a Humvee, four military personnel from the 711 HPW/RH acted as "victims" who were trapped in the vehicle following an explosion. By viewing the exercise from a Lab perspective, researchers will be able to determine if there is a better way to perform the mission, or adapt a technology to aid their efforts.


*PJs staged a rescue demonstration for researchers at AFRL's 711 HPW/RH at Wright-Patterson Air Force Base, Ohio.*



*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# Rapid Course-of-Action Analysis Capability Transitions to USTRANSCOM




*RCAT allows the Fusion Center to easily compare Transportation COAs by initial arrival date, mission count, cost and closure time. (pictured top) Fusion Center Planners can easily view and modify RCAT planning factors such as aircraft cycle time and throughput, resulting in more accurate COAs. (pictured bottom)*

The AFRL delivered a Rapid Course-of-Action (COA) Analysis Tool (RCAT) to the Agile Transportation for the 21st Century (AT21) program that was immediately transitioned for use at the US Transportation Command's (USTRANSCOM) Fusion Center.

The RCAT capability is the second phase of the Cognitive Visualization: Alerting and Optimization (CVAO) program, a USTRANSCOM-funded demonstration project that provides advanced visualizations to dramatically improve the fusion center's planning capabilities across a wide spectrum of logistics activities.

RCAT is a visual planning tool that leverages existing planning models to allow transportation planners to intuitively perform COA analyses in minutes, instead of hours or days. RCAT provides more precision in early planning resulting in less replanning through execution and more efficient use of mobility resources (planes, ships, fuel, crews, etc.).

The success of RCAT was because of the cognitive based design which more effectively integrates humans with complex automated systems such as transportation planning models. These approaches allow transportation planners to have confidence in the tool while minimizing required input and producing easily understood outputs.

RCAT automatically performs calculations in the background while transportation planners sketch out alternative COAs. The model is invoked through simple user gestures as COAs are defined (e.g. drawing routes) and responses are provided within the user's decision action cycle (seconds). RCAT provides visibility into the model's assumptions and planning factors so the user can better understand and work with the model. Finally, COA summary tables are automatically built for dynamic presentations to leadership where trade-offs on alternatives can be made in real time, replacing static PowerPoint presentations.

The immediate transition of RCAT occurred because of overwhelming user acceptance. An initial operating capability was fielded in September 2011 and is being used operationally today.





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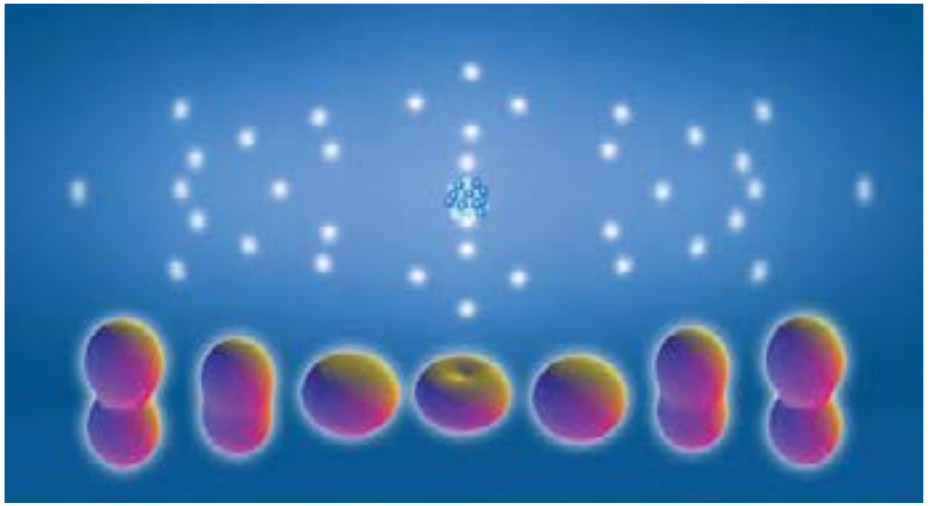
# Physicists First to Observe Electron Ejected from Atom

AFRL-supported physicists at the University of California, Berkeley, in collaboration with researchers from the Max Planck Institute of Quantum Optics and the US Department of Energy's Lawrence Berkeley National Laboratory, became the first researchers to observe the motion of an atom's valence in real time by investigating the ejection of an electron from an atom by an intense laser pulse.

In the experiments, an electron in a krypton atom is removed by a laser pulse that lasts less than four femtoseconds (one femtosecond is one millionth of one billionth of a second). This process leaves behind an atom with a pulsating positively charged hole in the valence shell, which originates from electronic wave functions of the atom.

The scientists used an extreme ultraviolet light pulse, the duration of which was 150 attoseconds (1 attosecond is one billionth of one billionth of a second), to capture and photograph the movement of valence electrons for the first time.

This research is expected to enable the scientists to better control processes and materials that will improve high-speed electronics and carbon-free energy sources that will benefit both the Air Force and consumers.



*This is the classical representation of electrons in a krypton atom.*



*For additional information on this technology contact AFRL/AFOSR* **publicaffairs@afosr.af.mil**, *(703)696-7797.*

# Flies in Flight Provide Insight for Aircraft Altitude Control Research

*A virtual reality tunnel for fruit flies allows simultaneous tracking of freely flying flies and computer-projected imagery on the walls and floor of the arena.*

AFRL-funded Caltech researchers are studying flying insects for inspiration and information on altitude control, hoping to transfer that intelligence into technology for a variety of Air Force aircraft. The study is focusing on how flies use visual information to guide flight in natural environments.

The scientists have found that, counter to earlier studies suggesting insects adjust their height by measuring the motion beneath them, flies in fact follow horizontal edges of objects to regulate altitude. Remarkably, this edge-following behavior is very similar to a rule they use for steering left and right and always turning toward vertical edges.

The scientists designed a virtual reality environment for their flying subjects which they found could regulate their altitude by enabling them to fly at the height of nearby horizontal visuals, such as the tops of rocks and vegetation.

"We developed a three-dimensional (3D) fly-tracking system which was our most significant technical challenge: localizing a fly in 3D nearly instantaneously," said Caltech's Dr. Andrew Straw. "Next, we developed visual stimulus software capable of making use of this information to project virtual edges and textured floors in which we could modify the fly's sensory-motor feedback mechanism."

The 3D fly-tracking system is significant because it will allow a rapid characterization of other fly behaviors with unprecedented levels of visual stimulus control.

Ultimately the scientists would like to build models of fly flight that can accurately predict behavior based on their sensory input and internal states. In the next phase, the scientists will study more sophisticated flight behaviors, investigating whether the fly creates a long-lasting neural representation of its visual surroundings or if flight is controlled by fast-acting reflexes.





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# Nanosat Review Winners Announced as New Competition Begins

Winners of the Nanosatellite-6 Program Flight Competition Review, sponsored by the American Institute of Aeronautics and Astronautics, were selected by a panel of judges from the AFRL Space Test Program, Air Force Institute of Technology and industry. The winners are:

- 1st Place: Michigan Technological University
- 2nd Place: Cornell University
- 3rd Place: University of Hawaii
- Best Outreach: Missouri University of Science and Technology
- Most Improved: University of Hawaii

The participants represented eleven universities: St. Louis University, Michigan Tech, Missouri S&T, Montana State University, University of Minnesota, University of Central Florida, Cornell University, University of Hawaii, Massachusetts Institute of Technology, Santa Clara University and Georgia Tech.

"One Nanosat-6 satellite will be selected from the winners and then given assistance by AFRL Space Vehicles Directorate to become fully flight ready," said Dr. Kent Miller, Air Force Office of Scientific Research (AFOSR) program manager.

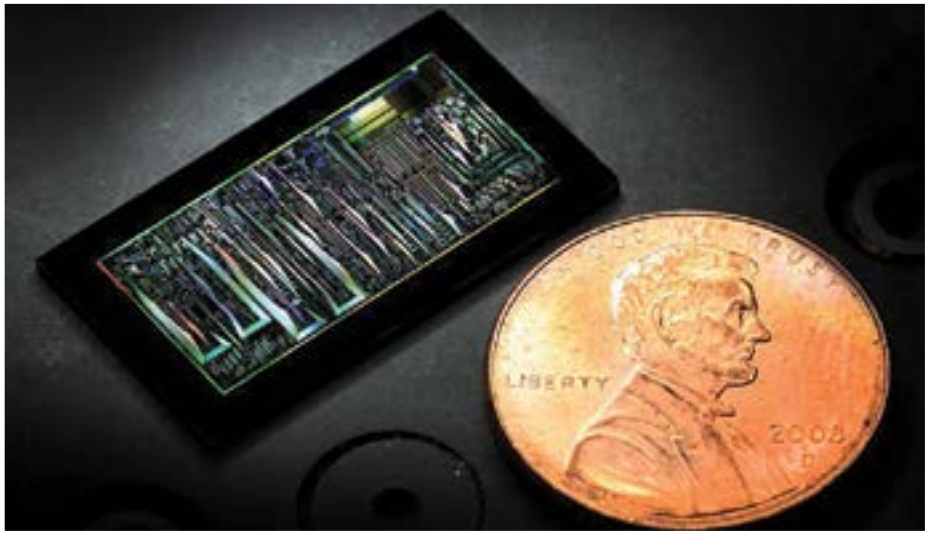
The University Nanosat Program's Nanosat-7 kick-off event occurred simultaneous to the Nanosat-6 event, and featured the following eleven universities which will participate in the competition: Boston University, Georgia Tech, University of Hawaii, University of Maryland, University of Michigan, Michigan Tech, Massachusetts Institute of Technology, Montana State, Missouri S&T, St. Louis University and the University of Texas, Austin.

The 2-year Nanosat programs begin with publication of a Broad Agency Announcement, which calls for proposals from principal investigators. A panel of experts evaluates the technical excellence of the proposals as well as their relevance to the Air Force mission, the qualifications of those who will administer the programs, and the quality of their educational program. The panel selects the universities for the program that culminates in the AIAA Flight Competition Review.

The University Nanosat program is run jointly by AFOSR and the AFRL Space Vehicles Directorate. This year's competition was held at the Sheraton Uptown Hotel in Albuquerque, New Mexico.

*NS-3 winner FASTRAC on its way to orbit.*

# Design Tools Aim for Silicon Optical Chips




*A common penny is shown to illustrate the actual size of a silicon photonic chip, shown in a dark-field optical image.*

In an effort to make it easier to build inexpensive, next-generation silicon-based electro-optical chips, which allow computers to move information with light and electricity, a University of Washington (UW) research team is developing design tools and using commercial nanofabrication tools.

The AFRL is funding this effort in silicon photonics, called Optoelectronic Systems Integration in Silicon, or OpSIS, at the university's Nanophotonics Lab in Seattle.

Unlike most research groups that design, build and test silicon photonic devices or optical chips in-house rather than at commercial chip fabrication facilities, the UW researchers are using shared infrastructure at the foundry at BAE Systems in Manassas, Virginia.

There they are working toward creating high-end, on-shore manufacturing capabilities that will be made available to the wider community. In the past few years, complex photonic circuitry has not been accessible to researchers because of the expense and a lack of standard processes.

The UW researchers are working on system design and validation so they can imitate what has been done in electronics by stabilizing and characterizing some processes so that the transition from photonics to systems can be smooth.

"The OpSIS program will help advance the field of silicon photonics by bringing prototyping capability within reach of startup companies and researchers," said research team leader Dr. Michael Hochberg. "They will provide design rules, device design support and design-flow development so that even non-experts will be able to design and integrate photonics and electronics."

Silicon photonics has developed over the last decade, and the transition from using devices to systems is something that has only recently occurred.





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# New Measurement Into Biological Polymer Networks

The development of a new measurement technology under a research project funded by the Air Force Office of Scientific Research (AFOSR)and the National Science Foundation is probing the structure of composite and biological materials.

"Our results have provided some of the first microscopic insights into a 60-year-old puzzle about the way polymeric networks react to repeated shear strains," said Dr. Daniel Blair, Assistant Professor,and principal investigator of the Soft Matter Group in the Department of Physics at Georgetown University.

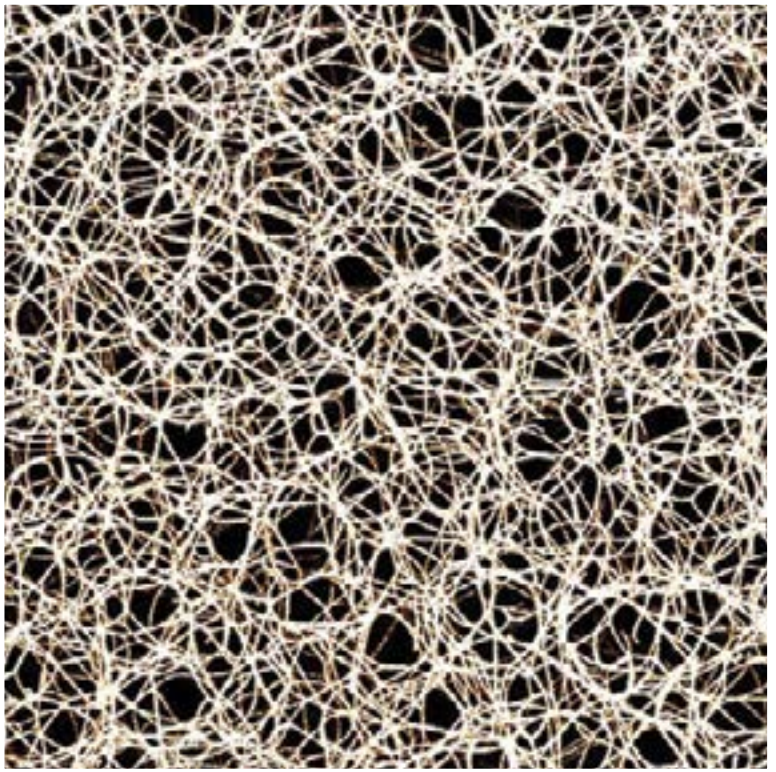
Blair, Professor Andreas Bausch and other researchers at the Technical University of Munich used the muscle filament known as actin to construct a unique polymer network. In their quest to understand more about bio-polymers, they developed the rheometer and confocal microscope system (measures the mechanical properties of materials), which provide a unique and unprecedented level of precision and sensitivity for investigating polymeric systems which were previously too small to visualize during mechanical stress experiments. The rheometer and confocal microscopes clearly visualized the fluorescently labeled actin network and they filmed the polymer filaments' movement in three-dimensional when mechanical stress was applied.

The rheometer and confocal microscopes will help to lay the groundwork for future generations of materials that will possibly be used to create synthesized muscle tissue for the Air Force. These materials may even be ideally suited for powering micro-robots. The microscopes enabled the scientists to see the shearing process during the Mullins Effect when biological polymers become dramatically softer as seen in conventional polymers. Moreover, these materials also demonstrate dramatic strengthening in a way that is very different compared to conventional polymeric solids.

The researchers' next steps will be to use the Mullins Effect as a mechanical standard for understanding the properties of composite and biological networks.

"We will use confocal-rheology as a benchmark system for generating new collaborations and expanding the technique to other AFOSR sponsored projects," said Blair.

Blair noted that the new technology is impacting a number of other AFOSR-supported projects as a platform for investigating the strengthening of nano-composite networks such as carbon nanotubes and cellulose nanofibers embedded in conventional materials.



*Confocal micrograph of an actin-filamin network.*



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# Research in Microscale Heat Transfer Will Benefit Military Systems

*Graduate student Huqrui Sun studies heat transfer at interfaces as part of a Multidisciplinary University Research Initiative.*

A 2-year-old Multidisciplinary University Research Initiative involving the AFRL the University of Michigan, Stanford University, Brown University, and the University of California at Santa Cruz, is making great strides in achieving a fundamental understanding of heat transfer at interfaces.

Heat transfer is important to the performance, power requirements, and reliability of many military and commercial systems, including thermoelectric refrigerators, waste heat recovery systems, heat sinks, power electronics, thermal barrier coatings, and thermal interface materials.

"Recent advances in nanoscience have enabled the precise control of interface physical and chemical structure, but the fundamental physics that link this nanoscale structure with thermal transport is not yet well developed, inhibiting the engineering of interfaces with radically enhanced thermal properties," said team lead Dr. Kevin Pipe, professor of Mechanical Engineering at the University of Michigan.

Interfaces can decrease a composite material's thermal conductivity by scattering the acoustic waves that are the primary carriers of heat in solids. The scattering process gives each interface a thermal resistance.

The researchers have made a number of achievements during the first two years of their effort, including the development of a high-speed thermal imaging system and a technique to measure the propagation of phonons, the elementary packets of vibrational energy that carry heat, with high signal-to-noise ratio. Using ultrafast laser systems that emit laser pulses less than 50 femtoseconds in duration, Pipe's team creates high-frequency acoustic waves at the surface of a material and in a process similar to medical ultrasound imaging measures how these waves scatter off of buried interface structures.

By applying precise nanofabrication techniques to create interfaces with known atomic structure, the researchers are able to link measured heat transfer properties with the predictions of atomistic simulations to yield further understanding of the fundamental processes involved.





*For additional information on this technology contact AFRL/AFOSR* **publicaffairs@afosr.af.mil**, *(703)696-7797.*

# "Reasoner" Evaluates, Suggests Fixes for System Health

A demonstration of the System Health Capability Reasoner was recently conducted, marking the maturation of this Integrated Systems Health Management (ISHM) technology from a PC-based, non-real-time simulation environment to a real-time simulation on avionics hardware representative of an actual vehicle.

This AFRL demonstration was conducted in conjunction with an industry team led by Lockheed Martin Space Systems, which developed the technology as part of a twelve-month technical effort. As part of the demonstration, simulated missions were run with varying failure modes and resulting mitigating actions. The effort successfully demonstrated the performance of the system running in a real-time simulation environment. This is an important step in the technology development because it demonstrates that the Reasoner is capable of operating under flight-like computational constraints.

ISHM technology assesses and determines the health (capability) of a system, relaying this information to vehicle flight controls to enable real-time trajectory re-planning if needed. The system's health information is also provided to ground crews, facilitating the most effective and efficient maintenance procedures and a quick return to service.

The System Health Capability Reasoner is part of the overall ISHM system. It determines system-level capability by monitoring the condition of each critical subsystem and then determining whether the vehicle is capable of meeting mission requirements.

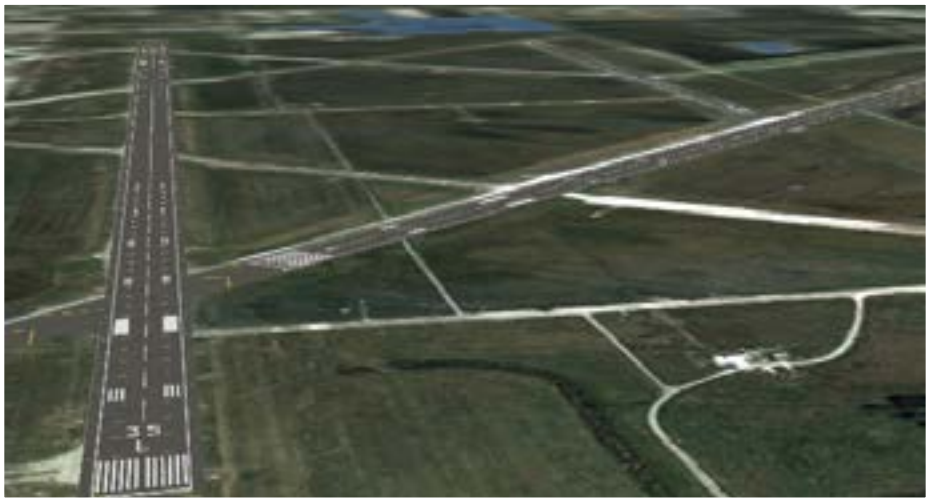
If the vehicle is determined not to be capable, the Reasoner determines possible actions to mitigate the problem. Potential actions can range anywhere from a simple adjustment to a mission abort. The technologies developed under this effort can be applied to any system that employs ISHM (RPA, UAS, hypersonics, etc).

*System Health Capability Reasoner demonstration may not look like much is going on, but the ISHM technology makes critical, real-time decisions on a system's health.*



*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# AFRL Steps Up Vital Role in Incident Investigations



*Computerized airfield simulation, designed by AFRL researchers to aid in the investigation of aircraft incidents.*

Computer simulations are often the best — and sometimes the only — way to piece together complexities of aircraft incidents, allowing investigators to virtually recreate events that are impossible to stage in a real-life scenario. Researchers at the AFRL are playing a key role in aircraft incident investigations through continuous advancements in database development and modeling.

In creating the most accurate terrain databases possible for simulations, AFRL researchers obtain vital information such as satellite imagery and elevation data. Once they have the necessary baseline data, they work on refining the databases, integrating features such as an airfield with the terrain.

AFRL's challenges include demand for quick turnarounds, complexity of the model, and revisions that are required after the model is integrated into the simulation. Because of their experience and ever-expanding library of terrain data, AFRL is ahead of the game in quickly producing quality databases. Most of the terrain databases are used to support AFRL programs, but as the capabilities expand, AFRL is providing more support to external customers such as Accident Investigation Boards. AFRL's ability to create these databases in-house results in significant cost savings, which allows funds to be allocated toward other necessary project needs.

To further expand capabilities, AFRL, in conjunction with InfoSciTex Corporation, is developing new open-source software for building databases. The new software will help reduce maintenance costs and further increase the speed at which researchers can produce the databases.





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# Unmanned Operational Envelope Expands Through Sense & Avoid Technologies

The AFRL took another step toward developing conflict and collision avoidance technologies for unmanned aircraft with the Multiple Intruder Autonomous Avoidance (MIAA) flight demonstration. The demonstration was a five-day effort to evaluate the software algorithms and other subsystems that make up the Sense And Avoid (SAA) Advanced Technology Demonstration (ATD). For the event, a Calspan Flight Research Learjet served as the in-flight simulator with a second Calspan Learjet, a Calspan Beech Bonanza, the FAA Tech Center's Beechcraft King Air, and the FAA Tech Center's Convair serving as intruder aircraft. During the demonstration, the in-flight simulator aircraft, equipped with the SAA system, encountered multiple intruding aircraft. Through these test scenarios, researchers were able to observe and gather data on the Electro-Optic sensors, Traffic Collision Avoidance System (TCAS), and Automatic Dependent Surveillance-Broadcast System (ADS-B), some of the key components of the SAA package.

These systems work in conjunction, each providing different information that is processed through a series of complex algorithms into data that provides inputs to the flight control system onboard the aircraft, identifying where and when to maneuver to avoid conflict and collisions. All the flights were successfully completed, with the researchers collecting valuable data on all the SAA components. The data gathered will be used to further refine the SAA algorithms to increase the variety of scenarios the system can process.

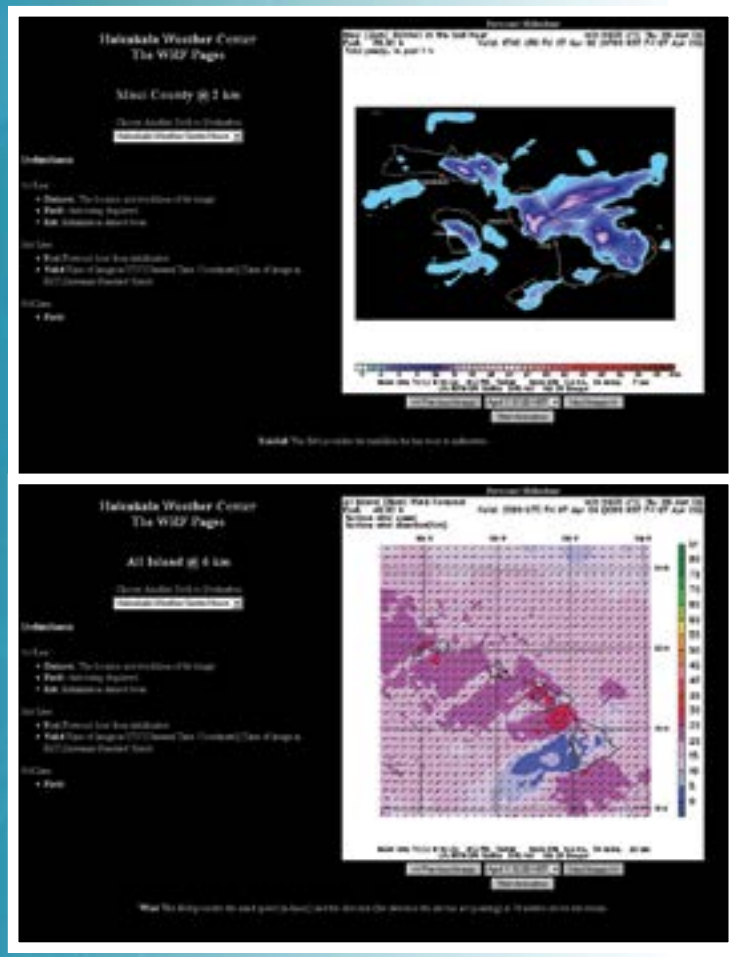
The SAA program seeks to expand confidence in autonomy and unmanned aircraft by using a series of sensors to detect other intruding vehicles, manned or unmanned, and maneuver to avoid conflict. Through this SAA program, researchers hope to move toward enabling the operations of unmanned aircraft in the National Airspace System.

*The MIAA team, which includes members from AFRL, Northrop Grumman, Calspan Flight Research, Birhle Applied Research, SelectTech Services, and FAA Hughes Tech Center, in front of Calspan's Lear Jet In-Flight Simulator.*



*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# Maui Center Tailors Weather Forecast Data to Telescope Needs




*Rain is forecast for the relevant areas (pictured top) and wind data (pictured bottom), provided by the Haleakala Weather Center to the AMOS site.*

When you're dealing with highly sensitive telescope operations, just knowing if it's going to rain is not enough. Weather plays a critical role in determining the effective use of AFRL's Air Force Maui Optical and Supercomputing (AMOS) site. The National Weather Service provides forecasts, but the information can be insufficient to accurately predict small-scale conditions that can adversely affect AMOS operations.

To provide more accurate forecasts, the Maui High Performance Computing Center (MHPCC) runs the Weather Research and Forecasting Model nightly to provide high-resolution forecasts to AMOS. The predicted weather conditions are posted every morning to **http://weather.mhpcc.edu** and are available for 48 hrs. These forecasts act as a decision aid in scheduling, and more specifically, planning for maintenance during conditions that would prevent operations.

The MHPCC, one of the Department of Defense supercomputing centers, has been forecasting weather since 2000 for AFRL's AMOS site. It has been based on many models, from the Regional Spectral Model, to MM5 (Mesoscale Model Version 5), to the most recent Weather and Research Forecasting Model. Over the years, the forecast has been refined to meet the needs of the AMOS operators, and many advances have occurred. This has been accomplished by posting relevant data to daily operations, improved fault tolerance to ensure high reliability, improved forecast accuracy through higher resolution runs, and use of better terrain and land use data, and improved capabilities such as examination of optical turbulence predictions through the Jackson and Dewan algorithm models.





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# Aero-Optics Beacon Corrects Turbulence Around Aircraft Platform

In response to an Air Force (AF) need for a beacon to correct for the near-field turbulence around an aircraft platform, the AFRL worked with Passat Inc. through a Small Business Innovation Research (SBIR) project to develop a technology that would assist in this correction. This Phase II SBIR project allows for the building of two kinds of imaging systems: (1) an airborne system for target imaging in turbulent atmospheres; and (2) a ground system for both satellite imaging and adaptive telescope adjustments for turbulent atmospheres. It is clear that the AF and the Department of Defense can use this technology to record existing interference patterns as well as to build sets of imaging recognition systems (i.e., ground - for satellites; airborne - for air and ground targets).

When an aircraft is in motion, a great deal of atmospheric turbulence is created and encountered. Aircraft with laser systems must address this turbulence as well as the distance to a target when performing various missions. Unfortunately, the combination of atmosphere and distance tends to greatly reduce the overall quality and effectiveness of the laser system. The end results include degraded end output and lowered energy-to-target measurement levels.

This SBIR innovation raises the possibility of accounting for atmospheric turbulence and disturbances. By correcting encountered turbulence and disturbances, a cleaner path from point A to point B can be achieved. This provides laser-system enabled aircraft with greater missile self-defense coverage and overall higher mission success rates.

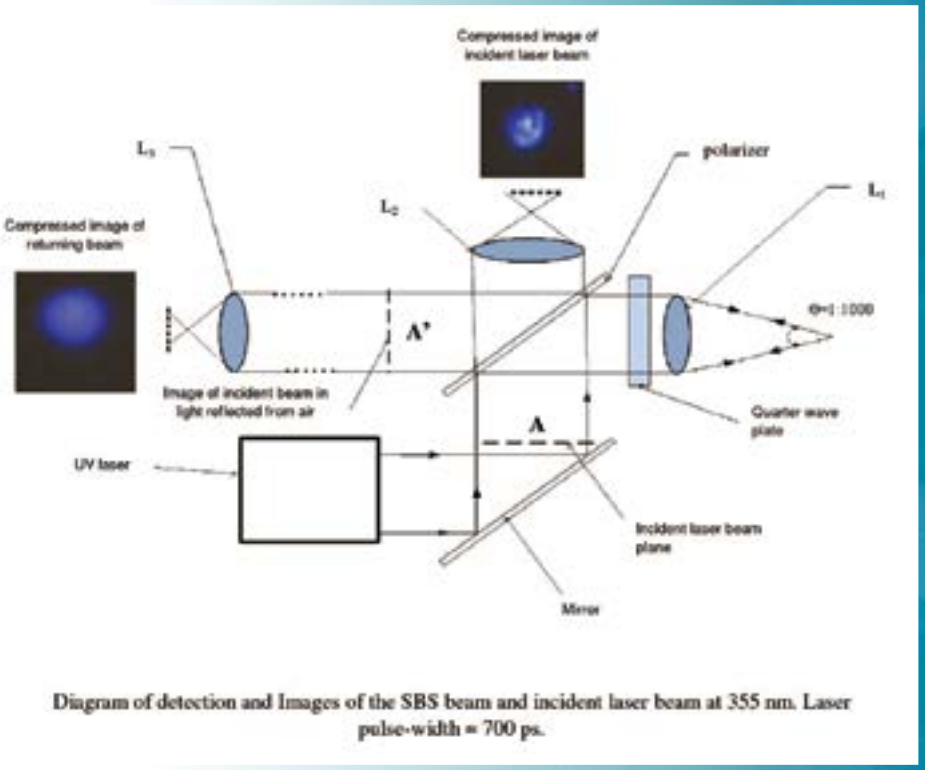


Diagram of detection and Images of the SBS beam and incident laser beam at 355 nm. Laser pulse-width = 700 ps.

*Diagram showing demonstration of excitation of a local beacon in air, via backward stimulated scattering which are realized in beam cleanup geometry in the form of coherent spherical waves.*



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# Single Board Computer Debugging Enhancements Up and Running


*A representation of the SBIRS SBC, now running.*

The Space Based Infrared System (SBIRS) Single Board Computer (SBC) is now running on the emulation board and has been verified via the program counter to run all the way through the boot code, just as the Register Transfer Level (RTL) version does.

The Universal Asynchronous Receiver/Transmitter (UART) has been confirmed to work. Regression tests have also been performed on the RTL, originally indicating errors in the floating point processor that have since been corrected. The next step is to implement debugging features and test the board at either Honeywell or Aerospace.

The current SBIRS program is designed to provide early warning of missile launches while simultaneously supporting other missions including missile defense, technical intelligence, and battle space awareness. This program will develop a software debugging system for use on the SBIRS. The approach uses an SBC emulation board that will have built-in debugging hardware capable of exporting desired data without affecting the SBC's program flow.

The SBC emulation board provides the potential for nearly infinite code visibility. By replacing one or more of the eight SBC boards with this form fit and function emulation board, useful debugging data can be extracted without perturbing the software. Tracking the program counter, specific register values, I/O, and myriad other functions can be accomplished without changing the timing, allowing for faster software debugging in the system.





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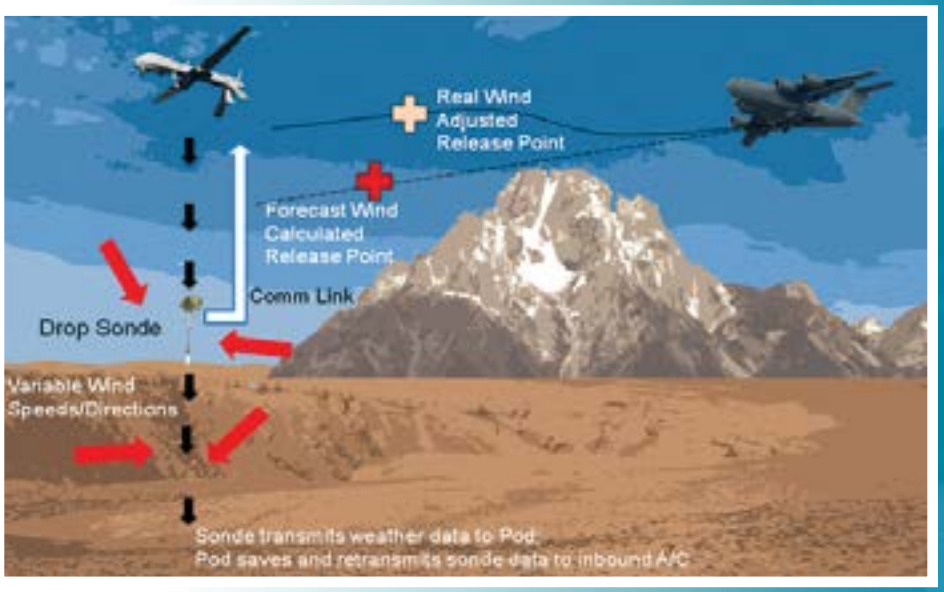
# AFRL Addresses Urgent Need for Single Pass Airdrop Capability

In response to urgent Air Force needs, a capability to conduct high-altitude airdrop operations without making two passes was developed by the AFRL.

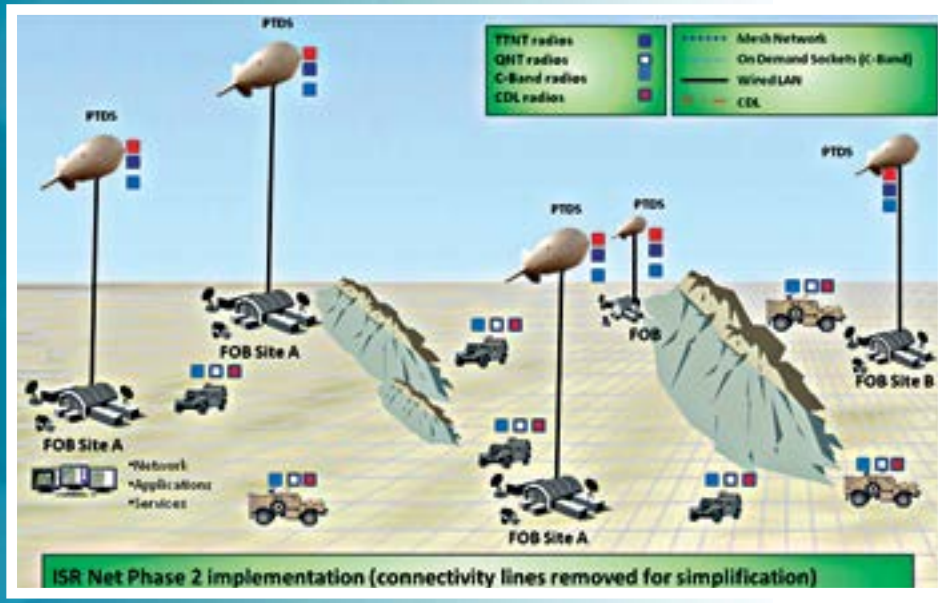
The current airdrop process requires two passes by the aircraft before dropping supplies, putting the aircraft at risk. The Single Pass AirDrop (SPAiD) solution requires one single pass as supplies are dropped. One concept being pursued is using a Predator to release a drop sonde that measures wind speeds and direction and sends this information to the aircraft with the supplies. The SPAiD program completed a successful Form/Fit/Function test of the M34 Tactical Meteorological System (TMS) Pod by successfully mounting it aboard an M299 Hellfire Missile rail on an MQ-1 Predator drone at the Gray Butte test facility in Palmdale, California. The Pod, a modified M34 Inert Hellfire Missile training device, equipped with TMS components, looks and feels like a Hellfire missile but contains no propellant, cannot be launched from an aircraft, and carries no explosives.

The Pod was developed as a solution to US Air Forces Central urgent operational need (UON) requiring a method to inconspicuously acquire local weather conditions over a dropzone, to enable the accurate delivery of airdrop bundles. The only remaining requirements to reach TRL-7 are a final flight test and operational system's demo aboard an MQ-1, Predator RPA tentatively scheduled for late 2011 at Creech Air Force Base.




*Single Pass AirDrop is being developed in response to an urgent operational need.*

# Tactical Targeting Network Technology Builds on Unit Strength




*TTNT and QNT are part of Airborne ISR-Net System.*

The USA, DARPA, and AFRL are rapidly fielding sophisticated airborne wireless networking solutions, known as Tactical Targeting Network Technology (TTNT) & tactical QUINT Networking Technology (QNT), as part of the ISR-Net Quick Reaction Capability (QRC) in response to an urgent operational need to provide dismounted soldiers with ISR products and network application support.

The ISR-Net QRC will deliver near-term, line-of-sight (LOS), Internet Protocol (IP) networking capabilities to minimize identified gaps in the theater communications architecture. ISR-Net links various types of radio networking equipment into a cohesive communications network. By combining a mixture of units together, a network is formed using the strengths of the different units. The ISR Net provides mesh networking capabilities between and across ground and air assets.

The system relies on the TTNT waveform to set up and maintain the airborne ad hoc network and manage network resources. QNT adds on demand sockets and provides a robust and affordable miniature, multiband modular capability to close the seams between tactical nodes. Current nodes are the Persistent Threat Detection System (PTDS) and Persistent Ground Surveillance System (PGSS) aerostats, various towers, as well as several ground vehicles.

TTNT airborne network wireless technology provides tactical targeting network capabilities for aircraft with low latency, high throughput, ad hoc network security authentication, real-time on-demand capacity allocation, complete coexistence with Link 16, minimal purchase cost/life cycle cost/installation, and network planning, monitoring, and management tools.

QNT is focused on providing improved tactical edge connectivity to allow warfighters on-demand access to tactical data (i.e. sensor video/imagery). A mesh network using the TTNT waveform provides basic airborne IP connectivity and allows for the setup of on demand 'socket' waveforms for higher rate sensor data. In addition to advanced mesh networking and socket waveform capabilities, the radio supports legacy communications interoperability.





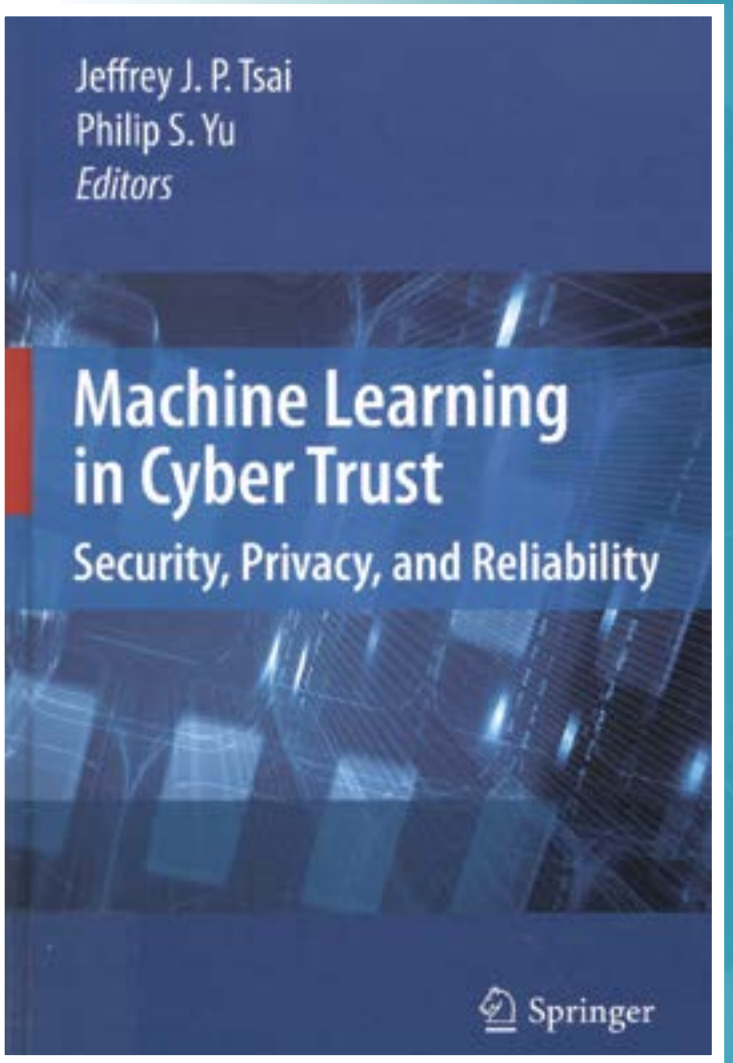
*For additional information on this technology contact AFRL/RI techinfo.if@rl.af.mil, (315)330-2143.*

# AFRL Publishes Chapter in Book on Cyber Trust

In collaboration with authors from Illinois Institute of Technology and the University of Illinois at Chicago, Dr. Kevin Kwiat of the AFRL published a chapter in the "Machine Learning in Cyber Trust" produced by the Springer Science and Business Media. This book contains original materials enabling readers to discover what types of learning methods are at their disposal and summarizing the state of the practice to guide those creating systems resistant to cyber attack.

