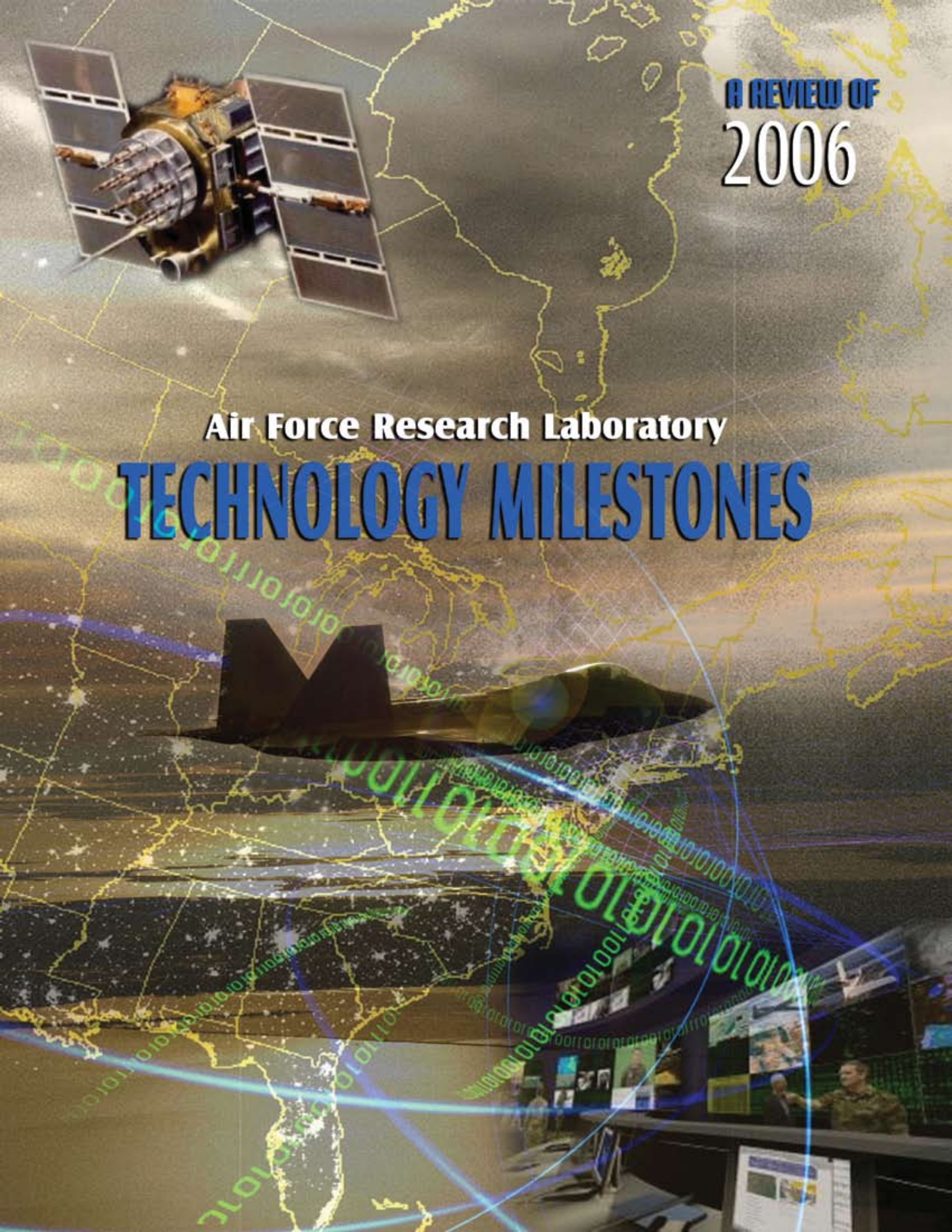

A REVIEW OF

2006

Air Force Research Laboratory

TECHNOLOGY MILESTONES

REPORT DOCUMENTATION PAGE

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14. ABSTRACT

AFRL Technology Milestones highlight significant scientific and technical accomplishments for visually-coupled acquisition and targeting systems for our warfighter to automatic spoken language translators for our international warriors. AFRL, headquartered at Wright-Patterson AFB, Ohio is the Air Force's largest employer of scientist and engineers, with partnerships in industry and academia, working to develop and transition affordable integrated technologies to support a broad range of future capabilities. This Technology Milestones book includes stories from the following categories: Support to the Warfighter; Sustainment; Emerging Technologies; Technology Transfer; and Awards Recognition.

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http://www.afrl.af.mil/technologymilestones/.
To receive more information about AFRL, visit the home page at
www.wpafb.af.mil/afrl.

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AFRL
Technology Milestones Program

Helping to maintain the Air Force's strong
Science and Technology foundation
one milestone at a time.

The Air Force Research Laboratory (AFRL) is a tremendously important and exciting organization represented by exceptional people, all dedicated to envisioning solutions and delivering the "art of the possible" to the warfighter.

Our mission is to lead the discovery, development, and integration of affordable warfighting technologies for our air and space forces. We execute our mission through our nine technology directorates located throughout the United States, our Air Force Office of Scientific Research, and our central staff.

Innovation and technology are key components of the Air Force's strong foundation. The imagination of the world's best and brightest minds—in government, industry, and academia—ultimately delivers the equipment, weapon systems, and ideas driving our organization. These technology milestones showcase some of the technological advancements accomplished within AFRL.

Headquartered at Wright-Patterson Air Force Base, Ohio, AFRL is the Air Force's largest employer of scientists and engineers. In a population of about 3,400, approximately 23% have doctorate degrees in science and engineering disciplines.

The laboratory's research spans the full spectrum of science and technology—from conducting basic research to launching experimental microsatellites. Our scientists and engineers create technologies today that will be used by the nation's air and space forces of tomorrow.

You will find in these pages some of our most noteworthy technology milestones for 2006. These stories represent just a fraction of the AFRL technologies currently under development.

Technology Milestones can be reviewed at **http://www.afrl.af.mil/technologymilestones/**.

You can also visit the AFRL Web site at **www.afrl.af.mil**.

Introduction

The Air Force Science and Technology Milestones herein often represent the combined effort of several scientists and engineers working as a team. The basic and applied research, plus the follow-on technology development described, are essential to the continued success of the Air Force mission.

This book contains Technology Milestones selected from one or more of the following categories:

Support to the Warfighter (Air, Space, and Cyberspace)

Technology that has potential for, or has achieved, application on a Department of Defense system in development or operation or that has provided "quick-reaction" response to problems or needs of field organizations

Sustainment

Technology that increases readiness and reduces life-cycle costs of legacy systems, applicable to (1) base infrastructure, (2) maintenance, (3) logistics, (4) training, and (5) human performance

Emerging Technologies

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

Technology Transfer

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

Awards and Recognition

Awards and recognition of AFRL contributions within the scientific community at large, concerning technology advancements in the areas of technology transition, technology transfer, or technical achievement

AFRL Technologies

Air Force Office of Scientific Research (AFOSR)

Mission Statement: AFOSR orchestrates the Air Force basic research program with universities, industry, and other government organizations.

Structural Mechanics
Boundary Layers and Hypersonics
Combustion and Diagnostics
Metallic Materials
Theoretical Chemistry
Polymer Chemistry
Surface and Interfacial Science
Atomic and Molecular Physics
Electromagnetics
Remote Sensing and Imaging Physics
Quantum Electronic Solids
Sensor and Detector Materials
High-Density Optical Memory
Chronobiology
Cognition and Decision
Biological Response Profiling and Assessment
Computational Mathematics
Operations
Sensing, Surveillance, and Navigation
Information Fusion and Artificial Intelligence
Mechanics of Multifunctional Materials and Microsystems
Unsteady and Rotating Flows
Space Power and Propulsion
Ceramic and Nonmetallic Materials
Molecular Dynamics
Polymer Matrix Composites
Electroenergetic Physics
Physical Mathematics and Applied Analysis
Laser and Optical Physics
Space Sciences
Electronic and Detector Material Structures and Device Concepts
Optoelectronics: Components and Information Processing
Biophysical Mechanisms
Biomimetics, Biomaterials, and Biointerfacial Sciences
Sensory Systems
Dynamics and Control
Information Forensics and Process Integration for Network
Optimization and Discrete Mathematics
Software and Systems

Air Vehicles Directorate

Mission Statement: The Air Vehicles Directorate plans, formulates, and directs US science and technology for research/exploratory/advanced technology development for military air vehicles; orchestrates and executes technology developments in aeronautical/control sciences and aerospace structures; integrates air vehicle technologies with 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, and the North Atlantic Treaty Organization and other foreign research organizations.

Propulsion Integration
Experimental Aeronautical Sciences
Plasma Physics
High-Speed Aerodynamic Configurations
High-Speed Computational Research
Control Systems and Theory
Space Access and Hypersonics Guidance and Control
Simulation-Based Research and Development
Advanced Structural Concepts
Adaptive Structures
Computational/Analytical Certification
Multidisciplinary Design and Demonstration
Structural Integrity
Experimental Structures
Weapon Integration
Flow Control/Flow Physics
Low-Speed Aerodynamic Configurations
Multidisciplinary Computational Research
Applied Computational Science
Unmanned Air Vehicle Cooperative Control
Flow Control, Mechanization, and Automation
Multifunctional Structures
Thermal Structures
Structural Health Assessment
Combined Environments (Structures)
Aeroelasticity Analysis Methods
Structural Dynamics

AFRL Technologies

Directed Energy Directorate

Mission Statement: The Directed Energy Directorate develops, integrates, and transitions science and technology for directed energy—including high-power microwaves, lasers, adaptive optics, imaging, and effects—to assure US preeminence in air and space.

Lasers:
Gas/Chemical Lasers
Electric Lasers
Bulk Solid-State Lasers
Fiber Lasers
Semiconductor Lasers, Hybrid Lasers
Laser Vulnerability and Lethality

Beam Control:
Atmospheric-Propagation/Adaptive Optics
Acquisition-Tracking and Pointing
Space Situational Awareness

Modeling and Simulation:
Laser/Optics
Radio Frequency (RF)/Plasma
Systems
Missions

High-Power Microwaves:
Pulsed-Power Plasmas
RF Sources/Antennas
RF Effects

Human Effectiveness Directorate

Mission Statement: The Human Effectiveness Directorate leads revolutionary science and technology for superior Airman cognition, readiness, performance, and survival through concentrated efforts focused on providing decision-quality information, immunity from threat, and mission-effective performance.

3-D Audio
Biomechanics
Chemical-Biological Agent Defense
Cognitive Modeling
Continuous Learning and Learning Management Technologies
Cultural Behavior Modeling and Representation
Fatigue Countermeasures
Human-System Interface Design
Laser Eye Protection
Maintenance Job Aiding
Night-Vision, Helmet-Mounted, and Large-Screen Displays
Optical Radiation Bioeffects
Situational Awareness
Toxicology
Warfighter/Weapons Systems Integration
Aircrew Performance and Protection
Biotechnology
Cognitive Interface Technologies
Competency-Based Performance Measurement and Tracking
Counterproliferation
Distributed Mission Operations Training Research
Human-Centered Logistics Research
Immersive Training/Rehearsal Simulation Environments
Live-Virtual-Constructive Integration
Nanotechnology
Nonlethal Technologies
Radio Frequency Radiation Bioeffects
Speech-Recognition Technologies
Veterinary Sciences

AFRL Technologies

Information Directorate

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

Information Dominance (and its transition to ground, air, and space systems, especially in the area of command and control)
Information Fusion
Signal Processing
Collaborative Environments
Modeling and Simulation
Information Assurance Intelligent Information Systems Technologies (including intelligent agents, planning/scheduling and decision aids, knowledge bases, and access)
Information Exploitation
Communications and Networking
High-Performance and Adaptive Computing
Advanced Displays and Intelligent Interfaces

Materials and Manufacturing Directorate

Mission Statement: The Materials and Manufacturing Directorate plans and executes the US Air Force program for material and manufacturing in the areas of basic research, exploratory development, advanced development, and industrial preparedness and provides responsive support to Air Force product centers, logistics centers, and operating commands to solve systems- and deployment-related problems and to transfer expertise.

Accelerated Insertion Materials
Advanced Industrial Practices
Advanced Metallics
Airbase Infrastructure Technologies
Amorphous Metals
Atmospheric Threat Protection
Ceramics and Ceramic Matrix Composites
Computational Chemistry
Electronics
Engine Rotor Life Extension
Firefighting Technology
Force Protection Research
High-Cycle Fatigue
High-Resolution Flaw/Feature Imaging
Infrared Sensors and Transparencies
Magnetic and High-Temperature Superconducting Materials Processing
Manufacturing Processing and Fabrication Technology
Materials Behavior and Evaluation
Materials Process Design
Metallic Composites
Metals Processing
Nondestructive Evaluation
Optical Materials
Pollution Prevention Materials
Power and Chemical Processes
Robotics Research
Sensor Technologies
Structural and Electronic Failure Analysis
Surface Phenomena/Interactions
Thermal Protection Materials
Wide Bandgap Materials
Advanced Composite Processing and Behavior
Advanced Inspection Technologies
Air Mobile Systems Research
Aircraft and Spacecraft Coatings
Analytical Chemistry Research
Biotechnology
Composites Supportability
Corrosion Control
Electrostatic Discharge Research
Environmental Technologies
Fluids, Lubricants, and Tribological Research
Hardened Materials Technology
Hazardous Materials Elimination/Minimization
High-Temperature Superconductor Materials
Laser-Hardened Materials
Manufacturing and Engineering Systems
Materials Affordability Initiatives
Materials Life Prediction and Durability
Materials Supportability
Metal Matrix Composites
Nanotechnology
Nonmetallic Composite Materials
Organic Matrix Composites
Polymeric Materials
Quantitative Defect Characterization
Semiconductor Materials
Solid and Liquid Lubricant Development
Superlattice and Quantum-Well Materials
Systems Support
Virtual Reality Training

AFRL Technologies

Munitions Directorate

Mission Statement: The Munitions Directorate leads the discovery, development, integration, and transition of affordable munitions technologies for the US air and space force.

Ordnance Technologies (warheads, fuzes, and explosives)
Guidance Technologies
Computer Analysis and Modeling Capabilities

Propulsion Directorate

Mission Statement: The Propulsion Directorate plans and executes the Air Force 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 principle 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.

Turbine Engines
Turbine Engine Augmentors
Turbine Engine Bearings
Combined-Cycle Engines
Subsonic and Supersonic Combustion
Compressors
Turbine Engine Controls
Turbine Engine Diagnostics
Endothermic Fuels
Engine Starting Systems
Engine Health Monitoring Systems
Exhaust Nozzles
Fans
Fuel Pumps and Fuel Systems
Gas Generators
Gears
High-Cycle Fatigue and Its Mitigation
Ignition Prognostics
Lubrication Systems
Oil Specifications, Diagnostics, and Analysis
Oil Monitors
Optical Diagnostics
Pressure-Sensitive Paints
Pulsed-Detonation Engines
Scramjets
Seals
Turboramjets
Turboshaft Engines
V/STOL Propulsion
Air Turborockets
Hybrid Rockets
ICBM Propulsion
Liquid-Fueled Ramjets
Rocket Engine Test Facilities
Solid-Fueled Ramjets
Solid Propellants
Solid Rocket Boosters
Solid Rocket Service Life
Solid Rocket Motors
Carbon Fibers and Composites
Ceramic Processing
Computational Chemistry
Electric Propulsion
High-Energy-Density Matter
Injectors and Spray Measurements
Laser Propulsion
Liquid Rockets and Combustion
Micropropulsion
Monopropellants
Nontoxic Propellants
Plume Phenomenology
Power Conditioning Equipment
Propulsion Fluid Dynamics
Rocket Materials
Rocket-Based Combined-Cycle Engine
Solar Propulsion
Thermal Management
Thermionics
Auxiliary Power Units
Batteries and Fuel Cells
Capacitors
Circuit Breakers
Converters/Inverters
Electric Motors
Conventional, Superconducting Generators

AFRL Technologies

Sensors Directorate

Mission Statement: The Sensors Directorate leads the discovery, development, and integration of affordable sensor and countermeasure technologies for the warfighter.

Radio Frequency
Photonics/Countermeasures
Radar
Reconnaissance
Electro-Optics
Automatic Target Recognition
Sensors
Electronic Warfare

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.

Aerospace Environment Warfighting Systems
Revolutionary Space Capabilities for Global Awareness
Vital Developing Military Space Concepts

Support to the Warfighter

Page

Air

Space

Cyberspace

AFRL Successfully Tests V-22 Flight Dynamics

AFRL engineers completed successful wind tunnel tests of a 6%-scale V-22 Osprey-powered wind tunnel model in an effort to improve the understanding of the aircraft's flight characteristics. Conducting these tests will enhance V-22 modeling and simulation fidelity by updating and expanding the data on which current modeling is based. The V-22 is the world's first production tilt-rotor air vehicle. The vehicle is capable of taking off and landing vertically—as well as hovering—like a helicopter; it can also transition to fly like a turboprop aircraft for enhanced speed, range, and fuel efficiency.

AFRL and contractor Bihrle Applied Research, Inc., assisted Naval Air Systems Command in designing and fabricating the V-22 model and testing it over a period of 2 months (constituting over 650 wind tunnel occupancy hours). The purpose of the testing was to determine the V-22 aircraft's flight dynamics at extreme attitudes, as well as its resistance to poststall departures. During the test period, the team used a vertical wind tunnel to subject the model to different aerodynamic orientations, propeller speeds, nacelle angles, and blade angles. The researchers also performed forced-oscillation tests to acquire dynamic stability derivatives.

Bihrle engineers will use the test data to construct an updated flight dynamics math model and integrate it with existing V-22 simulations. The updated simulations will improve the ability of pilots and engineers to understand the aircraft's stability and control its characteristics, achieving maximum V-22 performance without compromising safety.