Dr. Kwiat and his co-authors cast the trust issue as a continuous re-evaluation: a system's reliability and security are automatically scrutinized, not just before but during its deployment. They apply this to distributed, embedded control systems having a 24x7 availability requirement. A "zero downtime" mandate prohibits taking these systems offline so that they can evolve to the changing cyber-threat environment. However, the authors' solution allows for extending the capabilities of such systems even while the systems are operating.

Machine learning is critical in the study of how to build computer programs that improve their performance through experience. Machine learning algorithms have proven to be of great practical value in a variety of application domains. They are particularly useful for poorly understood problem domains where little knowledge exists for the humans to develop effective algorithms; domains where there are large databases containing valuable implicit regularities to be discovered; or domains where programs must adapt to changing conditions. Many networked computer systems are far too vulnerable to cyber attacks that can inhibit their functioning, corrupt important data, or expose private information. The field of cyber-based systems turns out to be a fertile ground where many tasks can be formulated as learning problems and approached in terms of machine learning algorithms.




*AFRL researcher Dr. Kevin Kwait and collaborators from the Illinois Institute of Technology and the University of Illinois at Chicago contributed a chapter to this book, Machine Learning in Cyber Trust: Security, Privacy and Reliability.*

# Thermal Battery Production Boosted by Title III Project

*Thermal batteries can remain inert for years, delivering instantaneous power when activated. They also have a high power output relative to their size, making them ideal for many strategic weapons systems.*

The AFRL has teamed with ENSER Corporation in a Defense Production Act Title III project to advance the domestic production capability for cobalt disulfide (CoS2) thermal batteries, which will be used in a wide variety of air-to-air, air-to-ground, and ground-to-air defense systems.

Thermal batteries have a number of unique applications because of their long shelf life and high-power output relative to their size. In thermal batteries that employ CoS2 cathode chemistry, a powder mixture electrolyte is placed between alternating cathode and anode material. As long as the electrolyte is solid, the battery can be stored for 20-years or more without suffering from loss of power. Relative to their alternatives, CoS2 batteries provide longer life and upward of 50% more energy output. Additionally, they offer better chemical stability and have a near metallic conductivity.

The Thermal Battery Title III program's goal is the establishment of a world-class manufacturer of CoS2 batteries. Working with The ENSER Corporation in Pinellas Park Florida, the project team has already installed new production equipment, significantly increasing the manufacturing capacity for high- performance thermal batteries provided to producers of guided munitions. They have automated labor intensive tasks and implemented Lean manufacturing and continuous improvement activities to improve manufacturing process control and lower costs. Further, the project has facilitated the installation of comprehensive on-site environmental testing capabilities, and has improved the in-house production of raw materials to support higher levels of production. Project officials are optimistic that this program will ultimately provide a domestic source of batteries that meets the growing Department of Defense demand for smarter and smaller weapon systems.





*For additional information on this technology contact AFRL/RX techinfo@wpafb.af.mil, (937)255-6469.*

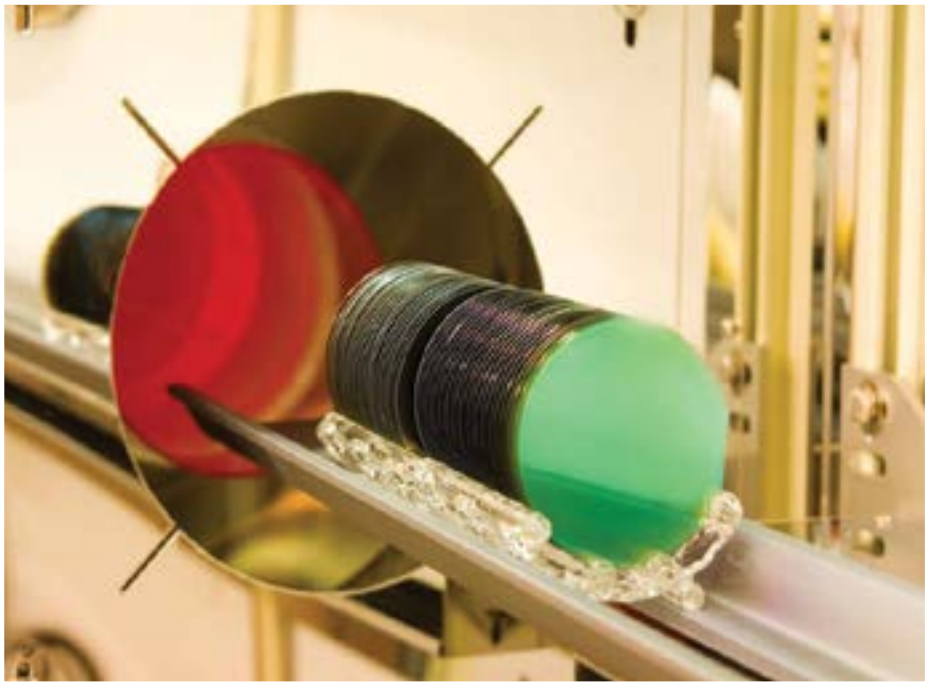
# Title III Program Lowers Costs, Raises Production of SiC MMIC Devices

The AFRL and Cree, Inc., a merchant manufacturer of silicon carbide (SiC) materials and wide bandgap devices, recently completed a 5-year Title III project designed to improve production capability, device capability and affordability of SiC monolithic microwave integrated circuits (MMICs) for US defense systems.

The program developed SiC MMIC switches for the Army's Joint Tactical Radio System program, high-performance S-band drivers and high-power MMICs at a reduced cost to other defense systems. In addition, the program reduced the cost of SiC MMIC devices by 77%.

SiC wafers are the foundation for the production of energy-efficient white Light Emitting Diodes (LEDs). Economies-of-scale can be generated if a large commercial demand for LEDs is created; this drives down cost for SiC MMICs because the higher SiC wafer volume required for LEDs will lower costs for the wafers needed for the MMIC devices. Cree has developed the LR24, an eco-friendly LED light fixture design for commercial applications, which the Pentagon has evaluated and approved. More widespread use of these LED devices helps SiC MMICs remain more affordable for defense.

Improvised Explosive Devices (IEDs) are the single largest threat to US forces deployed in Iraq and Afghanistan. In September 2006, Cree was awarded a SiC Metal Semiconductor Field Effect Transistor (MESFET) production contract to support the Army's Counter Radio-Controlled IED Electronic Warfare (CREW) program. The Title III SiC MMIC Devices program enabled Cree's manufacturing infrastructure to help make CREW an unquestioned success. Over 25,000 10 W SiC MESFET transistors have been delivered to support the program with no field returns.



*SiC wafers, the foundation for the production of energy-efficient white LEDs, are loaded into a furnace.*



*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Microprocessors Hardened to Survive in Space


*This radiation-hardened microchip enables spaceship operations to survive in harsh environments.*

The AFRL and BAE Systems are developing and fielding powerful, state-of-the-art, radiation-hardened microprocessors for space applications. The RAD750 microprocessor enables survivability of spacecraft operation in harsh, high-radiation environments. In order to meet greater on-orbit processing demands and fewer ground support capabilities, the RAD750 design architecture was modified for increased processor speed.

This Defense Production Act Title III program project secures a viable source for a family of QLM qualified RAD750 microprocessors ready to serve military mission requirements. Military users have the option of selecting the first generation RAD750, which is radiation-tolerant with a modest process speed, or several strategic radiation-hardened versions with higher processor speeds.

As microelectronics shrink to increase speed and performance, the microelectronics operating in space become increasingly more susceptible to degradation or damage from radiation effects. The desire for greater on-orbit processing capability has driven system designs to use microprocessors that operate at lower power, faster speeds and a higher density of complex circuitry. Microelectronic devices developed for space begin as mature, state-of-the-art, commercial designs (to reduce research and development costs) that are adapted to radiation-hardening design rules which result in either radiation-tolerant or strategic radiation-hardened devices.

The Department of Defense (DoD) needs space-qualified microprocessors with increased processing speed and performance to meet increasing mission autonomy. Data links, communications, sensors, enhanced hyper-spectral imaging and video processing capabilities, which will enable this autonomy, require space qualified microprocessors.

Numerous National Aeronautics and Space Administration satellite missions have successfully used various generations of the Rad750 PowerPC technology. The DoD has also incorporated the technology in military communications and Global Positioning System satellites. As we move forward, the Title III/BAE partnership is expected to deliver the final increase at 250 MHz on the current Power PC architecture, which will further advance our real-time computing power in space.





*For additional information on this technology contact AFRL/RX techinfo@wpafb.af.mil, (937)255-6469.*

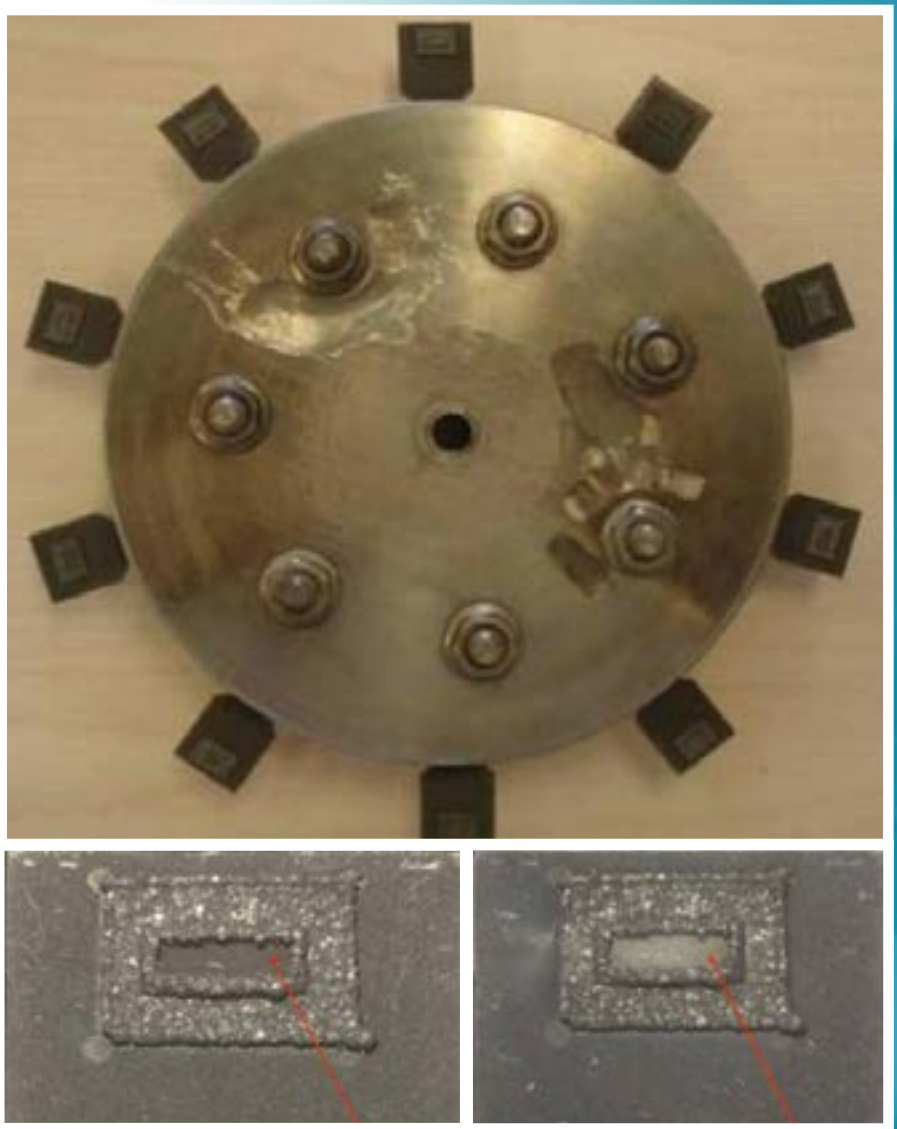
# Wireless Sensors Cling To, Perform Well on Turbine Engine Components

AFRL researchers have successfully attached sensors to scaled, rotating turbine engine components, measuring temperature, pressure, strain, and a host of other physical properties. The surface acoustic wave (SAW) sensor is wireless and passive, replacing wired sensing systems that require slip rings. This capability could greatly simplify engine instrumentation and reduce associated costs during validation testing.

The SAW sensor consists primarily of a 0.01 in. thick langasite piezoelectric material. During the recent test, researchers attached twelve 0.08 in. x 0.20 in. pieces of this material to a rotating turbine engine component and exposed them to 1,200°F and up to 58,000 g's (gravitational acceleration) for several hours. The twelve material samples experienced no observable damage and all remained adhered to the engine components.

In addition to sensor survivability, it was necessary to demonstrate that the piezoelectric crystal substrate material could be applied to rotating components and not only survive the rapid temperature cycling, but also the centrifugal forces that can be as high as 58,000 g's. Researchers at the University of Maine developed an attachment methodology that was recently tested by an independent agency. Test conditions included engine operation at temperatures between 800°F and 1,200°F at rotational speeds as high as 24,300 rpm. These rotational speeds resulted in centrifugal forces as high as 58,000 g's at the sensor locations.

After several hours of testing, all of the crystals were attached and no visible damage was observed either on the crystals or on the attachment material. Researchers are now preparing for a 25-hour-long sensor durability test that will consist of 1,500 rapid temperature cycles between 800°F and 1,200°F at 58,000 g's.



*This instrumented test rotor was placed in turbine exhaust flow and rotated up to 24,300 rpm. Each sensing element on the blades measures 2 mm x 5 mm. (pictured top) Pictured bottom left is the sensing element before a 3 hrs engine test and bottom right after a 3 hrs engine test, showing no observable element damage.*



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# Commercialization of Improved Optical Fiber Expands Capabilities


*The ASE source two-micron unit, with more than twenty times the power of previously available sources, allows for the broadest bandwidth, near infrared wavelength range, customized center wavelength, and high-output power.*

An AFRL-managed Small Business Innovation Research (SBIR) program has developed a new kind of optical fiber that enables the commercialization of high-power, two-micron Amplified Spontaneous Emission (ASE) sources.

AdValue Photonics of Tucson, Arizona, developed the new fiber, which allows for the broadest bandwidth, near infrared wavelength range, customized center wavelength, and high-output power. The ASE source has more than twenty times the power of previously available sources.

ASE is useful for a variety of optical tasks. Researchers use ASE to characterize laser components such as Fiber Bragg Gratings (FBGs), and to monitor the wavelength and reflectivity of the FBGs. ASE also facilitates characterization of other infrared optical component parameters such as optical insertion loss and polarization. Researchers also use ASE for optical tomography – a procedure to obtain the dimensions of an object's internal structure by analyzing light beamed through it from several angles. ASE is also useful for gas sensing, spectrum analysis, bio-medical applications, and scientific measurements. Thus, the commercialization of the two-micron ASE source enables the further development of two-micron fiber lasers and a variety of infrared optical systems.

The improved ASE source, at 88 nm, has twice the bandwidth of previously available commercial two micron ASE sources. The new commercialized version ASE is available in 50 mW and 500 mW versions. The 500 mW power source has more than twenty times the power of previously available power sources. The increased power source and bandwidth capability extend the range of accessible measurements for optical characterization and chemical detection.

AdValue has also developed Silicate fiber, an alternative to Thulium-doped silica fiber. The Silicate fibers can be easily fusion-spliced with Thulium-doped silica fiber, making them desirable for fiber-based device design. They are also immune from the photo-darkening associated with heavily rare-earth doped silica fiber.





*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# New Body Armor Advances Ergonomics, Comfort

Air Force (AF) personnel are losing weight and gaining comfort thanks to new non-ceramic ballistic armor developed by the AFRL Working with Universal Technology Corporation and Armacel Armor Corporation, AFRL scientists developed armor that demonstrates protection against ammunition from shoulder-fired weapon threats while weighing 32% less than current armor systems.

The new body armor technology also increases the survivability of warfighters in armed conflicts, while its lighter weight translates into increased mobility and a decrease in thermal load. Based on stopping power and back face deformation against standard small arms fire, the new armor offers significantly improved ballistic performance and ergonomic benefits.

The current standard for body armor, known as Enhanced Small Arms Protective Inserts (ESAPIs), combines a ceramic and composite material torso plate with a woven aramid multi-ply carrier system. While the ESAPI system is effective against rifle threats, the material is fragile, the ceramic strike face is breakable, can fracture with rough handling, and the carrier system is obtrusive and heavy.

The new ballistic armor technology uses polymer and composite materials technologies; advanced manufacturing processes are also being developed to provide the warfighter with affordable, survivable body armor. One advantage of the new system is that it can be molded into more complex shapes, offering designers more options.

The armor was tested during a Tech Warrior Pre-Deployment exercise in a simulated operational environment. It is currently deployed to military personnel at Bagram Air Base, Afghanistan, where scientists are conducting non-combat ergonomic fit testing and eliciting feedback from deployed AF personnel.

*Lightweight, ergonomic, non-ceramic ballistic armor offers more comfort and mobility for deployed warfighters.*



*For additional information on this technology contact AFRL/RX techinfo@wpafb.af.mil, (937)255-6469.*

# Titanium Powder Plant gets Boost from Title III

*International Titanium Powder's production facility in Ottawa, Illinois. Funds from a Title III program contributed to the construction of equipment. (pictured top) Low-cost titanium powder and titanium parts. (pictured bottom)*

A team from the AFRL and International Titanium Powder are expanding the domestic capacity to produce low-cost titanium powder. The Armstrong process employed is a unique, continuous process that produces metallic titanium powder directly from titanium ore. This project is expected to increase International Titanium Powder's titanium powder production capability to 4.4M pounds per year.

Titanium has excellent strength-to-weight and corrosion properties that make it useful for many structural aerospace and technology applications. Titanium is stronger and lighter than steel, and low-cost titanium powder has been tested in doors and side panels for ground vehicles. Using titanium reduces the material required to manufacture an aerospace component by up to 90%.

The combination of low-cost powder with solid state consolidation offers the potential of cost reduction for titanium components by more than 50% It is also expected to offer a 50% weight reduction in structural applications and a 30% weight reduction in ballistic applications. Weight reductions often lead to decreases in fuel consumption and logistical costs, while the increased strength and corrosion properties offer wear resistance and improved warfighter safety.

By working outside of the aerospace titanium supply chain, which suffers from long lead times and rising costs, researchers expect to reduce costs and shorten titanium delivery lead times. Using affordable titanium is expected to increase force mobility, enhance survivability and reduce total lifecycle costs in military systems.

The Title III project, launched in 2009, contributed to the purchase of equipment for a new powder plant for International Titanium Powder in Ottawa, Illinois, that will have 2 production lines.





*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Devices Enable High-Speed Feedback from Networked Weapons

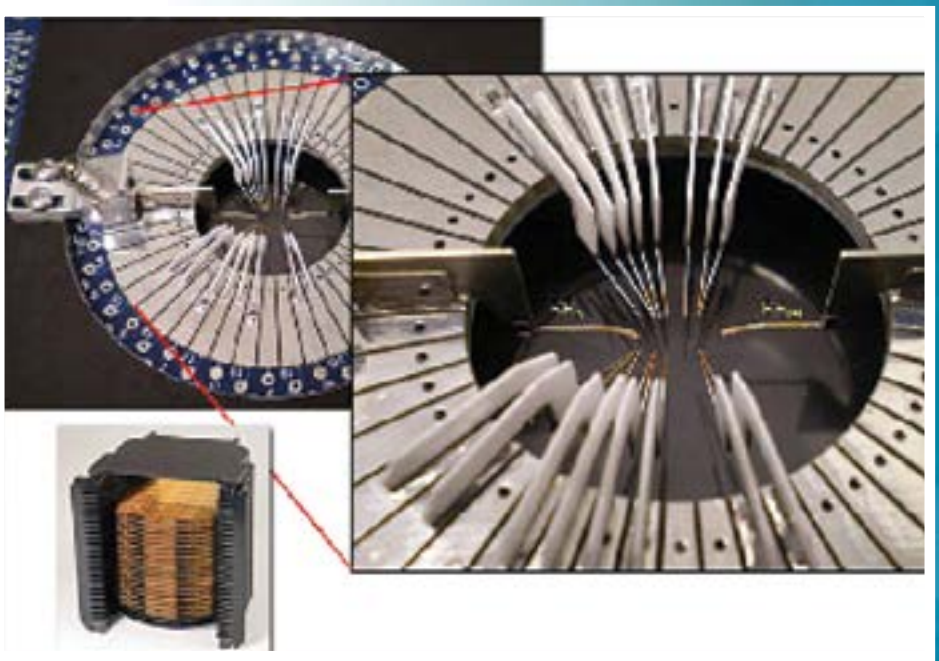
The AFRL has completed the Affordable Weapons Datalink Insertion (AWDI) program for the development of production-grade Gallium Nitride-on-Silicon (GaN-on-SiC) monolithic microwave integrated circuits (MMICs). The program is a joint effort between Rockwell Collins, Nirtronex Corporation, and AFRL. It has been a key enabler for Air Force/Navy development of a networked weapons capability in which high-speed weapons datalinks provide feedback between weapons, real-time mission analysis, and targeting.

This technology has lowered overall datalink system acquisition costs and enabled early transition of current datalink programs such as the Multifunction Information Distribution System-Joint Tactical Radio System and the Ground Mobile Radio. During the AWDI program, yields for small MMIC devices have increased from less than 25% to greater than 95%.

The 41-month, $5.1M program was aimed at improving technology critical to weapons datalink operation. Weapons datalinks operate in environments that require higher power over large bandwidths to maximize the amount of data transmission over the maximum possible distance

Three core capabilities were established regarding GaN-on-SiC MMIC reliability: Quarterly monitoring of baseline process reliability; pulsed reliability testing and radio frequency (RF) degradation; and MMIC RF testing capability and assessments. In addition, the AWDI team made significant strides in manufacturing readiness. Ultimately, the AWDI program approach led to the maturation of low-cost, wide-bandgap GaN-on-SiC MMIC foundry processes to develop Size, Weight and Power Cost (SWaP-C) chip sets for small form-factor (SFF) datalinks to enable higher gain and output power across a broader frequency range than that of existing technologies. Success of the program is already having an impact on several Department of Defense systems.

A Technology Readiness Level 9 has been achieved through extensive field testing of the devices, including in-theater operation; incorporation of GaN-on-SiC MMIC designs for tactical communication transceivers is continuing. Development of system-on-a-chip silicon applications and GaN-on-SiC is enabling further circuitry consolidation.



*A Gallium Nitride-on-Silicon monolithic microwave integrated circuits probecard.*



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# Miniature Air Launched Decoy May Get Fuselage Facelift

*MALD, a low-cost, air-launched, programmable craft that accurately duplicates combat flight profiles and signatures of US and allied aircraft.*

AFRL scientists are characterizing the use of Shape Memory Polymer Mandrels (SMPMs) to produce a piece of fuselage for the Miniature Air Launched Decoy (MALD), a low-cost, air-launched, programmable craft that accurately duplicates combat flight profiles and signatures of US and allied aircraft.

This research gives Department of Defense and aerospace system manufacturers a better understanding of SMPM and non-autoclave composite technology development processes and limitations. AFRL expects to reduce the risks and costs associated with the MALD and reduce production cycle times to allow faster delivery to the field. Researchers also expect advancements in this technology to offer benefits such as faster fabrication, a simple extraction process, and an improved internal surface finish in the production of other unmanned aerial systems and armament systems.

The MALD is a technology designed to protect valuable Air Force aircraft, offering counter air operations to neutralize air defense systems that pose a threat to US and allied pilots. During this 15-month project, Universal Technologies Corporation and Raytheon Missile Systems will assist Cobham Composites in planning and conducting test fabrication runs for an SMPM application on the MALD fuselage.

To date, processing trials have demonstrated that this technology is capable of producing a MALD fuselage that is a relatively large (approximately 10 ft in. length) and has complex geometry (not a round cross section). The long-term manufacturing characteristics of the process, however, are not well understood. For example, the effective life cycle of each mandrel (how many times it can be reformed), and what impact pressure and temperature extremes have on the mandrel and composite laminate over multiple reuses, remain unknown. As a result, the current process carries an inherent risk that long-term pricing assumptions may be inaccurate, and additional technical risks may surface.

Test planners are using a Design of Experiments approach, focused on identifying and measuring the effects and interactions of all key parameters related to SMPM characteristics and performance while in production. Researchers will also determine life-span expectations for SMPM and determine the technology's life span in relationship to the frequency of mandrel usage. Based on the results, areas with the potential for further testing will be exploited and future test activity planning will occur.

Cobham Composites and AFRL will conduct an assessment; if the results are favorable, the technology will be incorporated in the production of MALD fuselage structures.

*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# SBIR Program Makes F-35 Fastener Insertion Cheaper, More Accurate

Researchers from the AFRL have created an improved projector guidance system in manual cells for fastener insertion during F-35 assembly. The resulting technology could be used at any fastener installation station throughout the F-35 assembly process to standardize data entry processes and to eliminate manual data entry.

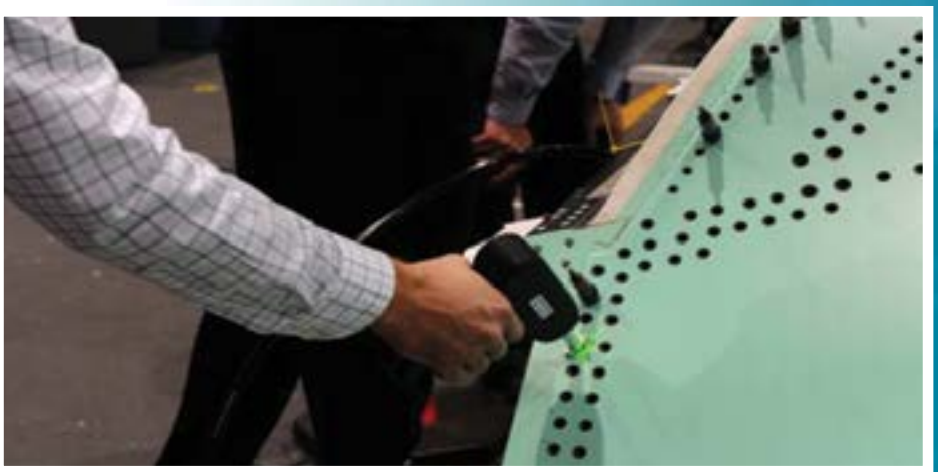
The Fastener Insertion Live Link System (FILLS), a Phase III Critical Manufacturing Technology (ManTech) Small Business Innovation Research (SBIR) program, will result in significant recurring cost savings for the F-35. The cumulative unit recurring flyaway (URF) cost savings expected total $82.9M, and the average time savings per shipset is expected to average 111 hrs.

Accurate hole location and fastener size information provided by the system reduces kitting preparation and delivery time, reduces fastener installation span time, and assures accuracy. Though the specific database is currently applicable to the F-35 aircraft assembly process, it is expected to find application to other military and industry applications, which will result in reduced manufacturing time and production costs.

Another initial FILLS objective is supporting all current gripping methodologies and establishing a standard for future grip length interfaces. FILLS will be usable at any station throughout the F-35 process to acquire grip length through manual or automated processes. The system will standardize data entry processes to eliminate manual entry.

To date, FILLS has resulted in a central database where each shipset's fastener engineering and as-built-data can be maintained. This includes historical reports on grip length variation and fastener usage, which will lead to process and inventory optimization.

AFRL partnered with Variation Reduction Solutions, Inc. (VRSI) under a SBIR Phase III contract to develop the technology for FILLS. Concurrent with the MRL 4 concept review, VRSI connected with Delta-Sigma Corporation (DSC) to explore and validate their self-funded development of an optical projection system – Projection Works – and a publishing tool called Assembly Works.



*AFRL ManTech developed this wireless grip gun technology to determine the proper fastener length for insertionon an as-built structure.*



*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Materials Team ID's Hazardous Substandard Titanium


*Engineers from the AFRL load a titanium billet for ultrasonic testing, evaluating the substandard material that posed a possible threat to flight and operational safety.*

An AFRL team tackled one of the command's most important issues: Evaluating the mechanical properties of titanium billet, improperly substituted for finished titanium bar or plate. The team provided material expertise and key technical guidance on titanium parts issues on the C-17, F-15, F-18, F-22 and F-35 aircraft, and ensured that key AFMC personnel had proper information and knowledge to discuss issues with senior leaders.

This team's efforts produced characterizations of rogue titanium that were previously unavailable. The rogue titanium threatened flight and operational safety because mechanical properties such as strength, stiffness and fatigue resistance are inferior to titanium bar and plate and may not meet design requirements. The information provided by AFRL enabled the Air Force (AF) to take proper risk management actions, such as increased inspections or removing components from service. Without these efforts, the AF and Department of Defence (DoD) would be unable to mitigate risks from substandard titanium.

Because of their high strength, high corrosion resistance, high crack resistance, and ability to withstand moderately high temperatures without creeping, titanium alloys are used in aircraft, armor plating, naval ships, spacecraft, and missiles. To develop the properties required in these applications, titanium must be mechanically worked at elevated temperature, a process known as thermomechanical processing. The thermomechanical processing of titanium is closely controlled, and results in a product with well understood behavior. Titanium billet is a semi-finished product that has not undergone the full thermomechanical processing steps. In this case, billet was cut down and passed off as bar or plate. The mechanical behavior of billet is not well understood and this substitution posed an unquantified risk to flight safety.

When AFRL was asked by the AF Titanium Task Force to identify and mitigate risks associated with improperly processed titanium in the DoD supply chain, a team rapidly located and procured over 4,000 lb of partially processed titanium billet and developed 1600 specimens for testing.

The AFRL team served as the Air Force Materiel Command's technical authority on mechanical properties, processing, and metallurgy of titanium. Their support of AF efforts to understand the impacts of improperly processed titanium contributes significantly to the mission, reinforcing AFRL's reputation as a world-class source of expertise in aerospace materials.





*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# AFRL Program Offers Engineers Prime Facilities, Opportunities

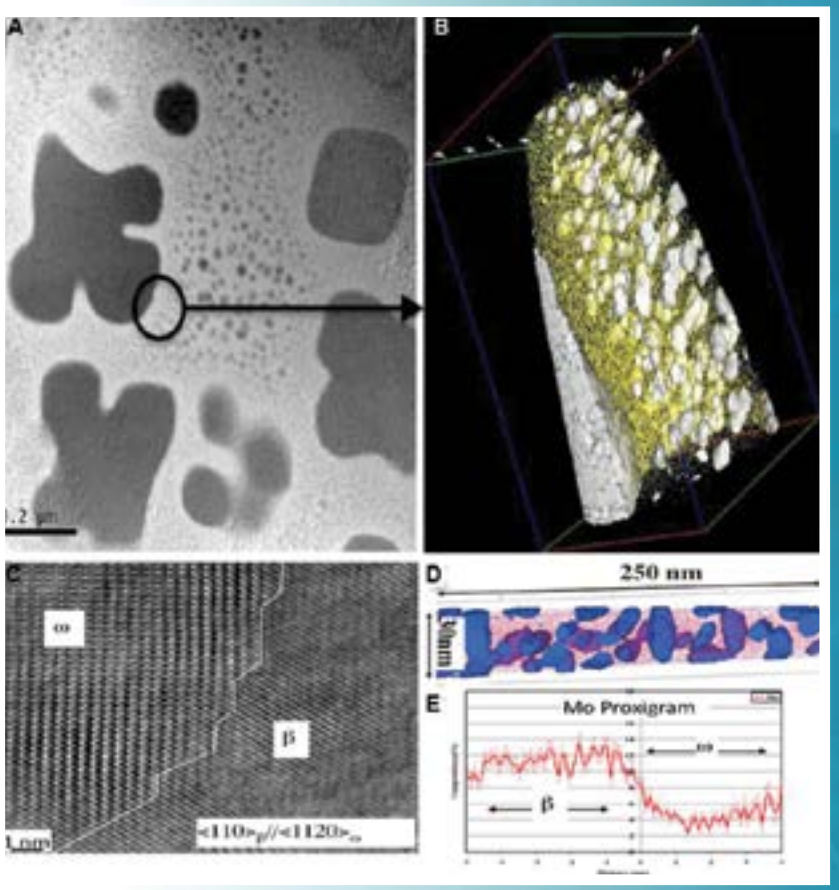
AFRL designed and managed the Institute for Science and Engineering Simulation (ISES) Program, allowing researchers access to state-of-the-art material characterization, modeling and simulation facilities. ISES enables the design of experiments aimed at identifying damage and failure mechanisms of structurally significant aircraft components and structures.

Research conducted at ISES to improve the durability and reliability of aircraft structures and engines will result in extended service life of aircraft. These improvements also enhance the safety and success of US military missions and personnel. The program has already resulted in multiple applications and material classes; imaging and characterization techniques that have been transitioned; advanced models for life prediction of propulsion components; 30 refereed journal papers; and new Small Business Innovation Research (SBIR) topics. The ISES's leading-edge facility is quickly becoming a nationally recognized destination for research and education in computer simulation techniques and predictive tools.

Materials used to construct Air Force aircraft must be designed with structural integrity and be resistant to fatigue and failure in extreme conditions, including excessive heat, cold, wind and sand. AFRL and the University of North Texas established the ISES to address complex research issues related to aircraft materials operating under these harsh environmental conditions.

Currently, AFRL builds task descriptions, establishes milestones, and manages technical evaluations and oversight for ISES efforts. ISES currently has three major thrusts, including: Influences of Microstructure and Chemistry on Mechanical Properties of Advanced Propulsion Materials; Life Cycle Prediction of Critical Jet Engine Components; and Hybrid/Composite Materials for Aerospace Applications. A fourth thrust was initiated in 2011, namely Evaluation of In-Service Aerospace Components.

To date, ISES program funding has led to several significant accomplishments, including a new computational model and experimental inputs for predicting creep failure of turbine blades in jet engines by applying weight at a high temperature to study how it deforms. The ISES program has also developed a new ceramic coating for turbine engine bushings that will allow them to operate at high temperatures, and a novel hybrid material for next-generation aircraft that offers temperature and fracture resistance, high hardness, strength and novel in-situ lubrication characteristics.




*An example of coupling of energy-filtered transition electron microscope, or TEM (Figure A) with atom probe tomography (Figure B) to investigate different generations of gamma prime precipitates, at multiple length scales, in the nickel base superalloy, Rene 88, used in turbine disk applications. Figure C shows coupling of high-resolution TEM (C) with atom probe tomography (D and E) to study the atomic scale structure and composition of nanoscale omega precipitates in a titanium-molybdenum alloy.*

# B-2 Windows Get Quicker Fixes Thanks to SBIR Program

*Maintainers and crew chiefs from the 509th Aircraft Maintenance Squadron prepare a B-2 aircraft for operations using the Laser-Assisted Coating Repair process developed by AFRL and Physical Optics Corporation under a SIBR Phase II effort.*

A Small Business Innovation Research (SBIR) program between the AFRL and Physical Optics Corporation has introduced a method for repairing scratched indium tin oxide (ITO) coatings on aircraft canopies. The Laser-Assisted Coating Repair (LACR) will be performed during regular ground maintenance operations.

The LACR process repairs damaged canopies with a transparent conductive material. The handheld LACR unit will be able to repair B-2 transparency (windshield and side window) geometries without removal of the aircraft from the field, and with minimal preparation time for the damaged surface and surrounding areas. The resulting technology provides modern and improved maintenance procedures, greatly simplified logistics for critical repair processes, and cost savings, while keeping valuable Air Force systems mission-ready.

In operation, conductive metal oxide coatings on aircraft canopy windshields and lamp housings perform several functions, including absorption of light that makes it difficult to see instruments and resistive heating for de-icing to remove condensation that solidifies during high-altitude and cold-weather flights. During the lifetime of the ITO coating, scratches and nicks develop and it begins to degrade. Current repair processes are temporary, time consuming and labor intensive; they reduce visibility in the repaired area and tend to chip or peel off.

When the size of the damaged area increases beyond an acceptable level, the entire coating must be replaced. Currently, this repair process includes the removal of the entire canopy and shipment to specialized facilities wherein the coating is stripped and reapplied in large vacuum chambers. Although this approach successfully returns windshield and side windows in pristine condition, it also requires several weeks or months to complete.

The LACR process includes a method of ITO deposition that can be performed under ambient conditions without removing damaged fixtures and that can be applied during routine repair of irregular scratches and nicks that occur during flight missions. Support equipment, such as the laser source and power supply, operate on standard AC power and require minimal maintenance.





*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Desert Sand Meets its Match in New Military Testing Standards

Today's Air Force operates in hot, arid, sandy environments that are tough on systems and their components. Reliable testing of protective materials is essential to assess their durability and safe operation, but it has been discovered that the decades-old characterizations of sand don't match the reality of today's warfighter experience.

Thanks to work by the AFRL, there is a new military standard for measuring the resistance of materials used to prevent particle and sand erosion on the leading edges of rotor blades. The standard will be used to assess protective materials for systems and components, such as jet engine turbine blades, helicopter rotor blades, electric power turbine blades, thermal protection coatings, and missile materials. Testing was conducted using AFRL's particle erosion test apparatus, which researchers use to formulate new materials and application methods intended to protect aircraft from erosion damage.

Harsh desert environments have resulted in a growing need to test aerospace material capabilities at ambient and elevated temperatures to determine their resistance and durability to particle and sand erosion. Until recently, sand characterization requirements that originated at the Department of Geology at the University of Chicago in 1941, and specifically the Krumbein particle roundness and sphericity chart developed by W.C. Krumbein, were used to determine particulate shape and size used in material and coating testing. AFRL researchers discovered that sand from dry and arid theaters of operation differed from those covered in aging standards.

During an Office of the Secretary of Defense-funded effort in 2007, researchers characterized numerous natural sand samples which ultimately led to the identification of a more aggressive synthetic test media to better replicate damage on aerospace materials exposed to a dry-arid environment. Additionally, the size range and particulate cloud density for the new test method were verified with sand characterization results accomplished during touch-and-go flight testing in Yuma, Arizona.

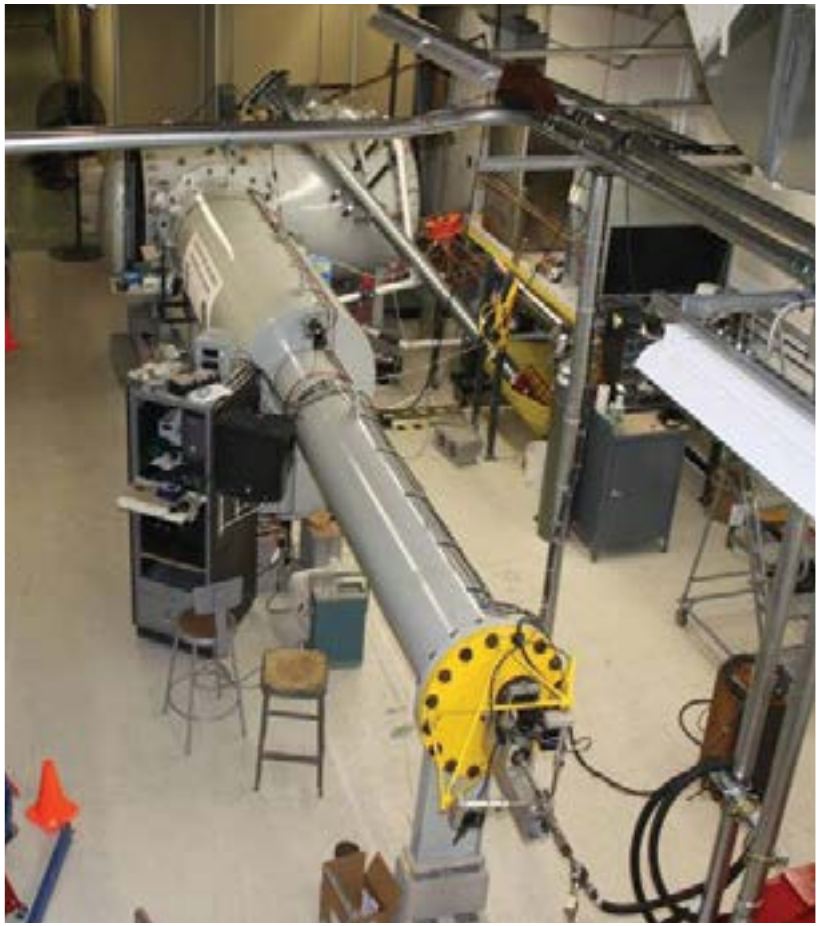
The particle erosion test apparatus is operated and maintained by personnel from the University of Dayton Research Institute (UDRI) by way of an on-site contract with the CTIO. A cooperative research and development agreement between AFRL and UDRI accommodates testing for commercial and industrial customers. The CTIO also offers rain erosion testing in its Rain Erosion Test Facility and the newly integrated Supersonic Rain Erosion apparatus.