AFRL Completes Subsonic Swept-Wing Laminar Flow Flight Test

Turbulent airflow over an air vehicle wing surface increases airfoil drag and inhibits efficient flight. In an effort to reduce this problem, AFRL researchers completed a subsonic swept-wing laminar flow flight test (SWIFT) to investigate spanwise periodic discrete roughness element (DRE) technology for maintaining wing laminar flow. DREs are small, dimple- or bumplike structures designed to reduce drag by controlling instabilities and inhibiting transition from laminar to turbulent airflow. The use of DREs can cut fuel consumption and increase range or time on station for future aircraft.

DRE technology has potential application to the SensorCraft concept, a high-altitude, long-endurance surveillance aircraft. During the SWIFT effort, engineers collected data from a swept-wing test article mounted on a Cessna test bed aircraft. Testing the swept-wing section in flight as opposed to in a wind tunnel enabled the researchers to study the wing in an environment more representative of the SensorCraft's actual flight environment.

The test results support the idea that DRE technology has use in pushing the boundary layer's transition from laminar to turbulent flow further back on the wing, minimizing drag to permit more efficient flight. While the data generated from the testing validates computational fluid dynamics predictive calculations and confirms the viability of DRE technology for application to the SensorCraft concept, further maturation of the technology with associated boundary layer flow physics is warranted. AFRL is continuing this line of research through the Air Force Office of Scientific Research.

AFRL Demonstrates Tactical Solid-State Laser Weapon Technology

A team of engineers from AFRL and Northrop Grumman Space Technology (NGST), of Redondo Beach, California, demonstrated a solid-state (electric) laser. This research effort addressed the laser device output for high-power solid-state laser (HPSSL) technologies, which have the potential to meet the performance, efficiency, and weight/volume requirements for tactical laser weapons integration on airborne military platforms. These lasers have minimal logistical requirements; they also fire as long as there is fuel to generate electricity, deliver energy at the speed of light at extended ranges, allow discriminate targeting, and reduce collateral damage.

The team's research goal was to develop and demonstrate alternative, 25 kW class, near-diffraction-limited, diode-pumped solid-state lasers that have favorable architectures in terms of size; weight; efficiency; affordability; reliability; maintainability; supportability; environmental (air, land, and maritime) acceptability; and ruggedness for tactical weapon applications. Using a solid-state laser, the team exceeded the goal of 25 kW output power for 300 sec, achieving the desired beam quality for power levels below 17 kW. This achievement demonstrated the engineering feasibility of scaling HPSSLs to the average, 100 kW power level. As a result of the demonstration, NGST earned a contract to produce a 100 kW solid-state laser.

AFRL Transitions Wrist-Worn Display System

AFRL recently transitioned a wrist-worn video and graphics display system to industry. On-the-move warfighters need information on demand and with no increase to the weight they carry. The laboratory seized the opportunity to develop a new, lightweight, on-the-move information capability for aircrew, soldiers, sailors, controllers, and commanders.

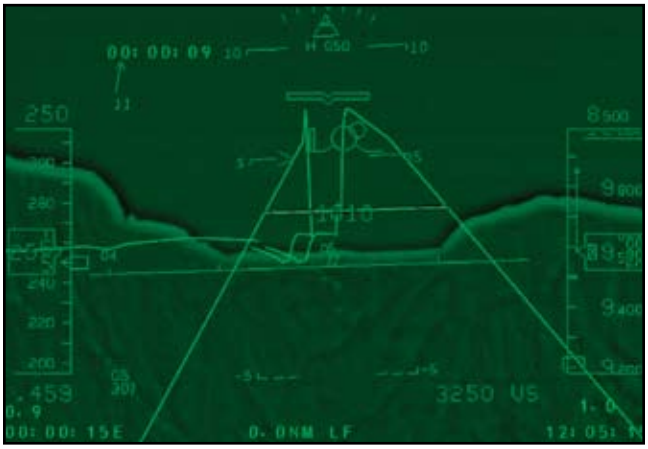
Warfighters ordinarily wear a watch for all tasks, from piloting an aircraft to running a command center. AFRL engineers took a creative approach to meeting the warfighters' information-on-demand need, combining regular television, video, and computer functions in a wristwatch format. The required time to expose or store a wrist display is minimal compared to the cumbersome requirements of viewing a notebook computer display.

AFRL personnel conceived and fabricated this first-of-its-kind wrist display unit in-house from a developer's kit for the first commercial active matrix organic light-emitting diode (AMOLED) device in 2003. In a 2004 field demonstration, AFRL engineers combined the 2.2 in. AMOLED unit with a radio to demonstrate on-the-move access to unmanned air vehicle (UAV) video.

AFRL engineers demonstrated this Spiral 2 unit based on a sunlight-readable 2.5 in. transmissive active matrix liquid crystal display (AMLCD) with UAV and satellite communication inputs. L-3 Communications Corporation (New York), previewed the unit live on CNBC television.

AFRL more recently developed the sunlight-readable Spiral 3 system. The 8 oz unit integrates a transflective AMLCD with wireless capability, an 8 hr battery, and an improved user interface design. The Spiral 3 unit ultimately became L-3 Communications' Battleview Warfighter Alliance in a Virtual Environment product for Department of Defense users. This successful development is an example of AFRL's delivery on a previously unmet user need.

AFRL Program Demonstrates Synthetic and Enhanced Vision for Low-Level Flight



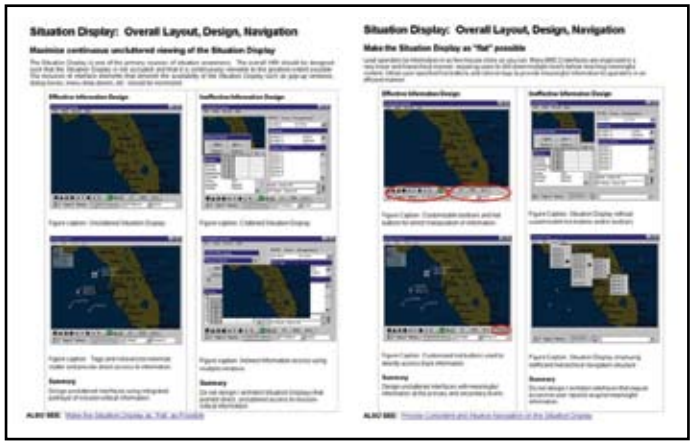
AFRL, the National Aeronautics and Space Administration's Langley Research Center (Virginia), and Rockwell Collins (Cedar Rapids, Iowa) collaborated under a Dual-Use Science and Technology program to conduct the first-ever industry demonstration of synthetic and enhanced vision technologies in low-level terrain-following flight and curved, descending, low approaches.

Synthetic and enhanced vision technologies promote safety by providing crews with greater situational awareness, thereby reducing mishaps that stem from terrain, threats, and navigation. Integration of synthetic and enhanced vision provides a usable image in all visibility conditions. Military applications of synthetic and enhanced vision technologies include such activities as flying complex approaches using the Global Positioning System to facilitate landings at austere locations in reduced-visibility conditions, reducing controlled-flight-into-terrain (CFIT) incidents, avoiding noise abatement areas, and increasing air traffic throughput at airports.

AFRL researchers had two program objectives: (1) enable Air Force aircraft to fly in instrument meteorological conditions with as much terrain awareness as in visual meteorological conditions, and (2) prevent CFIT accidents. The team strove to develop head-up and head-down display formats that incorporate primary flight information, command path guidance, synthetic terrain, and embedded infrared sensor imagery suitable for low-level flight profiles and complex approaches in reduced-visibility conditions.

AFRL and its partners used a Boeing 727-100 to perform demonstrations of low-level terrain-following flight (at 650 ft); they also executed approaches as low as 100 ft. These were the first flight tests in which researchers conducted military, low-level terrain-following flight and approaches in simulated zero-visibility conditions using both synthetic (database) and enhanced (sensor) vision technologies. Synthetic and enhanced vision technologies show promise for civil aviation purposes. AFRL is continuing its collaborative research efforts with industry through the Autonomous Approach and Landing Capability demonstration program for the US Transportation Command and Air Mobility Command.

AFRL Interface Design Guide Increases Operator Performance for the Air Battle Management Community



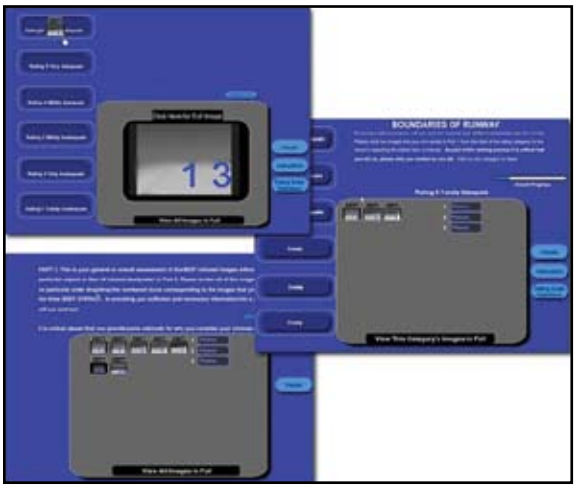
AFRL research scientists developed and delivered a battle management command and control (BMC2) *Human-Machine Interface (HMI) Design Guide* to Air Combat Command. The *HMI Design Guide* promotes a common look and feel among operator interfaces without making any one platform too specific. The guide provides critical research-based interface design guidance to the air battle management community by allowing commonality among future tactical-level BMC2 workstations regardless of airborne platform or operator function.

Air battle management crews often move between three platforms, with little commonality existing between the HMI employed at the operator consoles. The differing consoles often require operators to undergo weeks of training to gain proficiency on each system. Prior to drafting and coordinating the *HMI Design Guide*, AFRL researchers acquired a thorough understanding of operator roles and responsibilities, platform-specific HMI designs and functionality, and usability issues and challenges associated with two tactical command and control systems: the E-3 Airborne Warning and Control System and the Joint Surveillance Target Attack Radar System.

The *HMI Design Guide* addresses operator performance challenges by increasing operator understanding of the family of system interfaces while still accommodating individual program tailoring in order to meet unique requirements. Research scientists anticipate that the new guide will promote increased user performance and reduce training.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Fields Web-Based Tool for Evaluating Image Quality



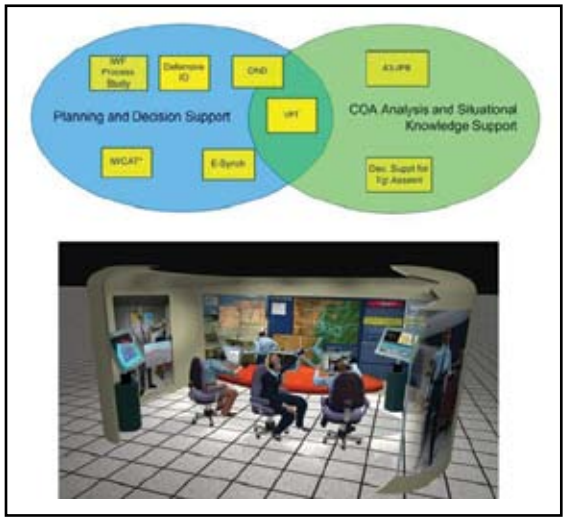
AFRL engineers conceived, designed, and developed an online image-quality evaluation tool to fulfill a critical need associated with the creation of an autonomous approach and landing capability (AALC). The AALC encompasses sensor, human, and air vehicle considerations and thus employs an interdisciplinary approach for capturing both the hardware and software aspects and the human-use characteristics required to field a cost-effective and reliable sensor system.

AFRL's online interactive survey tool provides the means to test the informational quality of images derived by the various sensor platforms proposed for the AALC. Sensors validated by the survey tool will permit Air Force assets to safely approach, land, and taxi in conditions of zero visibility at remote, austere airfields lacking ground-based navigation aids. Additionally, the Web-based tool provides the ability to collect data from evaluators in remote or deployed locations, achieving considerable savings in travel and logistical expenses.

Nine current and former transport/tanker pilots, including one individual deployed to Afghanistan, successfully tested the Web link and evaluated 30 infrared runway images. The evaluators completed a three-part review using a six-point adequacy scale, targeting general scenes of the runway, focusing on a specific aspect or item of interest in the scene, and requesting an overall assessment. Based on these evaluation results, AFRL scientists were able to effectively discriminate among several sensor packages and define important design considerations, as well as identify the package that provided the best information for aiding aircrew decision making.

AFRL's Web-based survey tool has proven itself as a crucial component for the development and eventual implementation of the 2004 Air Mobility Master Plan supporting US Defense Planning Guidance. The tool has generated interest within and outside the sensor community as a versatile, user-friendly, and self-contained assessment resource that can contribute to the design and development of many image-based warfighter systems.

AFRL Develops Next-Generation Effects-Based Decision Aids



AFRL engineers working under the Cyber Crew Interface and Development program developed and demonstrated prototypes for next-generation effects-based decision aids and warfighter-tailored information visualizations that support the information warfare (IW) planning cycle. Powerful decision support system tools and information management applications will reduce volumes of complex data into tailored cognitive displays, enabling staff and commanders to rapidly grasp the impact of current operational decisions on mission success and future combat capability.

AFRL developers employed a cognitive systems engineering approach to the design, ultimately producing a comprehensive record of the cognitive tasks associated with the Air Force (AF) IW flights' work domain, as well as a process for translating the findings into informational requirements and software concept design requirements. The team's resulting prototypes demonstrate the visibility of mission, commander's intent, and information requirements needed for dynamically, proactively, and rapidly driving coordinated operations, while providing a common battlespace representation of these effects-based operations.

Thus far, all concepts developed under this program have transitioned to the Information Warfare Planning Capability (IWPC), a suite of automated, collaborative tools supporting the integration of IW effects into operational planning and execution. The Secretary of Defense has designated the IWPC as the joint planning tool for information operations (IO). This effort has provided information warfighters with effects-based analysis and portrayal tools to assist the completion of IW planning and assessment tasks. In addition, the effort has contributed both to the design of the user interface for the Advanced Master Caution Panel Defense Technology Objective and to the completion of a task analysis supporting the AF defensive IO mission.

AFRL Transitions Hyperspectral Exploitation Technology to the Operational Environment

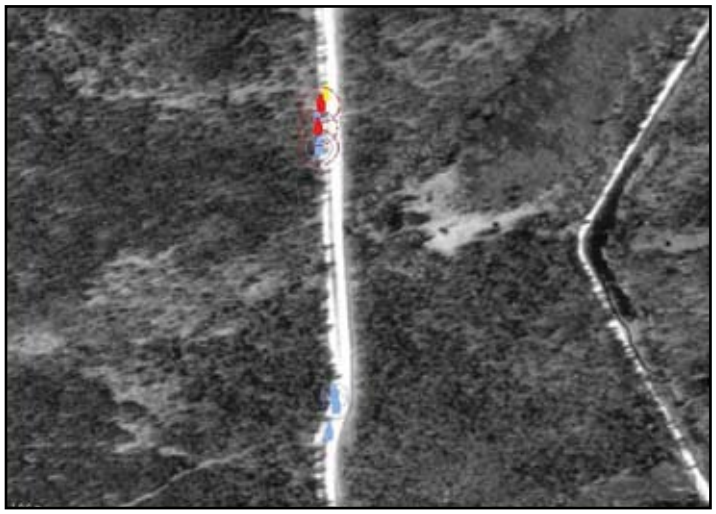
Researchers from AFRL and SRA International, Inc., developed Visual Checklist—a software program that provides process standardization, simple process documentation, decision support, and repeatable analyses—increasing both the productivity and the target identification accuracy of hyperspectral analysts. The Visual Checklist tool has aided the transition of hyperspectral exploitation technology from the scientific community to the operational environment.

Visual Checklist is integrated with the Common Measurement and Signature Intelligence Advanced Geospatial Imagery Exploitation Tool (COMET), incorporated as part of that system's core functionality. Currently in use at the National Air and Space Intelligence Center, the technology has proven itself useful in an operational environment, transitioning successfully into practical application.

The utility of Visual Checklist lies in its capacity to document analysis procedures and disseminate them to operational analysts. The user-friendly tool provides a means for easily locating established procedures and thus enables analysts to perform their duties more efficiently and consistently. Further, the tool's additional features, such as its integration with COMET wizards, facilitate automation of the many steps constituting the analysis checklist.

Because Visual Checklist provides detailed steps for performing the level of analysis needed to maintain operational continuity, it also reduces the learning curve associated with training new analysts. For each step involved in a process, the tool provides decision support that explains the reason for completing that particular step. Another valuable Visual Checklist feature is its capacity to record the actual process an analyst chooses to employ for a given analysis sequence. The software automatically captures and marks steps as complete as the analyst performs them. Once captured, the analysis becomes available for repeated use. A related feature provides analysts a simple method for entering notes throughout the process. The varying levels of accessible detail included in Visual Checklist support novice and experienced users alike.

AFRL Demonstrates Network Embedded Systems Technology at Team Patriot Exercise



AFRL combined Network Embedded Systems Technology (NEST) program activities with Small Unmanned Air Vehicle Persistent Visualization for Operational Response (SUPERVISOR) experiments, demonstrating the capability to provide combat commanders with timely situational awareness across a multitude of scenarios, including improvised explosive device detection, mass casualties from a terrorist bus explosion, convoy reconnaissance, and perimeter defense.

AFRL demonstrated the embedded wireless network algorithms created as part of NEST, a Defense Advanced Research Projects Agency-funded program, to interested Army, Air Force, and National Guard representatives attending the Team Patriot exercise at Fort McCoy, Wisconsin. AFRL integrated its NEST and SUPERVISOR experiments to coincide with exercises performed by Team Patriot participants.

In each exercise, ground sensors running NEST applications detected vehicles entering and exiting the area of interest and summoned the SUPERVISOR aircraft to the area. SUPERVISOR used its camera to gather imagery of the vehicle as it passed ground sensors and provided timely information to Team Patriot participants.