*The particle erosion test apparatus, located at AFRL's Coatings and Technology Integration office, aggressively evaluates materials used to protect leading-edge blades in hot, sandy conditions.*



*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Unique Capability Tests Rain Erosion at High Speeds



*The supersonic rain erosion testing apparatus at AFRL's Coatings and Technology Integration Office simulates the impact of rain on aerospace systems traveling at transonic and supersonic speeds.*

A one-of-a-kind supersonic rain erosion (SURE) testing capability, simulating the impact of rain on aerospace systems traveling at transonic and supersonic speeds, has been developed by AFRL researchers. The SURE capability enables both predictive modeling, and large- and full-scale component rain erosion testing.

The SURE capability tests systems, materials and new technologies for missile materials; coatings for aircraft leading edges; optical materials; rotor blades; radomes; antennas; and other commercial technologies at speeds up to Mach 2.5. Because the SURE operates at speeds not offered by the AFRL Rain Erosion Test Facility or the Holloman High Speed Test Track (HHSTT), material and system developers can establish a testing baseline in the mid-range.

Materials and coatings on systems traveling at transonic and supersonic speeds may be repeatedly exposed to rain droplets, making them susceptible to damage or erosion. Air Force researchers developed the SURE apparatus for investigating the erosion behavior of technologies and materials before they are in service. The SURE apparatus, housed at the AFRL's Materials and Manufacturing Directorate's Coatings Technology Integration Office (CTIO), allows researchers to conduct predictive, multi-scale physical modeling to determine how systems and materials erode or resist erosion in rain while traveling at high speeds. The SURE apparatus produces 1-2 mm diameter water droplets, and achieves 12 gal of output a minute at 50,000 pounds per square inch.

To date, two pump/motor assemblies, which will produce the rain field, were successfully tested for continuous operation. In addition, because the pumps were not running at their maximum speed, AFRL engineers expect that the SURE apparatus will be capable of generating larger droplets (up to 2.5 mm). It is also expected to operate at speeds as high as Mach 2.5.

The SURE capability is operated and maintained by personnel from the University of Dayton Research Institute (UDRI) by way of an on-site contract with the CTIO. A cooperative research and development agreement between AFRL and UDRI accommodates testing for commercial and industrial customers. The CTIO also offers sand erosion testing, which will accommodate customer requests for performance testing with combined effects.





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# Vests Keep Pilots Cool, Enhancing Mission Endurance and Comfort

Pilots performing operations in hot environments are getting some relief as a result of work done by the AFRL. The air-cooled vest prototype development effort, a Company Grade Officer Initiative Program (CGOIP), resulted in a wearable technology that maintains a user's core body temperature.

This technology provides cool air to pilots as they perform walk-arounds and other duties before their missions. It is expected that the vest will combat physiological stresses, and enhance a warfighter's cognitive abilities and gravitational-force (g-force) tolerance during mission performance.

Researchers met with pilots from the Springfield Air National Guard, who said they suffer from heat-related fatigue while performing pre-flight aircraft inspections in layers of flight equipment. Additional thermal stresses encountered in the cockpit include in-flight heat from avionics and radiant heat entering through the canopy. Related research also found that a pilot's tolerance to g-forces decreases as a result of heat stress.

The idea for a cooling vest was conceived during a Thermal Management Science and Technology Team (STT) meeting in 2009. Researchers suggested using a thermoelectric heat exchanger to deliver cooled, ambient air to the vest as the warm, moist air is expelled. An integrated product team developed a list of requirements for the cooling vest, which included maintaining core body temperature for 30 to 60 min (the duration of a typical pre-flight walk-around), meeting current flight suit standards, a weight of less than 7.5 lb, low volume, and low cost.

Published research will reflect testing of peak oxygen consumption without the cooling vests, testing of the vests on each subject, and simulated air-traffic control cognitive testing. The final report will be published and briefed to the Thermal Management (STT) and AFRL's Materials and Manufacturing's Technology Advisor.

Follow-on programs for technology development and technology transition strategy implementation are already in progress, and researchers expect to find funding that will support eventual Phase I transition. The Air Force Uniform Office has expressed interest in providing the vest to Air Force users.


*An artist's depiction of the layers of flight equipment worn by a typical Air Force pilot, resulting in complaints of heat-related fatigue from pilots and the idea for a wearable cooling vest.*



*For additional information on this technology contact AFRL/RX techinfo@wpafb.af.mil, (937)255-6469.*

# SBIR Program Improves Manufacturing for Composite Engine Components

*Pratt & Whitney's F135 engine for the F-35 Joint Strike Fighter at test.*

Researchers from the AFRL have successfully completed a Phase II Small Business Innovation Research (SBIR) program to reduce the cost of high-temperature polyimide materials. The program resulted in improvements to the manufacturing process, and the qualification and delivery of production prepreg materials for F-35 Joint Strike Fighter engine and airframe applications.

This effort expanded the industrial supply base for critical polyimide resin monomers. Incorporation of these materials in Pratt & Whitney's F135 engine offers a significant cost advantage over other high-temperature composite structures. Even at low-rate initial production quantities, the composite prepreg materials delivered in July 2010 were priced below the program target cost for engine T250, which will translate to millions of dollars of material cost savings over the life of the F135 program.

AFRL researchers and aerospace manufacturers have expressed interest in polyimide composite materials as they offer a desirable alternative to current titanium and Bismaleimide composite materials found in many high temperature aerospace parts.

During the SBIR program, personnel at Maverick Corporation in Blue Ash, Ohio, identified, tested and demonstrated multiple alternate sources for critical monomers used to manufacture their AFR-PE-4 Polyimide resin system. Renegade Materials in Springboro, Ohio, combined the resin with carbon fiber and fabrics using high-rate prepreg manufacturing equipment and processes.

Maverick and Renegade Materials used internal funding for qualification of their materials, and they have been approved for use in several F135 engine components.

The ultimate result of this effort is a robust supply chain for monomer components, resin and prepreg manufacturing, and the transition of the technology to the Joint Strike Fighter program.





*For additional information on this technology contact AFRL/RX techinfo@wpafb.af.mil, (937)255-6469.*

# Solar Cells Increase UAV Stamina, Flight Time

Unmanned air vehicles (UAVs) are getting a power boost thanks to a partnership between the AFRL and Microlink Devices Inc., which has developed technology to integrate lightweight, flexible, high-efficiency solar cells onto a UAV platform. The additional power provided by solar cells to UAVs with electrically powered propulsion systems will increase their endurance and flight time; in addition, special operations personnel will benefit by added field surveillance capabilities.

Advanced solar cell technology is expected to extend the potential daytime flight capability of a variety of small, hand-launched UAVs used by special forces for situational awareness in combat areas. Currently, AFRL is working with Microlink Devices Inc., a solar cell manufacturer, to demonstrate this capability on the Raven platform, made by Aerovironment. AFRL engineers are developing three identical prototype Solar Raven UAVs, which they expect will operate up to 300% longer than those now in use.

The Raven is a small, hand-launched, remote-controlled aerial vehicle powered by an electric motor. It can fly up to 6.2 mi at altitudes of 10,000 to 15,000 ft, and obtain speeds of 28 to 60 mi per hour. Currently, the Raven is powered by a lithium ion battery and has a flight time of approximately one hour.

The solar-powered Raven program, initiated by AFRL's Nanostructured and Biological Materials Branch, was designed to integrate lightweight, flexible, high-efficiency solar cells onto the wings of the UAV to harvest solar energy and extend vehicle flight times. The 20 $cm^2$ solar cells adhere to the wings of the vehicle with a thin plastic film and adhesive. The wing of a solar-power-enabled vehicle is expected to carry anywhere from 80 to 100 cells.

AFRL researchers recently briefed the solar-powered Raven's progress to the United States Special Operations Command (USSOCOM), Special Operations Research, Development and Acquisition Command Science and Technology Office, fixed and rotary wing representatives, and Air Force Special Operations Command (AFSOC). Special Forces are a significant user and supporter of both solar- and battery-powered technologies, and USSOCOM proposed a program for AFRL to establish an industrial base for both solar cells and conformal batteries.

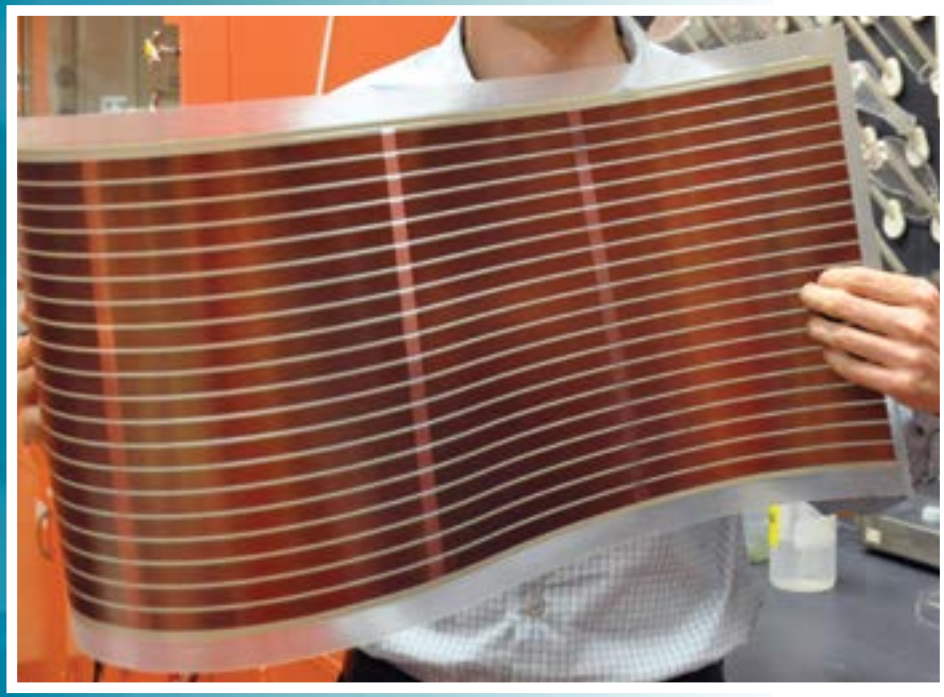
Flight demonstrations will be conducted by both AFSOC and USSOCOM through their Technical Network Topology venue.

*An Air Force warfighter launches a Raven, which will experience increased flight time and endurance thanks to an AFRL partnership that developed lightweight, flexible, high-efficiency solar cells that will adhere to the UAVs wing.*



*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Researchers Develop Groundbreaking Flexible Solar Cell Technique



*AFRL researchers have found an important source of performance variability in flexible solar cells such as this one, an essential component in evaluating new materials and architectures, and improving the efficiency of organic solar cells.*

A groundbreaking research technique demonstrated by the AFRL detects performance variability at a microscopic scale during operation of flexible solar cells. This technique will be essential in evaluating new materials and architectures for organic solar cells, and improving their efficiency for Air Force (AF) applications.

The AF needs power, and flexible solar cells have the potential to affect a wide range of applications, including those used for air vehicles, personal power, and even air bases. Integrating solar cells onto the wings of unmanned aerial vehicles will dramatically increase their range, and the logistical burden of powering a deployed airbase could be significantly reduced by building solar cells directly onto structures such as tents.

A large class of flexible solar cells is based on plastics, which offer many advantages including possible manufacture by low-cost techniques such as spraying, casting, and printing. The solar cells work via photovoltaic properties of the plastic, which convert a portion of the light that hits the solar cells to electricity. Because these materials are very effective at absorbing light, the plastic can be less than one ten-thousandth of an inch thick, allowing flexibility and semi-transparency.

In addition to the plastic layer, these devices include a transparent electrode, called indium-tin-oxide (ITO), which is also used in flat-panel TVs and computer monitors. Although it was well known that this transparent electrode was not electrically uniform, the impact of this variability on the performance of solar cells was not understood. Working with Northwestern University, AFRL researchers developed a new technique to determine how the electrical variability in the transparent electrode layer impacts the solar cell performance.

The technique is called Atomic Force Photovoltaic Microscopy (AFPM), and it works by scanning a nano-scale stylus across an array of microscopic solar cells. These small solar cells are illuminated with simulated solar light so that they actually function during the experiment, a significant improvement over previous methods. The small size of the solar cells enables the identification of variations in the performance of the plastic at a very small scale. The technique allows full characterization of each microscopic solar cell, and it also enables the generation of a "map" of the plastic film showing locations of improved and degraded performance.





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# Mosquito Becomes Easily Portable with Mounting, Towing Prototype

An urgent warfighter requirement developed by the AFRL provides the capability to perform quick and efficient ground-hardness surveys needed for landing-zone preparation in support of remote operations. AFRL researchers developed prototype methods for mounting and towing the Mosquito automated cone penetrometer, allowing Air Force Special Operations Command (AFSOC) personnel to perform ground-hardness surveys to determine the ability of soil to support the weight of landing aircraft. In two weeks, the AFRL Materials and Manufacturing Directorate's Airbase Technologies Division designed and fabricated a mounting/towing prototype for use with a small, 70cc, dirt bike, delivering it to impressed AFSOC users.

Air Force (AF) operations in remote areas often require the use of unprepared landing zones for cargo aircraft transporting equipment. Prior to flight operations, Airmen perform landing-zone surveys to determine if the soil will support the weight of a landing aircraft. A ground hardness survey is conducted by manually driving a dynamic cone penetrometer – a long rod with a cone-shaped tip — into the ground. An operator then measures and records the depth of penetration on each blow.

In response to users' requests for a lightweight, automated system that make the process of taking penetration measurements easier, AFRL engineers conducted a Phase II Small Business Innovation Research program with Alliance Spacesystems. Alliance Spacesystems, a company with experience building lightweight, low-power, percussive coring systems for space exploration, developed a portable, automated dynamic cone penetrometer called the "Mosquito." The device is powered by batteries and uses a feedback-controlled linear actuator to provide a consistent driving impact to the specially designed penetrometer. It produces measurements of soil hardness for each impact and provides California Bearing Ratio (CBR) information related to the depth of the device's penetration.

An operator views the CBR information on a light-emitting diode (LED) display in one-inch increments up to 36 in. in depth. The CBR, as well as raw data measuring displacement of soil per blow, is also stored on a removable digital card. The data can be transferred to a computer using a process similar to importing photos from a digital camera. The stored data is tagged with date, time and Global Position System coordinate information for easy import into AF mapping applications.

*A small bike equipped with a removable hitch for a Mosquito, which provides the capability to measure ground hardness, a crucial element to landing zone preparation.*



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# AFRL Engineer Identifies, Solves Problem with Minuteman III Support

*The efforts of an AFRL Materials & Manufacturing Directorate engineer helped resolve a problem with Minuteman III retry vehicle support equipment and mitigate future mishaps, reducing costs and allowing the Minuteman III re-entry test equipment to service.*

An engineer from the AFRL identified the cause of damage to Minuteman III re-entry vehicle support equipment, assessed the damage, and identified novel solutions to allow the command to quickly reduce mishap cost estimates and mitigate future incidents. He developed and provided a risk analysis that allowed Minuteman Intercontinental Ballistic Missiles to remain operational.

The AFRL engineer used an inventive application of materials science, engineering, and physics of failure principles to identify the extent of the damage. The methods included an electronic troubleshooting process that removed and replaced various equipment elements not previously used by other investigation boards to identify the root cause. These innovative solutions and recommendations allowed the Air Force (AF) to quickly assess the damage and estimate repair costs that allowed for prompt repair by the original equipment manufacturer, while ensuring the safety of support equipment personnel and protection of AF resources.

During initial operational testing of a refurbished piece of support equipment used to test Minuteman III re-entry vehicles, a catastrophic failure caused damage initially estimated at $2M. The mishap impacted the ability to test and certify equipment used to validate the serviceability of ICBM re-entry vehicles. Air Force Material Command (AFMC) officials sought AFRL expertise to identify the root cause of failure of critical test equipment involved.

An electronic materials engineer was selected to serve as the technical lead on an AF Class A Safety Investigation Board (SIB) requested by the AFMC Commander.

Over a three-week period, the engineer successfully directed the technical aspects of the mishap investigation. He identified an improperly wired power adapter, the lack of internal system safety devices, substandard engineering change processes and design deficiencies as contributing factors. He then worked with AFMC, the Program Office, and Ogden-Air Logistics Center technicians, engineers and managers to ensure they understood and accepted the technical get-well plan he devised. It provided a quick reaction solution that effectively restored the Minuteman III re-entry vehicle test equipment to service.





*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# New Fuel Cell System Reduces Weight for Warfighters

AFRL engineers are developing a new fuel cell system that will reduce the amount of weight that warfighters must carry in the field. The new UltraCell XX55 fuel cell system replaces batteries needed for recharging, allowing recharge of batteries for fielded gear via a methanol-fueled system, reducing the weight carried by warfighters for a 72 hrs mission by greater than 70%.

This system will eliminate the need for warfighters to carry additional batteries for communications equipment, cameras, computers and other gear used in the field. The reduced weight will enhance the ability of deployed personnel to perform their primary duties.

The BB-2590 is the military standard rechargeable Lithium Ion battery. The MBITR is the AN/PRC-148 Multiband Inter/Intra Team Radio, the most widely fielded handheld multiband, tactical software-defined radio, used by the US military and NATO forces around the world. Currently, soldiers carry many BB-2590s into the field and use them to recharge the battery in the MBITR, along with AA batteries and other batteries used for targeting systems, cameras and computer systems. The new UltraCell XX55 replaces the need for batteries for recharging by providing the next generation of portable power solutions.

The new fuel cell system is being produced using a single optimized manufacturing method and provides a portable power solution for field recharging of BB-2590 and MBITR batteries. Instead of using batteries, the new UltraCell XX55 system uses a methanol-fueled system.

The XX55 fuel cell system uses various fuel cartridges and fuel tanks for application and mission specific power requirements and duration. UltraCell's fuel products range from a small and ultra-portable eight-hour cartridge, to a larger five-gallon fuel tank that can provide almost two weeks of continuous 50 W charging capability. The XX55 provides additional capabilities and versatility for the charging and powering of cell phones, laptops and other auxiliary devices.

AFRL engineers worked with UTC (Universal Technologies Corporation), of Dayton, Ohio, and Ultracell Corporation of Livermore, California, to successfully address materials and scale-up challenges, to increase throughput and to enable cost-effective manufacturing. Ultracell is producing 50 XX55 fuel cell systems as part of this effort; the first six of which were delivered to the Army and shipped to Afghanistan in April.


*The UltraCell XX55, a battery-recharging fuel cell system that will reduce by 70% the weight warfighters carry in the field during a 72 hrs mission.*



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# New Firefighting Suit Increases Chemical, Biohazard Protection


*Staff Sgt. Timothy Cruz practices donning and doffing procedures with the new Joint Firefighter's Integrated Response Ensemble. Airmen participated in a final field evaluation of the suit testing the time to put on the JFIRE suits versus the previous version.*

Military firefighters can count on increased protection from the effects of chemical and biological agents thanks to a cooperative project between the AFRL and the Air Force (AF) Civil Engineer Support Agency's (AFCESA) Fire Emergency Services Program. The new Joint Firefighter Integrated Response Ensemble (JFIRE) allows operations in a chemically contaminated environment. The JFIRE includes a modified chemical protective overgarment (a modified Joint Services Lightweight Integrated Suit Technology (JSLIST)), traditional proximity turnout gear, a new helmet, new boots and gloves. The prototype ensemble was field tested by airmen at Kunsan Air Base, South Korea, in July 2011.

The modified JSLIST suit consists of an outer shell that provides liquid protection and an inside carbon-bead filter material that offers vapor protection. The new, one-piece JSLIST suit is also lighter weight, breathable, more flexible and less bulky than the current JSLIST.

AFRL and AFCESA established a collaborative, three-year effort to identify and improve technologies that allow AF firefighters to respond to emergencies and perform operations in an expanded variety of hazardous situations including fire, toxic chemicals, and technical rescue in chemical and biological environments. In Mission Oriented Protection Posture (MOPP) 4, firefighters are required to wear the JSLIST chemical protective overgarment underneath their proximity firefighting ensemble, which is extremely hot and taxing on firefighters.

The modified JSLIST coverall is a two-layer material system consisting of a flame-resistant, durable, camouflage-printed outer fabric and a light, thin, highly efficient inner filter layer. This system is air permeable, enabling thermo-regulation through evaporative cooling. The new filter material uses nanoporous activated carbon micro-spherical absorbers, and is produced using advanced textile manufacturing processes. The outer shell material is a blend of four fibers — Nomex, FR Rayon, Kevlar, and Nylon — engineered to provide flame resistance, low-noise signature, durability and tear resistance, air permeability and oil and water repellency.

Initial testing of the modified JSLIST showed a 35% reduction in weight, a 14% reduction in bulk, a 36% increase in breathability, and an 85% improvement in flexibility. Additional improvements in the weight of the boots and helmet were also achieved.





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# AFRL's Munitions Directorate Stands Up New, Unique Capability

The AFRL's Munitions Directorate is standing up a brand new capability, the High Pressure Particulate Physics (HP3) Facility, to enhance the role of science and technology in smart munitions development. This capability will include a 60 mm smooth bore gun, complemented with high-resolution, high-precision time-resolved diagnostics (interferometers, X-rays and photography). The gun will be able to launch a few kilogram mass far and fast and will address basic fundamental questions related to munitions weapon systems and weapon effects. This new capability will be operational by the end of 2011.

As part of a long term strategic goal, higher velocities are planned using an old Lawrence Livermore National Lab gun (a $1M asset). This will increase the understanding of dynamic material behavior at much higher engagement velocities that are relevant to Directed Energy and Space Vehicles Directorates. This capability is unique as a Department of Defense facility and will provide AFRL the technical leadership in munitions-related science and technologies.

*The AFRL's Munitions Directorate is standing up a new capability, the HP3 Facility, which will be operational at the end of 2011.*



*For additional information on this technology contact AFRL/RW* **afrlmark@eglin.af.mil**, *(850)882-3009.*

# Precision Lethality Responds to Urgent Operational Need

*The newly developed Precision Lethality MK82, designed to minimize fragmentation, decreasing damage and injury to nearby structures and personnel.*

Precision Lethality MK82 is a Quick Reaction Capability acquisition program to field a 500 lb composite case warhead (BLU-129) capability in response to a United States Central Command Joint Urgent Operational Need for a very low collateral damage weapon. The AFRL teamed with Lawrence Livermore National Laboratory (LLNL) to design the PL82 composite warhead case which disintegrates during the explosion and minimizes fragmentation, thus decreasing damage and injury to nearby structures and personnel, including friendly forces and civilians. Physical properties of the warhead are customized to closely match the Mk82, an existing 500 lb General Purpose Bomb. The case has the same outer shape and interfaces as the Mk82, which maintains compatibility with existing fuzes and precision guidance kits and provides ready application to a broad range of military aircraft. AFRL simultaneously developed a heavy explosive formulation to increase the weight of the warhead, because the composite case is lighter than the steel-cased Mk82.

This explosive also provides increased blast effects for improved near-field lethality performance. The BLU 129/B QRC program worked closely with AFRL and LLNL to prioritize requirements and maximize PL82 Risk Reduction testing for relevance to the final munitions development and to reduce schedule risks. This effort is a showcase for close cooperation between the munitions research, development, and production communities to rapidly provide a valuable munitions capability for the warfighter.





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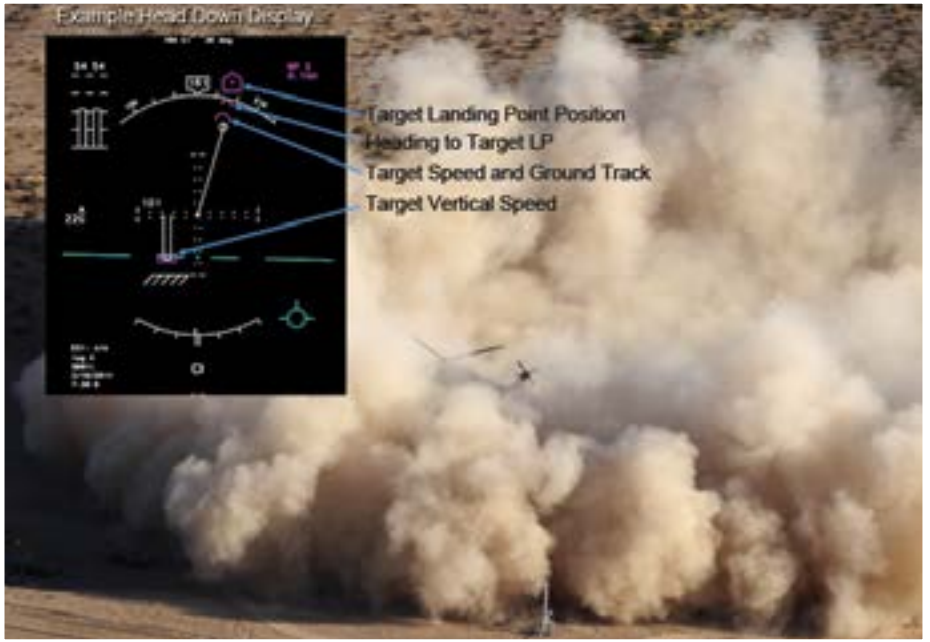
# Symbology Collaboration Helps Pilots "See" During Brownouts

Degraded visual environments, including brownout in the desert environments of Afghanistan and Iraq, account for one third of non-hostile combat and non-combat helicopter mishaps. AFRL has been conducting a collaborative in-house effort with the US Army Aeroflightdynamics Directorate (AFDD) to develop flight symbology to safely land helicopters in zero visibility.

AFDD is developing the BrownOut Symbology System (BOSS); AFRL is developing the guidance and manual control laws/algorithms, known as BOSS-LG, to provide landing guidance. The guidance provides ground track, ground speed, and sink rate commands to the pilot. The goal of the design is to achieve "visual quality" landings in zero visibility.

AFRL has reached a major milestone with completion of the preliminary development of the landing guidance in a rapid prototyping simulator environment. Simulator evaluations were conducted with US Army test pilots, with encouraging results. The next step is flight verification on the AFDD EH-60L flight test helicopter. The completed design will be demonstrated in a US Army flight test program later this year.

Deployment of this capability to joint-service helicopters is projected to substantially reduce mishap rates, with improved performance and mission capability.

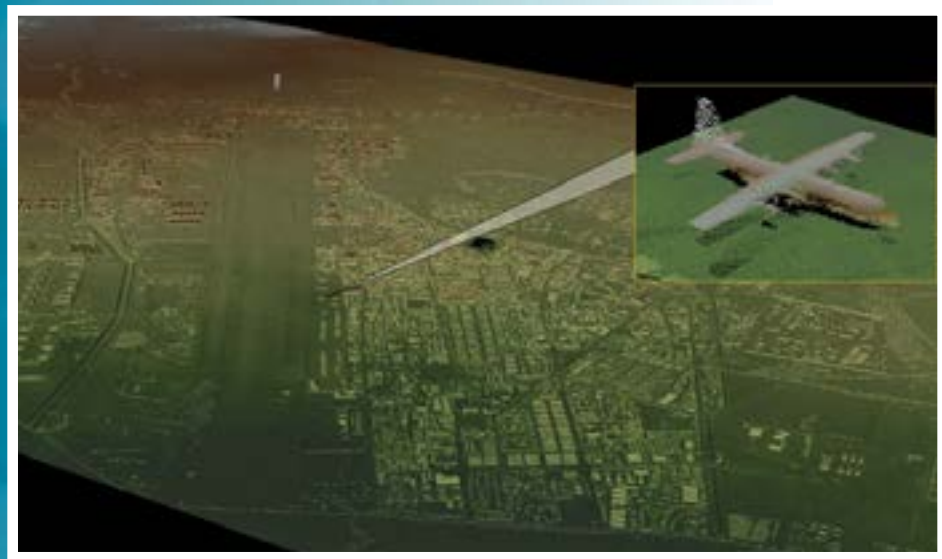



*Brownout conditions often found in Iraq and Afghanistan are a major cause of helicopter mishaps. (Inset) BOSS with manual control laws/algorithms, known as BOSS-LG, whose goal is to provide "visual quality" landing for helicopter pilots.*



*For additional information on this technology contact AFRL/RY* **afrl.ry.marketing@wpafb.af.mil**, *(937)904-9771.*

# AFRL Plays Pivotal Role In Response To Urgent Operational Need In Afghanistan



*AFRL expertise was key in the successful development, testing and deployment of the HALOE system to the Afghanistan area of responsibility.*

In response to an urgent operational need for high-resolution three-dimensional (3D) data, the AFRL partnered with Northrup Grumman, John's Hopkins University Applied Physics Lab and NASA, to develop, test, and deploy the High Altitude Lidar Operational Experiment (HALOE) system to the Afghanistan area of responsibility (AOR). AFRL played a key role in the over 10-year development of the Geiger Mode Avalanche Photo-Diode focal plane array, the enabling technology that made this system possible. The unprecedented sensitivity, accuracy and speed of this array allowed in flight mapping operations at ranges, scan rates and altitudes several orders of magnitude greater than anything currently fielded today. While DARPA funded system development and the initial deployment during first quarter of FY-11, ultimately it was the success of the effort that led to an Army Geo-Spatial Center request and funding for the system to remain in theater for an additional 180 days to continue the high-resolution 3D mapping mission.

AFRL personnel played a key role throughout the effort, providing technical expertise to characterize system performance and assess system readiness to deploy. Ultimately two AFRL personnel deployed with the system to act as the mission lead. These personnel acted as the single point of contact to coordinate all aspects of the mission from tasking to dissemination of the exploited data products to the warfighting customer. AFRL personnel regularly coordinated with CENTCOM, International Security Assistance Force Joint Command and the various Afghanistan Regional Commands to optimize collection requests and ensure finished intelligence products were delivered on time to meet operational needs. While deployed, the team flew over 550 operational flight hours in 140 sorties while collecting over 55,000 $km^2$ of data at an unprecedented 20 cm resolution. Working closely with both onsite and geographically separated exploitation teams, HALOE answered over 200 requests for information. Exploited HALOE data has directly supported operations against high value individuals and ongoing combat operations through the characterization of compounds, helicopter landing zone, traffic ability and line of sight analysis.





*For additional information on this technology contact AFRL/RY* **afrl.ry.marketing@wpafb.af.mil**, *(937)904-9771.*

# True Time Delay Module Finds 'Needle in a Haystack' Frequencies

The AFRL, in conjunction with L3 ComCept of Rockwall, Texas, has integrated an AFRL True Time Delay (TTD) module into the L3 Miniature Reconfigurable Beamformer (MRB) cards.

The MRBs were integrated into an aircraft pod in a ground demonstration, raising the technology readiness level from 4 to 6.

The TTD module, jointly developed by AFRL engineers and Cobham Sensor Systems of Richardson, Texas, provides a highly integrated capability to accurately find signals of interest over a wide frequency range. For an airborne platform, the TTD module provides the capability to locate 'needle in a haystack' radio frequency signal emissions on the ground. The AFRL TTD module provides this capability with a 13x size reduction, a 6x reduction in weight, and 3.8x less power than comparable TTD units currently used in the field.

This technology is a key enabler for future multi-functional wideband phased arrays as well as large arrays for ground, airborne, or space-based sensors.

*L3 Miniature Reconfigurable Beamformer with AFRL TTD module integrated with an antenna into an aircraft pod. (pictured top) L3 Miniature Reconfigurable Beamformer with AFRL TTD module. (pictured left) Simulation of an aircraft searching for signals of interest, showing reach of TTD module. (pictured right)*



*For additional information on this technology contact AFRL/RY* **afrl.ry.marketing@wpafb.af.mil**, *(937)904-9771.*

# TacSat-3 Celebrates Milestone, Surpasses Requirements

*TacSat-3 recently celebrated its 2-year anniversary on-orbit, surpassing original mission requirements.*

AFRL's Tactical Satellite-3 (TacSat-3) celebrates its two-year anniversary on-orbit. The spacecraft was originally designed for six months of operation with a one-year goal. It successfully transitioned from experimental to operational status last year, outliving its design life and surpassing original mission requirements.

Launched in May 2009, TacSat-3's mission is to demonstrate capability to conduct hyperspectral imaging that is responsive to warfighter needs. Since then, the spacecraft has delivered over 2,100 images and demonstrated the ability to transmit processed data to a ground station within 10 min.

TacSat-3 was transitioned to US Space Command in June 2010.



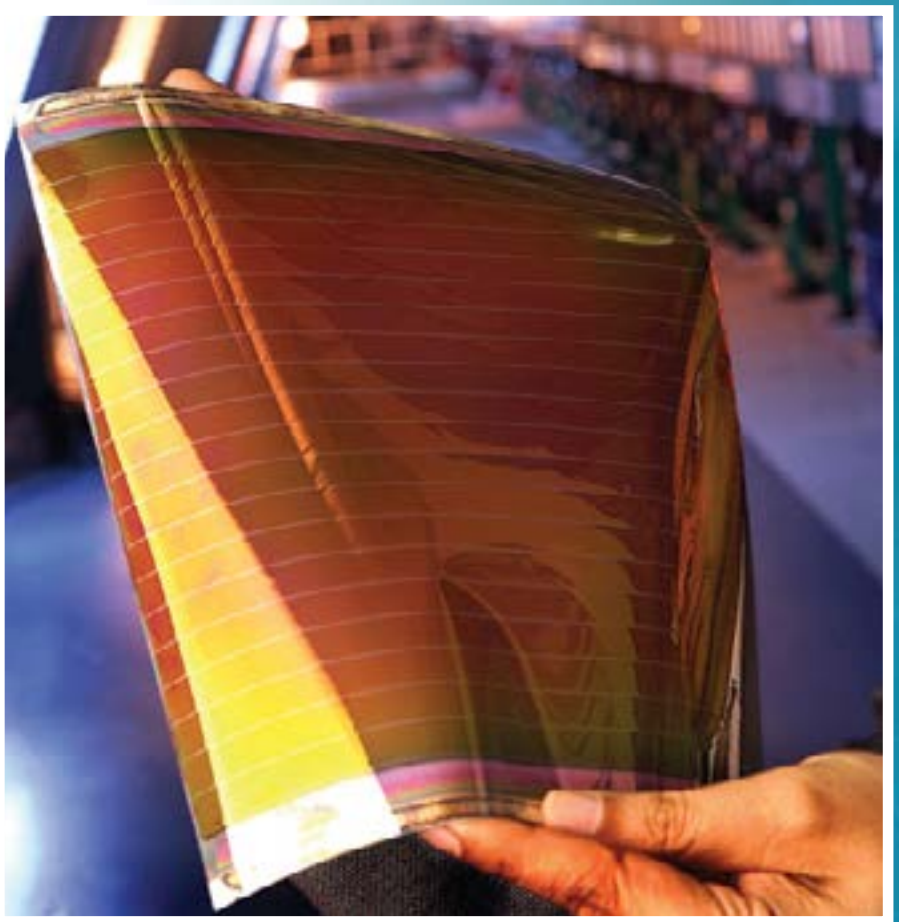


*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# AFRL Program to Enable Solar Cells

The AFRL, in cooperation with United Solar Ovonic LLC, established a program to build on technology developed under previous Air Force Small Business Innovation Research (SBIR) projects. Taking full advantage of the research and development findings gleaned from SBIR projects accomplished by Energy Conversion Devices, Inc. (ECD) and United Solar Ovonic, AFRL leveraged United Solar Ovonic's existing terrestrial solar cell product (a solar cell optimized for use on Earth and deposited on a heavy 5 mil stainless steel substrate) to develop a product applicable for space use.

Since May 2003, United Solar Ovonic has been working with the AFRL to develop ultra-lightweight solar arrays on thin stainless steel foils and polymers for use in space and airship vehicles. Solar cells on thin stainless steel foil are already being tested in AFRL experimental missions such as TacSat-2 satellite, which was launched in December 2006.



*United Solar Ovonic's existing terrestrial solar cell product, optimized for use on Earth and deposited on a heavy 5 mil stainless steel substrate.*



*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# Student Satellites Successfully Separate

*AFRL's student-built satellite program, FASTRAC, built by University of Texas (Austin), was launched in November and successfully separated in March.*

Two satellites designed and constructed by students at the University of Texas' Cockrell School of Engineering successfully separated in space March 22, completing the most crucial goal of the mission since its November 19 launch and making them the first student-developed mission in the world in which satellites orbit and communicate with each other in real-time.

The AFRL's University Nanosat Program/FASTRAC (Formation Autonomous Spacecraft with Thruster, Rel-nav, Attitude, and Crosslink), built by University of Texas (Austin), launched in November.

Now that the 60+ pound, tire-sized satellites are apart, they will be able to perform the main goals of the project and could pave the way for more complex satellite missions that require real-time coordination between small satellites.

Traditionally, larger and expensive satellites have been commonplace in space missions but the satellites developed by more than 150 aerospace engineering graduate and undergraduate students could demonstrate the potential for space technology that's more affordable and accessible — a forward-looking approach that's attracted the interest of the Air Force and NASA.

The satellites will collect scientific data and be able to report their location and proximity to each other to students and amateur radio operators tracking their orbit some 400 mi above.





*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# Deployable Boom Successfully Unfurls

The AFRL's deployable boom experiment was successfully unfurled in low-Earth orbit, or LEO, from NASA's NanoSail-D satellite on January 20, 2011. This is the first in-orbit deployment of the Triangular Rollable And Collapsible (TRAC) boom, and the first deployment of a 100 $ft^2$ solar sail using these booms.

When collapsed, the four 7 ft long TRAC booms and the deployment mechanism are the size of a few slices of bread, or 4x4x2 in. In 5 sec, the booms expand into a radial pattern large enough to support the thin 100 $ft^2$ polymer sheet. The mission of the sail is to investigate the possibility of using a highly compact solar sail package to de-orbit old satellites. According to the NASA mission team, the solar sail will remain in LEO between 70 and 120 days depending on the atmospheric conditions.

"The TRAC boom experiment was a great success in demonstrating this unique stored-strain-energy, free-deployment approach as viable for unfolding large, thin, planar payloads from very small spacecraft packages," said Jeremy Banik, program manager and co-inventor of the TRAC boom. Thomas Murphey is the other co-inventor, and the device has been licensed to NeXolve Corporation.

Recently, the longest TRAC mast, with a length of 13 ft, was successfully fabricated in-house at Kirtland Air Force Base. The slender mast can be rolled to a mere 1¾ in. diameter spool (about the size of a roll of quarters), along with three other identical masts.

*Jeremy Banik, program manager and co-inventor of the TRAC boom, with the slender, 13 ft TRAC mast, fabricated at Kirtland Air Force Base.*



*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# AFRL Experiments Fly on One of the Last Shuttle Flights

*AFRL's VADER, 1 of 2 thermal management experiments to more efficiently control and manage heat transfer. VADER and MHTEX were included in this year's Endeavor shuttle flight.*

National Aeronautics and Space Administration (NASA) launched 2 AFRL experiments on the Space Shuttle Endeavour on May 16, 2011, as part of a four-experiment package sponsored by the Space Experiments and Review Board and the Space Test Program.

MHTEX (Massive Heat Transfer Experiment) and VADER (Variable emissivity device Aerogel insulation blanket, Dual zone thermal control, Experiment suite for Responsive space) are 2 thermal management experiments to more efficiently control and manage heat transfer.

VADER will test a robust, reconfigurable thermal control system that is focused primarily at small responsive space missions. It will also test a new form of Multi-Layer Insulation (MLI) protection using Aerogel material as the thermal isolator.

It was feared that the variable emissivity material is humidity sensitive and would have suffered some degradation due to shuttle launch delays, but the experiment was able to continue as planned.

This 1-year experiment will also demonstrate spacecraft thermal control, as when the power has been turned off, each coating retains the heat. A control system will monitor energy applied to the coatings, as well as the temperature of the payload. Another part of the VADER trial, the Aerogel Insulation Blanket, developed by Aspen Aerogels, Northborough, Massachusetts, will cover the back of the experiment, directly behind the coatings. Similar to the MHTEX, data will be downloaded and processed at Kirtland Air Force Base.

Ultimately, the information will be used to develop thermal control systems for future small satellites.





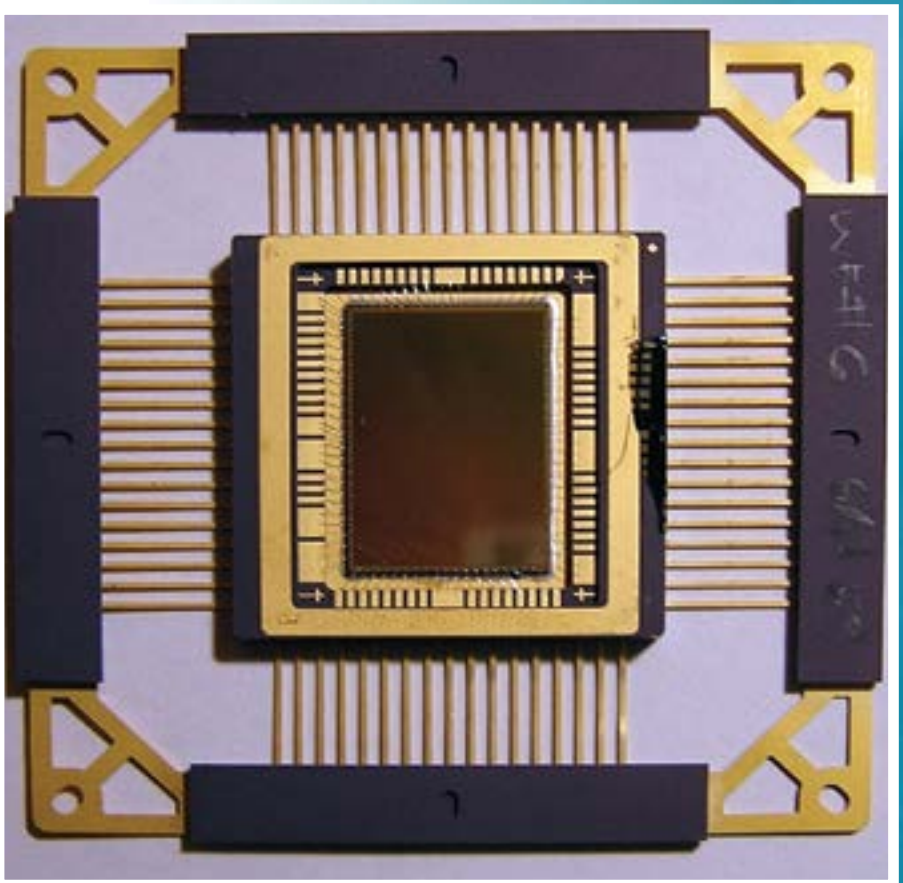
*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# AFRL Leads Innovation with Texas Instruments Release

The AFRL's investment in radiation-hardened components pans out with Texas Instruments' newest release – a commercially available 16 Mb radiation-hardened memory component. The component, called Static Random-Access Memory, or SRAM, allows the Department of Defense (DoD) to address "big space" satellite needs to support warfighter and customer needs. More than 2000 hrs of failure-free life testing have been conducted and an additional 2000 hrs are planned.

The SRAM was officially released as a "Quality Manufacturer's Line" rated part.

Silicon Space Technology (SST), working with AFRL and Texas Instruments (TI), proposed to demonstrate an innovative approach for manufacturing radiation hardened high-density SRAMs for space applications by adding two proprietary RH modules plus a simple stacked capacitor structure to TI's baseline 130 nm process flow. SST has solved the major space radiation problems, Single-Event Effects, Total Ionizing Dose and Dose Rate, by combining process modifications and layout design innovation. The proven-in-silicon approach enables production of radiation-hardened integrated circuits at leading-edge circuit densities within any commercial silicon foundry, for use in both terrestrial and space systems.

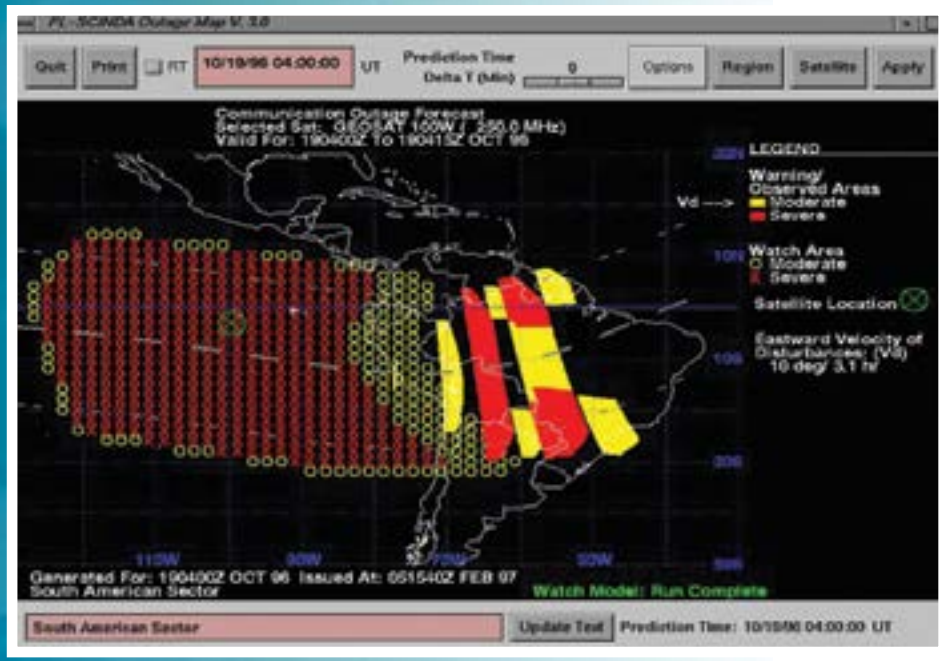


*Static Random-Access Memory, or SRAM, allows the DoD to address "big space" satellite needs to support warfighter and customer needs.*



*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# Ionospheric Tool Expands to South America




The Scintillation Network Decision Aid (SCINDA), a system designed to specify ionospheric scintillation in real time, has now installed UHF and GPS scintillation monitoring equipment at Apiay Air Base, Colombia. The installation expanded the SCINDA network in South America. SCINDA includes dual software digital radio receivers capable of simultaneously monitoring scintillation activity on 16 SATCOM channels. As part of real-time SCINDA network, data from the new site will significantly increase regional scintillation monitoring capabilities. Following quality testing at AFRL, the data will be used in operational products for the UHF SATCOM community hosted at the Air Force Weather Agency.

SCINDA is currently a prototype system and is fielded at stations in South America. It is envisaged that SCINDA sites will be set up around the globe to provide data to the warfighter.

Timely location of outage regions would enable the warfighter to effectively use satellite communication, navigation, or surveillance assets to modify mission plans and prevent errors as scintillation warnings become available.

SCINDA provides the warfighter with an efficient, graphical interface needed to evaluate the effects of local ionospheric scintillation on critical military space communication and navigation links. Specialized ground-based UHF and L-Band receivers, monitoring signals from geosynchronous communication satellites, are used to measure scintillation intensities and zonal drift velocities. Sites are connected to the Internet, providing the warfighter with an automated local real-time data retrieval system. The SCINDA decision-aid software then processes this data and generates a three-dimensional real-time local visualization of the ionospheric disturbance structure.





*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# New System Provides Valuable Assessment of High-Energy Laser Damage

In response to an Air Force (AF) need for a sensor system to optimize directed energy delivery from advanced tactical lasers (ATLs) to the targets, Physical Optics Corporation (POC) developed a system based on sensor and data fusion of 3 laser remote-sensing technologies: laser remote polarimetry, spectroscopy, and vibrometry. The system, Holographic-Optical-Element-Based Damage Assessment (HOEDA) provides accurate, comprehensive, remote, real-time damage data.

This technology has the potential to positively impact the AF's development of airborne and ground-based high energy lasers (HELs) and high power microwaves (HPMs).

Other anticipated benefits of HOEDA include remote assessment of damage in inaccessible areas, specifically in furnaces or chemical plants, subsurface damage assessment in automobile engines, and nondestructive testing of aircraft wing surfaces

Emerging Directed Energy Weapons (DEWs) offer virtually instantaneous fly-out time, stealth, precise targeting, agile retargeting capability, operation unaffected by gravity, and lethal/less-lethal options. In the case of strategic lasers, determination of the damage timeline is critical in saving laser resources, costs, and dead time

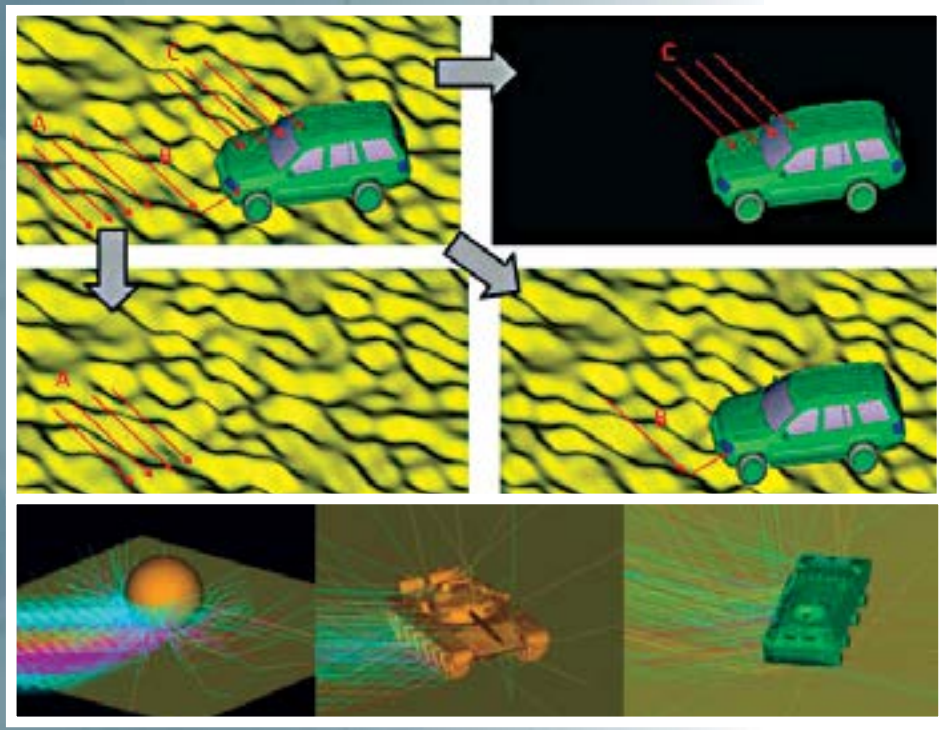
This technology will be an indispensable tool to assess damage made by the technology on its targets. The vibrometry module can be used to determine structural integrity. The spectroscopy module can be used as a novel scientific instrument for conducting in situ robotic geochemical exploration of the solar system. The polarimetry model can be used in the medical imaging field to determine sub-surface damage in burn victims.

*HOEDA system*

Air Force SBIR/STTR

*For additional information on this technology contact AFRL/HQ* **milestones@wpafb.af.mil**, *(937)904-6930.*

# Ground Target Interaction Encompasses More Characteristics



*The Electromagnetic (EM) physics model is broken down into three coherently additive components: a) ground only, b) ground-Target Interaction, and c) target only. (pictured top 4) Ground-target interaction during ray trace for three targets. (pictured bottom 3)*

Populating radar signature databases for ground targets is costly: in addition to representing the target variations, the database must capture the signature variability introduced by the ground contributions. Simulated radar data is a cost-effective addition to the database; however, its inability to efficiently represent the deterministic ground contributions limits its utility. In response to this need for modeling ground response for synthetic aperture radar (SAR) and high-range resolution (HRR) signatures, models were generated for three ground characteristics: dielectric attenuation, small scale (Rayleigh) roughness, and large scale (Kirchoff) roughness.

This Small Business Innovation Research (SBIR) project was completed by Etegent Technologies, Ltd. (formerly known as Sheet Dynamics, Ltd.). The technology provides an enhanced data product that captures the statistics of each pixel/range cell based on assumptions of the known operating conditions, allowing consumers of the simulated database to adapt the signatures to multiple operational environments without additional physics models.

There were several things that worked relatively smoothly, namely the dielectric attenuation and application of the small scale roughness as a post process. These 2 components address the capability to dynamically regenerate data corresponding to arbitrary ground surface (e.g., adapt to concrete versus wet sand) and minor surface perturbations. The remaining piece of the puzzle was the application of large surface roughness (greater than a wavelength), which was successfully implemented.

This technology provides an enhanced data product that captures the statistics of each pixel/range cell based on assumptions of the known operating conditions. In order for the full potential of this technology to be realized and integrated into current and future automatic target recognition (ATR) systems, data consumers must to be willing to make a paradigm change and begin ingesting data in such a format. This involves a cultural mind shift, but one that AFRL leadership has begun to implement under "performance driven sensing."





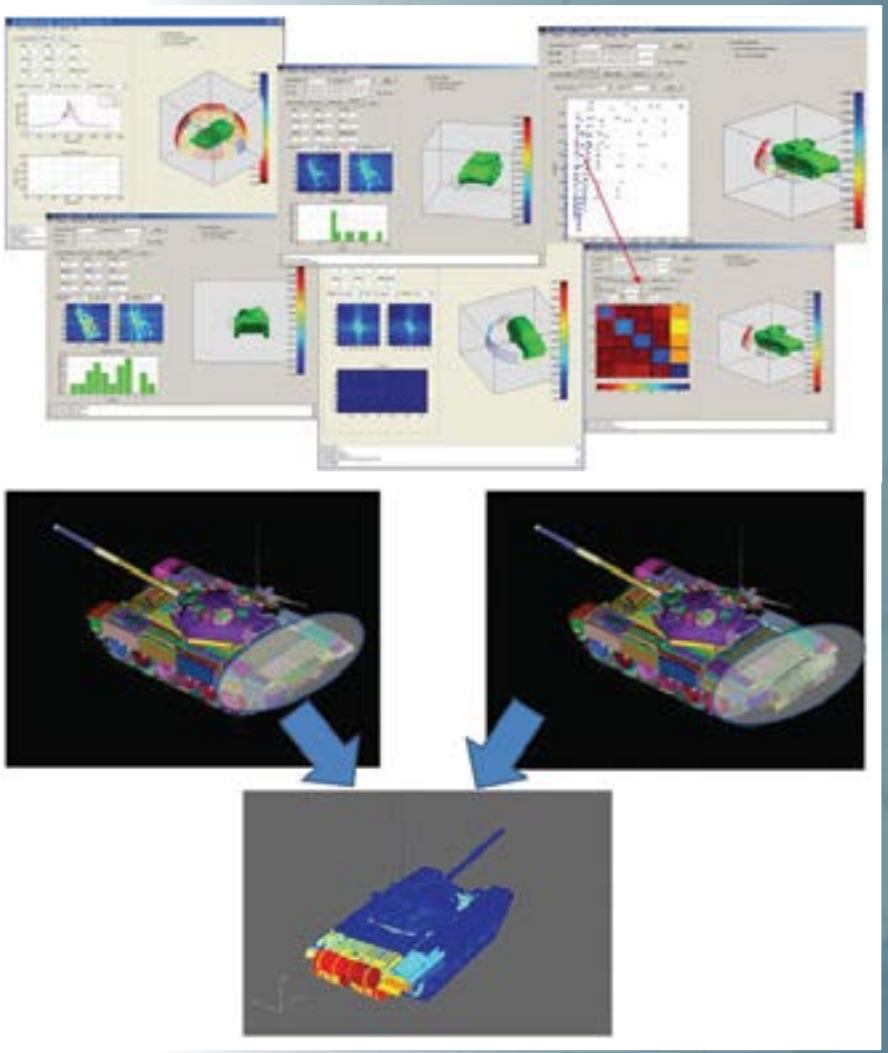
*For additional information on this technology contact AFRL/HQ* **milestones@wpafb.af.mil**, *(937)904-6930.*

# Scattering Center Toolkit for Automatic Target Recognition Performance and Model Saliency Analysis

Key enabling synthetic signature technologies are required to support faster development of new target entries in signature databases. Etegent Technologies, Ltd. (formerly Sheet Dynamics, Ltd.) made primary contributions to the state of the art of signature database optimization in the areas of performance modeling and signature saliency.

The technology generated under this Small Business Innovation Research (SBIR) contract is being used to support the automatic target recognition (ATR) performance modeling task for a variety of exploitation applications within the AFRL The technology is also being funded internally as a research and development project to formalize performance model testing and evaluation for use in Air Force performance evaluation facilities

Emerging radar combat identification (CID) capabilities are dependent upon synthetic signature database development technology. Several CID transition candidates are currently pacing the development rate of companion signature databases.



*Performance prediction tool visualization for class separability. (pictured top) Synthetic signature saliency or barrel vs. no barrel class derived linear optimization of required features. (pictured bottom)*

Air Force SBIR/STTR

*For additional information on this technology contact AFRL/HQ* **milestones@wpafb.af.mil**, *(937)904-6930.*

# USAFSAM Closes One Chapter, Begins Another

*The USAF School of Aerospace Medicine celebrated its transition to Wright-Patterson Air Force Base, Ohio, at Brooks City-Base in San Antonio, Texas.*

The US Air Force School of Aerospace Medicine took the final step in its transition to Wright-Patterson Air Force Base (WPAFB), Ohio, in mid-February, decommissioning the Brooks-based school after 85-years in San Antonio. Nearly 600 people, including current and former students, faculty, and distinguished alumni, attended the ceremony in a celebration of the school's history, the achievements of the students, the lives that were saved because of the training received at the school, and the medical advancements made possible because of the experts within USAFSAM.

USAFSAM is relocating from Brooks City-Base to WPAFB as part of the nation's 2005 base realignment and closure (BRAC) decisions, and formally activated the new complex in June 2011. The school is part of the AFRL's 711th Human Performance Wing. In his address to the crowd, Colonel Charles Fisher, USAFSAM commander, recounted highlights of the school's history back to 1918, during the beginning of military aviation. He noted the school's first establishment at Brooks in 1926 and cited the nation's space race as a key turning point for the school and its heyday at Brooks.

After nearly two decades at Randolph AFB, the school relocated to a massive new complex at Brooks Air Force Base. "The School of Aerospace Medicine's began teaching in the new Brooks facilities in 1959," Col. Fisher said. "And, in 1963, on his last day of life, President Kennedy dedicated the new Aeromedical center at Brooks, launching explosive growth in research and knowledge in space, aviation, environmental medicine, physiology, and biosciences over the next four decades. Brooks was the epicenter, where the action was for biomedical research and for Aeromedical training."

Chief Master Sergeant Joel Berry, USAFSAM superintendent, described personal contributions that members of USAFSAM have made to the Air Force and to the nation, thanking the enlisted team members who have been deployed into harm's way.

"Collectively, it is our duty to ensure that USAFSAM's foundation of commitment, dedication, education, and excellence is continued from this day forward, no matter the mission and no matter the location," Chief Berry said.

The mission of USAFSAM is to be first-call consultants in aerospace medicine, find solutions to operational needs of today and tomorrow, and prepare new aeromedical experts for future global challenges.



*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# Advanced Algorithm May Improve Breeding of Military Working Dogs

Scientists at the AFRL and their collaborators at Ohio University in Athens, Ohio, have developed an algorithm for DNA analysis that successfully determined dog breeds with an accuracy of more than 90%. The prototype algorithm performs an unsupervised genome-wide association data analysis that may provide breeding tools that reduce training and selection costs, predict intelligence, behavior, and health for military working dogs.

To develop robust computational methods for the analysis of genome-wide single nucleotide polymorphism (SNP) data, different approaches — Biologically Guided Feature Selection and Computational Based Feature Synthesis and Classification — were pursued in parallel. As a proof-of-concept, genomic DNA prepared from canine blood was typed by means of the Affymetrix Canine SNP Array v2. A classification analysis of a data subset (117) from behavioral assessments of canine subjects consisting of German shepherds, Labrador retrievers, and Belgian malinois provided this new classification technique where these subjects were successfully classified into the correct breeds with an accuracy ranging from 89 – 100%, solely based on the SNP data.

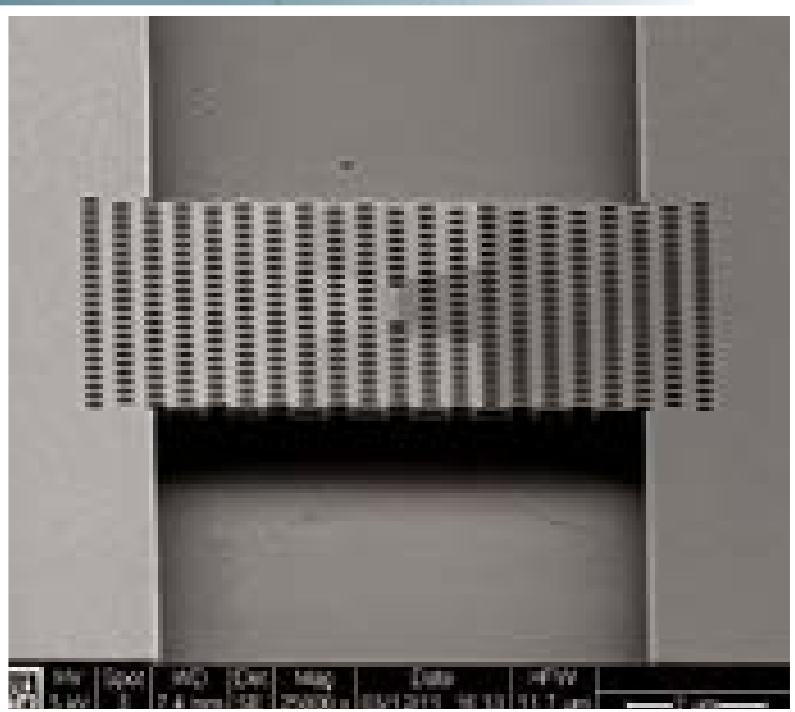
Current efforts include further refinement and optimization of the algorithm so that the analysis can classify canine subjects according to their intelligence in a prior or unsupervised manner and provide identification of the SNP markers responsible for such classification. This approach may allow significant biological findings and provide novel insights into the molecular pathways associated with intelligence. Additionally, this approach may facilitate the development of genetic tests and canine breeding tools predictive of behavior and health in military working dog litters. The expected gains from this project are lowering the significant dropout rates and decreasing the training and selection costs for providing skilled military working dogs.

*AFRL's Genomics/OmniGenomics Group from the 711th Human Performance Wing (from left): Amy Walters, Dr. Camilla Mauzy, Dr. Victor Chan, Armando Soto, Tiffany Hill, Jeanette Frey and Jessica Wagner.*



*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# Nanoscale Photonic-Crystal Lasers: 10 Times Faster, 1000 Times Less Energy



*Researchers have developed a nanoscale, highly efficient optical data transmitter or semiconductor laser, the key to which is a multi-layered nanophotonic layered wafer, the holes of which are almost perfectly round with smooth interior walls and act like a hall of mirrors to reflect photons back toward the center of the laser.*

Supercomputers consume super amounts of energy, and there is an ongoing technological solution to reduce that consumption. Funded in part by Air Force Office of Scientific Research, a Stanford University team unveiled a tiny, highly efficient semiconductor laser that could herald a new era in low-energy data interconnects that communicate with light as well as electrons.

The effort concerns a type of data transmitter known as a photonic-crystal laser that besides being fast and small, also operates at very low energy levels. The team has produced a nanoscale optical data transmitter – a laser – that uses 1,000 times less energy and is 10 times faster than the very best laser technologies in commercial use today. The laser is based on a multi-layered wafer of gallium arsenide, embedded with three thin layers of a second crystal, indium arsenide, with quantum dots within the wafer. When compiled, the nanophotonic layered stack is only 220 nm thick. At the heart of the wafer, photons are concentrated and amplified into a tiny ball of laser light which can be modulated up to 100 billion times per second (10 times the rate of the current top-rated data transmitters) with the light becoming binary data: light on for one; light off for zero. Hundreds of these nanophotonic transmitters could be arranged on a single layer, and many layers could then be stacked into a single chip.

While this new technology currently operates at relatively cold temperatures (about -190°F), the team is working toward perfecting operation at room temperature while maintaining energy efficiency at about 1,000 times less than today's commercial technologies.



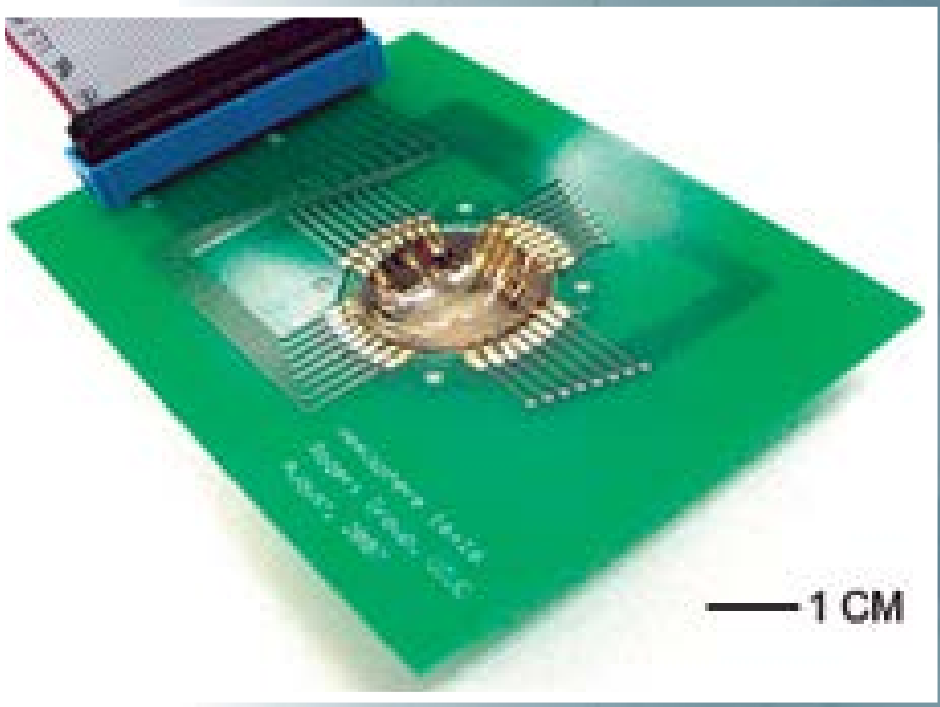
*For additional information on this technology contact AFRL/AFOSR* **publicaffairs@afosr.af.mil**, *(703)696-7797.*

# First Hemispherically Shaped Camera Reduces Distortions

AFRL-funded researchers at the University of Illinois at Urbana-Champaign and Northwestern University have developed the first curvilinear, or hemispherically shaped, camera that reduces optical distortions normally associated with flat-sensor cameras

The camera is built from planar silicon optoelectronic components that are formed into an eye-shape nonplanar distributed focal array using a unique and repeatable process. This camera follows the development of two breakthroughs at Stanford: expandable silicon designed to meet large-area applications; and a curved silicon sensor array.

A critical advantage of this method is that the silicon structures and the deformable interconnects can be fabricated using conventional planar processes. The research team notes that these strategies might offer opportunities for new classes of imaging systems in which design optimization involves not only the lens configurations but also the detector geometries, and that additional opportunities might arise from the ability to integrate electronics and optoelectronics with the curvilinear surfaces of the human body —Inconceivable with conventional, rigid, wafer-based technologies.




*Array of photodiode and p-n junction-blocking diodes with metal inter-connects allows capture of visible images.*

# Heat Resistant Ceramic Coatings Offer Thermal Protection for Hypersonic Flight

*There exist critical challenges in performing some of the relevant tests that require simulating extreme aerothermal environments where temperatures on the surface of hypersonic aircraft can go as high as 2800°C or one half the surface temperature of the sun.*

Air Force Office of Scientific Research (AFOSR)-supported research at the University of Arizona is investigating high-temperature resistant ceramic coatings that will provide thermal protection for Air Force hypersonic flight vehicles.

The research team, led by Dr. Erica Corral, is using advanced chemical synthesis and ceramic processing methods to process the ceramic compositions onto carbon composites, which are the materials used to fabricate lightweight and high-strength aerospace vehicles. The major steps in advancing this technology are based on relevant testing of the ceramic coatings under extreme temperature, heat flux and gaseous species environments.

Even now there are challenges in performing some of the relevant tests that require simulating extreme aerothermal environments where temperatures on the surface of the aircraft can go as high as 2800°C or one-half the surface temperature of the sun. The researchers have been harnessing the power of the sun and focusing the solar radiation at a specific heat flux to investigate high-temperature oxidation resistance that their coatings provide,

Scientists anticipate future hypersonic vehicles with ultra-high temperature ceramic coatings will be capable of sustained flight at Mach 7 or more, making it possible to travel from Los Angeles to New York in 30 mins.

In the process of leading this research effort, Dr. Corral was named the most promising doctoral engineer or scientist this year by the Hispanic Engineer National Achievement Awards Conference, or HENAAC. She also received an AFOSR Young Investigator Program Award in 2010.



*For additional information on this technology contact AFRL/AFOSR* **publicaffairs@afosr.af.mil**, *(703)696-7797.*

# Speed Agile Transport Vehicle Concept Undergoes Critical Testing

AFRL researchers are embarking upon a critical set of experiments designed to test a new Short Take Off and Landing (STOL) transport vehicle concept. During this set of experiments, a 23% scale model vehicle is being tested in the Arnold Engineering and Development Center's (AEDC) National Full Scale Aerodynamics Complex (NFAC), the world's largest wind tunnel. This testing will validate the low speed aerodynamic performance of the hybrid powered lift system. Powered testing at this scale with Williams FJ-44 engines achieves realistic conditions and allows researchers to obtain crucial data on lateral directional stability, ground effects, aircraft performance, engine performance, and engine operability.

Data gathered from the testing will be analyzed to determine the technology's applicability toward future vehicles. This technology could potentially benefit transport aircraft in both the civil and military realms.

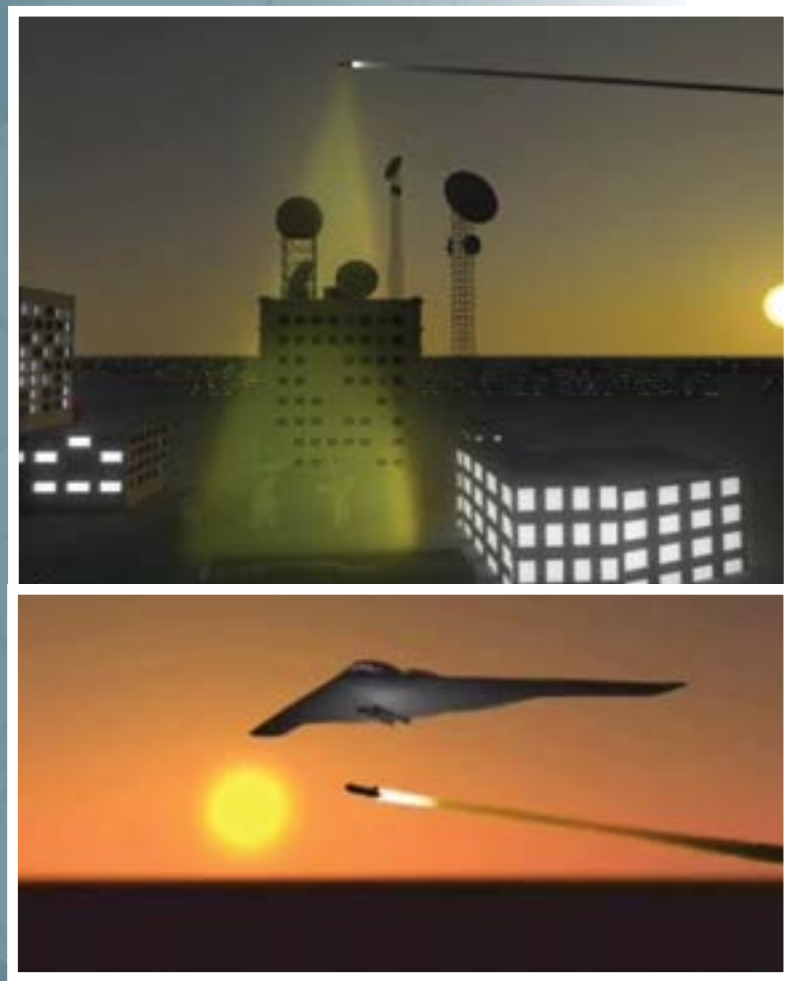
The Speed Agile Concept Demonstrator (SACD) concept is a four-engine, multi-mission aircraft that offers speed agility; operates routinely from short, improvised airfields; carries larger and heavier payloads; and employs precise and simple flight controls. The SACD's high-efficiency STOL design incorporates a hybrid powered lift system. This lift system features a simplified mechanical design and low-drag integration. Together, these features greatly reduce both the vehicle weight and overall drag on the vehicle, resulting in greater efficiency and payload capacity than conventional powered lift systems. An aircraft employing Speed Agile technology could potentially operate from short, unprepared airfields. These benefits, coupled with the overall vehicle efficiency, could result in an extremely versatile aircraft capable of quickly and safely transporting equipment, supplies, and troops to remote areas.

*AFRL researchers are testing this 23% scale model of the Speed Agile vehicle at the Arnold Engineering and Development Center's National Full Scale Aerodynamics Complex, the world's largest wind tunnel.*



*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# Counter Electronics Aerial Platform Demonstrates Accuracy



*Pictured top is a representation of a CHAMP beacon on target facility. Pictured bottom is a launch of the CHAMP.*

The Counter-Electronics High Power Microwave Advanced Missile Project (CHAMP) Joint Concept Technology Demonstration (JCTD) recently executed the flight-test Pointing Demonstration. This test demonstrated the navigational and pointing accuracy of the CHAMP aerial platform, as well as the ability to correctly trigger the payload with great timing accuracy. CHAMP provides the warfighter a non-lethal, low collateral damage capability that can be used against targets currently on the kinetic restricted target list. The technical requirements for the CHAMP system came directly from warfigher-provided inputs. CHAMP supports Combatant Commands faced with increasing operational limitations by providing an option to achieve mission needs while keeping collateral damage and post-conflict reconstruction costs to a minimum.

Combatant commanders expressed the need for military options on the battlefield that will keep troops far from enemy fire while achieving the desired effect of containment and control of the area. One possible method employs directed energy against the variety of electronic systems that our enemies use in military and asymmetrical warfare applications. The AFRL Directed Energy Directorate's High Power Microwave Division, is developing a multi-shot and multi-target aerial, high-power microwave (HPM) demonstration system to Deny, Disrupt, Degrade, and Destroy an adversary's electronic systems.

The CHAMP JCTD will develop and test a counter-electronics capability that integrates a HPM source into an aerial platform. HPM beams disrupt or damage targeted electronic circuits and components through various physical avenues. Through several years of testing, AFRL has proved these counter-electronics HPM effects. Several tests are being performed to demonstrate the capability; one major testing milestone is the Pointing Demonstration.



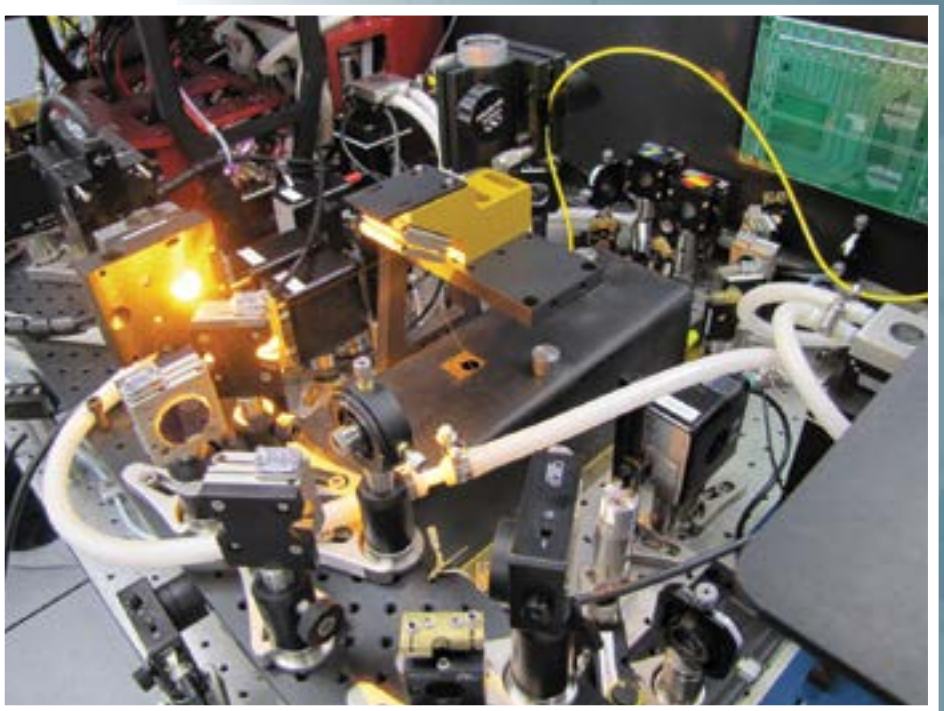
*For additional information on this technology contact AFRL/RD* **afrl.public.affairs@kirtland.af.mil**, *(505)846-1911.*

# Guidestar Laser Reaches, Surpasses Wattage Goal

The AFRL's experimental guidestar laser system has achieved its design goal of 50W, providing sufficient power to enable operation of the adaptive optics system. Laser guidestars are used to adapt a telescope's optics to more clearly image space objects. This breakthrough, eclipsing the previous output power of 12W, enhances 24 hrs space situational awareness (SSA) operations and advanced research, and enables better detection of small space objects. This technology, coupled with AFRL's ground-based telescopes, helps provide Air Force Space Command with real-time, high-resolution imaging of space objects for SSA, collision avoidance, and satellite health and status assessments.

In order to measure the atmospheric turbulence for adaptive optic wavefront correction, a reference star is required. The reference has to be very close to the object being imaged to obtain good correction. AFRL's Directed Energy Directorate Frequency Addition Source of Optical Radiation (FASOR) team used a 589 nm laser, enabling the creation of an artificial reference star over a broad area of the sky to provide superior imaging of objects for SSA.

Additionally, 50W is the design threshold that provides nominal power to ensure adequate guidestar return from the sodium layer to operate the adaptive optics system, compensate telescope images, and meet current test objectives during most of the year. Even better, the team repeatedly reached 55W, which meets the objective level of performance and ensures adequate system performance during more nights of the year (because of natural fluctuations in the sodium layer thickness). This will improve the ability to meet science and technology research and customer test objectives more rapidly, thus reducing test nights and cost.

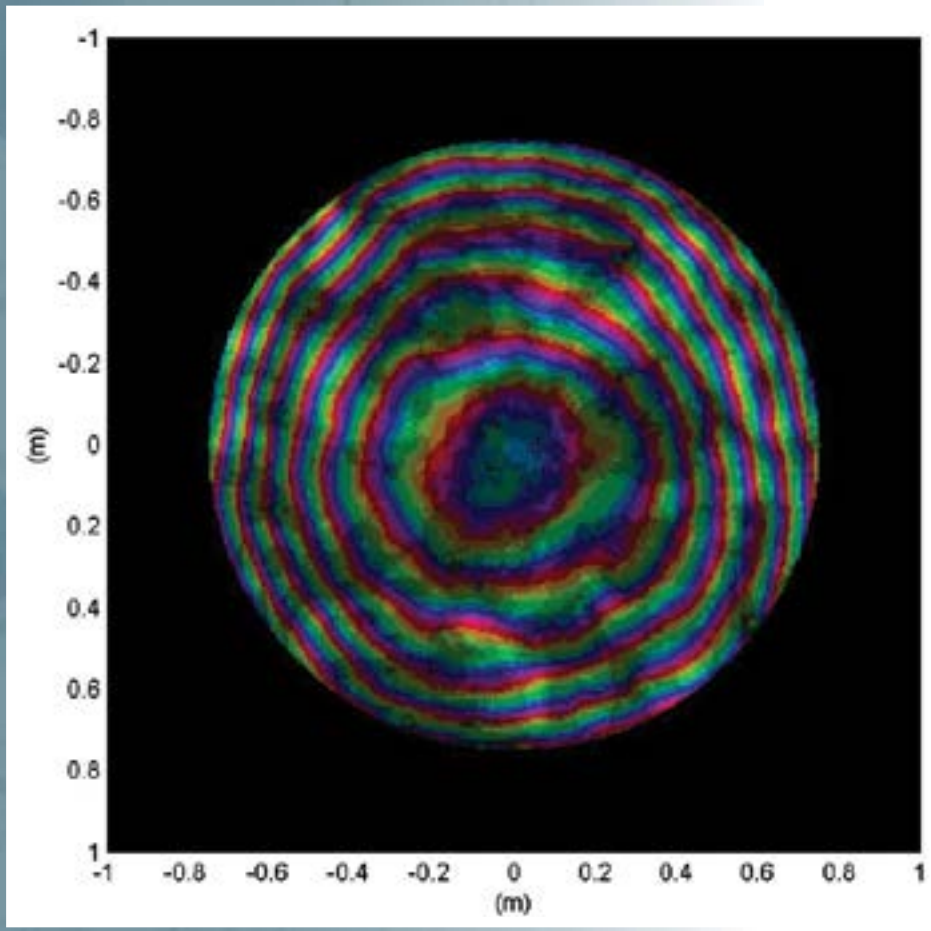


*Resonant 'bowtie' FASOR cavity, achieving 55W, which ensures adequate system performance during more nights of the year. The exiting port carries 55W of power with near perfect beam quality.*



*For additional information on this technology contact AFRL/RD* **afrl.public.affairs@kirtland.af.mil**, *(505)846-1911.*

# AFRL Develops Advanced Techniques for Electromagnetic Propagation




*Pupil Plane Depiction of Phase Distortion and Scintillation of a Point Source Propagating through Turbulence.*

The Air Force (AF) is interested in increasingly more complex optical systems, which often include optical propagation through the turbulent atmosphere followed by sensing and compensating with complex devices. The AFRL, through a Small Business Innovative Research (SBIR) contract, developed a simulation tool called WaveProp. Advanced modeling techniques were developed for imaging extended objects, accurately representing disturbance effects such as turbulence and thermal blooming, and dealing with simulaton effects such as propagation aliasing. The tool is used to model lasercom systems, weapons systems, laser guide star systems and phase array systems, among others. With this tool the AF can test new designs in simulation, instead of building trial designs at much greater expense.