During several exercises, AFRL technicians deployed multiple, distinct ground sensor fields up to a mile away from the data collecting station. NEST then converted the raw sensor data to Transducer Markup Language (TML), a language for passing sensor information between a system and its associated processing station over long-range directional antennas to the data collecting station. NEST correlated the multiple TML datastreams from the separate sensor fields to predict the movement of the intruding vehicle. The large distances between sensor fields allowed SUPERVISOR operators to set individual sensor fields as waypoints for the aircraft, which simplified unmanned air vehicle retasking.

AFRL Demonstrates Remote-Controlled Aerial Vehicle for Pesticide Application

The Remotely Controlled Aerial Vehicle for Application of Pesticides (RCAVAP) is an unmanned helicopter that sprays pesticide to moderate diseases, such as malaria, that insects carry into areas that are hostile or otherwise difficult to access. This aerial spray platform should fill the niche between ground applications and larger manned platforms, such as the Air Force Spray Flight's C-130, that place personnel in potentially high-risk situations.

AFRL developed the RCAVAP prototype under a Force Protection Battlelab initiative and in coordination with the Armed Forces Pest Management Board, the Naval Disease Vector Ecology Control Center, and the 757th Aerial Spray Flight. They demonstrated the RCAVAP at the Force Protection Equipment Demonstration (FPED) at Quantico Marine Corps Base, Virginia. At the FPED, the RCAVAP performed two demonstration flights consisting of automatic takeoff, waypoint-navigated flight, automatic payload delivery, and automatic landing. The flight path for each flight was between 0 and 100 ft altitude and spanned an area of approximately 1,000 sq ft.

Conducted by members of AFRL's Robotics Research Group, the demonstration informed government organizations about the existence of RCAVAP and its possible uses for pest management and other applications. The vehicle will provide an opportunity for technology transfer, and AFRL will deliver a prototype system to the 757th Aerial Spray Flight (Youngstown, Ohio), the Department of Defense's only full-time aerial spray operation, for user assessment.

The C-130, the current pesticide platform, is expensive and difficult to maintain; in addition, its large size poses a problem for today's warfighters, who often deploy as a small force. Warfighters can use the RCAVAP in smaller areas before checking for land mines, clearing the area of harmful insects before troops even enter and thus avoiding unnecessary risk to human life. The RCAVAP provides a smaller platform that is easier to maintain, facilitates more rapid setup, and delivers more effective spraying of infected areas. It also allows areas to be treated without placing personnel in harmful situations.

AFRL Converts Mine Area Clearance Vehicle to Remote Operation

AFRL researchers modified a mine area clearance vehicle (MACV) and converted it into a remotely operated vehicle. By operating the MACV remotely, personnel keep safely out of areas that may contain mines and similar devices. AFRL engineers determined that the remote operator can be up to a mile away, provided no major obstructions stand between the antenna at the operator's end and the MACV. During most operations, the operator will be positioned 2,000-3,000 ft away.

At the request of Air Combat Command, AFRL installed a remote control system in a MACV, a commercially available mine clearing system designed by Danish heavy equipment manufacturer Hydrema. The vehicle's articulated chassis ensures that all four wheels remain in contact with the ground at all times. When driven on roads, the vehicle moves forward with the cab oriented towards the front. However, mine clearing operations require that the vehicle be driven in reverse, with the cab to the rear.

During mine clearing operations, the operator engages a separate hydrostatic transmission, which provides a continuously variable speed and considerable force. The operator can rapidly lower the vehicle's complete flail system into position (at the rear of the vehicle) and clear a mine path 3.5 m wide. Operators can control the MACV either manually, using the joystick provided in the cab, or remotely, using a computerized, fully autopilot steering system.

AFRL developed the remote system, which operates via radio frequency, using a laboratory-developed joystick controller, a laptop computer, and an operator control station that houses the Ethernet and power for the system. The team also incorporated a high-end differential Global Positioning System, a feature that allows the remote operator to more accurately control the vehicle and provides positioning feedback to further promote improved accuracy. AFRL engineers completed the programming work necessary for sending and receiving the required signals and messages.

Researchers conducted experiments in various environments, including both open and wooded areas, to determine the optimum radio and antenna combination enabling the best possible remote control distance capability. They also performed experiments involving explosives to ensure the MACV system could withstand the shock of detonations with no degradation.

Alternative Stripping Process for Landing Gear Saves Time and Labor

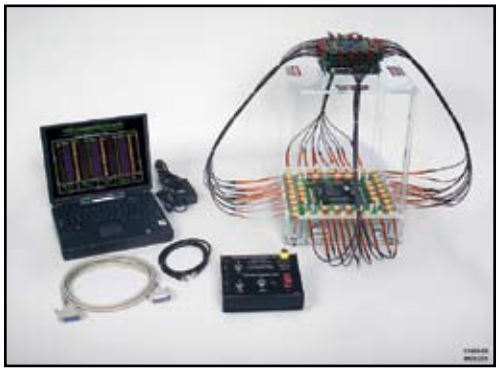
Ogden Air Logistics Center (OO-ALC), located at Hill Air Force Base, Utah, is the primary Air Force facility for the maintenance and overhaul of aircraft landing gear. OO-ALC technicians experienced an excessive number of issues related to the smut removal tasks they perform as part of regular maintenance activities. The current process involves the labor-intensive procedure of manually brushing smut from parts during stripping. OO-ALC requested support from AFRL to identify and validate an alternative process for reducing smut buildup and improving the current labor-intensive method for removing the buildup.

Under a Small Business Innovation Research (SBIR) contract, AFRL and Concurrent Technologies Corporation (CTC) identified an alternative process for removing plated nickel coatings from aircraft landing gear. This new technique is significantly faster than the current stripping process and can reduce labor costs by at least 30%. In an effort to reduce excessive smut buildup (residual coating, dirt, and grime), the researchers evaluated the capability of eight different noncyanide products to strip nickel coatings. Test results revealed that one of the alternatives—Enthone EN-86—could serve as a potential replacement product. The researchers also found that by applying ultrasonic energy to the bath used to aid the removal of plated nickel coating, they could further enhance stripping tasks and also minimize smut buildup formed during the Enthone EN-86 process.

During the SBIR Phase I effort, scientists established OO-ALC's nickel stripping requirements and conducted a literature search to gather information on commercially available non-cyanide-based nickel stripping products. In Phase II, AFRL and CTC tested and compared the eight identified candidates via a series of screening and performance evaluations.

The AFRL/CTC team determined that the Enthone EN-86 stripping solution best met OO-ALC's needs, due primarily to the product's high stripping rate and long bath life. The researchers discovered that ultrasonic agitation increased the stripping rate for each stripping bath/nickel coating combination. Specimens treated in the stripping baths with ultrasonics showed little visible smut buildup compared to specimens stripped without ultrasonic agitation. Further, hydrogen embrittlement testing revealed that the use of ultrasonic energy with the stripping solutions did not have an embrittling effect on the substrate. The combined effect of the alternative nickel stripper and applied ultrasonic energy can greatly increase the stripping process speed and reduce worker exposure to the stripping bath by eliminating the need for manual removal of smut from landing gear parts during the stripping process.

AFRL Establishes AMIST for Focused Warhead Development



AFRL and the Department of Energy's Kansas City Plant are collaborating to provide ordnance designers the initiation tools necessary for developing focused warheads, such as the dual-role munition. These advanced weapons will require an interdisciplinary technical solution that incorporates aerodynamic, energetic, warhead, target detection, and initiation system technologies. One of the tools currently in development is the Adaptable Miniature Initiation System Technology (AMIST), which is a multipoint initiation system designed to detonate explosive warheads.

AFRL is developing a distributed multipoint initiation system that has highly accurate and precise timing between fire points. Precision multipoint initiation gives warhead designers the ability to control the detonation front from a weapon via the initiation sequence of fire points located within the explosive fill. The resulting munition is able to bias the path of its fragments and thus increase the explosive energy directed towards the selected target.

The current system architecture, AMIST Configuration II, can program multiple fire points to operate autonomously upon disconnect from the controller. Users can program the fire points to fire simultaneously or sequentially (with negligible timing error).

AMIST Configuration II is the first multipoint initiation system to combine high timing precision with fire point autonomy. Each fire point consists of a logic board with built-in processing and memory, a firing capacitor, high-voltage switch, and the explosive detonator. A centralized controller uses a data bus to communicate with the fire points to update firing modes at rapid intervals. Users can program firing modes into the multipoint system, and each mode produces a different warhead effect. The centralized controller selects the warhead mode based on the location of a given target relative to the warhead, a method that optimizes lethality by focusing the explosive energy in a specific direction. Upon receiving the fire command, each fire point can disconnect from the data bus without affecting operational performance. Once disconnected, the fire point no longer receives firing mode updates from the controller.

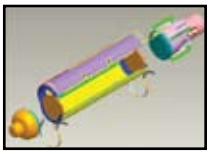
Instead, it operates completely autonomously, using its own internal processor and memory to detonate at the time that corresponds to the selected firing mode. AMIST has proven itself as a precise and reliable means of achieving focused lethality for future weapon systems by the use of multipoint initiation.

AFRL Develops Near-Precision Soft-Landing Resupply Dispenser

AFRL and Systima Technologies, Inc. (Bothell, Washington), developed the Covert Resupply (COVRES) dispenser under a Small Business Innovation Research contract. The COVRES dispenser, which utilizes a wind-corrected munitions dispenser (WCMD™) near-precision tailkit, allows air delivery of critical supplies to troops who are isolated or under fire. The system design permits high-altitude release of the supply canister to minimize potential dangers to delivery aircraft, as well as low-altitude deployment of the soft-landing parachute to minimize potential disclosure of friendly force locations. Currently, each COVRES canister can soft-land over 400 lbs of supplies, and system capacity may eventually top 700 lbs.

COVRES' canister design and mass properties leverage features of the existing WCMD. The COVRES system aligns with the WCMD in terms of total weight; center-of-gravity location; and outer moldline, with the exception of the parachute pack positioned on the end of the canister. This COVRES-WCMD matchup allows engineers to perform streamlined integration and certification of COVRES into WCMD-qualified platforms.

The already-operational WCMD provides guidance for COVRES, employing inertial guidance from delivery aircraft release to parachute system deployment. The parachute system is paramount to achieving a soft-landing delivery. The COVRES system design holds the danger posed to delivery aircraft to a minimum by permitting the use of standoff/high-altitude release from high-speed aircraft. The baseline WCMD, with its inertial guidance capabilities, allows a standoff distance exceeding several miles.



Scientists completed initial flight testing of COVRES, and the system successfully met all test objectives. The delivery aircraft released the COVRES unit at a medium altitude while flying at speeds less than Mach 1. An AFRL-developed, pulsed-Doppler radar system successfully initiated the parachute deployment sequence at the intended altitude. A drogue chute, followed by the main chute, decelerated the COVRES unit until the canister reached its terminal velocity. While multiple approaches exist for troop resupply, COVRES' unique attributes (namely, its fast-moving high-altitude delivery and covert aspect attributed to the parachute's deployment near the deck) offer the important advantages of minimizing both hostile threat to the delivery platform and unintended disclosure of troop position.

AFRL Develops WASSAR to Detect Mobile Targets

AFRL is developing state-of-the-art weaponry that users can launch into the vicinity of mobile targets to autonomously find and defeat them. This capability provides increased survivability, multiple kills per pass, and minimal pilot workload. Since there is an inherent delay between observing a target and subsequently launching a weapon, users require the capability to rapidly search a large area. Additionally, they need a weapon that can operate day or night and in adverse weather.

Under the Wide-Area Search Synthetic Aperture Radar (WASSAR) program, AFRL and Northrop Grumman Electronic Systems (Baltimore, Maryland) are refocusing synthetic aperture radar (SAR) weapons technology development addressing the need to perform wide-area searches for mobile and relocatable targets in adverse weather. The research team transformed a SAR device into a breadboard multimode radar seeker, combining SAR technology with ground moving target indicator (GMTI) and high-range resolution (HRR) radar signal processing. Users will employ these modes to perform autonomous target classification to increase probability of kill.

The scientists developed a demonstration system using the tactical unmanned air vehicle radar (TUAVR). The TUAVR system includes the radar, the data collection system, and both SAR and GMTI software. The modified system incorporated a new, 6 inch round antenna and a new HRR waveform. The team also developed the required ground-based data analysis suite, which involved an adaptation of existing automated target recognition algorithms.

The wide-area search capability is a requirement due to the uncertainty that arises regarding a mobile or relocatable target's location after its initial detection. Based upon several factors, scientists calculate that a target's new position will be located anywhere within a 50 km^2 area. Scientists tested the modified system 12 times, with successful results. The effort demonstrated all program objectives, including the capability for a weapon-quality radar seeker to search a 50 km^2 area for stationary and moving targets in less than 2 minutes and under adverse weather conditions.

AFRL Develops Brassboard GI Fuze for Glide Bombs

Presently, all Air Force glide bombs incorporate fuzes that contain an embedded safety and arming (S&A) device. The S&A mechanism is responsible for maintaining the fuze in a safe state until a prescribed set of postlaunch arming conditions is satisfied. Because of the potentially catastrophic consequences associated with fuze safety failures, all S&A devices must conform to the stringent design criteria set forth in MIL-STD-1316E, the military standard for fuze safety.

Under a Small Business Innovation Research contract, AFRL and System Dynamics International, Inc. (SDI), are developing and testing an innovative glide bomb fuze that eliminates the air turbine initiator and derives arming power from the bomb's thermal battery. One advantage of this configuration is that the fuze's source of arming power is no longer inhibited by low air densities at high altitudes or inlets occluded by mounting hardware or weapon attitudes. Another advantage of the new fuze is its elimination of the (somewhat unreliable) lanyard for exposing the air turbine to the airstream after launch.

AFRL and SDI identified acceptable arming environments and an S&A algorithm for three glide bomb systems. The algorithm, known as the Guidance-Integrated Safety and Arming (GISA) algorithm, processes data from microelectromechanical systems inertial sensors embedded both in the fuze and in the glide bomb's autopilot system to detect the sequence of postlaunch events that satisfy the second arming environment. Embedded within a microcontroller built into the fuze, the GISA algorithm will begin executing upon the weapon's release.

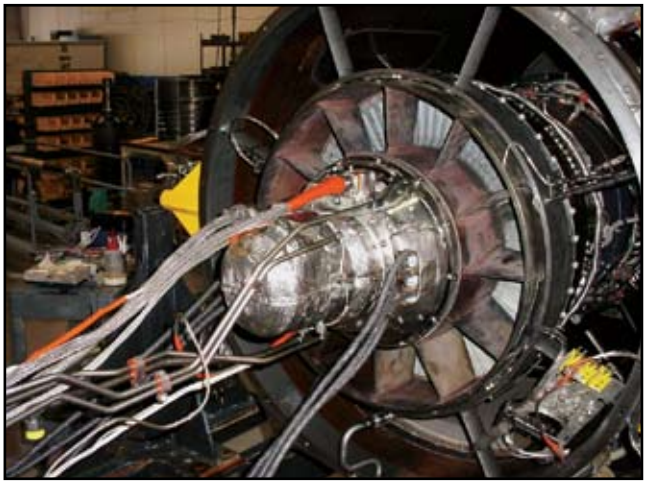
To facilitate the GISA algorithm's development and test its performance within a brassboard guidance-integrated (GI) fuze, the AFRL/SDI team developed the Guidance-Integrated Fuze Test Software application. In addition, Kaman Dayron, Inc., and L-3 Communications KDI Precision Products, Inc., each began development of a brassboard GI fuze that incorporates the GISA algorithm. Both manufacturers designed their respective brassboard GI fuzes to detect the launch event following a prescribed sequence of subevents. Both GI fuzes maintain a direct connection to the bomb's thermal battery for their arming power. After detecting the launch event, both fuzes execute the GISA algorithm to search for the prescribed second (i.e., postlaunch) arming environment conditions. Upon detecting these conditions, both GI fuzes activate their respective arm delay timers (ADT) to satisfy the safe separation requirement. After their ADTs expire, both fuzes arm by closing switches that allow battery power to flow to the firing circuitry.

AFRL Completes Successful Supersonic Demonstration Engine Testing

AFRL completed XTL17/1 supersonic demonstrator engine testing at the Allison Advanced Development Company/Rolls-Royce Corporation test facility (Indianapolis, Indiana). During subsequent performance testing, the XTL17/1 expendable turbine engine achieved a specific thrust 87% higher than the baseline defined for this engine class in the Integrated High-Performance Turbine Engine Technology (IHPTET) program.

The XTL17/1 is part of the Joint Expendable Turbine Engine Concept portion of the IHPTET program, demonstrating expendable and limited-life engine technologies for applications such as cruise missiles. Demonstrations such as those involving the XTL17/1 provide the warfighter with low-risk technology transition, resulting in a high level of readiness and increased safety and performance. This engine's specific thrust level is the highest ever produced by an expendable turbine engine, marking another first for the IHPTET program.

Global Hawk Low-Pressure Turbine-Driven Generator Completes Simulated Altitude Testing



An AFRL team completed demonstration tests simulating altitude operation of a low-pressure (LP) turbine-driven, 270 VDC, 75 kW generator mounted onto an AE3007H engine. The tests accomplished AFRL's goals to develop Global Hawk power upgrades that increase the available payload power over the present RQ-4 Global Hawk baseline by a factor of 3. The tests will also enable the technology's transition to the Global Hawk Systems Group (GHSG) for production development.

The AFRL team integrated the LP generator with the engine and received assistance from the laboratory's general contractor, Innovative Power Solutions, as well as from Rolls-Royce Corporation, LibertyWorks™, and Northrop Grumman. The LP generator utilizes direct drive with the LP shaft of an AE3007H engine as a means to provide an increase in available payload power over the present RQ-4 Global Hawk baseline. The objective of the final test was to verify the LP generator thermal environment and engine performance with LP generator power extraction at Global Hawk mission altitudes.