AFRL partnered with Optical Sciences Company of Anaheim, California, to develop the WaveProp technology. A key component of the development is extensibility, which enables non-expert users to not only use existing classes but to enhance or develop new classes. WaveProp is being used at AFRL's Directed Energy Directorate's Starfire Optical Range, which houses its 3.5 m telescope, and its Maui site, which houses the 3.6 m telescope. The Air Force Institute of Technology has also used WaveProp in its graduate courses on wave optics simulation and several graduate students have used WaveProp in their dissertation research.



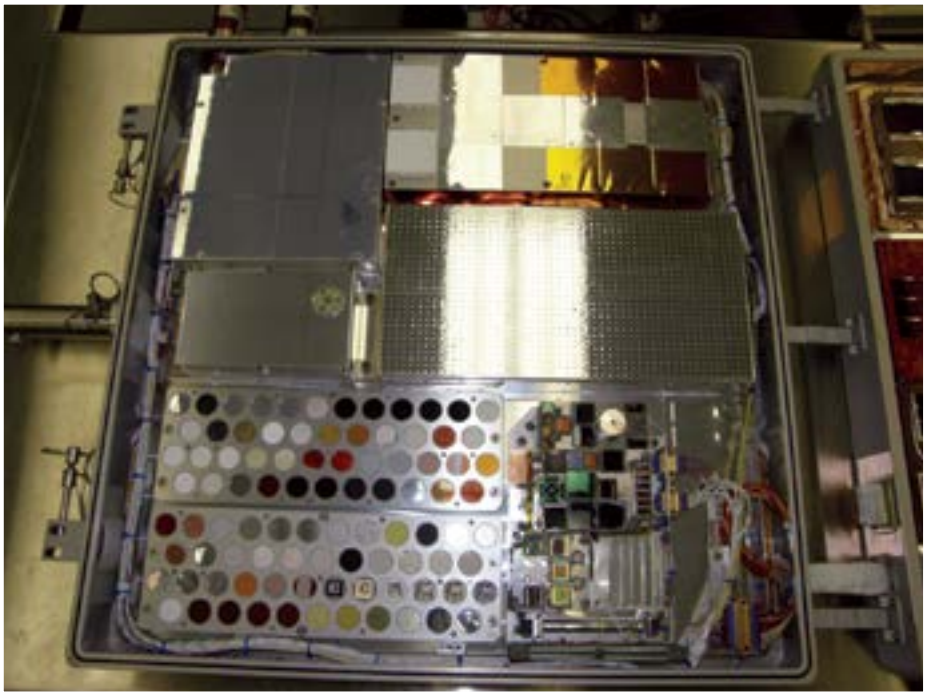


*For additional information on this technology contact AFRL/RD* **afrl.public.affairs@kirtland.af.mil**, *(505)846-1911.*

# AFRL Materials Experiments Fly on Endeavour, Return on Discovery

On May 16, 2011, the National Aeronautics and Space Administration's Endeavour space shuttle carried AFRL materials on International Space Station Experiment - 8 (MISSE-8) to the International Space Station (ISS). AFRL researchers designed, built and are flying one of the eight experiments to gain a better understanding of how common space materials age, degrade and change in low earth orbit. After 2-years in space, AFRL scientists will analyze how the optical characteristics of the materials changed. AFRL scientists completed the seventh in a series of materials-related experiments when Space Shuttle Discovery MISSE-7 returned to Earth on June 1, 2011 after 18 months in space.

There is currently very limited data on how the optical characteristics of materials change while on-orbit in space. Most existing space effects data is collected via vacuum testing on the ground. The data collected in this experiment will provide truth data to compare to predicted results to enhance our understanding of space effects on the optical characteristics of materials. AFRL and space mission partners use this information for a variety of reasons, including being able to more accurately identify space objects from optical imagery.



*Payload Experiment Container (PEC) of the MISSE-8.*



*For additional information on this technology contact AFRL/RD* **afrl.public.affairs@kirtland.af.mil**, *(505)846-1911.*

# Tactical Relay Mirror System Achieves High-Power Laser Milestone

*TRMS weapons concept accomplished for MATRIX, which provides the ability to track, acquire, illuminate, and lock on to targets using game-changing laser technology to negate unwanted threats.*

The AFRL accomplished end-to-end high power laser testing for the Tactical Relay Mirror System (TRMS) and Mobile Active Targeting Resource for Integrated eXperiment (MATRIX). A high-power beam was propagated from MATRIX through the Relay Mirror, kilometers away, then on to a down-range target. Uplink testing was completed at low and moderate power, followed by successful full power tests. A series of 17 full-power tests were completed to optimize uplink beam size and characterize transmitter focus at full high energy laser power. These tests are highly valuable in extrapolating to higher power "weapon-grade" lasers in the future. TRMS will provide the warfighter with real-time sensor shooter capability in an urban environment.

This milestone concludes the development of the TRMS payload development and field integration. The program now will begin transition to risk reduction experiments for the Integrated Protected Shield application. The Tactical Relay Mirror System can be tethered above the MATRIX, and uses a series of mirrors to re-direct or relay a high-energy laser to perform Integrated Force Protection activities.

The TRMS is especially useful for the warfighter because it can see and engage targets over the horizon or around urban structures in tactical environments. MATRIX is a mobile, trailer-mounted test bed that provides the high energy laser source for TRMS. MATRIX provides the ability to track, acquire, illuminate, and lock on to targets using game-changing laser technology to negate unwanted threats.



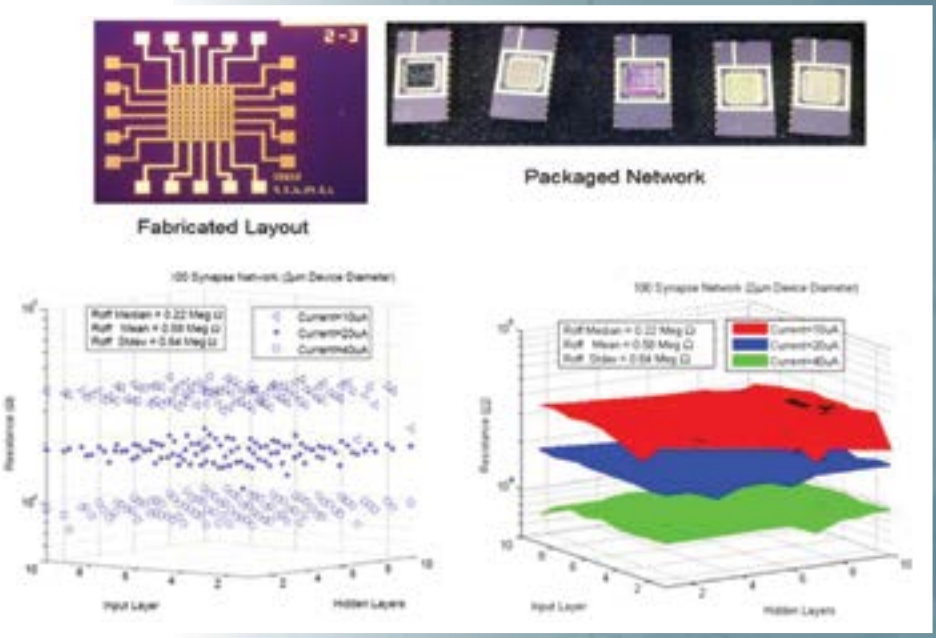
*For additional information on this technology contact AFRL/RD* **afrl.public.affairs@kirtland.af.mil**, *(505)846-1911.*

# Memristor-Based Neural Network Fabricated, Characterized

AFRL's in-house Computational Intelligence research group, led by Dr. Robinson E. Pino, has achieved a critical milestone in the design, fabrication, and characterization of a 100-synapse memristor-based neural network. In collaboration with Boise State University (BSU), the team fabricated and characterized a memristor-based neural network, leveraging BSU-developed ion-conductor chalcogenide-based memristor devices.

The characterization results demonstrate that neural networks containing 100 interconnected memristor-based synapses can be programmed individually to various memristive states. For example, we have programmed three distinct memristance states for each of the 100 memristor-based synapses in the neural network.

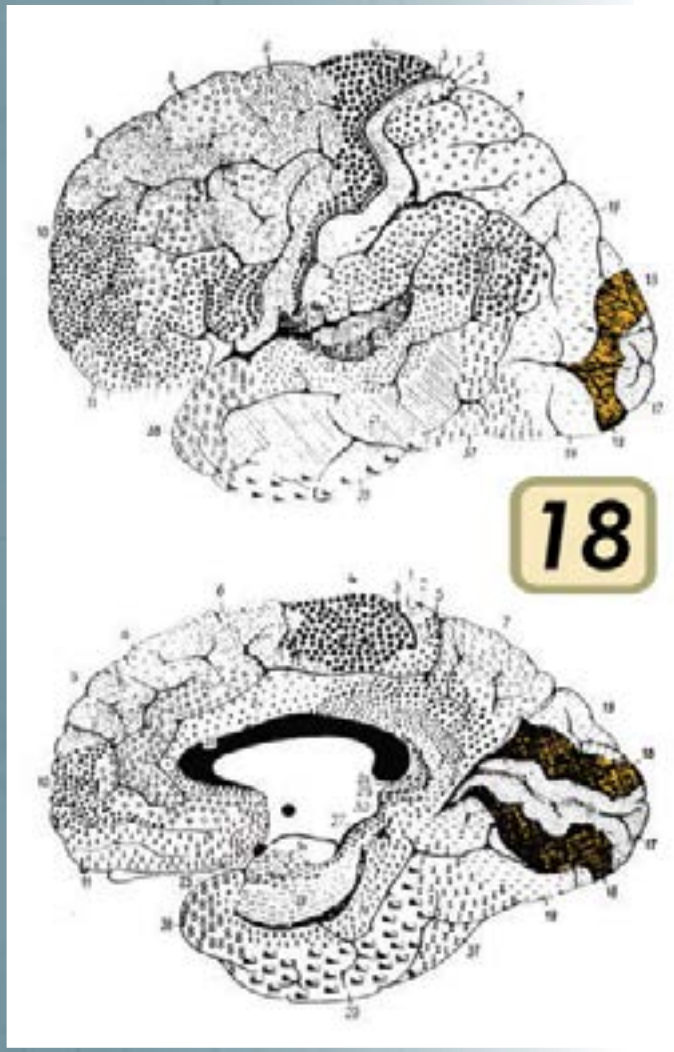
The Computational Intelligence group has been working for over four years developing cognitive computing architectures to enhance the robust decision-making capabilities of the Air Force (AF). Today is the age of information overflow, and the Advanced Computing Architectures division has foreseen the need to develop computing technology with the ability to perform autonomous intelligent functions that will enhance the performance of the warfighter.




*Decision-making capabilities of the AF are enhanced by neural networks containing 100 interconnected memristor-based synapses that can be programmed individually.*

Discovery

# Researchers Identify Path to Emulate Visual Cortex V1 and V2 Layers




*Architecture of Visual Cortex V1 and V2 layers, areas of the brain the Computational Intelligence research group is seeking to emulate with computer architecture.*

The AFRL's Computational Intelligence research group has developed a rapid prototype of the functions traditionally attributed to the visual Brodmann Area 18 (V2) "pale stripe" and has been built to assess "templating" as a plausible mechanism for form perception. V2 pale stripes are thought to detect a lexicon of spatial symbols whose complexity is modestly greater than the edge detections attributed to area V1. The prototype, based on hierarchical object recognition models, consists of a selected lexicon, a V1 to V2 mapping, and a distance calculation. Also, work is being done to incorporate timing-dependent plasticity feedback to V1, and a recurrent neural network point attractor for fusing multiple streams of evidence (feed forward, feedback and lateral context) into a perception belief. The vision of the Computational Intelligence group is to enable superior adaptive, intelligent and autonomous computing for the Air Force.

Our advanced computing architectures division has foreseen the need to enable computing systems the ability to perform autonomous intelligent functions that will enhance the performance of the warfighter. Thus, the research group has been tasked to develop the next generation of emerging computing architecture that can perform intelligent tasks and learn autonomously.



*For additional information on this technology contact AFRL/RI* techinfo.if@rl.af.mil*, (315)330-2143.*

# Engineering Methodology Designed to Monitor Software Security

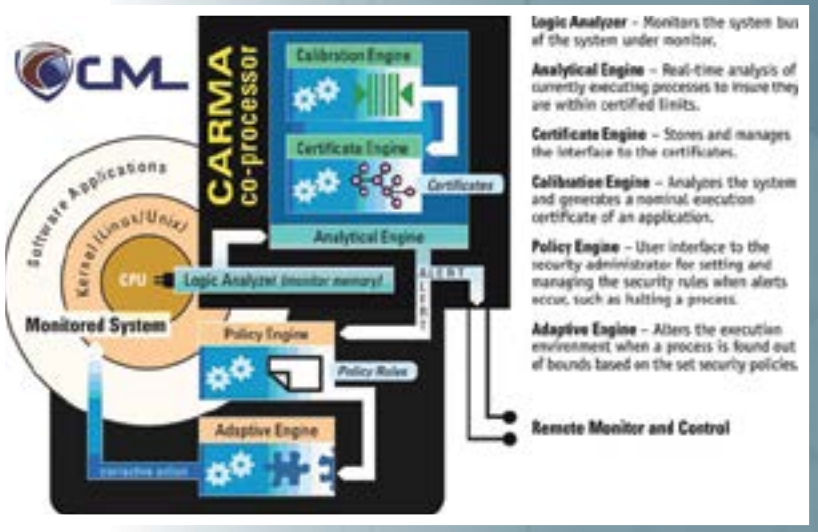
Computer Measurement Laboratory, Inc. (CML) designed an engineering methodology for software process control developed around an 8-Lane PCI Express (PCIe) card, which is the initial release of an extensive family of software process control systems. Through use of the CML Attack Recognition Management Architecture (CARMA™), which represents a proof-of-concept in the PCIe card environment, software processes can be monitored during their execution by a hardware-based control system.

The savings for the full utilization of the software/system process control would extend the lives of legacy systems and significantly reduce the lifecycle costs.

The Global Information Grid (GIG) requires software security that extends to the end-nodes of the network. Software applications that are vulnerable to malicious alteration, piracy, and reverse engineering can result in the compromise of command, control, and communication channels. The Anti-Tamper Software Protection Initiative (AT-SPI) Technology Office is performing research and development in kernel-mode software protection as a means to protect applications by making them less accessible (i.e., more out-of-band) to the attackers. The Department of Defense needs to develop advanced self-monitoring and self-healing techniques for kernel software protection technology.

If a software system has been compromised, its normal activity profile will change. Processes may then be instituted to restore the system to a nominal state. CML has leveraged dynamic measurement technology to develop an engineering approach to software process control. The objective of this approach is to break the traditional software vulnerability cycle. Through the use of software process control, a software system may be monitored, in real time, for evidence that it has been compromised.

This technology can be readily integrated into the current servers and desktop systems in use today. The objective of the ongoing Phase II program enhancement is to migrate software process monitoring technology to the embedded systems design and development environment. Using the embedded CARMA technology, software processes can be monitored during their execution by a hardware-based control system.




*CML CARMA™*

# Ergonomic Design Benefits Users of Large-Display Workstations

*This ergonomically designed large-display workstation is designed for ease of adjustment, portability, and comfort for seated or standing users.*

Advances in computer and display technology and a dramatic shift in work responsibilities have rendered small, standard computer monitors inadequate because they no longer meet the demands of the workplace. There has been a great deal of work designing ergonomically friendly office furniture, but to date no published guidelines exist for large-display workstations, which are being increasingly integrated into the workplace. What works for a small monitor does not work for a large monitor. The ergonomically designed large-display workstation consists of two 30 in. displays, each with a resolution of 1600x2560 and one 56 in. Quad-HD display with a resolution of 3840x2160. This creates a display system with a combined resolution of 16,486,400 pixels, which is 7.95 times that of HDTV. The display height, display tilt, and keyboard tray height are independently electro-mechanically controlled and paired with a manual keyboard tray distance adjustment. The system is on casters for portability and can be collapsed to a depth that fits through a standard 3 ft doorway. It maximizes a user's workspace while minimizing the footprint necessary to provide such a powerful display system.

The workstation was showcased at the Advanced Maui Optical and Space Surveillance Technologies (AMOS) Conference in September 2011, where it was pivotal in showing off other AFRL-developed software.

The display met or exceeded all expectations and was a constant item of conversation and interest from all attendees. The actual unit displayed is on its way to the Joint Space Operations Center's (JSpOC) Mission Integration Enclave (MIE) facility at Vandenberg Air Force Base, California, where the workstation and software will be tested against actual mission needs and find a suitable home where its unique capabilities will enhance warfighter effectiveness. A clone of the workstation is being fabricated to host at the AFRL's Rome Research Site's 222nd Command and Control Squadron detachment of the Air National Guard. Here it will be used to train and support their unique mission for both the National Reconnaissance Office and the US Air Force's Space Command. Having operators on both coasts use the workstation with various software requirements gives researchers at AFRL valuable insight into future enhancements and how best to serve the Air Force and its mission.





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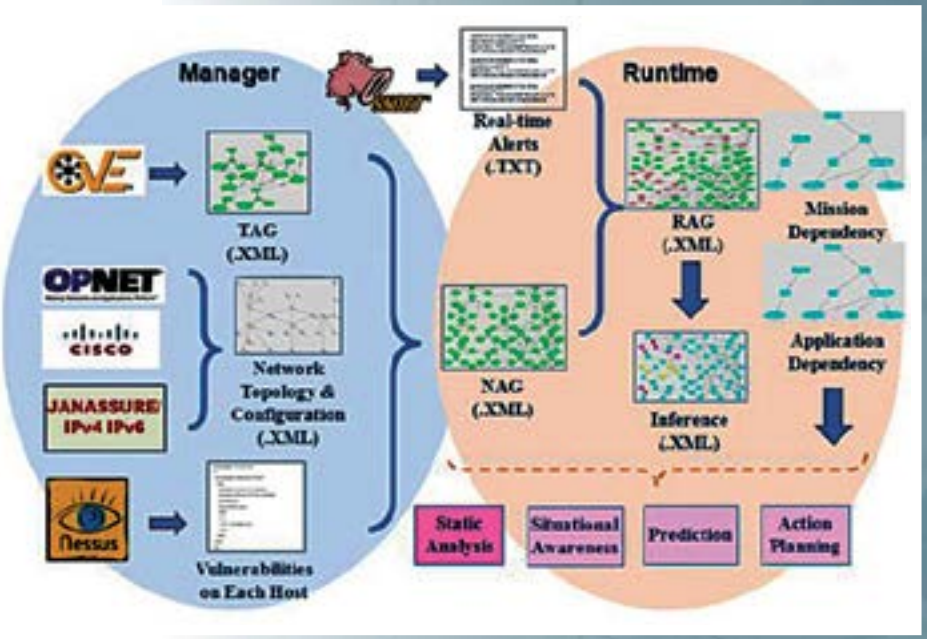
# Software "Sees" Situation's Vulnerabilities, Consequences of Cyber Attack

The AFRL developed a Network Intrusion, Risk and Vulnerability Analysis (NIRVANA) software tool under a Small Business Innovation Research (SBIR) project to provide a comprehensive cyber security analysis capability. The tool uses data from multiple intrusion detection systems to produce a comprehensive situation awareness picture, including a static evaluation of network vulnerabilities.

In this tool, network vulnerabilities are identified using the novel attack graphs associated with applications and mission requirements, allowing the tool to identify the consequences of actions. The technology can estimate the probable targets intended by the attacker, allowing operators to counter with near-real-time actions, effectively denying the attacker's goals. The technique is designed to scale, allowing for coordination of multiple security domains, and several runtime operators.

Using this tool, the Air Force, Department of Defense (DoD) and other large enterprises have the first comprehensive capability to visualize the implications of a cyber attack. Operators will be able to anticipate the actions of attackers, even when a slow-brewed or multi-prong attack is in progress. The ability to anticipate and adjust in order to maintain mission readiness during the attack, although present in DoD cyber security strategy, is a missing component of our current cyber deterrence arsenal. This NIRVANA technology is the first to provide coherent enterprise-wide network cyber attack damage assessment.




*NIRVANA architecture – Integrated graphic models for efficient, practical network attack damage assessment.*

*For additional information on this technology contact AFRL/RI* **techinfo.if@rl.af.mil**, *(315)330-2143.*

# Smaller Antenna Aperture Draws Interest from Military, Radar Technology Contractor

*A flight-worthy VHF SAR antennas was tested on a C-131 Aircraft.*

The AFRL identified and implemented an effective method of reducing the size of the antenna aperture for Very High Frequency (VHF) Synthetic Aperture Radar (SAR) systems. Under a Small Business Innovation Research (SBIR) project, 2 antenna elements were used to form a beam while maintaining a high level of signal fidelity in the desired direction. The 2 antennas are combined using a novel phase steering mechanism that directs energy from horizon to nadir while simultaneously placing a null at the direction of the conjugate beam. The planar wideband phased-array is capable of pointing a beam at a desired depression angle on both sides of the aircraft over the entire bandwidth. A 10 decibel (dB) goal was initially set front to back ratio to make it effective for imaging.

During Phase II of this Air Force program, a flight-worthy prototype of this system was constructed. The electrical and mechanical characteristics of this system also drew interest from another military service and prime contractor for a radar technology program. The success of this SBIR project was further enhanced by the inter-directorate cooperation between the AFRL's Information and Sensors Directorates, as well as the active sponsorship of the Aeronautical Systems Center's Advanced Imagery Technology Branch.

VHF is a useful operating band for SAR systems for two main reasons: the radar hardware at these frequencies is relatively inexpensive, and the wavelengths allow foliage and ground penetration. However, antenna design is a perpetual problem with VHF SAR systems. In order to produce high fidelity images, SAR systems require high isolation between the antenna main beam and the conjugate beam. The conjugate beam is energy radiated at the opposing depression angle. In order to achieve this high front-to-back (F/B) ratio, conventional arrays need a large number of elements and or area for a reflector. Operating at VHF, this array would be very large and its installation aboard any platform is permanent because of the inherent difficulty in installing an array of its size. The goal of this program was to develop an electrically small array that could meet the requirements for SAR (high F/B ratio) and could be quickly installed and removed.



*For additional information on this technology contact AFRL/RI* **techinfo.if@rl.af.mil**, *(315)330-2143.*

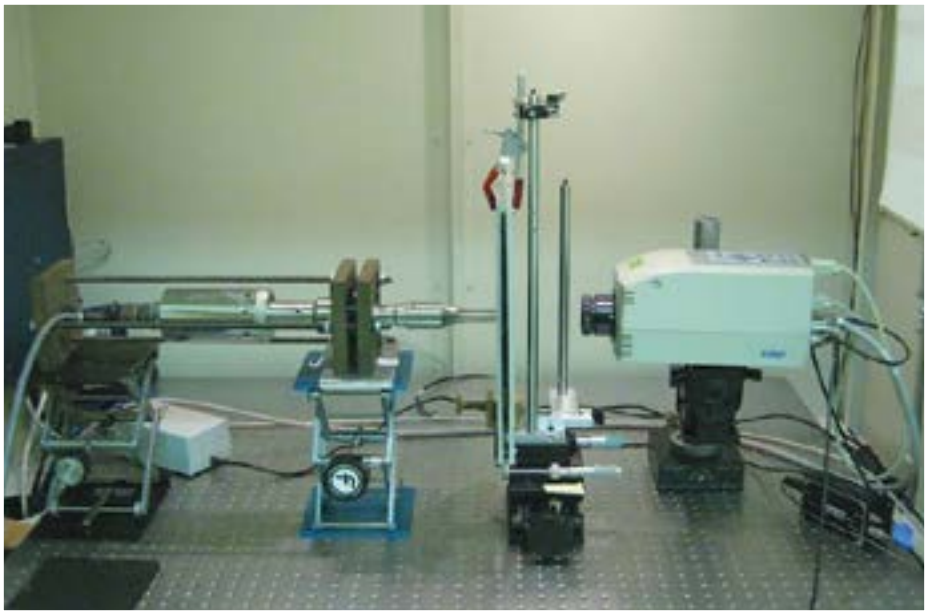
# Patented NDE Method Detects Incipient Damage

In developing a new nondestructive evaluation (NDE) technique for characterizing heat-induced damage in composite materials, AFRL scientists have helped to evolve Air Force systems maintenance to a condition-based (improved), rather than schedule-based (outdated), routine. The novel technique—which leverages acousto-thermal technology and recently earned researchers a patent entitled "Non-contact Thermo-elastic Property Measurement and Imaging System for Quantitative Nondestructive Evaluation of Materials"—also demonstrates potential in characterizing fatigue and plastic deformation before cracking occurs in metallic materials.

The characterization of material degradation provides input data critical to the development of material prognosis and lifing models. While numerous NDE techniques are available—and regularly used—for evaluating heat damage in composites, most detect surface and subsurface cracking and delamination via ultrasonics, electromagnetics, and thermography, none of which have proven effective in detecting incipient damage stemming from thermal exposure. Conversely, AFRL's newly created NDE technique reliably detects this initial—often hidden—damage by gauging relative changes in temperature as generated by the absorption of high-amplitude acoustic waves propagating through the material.

Polymer composites with reinforced carbon fibers are widespread in aerospace applications, especially in high-performance aircraft, because of their low density and excellent mechanical properties. Unfortunately, a significant problem with polymer composites is their loss of mechanical strength (up to 60%) when exposed to temperatures above those specified for the material. This loss may occur without evidence of cracking, delamination, or other visible indication of damage. The availability of an NDE technique enabling the detection of incipient damage (initial material property changes that occur before cracking or delamination) caused by exposure to elevated temperatures has therefore emerged as an important challenge.

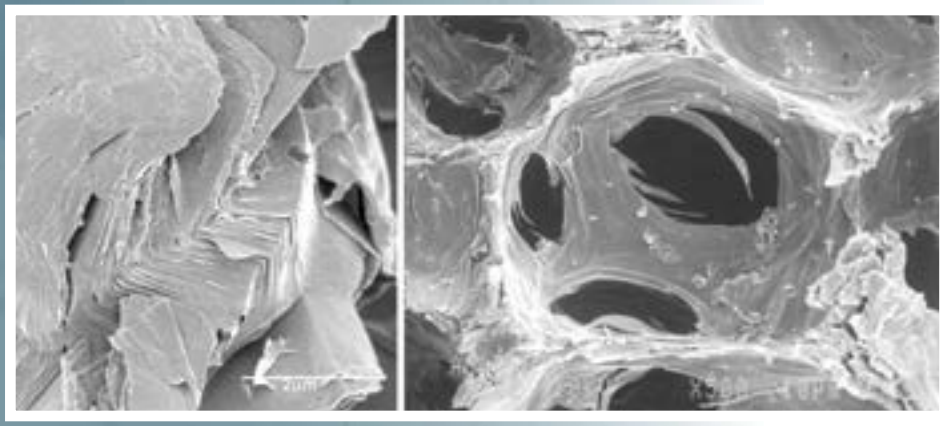
The new process uses an ultrasonic horn placed a short distance from the material. The horn creates an acoustic pulse as a highly sensitive infrared camera records the maximum temperature increase on the opposing surface. Since incipient heat damage affects the maximum temperature increase generated by a material for a given acoustic pulse, the relative change in maximum temperature increase between an undamaged and a damaged material enables the detection and evaluation of material changes, including a correlation to strength loss.



*The noncontact thermoplasting property measurement and imaging system setup.*

*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Carbon Foam Well Suited to Thermal Management



*The complex geometry of carbon foam is enhanced by this microscopic imagery.*

Thermal management is critical to aerospace systems, and researchers at the AFRL are tailoring carbon foam materials to enhance thermal protection in Air Force applications. Carbon foam materials are well suited to the task because of their unique high-temperature properties, high thermal shock resistance and dimensional stability. Ultra lightweight, thermally stable, multifunctional materials are critical in the development of thermal protection systems (TPS), thermal management systems (TMS) and heat exchangers.

Materials that can be tailored to carry, store, and shield thermal energy in an aerospace system improve performance while increasing speed and operational life. Carbon is an extremely tailorable material, with intrinsic attributes ideal for TPS and TMS. Carbon offers more stiffness than polymer foams and elastomers, and is lighter than many polymer and ceramic composites, elastomers, polymer foams and metals. Some varieties of carbon foam offer low temperature processing, which is ideal for insulating. Other processes yield carbon foam that can process high temperatures. The open-cell porosity of conductive carbon foam also offers a scaffolding microstructure for solid state thermal storage devices, significantly reducing the charging/decharging cycle time.

TPS-hybrid materials designed with embedded carbon foam of connected porosity will enable micro channel cooling of TPS sharp leading edge (tip diameter < 0.02 in.)—existing technology of high-temp alloys cannot do this. Replacing metal heat exchangers with air-to-air heat exchanger designed with carbon foam provides a weight savings of 30% and doubles performance life.



*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# New Welding Process Proves Better at Joining Airframe Structural Materials

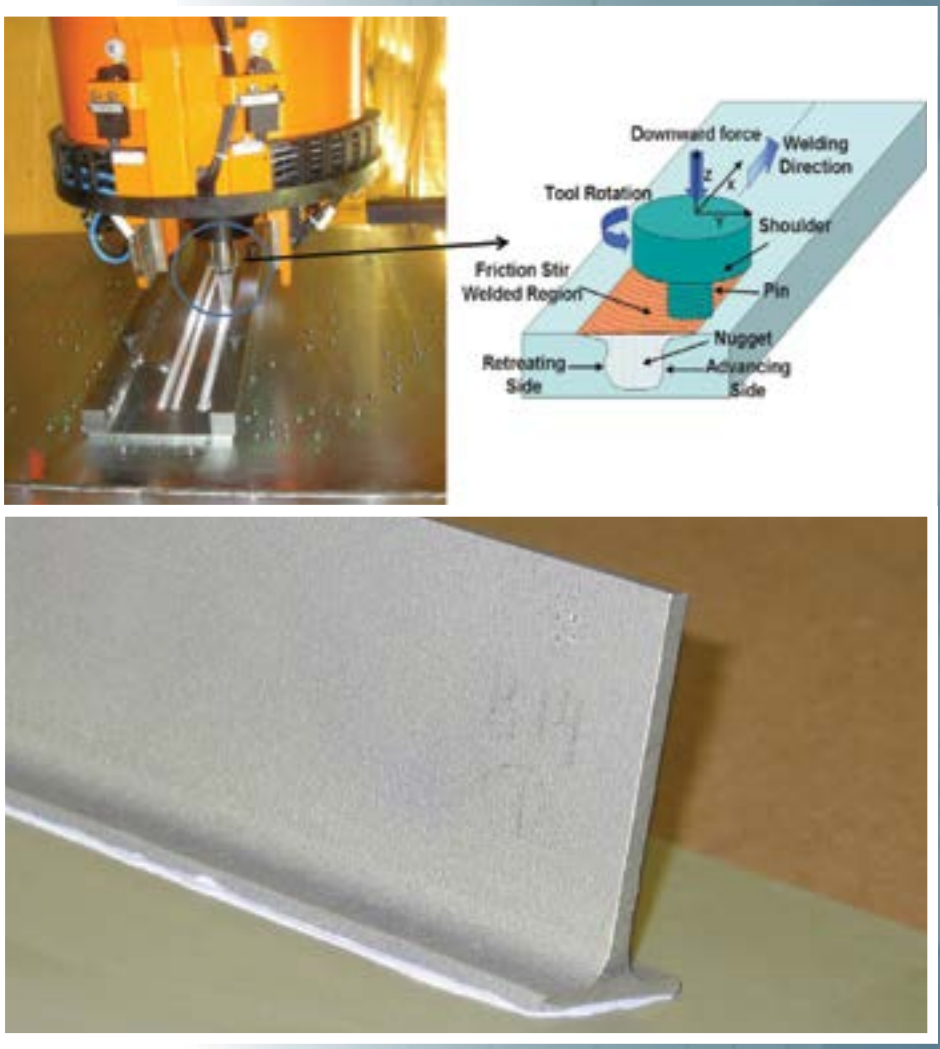
AFRL researchers are working with a team from the Missouri University of Science and Technology (MS&T) to improve the process for joining airframe structural materials. A promising new technology application—frictionstir welding of critical aerospace alloys—reduces the number of fasteners required in structural assemblies, thereby saving money. In addition, traditional materials used for corrosion protection cannot be used if alloys are subsequently welded, so a new process was developed to help solve the application problem of providing corrosion protection to lap joints.

MS&T, under contract with AFRL, developed the Center for Aerospace Manufacturing Technologies (CAMT), which serves as a national center for research, development, evaluation, demonstration and transfer of tools for the rapid and cost-effective manufacture of aerospace components and products. Friction stir welding (FSW) is one of these technologies, showing promise as replacement for riveting in the assembly of airframe structures.

During FSW, two pieces of sheet or plate material are overlapped and clamped in place. A cylindrical-shouldered welding tool with a profiled tip is plunged into the top work piece, rotated at a constant speed and fed at a constant rate, stirring the materials together. Frictional heat is generated between this tool and the clamped pieces, causing the stirred materials to soften and flow plastically together.

Regardless of assembly technique, the lap joints formed require sealants to prevent corrosion. In the FSW process, however, technicians cannot use traditional corrosion protection schemes because their beneficial properties are destroyed during the welding process. In the improved process developed at CAMT, a sealant is applied on the mating surfaces by plasma spray before fixturing, which then melts as heat is generated during FSW. As the sealant melts, the clamping pressure distributes the sealant, which solidifies to form a sealed joint. The pressure from the tool shoulder forces the polymer to flow out of the tool area so it is not incorporated into the weld nugget, allowing the entire weld area to be coated with the sealant during plasma spray application—masking of the weld path is not required.

One of the benefits MS&T provides in partnering with industry is solving the application problems that a new process generates, such as joint corrosion protection. This bridges the powerful analytical work of understanding the metallurgical echanisms with the development of practical techniques to apply solutions in a production environment.




*Missouri University of Science & Technology's friction stir welding operation (pictured top left), and a schematic of the friction stir welding process. (pictured top right) Nylon sealant after friction stir welding, a process that reduces the number of fasteners needed in airframe structural assembly. (pictured bottom)*



*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# AFRL's Space Experiment Yields Valuable Data

*MISSE 7 on orbit after astronaut deployment.*

Specimens and technology from the AFRL have returned to earth after 15 months in space, completing the seventh in a series of experiments studying the effects of the space environment on material and device performance. The combination of space effects is unique; therefore, the Materials on the International Space Station Experiment (MISSE) provides invaluable testing ground for new materials as well as those needing requalification because of processing changes. MISSE also reduces material screening and qualification costs.

During MISSE, material specimens and technology experiments are sent to the International Space Station (ISS), where containers that house the specimens and experiments are attached to the space station's exterior, opened and exposed to environmental effects. The experiments are designed to expose key technologies to atomic oxygen bombardment, solar radiation, and other space environment extremes.

MISSE7 included over 150 samples in 10 experiments, 6 of which were active. Active experimentation provides unprecedented information that reveals how material properties are affected by on-orbit exposure. Until MISSE5, only passive material experiments, which limit analysis to the period before and/or after deployment, were included. MISSE7 is the most advanced study in the series, and for the first time, transmits digital data through the ISS down to AFRL, the Naval Research Laboratory, and the National Aeronautics and Space Administration ground stations for real-time processing.

The AFRL technologies evaluated during MISSE7 include: Electro-Magnetic Hardening, Composites, Fibers, Nanomaterials, Metamaterials, Resins and Adhesives, Deployable Structures, Solar Cells, Optical Coatings and Hardening, Tribological Coatings and Materials, Mirrors and Reflectors, and Ultra Hi-Temperature Ceramics. One additional experiment is planned before the space shuttle retires.





*For additional information on this technology contact AFRL/RX techinfo@wpafb.af.mil, (937)255-6469.*

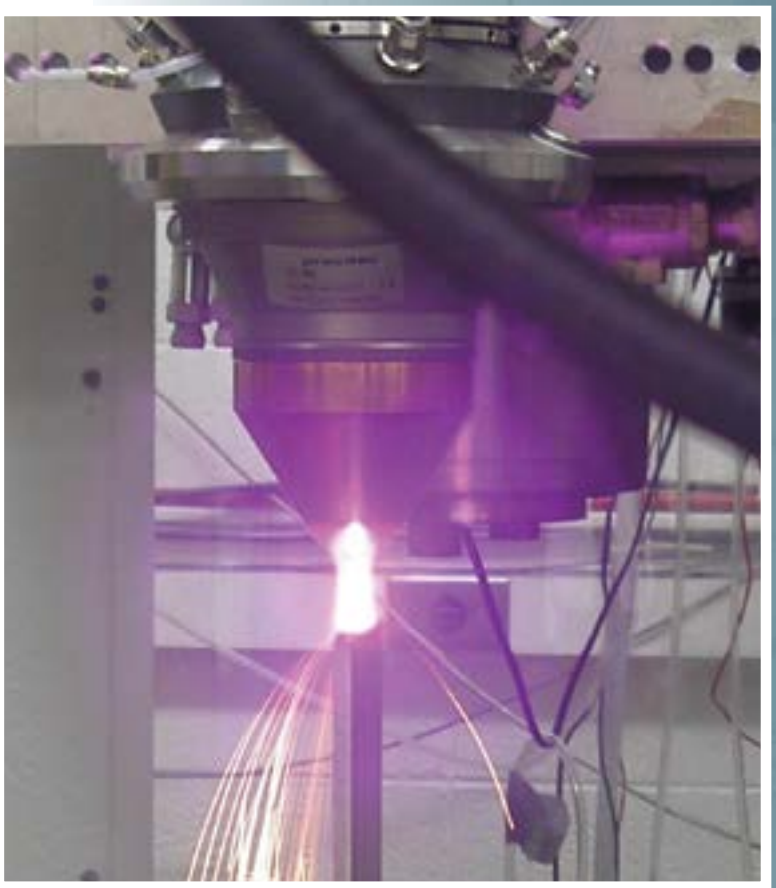
# Additive Manufacturing System Laser-Precise with Aerospace Parts

Researchers from the AFRL and the Missouri University of Science and Technology (MS&T) developed a world-class hybrid laser deposition and machining system. The metal additive manufacturing system integrates laser deposition with machining processes to form a hybrid manufacturing process to build precision metal parts for aerospace components.

This hybrid process allows higher precision dimensional control along with the ability to characterize material properties as the part is generated. This state-of-the-art system will allow the rapid creation of prototype metallic components using high-temperature materials such as titanium alloys and tool steels, and will reduce the amount of required support structure during the build by up to 60%.

Rapid prototyping technology is of interest to various industries that are looking for a process to build a part directly from a computer-aided design model in a short time. Among the processes used for this, the direct metal deposition process is one that directly manufactures a fully dense metal part without intermediate steps. A process planning tool assists in the determination of deposition parameters and material soundness, which are complicated by complex geometries, thermal history and laser-powder interactions.

Hybrid laser deposition and machining is a unique MS&T process, and potentially a very competitive approach to the fabrication and repair of metallic structures. As part of an AFRL program, MS&T developed the hybrid additive-subtractive process for high temperature metallic materials, including tool steel and titanium.



*The MS&T hybrid laser deposition and machining system, which integrates laser deposition with machining processes to form a hybrid manufacturing process to build precision metal parts for aerospace components.*



*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Flexible Aerogel Materials Production Increased, Energy Savings to Follow

*Flexible aerogel, whose nanoscale lattice structure and pores create unique properties in solid material that make it an incredible insulator.*

Domestic manufacture of high-quality, low-cost aerogel-based blanket material is being expanded, thanks to a DPA Title III program that partners Aspen Aerogels with the AFRL. Aerogel materials provide thermal and acoustic insulation, infrared signature reduction, and thermal management properties for a variety of ground, air and sea systems.

An aerogel is a solid material with nanometer-sized pores, typically made from silica. The pores, which are typically about 10 nm in diameter, are formed by the open silica lattice structure. An aerogel offers around 99% open porosity, and the nanoscale lattice structure and pores create unique properties in solid material that make it an incredible insulator. As thermal insulation, aerogels are 2 to 5 times more effective than foamed plastic or fiberglass.

Conventional aerogel materials are brittle and exhibit low shear strength, making them impractical for many applications. However, flexible aerogel materials can be handled and installed like any other thermal insulation. High-volume production will decrease costs to the Department of Defense and ensure a stable and secure domestic supply of these materials.