AFRL developed the Range Altitude Power Innovative Technology (RAPIT) program to coordinate with the GHSG. The RAPIT program's purpose was to develop engine upgrades and electric power enhancements—with funding from the laboratory's Integrated High-Performance Turbine Engine Technology program—for transition to the RQ-4 Global Hawk.

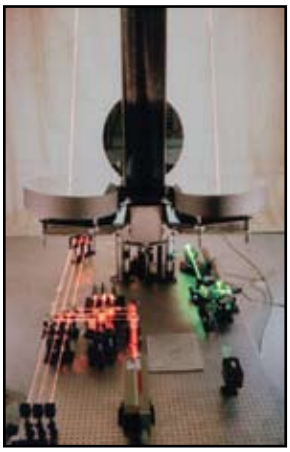
Global Hawk Electric Starter/Generator Completes Simulated Altitude Testing

An AFRL team completed demonstration tests simulating altitude operation of a 28 VDC starter/generator (S/G) mounted onto an AE3007H engine. The S/G successfully completed its planned test set of in-flight engine restarts at multiple simulated altitude/Mach points. The tests accomplished AFRL goals and will enable transition of the S/G technology to the Global Hawk Systems Group (GHSG) to develop and meet the Global Hawk's operational in-flight restart needs.

The S/G's combined mode consists of a backup 28 VDC utility power source with the engine start function. Innovative Power Solutions designed and built the S/G under the swift execution of a Phase II Small Business Innovation Research project, which allowed researchers to include the S/G in the test schedule of an AE3007H engine at Arnold Engineering Development Center (Arnold Air Force Base, Tennessee).

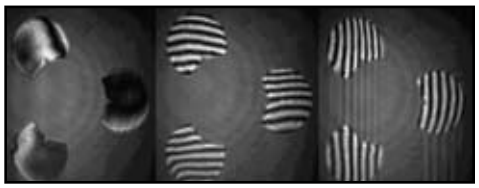
AFRL developed the Range Altitude Power Innovative Technology (RAPIT) program to coordinate with the GHSG. The RAPIT program's purpose was to develop engine upgrades and electric power enhancements—with funding from the laboratory's Integrated High-Performance Turbine Engine Technology program—for transition to the RQ-4 Global Hawk.

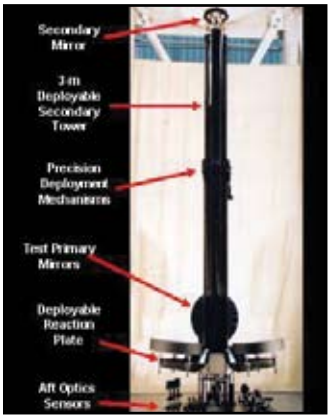
AFRL Completes 10-Year Deployable Optical Telescope Program



AFRL scientists completed their final task of phasing multiple, large mirror segments for the laboratory's Deployable Optical Telescope (DOT) system. The DOT ground demonstration enables space-based imaging apertures larger than launch vehicle fairing sizes through multiple-segment telescope phasing.

The AFRL Ultralightweight Imaging Technologies Experiment (UltraLITE) program, initiated in 1995, focused on the development of technologies vital to the success of future Department of Defense requirements for large space-based optical systems, such as the Space-Based Laser system. Current launch vehicle shroud and weight constraints limit the size of primary mirrors for such systems to less than 5 m, restricting systems to low earth orbits and, in turn, necessitating large, expensive satellite constellations to ensure global coverage. The UltraLITE and DOT programs provided an integrated ground demonstration of technologies that will allow future optical systems to be stowed for launch and deployed on orbit to their operational configuration.





AFRL scientists' final task, the last laboratory-funded activity under the DOT program, completes the Technology Readiness Level 5 milestone. The brassboard consists of three deployable 60 cm primary mirror segments and a deployable 3 m secondary mirror tower structure. The advanced control system automatically phases the mirrors from an initial deployment error exceeding 1/4 in. to a margin within 8 nm (1/5000 the width of a human hair). The control system also eliminated simulated satellite vibrations in the test. Previous program successes involved phasing smaller, 20 cm mirrors using simpler control systems that did not include rejection of simulated satellite vibrations. This program resulted in these specific technology developments: lightweight mirror structures, stiffness-critical precision composite structures, advanced control system architectures for autonomous phasing and maintenance, advanced structural dynamic system identification methods, and precision mechanisms for deployable space optics applications.

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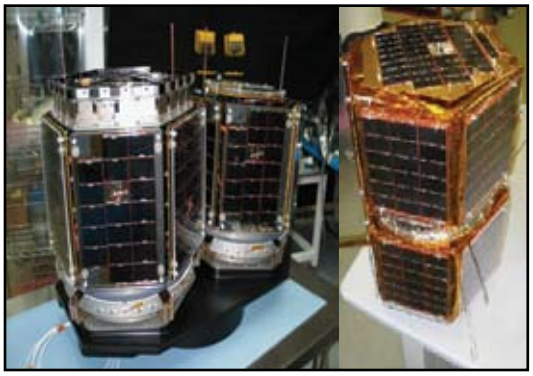
AFRL-Led University Competition Provides Innovative Solutions for the Small-Satellite Community



Through AFRL's University Nanosat program, a student-built spacecraft made its first flight into orbit aboard a Boeing Delta IV heavy demonstration launch vehicle. The objectives of the program's funded projects are to complete small satellite (i.e., nanosat) design, fabrication, and functional testing; foster research to enable nanosat technologies; and design experiments that orbiting nanosats can perform.

In 1999, AFRL, the National Aeronautics and Space Administration's (NASA) Goddard Space Flight Center, and the American Institute of Aeronautics and Astronautics (AIAA) cofounded the University Nanosat program to provide a cooperative environment in which universities, government, and industry can develop innovative nanosat technologies. NASA, AIAA, Air Force, and industry personnel act as judges and oversee activities at various student competitions. AFRL contributes funding for these program-level competitions and provides programmatic and technical program oversight, expert design guidance, integration and test services for the winner, and postlaunch oversight.

Nanosat-2, the second in a line of spacecraft designed and built by university participants, is also known as the Three Corner Satellite—a designation referencing the geographical dispersement of the student team members' respective universities: Arizona State University, the University of Colorado at Boulder, and New Mexico State University. Nanosat-2 incorporates state-of-the-art, AFRL Small Business Innovation Research-sponsored technology, including the Lightband Separation System (from Planetary Systems, Inc.) and the QwkSep Clamp Band (from Starsys Research Corporation). The mission successfully demonstrated the student-built spacecraft's safety caliber and the operation of the Starsys separation systems using an AFRL-built satellite deployment platform.

In parallel with Nanosat-2 integration and launch activities, the University Nanosat program oversaw the third program cycle (i.e., Nanosat-3), in which 13 universities designed and built hardware for the Nanosat-3 launch. A panel of 15 judges from the aerospace industry selected the University of Texas at Austin to receive funding for a student team's design known as FASTRAC [formation-autonomous spacecraft with thruster, relative navigation, attitude, and cross-link], currently under final construction. FASTRAC will characterize state-of-the-art Global Positioning System-based relative navigation, a novel micropropulsion system, and an improved version of Planetary Systems' Lightband Separation System.

AFRL Delivers Linerless Composite Tanks for Nanosat-3

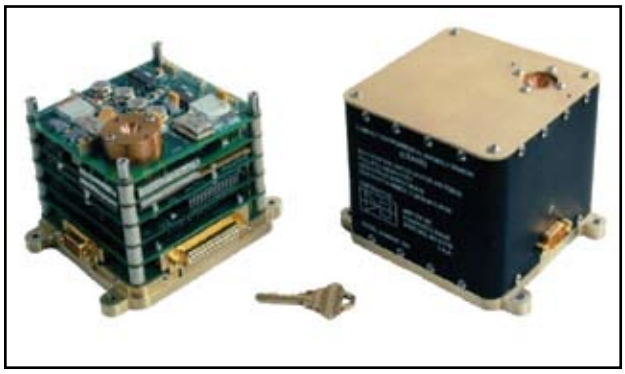
The University of Texas at Austin developed the FASTRAC [formation-autonomous spacecrafter with thrust, relative navigation, attitude, and cross-link] nanosatellite (Nanosat-3) to demonstrate technologies that enable formation flying. The University Nanosat program entails an annual competition amongst US universities to develop, fabricate, and functionally test small satellites (i.e, nanosats), foster research to enable nanosat technologies, and design experiments that orbiting nanosats can perform. Nanosat-3 requires microdischarge plasma thrusters for maneuvering, and its fuel tanks must contain argon fuel at 100 psi (implying a proof pressure test at 150 psi before integration).

During the university's proof-of-concept tests of the custom aluminum tanks, the dome sections yielded, requiring immediate replacement. With only 6 weeks remaining before full spacecraft integration, the University of Texas contacted AFRL for assistance.

Under a Small Business Innovation Research Phase II contract with AFRL, Composite Technology Development, Inc. (CTD), of Lafayette, Colorado, solved the critical hardware failure problem by designing linerless composite tanks. The composite manufacturing facility at Kirtland Air Force Base, New Mexico—with on-site support from Jackson and Tull Engineering and United Industrial Engineering—manufactured the new tanks.

Within a 6-week time frame, the AFRL/industry team designed the composite tanks and associated tooling; manufactured the tooling; produced 20 tanks (2 flight, 2 backup, and 16 test articles); tested the tanks; and delivered 4 flight articles to the University of Texas for integration into Nanosat-3. The CTD-designed tanks weigh 40% less and have 18% more volume and 12 times the pressure capacity of the custom-built aluminum tanks they replaced. The flight of NanoSat-3 will mark the first use of linerless composite tanks for spacecraft operations.

AFRL Completes Six-Year Space Mission to Monitor Radiation Environment



The Compact Environmental Anomaly Sensor (CEASE) recently completed a 6-year mission in low earth orbit, during which it monitored and mapped the near-earth radiation environment and provided real-time space environment hazard warnings to satellite operators. AFRL sponsored the June 2000 launch of CEASE aboard the Space and Missile Systems Center, Space Development and Test Wing, Triservice Experiments Mission-5 spacecraft along with the Missile Defense Agency-managed Space Technology Research Vehicle-2 payload. Originally flown with a 6-month operations requirement and a 1-year mission goal, the apparatus performance surpassed all expectations. Turned and initialized 1 day following liftoff, CEASE operated continuously until August 3, 2006, accomplishing more than 30,000 revolutions around the earth as it measured the radiation belts surrounding the planet.

CEASE consisted of a small (10 x 10 x 8.2 cm), low-power (1.5 W), low-mass (1 kg) structure featuring five sensors for gauging the following hazards: total radiation dose, radiation dose rate, single-event effects, deep dielectric charging, and surface dielectric charging. The CEASE equipment also calculated incident electrons and protons and, using onboard data processing algorithms, produced hazard warnings transmitted to satellite facilities on the ground. As a result of these forewarnings, spacecraft operators were able to identify and understand radiation-environment-induced anomalies.

Data produced by CEASE will enhance space radiation climatology and specification/forecast models. Its representations will lead to more realistic requirements for satellite designers, enabling improved risk/benefit trade-off decisions. CEASE data will also provide satellite operators with increased situational awareness for threat assessment and procedural planning.

Meanwhile, CEASE II has been in operation aboard the Defense Support Program Flight 21 since August 2001, and a commercial version of the sensor—dubbed the Space Radiation Alarm—has been flying on a US telecommunications satellite since February 2005. A CEASE apparatus will also fly on the Demonstration and Science Experiments satellite, which is scheduled to launch in October 2009.

AFRL's Covert Wireless Networking Technology Showcased at USSOCOM

AFRL showcased its covert wireless networking technology to representatives from US Special Operations Command (USSOCOM), Air Force Special Operations Command, and the US Navy and Army. As part of the lab's USSOCOM-sponsored program, Scientific Research Corporation (SRC) integrated its MobileRoute® mobile ad hoc networking software into Thales Communications' Joint Tactical Radio System Enhanced Multiband Inter-Intra Team Radio (JEM) product. SRC also enhanced its Wavelet Packet Modulation (WPM) covert waveform radio hardware to include half-duplex operation and integration with MobileRoute to provide networking capabilities. The overall success of this technology demonstration is largely attributable to a very effective collaboration between SRC and Thales Communications.

AFRL's demonstration of MobileRoute on the JEM involved six radios in clustered and multihop configurations. This network arrangement demonstrated range extension over a distance of approximately 1,600 ft in an outdoor/urban environment (greater distances are possible through the incorporation of more hops and/or the use of higher JEM power settings). These demonstration results are of particular significance because they verify the addition of a meaningful network capability to the JEM radio—a network capability that provides range extension, blue force tracking, and instant messaging to dismounted forces and requires zero additional hardware (no infrastructure and nothing to carry).

SRC's covert waveform radio network—MobileRoute on WPM—consisted of five WPM radios in point-to-point and multihop configurations. Demonstration results showed successful data dissemination, including blue force tracking, chat, and whiteboard capabilities, via networked WPM nodes in an ad hoc multihop network. In addition, the use of voice-over Internet protocol and video applications for the point-to-point WPM demonstration revealed the capacity for higher throughput support. AFRL continues to refine and enhance the implementation of MobileRoute on the JEM.

Sustainment

Page

Support to the Warfighter

Air

Cyberspace

Emerging Technologies

Technology Transfer

Awards and Recognition

AFRL Continues to Find Ways to Decrease Air Vehicle Costs

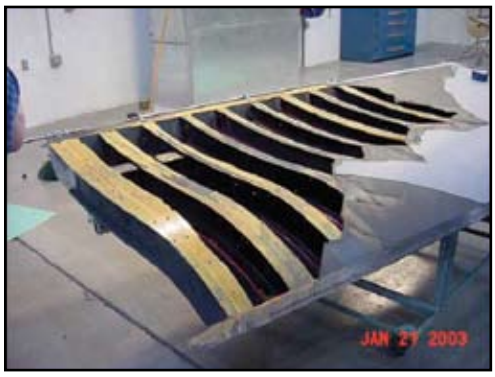
An AFRL-led team determined that an air vehicle's pressure gradient can mitigate the detrimental effect that small surface defects have on air vehicle performance. This finding may result in less restrictive manufacturing tolerances, reducing air vehicle manufacturing and maintenance expenses.

During the 1940s and 1950s, scientists conducted extensive research on the effect of surface imperfections (e.g., bumps, steps, and waves) on the air flowing nearest the air vehicle's body during flight (i.e., in the boundary layer). As the boundary layer transitions from laminar (i.e., smooth) airflow to turbulence, the drag increases, which reduces the aircraft's performance. The research results of this broad concept continue to set the standard for today's manufacturing tolerances. However, these past studies incorrectly concluded that pressure gradients did not affect manufacturing tolerances.

In support of the Global Hawk Systems Group, AFRL teamed with the Aeronautical Systems Center, Northrop Grumman, and Washington State University to study the effects of surface imperfections on the laminar airflow over an air vehicle's wing. Throughout 400+ test runs at the Washington State University Contractionless Boundary Layer Wind Tunnel, engineers fit various surface imperfections, such as forward- and rearward-facing steps, bumps, and surface waves, into a slotted, flat plate with a rounded leading edge, which represented an air vehicle's wing.

Engineers adjusted the pressure gradient (i.e., the change in air pressure from the plate's leading edge through the trailing edge) from positive to neutral and then negative. They used instruments that measured skin friction (an indicator of laminar flow) in order to gather statistics. Data analysis showed that a favorable pressure gradient has a very significant benefit that cancels some of the negative effects of surface imperfections. The new measurements allow over twice the manufacturing errors with no loss in performance characteristics. Following the new standards would offer substantial manufacturing savings without sacrificing capability.

AFRL Improves Durability for C-17 Main Landing Gear Doors



AFRL and Boeing engineers developed a manufacturing process to produce a durable composite C-17 main landing gear (MLG) door featuring stitched preforms, vacuum-assisted resin transfer molding, and an overall improved design. The AFRL/Boeing team applied several emerging technologies to an improved design. They changed the baseline composite door from a preimpregnated composite laminate construction to a stitched fiber preform with vacuum-assisted resin transfer molding (VARTM).

The stitching of the skin composite preforms to the rib preforms provides the necessary reinforcement to improve delamination resistance over the original baseline skin, which was adhesively bonded to the ribs. The VARTM process provides a lower-cost alternative to the current design. The new process also enables a one-piece door compared to the several pieces represented in the baseline design.

The team redesigned the hinge and actuator fittings of the composite box and eliminated the titanium sheets originally embedded in the composite ribs. They changed the loft of the door to reduce stresses, which caused skin waviness when closed under stress. This redesign, coupled with the stitching, will minimize or eliminate the skin delamination and departure problem. The AFRL/Boeing team made design changes to improve resistance to foreign object damage on the leading edge of the door by incorporating a field-level approach of applying foam and polyurethane tape to the leading edge to absorb impacts.

Boeing and the C-17 program office have decided to implement the new door process and design for the two forward inboard doors, beginning with P160 aircraft. Boeing has tentatively scheduled the remaining door improvements for application to the next block purchase of aircraft. By decreasing MLG door failure rates AFRL expects a 40% increase in reliability and no adverse maintainability impact. Phase I of the effort, which affects the two forward inboard doors, should result in an operation and support savings of $532,000 over 25 years and save about 60 mission readiness days per year. Phase II, which affects all eight doors, should generate an operation and support savings of $5.9 million over 25 years and save an additional 30 mission readiness days per year.

AFRL Develops Environmentally Compliant Corrosion Protection

AFRL scientists and engineers led the development of a non-chromate-based surface treatment for aluminum aircraft surfaces and structures. This resulting nonchromated coating is the product of a collaborative effort between AFRL; the University of Missouri-Rolla (UMR); Deft, Inc.; and Warner Robins Air Logistics Center (WR-ALC). WR-ALC depot workers applied the new coating to the first operational F-15 in August 2005 and will treat the entire F-15 fleet as the aircraft arrive for regularly scheduled depot refurbishment.

AFRL sponsored a research grant at UMR to explore the viability of using rare earth compounds to inhibit corrosion of aluminum alloys. After several years of promising exploration, AFRL initiated a research and development program with UMR. This program developed a chrome-free inhibitor technology that eventually developed into paint formulations and a primer coating. AFRL subcontracted Boeing Phantom Works (St. Louis, Missouri) to provide assessments and to guide the university in transitioning a product.

Following the Boeing-led assessments, UMR partnered with Deft, Inc. (Irvine, California), and subsequently licensed the technology for production. The F-15 Systems Group, Robins Air Force Base, Georgia, became interested in using the nonchromated treatment to reduce hazardous waste and personnel exposure. WR-ALC workers treated a Boeing production model F-15C with the environmentally compliant coating manufactured by Deft for a trial. As a result, the F-15 Systems Group approved the use of this coating, marking the first fleet of Air Force (AF) aircraft using a nonchromated surface treatment method.

Development of an environmentally safe, non-chromate-based surface treatment for aluminum aircraft structures is one of several AF initiatives concerned with providing aircraft maintainers and manufacturers with environmentally friendly, advanced corrosion protection. By replacing existing, chromate-containing treatments, AFRL expects to eliminate 90% of the AF's hazardous waste stream and reduce costs associated with handling and disposal of the current chromate-based treatments, which are carcinogenic. Along with reducing the amount of hazardous waste, the new treatment protects Airmen from exposure to these dangerous chemicals.

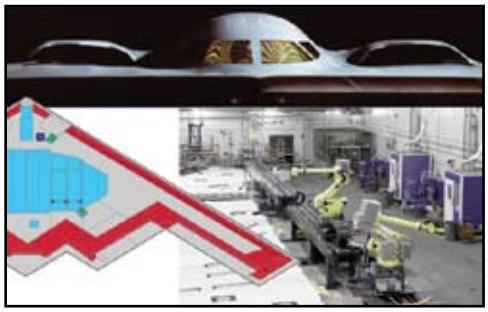
AFRL Develops Hot Air Module for Composite Repairs

AFRL and Karta Technologies, Inc., developed a hot air module (HAM) at the request of the B-2 Systems Group. The B-2 Systems Group requested a small, portable heat source with high-temperature capability to provide the heat and pressure needed to make high-quality composite repairs. The group wanted the unit's individual pieces to weigh less than 30 lbs and further requested that it operate on 20 kW, have a normal wall plug, be operable in voltage and amperage units, and use shop air. The B-2 Systems Group also requested that the HAM pass qualification tests enabling the unit's operation on a fueled aircraft with no danger of creating sparks that could ignite fuel vapors.

AFRL and Karta Technologies developed this HAM according to the B-2 Systems Group's specifications. The module consists of three hot boxes, each capable of supplying hot air >990°F while operating on standard wall outlets and shop air. The units can also provide a greater volume of air when operating as a group. Users can manually operate the HAM unit or control it via standard commercial hot bonders.

The B-2 Systems Group was using the portable cooling and heating system (PCAHS) unit to perform repairs. The PCAHS unit measures 8 x 5 ft, requires its own generator, and costs roughly $2 million. However, the HAM provides heat to cure repairs for composite parts and coatings, is more compact, and is significantly less expensive than current equipment. Employing the HAM will reduce the amount of equipment that deployed military personnel need. The unit will cost approximately $10,000-$20,000. A demonstration of the HAM occurred at an F-22 follow-on test and evaluation. The F-22 System Program Office and Air Combat Command expressed interest in the units and requested additional information. The Air Force has transferred the technology to industry to make it commercially available in the future.

Manufacturing Technology Program Reduces B-2 Bomber Fleet Maintenance Time



The B-2 Systems Group initiated a major effort to improve the B-2 fleet mission capability (MC) rate. This effort involved the removal of the tape that covers access panel gaps and fasteners, followed by the replacement of the tape with a material known as alternate high-frequency material (AHFM). AHFM exposes the gaps and fasteners, allowing easy removal and replacement of access panels without the requirement of material restoration. Successful flight tests demonstrated the AHFM design's effectiveness, but upon the material scale-up for fleetwide implementation, scientists could not obtain consistent batch-to-batch performance.

Consequently, the high risk associated with the material's performance resulted in the postponement of the fleetwide AHFM implementation. With the threat of cancellation looming, AFRL experts quickly initiated a $2.8 million AHFM Rapid-Response Process Improvement (RRPI) program to solve the B-2 Systems Group's primary maintainability problem. AFRL's Manufacturing Technology engineers worked with the B-2 Systems Group to solve the critical material scale-up problem, rapidly identifying AHFM manufacturing problems and implementing appropriate solutions. The AHFM RRPI program enhanced the fleet's high-priority maintainability program and improved material delivery schedule and production costs.

The AHFM RRPI program reduced the material production schedule from 26 weeks to 12 weeks and implemented an improved test method that saved 8 calendar days per batch. The program also enhanced risk mitigation, improved material durability, and reduced maintenance and material costs. Maintenance actions that previously required a week of aircraft downtime now require as little as 30 minutes.

The successful program gave the B-2 Systems Group and Air Combat Command the confidence to implement AHFM fleetwide, allowing a 50% increase in the MC rate and a 50% decrease in maintenance man-hours per flight hour. This program resulted in a significant increase in aircraft availability and cost savings. Other weapons system program offices have since expressed interest in this program.

Aerial Multiaxis Platform Enhances Air Force Depaint and Maintenance Operations

AFRL partnered with US Technology Corporation (Canton, Ohio) to develop and implement a low-cost and highly effective aerial-based, semiautomated system for performing maintenance, repair, and overhaul work. This revolutionary system, the Aerial Multiaxis Platform (AMP), successfully integrates advanced depainting concepts with coordinated control technology developed at the National Institute of Standards and Technology, providing the depot community with simple, reliable access to the surfaces of large aircraft such as the C-130, C-5, and C/KC-135.

Aircraft coating removal is the most labor-intensive task performed by aircraft maintenance depot personnel. A typical maintenance cycle for large aircraft requires the removal of exterior coatings approximately every 6 years. Aircraft access during depot maintenance is difficult; the physical demands and toxic environment are a significant source of both worker compensation claims and employee turnover. AFRL's new functional, production-hardened aerial platform for depainting environments provides an operator-controlled depaint manipulator with multiple nozzles for performing abrasive blasting, as well as an aerial workstation that allows efficient access to aircraft surfaces with minimal ground clutter.

AMP's ergonomically friendly operator interface reduces collisions, injuries, and operator stress and fatigue 70%-100%. It optimizes labor by maximizing worker efficiency and decreasing abrasive blasting time and costs. In addition, the AMP system's design reduces depot depaint flow time 40%-50%—the equivalent of 4-5 days for a C-5 aircraft.

The improved positioning accuracy and aboveground access for completing aircraft maintenance tasks eliminate ground-based scaffolding, hoses, and other inefficient clutter. The AMP system does not require a heavy hangar structure; furthermore, its flexibility to be deployed from an existing facility or incorporated into a new one further reduces direct costs. AMP's improved, heavy-duty, off-the-shelf winch motors are centrally located above the basket on a crane rail structure and provide man-rated lifting capacity up to 3,600 lbs. The system also provides increased material handling/hoisting capacity up to 6,000 lbs for precision crane application.

AFRL Alternatives Planning Technology Aids Decision Makers

Technologies for Net Centric T&E	Alternative 1						
	Description	Mitigation Actions	Dependant Risk	Risk/Impact			Universal Risks
				87%	87% (H,M,L,N,#)	87%	87%	(N/A,H,M,L,#)
Risk Categories				Catastrophic	Critical	Moderate	Negligible	
Definition of NCOW			1	L	L	M	M	N/A
ID of NCOW shortfalls			1	H	H	H	H	H
Sufficient Solution			1	H	H	L	L	L
Op. T&E:			1	H	H	L	L	N/A
T&E Methods combatable with	existing systems		1	H	H	H	H	N/A
minimum of systems'	Proposes using high capacity comput		1	12%	6%	N	8%	N/A
Coherence of Information			1	L	L	N	N	N/A
Infrastructure Taxing			1	16%	11%	9%	3%	N/A
Live fire testing			1	H	H	H	H	N/A
EW			1	H	H	H	H	N/A
Interference			1	?	?	?	?	N/A
Bandwidth surges			1	H	H	H	H	H
Interoperability	COTS/GOTS		1	H	H	H	H	N/A
Method (series/parallel)	Must be determined/defined otherwi		1	H	H	H	H	H

Department of Defense (DoD) professionals frequently confront daunting amounts of data that, considered collectively, contribute to an informed decision but, viewed individually, mean nothing or add no value. Many times, this data represents inexplicit averages, approximations, and expert opinion. AFRL scientist and engineers have developed a technology that fuses such amassed information into a comprehensible display that facilitates effective and efficient decision making.

Every DoD mission—from developing aircraft maintenance schedules to managing laboratory research and development programs—involves some type of risk. The AFRL-developed technology is a Microsoft Excel®-based tool enabling the quantitative comparison of alternatives. The new alternatives planning tool, RiskAoA, was previously known as RiskHammer; it requires no software license and is free of charge, providing decision-quality information for anyone.

	Catastrophic	Critical	Moderate	Negligible
Alternative 1	87%	87%	87%	87%
Alternative 2	20%	20%	20%	20%
Alternative 3	89%	89%	89%	89%
Alternative 4	7%	7%	7%	7%
Alternative 5	45%	45%	45%	45%
Alternative 6	88%	88%	88%	88%
Alternative 7	36%	36%	36%	36%
Alternative 8				

The RiskAoA program combines textual, quantitative, and qualitative inputs to generate (using distribution statistics and the generalized mean) an ordered comparison of the risks associated with any alternative. Whereas current risk tools fill an important gap in risk analysis by displaying the risk of a program under current conditions, RiskAoA fulfills another niche: it compares and contrasts alternatives for both future planning and instantaneous review purposes. This capability represents an enormous aid to future planning and the comparison of current program portfolios. Furthermore, risk evaluations from current tools map directly into RiskAoA for other quantitative comparisons.

RiskAoA is not only a program manager's tool; it is easily adapted to quantify any alternative, comparison, or set of choices. For example, the program has the capacity to analyze choices such as those involved in comparing the risks of contract proposals, stock portfolios, or even different routes to work. The use of RiskAoA promotes preemptive management by transforming daunting amounts of accumulated data into concise, relevant information.

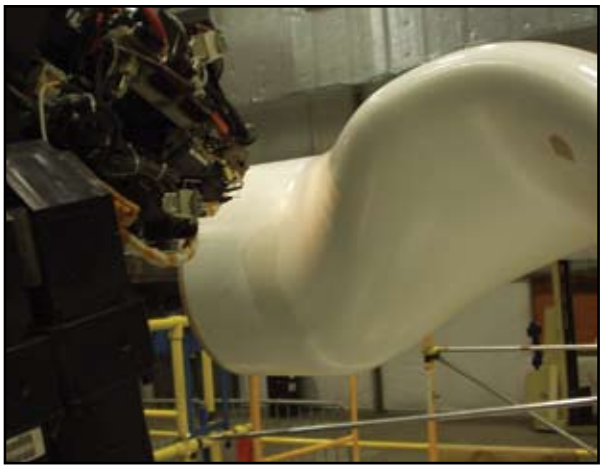
AFRL Supports Operationally Responsive Spacelift

Under its Durable Efficient Thermal Protection System (TPS) Seals and Attachments program, AFRL validated a low-maintenance TPS component by subjecting the unit to multiple cycles of shuttle-launch noise levels combined with surface temperatures up to 1800°F. The test sample, a 12 x 24 in., mechanically attached, tile-based TPS section, successfully withstood all test conditions. This test series was an important step in creating TPS components that are far more durable and faster to remove and replace than traditional designs. Their use could dramatically reduce the turnaround time for reusable launch vehicles (RLV). AFRL engineers are now working to increase the temperatures the TPS can withstand and lower the TPS weight by reducing the number of parts and employing lower-density materials.

AFRL engineers validated the TPS at AFRL's Consolidated Aerospace Structures Research Laboratory. This facility, the largest combined-environment experimental facility in the world, provides state-of-the-art validation capabilities to all government agencies and to industry and academia through Cooperative Research and Development Agreements.

Low-maintenance, mechanically attached TPS panels could one day dramatically reduce the turnaround time for RLVs such as the current space shuttle from months to a matter of hours. This capability is an important requirement for operationally responsive spacelift.

AFRL Demonstrates Low-Cost Production of Compact Unmanned Air System Inlet Duct

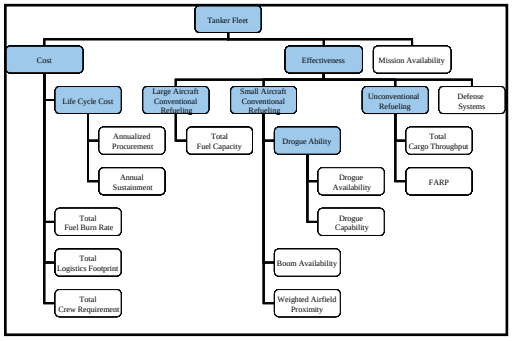


AFRL teamed with Lockheed Martin (Bethesda, Maryland) and Ingersoll International (Rockford, Illinois) to demonstrate the low-cost manufacturability of a structurally integrated, compact air vehicle engine inlet. This advanced compact inlet technology will benefit future unmanned air systems by providing significant weight and cost savings, as well as maintaining state-of-the-art performance characteristics.

Current air vehicles require relatively long engine air inlets to meet performance requirements. These inlets contain numerous parts, such as fasteners, that make them heavy and expensive. In addition, their complex shape makes them difficult to manufacture. As a result, AFRL teamed with Lockheed Martin and Ingersoll International through AFRL's Active Integrated Inlet-Duct-Engine Demonstration (AIIDED) program. Using flight-certified processes, engineers at Ingersoll International's Rockford facility manufactured the inlet using fiber placement, a low-cost composite material fabrication process. This AIIDED effort successfully demonstrated the capability to manufacture the inlet using the fiber placement machine, producing the world's first complex shape created using fiber placement. Engineers will conduct a follow-on static engine ground test to evaluate the duct's impact on air vehicle engine performance.

The AIIDED program's compact inlet product incorporates active flow control technology, which allows engineers to shorten the inlet to reduce inlet weight without sacrificing performance. Fabricating the compact inlet as a single composite piece and integrating it with the aircraft structure eliminates fastener production and further reduces cost and weight. These new, compact inlets will translate into more compact unmanned air systems with reduced weight and system costs.

AFRL and AFIT Develop Tanker Fleet Replacement Model



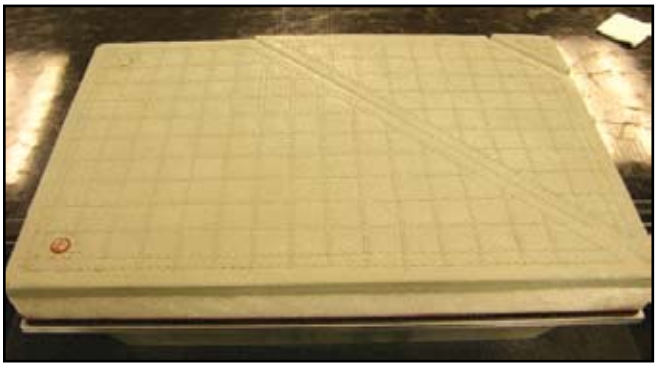
With 90% of Air Force (AF) tankers approaching 50 years of service, the replacement or recapitalization of the fleet is an AF priority. Accordingly, AFRL and the Air Force Institute of Technology (AFIT) developed an objective model to provide insight into the costs and benefits of various existing and potential fleet replacement proposals.

Age and costs are not the only impediments the AF tanker fleet faces. For instance, just as bomber and fighter aircraft are limited by fuel-related constraints, tanker capabilities are restricted by airfield requirements and the number of en route basing options. Due to their size, tankers require established overseas airfields with robust logistical support. Tanker aircraft equipped with advanced technologies offer the additional capacity to perform both reconnaissance and communication operations. Furthermore, large aircraft tankers lend themselves to supporting airlift operations by providing additional space for cargo. The possibilities of a future AF tanker fleet to improve upon current limitations—and the necessity for fleet aircraft to perform as valuable multipurpose assets—drive the ultimate decisions regarding which aircraft should be incorporated into the future tanker fleet.

Using a value-focused thinking (VFT) methodology, the AFRL/AFIT team developed a comprehensive model encompassing the myriad objectives to consider for tanker fleet replacement alternatives. Using VFT in this context allows decision makers to evaluate value trade-offs between the various objectives independently of the alternatives offered. The value model also permits the comparison of objectives measured via otherwise incompatible units, such as "dollars" versus "effectiveness." Further, it accommodates the inclusion of value functions to show increasing or decreasing rates of return for a given objective.

Insights acquired from the tanker fleet model convey the importance of procuring a relatively large fleet with a low-per-aircraft-cost. The larger fleet size best satisfies the needs for substantial total fuel capacity and boom availability. Advanced boom technologies are a highly valuable consideration in new tanker designs. However, trade-offs pertaining to the fleet's several cost-related considerations indicate the need to utilize existing, low-cost airframes. The AF can select from a wide variety of approaches for replacing its tanker fleet, including approaches involving the incorporation of unmanned air vehicle dedicated tankers, commercial derivatives, and designs capable of deployment in both larger and smaller theaters.

AFRL Conducts Successful Tests of Mechanically Attached Blanket



AFRL engineers completed testing of three mechanically attached blankets designed to improve current thermal protection systems (TPS) for reusable space access vehicles. These flexible, insulating blankets are easier to attach and remove than the current adhesive tile TPS used on the space shuttle and other reentry vehicles subjected to high heat during reentry.