This flexible, high-temperature aerogel materials project, a multi-phased effort between Title III/ AFRL and Aspen Aerogels in Northborough, Massachusetts, has completed several significant activities. To date, a high volume production capability has been established and further expansion is under way, manufacturing yields have improved, cycle time has been reduced significantly, and manufacturing costs have decreased.

Testing is under way at the National Training Center, Fort Irwin, California, in the Net Zero plus Joint Capabilities Technology Demonstration. Two prototype aerogel tent-liners are being evaluated. In addition, aerogel material has been investigated for use as a thermal management system in up-armored High Mobility Multipurpose Wheeled Vehicles (Humvees).

Ninety thousand square feet of aerogel insulation was recently installed in the interior walls of Wedge 5-2 in the Pentagon during its renovation. It is anticipated that there will be a savings in energy as well as a reduction in $CO_2$ emissions. It is hoped that this small-scale demonstration effort will be a catalyst to migrate the aerogel insulation technology to other Federal installations, thereby accruing significant energy savings.





*For additional information on this technology contact AFRL/RX techinfo@wpafb.af.mil, (937)255-6469.*

# Solid Lubricating, Fracture-Resistant Composite a Boon to Engineering Applications

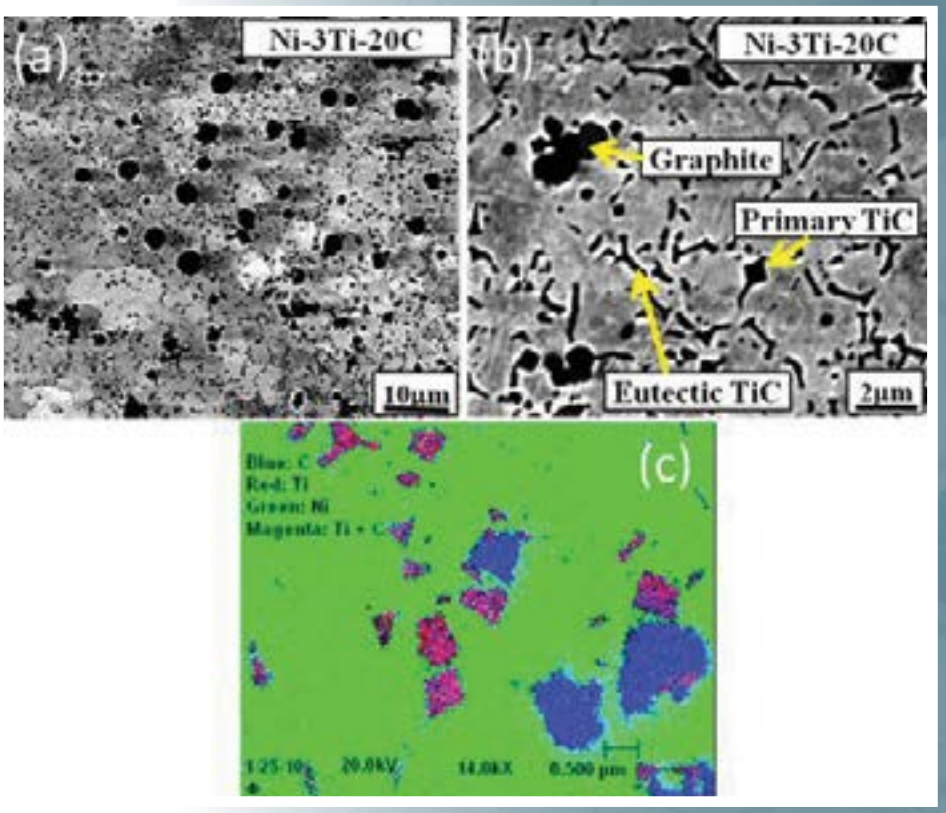
AFRL scientists have developed a new solid lubricating, high hardness and fracture-resistant composite for use in surface engineering applications. The program was a joint effort between AFRL and the Institute for Science and Engineering Simulation (ISES).

This multifunctional hybrid composite material can be processed in near net shape, and exhibits a perfect balance of high hardness, fracture toughness and low friction wear. Because of these characteristics, the material is a good candidate for applications where all three properties are required, such as in land-based turbines and compressors, oil-drilling components such as wear bands, stabilizers and drill collars, and tunnel boring applications.

Engineers need composites such as this for use in surface engineering applications. Many materials use thin films or coatings that are directly deposited on the material; unfortunately, these coatings and films eventually wear away, delaminate, fracture or fail.

AFRL is teaming with multi-disciplinary research teams at ISES, located at the University of North Texas in Denton, Texas, to develop and transition engineering technologies to the Air Force for use in aerospace applications.

Researchers are currently working to further optimize the materials and commercialize them for specific industrial applications. Patent disclosure efforts are on-going and researchers anticipate additional coatings based on similar technical strategies. Future efforts include expanded mechanical testing of the coatings under differing load environments and additional high resolution characterization of the microstructure and phase interactions using advanced electron imaging techniques.




*Low (a) and high (b) magnification SCM images and (c) Auger electron spectroscopy (AES) color map (512x512 pixels) of phases in the Ni3-Ti-20C composite. The thermal pseudocolor AES image shows relative amounts of the constituents.*



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil*, (937)255-6469.*

# Polarizing Lenses Give Warfighter Edge in Identifying Targets

*Images demonstrating polarimetric information in different orientations.*

The AFRL successfully designed and demonstrated miniature metallic polarizing lenses that will provide the warfighter better polarimetric imagers and better information about targets. The miniature spiral plasmonic lenses, designed by AFRL and University of Dayton researchers, will be demonstrated on imaging focal plane array pixels and will provide a capability suitable for use in Air Force (AF) imaging systems.

This technology will provide new information within polarimetric imaging systems by providing for direct circular polarimetric images to complement the existing linear polarimetric images. Because the new polarizer-lenses will be fabricated directly onto focal plane array pixels next to linear micro-polarizing pixels, this represents an added capability with no added size, weight or power. The new information will add to the ability to characterize target objects: polarimetry can significantly increase the probability that AF systems can easily identify man-made objects, characterize and distinguish them from their natural environments. Beyond AF applications, the technology is desirable for use in national security, agriculture, environmental studies and other remote-sensing applications.

Current generation polarimetric imaging systems that have been developed for remote sensing are sensitive only to linear polarization states and cannot directly utilize circular polarized light. Spiral plasmonic micro-polarizer lenses have been shown to selectively focus light according to the circular polarization state.

These lenses have spiral-shaped slots milled into a metal film that allow energy originating from circular polarization of a selected handedness to be focused into a small area, while the opposite handed circular state is defocused. If this technology can be integrated into traditional imaging focal plane arrays, it would complement the linear polarization sensitive devices and provide a more complete set of polarimetric image data.

AFRL and University of Dayton researchers fabricated spiral plasmonic lenses and conducted experiments confirming that their techniques were sufficient for incorporation with current imaging applications.

A recent report (Chen et al. Nano Letters 10(6) 2010) describes the details of these spiral plasmonic lenses and gives proof-of-concept examples of the ability of the lenses to selectively detect the circular state of polarized light. During future testing, expected in early 2012, the lenses will be demonstrated on infrared focal plane arrays.



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil*, (937)255-6469.*

# Liquid Behavior of Nanoscale Ionic Materials Explained, Utilized

Researchers from the AFRL were part of a team that provided a crucial scientific insight into the molecular mechanisms of the liquid behavior of nanoscale ionic materials (NIMs). The Air Force (AF) may use NIMs in conductive lubricants, heat transfer fluids, battery materials, microelectronic inks and responsive tags.

Inorganic nano-sized particles show new and important electrical, optical, mechanical and magnetic properties relative to the bulk materials, but they are difficult to incorporate into devices such as microelectromechanical structures (MEMs). NIMS offer a means to prepare high-volume fraction nanocomposites as self-healing surfaces to facilitate rapid insertion of these multifunctional materials.

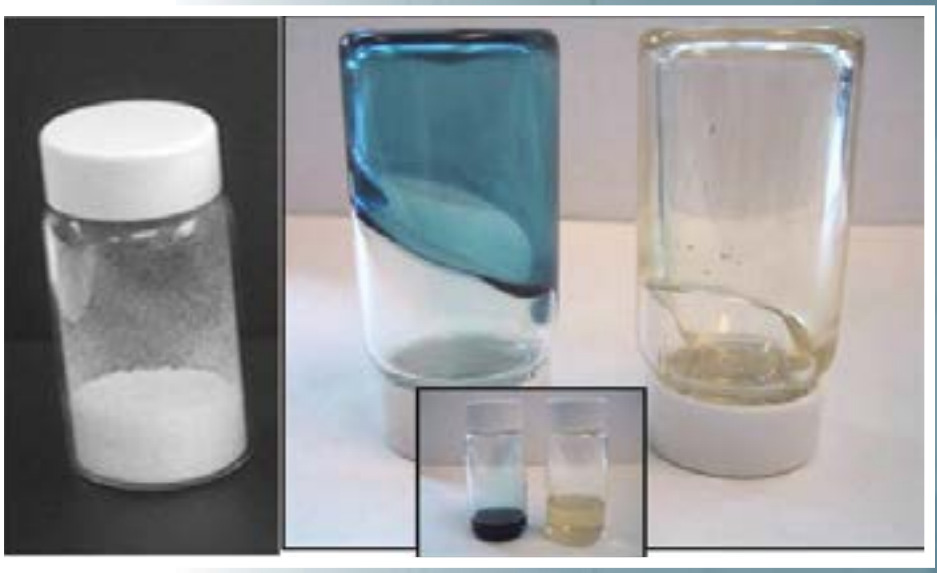
NIMs are revolutionary single-component nanoparticles (NPs) that flow like a fluid at room temperature. NIMs contain a metal, metal-oxide, organic or biomaterial nanoparticle core with a designed polymeric corona. Before this effort, the molecular basis for these liquid-like properties was unknown and this limited technology insertion.

These liquid-like properties are what give the nanocomposites their "self-healing" abilities. This is particularly important for conductive liquids in MEMs applications. A normal MEMs device will be destroyed with an electrical short, but because of the liquid-like properties, NIMs can flow into damaged areas and "heal" any small imperfection. Researchers believe this is why the devices have much longer lifetimes.

AFRL researchers developed novel nuclear magnetic resonance (NMR) relaxation studies to measure the high frequency (nanosecond) dynamics of polymers in close proximity to NPs. This showed that within one nanometer of the surface, the corona has similar dynamics to a polymer melt without NPs. The NPs did not impact the high frequency dynamics, and this was a profound finding for the materials community.

The team developed a model to account for their findings and related the size of the polymer in the corona to molecular-level crowding at the NP interface. This established the key, quantifiable molecular design parameter for NIMs and established the fundamental driver of liquid-like behavior in NIMs.

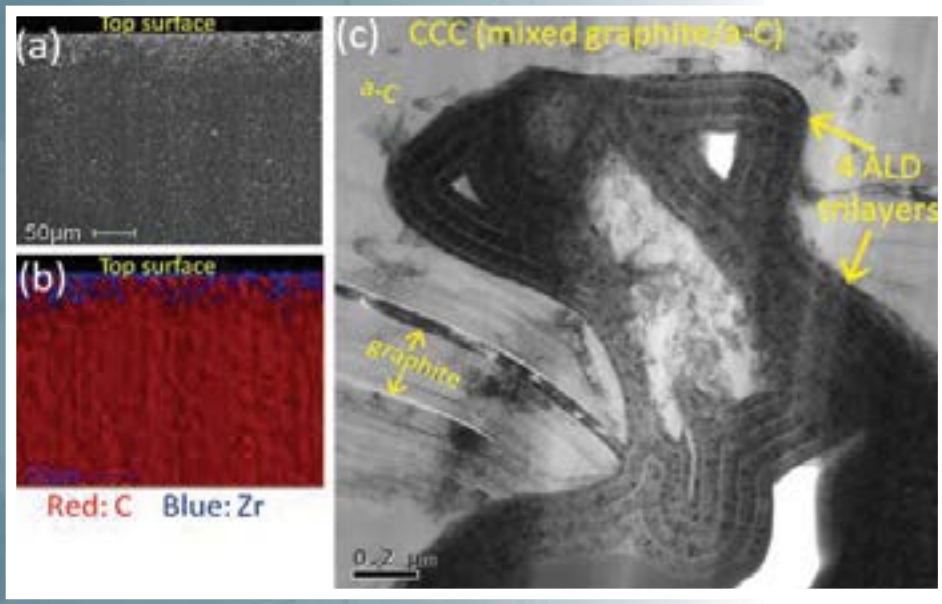
This work established the fundamental mechanistic understanding of the liquid-like behavior of NIMS and demonstrated the incredible value of NMR to understand dynamics within nanoscopic, heterogeneous materials. This insight provides a basis for the design of new NIMs for AF applications and will accelerate development and transition.



*Comparison of silica nanoparticles (pictured left) with Nanoscale Ionic Materials (pictured right) shows the room-temperature liquid-like properties of polymer nanocomposites.*

*For additional information on this technology contact AFRL/RX* **techinfo@wpafb.af.mil**, *(937)255-6469.*

# Carbon-Carbon Composite Coating Improves Fretting Wear




*Cross-sectional SEM (a) and corresponding EDS color map (b), showing surface and subsurface atomic layer deposition $ZrO_2$ coating infiltration of CC composite. Cross-sectional TEM image (c) of 4 ALD $ZnO/Al_2O_3/ZrO_2$ trilayers (~220 nm overall thickness) showing excellent coating conformality/uniformity and infiltration (pore filling) of the CC composite.*

Scientists from the AFRL have developed a new composite coating for use with carbon-carbon (CC) composites, commonly used in aerospace structural material applications such as high-temperature bushings. The program was a joint effort between AFRL and the Institute for Science and Engineering Simulation (ISES).

This coating offers a 65% fretting wear improvement over uncoated carbon-carbon composites. The coating exhibits tremendous uniformity and pore-filling characteristics not available from any other existing coating. It is also capable of providing self-lubricating behavior in room- and high- temperature environments. The nanolaminate coatings are good candidates for providing low-friction wear surfaces, subsurfaces and interfaces in moving mechanical assemblies.

Carbon-carbon is a well-recognized aerospace structural material. It is known for its high-temperature strength and low relative density. However, uncoated CC suffers from fretting wear that limits its lifetime in applications such as bushings used in jet engine blade integrated disks, used in commercial and military jet engines.

Jet engine manufacturers require part replacement at routine, schedule-based maintenance intervals for commercial, porous CC bushings. AFRL teamed with ISES, located at the University of North Texas, which uses multi-disciplinary research teams to develop and transition engineering technologies to the Air Force for use in aerospace applications. The team developed a method to chemically infiltrate porous CC with structurally-engineered lubricious trilayers of $ZnO/AL_2O_3/ZrO_2$ coatings.

The materials are currently in the process of being patented for commercial development by ISES. Plans include working directly with commercial material manufacturers to transition the technology into the production of low-friction and high-temperature bushings for high wear aerospace applications. In addition, researchers are continuing to optimize the mechanical performance of the coatings through ongoing research activities at ISES.





*For additional information on this technology contact AFRL/RX techinfo@wpafb.af.mil, (937)255-6469.*

# Graphene Research Could Totally Transform Technologies

AFRL research on graphene, a recently discovered form of carbon, has made a significant contribution to materials development of carbon-based electronics. These efforts improved the understanding of the growth process for both graphene and carbon nanotubes (CNTs) on silicon carbide.

Researchers predict that graphene will be as transformative as the television, atomic bomb, and silicon chip. It has the potential for enormous impact on Air Force (AF) capabilities, such as enabling band-hopping radar and leading to radio frequency semiconductors that are 100 times faster than the current state-of-the-art. Graphene may lead to the production of lighter aircraft and satellites, and may be used in sensors, electric batteries, transparent conductive coatings for solar cells, and in a variety of other applications.

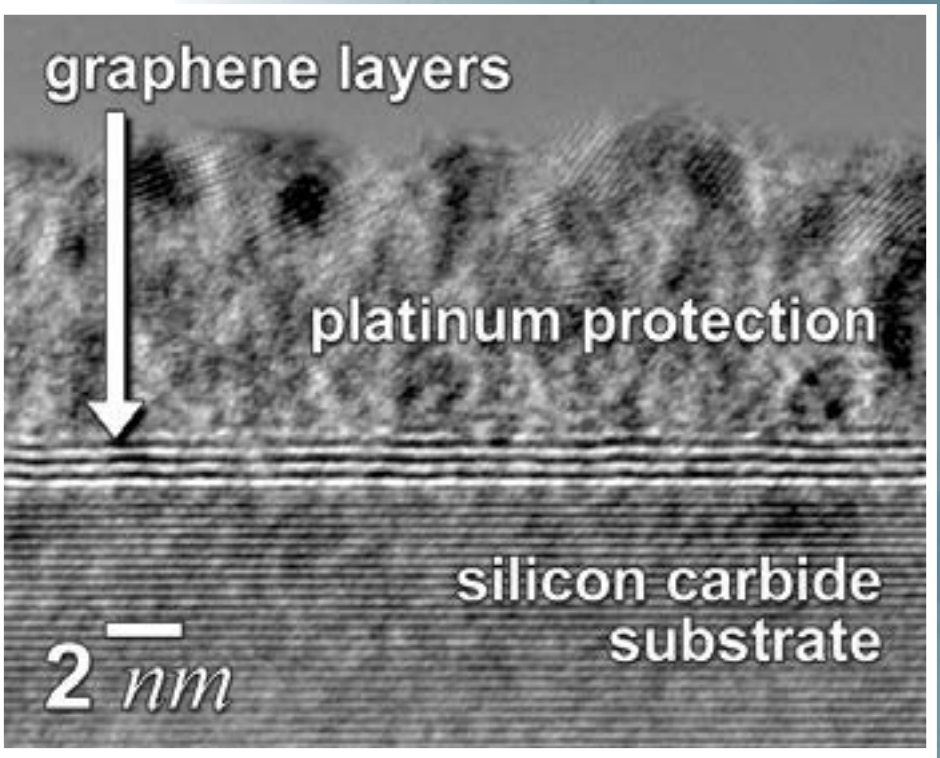
Graphene's structure is a one-atom-thick sheet of carbon atoms, most easily visualized as an atomic-scale chicken wire made of carbon atoms at the crossing points and strong covalent bonds connecting them. The crystalline or "flake" form, graphite, consists of many graphene sheets weakly stacked together. A stack of three million graphene sheets would be only one millimeter thick. Graphene exhibits the highest conductivity and other intriguing properties and has been widely popularized as the successor to silicon.

AFRL researchers improved the understanding of the graphene growth process on silicon carbide (SiC) and demonstrated the important catalytic role of oxygen in this process. They enabled metal-free growth of both CNTs and graphene on SiC substrates, improving the purity by an order of magnitude and enhancing the quality of in-house grown graphene.

Researchers at Columbia University's Fu Foundation School of Engineering proved that graphene is the strongest material ever measured. It's also the thinnest possible material that is feasible; about 200 times stronger than steel; and it conducts electricity better than any material known to man – at room temperature.

The development of graphene transistors (to replace silicon) may result in faster speeds and improvements in computer chips. Other potential applications include replacement of carbon fibers in composite materials, high-power high-frequency electronic devices, stronger medical implants and better sports equipment.

While the AF is focusing on potential electronics applications, many other commercial and medical uses could be possible.




*A transmission electron micrograph (TEM) of a graphene film grown by AFRL researchers with 4 layers of graphene. TEM samples were prepared using a focused ion beam lift out technique in which a platinum layer is deposited on the surface for protection.*



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# Nanocomposites May Allow Morphing Material Applications

*An artist's rendering of the 21st Century Aerospace Vehicle, nicknamed the Morphing Airplane, shows advanced concepts National Aeronautics and Space Administration envisions for an aircraft of the future.*

A team from the AFRL is investigating a new series of stimuli-responsive nanocomposites, which change their mechanical properties when exposed to electric fields and electromagnetic radiation. The mechanical morphing of the new materials is the result of synergistic interactions between the nanofiller and the polymer matrix. The team established a coherent material-performance relationship for electric-field actuation, enabling evaluation and optimization for various structural morphing applications.

This research was the first to clarify the role of carbon nanotubes in electrostrictive polymer nanocomposites (PNCs), thereby focusing subsequent development in the community. It provides a rational basis for the design of PNC-based devices and establishes limits on conductive nanoparticle-filled PNCs for mechanical actuators. It will enable an assessment of the manufacturability of the materials and their use in various Air Force applications.

Lightweight, mechanically adaptive materials are desirable for a broad array of technologies, from medical stents to deployable telescopes and morphing air vehicles. They are crucial for morphing systems including Remotely Piloted Aircraft, low-profile munitions, satellites, and automatic target recognition sensor arrays. However, inadequate temperature stability, cyclability and controls limit their use in some applications. Researchers recognize polymer nanocomposites (PNCs) as a solution to this, but actuation and mechanical adaptivity were not well understood. A realistic assessment of their impact, durability prediction and performance optimization was needed.

Researchers assembled a multi-disciplinary team to investigate the mechanism of electric field actuation in PNCs. They developed predictive mechanical models which showed that PNC electrothermal actuation does not depend on the composition of the nanofiller, but only on the resultant macroscopic conductivity of the PNC. This establishes the rationale for nanofiller selection, amount of nanofiller addition, and processing methods to control morphology.

These findings will help focus efforts on next-generation adaptive materials and provides a rational basis for design of PNC-based devices.



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# AFRL Researchers Discover Atomistic Scale Design Methods for Tailoring 3D Thermal Properties of Materials

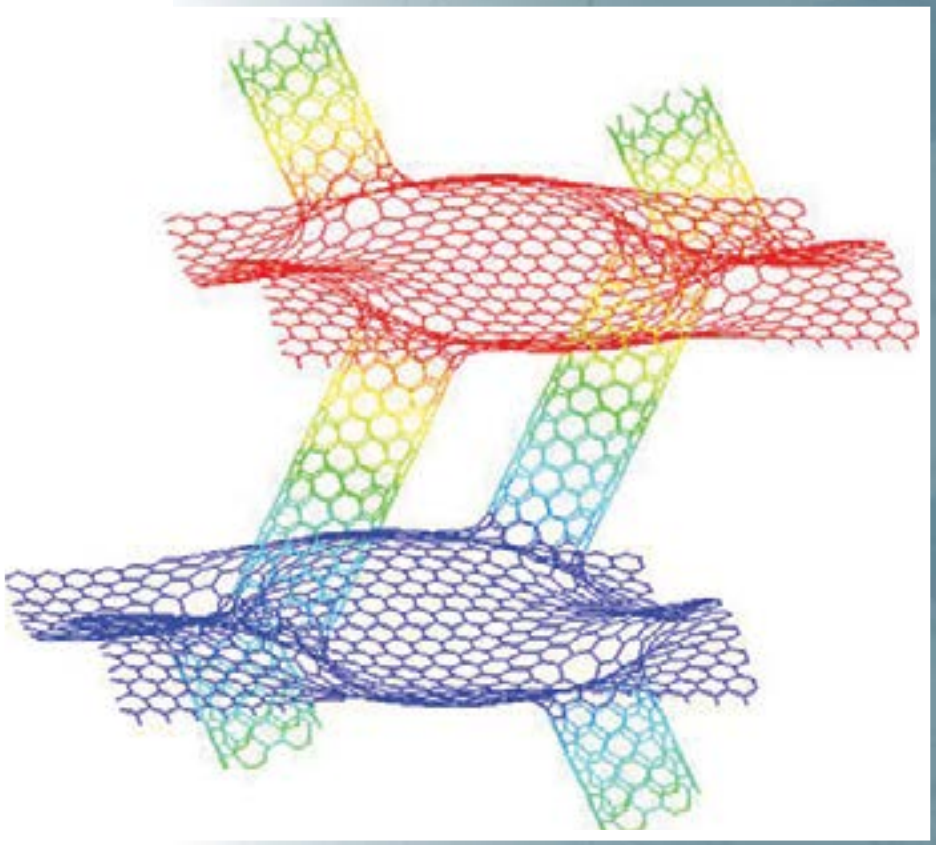
Researchers from the AFRL stand ready to advise materials processing professionals on heat management, a critical issue that plagues the electronics and aerospace industries. AFRL's groundbreaking research has discovered methods for designing materials at the atomistic scale, allowing the fine tuning of material properties.

Modeling materials to create three-dimensional truss-like nanostructures will allow AFRL researchers to develop directional thermal materials for a variety of electronic and aerospace applications. The new materials will enable systems engineers to solve problems with managing heat and to develop new materials for electrodes and energy storage. These activities represent a new frontier in materials design and are expected to result in a new class of cost-effective and innovative materials.

As aerospace system developers search for ways to create systems that are faster, more efficient and cost effective, they've given significant attention to thermal management challenges that hinder getting rid of or managing waste heat generated by electronics or other aerospace applications. With the development of micro and nanoscale electronic devices, the need to quickly dissipate thermal energy is absolutely critical for device performance. This concern has provided motivation for understanding, improving and guiding the development of materials with tailored, multi-dimensional thermal transport characteristics.

Carbon nanotubes and graphene are candidates for many nano/microscale integrated devices because of their thermal properties. However, neither system is isotropic in its thermal conduction, which limits performance as a three-dimensional thermal transport material. When carbon nanotubes and graphene are introduced as fillers or additives in polymer composites, researchers observe only a minor enhancement in the effective value of thermal conductivity.

One way to tailor this is to design alternative, carbon-based, three-dimensional (3D) nano architectures. In order to overcome thermal barriers, AFRL scientists are designing robust connectivity of the 3D architectures with low thermal interface resistance at the joints (connections) of the nano elements. Researchers are investigating thermal transport in a pillared-graphene (PG) network nanostructure that combines graphene sheets and carbon nanotubes to create a 3D network.

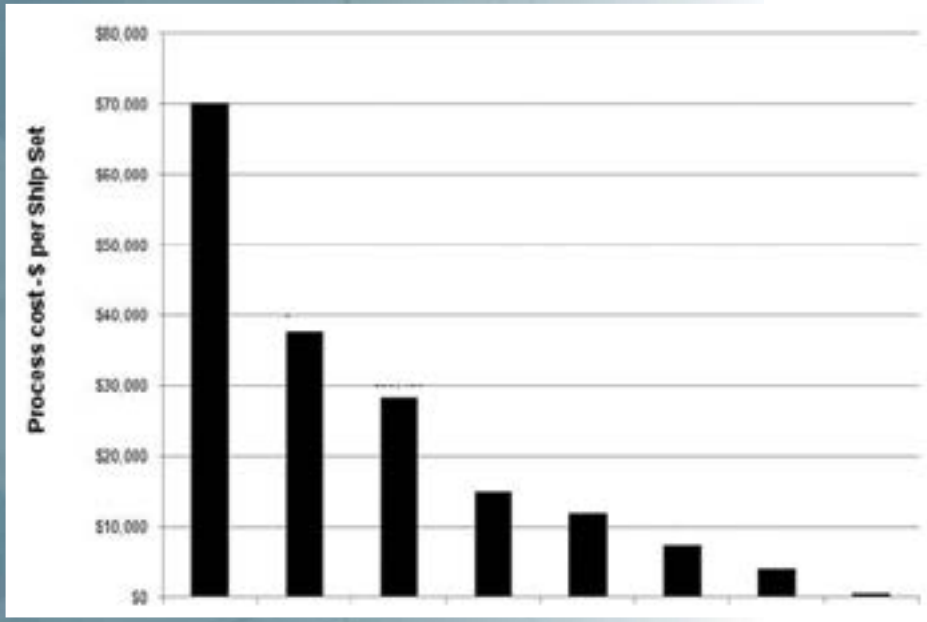


*A computer generated graphic shows the buckling behavior of the 3D carbon nanotube grapheme nanostructure. Research discovered that phonon scattering at the carbon nanotube pillar graphene junctions is the governing mechanism that limits thermal transport in this system.*



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# Value Stream Analysis Improves Processes, Saves Money




*An example Pareto chart from a value stream analysis shows the potential benefit of implementing VSA findings.*

Engineers from the AFRL have stimulated industrial base investments in infrastructure and technology by leveraging the value stream analysis (VSA) process to identify significant process improvement opportunities.

As a result, General Electric Aviation, Pratt & Whitney and Rolls Royce, together with some of their suppliers, invested in process improvements to produce an expected $34M cost avoidance for current and future products. Because many of the manufacturing technologies are applicable to advanced turbine engine performance improvements, the potential for an additional $126M cost avoidance for current projects exists.

For the last 5-years, AFRL's Manufacturing Technology Division (AFRL/RXM), in cooperation with General Dynamics Information Technology and TechSolve, Inc., has been conducting VSAs within the advanced turbine engine industrial base. Each VSA generated a list of potential process improvements, projected costs, and assessed the risks associated with achieving the anticipated benefits.

AFRL/RXM used the data from these VSAs to develop successful ManTech programs, including a program for the advanced machining of CMCs. This program yielded increases in material removal rates and a reduction in cutting tool costs by two orders of magnitude. Additionally, the 3D airfoil inspection process reduced the dimensional inspection of complex shapes from 60 mins down to 3 mins.

Industry has used this data to pursue lower risk process improvements. These process improvements have been implemented and are anticipated to yield benefits of $27M. Process improvements that have been partially implemented through industry investment are anticipated to yield an additional $7M. When implemented, processes that are still maturing could provide an additional $126M in benefits. For industry, the return on investment is about 15 to 1 and it is even greater for the Air Force, at 28 to 1.





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# Ferroelectric Nanoparticle Discovery Greatly Enhances Optical Materials

AFRL researchers have developed the world's smallest ferroelectric nanoparticles. At less than ten nanometers in size, these materials, with enhanced ferroelectric properties, can be easily incorporated into a range of host materials with uses in photo-activated optical filters, liquid crystal displays, electrical energy harvesting and storage, metamaterials, and directed energy applications.

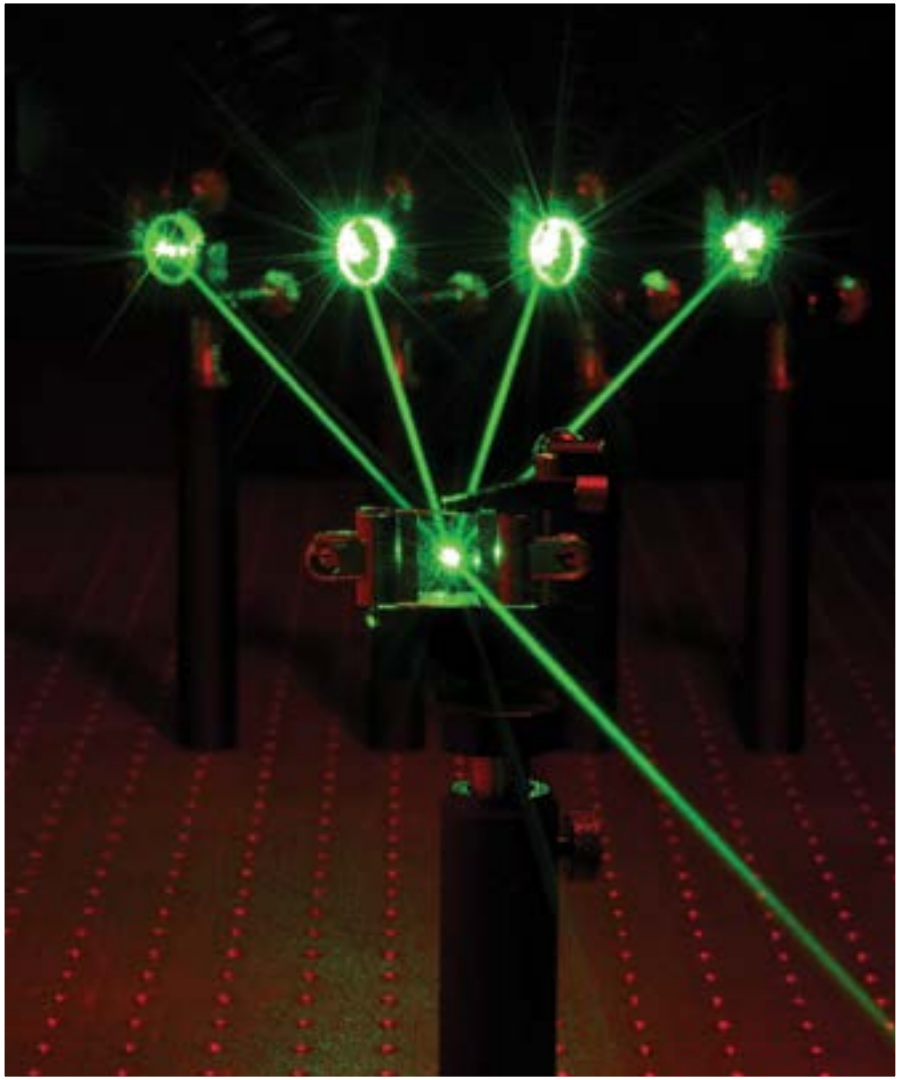
This discovery resulted in a dramatic improvement of the photorefractive effect in materials incorporating ferroelectric nanomaterials. The advancement will lead to new optical filter technologies and coherent beam combination methods for laser applications. It also has potential commercial applications in liquid crystal displays, improved materials for electrical energy storage, and new smart sensor technologies.

Ferroelectricity refers to the property of certain materials possessing a spontaneous polarization, that is, electric dipole, in which the dipole orientation can be controlled by an electric field. For beam coupling, the ferroelectric nanoparticles respond to electric torque, resulting in a more sensitive liquid crystal modulation. In liquid crystal display applications the nanoparticles create a direct current bias, thus reducing voltage requirements. In other applications, electrical or mechanical modulation of the dipoles leads to the generation of current.

As ferroelectric nanoparticles are made smaller, they lose their ferroelectricity. AFRL researchers succeeded in overcoming this size dependence to make the world's smallest ferroelectric nanoparticles. This is because of the unique combination of fabrication methods developed in AFRL, which induces surface stress.

Because of a combination of nano-scale dimensions and enhanced ferroelectric properties, researchers have observed dramatic increases in the electro-optical properties of materials. Such an example can be found in photorefractive hybrid devices, where researchers have achieved world-record optical gain coefficients in photorefractive beam coupling through the incorporation of these nanoparticles. Similar technology has also created an 80% reduction in the voltage required to drive liquid crystal modulation, which is likely to dramatically reduce the energy requirements of liquid crystal displays.

The breakthrough methods are likely to be transferable into other nanotechnologies, creating new opportunities and a renaissance in nanometric ferroic material development.



*Photorefractive beam coupling in a photorefractive organic-inorganic hybrid device: several laser beams entering a photorefractive hybrid cell resulting in a single combined (amplified) coherent beam.*



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# Legacy Platform Weapon Integration

*The Legacy Platform Weapon Integration enables direct interface and communication between the Navy Surface Warfare Center and AF BRU-61/A carriage system and SDB stores.*

Legacy Platform Weapon Integration Small Business Innovation Research/Small Business Technology Transfer (LPWI SBIR/STTR) effort has provided the Navy Surface Warfare Center with the capability for their Battle Management System (BMS) store control technology.

This technology enables the Navy Surface Warfare Center to directly interface and talk to Air Force (AF) BRU-61/A carriage system and Small Diameter Bomb (SDB) stores. Previously the technology did not exist for current, Legacy Weapon Store Platforms, such as the BMS, to operate and communicate with the existing MIL-STD-1553/1760 signals and message formats.

With the funding and collaboration of the LPWI SBIR/STTR, WINTEC, Inc., designed a BRU Translation Bridge (BTB) that processes RS-422 interface command and control signals produced by the BMS and translated those signals into MIL-STD-1553/1760 signals. Captive carry testing was a success. Tests were successfully carried out on a single Guided Test Vehicle Release and a ripple two Guided Test Vehicle Release. Future testing will consist of releases of live SDBs on the White Sands Missile Range.



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# Laser-Induced Ignition Eliminates Need for Spark Plug

AFRL researchers successfully demonstrated resonant laser-induced ignition of a propane-air flow mixture, a concept in an aircraft combustor that would eliminate the protruding spark plug. In place of the spark plug would be an insulated wall electrode where the fiber-optic-coupled laser enters and induces the spark, using the combustor wall as the ground electrode.

The innovative spark initiation scheme uses a relatively low-energy, single-pulsed ultraviolet laser to create a pre-ionized channel, allowing a relatively low applied voltage to create an electrical spark that directly follows the channel and ignites the fuel. Because the spark follows the channel, this may provide a more reliable ignition by delivering the spark to an optimal location inside the ignition volume with a rich fuel-air mixture.

The ultraviolet laser pulse is tuned to the precise wavelength to generate a pre-ionized path through the air via resonant enhanced multiphoton ionization (REMPI) affecting the molecular oxygen in the flow. In these initial laser-ignition experiments, the 10 ns laser pulse created the pre-ionized path that generated breakdown and a spark within a microsecond. The eventual propane flame formed within milliseconds.

*This photograph, exposed over several milliseconds, shows both the laser-induced spark and the subsequent ignition of the flame.*



*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# Study Saves Resources by Extending Storage Life of JP-10 Fuel


*Cruise missiles rely on JP-10 fuel, which was given an extra nine years of storage life after an AFRL fuels study.*

The Air Force (AF) Petroleum Agency (AFPET) asked the AFRL's fuels and energy experts to determine if the current 19-year storage life limit authorized for JP-10 fuel could be extended. Under the current limit, several field units would soon be forced to discard their existing JP-10 storage fuel and resupply with fresh fuel at the present cost of $15.75 per gal.

Using data obtained by testing during an ongoing 28-year AFRL Propulsion Directorate fuels service life study, a shelf-life extension for JP-10 fuel from 19- to 28-years was authorized for AFPET implementation and management. AFPET estimated this relatively inexpensive AFRL fuels study will, at current prices, save USAF operational units approximately $750,000 per year, or $7.5M over 10-years.



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# ADVENT Milestone: Fan Rig Test Successfully Completed

The AFRL hit a major milestone in the Adaptive Versatile Engine Technology (ADVENT) demonstrator program by successfully completing the Rolls Royce North American Technologies Inc. (RRNATI) fan rig test at the Compressor Research Facility at Wright-Patterson Air Force Base (WPAFB).

The combined AFRL and RRNATI test team accumulated over 250 hrs of run time to establish the fan's performance, operability, and mechanical behavior. Testing of the fan rig was conducted over several months and focused on demonstrating variable cycle engine performance, a critical component in achieving high-thrust capability for take-off and maneuvering, while reducing fuel consumption for long range and loiter operations.

ADVENT is designed to provide significant improvement in average fuel consumption. The ADVENT core and engine will be available for future US military aerospace platforms, including medium or large unmanned air systems. ADVENT is part of Phase II of the Versatile Affordable Advanced Turbine Engines (VAATE), an initiative sponsored by industry and Government partners to advance state of the art turbine engine technology for military and commercial aviation.

*The ADVENT program hit a milestone with the successful completion of the Rolls Royce North American Technologies Inc. fan rig test, held at the Compressor Research Facility and WPAFB.*



*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# X-51A Team Receives Aviation Week Laureate

*X-51A Team members Charles Brink, George Thum and Joseph Vogel accept the Aviation Week award at a black-tie dinner in March 2012 in Washington, D.C.*

The AFRL's X-51A Waverider Hypersonic Vehicle Team was presented with an Aviation Week Laureate in the Aeronautics/Propulsion category. Accepting the award for the entire team were Program Managers Charles Brink of the AFRL's Propulsion Directorate, Joseph Vogel of Boeing Phantom Works, and George Thum of Pratt & Whitney Rocketdyne.

The award honors outstanding achievements in defense, aerospace, and aviation. The team successfully designed the X-51A Waverider that was launched from a B-52 above the Pacific Ocean on May 26, 2010.

That historic event proved that a scramjet-powered engine could accelerate in controlled flight for a sustained amount of time.

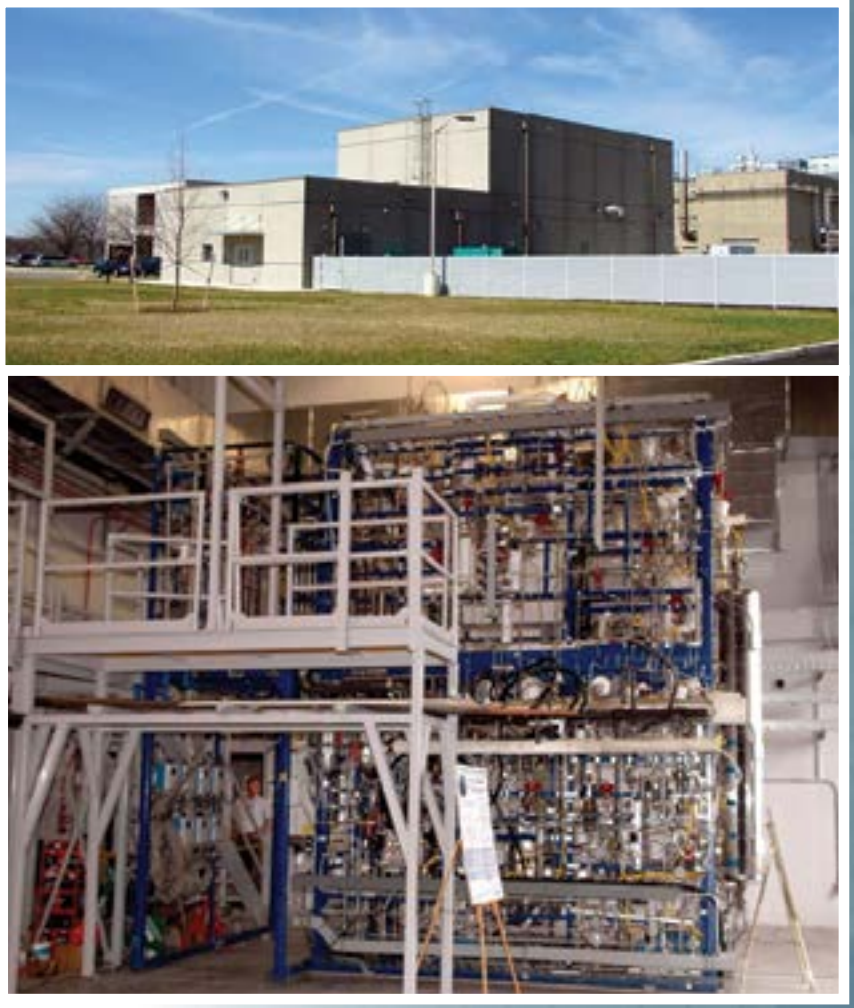


*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# Center Dedicated to Understanding, Developing Alternative Fuels

The Air Force (AF) Energy Policy outlines the goal of certifying all AF systems for operation on alternative fuels, and to begin acquiring significant portions of our aviation fuel from sources of alternative fuels.

In order to meet this objective, the AF must understand the characteristics of fuels produced from alternative sources and the variables that impact their characteristics. To produce test quantities of fuel, the USAF is working with the University of Dayton Research Institute (UDRI) and Battelle to operate an Assured Aerospace Fuels Research Facility (AAFRF) to produce testable quantities of alternative jet fuels and jet fuel components using a variety of potential sources. Newly constructed Building 496 at Wright-Patterson Air Force Base (WPAFB) was dedicated in May 2011. This facility will house the Sample Preparation Unit, which is one of the key components in this effort.



*WPAFB's new Building 496 will house the Sample Preparation Unit, which is one of the key components in the effort to understand alternative fuel characteristics.*



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# X-51A Waverider Honored with National Space Society's Pioneer

*Space Pioneer Award awarded to the X51-A Scramjet Engine Demonstrator – Waverider team, for "truly significant" achievement and historic accomplishment in the Waverider's success during its 2010 maiden fight.*

The National Space Society has awarded the 2011 Space Pioneer Award in the Science and Engineering category to the X-51A Scramjet Engine Demonstrator – Waverider team for their historic accomplishment during 2010.

This Space Pioneer Award was given specifically to the X-51A team (Air Force, Boeing, and Pratt & Whitney) in recognition of the success of the X-51 Waverider, the first scramjet-powered vehicle to achieve sustained hypersonic flight. This is the first achievement of a longstanding goal, and the fact that the vehicle accelerated and maintained controlled flight during its two and half minute maiden flight was found to be truly significant by the awards committee.

Creating a reusable, hypersonic vehicle is a critical step toward being able to build an air-breathing, reuseable, first-stage space launcher, which would greatly reduce the enormous cost of space launches.

The 2011 Space Pioneer Award for Science and Engineering was presented on May 20, 2011, in Huntsville, Alabama, at the Governor's Gala. The X-51A Waverider Team was represented by its by Project Managers: Charles Brink, AFRL; William Cook, Boeing Phantom Works; and Michael McKeon, Pratt & Whitney Rocketdyne. All personnel who contributed to this effort are honored with this prestigious award.



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# Lightweight Megawatt Generator Comes Through in Demonstration

The AFRL and Small Business Innovation Research (SBIR) Phase III industry partner Electrodynamics Associates, Inc. demonstrated a multi-megawatt, high speed (15,000 rpm) generator to 25 members of industry and the Department of Defense (DoD).

The demonstration showed 10X power improvement for its weight/package (under 500 lbs) over existing state-of-the-art generators. The generator is intended to supply power through a compact package for directed energy applications and for supplying megawatt power to aircraft with increasing load and mission requirements. The generator's rated peak power is 2.5MW.

*Representatives from the DoD and members of industry were witness to a successful demonstration of this multi-megawatt, high-speed generator by AFRL and a SBIR Phase II partner Electrodynamics Associates Inc.*

Air Force SBIR/STTR



*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# Universities Succeed in Small Hybrid Propulsion System Demonstrator


*Four university teams took part in the Propulsion System Demonstration sponsored by the Propulsion Directorate at the AFRL.*

The objective of the AFRL's Small Engine Research Laboratory (SERL) Capstone Project was to develop a ground-based demonstrator platform to evaluate small, hybrid-electric propulsion/power systems of particular interest to the RPA development community. The project leveraged resources and collaboration efforts of the SERL with academia to promote engineering education, design, and application of scientific fundamentals in a competitive capstone project environment.

Each of the four undergraduate engineering teams was given an all-electric, ground-based propulsion system (an electric motorcycle) and challenged to extend the range by modifying the system into a hybrid propulsion system. Two of the universities — Colorado State University and University of California-Davis — created an electro-chemical energy conversion hybrid system utilizing a hydrogen fuel cell. The other two teams (Brigham Young University and the University of Dayton) were challenged to tackle the problem via a thermo-chemical energy conversion approach utilizing a small 6-hp class IC engine, exploring both series and parallel hybrid approaches. The teams were able to able to develop up to a 50% increase in system range and up to a 10% reduction in system weight.



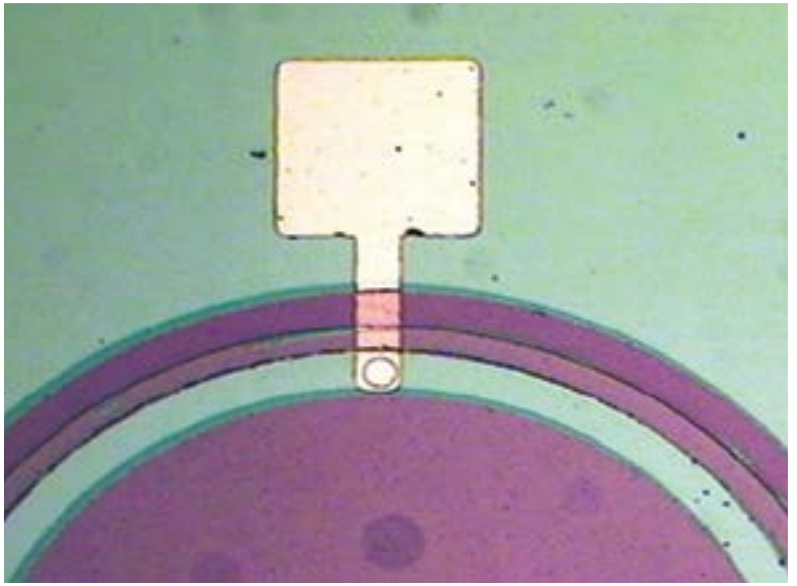
*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

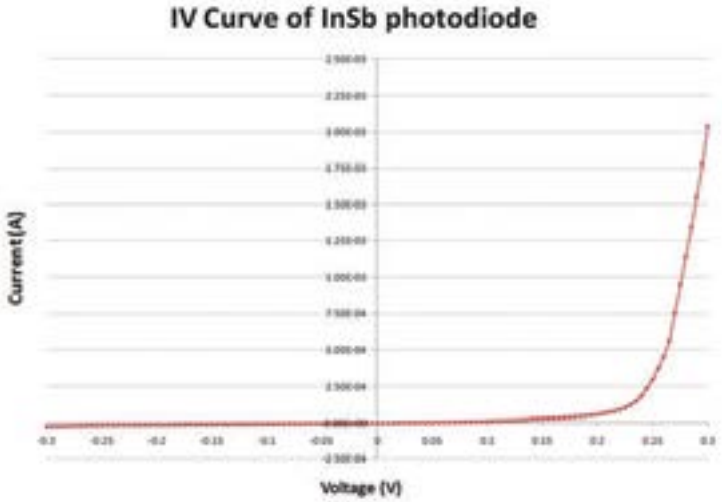
# Photodiodes Doped by Ion Implantation Show Promise for Advanced Photodiode Fabrication

Researchers at AFRL and the University of Dayton collaborated to fabricate indium antimonide (InSb) photodiodes for mid-wave infrared (MWIR) detection. These photodiodes were doped using ion implantation, which provides greater control over doping profiles than the commonly used thermal diffusion technique. This improved control could provide a method for producing advanced photodiode structures such as avalanche photodiodes (APD) for high performance detection in the MWIR.

The researchers performed a detailed study on the implantation depths and thermal annealing affects on the doping profile. They determined that software modeling accurately predicted the doping profile for implant energies in the 20-160keV range, suggesting ion implantation is a viable technique for producing buried doping layers, a prerequisite for the fabrication of advanced diode structures.

The development of this photodiode fabrication process is a stepping stone toward the development of MWIR imaging arrays. Imaging arrays fabricated in AFRL facilities will allow the integration of polarimetric and plasmonic structures into the fabrication process, for next-generation imaging array technology. These advanced structures will allow arrays to combine polarimetry, MWIR, and other imaging modalities for more versatile imagers in very small low-power form factors.






*InSb photodiode with ring contact and square bonding pad. (pictured top)*
*Current/Voltage measurement which demonstrates clear diode behavior. (pictured bottom)*

*For additional information on this technology contact AFRL/RY* **afrl.ry.marketing@wpafb.af.mil**, *(937)904-9771.*

# Battlespace Environment Laboratory Dedicates New Location

*The newly opened Battlespace Environment Laboratory, the 145,000 $ft_2$ home of the Battlespace Environment Division of AFRL's Space Vehicles directorate.*

The AFRL celebrated the grand opening of the Battlespace Environment Laboratory with a technology outreach event and ribbon-cutting ceremony. The Battlespace Environment Laboratory, or BEL, will house the Battlespace Environment Division (RVB) of the Space Vehicles Directorate.

RVB relocated to New Mexico from its former home at Hanscom Air Force Base in Massachusetts as part of the 2005 Base Realignment and Closure Act (BRAC). On June 15, a formal inactivation ceremony effectively marked the end of operations at Hanscom.

The 145,000 $ft^2$ Battlespace Environment Laboratory operates under an annual budget of approximately $89M and can accommodate up to 300 people.

The BEL measures, forecasts and determines the impact of space and the upper atmosphere environment on space systems and on command, control, communication, intelligence, surveillance and reconnaissance systems. The mission is to specify, forecast, mitigate and exploit these environmental impacts for the benefit of Department of Defense systems.



*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# Space Weather Imager Reaches 8-Year Anniversary

October 2011 marks the 8th anniversary of the Coriolis satellite that carries the AFRL's Solar Mass Ejection Imager, or SMEI.

SMEI has successfully detected and tracked 360 coronal mass ejections (CMEs) and shown the practicality of forecasting effects at Earth of these hazardous space weather phenomena.

Since 2003, SMEI cameras have captured nearly full sky images of great sensitivity every 103 min; there is no other celestial record of this length, field of view, continuity, sensitivity and cadence.

SMEI has collected unprecedented data in many areas of heliospheric observations including CME-comet tail interactions, zodiacal background variation through the solar cycle, discovery of high altitude auroras, and resident space object observations.

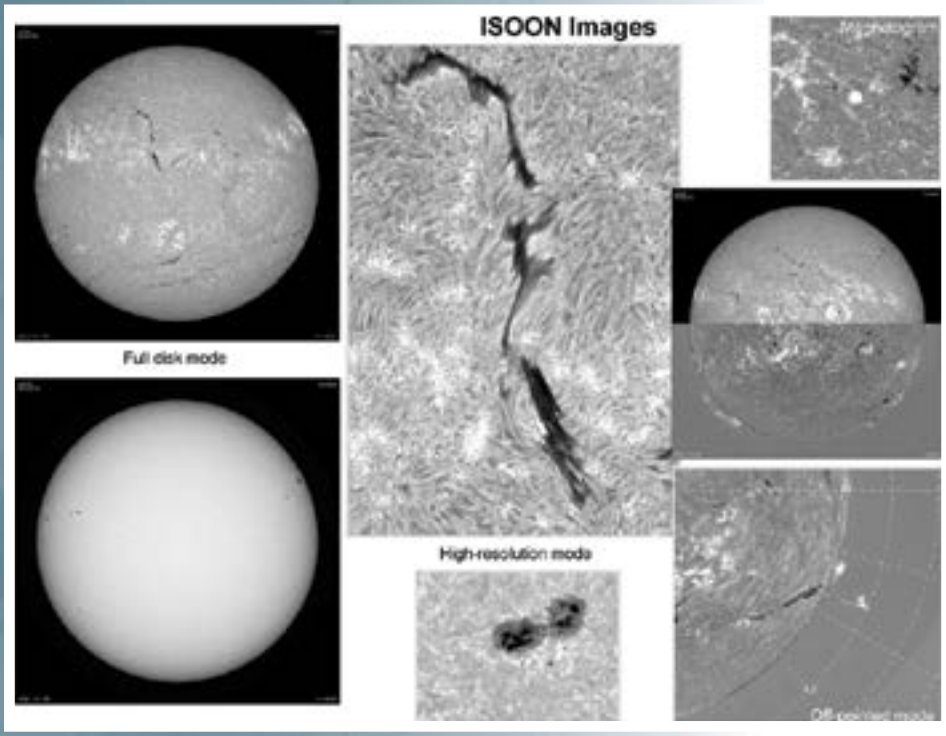
SMEI data have also produced light curves for variable stars and novae with unparalleled time resolution.


*October 2011 marks the eighth anniversary of the Coriolis satellite that carries the AFRL's Solar Mass Ejection Imager, or SMEI.*



*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# Observatory Construction Awarded




*Unlike, SOON, the ISOON telescope is a completely robotic telescope and no on-site personnel observing personnel are required.*

The Improved Solar Optical Observing Network (ISOON) contract for construction at Kirtland Air Force Base was awarded to GranCor Construction on July 1, 2011.

The Improved Solar Observing Optical Network (ISOON) is collaboration between the AFRL Space Vehicles Directorate, the Air Force Weather Agency (AFWA), and the Air Force Space and Missiles System Center. ISOON was developed as a modern replacement for the existing SOON system that is currently operational at four sites around the globe and was designed to continuously patrol the sun for flares and other activity that could affect systems on or near the earth.

Construction is expected to be completed in early 2012. Following building construction, the ISOON telescope will be relocated from the National Solar Observatory, Sunspot, New Mexico, to Kirtland Air Force Base. This will be first of the deployed ISOON units for daily, continuous monitoring of the sun.

Unlike, SOON, the ISOON telescope is a completely robotic telescope and no on-site personnel observing personnel are required. Instead, the high-quality images of the sun are continuously monitored by computers at the site and also by personnel located at a central forecasting facility at the AFWA located at Offutt Air Force Base, Nebraska. Individual telescopes will be deployed to San Vito, Italy, Kaena Point, Hawaii, Learmonth, Australia, and Holloman Air Force Base, New Mexico.





*For additional information on this technology contact AFRL/RV* **afrl.rv.publicaffairs@kirtland.af.mil**, *(505)846-4704.*

# AFRL's Inexpensive Snubber Prevents Expensive Maintenance

An innovative solution from the AFRL is expected to save the Air Force more than $40M.

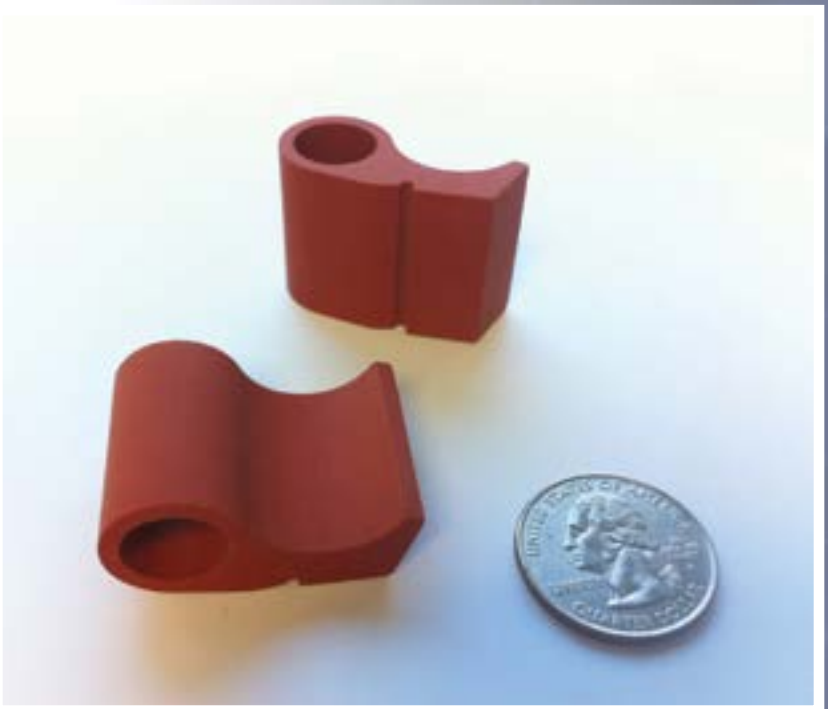
The $35 "snubber," developed by the Propulsion Directorate, is a vibration damper that will prevent cracks in the J-seal on the F119 engine's inlet case, a spoked, ring-like device that helps control the air going into the engine. Previously, if cracks were discovered, the engine would need to be pulled and the end of the crack drilled to stop it from growing. If any problems arose during drilling, the $362,000 inlet case had to be discarded.

The Aeronautical Systems Center F-22 Division contacted the Propulsion Directorate just across the street at Wright-Patterson Air Force Base and asked them to study the problem. The directorate responded with the snubber in a mere six months.

The little orange snubber looks like an exotic pencil eraser and fits in the gap opposite where the J-seal is welded to the inlet case. Seven $35 snubbers are fit on each engine, meaning outfitting each F-22 costs $245.

"On the F119, we hope this will eliminate a huge maintenance driver at a very, very low cost," said Stephen Brinkman, F119 Fan and Compressor WBS Manager for the F-22 Division. "You would not believe how expensive these parts are. And that's the beauty of it - it's such a simple, cheap fix."

The snubbers began being used in April 2011, and about 3,000 flight hrs have been logged. They were designed to last half the life of the engine, but because they're so cheap, new ones will be installed whenever the engine is pulled.

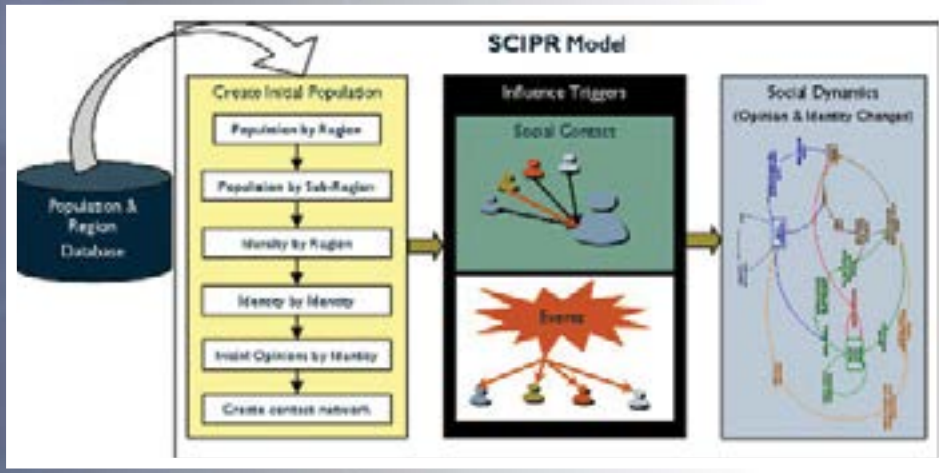


*The cost effective snubber, designed by the AFRL Propulsion Directorate, fits in the F-22 engine to prevent costly cracks from developing.*



*For additional information on this technology contact AFRL/HQ* **milestones@wpafb.af.mil**, *(937)904-6930.*

# Simulation Model Predicts Cultural Attitudes, Responses




*Overview of interactions within the SCIPR, showing multiple feedback loops.*

A wealth of behavioral research describes normative differences between individuals from different cultures. Researchers report qualitative and quantitative differences in such areas as cognition, interpersonal processes and belief structure; several researchers have developed taxonomies of cultural differences. For example, Hofstede (2001) proposed several cultural dimensions which affect behavior, and those dimensions have been explored for their applicability to military command and control. Research to date, however, has not determined which cultural factors are most statistically relevant as performance moderators. The predictive role of culture in interaction with other variables such as organizational training, stress or fatigue remains unclear. This lack of sufficient data on culture as a performance moderator stands as a barrier to accurate human behavior representation (Silverman, 2001). Innovative approaches are needed to empirically determine the most relevant and influential cultural factors for a range of human behaviors. Furthermore, moderating variables that shape or bound the influence of culture need to be identified. Innovation is needed to move from theory to statistically supported application.

Aptima, Inc., developed the Simulation of Cultural Identities for Prediction of Reactions (SCIPR) model to allow planners to predict how attitudes may change in response to certain events. SCIPR is an agent-based computer simulation that forecasts the effects of actions on peoples' opinions and cultural identities. SCIPR utilizes a number of principles that are well substantiated by research, including the principle that communications takes place more often among people who are alike and physically close. Addressing the root causes of state failure and instability requires the cooperation of local populations and governments. To win this cooperation, military decision makers need to predict changes in the opinions of local populations. Cultural identity is a critical factor in this process; however, cultural identities are multi-layered and dynamic. Each individual has multiple identities and these identities change over time. Attitudes also change based upon people's contact with other individuals. When attitudes change, people's participation in groups changes as well. Understanding and predicting these complex dynamics are extremely difficult, yet critical to success. Aptima has received a Phase II Small Business Innovation Research (SBIR) Enhancement for additional development of SCIPR and its application to operational domains.





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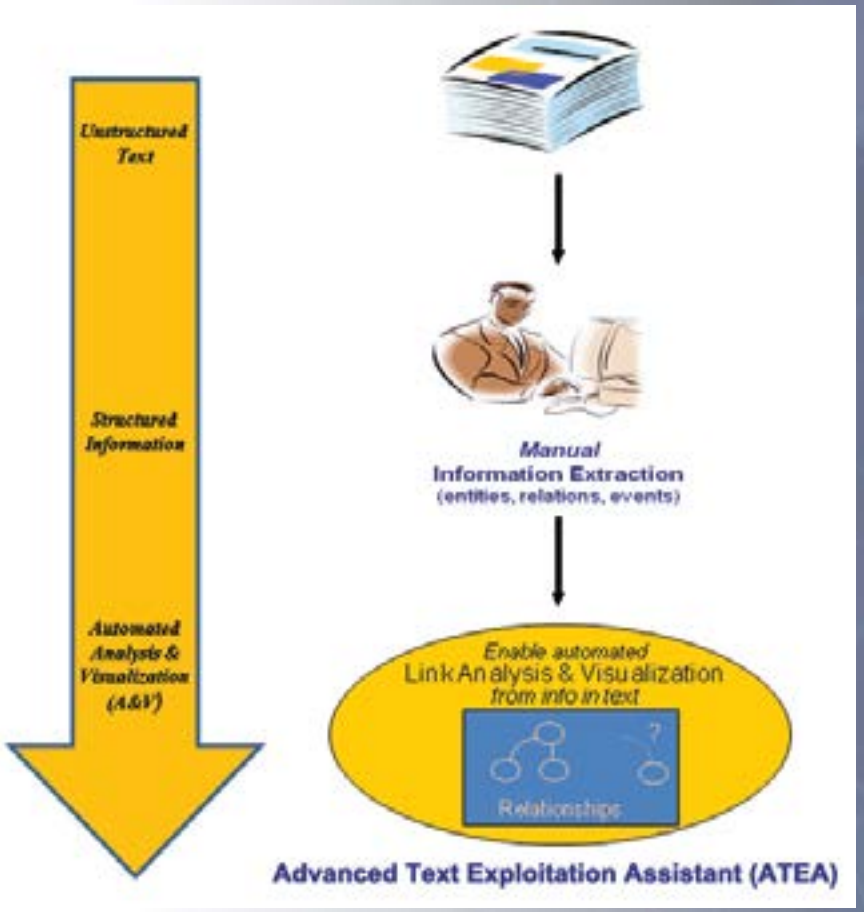
# NASIC Using AFRL-Developed Advanced Text Exploitation Assistant

The AFRL has transitioned the Advanced Text Exploitation Assistant (ATEA) to the National Air and Space Intelligence Center (NASIC), where it is being used operationally by NASIC intelligence analysts.

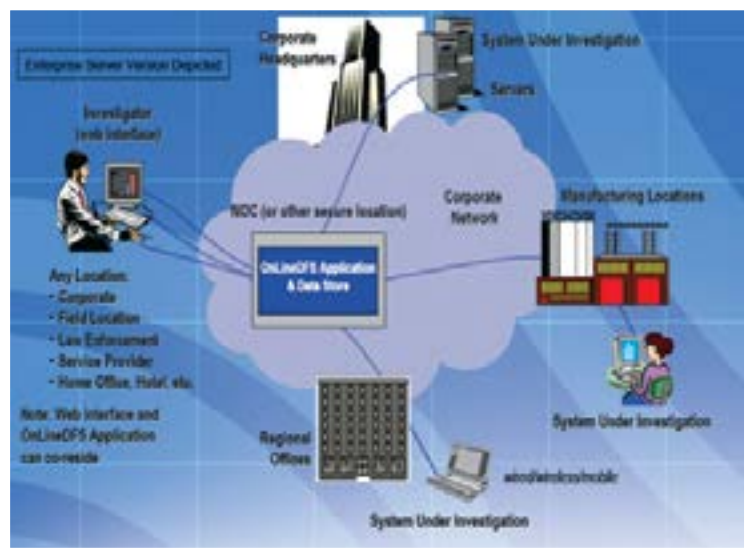
ATEA automates the extraction of entities such as people, organizations, locations, events and relationships from intelligence message reports. The technology supports the analyst in the search and discovery of information faster across many more documents than they could have manually processed. It automates the generation of Organizational Network Charts and the storage of the Analyst's 'Body of Knowledge'. ATEA has shown to be a tremendous 'added value' to the analysis performed by C2 analysts, Behavioral Influence (BI) analysts, and Open Source INTEL (OSINT) analysts and, is a force multiplier in exploiting large volumes of intelligence message traffic for C2, BI and OSINT analysts.

ATEA processes and exploits large Unstructured (Textual) Data Sets; processes thousands of documents a day; reduces textual data overload; automates extraction of information from text; supports human-in-the-loop validation and correction of extracted info, looking at original text; improves accuracy, building trust in tool's results; creates "electronic dossiers" consolidating all information extracted on real-world entities (people, organizations, etc.) from thousands of documents; and enables use of Link Analysis & Visualization (A&V) and Social Network Analysis (SNA) tools. ATEA leverages advanced test extraction technology to transform information in unstructured text into a structured form, thus enabling the use of automated A&V tools.




*The ATEA automates the extraction of entities to aid analysts in their mission to develop expertise. ATEA has been transitioned to the NASIC.*

# AFRL's Fast, Secure Forensic Suite Moves to Commercial Market




*OnLine Digital Forensic Suite can be quickly deployed on any network, does not require high-speed access, and has a high degree of security. It is used in forensic investigation of computers when possible security breach is suspected.*

The AFRL's OnLine Digital Forensic Suite (DFS) Small Business Innovation Research (SBIR) effort resulted in the commercialization of ATC-NY's OnLineDFS™ using ATC-NY's Mobile Forensic Platforms (MFP) SBIR technology. OnLineDFS aids investigators and administrators with the forensic task of system assessment following a suspected intrusion or internal security issue and the potential compromise of a host. It can be quickly deployed on any network to perform remote forensic investigation of a running system with very high assurance of security. No software needs to be preloaded on the target machines.

A web-based interface allows the investigator to connect to OnLineDFS and manage an investigation from anywhere using a wide variety of web browsers and operating system (OS) platforms. The connection, which does not need to be high speed, is encrypted via the Secure Sockets Layer (SSL) protocol. Analysis with OnLineDFS is forensically sound, employing accepted best practices to document all actions, preserve the integrity of evidence, and maintain the chain of custody. Data is stored in non-proprietary formats, making OnLineDFS work easily with third-party tools.

After completion of AFRL's SBIR Phase II, ATC-NY and its parent company, Architecture Technology Corporation, formed a new company named Cyber Security Technologies (CST) Corporation to launch the OnLineDFS into the commercial market. Both Architecture Technology and CST have invested significant financial resources in marketing OnLineDFS and further enhancing it. It is now on its fourth major release. OnLineDFS is in use in federal, state, and local law enforcement agencies in the United States and internationally, and in public and private sector enterprise security operations. OnLineDFS is a low-cost alternative for information technology (IT) security organizations that need to conduct investigations of live computers over their internal networks. It is also an ideal product to integrate with other security technologies, such as firewalls, intrusion detection systems, security information and event management products, to automatically initiate investigations of suspect computers when possible security breaches are detected. Because OnLineDFS does not rely on pre-installed agents, it is very simple and inexpensive to deploy, maintain and use in response to an incident, on new networks/machines, and on a wide variety of target operating systems.





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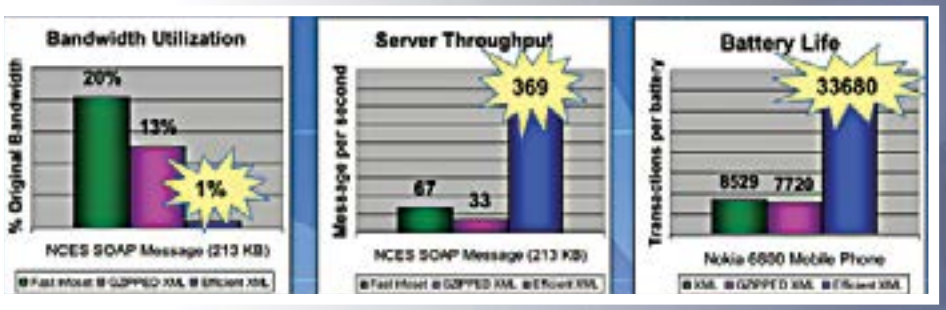
# Efficient XML Program Moves to Commercial, Defense Markets

A Small Business Innovation Research (SBIR) effort by the AFRL with AgileDelta has resulted in the development of a breakthrough data optimization technology, called Efficient XML™. The technology optimizes the bandwidth and resource utilization of Net-Centric data standards to levels far beyond those previously possible. It is the first technology capable of optimizing XML and web services to levels that consistently meet or exceed the Department of Defense's best tactical data formats. As such, it enables deployment of Net-Centric systems and capabilities to the most demanding tactical environments and enables broad interoperability across command centers, aircraft, ships, vehicles, ground troops, and satellites using inexpensive, open Net-Centric data standards.

Independent tests by the Air Force, Navy, and Army measured over 100-fold improvements in bandwidth utilization and transfer speeds using Efficient XML. Efficient XML dramatically accelerated Air and Space Operations Center (AOC) systems and enabled deployment of Net-Centric data standards to live aircraft, ships, vehicles, SOF units, and satellite systems. Independent tests by the World Wide Web Consortium (W3C) found Efficient XML consistently outperforms previous XML optimization technologies, compression technologies, and even packed binary data formats. Efficient XML includes plug-ins that instantly optimize Net-Centric systems without changing a single line of code.

The plug-ins automatically detect and use Efficient XML where available or otherwise fall back to traditional XML, meaning that they can be deployed incrementally with no disruption to existing systems.

Through AFRL's SBIR effort, AgileDelta has commercialized Efficient XML as a set of broad based, commercial off-the-shelf (COTS) products used by both defense and commercial customers. It has been proposed as a standard for airborne networking and is being integrated in military fighter aircraft. Efficient XML has also significantly reduced system development costs by enabling common Net-Centric solutions built on open standards to be used across all operating environments.

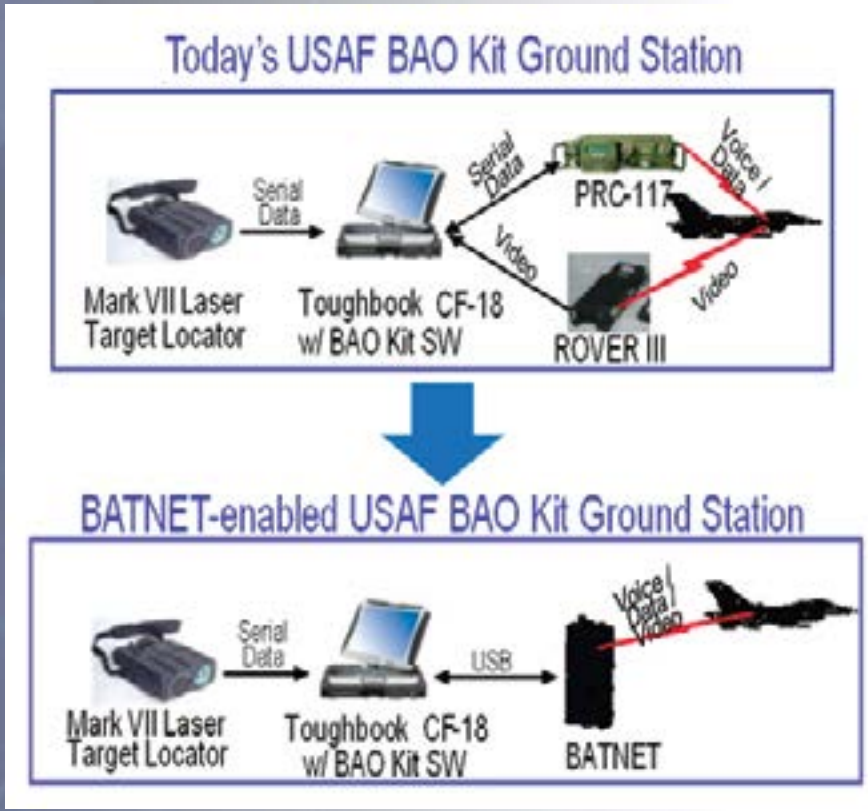



*Efficient XML extends the reach of Net-Centric capabilities to limited tactical environments, providing levels of performance never before possible. The AFRL SIBR-developed capability has been commercialized to both defense and commercial customers.*



*For additional information on this technology contact AFRL/RI* **techinfo.if@rl.af.mil**, *(315)330-2143.*

# Military Customers Make Good Use of BATNET Capabilities




*BATNET is lighter and smaller, while providing increased IP capabilities for dismounted troops.*

The Battlefield Airman Targeting Network (BATNET) provides Special Operations Forces (SOF) with small, handheld, multi-data rate/multi-waveform, Internet Protocol (IP) capable radio network capability with UAVs, weapons, and the tactical air network. Flight and ground tests of the prototype radios were conducted at China Lake in 2008.

BATNET provides efficient connection of dismounted SOF to the Global Information Grid (GIG). The BATNET program leveraged the DARPA Quint Networking Technology (QNT) program to develop a small form factor IP capable radio that networks SOF teams with UAVs, weapons, and tactical air assets.

BATNET leverages the latest technology, including use of advanced IP networking and legacy waveforms (including improved IP packet performance and Forward Error Correction); IP-enabled, omni-directional antennas; and increased capability and reliability with reduced size, weight, power (SWAP) and volume.

During August 2011, BATNET, with a Technical Readiness Level (TRL) of 6, transitioned to the Air Force Special Operations Command (AFSOC) and Air Force Aeronautical Systems Center (ASC) Battlefield Airman Program Office. Customers include AFSOC, Naval Air Systems Command (NAVAIR), OSD Airborne ISR Task Force, Army Communications-Electronics Research, Development, and Engineering Center (CERDEC), and the Air Force Flight Test Center.





*For additional information on this technology contact AFRL/RI* techinfo.if@rl.af.mil, *(315)330-2143.*

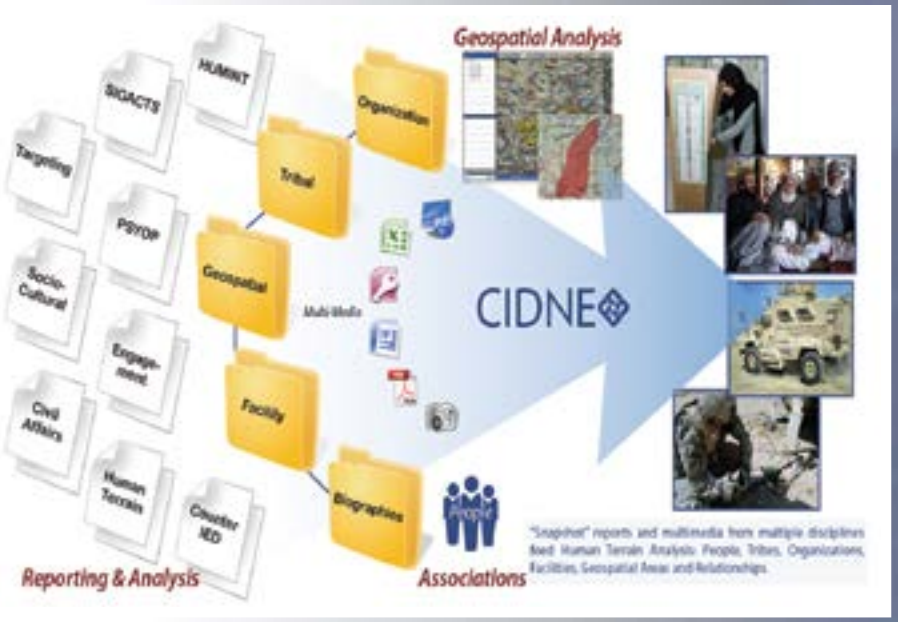
# Data Exchange Becomes "Go-To" Software for Theater Information

Combined Information Data Network Exchange (CIDNE) is CENTCOM's answer to managing the complexities of theater-wide operational reporting, quality assurance and quality control. With millions of records vetted and finalized for operational and intelligence reporting, CIDNE is the originating source database for nearly all information formally presented to Congress and the White House regarding events in Afghanistan and Iraq.

CIDNE leverages the latest Service Oriented Architecture and Net-Centric Enabled technologies. According to Major General Michael T. Flynn, ISAF CJ2, "CIDNE provides a platform for organizing knowledge in order to answer the fundamental questions about the environment in which we operate and the people we are trying to protect and persuade." General Stanley A. McChrystal, Commander, ISAF/USFOR-A, added: "CIDNE is core to the ISAF HQ and IJC Information Environment. It is absolutely integral to the success of IJC Information Dominance operations; the dedicated use of CIDNE transcends the intelligence function and it is a critical component of the ISAF/IJC Governance and Development Information System."

Based on the realization that traditional software development and acquisition timelines were inadequate to support the ground commander's constantly evolving requirements, CIDNE was created to collect and analyze critical battlefield data to provide daily operational and intelligence community reporting relevant to a commander's daily decision-making processes. With CIDNE, data can be collected quickly and consistently in a manner that allows for automated data correlation and aggregation across the entire theater.

During April 2011, CIDNE software version release 2.2, with a Technical Readiness Level of 9, transitioned to USCENTCOM, USFI, ISAF and is fielded operationally throughout the Iraq and Afghanistan Areas of Operation. The program was funded by USCENTCOM, Army, DIA, and DNI.