During the testing, engineers used AFRL's Combined-Environment Acoustic Chamber to subject three blankets with different attachment configurations to extremely high temperatures and vibration in order to simulate vehicle reentry conditions. They designed the tests to verify the attachment for the mechanically attached insulation and demonstrate the readiness of an attachment concept for near-term structural ground demonstrations. All tests ran successfully, and all three blanket concepts exceeded expectations.

The design employs fasteners, magnets, or bolts to attach the one-piece blanket to the vehicle, which allows maintenance crews to attach and remove the blankets more easily than the current adhesive tiles permit. Due to the simplified maintenance process, the total maintenance time after reentry could potentially be reduced from 3 weeks to 1 day, allowing a quicker turnaround time before relaunch. Upon completion of the analysis, engineers will select two of the three blanket concepts for further tests involving each blanket's thermal/acoustic characteristics, attachment mechanisms, and removal/attachment process.

AFRL Sets Sights on Reducing Cost, Enabling Production of Active Electronically Scanned Arrays

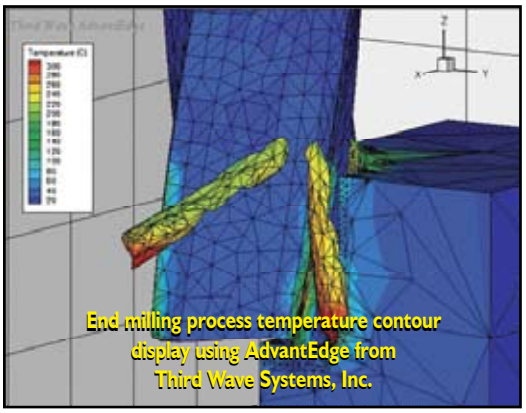
AFRL is improving processes related to current and next-generation radar systems. Leading related efforts with both Raytheon (Dallas, Texas) and Northrop Grumman Corporation (NGC) (Baltimore, Maryland), AFRL engineers are evaluating Active Electronically Scanned Array (AESA) production to improve yield and reduce touch labor, cycle time during assembly, and costs of the radar.

To surpass the capabilities of conventional radar technologies such as the Mechanically Scanned Array (MSA), AFRL developed the AESA. AFRL's engineering team designed the AESA with multiple transmitter and receiver (T/R) modules to replace the Passive Electronically Scanned Arrays (PESA). PESA technology improved upon the original MSA by scanning a volume more quickly, but still used one central T/R. Up to 6% of the AESA's hundreds to thousands of T/R modules can fail before the radar needs repair, allowing the system to remain operational for a longer period of time.

For its Phase I effort, NGC proposes to replace radiator ground springs, devise a new method to mask and demask radiator pre- and postconformal coating, and improve both radio frequency (RF) distribution and tile-to-panel assembly. AFRL anticipates circulator grounding to a radiator structure will save $23,000 per AESA unit, with overall savings to the Air Force (AF) estimated at $28 million. In addition, AFRL predicts RF distribution enhancements (once incorporated into aircraft platforms) will generate $36 million in total AF savings.

Improved tile-to-panel assembly will reduce both touch labor cost and expenses stemming from the tile damage associated with the current, manual attachment process. AFRL expects a total savings of $3.7 million for space radar applications.

AFRL Achieves Breakthrough in High-Speed Machining of Titanium



End milling process temperature contour display using AdvantEdge from Third Wave Systems, Inc.

Machine pockets in Ti-6Al-4V plate, created using the results from AdvantEdge.

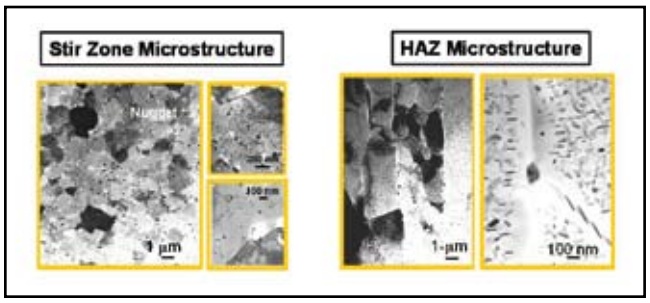
AFRL and Third Wave Systems, Inc (Minneapolis, Minnesota), collaborated to cut the time and cost of titanium machining. Entering into a Small Business Innovation Research (SBIR) agreement, the team reduced titanium machining time by 30%.

The use of titanium alloys in aircraft manufacturing continues to increase over time due to the element's high strength and low weight. Manufacturers use titanium alloys for jet engine discs, blades, shafts, and casings because the alloys can operate at temperatures ranging from subzero conditions to 600°C. Structural engineers specify that titanium alloys be used on airframes in several capacities—from small fasteners that weigh less than an ounce to large wing beams that weigh up to a ton.

AFRL and Third Wave Systems used AdvantEdge™, a finite element machining model, to reduce machining cycle time by 30%, unit cost for the customer (without reducing profitability), and manufacturing risk by understanding the cutting process at the microlevel. AdvantEdge analyzes machining processes, such as milling, drilling, and turning processes, to improve machining rates and tool performance. The software predicts cutting forces and temperatures in the tool and work piece to optimize cutting conditions. The US Navy and the Department of Energy are also using AdvantEdge to achieve cycle-time reductions.

During Phase I of the SBIR project, the software demonstrated the possibility of reducing costs and improving the rate of productivity. In Phase II, the application of AdvantEdge and high-speed machining technologies reduced machining cycle time by 30%. Third Wave Systems subsequently received a Phase II enhancement to continue this research effort. During this enhancement effort, researchers fortified the modeling and software technology, making it useful for computer numeric control programmers. As a result of this enhancement endeavor, Third Wave Systems has entered into another SBIR contract with AFRL to apply the technology to additional engine components with complicated design features.

Friction Stir Welding Provides Advantages Over Conventional Fusion Welding Process



AFRL scientists conducted groundbreaking research using a revolutionary welding process to join the structural metal alloys employed in manufacturing aircraft, civil structures, and other major assemblies. The process, known as friction stir welding (FSW), is an efficient and cost-effective alternative to the fusion welding technique routinely used to join structural alloys (such as those used to build military aircraft). Some aluminum alloys (e.g., the 7000 series) are difficult to weld with conventional fusion welding methods; however, FSW offers the advantages of fusion welding in addition to better retention of baseline material properties, fewer welding defects, lower residual stresses, and improved dimensional stability of the welded structure.

AFRL researched FSW's effect on the microstructure and fatigue of numerous high-strength aluminum and aluminum-lithium alloys, including a principal alloy used in military and commercial aircraft construction. The laboratory's research data is helping to determine how and when users can employ FSW to reduce aerospace manufacturing costs for the Air Force (AF), Department of Defense, and commercial aerospace. With FSW, the welded material does not melt or recast. As a result, material transformations that occur during a weld's cooldown are in solid state. FSW is devoid of gases that normally accompany fusion welding. FSW also joins aluminum alloys fairly rapidly (approximately 4 mm/sec), with low heat input and without shielding gases and costly filler materials.

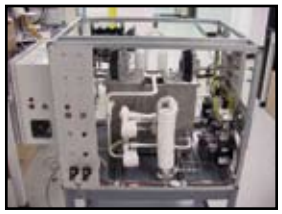
During AFRL's in-house research effort, many aerospace aluminum alloys, including the widely used 7050-T7451, underwent FSW to assess the effects on microstructure and mechanical properties. Researchers are further expanding the knowledge of microstructure-property relationships, corrosion and failure modes, and life-cycle benefits in friction stir welds. Additionally, they are developing databases and process specifications in an effort to achieve desirable and predictable properties and to qualify FSW for use in manufacturing components for transportation systems and reusable cryotank space applications.

The AF and industry are vigorously pursuing FSW technology to join steels and, more recently, titanium alloys. Research is rapidly progressing on all fronts, including the design of novel tools, the optimization of process parameters to produce mechanical properties equal to or better than fastened structures, and the development of process models to understand and guide the FSW process. Further FSW advancements could lead to cost-effective ways to repair metal surface defects without changing the original structures.

AFRL Researchers Demonstrate Fuel Cell Powered With JP-8

AFRL researchers demonstrated a planar solid oxide fuel cell (SOFC) running on logistic fuel (JP-8) to the US Army Corps of Engineers. The device that made this demonstration possible is the logistic fuel processor (LFP), developed at Tyndall Air Force Base, Florida. The LFP, which uses steam reforming technology to convert JP-8 into fuel suitable for the SOFC, permits the use of a reliable and easily operated fuel cell power system as an alternative to current mobile electric power (MEP) units.

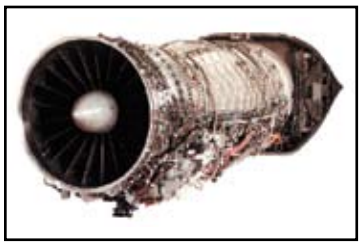
Forward-deployed basic expeditionary airfield resource (BEAR) bases use MEP-12 generators to provide power base-wide. Deploying this equipment requires four transport aircraft and 4,000 gal of fuel per day, a severe burden to an already stressed air fleet.



Seeking an alternative to the MEP-12 generators, AFRL researchers explored the feasibility of using an LFP to convert JP-8+100 fuel to the hydrogen-rich gas needed to fuel a fuel cell power system. A fuel cell is an electrochemical energy conversion device that converts hydrogen and oxygen into electricity and water. The research team developed a fuel processing technology that completely converts JP-8 jet fuel and diesel fuel to hydrogen-rich gas with an 81% conversion efficiency while removing the sulfur and eliminating the impact of aromatics.

These results will lead to the use of fuel cells for MEP generation at forward-deployed BEAR bases. Fuel cells operating on JP-8+100 fuel will generate electric power with greater efficiency, lower noise and vibration signatures, and reduced maintenance requirements compared to current diesel generators. Furthermore, the decreased size and weight of LFP fuel cell systems relative to diesel units will permit a significant reduction in overall airlift requirements for future BEAR base installations.

New Triservice Collaboration Unites Propulsion Community



A unique triservice collaboration known as Propulsion – Safety, Affordability, and Readiness (P-SAR) is unifying the propulsion community to achieve common sustainment goals across the Army, Navy, and Air Force fleets. Originally conceived in 2005 as a follow-on effort to the highly successful High-Cycle Fatigue program, P-SAR has quickly evolved into a benchmark collaboration initiative including all Department of Defense (DoD) propulsion organizations, as well as original equipment manufacturers (OEM).

P-SAR includes a subcommittee chartered under the Joint Propulsion Coordinating Committee to establish proactive propulsion management strategies leading to technology solutions of benefit to all member organizations. P-SAR has established rigorous program goals to increase operator safety by reducing fleetwide catastrophic propulsion-related accidents by 75%, improve affordability by reducing DoD propulsion maintenance costs by $420 million per year, and enhance warfighter readiness by doubling the average engine time on wing between unscheduled removals.

The scope of P-SAR initiatives will grow in response to the warfighter's most urgent needs. As the program gains momentum, additional academic and propulsion system component vendors and material suppliers will join the various technology teams. These members will bring specialized abilities and expertise to complement the capabilities of propulsion system OEMs. The outlook is extremely promising for the P-SAR program to provide its DoD members with highly effective technology solutions to safety, affordability, and readiness issues.

AFRL Demonstrates Low-Cost L-Band Array Tile

AFRL successfully designed, fabricated, and tested a six-element, L-band, electronically scanned phased-array antenna tile. The tile concept demonstrates enabling technologies addressing both the technical obstacles and the cost-related barriers currently preventing the fabrication and deployment of large space-based radar arrays.

Sensor arrays, which are vital to achieving the Air Force mission, currently use custom, ceramic-brick-type radio frequency (RF) modules that are expensive and heavy. In addition, the array controllers use custom, application-specific integrated circuits that require complicated software development, as well as expensive design and fabrication runs.

The laboratory's effort demonstrated technology concepts that can significantly reduce sensor array cost and mass while maintaining their excellent performance. AFRL's six-element L-band array tile uses several novel technologies. The aperture comprises layers of flexible materials, known as "RF on flex," in which RF and bias direct current (DC) signals travel. The RF on flex contains all RF and DC feeds in as few as three routing layers, greatly reducing tile mass, complexity, and fabrication cost. The array tile also uses plastic-packaged, highly integrated transmit/receive (T/R) monolithic microwave integrated circuits, which significantly lowers the cost and mass as compared to current state-of-the-art ceramic-packaged T/R modules. A field-programmable gate array (FPGA) using AFRL-designed control software and graphical user interface controls the array. A single FPGA could potentially replace multiple custom RF control modules, again reducing overall array cost and mass.

Contemporary radar array concepts often use circuit boards that have more layers than the RF-on-flex approach and are significantly heavier and more costly. A key drawback to these array architectures is the significant amount of touch labor and customized tuning needed during fabrication, the result of which is higher costs. The array architecture demonstrated under the AFRL effort is suitable for manufacturing using automated systems that require minimal touch labor, resulting in low-cost, thin, lightweight arrays for unmanned air vehicle applications.

AFRL Sponsored Research in Amorphous Silicon Thin-Film Solar Cells Will Enable High-Power, High-Radiation Space Applications

AFRL established a program with industry partner United Solar Ovonic Corporation (USOC) (Auburn Hills, Michigan) to build on technology developed under a previous AFRL Small Business Innovation Research project. Under the earlier effort, AFRL leveraged USOC'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.

USOC modified its existing deposition process to optimize the solar cell for the solar spectrum outside the earth's atmosphere. The company also developed a process for thinning the stainless steel substrate, thus significantly reducing mass. In parallel, USOC accomplished research and development-level work to demonstrate the feasibility of producing high-efficiency amorphous silicon (a-Si) solar cells on a polymer substrate in a high-volume manufacturing process. USOC technicians deposited the a-Si layers on the polymer/stainless steel cladding to create the solar cell; they subsequently etched off the stainless steel, leaving the polymer as a substrate.

The effort achieved beginning-of-life efficiencies of 9.44%, which translates into a cell-level specific power >1000 W/kg. The original USOC terrestrial product exhibited a specific power approximating 115 W/kg, whereas the specific power of the a-Si on a thinned stainless steel substrate was ~500 W/kg. These figures translate into an array-level specific power as high as 250 W/kg, in contrast to a crystalline multijunction array with specific power typically around 50-70 W/kg.

The inherent radiation hardness of thin-film solar cells should enable missions in extremely high-radiation orbits, where crystalline multijunction cells degrade too quickly. Lastly, because manufacturers use large-area deposition techniques for thin-film solar cells, they project thin-film solar cells to be three to five times less costly than crystalline multijunction solar cells and possibly more suitable for large power requirements.

Phase II SBIR Will Result in Reduced-Cost, High-Quality Reengineered Software

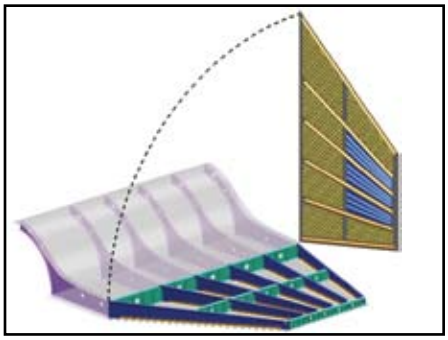
AFRL awarded Capraro Technologies, Inc. (CTI), a Phase II Small Business Innovation Research (SBIR) contract to develop an automated method of reengineering legacy application software. This development will result in an innovative approach for reengineering and translating legacy software into a number of different programming languages on a variety of platforms, allowing the reuse of proven applications across emerging and future technologies. The new approach will not only allow quality software to be more rapidly fielded, reused, and maintained, but will also reduce the expense of manual reengineering—a benefit that will inherently support all major weapon systems.

Many missile defense programs use proprietary software systems in the research and development environment of the laboratory. These systems are subject to expensive, time-consuming, and customized systems integration. Furthermore, many legacy Department of Defense systems upgraded for the Missile Defense Agency (MDA) utilize outdated software that is difficult to modify and maintain. Application of CTI's automated reengineering method will both alleviate resource-intensive systems integration efforts and assist the MDA's efforts to enhance and modernize its current radar systems.

CTI has been researching and developing an automated method to read, interpret, store, and translate mathematic-intensive signal processing software using new open-source technologies within the Extensible Markup Language-based Semantic Web initiative. The use of these technologies creates a system that can be extended—through understandable, open-source transparency—to new applications. CTI scientists developed methods that can interpret legacy software and change its associated application code into a format they have dubbed Code Markup Language. CTI has named its new program SapientWare.

CTI successfully demonstrated Phase II project objectives by using the newly developed program to translate a simple matrix multiplication program into MATLAB, C++, and other language versions. Under AFRL's management, CTI has demonstrated this process on an industrial-sized radar signal processing software application consisting of approximately 218,000 lines of 20-year-old Fortran code provided by subcontractor Lockheed Martin. CTI's program will facilitate the automated reengineering of legacy application software, allowing its transfer from outdated hardware systems to the various formats applicable to operation on newer computers. The new program will store legacy algorithms in an open, extensible format to facilitate cataloging, aid understanding, and promote reuse.

CAI Technologies Mitigate Risks of Certifying Bonded Structures



Thanks to the AFRL-sponsored Composites Affordability Initiative (CAI), the Department of Defense (DoD) supplier base now has access to a suite of tools and technologies enabling confident certification of bonded composite structures for primary load-bearing applications. The use of these resources will promote the development of more efficient concepts for air and space applications.

The CAI team—which includes members from AFRL and the Navy, as well as industry representatives from Bell Helicopter Textron, Boeing, Lockheed Martin, and Northrop Grumman—took an aggressive approach to developing the technologies necessary for mitigating certification risks. The resulting product suite comprises advanced analysis tools to aid predictions regarding the onset and progression of failure mechanisms; process controls to improve the reliability of surface preparation and evaluation, adhesive mixing and dispensing, and assembly; and advanced inspection techniques to identify unique bond deficiencies and measure specific bond strength. These tools, along with a sound certification plan of analysis supported by testing, boost the confidence of certification authorities in trusting there are currently no technical barriers to certifying bonded structures. This represents a major breakthrough towards realizing the cost, cycle time, weight, and durability benefits associated with advanced bonded structures.

Following the team's technology development achievement, the advanced analysis tools—which can accurately predict failure onset as well as progression—transitioned to commercial vendors. The capability to certify bonded airframe structures allows designers to create more efficient structural concepts. Compared to conventional, fastened structures, bonded structures offer reduced weight, which improves aircraft speed, range, payload, and loiter capability. Lighter-weight composite airframes will translate into fuel savings as well. Furthermore, the DoD can expect to leverage a projected 14% to 35% reduction in airframe acquisition costs and a 25% reduction in manufacturing cycle time for the production of airframe structures. Bonded structures will promote savings in other areas as well, reducing life-cycle costs (which dominate total weapon system ownership costs) by about 75% over fastened structures. This reduction will occur as corrosion-resistant composite structures begin to replace conventional aluminum airframes. The various combinations of these payoffs have application to a wide range of advanced weapon systems currently under consideration.

AFRL Aids Memphis Belle Restoration Effort

In October 2005, the Memphis Belle, a Boeing B-17 that flew 25 missions during World War II and took part in the war bond tours, transferred from the Memphis Belle Memorial Association to the National Museum of the United States Air Force (NMUSAF). In 1946, the aircraft flew to Memphis, where it remained on display outside the National Guard Armory until 1987. At that time, the aircraft moved to the Mississippi River's Mud Island, where it displayed in a covered pavilion until 2003. Throughout these years, the Memphis Belle has remained susceptible both to the elements and to vandals.

Upon arriving at the NMUSAF, the aircraft became one of the museum Restoration Division's highest priorities. The restoration team plans to return the Memphis Belle to its original state; however, this will prove a challenge due to the amount of corrosion and vandalism the aircraft has experienced. The team estimates it will take 10 years to restore it to museum-quality condition.

One challenge in this process involved finding a paint stripper to remove the aircraft's paint buildup, which consists of a pretreatment that provides corrosion protection for the metal surface; the primer; and the outermost paint layer, or topcoat. The team sought an environmentally safe stripper, as opposed to one containing methylene chloride, a substance that provides effective removal but is a known carcinogen and therefore potentially harmful to technicians. For this challenge, the Restoration Division requested the help of AFRL.

Second Lieutenant Grant Parker, of AFRL's Materials and Manufacturing Directorate, recommended a variety of paint strippers to the restoration team. His guidance resulted in the team's selection of Dekote, an environmentally safe paint stripper manufactured by AeroChem, LLC (Oklahoma City, Oklahoma). Dekote uses a benzyl alcohol and hydrogen peroxide mixture to safely remove paint in just one application. The product was able to remove all coatings from the Memphis Belle test object in 8 hours.

Aiding the NMUSAF in selecting a paint stripper for the Memphis Belle restoration effort demonstrated AFRL's expertise in coating technology and provided invaluable assistance to the museum, ultimately reducing the exposure of Air Force personnel to harmful chemicals. The laboratory's involvement also saved the Restoration Division a significant amount of time in selecting a viable product. Technicians are using Dekote to begin removing the Memphis Belle's paint buildup, and they plan to use the product on other aircraft as well.

Emerging Technologies

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Emerging Technologies

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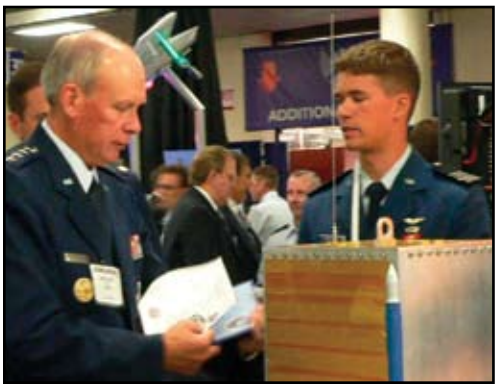
Air Force Academy Cadets' Work Presented to High-Ranking Air Force Officers



Cadet First Class Jeff Gurlach, along with one of his instructors, Lieutenant Colonel Michael Bettner, displayed a life-size model of the FalconSAT-2 satellite for public view at the Air Force (AF) Association's Air and Space Conference and Technology Exposition in Washington DC. The exposition included more than 100 exhibitors addressing cutting-edge aerospace technology.

FalconSAT-2 marks the latest nanosatellite (nanosat) technology effort completed in the academy's ongoing program. The eventual nanosat goal is to achieve the same capabilities of current satellites, but in space platforms far smaller in size and weight—typically under 25 lbs.

The conference provided an excellent opportunity for Cadet Gurlach to personally present FalconSAT-2 and the Falcon program to hundreds of high-ranking AF officers and senior executives from across the defense contractor community. Some of the distinguished AF officers included General Bruce Carlson, Commander of Air Force Materiel Command; Gen Lance W. Lord, Commander of Air Force Space Command; and Lt Gen Ronald E. Keys, Deputy Chief of Staff for Air and Space Operations.

AFRL is funding the Falcon nanosat program with plans to launch FalconSAT-2. Of the cadets participating in the Falcon program for 2005, five received Draper Fellowships to the Massachusetts Institute of Technology, one received a Fellowship to Rice University, and four went on to pursue graduate work at other schools.

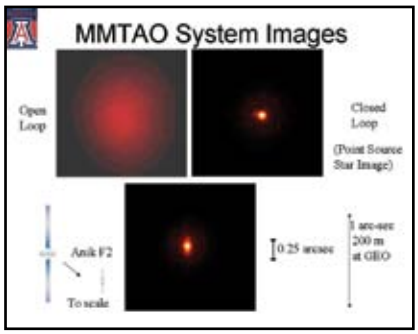
Providing today's engineering students hands-on training and experience in advanced satellite design and engineering is very important to the development of future aerospace engineers. The United States Air Force Academy's Falcon nanosat program has received various awards and accreditations for the excellent opportunities it provides for advanced training and education.

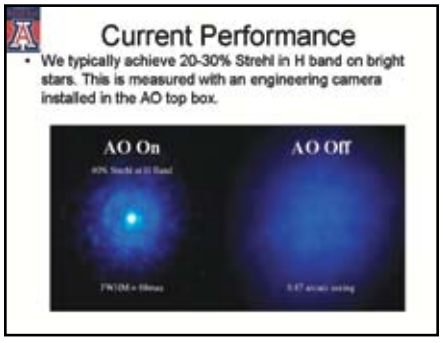
AFRL-Sponsored Research in Adaptive Optics Produces Images With 10 Times Higher Resolution Than the Hubble Telescope

Using basic research funds from AFRL, a team of astronomers and astrophysicists successfully photographed faint stars in space, producing digital photographs with 10 times higher resolution than images produced by the Hubble telescope. The team is located at the Center for Astronomical Adaptive Optics at the University of Arizona.

To obtain the image, researchers used the multimirror telescope natural guide star adaptive optics system at the Steward Observatory, in Tucson, Arizona. It is the first adaptive optics system that uses a deformable secondary mirror to correct optical distortions introduced by the earth's atmosphere and provides defraction-limited imaging from 10 μ to the near infrared.

To achieve the sharper image quality, the researchers developed an entirely new capability by physically incorporating the adaptive optic correction on the telescope optics. They built the correction into a secondary mirror that can change its shape very quickly (500 times a second) to compensate for atmospheric blurring, making it the only operating telescope in the world with this capability. This telescope uses a 6.5 m diameter mirror, giving the telescope a very large aperture and thus enabling the team to take sharper images of geosynchronous satellites.





The research team also developed a "top box," which they attached to the telescope and used to create sharp images. Light enters through the top box, is reflected upwards into a horizontal plane, and reimages a set of optics which then selects what star/object to observe by moving the small mirrors and then sending the images to a charge-coupled device camera. Bolted to the bottom of the top box are three science cameras for capturing images.

Multimirror telescope natural guide star adaptive optics system technology allows astronomers to explore faraway stars that are difficult to see even with modern telescopes, a capability potentially leading to the discovery of new moons and planets. For the Air Force, this technology also has the future potential to serve as a tool for observing and identifying faint objects near US-owned satellites in space.

For more information contact
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AFRL-Sponsored Technology Enables Surface-Enhanced Raman Detection of Hazardous Chemicals

Surface-enhanced Raman spectroscopy (SERS) is a technology that enables scientists to detect the presence of chemicals at extremely low levels of concentration (potentially as low as the single-molecule level). This technology applies both to national security—particularly for the identification of threatening chemical and biological agents—and to the medical field (e.g., for glucose monitoring).

AFRL sponsored the research and development of a reliable, robust substrate that greatly enhances hazardous species detection. Under the Multidisciplinary University Research Initiative, Northwestern University scientists developed metal-film-over-nanosphere substrates, which enable SERS-based rapid detection of an anthrax biomarker. By effectively targeting the anthrax biomarker calcium dipicolinate, the SERS method permits detection of anthrax spores present in an extremely small sample size (smaller than a regular aspirin tablet) in approximately 10 minutes. Most importantly, this method enables detection of anthrax at 1/4 the lethal dosage. The scientists also demonstrated SERS detection of Bacillus spores. The team successfully transitioned these laboratory-developed sensing capabilities to a portable Raman spectrometer for use as a commercially available (via DeltaNu, LLC), field-deployable device.

The SERS demonstration results indicate that the team's efforts improved the detection sensitivity for molecular species by a factor of 10 million. This remarkable surface enhancement results from plasmon resonances that can arise when a molecule is between (or in the immediate vicinity) of various metallic nanostructures. Recent advances in the ability to fabricate and control nanostructures enable the development of techniques and methods for using SERS for control and reproduction purposes; these capabilities will enhance the detection sensitivity of molecular and biomolecular species. An 11-minute procedure can detect ≤2,600 spores, far below the anthrax infectious dose of 10,000 spores. The SERS sensing technology's speed and sensitivity make it a viable option for field analysis of potentially harmful bioagents.

AFRL continues to lead the effort to develop this exciting new technology. A Small Business Technology Transfer project is currently under way to further explore ways to use SERS nanotechnology to identify and detect biomolecular and biological entities, including trace amounts of chemical and biological agents, toxic species, and biological species such as proteins.

AFRL-Funded Scientists Surprised With Silicon Conductivity Results

With her face reflected in a small glass port, physics graduate student Pengpeng Zhang peers into a scanning tunneling microscope that uses electrical current to measure atomic-sized features on the surface of nanoscale silicon membranes. Zhang is a research assistant working in the lab of materials science and engineering professor Max Lagally. She is part of the team that demonstrated how nanoscale silicon surfaces can conduct electricity—a surprising finding that will have implications for nanotechnology development.

A team of AFRL-funded scientists and engineers from the University of Wisconsin-Madison (UW-Madison) successfully demonstrated the ability of nanoscale silicon membranes to conduct electricity. For years, the scientific community incorrectly assumed that very thin layers of silicon were incapable of conducting electricity, which limited the study of these thin layers. The assumption was partly due to the lack of a viable tool for viewing the layers' microscopic details. However, with the advent of specialized microscopes—specifically, the scanning tunneling microscope (STM)—scientists have acquired the ability to see more. After using an STM to image a piece of silicon 10 nm thick, the UW-Madison researchers observed an electric current running through the thin layer of silicon. The fact that they were able to image such a thin layer was an accomplishment in itself, but the discovery of the electric current was an added bonus and a surprise.

The team soon discovered that when the surface of a nanoscale silicon membrane undergoes proper cleaning, it becomes capable of conducting electricity. The membrane's electrical conductivity is normally nonexistent unless the cleaning process occurs. The special cleaning method enables conductivity by creating new electronic states on the silicon surface; as a result of the new conditions, electrons can reside on the surface, using it as a dopant. Through continuing research of this exciting discovery, the UW-Madison team hopes to explore ways of merging silicon electronics technology with nanoelectronics technology.

Eventually, this discovery could impact commercial electronics, as well as Air Force and other military electronics, potentially leading to the use of silicon nanomembranes as the primary platform for future high-speed electronics; flexible electronics; and nanophotonics, including silicon lasers. The breakthrough could also impact the advancement of sensors technology, aiding efforts to develop highly sophisticated guided wave and wireless networks for connecting command and control operations with dense arrays of intelligent sensors, compact reconnaissance platforms, and unmanned and manned military assets.

AFRL Developing Options for Next-Generation Strike Tanker

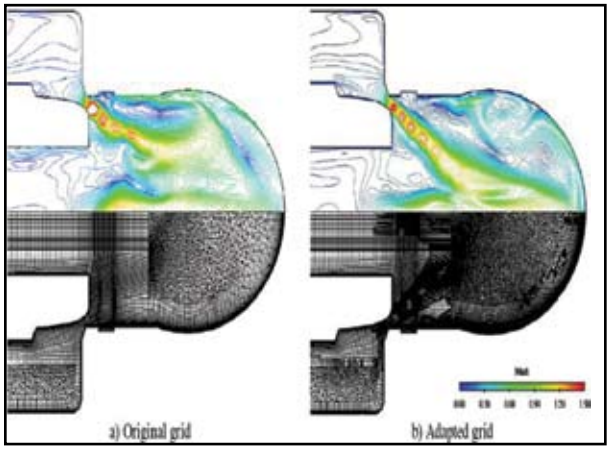
AFRL is laying the groundwork to develop a next-generation tactical tanker concept. This tanker will retain its high-lift characteristics to enable forward basing while producing a very stable wake, which will create an acceptable flow field to refuel a wide variety of air vehicles.

AFRL and Lockheed Martin partnered to complete approximately 200 hours of wind tunnel tests on a next-generation tanker concept model. During 2 weeks of testing at Lockheed Martin's Marietta (Georgia) facilities, engineers collected aerodynamic data to show the effects of placing tanker equipment in various positions on the model. The team analyzed this data to better understand how changing the equipment's position between locations (e.g., on the model's centerline or in a pod on the wingtip) might affect a future tanker's lift and drag, as well as its compatibility with advanced platforms.

In addition, the engineers conducted several tests in which they placed a receiver model in refueling positions behind the tanker. Their test data showed how the tanker-generated aerodynamic flow affected the receiver. Engineers will use this information to evaluate design options for the future tanker concept.

These tests were part of a continuing effort to develop options for the Air Force's next-generation tanker. To develop this highly versatile tanker of the future, AFRL is conducting in-house work in conjunction with Lockheed Martin and Boeing. The team is exploring the combined use of existing technology and unconventional thinking to create a tanker that can refuel a range of aircraft, including fighter aircraft, unmanned air vehicles, and helicopters.

AFRL Improves Accuracy of Computational Fluid Dynamics Calculations



AFRL designers can maximize air vehicle performance and minimize cost when they know how air flows over an air vehicle concept. AFRL developed a tool that improves the accuracy of the computational fluid dynamics (CFD) solutions that the laboratory uses to study this type of airflow. This advancement improves AFRL's ability to deliver low-cost, high-value designs to support the warfighter.

As part of a Small Business Innovation Research effort, AFRL worked with Combustion Research and Flow Technology, Inc. (known as CRAFT Tech®), of Pipersville, Pennsylvania, to develop a tool that improves the accuracy of unstructured CFD solver programs. The tool uses the solver's initial solution to determine where scientists should add or remove grid points within the CFD mesh. This capability enables more accurate solutions for problems such as predicting design performance before air vehicle production; this knowledge narrows design options prior to completing an expensive manufacturing process. In addition, scientists can use the same technology to analyze existing air vehicles. This technology also complements existing wind tunnel testing tools that laboratory experts currently use to improve vehicle performance.

CFD computer programs solve mathematical equations to predict what will happen when a fluid (or air) flows around a structure, such as an air vehicle. The CFD mesh is the three-dimensional grid of data points on and around the structure. Equation solutions occur at these grid points. This grid can be (1) structured, a method which uses multiple cubes (or blocks) of regularly spaced points deformed to follow the vehicle geometry; or (2) unstructured, a method in which the field contains irregularly placed points that connect to form various geometric shapes (e.g., tetrahedrons or prisms). The regular pattern of structured grids simplifies the process of solving the mathematical equations to a given level of accuracy; however, this requires an immense amount of time and expertise to lay out a model's optimal block structure, especially when the model is complex.

Because unstructured grids do not have to adhere to the prescribed layout of a structured grid, their creation is much more automated. Thus, scientists can create an unstructured grid for complex vehicle geometry in days or weeks (versus the weeks or months needed for producing a structured grid). Therefore, unstructured methods result in quicker attainment of CFD solutions for complex air vehicle designs. The drawback of both unstructured and structured grids is that the initial placement of grid points is not necessarily the layout scientists need for obtaining an accurate answer. AFRL's new CFD tool helps to overcome this drawback by using the initial CFD solution to determine what grid points scientists should add or remove to improve the final solution's accuracy.

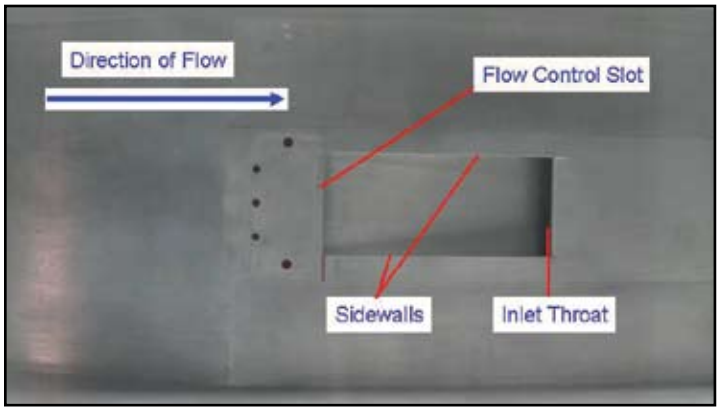
AFRL Proves Feasibility of Plasma Actuators

AFRL is laying the groundwork to develop revolutionary hypersonic aerospace vehicles. Researchers are examining the feasibility of replacing traditional mechanical actuators, which move like wing flaps to control an air vehicle's flight control surfaces, with plasma actuators that require no moving parts and are more reliable.