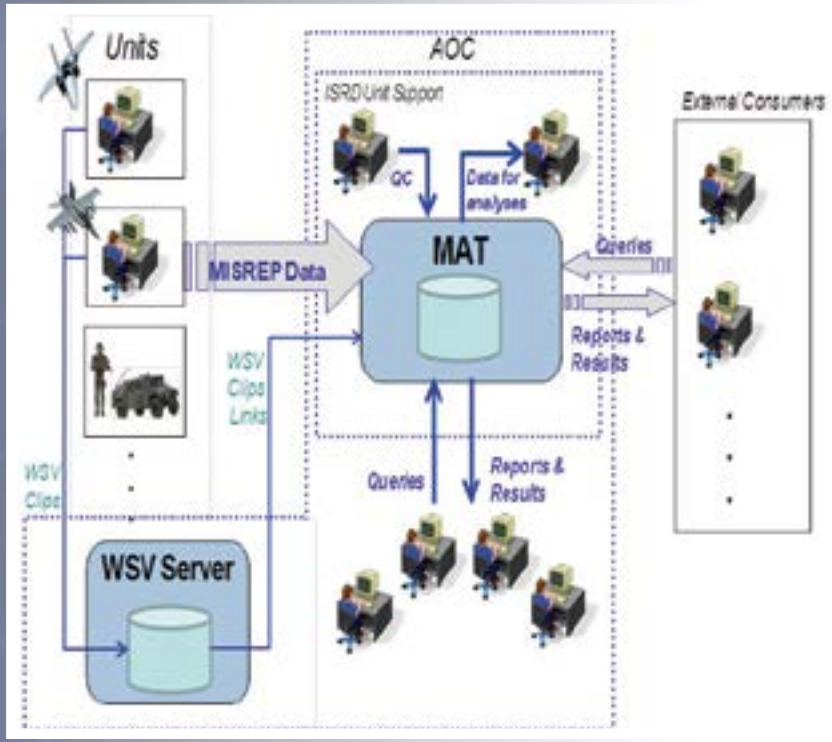



*CIDNE is used daily by thousands of military personnel, civilians and analysts as the US CENTCOM-directed tool for the majority of operational reporting within Afghanistan and Iraq.*



*For additional information on this technology contact AFRL/RI* **techinfo.if@rl.af.mil**, *(315)330-2143.*

# Mission Report Analysis Tool Saves Time, Improves Accuracy, Adds Capabilities




*AFRL's MISREP MAT saves Airmen hrs, improves accuracy, and provides interface to weapon system video and other intelligence products.*

The Mission Report (MISREP) Analysis Tool (MAT) was developed by the AFRL Information Directorate's in-house Information for Operational & Tactical Analysis (IOTA) program to automate mission reporting processes and data management, replacing the existing manpower intensive process. MAT is an automated capability for ingesting, storing, parsing, querying, and analyzing MISREP data. With MAT, the individual MISREP processing time was reduced from 15-90 min down to 0.25-3 min, saving approximately 64 staff-hours per day or 2,000 per month. It is one thousand times more efficient, and auto links MISREP data to weapon system video (WSV). MAT is able to do the work of 5 Airmen.

Prior to the transition of MAT, manual MISREP data handling processes were error prone and time consuming. MISREP analysis capabilities were limited, with no interface to weapon system video (WSV) and other intelligence products, and automated report generation and dissemination was non-existent.

By providing automatic ingestion and processing of mission data, MAT allows Air and Space Operations Center (AOC) intelligence analysts to focus on understanding the mission data and produce decision quality information instead of having to manually enter mission report data. MAT leverages the latest technology including Web-based Information Services; Web-based application frameworks; United States Message Text Format (USMTF) and structured text message processing.

MAT was also deployed to Shaw Air Force Base during the fourth quarter of FY11 and immediately went operational the same quarter. The MAT server at Shaw serves to replicate the MAT server currently deployed to the 609th Al Udeid Air Base. If the server were to go down at the 609th, the Shaw server will kick in, providing a critical backup capability for managing Mission Reports in support of the Warfighter. AFCENT currently pays for all sustainment/ enhancements associated with MAT.





*For additional information on this technology contact AFRL/RI* techinfo.if@rl.af.mil, *(315)330-2143.*

# User Needs Drive Air Space Cyber-User Defined Operational Picture

The AFRL's Air Space Cyber-User Defined Operational Picture (ASC-UDOP) program has embarked on a joint effort with MITRE and ESC to provide visualization solution to produce a Map the Mission capability for the Air Force's 624th Cyber Operations Center, San Antonio, Texas. This effort explores how to represent the cyber domain dependencies that mission assets have and how those dependencies impact overall mission effectiveness.

AFRL delivered a prototypical Map the Mission capability based on AFRL's in-house developed, JView-based, Joint Space Tasking Order Explorer (JSTO Explorer) which will allow MITRE to demonstrate its Map the Mission concept in September 2011 in San Antonio, Texas. This is an example of AFRL leveraging multiple in-house tools to create more robust applications for end-user demonstrations. ASC-UDOP brings to bear its ability to look at multiple, large datasets in order to visualize the cyber domain and provide a Cyber Situational Awareness capability for ESC and MITRE.

The ASC-UDOP program is an AFRL S&T RDT&E 6.3 budget activity funded critical experiment in response to a data call put out by AFCYBER (Provisional) for a visualization capability that is dynamic and reconfigurable (user-defined) and which could display large heterogeneous data sets. ASC-UDOP is built on the ACESViewer work done in cooperation with NASA and the FAA as part of the Airspace Concept and Evaluation System. It uses JView, an in-house developed graphical application programmer's interface as its rendering system.

The ASC-UDOP team spent time documenting the systems and data used in the Joint Interface Control Officer (JICO) cell at the 608th AOC in Barksdale, Louisiana, to address better ways of representing their data. In a remarkable demonstration of dynamic user-tailoring, immediately after speaking with the 608th's weather officer on how the UDOP technology could make the process of generating weather reports more efficient and accurate, a new visualization was composed to render a composite aircraft/weather display where the weather was abstracted into terms of aircraft state to show more non-conventional ways of representing the types of information in which the 608th is interested.

Finally, ASC-UDOP software was installed at the ISPAN program office EPL lab located at USSTRATCOM in Omaha, Nebraska. This collaboration was spawned from meetings between ISPAN program office and the AFRL's Information Directorate.

*Combined Information Data Network Exchange (CIDNE) is used daily by thousands of military personnel, civilians and analysts as the US CENTCOM-directed tool for the majority of operational reporting within Afghanistan and Iraq.*



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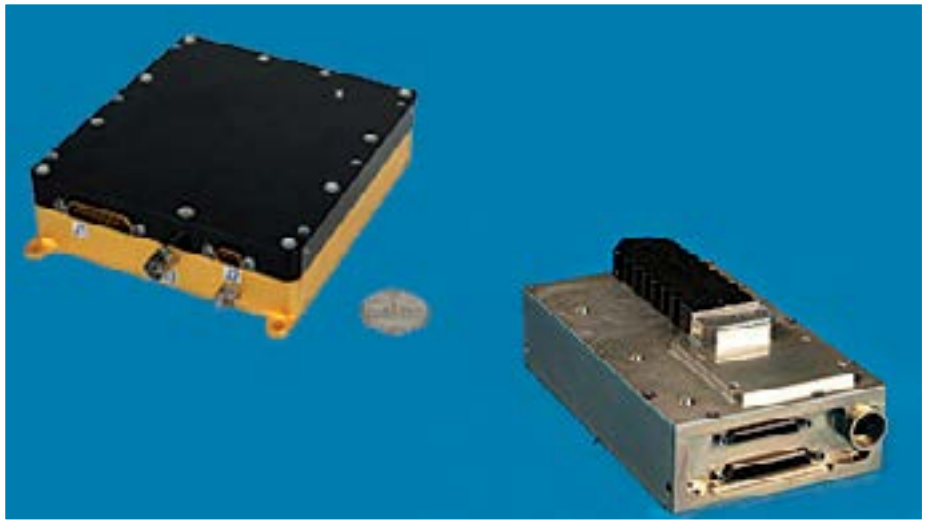
# Miniature Common Data Link Transitioned



*Miniature Common Data Link (Mini-CDL) is a small, lightweight, low power, low cost CDL system for use on small RPAs for dissemination of ISR data.*

The Miniature Common Data Link (Mini-CDL) is a small, lightweight, low power, low cost CDL system for use on small RPAs (Remotely Piloted Vehicles) for dissemination of ISR data.

Mini CDL provides range of data rates up to 45 Mbps in an approximately 2.5 pound, 25 in. 3 package. Key technology enablers include high speed Field Programmable Gate Arrays (FPGAs), small NSA approved Type –I encryption chips, high efficiency solid state power amplifiers, and miniaturized diplexer components.

Benefits to the warfighter include small, low-cost CDL technology for ISR data transfer, and dual source development reduces end cost to user; low Size, Weight, and Power (SWaP) enables use on 35 lb+ class of Remotely Piloted Vehicles (RPAs); interoperable with deployed CDL ground systems such as One System Remote Video Terminal (OSRVT), ROVER III/IV/V, Team Portable, and Video Scout; interoperable with legacy CDL airborne systems such as MR-TCDL, Mini-TCDL, and Hawklink.

During 2011, Mini-CDL, with a Technical Readiness Level (TRL) of 7, transitioned to the Air Force Electronic Systems Center (ESC) CDL Program Office. Customers include Army PM-Unmanned Aircraft System (UAS) RQ-7B Shadow Program and Naval Air Systems Command (NAVAIR) MQ-8B Fire Scout Program.





*For additional information on this technology contact AFRL/RI* **techinfo.if@rl.af.mil**, *(315)330-2143.*

# New Firefighting System Three Times More Effective Than Previous Method

AFRL researchers have developed ultra-high pressure (UHP) firefighting technology that is three times more effective than conventional capability and increases the length of time a firefighting vehicle can remain on scene. UHP technology, compared with conventional methods at the same flow rate, provides extended agent discharge distance and coverage and allows operators to more safely combat fuel fires. The first Air Force (AF) firefighting vehicle to use this new UHP technology is the P-34 Rapid Intervention Vehicle (RIV). The vehicle began production in September 2011. The P-34 RIV will replace older P-19 firefighting vehicles, which have been in service since the 1980s.

AFRL researchers develop a variety of new firefighting technologies to reduce cost, weight and volume for deploying effective airbase crash and rescue capabilities. The UHP firefighting system discharges a water and firefighting foam mixture at pressures of 1,500 lb per $in^2$.

With a capacity of 500 gal of aggregate firefighting agent, the P-34 RIV is smaller and more agile than older vehicles currently in the AF's crash response fleet. Built on a Ford F550 chassis with an enhanced front axle, the truck's cabin is designed to accommodate three firefighters and their equipment.

The UHP turret, which is mounted on the front bumper, is powered by a four-stage, high-pressure centrifugal pump that discharges 60 gal of firefighting agent per minute. The turret is designed to be operated via a joystick by an operator in the cab. The RIV operator can apply firefighting agent using the UHP turret while in motion or stopped. The vehicle also has two 200 ft hand lines that output 15 gal per min each and allow firefighters to perform interior firefighting and rescue operations. Firefighters can operate the turret and two hand lines simultaneously.

In 2010, the average cost of replacing a 1,000 gal P-19 firefighting vehicle was $564,000. The new, 500 gal UHP P-34 RIV has the firefighting capability of a 1,500 gal vehicle using conventional pumping technology and costs about $160,000. The AF is expected to purchase at least 207 RIVs, reducing the age of its vehicle fleet and achieving a cost-avoidance savings as high as $84M

*The P-34 Rapid Intervention Vehicle will be the first firefighting vehicle in the AF fleet to use new ultra-high pressure firefighting technology, which is three times more effective than conventional methods.*



*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

# AFRL Increases Production Size of Sapphire Sheets for Windows

*Collaborative work by AFRL and Saint Gobain Ceramics and Plastics Inc. developed new manufacturing processes that increase the size and thickness of sapphire sheets (shown) for electro-optic and infrared windows.*

AFRL Materials researchers teamed with Saint-Gobain Ceramics and Plastics Inc., to develop new manufacturing processes that increase the size and thickness of sapphire sheets for electro-optic (EO) and infrared (IR) windows.

This collaborative work pushed the state of the art in large-aperture windows to accommodate sizes 16 in. wide by 18 in. long and 0.8 in. thick. The new repeatable process for growing large, thick sapphire windows meets all transmission and durability requirements. The repeatable process also offers a reduction in post-production costs.

The demand for large-area windows for EO and IR applications in the visible to mid-wave infrared spectrum has increased considerably in the last 10-years. Applications in both the military and civilian arenas, such as for aircraft, missiles and ships, require hard, strong and transparent materials in order to achieve system goals. Sapphire possesses the desired properties for windows that are required to operate in a harsh EO or IR environment.

However, there are only a limited number of crystal growth techniques able to produce single crystal sapphire suitable for window applications larger than 6 in., and only a few of them are capable of producing commercially available plates in larger sizes that are suitable for fabrication into a finished window.

AFRL and Saint Gobain Ceramics and Plastics Inc. extended the state of the art of EFG for growing near net shape sapphire. They conducted design experiments, thermal modeling and experimental growth trials; the new size capability serves as an enabler for the sapphire sheets required by the Navy's DDG 1000 (Zumwatt-class destroyer) program. The manufacturing process is also under evaluation by the Air Force's Cobra Ball aircraft and by the Army's High Mobility Artillery Rocket System Office.





*For additional information on this technology contact AFRL/RX* techinfo@wpafb.af.mil, *(937)255-6469.*

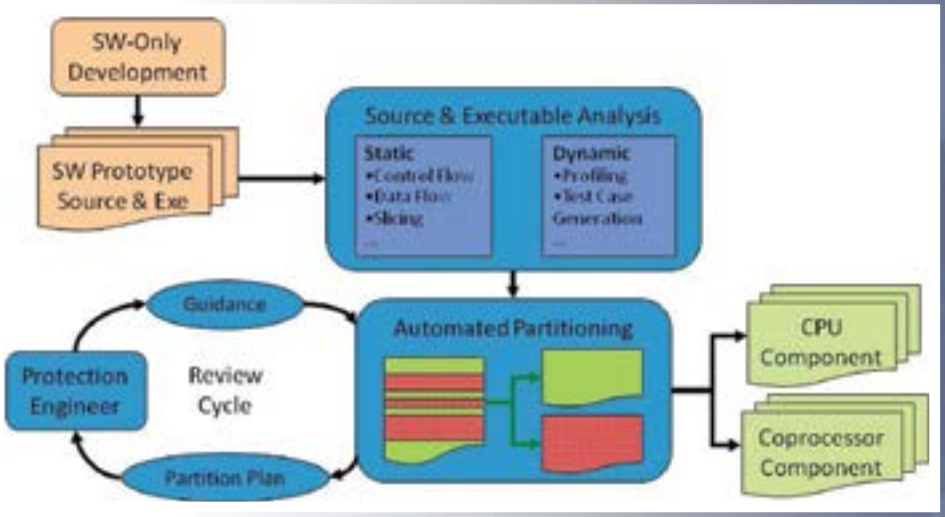
# Software Protection to Deter Malicious Forensic Data Collection and Exploitation

In response to a Department of Defense (DoD) need for software protection technologies to deter malicious forensic data collection and exploitation, GrammaTech has developed new technology that alleviates the extra costs involved in constructing systems that incorporate reconfigurable hardware. The technology frees the developer from the burden of joint software/hardware design and development, allowing system prototyping to be performed completely within the software domain.

GrammaTech's software partitioning tool can be used to automatically partition the software into separate components that will either be targeted at reconfigurable hardware or remain within the software domain. The power of this technology is that it provides the DoD system developer with substantial flexibility, resulting in cost savings and an improved ability to develop secure systems.

Reconfigurable computing systems provide a number of benefits to the system developer. Combining the flexibility of software with the speed of hardware, field-programmable gate arrays (FPGAs) can play a key role in software protection. By recasting critical program information (CPI) encoded in software as a custom circuit specification, the CPI can be moved out of band from a traditional central processing unit (CPU) and placed in an environment inaccessible to commonplace software reverse engineering tools. However, taking advantage of reconfigurable technology adds to the complexity of system design. Decisions must be made regarding which portions of an application should be implemented in hardware and which should remain in software. The system must be architected to account for the partitioning, including support for communicating between the different components. Routine development tasks, such as testing and debugging, require additional overhead due to the added complexity of the system as a whole. In addition, developers must have sufficient expertise to work directly with hardware development tools.

During this Small Business Innovation Research (SBIR) Phase II effort, GrammaTech developed new technology that alleviates the extra costs involved in constructing systems that incorporate reconfigurable hardware.




*Development process with software partitioning, a new technology that alleviates the extra costs involved in constructing systems that incorporate reconfigurable hardware.*



*For additional information on this technology contact AFRL/RY* **afrl.ry.marketing@wpafb.af.mil**, *(937)904-9771.*

# AFRL Scientist Wins Harold Brown Award for Pioneering Laser Materials Research

*Secretary of the AF Michael Donley presents Dr. Candace Lynch of AFRL's Sensors Directorate the Harold Brown Award for significant achievement in research and development.*

AFRL scientist Dr. Candace Lynch received the Harold Brown Award in a ceremony at the Pentagon late last year. Secretary of the Air Force (AF) Michael Donley presented the award, named for a physicist who was Air Force Secretary (1965-1969) and Defense Secretary (1977-1981). The Harold Brown Award recognizes significant research and development that led to or demonstrates promise of a substantial improvement in the Air Force's operational effectiveness, and is the AF's highest R&D award. Dr. Lynch is the first woman to receive the Award.

Dr. Lynch joined AFRL in 2005 as a National Research Council Postdoctoral Research Associate, becoming a member of a research group that was pioneering quasi-phase-matched (QPM) materials for new infrared countermeasures (IRCM) technology. Dr. Lynch's contribution was a breakthrough technology making it possible to create lasers that emit throughout the mid-wave infrared spectrum; it has also enabled generation of 1.5 terahertz emission for threat detection and for imaging weapons that are concealed under clothing.

Dr. Lynch became highly respected throughout the scientific community for her expertise and accomplishments regarding orientation-patterned gallium arsenide (OP-GaAs) crystal growth. She reported on OP-GaAs technology to the technical community in major conferences and became a leader within AFRL and the international scientific community.

Dr. Lynch's basic research was funded by the Air Force Office of Scientific Research; subsequent R&D -- in which Dr. Lynch and her AFRL team members from Hanscom and Wright-Patterson Air Force Bases collaborated with researchers at BAE Systems, Stanford University, the University of Massachusetts at Lowell, and small businesses -- has pushed OP-GaAs technology toward commercialization. Multiple small businesses have initiated programs to replicate the OP-GaAs fabrication methods pioneered by Dr. Lynch and her AFRL team.

This technology breakthrough is a national asset; it is the only capability of its kind in the world.





*For additional information on this technology contact AFRL/RY* **afrl.ry.marketing@wpafb.af.mil**, *(937)904-9771.*

# 2011 AFRL Fellows

Each year, AFRL recognizes outstanding scientists and engineers, bestowing upon them the title of AFRL Fellow - the laboratory's highest, national award, with only the top 0.2% of our professional technical personnel selected each year. The program recognizes excellence in either research and development or technical program management. This year's AFRL Fellows are:

**Mr. Chris Bozada** - Sensors Directorate was selected for his work in the field of electronic and device fabrication.

**Dr. Campbell Carter** - Propulsion Directorate was selected for his work in the field of optical diagnostics involving Particle Image Velocimetry and Planar Laser Induced Fluorescence.

**Dr. Tom Cooley** - Sensors/Space Vehicles Directorate was selected for his work in the field of Hyper-Spectral Imaging.

**Dr. Mark Draper** - 711th Human Performance Wing was selected for his work in the field of interfaces for remotely piloted aircraft (RPA).

**Dr. David Lambert** - Munitions Directorate was selected for his work in the field of selectable effects munitions which shape themselves dynamically to optimize lethality.

**Dr. Don Shiffler** - Directed Energy Directorate was selected for his work in the field of high power microwave (HPM) technologies for directed energy systems.

**Mr. Don Swihart** - Air Vehicles Directorate was selected for his work in the field of flight control systems and aviation safety.

**Dr. Al Viggiano** - Space Vehicles Directorate was selected for his work in the field of plasma chemistry.

*1st row, pictured left to right are Mr. Chris Bozada and Dr. Campbell Carter*
*2nd row, pictured left to right are Dr. Tom Cooley and Dr. Mark Draper*
*3rd row, pictured left to right are Dr. David Lambert and Dr. Don Shiffler*
*4th row, pictured left to right are Mr. Don Swihart and Dr. Al Viggiano*

# School of Aerospace Medicine Dean Achieves Prestigious Nursing Honor

*Colonel Karen Weis achieved one of nursing's highest honors by being inducted as a Fellow into the American Academy of Nursing.*

Colonel Karen Weis, dean of the US Air Force School of Aerospace Medicine, was inducted as a Fellow into the American Academy of Nursing at the Academy's 37th Annual Meeting and Conference in Washington, D.C.

Membership in the Academy is one of the most prestigious honors in the field of nursing, according to Academy President Catherine Gillis. Candidates are nominated by two current Academy Fellows and have made outstanding contributions to nursing and health care.

"My extreme thanks go to the Academy for this honor," Colonel Weis said. "It is wonderful to be one of more than 1,600 nursing leaders in education, management, practice and research who comprise the AAN's Fellowship."

As dean of the US Air Force School of Aerospace Medicine, Colonel Weis directs enlisted, officer and graduate medical education for more than 6,000 students each year. She also oversees the largest aeromedical library in the world.

Colonel Weis received a doctorate in nursing from the University of North Carolina at Chapel Hill; a Master of Nursing Science degree in acute care nursing with obstetric focus from University of Texas Medical Branch; and a Bachelor of Nursing Science degree (Magna Cum Laude) from Wichita State University.

She was commissioned into the USAF as a second lieutenant in 1987 and is a leading researcher in women's health issues. She has received more than $750,000 in federal research funding and recently co-authored the third edition of Psychosocial Adaption to Pregnancy with Dr. Regina Lederman. She serves as a consultant to the Air Force Surgeon General on nursing research.

Colonel Weis' military decorations include the Bronze Star, three Meritorious Service Medals, an Aerial Achievement Medal, three Air Force Commendation medals, the Air Force Achievement Medal and a Joint Meritorious Unit Award.





*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# AFRL Researcher Honored for Innovations

Dr. Mark Draper, senior research engineering psychologist with the AFRL, received the 2010 Harry G. Armstrong Scientific Excellence Award. The Armstrong Award commemorates Major General Armstrong's pioneering career in aerospace medicine research at Wright-Patterson Air Force Base, and is given annually to honor the most significant scientific or technical accomplishment.

Dr. Draper was selected for his scientific innovations that are revolutionizing Remotely Piloted Aircraft supervisory control interfaces. He is recognized as an international expert in that area. Among his many accomplishments, he presented and coordinated far-reaching research programs to leaders and tech experts in a number of military and civilian organizations, including Headquarters Air Force, NASA and NATO.

*711th Human Performance Wing Director Mr. Thomas Wells (left) presents the 2010 Harry G. Armstrong Scientific Excellence Award.*



*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# AFRL Toxicologist Wins Traveling Lectureship Award

*Dr. Saber Hussain of AFRL's 711th Human Performance Wing was awarded the prestigious 2011 AstraZeneca Traveling Lectureship Aware, presented by the Society of Toxicology.*

Dr. Saber Hussain, a senior research toxicologist with the AFRL, has won the prestigious 2011 AstraZeneca Traveling Lectureship Award.

The annual award, presented by the Society of Toxicology, recognizes excellence in research and service in toxicology. AstraZeneca Ltd. provides funding to promote greater collaboration between European and North American toxicologists, and to enable North American toxicologists to undertake a 3- to 4-week lecture tour of key European research sites. The award is intended to familiarize recipients with research and regulatory issues in Europe as well as to bring a North American perspective to toxicology issues.

Dr. Hussain is recognized as an expert in the emerging field of nanotoxicology, the study of the toxicity of nanomaterials. His studies contribute to the understanding of fundamental mechanisms involving the interaction of engineered nanomaterials with cells in complex biological matrices, and determining the benefits and the associated risks of their use.

Dr. Hussain also won the AFRL's 2010 711 Human Performance Wing International Individual Award, which recognizes individual efforts that leverage cooperative opportunities and provide mutual benefit in priority research areas to enhance the Air Force Science and Technology capabilities.





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# Human Effectiveness Deputy Honored by Peers with Prestigious Award

US Air Force (AF) Colonel Douglas Hodge, Deputy Director of the Human Effectiveness Directorate, 711th Human Performance Wing, AFRL at Wright-Patterson Air Force Base, Ohio, received the American Academy of Physician Assistants' 2011 Federal Service PA of the Year Award at the organization's conference on June 1 in Las Vegas.

The Federal Service PA of the Year Award recognizes a physician assistant who has demonstrated exemplary service in the federal service sector of the PA profession.

"It is quite an honor to receive this award," Colonel Hodge said. "The award tells me that my peers are validating me as a mentor and a leader."

Colonel Hodge entered the AF in 1993 and began his AF career as a physician assistant at Andersen Air Force Base, Guam, then moved to Geilenkirchen Air Base, Germany.

He has extensive experience in supporting military and humanitarian operations as a medical readiness officer, a medical intelligence officer, and a medical operations officer. Colonel Hodge was named Deputy Director of the Human Effectiveness Directorate in October 2010. He assists the director in managing the AF's primary and preferred source for research and knowledge on human-centered research.

*Col. Douglas Hodge (center) of the AFRL, received the American Academy of Physician Assistants' 2011 Federal Service PA of the Year Award.*



*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# Human Performance Wing Wins Air Force SMART Award

*Mike Griffin, SMART Focal Point, 711 HPW Chief Scientist's Office (pictured second from left), receives the award from Dr. Steven Walker, Deputy Assistant Secretary of the AF for Science, Technology and Engineering.*

The AFRL's 711th Human Performance Wing (711 HPW) has been recognized for its dedication to the Science, Mathematics, And Research for Transformation (SMART) Scholarship for Service Program. The 711 HPW earned the US Air Force (AF) SMART Sponsoring Facility of the Year for its part in the program, which provides a full scholarship and post-degree employment for students pursuing an undergraduate or graduate degree in Science, Technology, Engineering, and Mathematics (STEM) disciplines. Each military service participates in SMART as part of the National Defense Education Program.

"(The SMART program) uses a very successful method for conducting interviews and selecting students," said Ed Bujan, AF SMART program liaison. "711 HPW staff members do a tremendous job making sure each student has a positive mentor upon selection."

Bujan noted that the feedback of the students is a positive reflection of what the 711 HPW does to support SMART, and to ensure it is investing wisely for the future of the Wing, the AFRL, and the AF.

"We are delighted to receive this award," said Dr. Morley Stone, Chief Scientist, 711 HPW, "because it is recognition of the efforts that we are putting into a program that we believe is essential to the viability of our organization."

Twenty-three students, from undergraduates to those working on a doctorate, are participating in the SMART program at the 711 HPW. Dr. Stone has made the program a top priority with a goal of increasing the number of students who participate each year.





*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# Human Performance Wing Wins Air Force Outstanding Unit Award

The 711th Human Performance Wing (711 HPW) has won the Air Force (AF) Outstanding Unit Award for exceptionally meritorious service of national and international significance from March 25, 2008 to March 24, 2010.

The wing was recognized for a number of accomplishments, including successfully planning and leading the execution of the largest Base Realignment and Closure action at Wright-Patterson AFB while establishing and integrating a new organization. In spite of the BRAC demands, the wing's three mission units delivered superior support to their Department of Defense-wide customers.

"The AFOUA is a direct reflection of the dedication, effort, and competency of our people," said Thomas Wells, 711 HPW director. "I am absolutely thrilled, and I thank everyone in the 711 HPW for all they do every day to make the 711 HPW an outstanding unit."

The 711 HPW is the first human-centric warfare wing to consolidate research, education and consultation under a single organization. Established March 25, 2008, under the AFRL, the 711 HPW is comprised of the Human Effectiveness Directorate, the USAF School of Aerospace Medicine and the Human Performance Integration Directorate.


*711 HPW shield*



*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# AFRL Scientist Becomes First US Citizen Honored with British Award

*Lt Col Laura Barnes, 711 HPW, was the first US citizen to received the Special Commendation Coin from the United Kingdom's Defence Science and Technology Laboratory.*

Lt Col Laura Barnes of the AFRL's 711th Human Performance Wing became the first US citizen to receive the Special Commendation Coin from the United Kingdom's Defence Science and Technology Laboratory (DSTL). The award, which Lt Col Barnes received September 14, 2011, is one of the highest honors bestowed upon Ministry of Defence researchers.

The coin was presented by Jonathon Lyle, on behalf of the MOD's Chief Science Advisor, Sir Mark Welland, in recognition of Lt Col Barnes' work promoting and supporting the strategic relationship between the United Kingdom and US in science and technology.

DSTL focuses on the research and development of science and technology for the defense and security of the United Kingdom, with collaboration from government agencies and universities around the world.

Lt Col Barnes filled two roles during her 3-year assignment in Wiltshire, United Kingdom. She served as research scientist specializing in laser bioeffects, and she was a liaison between DSTL Headquarters and the AFRL. During her assignment, she worked with British researchers to define safe operating parameters for current and future laser systems used operationally by both nations.

She also provided liaison support across both scientific and medical research communities. Lt Col Barnes, a Biomedical Science Corps officer, holds two doctoral degrees — an OD in optometry and a Ph.D. in optics. Her familiarity with both medical and physical sciences was one of the reasons she was selected for the DSTL assignment.

Lt Col Barnes is currently the deputy chief of the Warfighter Interface Division.





*For additional information on this technology contact 711 HPW* **711HPW.reports.inbox@wpafb.af.mil**, *(937)255-7735.*

# MicroSatCom Terminal, Inventor Win Prestigious Tech Award

The AFRL's Information Directorate's X-Band MicroSatCom Terminal took home the Federal Laboratory Consortium for Technology Transfer (FLC) Excellence in Technology Transfer Award. This yearly award is one of the most prestigious in technology transfer. The honor brings great credit and national recognition to the Air Force (AF), Air Force Material Command, AFRL and the Information Directorate.

AFRL's David Legare developed a satellite communications terminal to be used by soldiers in the field. The terminal is designed to access X-band and Ka-band radio frequencies through the Department of Defense (DoD) high capacity Wideband Global SATCOM satellites, in a portable package previously unavailable to the warfighter.

The X-Band MicroSatCom Terminal comprises three state-of-the-art advancements in portable satellite communications systems, including an advanced antenna reflector with segmented "petals" that quickly unfold to operate the terminal and just as quickly re-fold for compact stowage and easy transport. The application of advanced nanomaterials technologies allow for the production of lightweight, rugged, highly efficient antenna reflectors and techniques for integrating these nanomaterials into an inexpensive thermoplastic molding process.

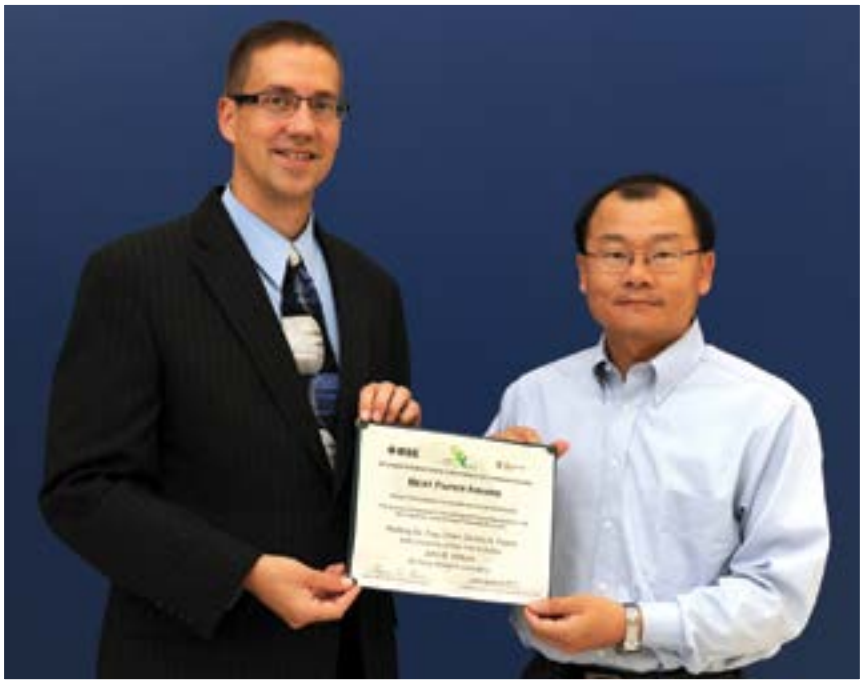
The knowledge was successfully transferred to Eclipse Composites to develop the technology into a deliverable commercial product. This was accomplished through several technology transfer mechanisms, including a Cooperative Research and Development Agreement and two Patent License Agreements. This system is currently meeting and exceeding the requirements for the AF's Special Operations Command.

*(pictured from left) Dr. J. Scott Deiter, FLC Chair; Cynthia Gonsalves, FLC DoD Representative; Franklin Hoke Jr., FLC Laboratory Representative for AFRL-RI; David Sikora, FLC AF Representative; and Dr. Theresa Baus, FLC Vice Chair.*



*For additional information on this technology contact AFRL/RI* **techinfo.if@rl.af.mil**, *(315)330-2143.*

# AFRL Adviser, NRC Associate Win IEEE ICC Best Paper Award



*AFRL adviser Dr. John Matyjas (pictured left), and AFRL NRC Associate Dr. Weifeng Su (pictured right), received the 2010 IEEE ICC*

AFRL adviser Dr. John Matyjas, and AFRL NRC Associate Dr. Weifeng Su, received the 2010 IEEE International Conference on Communications (ICC) Best Paper Award for their work on "The Outage Probability and Optimum Power Assignment for Differential Amplify-and-Forward Relaying." The award ceremony took place during IEEE ICC 2010 on May 25 in Cape Town, South Africa. IEEE ICC is the longest standing flagship conference of the IEEE Communications Society.

The awarded work proposes a novel differential cooperative relaying construct which is appealing in next-generation wireless network design for agile, robust communications; spectral effectiveness; and low implementation complexity. This contribution may revolutionize how UAVs (and other air/space assets) are used as wireless relays to achieve reliable end-to-end wireless network connectivity.

The work tackles an emerging communication concept – cooperative communications and networking. In contrast to conventional point-to-point wireless communications, cooperative communications enable different users/nodes to share resources and cooperate to establish and maintain robust end-to-end communication links through a distributed, resilient, and integrated transceiver strategy that exploits the dynamic nature of the ground/air/space network topology. In such a way, the cooperative transceiver design optimizes signal transmissions from both the physical and medium-access control (MAC) layers, whereby each user's information is transmitted not only by the node itself, but also by cooperating nodes. As a result, cooperating nodes create a virtual multi-input-multi-output (MIMO) system that can significantly increase the link capacity and realize a new form of spatial diversity, known as cooperative diversity.

The work also proposes "cyber smart" amplify-and-forward techniques in lieu of traditional decode-and-forward packet relaying strategies. As such, intermediary nodes are not required to decode the packets they are relaying. This minimizes information broadcast/disclosure and inherently mitigates potential vulnerabilities associated with cooperating nodes.

This novel communications approach has great potential to increase the capacity, reliability, and throughput/delay performance of future wireless networks. Dr. Matyjas and Dr. Su continue to conduct research and development on this emerging cooperative communication concept to design cognitive wireless networks for future integrated air, space, and terrestrial communications.





*For additional information on this technology contact AFRL/RI* **techinfo.if@rl.af.mil**, *(315)330-2143.*

# Scramjet Team Receives Aviation Week Excellence Award

The X-51 Scramjet Engine Demonstrator (SED) WaveRider team was honored by Aviation Week at its Program Excellence Awards. The X-51 SED Team includes members of AFRL's Propulsion Directorate, Boeing Phantom Works, and Pratt & Whitney Rocketdyne. The team was recognized in the category of System Level R&D/System Development and Demonstration.

Aviation Week's Program Excellence Awards result from an annual evaluation of the industry's top programs, identifying the strongest lessons and practices, then sharing these best practices across the industry.

The X-51 program goal is to demonstrate scramjet engine technology to a Technology Readiness Level of 6 and show that it is ready for transition to weapon systems applications. The program leverages prior investment by DARPA under the Affordable Rapid Response Missile Demonstrator (ARRMD) program.

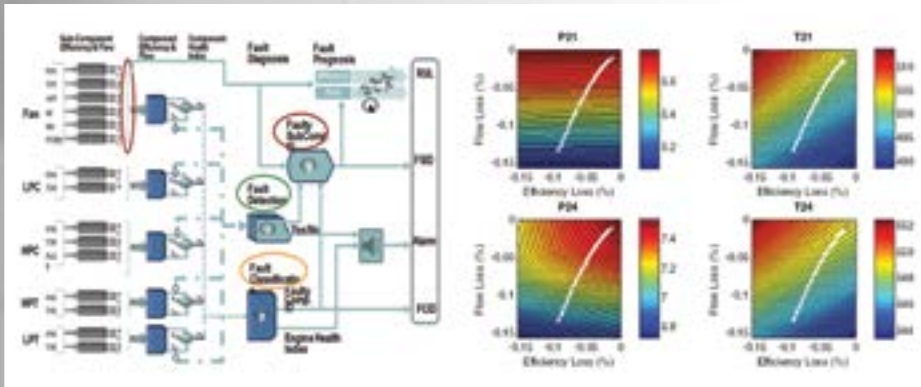
A modified Army Tactical Missile System (ATACMS) booster is used to accelerate the vehicle from the launch condition to Mach 4.5, where the scramjet takes over and accelerates the vehicle to cruise conditions. The historic, record-breaking first flight of the X-51 took place on May 26, 2010, and the next flight is tentatively scheduled for early 2011.

*X-51 Scramjet Engine Demonstrator team members, honored by Aviation Week's annual Program Excellence Awards in the category of System Level R&D/System Development and Demonstration.*



*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# New Diagnostics Give Turbines Onboard Health Checks



*Details of Distributed Diagnostics Architecture and Sample Results, used for onboard monitoring of turbine engine components.*

The main components of turbine engines are well-known —fan, compressors, turbines, etc.— and each of these components is influenced by several factors. It is important that distributed and dedicated software be developed to monitor and diagnose each component: One advantage of this distributed methodology is the ability to incorporate learning features to each such dedicated diagnostic software module. Another feature is the ability to implement the diagnostics in a distributed architecture, making onboard diagnostics more practical and realistic.

Presently, most US Air Force (AF) turbine engine monitors use Engine Trending and Diagnostic (ET&D) software to analyze engine performance. The data are generally steady-state, obtained immediately after takeoff or during cruise conditions, or reported when an engine event occurs. These data are manually analyzed by plotting past flights and notifying the user when a parameter is exceeding predetermined limits. Indecisive results occur regularly. In addition, the data and resulting analysis processed by the current trending tool generally remain at the local base, making fleet-wide data aggregation and analysis difficult to obtain because of the distance and time required to transport the data. As a result, there is little opportunity to detect trends within the fleet or to identify differences in engine performance between bases or commands. For these reasons, the AF has determined a need for improved ET&D.

A distributed diagnostic architecture has been developed, implemented and tested by simulation on a real commercial turbine engine model known as the CMAPSS. The diagnostic architecture is made up of 5 processing modules corresponding to the five relevant components of the engine, meaning each processing module is responsible for monitoring, tracking and reporting the health of one component.

As a whole, the system predicts different, sometimes conflicting, information. Therefore, information fusion algorithms were used to fuse the different decision made by each ensemble of neural networks, and to fuse different engine performance parameters (efficiency and flow) predicted by each neural network within the same ensemble.

The testing results show promise for software that would assess conditions of turbine engine components and subcomponents.





*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# Wright-Patterson Honors Propulsion Directorate for Diversity Initiatives

The AFRL's Propulsion Directorate received the Wright-Patterson Air Force Base 2010 Organizational Diversity Award.

The directorate was recognized for its mission-driven Diversity Plan and Vision, which is based on seven pillars: Leadership, Culture, Business Development, Recruiting & Retention, Career Development, Awards and Recognition and Communication. The directorate identified and modeled leadership behaviors supporting a culture that encourages, embraces and values diversity. Intercultural Development Inventory surveys results in the development of a directorate culture that values a shared understanding of diversity and inclusion.

The directorate conducted numerous business development activities with many historically black colleges and universities/minority institutions to provide diversity solutions to technology gaps. The unit initiated an Advanced Propulsion Outreach Program to develop partnerships with students and teachers at the high school and collegiate level with the goal of building minority interest in science and technology and to recruit co-op student candidates.

The directorate also created two internal annual diversity awards: the Propulsion Directorate Diversity Mentoring Award and the Propulsion Directorate Diversification Award, which have been instrumental in fostering an environment of inclusion through diversification awareness and communicating the organization's diversity successes throughout the directorate.

*Colonel William D. Hack accepts 2010 Diversity Award for the AFRL Propulsion Directorate.*



*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

# Propulsion Engineer Honored for Community Involvement

*Mr. Joseph Gordon was honored for his community involvement, winning the WPAFB Diversity Leadership 2010 Community Award.*

Mr. Joseph Gordon, Special Advisor to the Propulsion Director of the AFRL's Propulsion Directorate, has been recognized for providing outstanding service as a "servant leader" to the greater Dayton community. The period of service for which Mr. Gordon was honored with the Wright-Patterson Air Force Base (WPAFB) Diversity Leadership 2010 Community Involvement Award was July 1, 2009 to June 30, 2010.

Mr. Gordon successfully managed several student outreach programs providing Science, Technology, Engineering and Mathematics (STEM) opportunities to students and creating a more diverse Air Force workforce. He served as a coach to a successful robotics engineering team and actively participated as a STEM Fellow with the Montgomery County Education Center to develop STEM curriculum lessons for grades K through 12.

Mr. Gordon also served on multiple Executive Boards to support the Dayton, OH community through education, media, economic development and public policy. His tenacity and attention to detail enabled faith-based organizations to set up a SAT/ACT Prep Program, financial counseling program, multi-media center, and an education center.

The distinctive accomplishments of Mr. Gordon reflect great credit upon himself, the WPAFB workforce, and the greater Dayton community.





*For additional information on this technology contact AFRL/RQ* **afrl.rq.marketing@wpafb.af.mil**, *(937)938-4808.*

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