As part of its Boundary Layers and Hypersonics program, AFRL conducted a wind tunnel test to evaluate the feasibility of using plasma actuators for airframe flight control. The Boundary Layers and Hypersonics program is developing the knowledge of fluid physics to facilitate future revolutionary aerospace vehicle designs. The program focuses on characterizing, predicting, and controlling high-speed fluid dynamics phenomena, including boundary layer transition; shock/boundary layer and shock/shock interactions; and other airframe propulsion integration phenomena, such as real-gas effects, plasma aerodynamics, magnetohydrodynamics, and high-speed flow heat transfer.

In AFRL's Mach 5 Plasma Channel wind tunnel, engineers used a strong electric field to ionize air around an air vehicle model to create plasma. This wind tunnel relies upon a vacuum system to generate low-density airflows. High electrical voltage applied between metal electrodes on a model in the plasma channel ionizes the air between the electrodes and creates plasma, a state of matter in which electrons are stripped from molecules. Man-made plasma usually exists at the extreme temperatures and pressures common to the conditions within a star or around an in-flight hypersonic vehicle, but man-made plasma is also present in items such as fluorescent lightbulbs and computer screen plasma displays. In AFRL's tests, the plasma-heated air successfully exerted force on the model and demonstrated that the plasma actuator concept is a viable area for further study and development.

AFRL Enhances Reactive Conformal Inlet Technology



As part of its Reactive Conformal Inlet Technology Enhancement program, AFRL is examining conformal inlet technology. Conformal engine air inlets are flush to an air vehicle's fuselage, causing less drag and increasing survivability compared to other inlet designs. AFRL is examining technology to take full advantage of the benefits associated with conformal inlets while minimizing a common drawback—airflow distortion that negatively affects engine performance.

AFRL investigated a conformal inlet that incorporated active flow control with an injection slot near the leading edge of the conformal inlet ramp in order to keep flow attached to the ramp. AFRL evaluated two flow control slots. The first flow control slot was larger, with a slot height equal to 20% of the inlet height. The second flow control slot was smaller, with a slot height equal to 5% of the inlet height. In addition, engineers evaluated the effectiveness of the ramp's sidewalls, since the shape of these sidewalls passively influences air quality.

AFRL engineers evaluated the effectiveness of these active and passive flow control variations during a wind tunnel test involving various tunnel Mach numbers, inlet mass flow rates, and flow control mass flow rates. Test results showed that the smaller flow control slot performed as desired and was most effective at lower wind tunnel Mach numbers and at higher active flow control mass flow rates. While the ramp sidewalls did not significantly influence air quality, they proved a good starting point for further research. AFRL engineers are working to incorporate this valuable data into future conformal inlet designs that require smaller amounts of active flow control air and have improved passive flow control methods.

AFRL Earns Patent for Airframe Integrated Energy Storage Technology Concept

Future air vehicles with onboard systems for powering directed energy weapons will require capacitors that, if manufactured using today's technology, would weigh thousands of pounds. Consequently, AFRL researchers have begun exploring ways to integrate load-bearing capacitor fibers into air vehicle structure to reduce airframe weight, free up valuable space, and offer fuel cost savings.

Three AFRL scientists, Mr. William Baron, Dr. Maxwell Blair, and Ms. Sandra Fries-Carr recently earned a US patent entitled "Airframe Structure-Integrated Capacitor." The patent is for integrating high-performance capacitors with load-bearing, composite structures. The team proved the preliminary feasibility of this concept with analysis, fabrication, and test of a composite material. The resulting "compacitor" technology is part composite structure and part charge-carrying capacitor. Currently, AFRL is improving the concept's overall energy storage and structural performance capability. Laboratory scientists are also researching improved structural dielectrics and composite electrodes that offer even greater weight reductions.

The weight of conventional capacitors is a major factor in sizing future air vehicles for directed energy applications. The availability of compacitor technology will aid engineers in designing smaller air vehicles that can deliver short pulses of electrical energy to energize directed energy weapons or provide the power necessary for air vehicle subsystems. Compacitor technology has many potential benefits for commercial industry as well. For example, compacitor technology could support the development of future electric automobiles by providing surge current to complement emerging battery and fuel cell technology.

AFRL Successfully Tests Small Unmanned Air Vehicles

As part of the Cooperative Operations in Urban Terrain (COUNTER) project, AFRL scientists used unmanned air vehicles (UAV) to conduct flight tests designed to provide special operations forces with situational awareness in an urban environment. Small obscured urban targets are harder to detect from high altitudes. UAVs flying at lower altitudes increase the probability of detecting and identifying objects on the ground and are therefore an ideal solution for surveillance of potential threat targets in urban areas.

The COUNTER project involves a small UAV (the BAT-3), which flies at altitudes of 2,000 to 10,000 ft while collecting video telemetry that enables potential targets to be nominated for further inspection. The BAT-3 works in conjunction with a micro UAV (the Nighthawk). The Nighthawk flies at still lower altitudes in the urban area, performing close-range surveillance of nominated targets to determine if a threat exists. The two UAVs send their collected video telemetry to the Vigilant Spirit Control Station, the command and control interface, for analysis.

During recent tests conducted at the Jefferson Proving Grounds, located in southern Indiana, researchers conducted a series of three UAV flights over 2 days to test BAT-3 and Nighthawk performance. Although weather limited some of the tests, the team successfully confirmed the connectivity, two-way communication, video telemetry transmission, and cooperative control algorithms of both the two UAVs and the Vigilant Spirit Control Station. The tests also verified each UAV's ability to autonomously generate and follow specified trajectories. Future COUNTER project tests will include flight demonstrations in an urban terrain environment, which will test the vehicles' navigation capabilities in cityscapes.

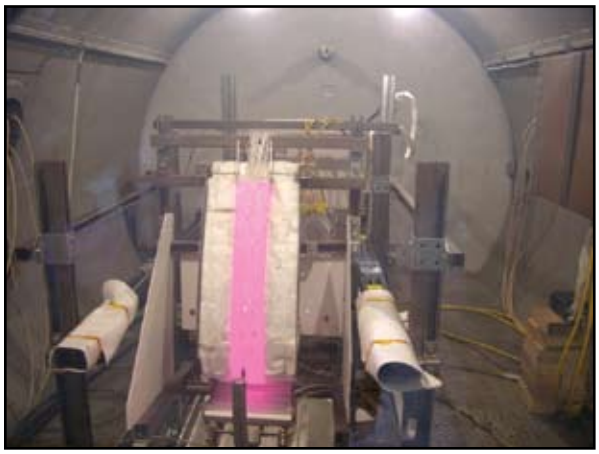
AFRL Leads Falcon HTV-1 Model Tests

The Falcon program, a joint effort between Air Force Space Command and the Defense Advanced Research Projects Agency, is an initiative focused on developing and validating technologies needed for prompt global reach while demonstrating affordable and responsive spacelift. The in-flight technologies undergoing maturity as part of this effort range from manufacturing technologies (including those enabling low-cost expendable launch vehicle concepts) to reentry technologies (including thermal protection materials and guidance and navigation systems).

AFRL researchers led the first Falcon Hypersonic Technology Vehicle (HTV-1) model wind tunnel tests. They conducted these tests to investigate localized aerodynamic heating and validate the accuracy of computational fluid dynamics (CFD) predictions. HTV-1 represents the first of three vehicle designs to be examined under the Falcon program.

Engineers from AFRL and Falcon prime contractor Lockheed Martin identified six HTV-1 flight configurations for experimental validation. The National Aeronautics and Space Administration (NASA) Langley Research Center manufactured six models representing these configurations. The models consisted of a ceramic base coated with phosphor paint, which when heated and exposed to ultraviolet light, emits radiant energy proportional to the model's surface temperature. During testing in the Mach 10 wind tunnel at NASA's Langley site, a charge-coupled device camera recorded the models' respective heating patterns. Engineers used this recorded data to verify corresponding CFD predictions. The entire process—from initiation through testing—took less than 2 months, a testimony to the team's skill.

AFRL Successfully Tests Heat-Pipe-Cooled Leading Edges



AFRL scientists completed thermal validation tests to verify the performance of a heat-pipe-cooled wing leading edge. The effort, which furthers the development of reliable, maneuverable space operating vehicle (SOV) technology, demonstrated a technology readiness level (TRL) increase, advancing the technology's viability from TRL 4 to TRL 5. The heat-pipe cooling technology could have potential application to any type of reentry aircraft or hypersonic cruise vehicle.

Heat pipes are metal tubes that evenly distribute heat from one spot on a structure across the structure's entire surface area. This redistribution prevents localized "hot spots" from forming; left unchecked, such hot spots could precipitate component failure. Consequently, AFRL scientists are seeking to incorporate heat-pipe cooling technology into vehicle wing structures. Heat-pipe-cooled leading edges reduce the mass of a wing's leading edge significantly compared to an actively cooled leading edge. Since SOVs require a high degree of maneuverability upon reentry, a small leading edge radius is critical.

Researchers tested a heat-pipe specimen constructed of a superalloy (which can withstand very high temperatures) surrounding lithium (which melts at lower temperatures). When the wing becomes hot, as it would during reentry, the lithium within the pipes vaporizes at the hottest areas of the leading edge and condenses into a liquid at the cooler areas. This process distributes heat evenly throughout the leading edge and ensures that materials in the hottest areas do not exceed their temperature limits. To mimic the heat distribution that a structure would encounter in a reentry situation, the researchers used heat lamps to test a heat pipe 4" in width and 36" long. The test successfully verified the pipe's functionality and determined the article's heat transfer capacity.

AFRL Completes Automated Aerial Refueling Station-Keeping Flight Test

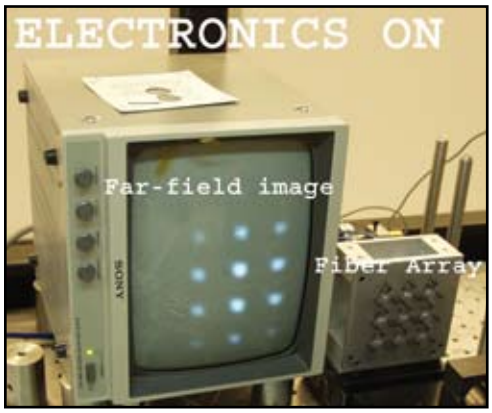
AFRL researchers completed a series of automated aerial refueling (AAR) station-keeping flight tests. The test series included the first autonomous flight of an aircraft in the refueling position behind a KC-135 tanker.

The purpose of the AAR program is to develop and demonstrate operationally representative subsystems enabling the existing Air Force (AF) tanker fleet to perform boom and receptacle refueling of unmanned air vehicle (UAV) systems. Expected benefits of AAR to UAV operations include increased combat radius, extended mission time, reduced response time for time-critical targets, reduced need for forward staging areas, and increased in-theater presence. The station-keeping flight test integrated components on the tanker and receiver aircraft to demonstrate the receiver aircraft's capacity to autonomously hold a position relative to the tanker throughout the tanker's execution of standard refueling maneuvers.

During the flight tests, a pilot manually flew a Learjet acting as a UAV surrogate to the contact position behind a KC-135R. Once the aircraft achieved a position at which it could receive fuel from the tanker, the Learjet's AAR flight control system was engaged, which enabled the aircraft to autonomously hold the contact position while the tanker executed both straight and level flight and turns. The AAR system remained engaged at the contact position for 23 consecutive minutes, allowing the Learjet to follow the KC-135 through two full orbits.

Over the next year, the AAR team will build upon the success of the station-keeping flight tests to facilitate new automated refueling capabilities. For example, the team will demonstrate autonomous maneuvering around the tanker, wherein the Learjet's AAR system will first engage at the observation position on the tanker wing and subsequently be directed from a control station to go to the precontact and contact positions upon approval from the tanker crew. This future test will employ simulations combining multiship operations around the tanker and long-distance tanker rendezvous to demonstrate the AAR system's readiness for transition from the Learjet test bed to AF assets.

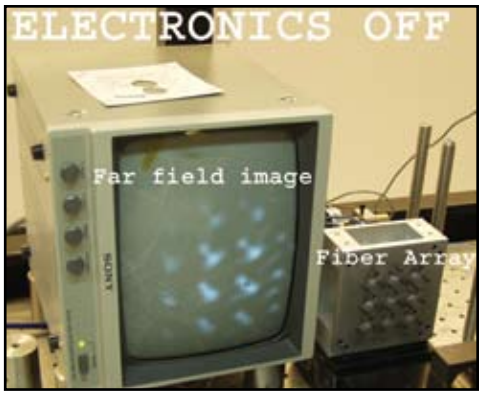
AFRL Invents Coherent Beam Combination Technique



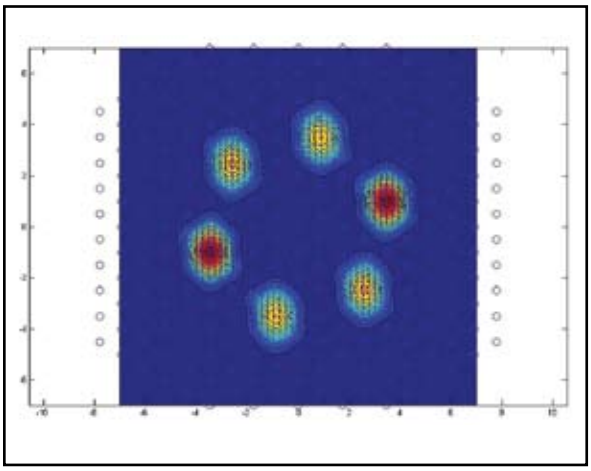
AFRL scientists invented a coherent beam combination technique—Locking of Optical Coherence by Single-Detector Electronic-Frequency Tagging (LOCSET)—that is scalable to a large number of array elements. Existing fiber amplifiers, which are suitable for high-quality beam combination, exhibit 400 W in a single amplifier.

The Department of Defense is interested in developing fiber amplifiers that provide high-efficiency, high-brightness, high-power lasers for tactical missions. The fiber waveguide structure determines the beam quality in single-mode fiber amplifiers and is not affected by thermal gradients. Fiber amplifiers do not require the complex, heavy, power-consuming cooling systems that conventional solid-state amplifiers need for maintaining high beam quality. However, the fiber amplifier obtains its diffraction-limited beam quality by limiting power handling capability. To reach the high power, efficiency, and brightness that tactical applications demand, systems must combine the output of many fiber amplifiers into a single, high-quality beam.

The LOCSET technique easily combines the output of 100 optical fiber amplifiers, providing a clear technical path to an electrically excited coherent fiber laser array with an output of 40 kW and requiring no additional advances in fiber amplifiers. Users can steer the LOCSET coherent array output beam over a small angle and readily apply it to programs using optical phased-array technologies. Efficient, high-brightness, high-power laser systems provide the warfighter with increased capability. The LOCSET technique combines a world-record nine optical fiber beams through coherent beam combination that uses active phase control. Currently, coherent beam combination using active phase control provides the highest power and best beam quality of any beam combination method under investigation.



AFRL-Developed Computer Model Enhances Fiber Laser Beam Quality



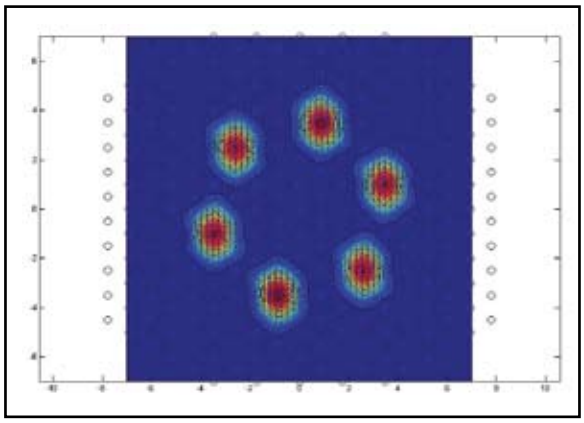
AFRL scientists developed a parallel computer code that incorporates a finite element solution for the thermal stresses induced in the photonic crystal lattice of a six-core, large-mode-area photonic crystal fiber. The code reveals the optimal configuration (i.e., the best placement of airholes and stress-applying parts) for achieving an even power distribution throughout the fiber laser.

Since the fiber acts as a coherent array, good beam quality requires an even power distribution in the core. A key discovery was the important role of the stresses caused by airholes, which can degrade the performance of configurations wherein only stress-applying parts were formerly a consideration.

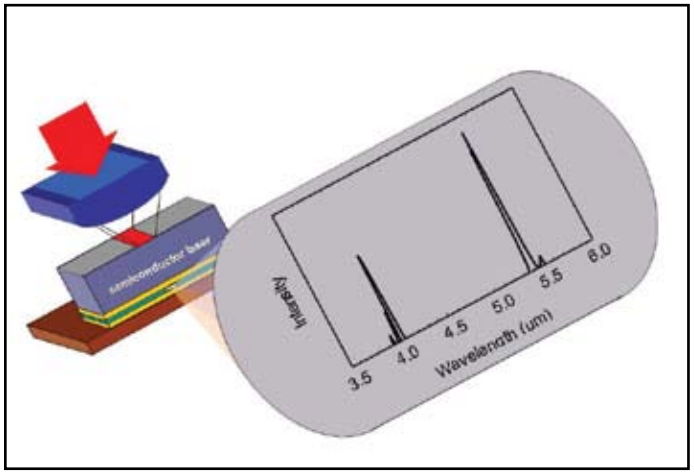
To determine the airhole-induced stress, scientists modeled the temperature change that occurs in the fiber drawing process as a result of differing coefficients of thermal expansion for the host glass and the embedded stress-applying parts. This calculation was the first of its kind in the world, and it is beginning to pay dividends in fiber laser design.

Engineers can use photonic crystal fibers to increase mode size, thereby reducing the peak intensity for a given power output. This technique uses multiple, large-mode cores in which modes are coupled to polarize all outputs in the same direction, in phase, and as one high-intensity beam.

This new design method will facilitate the development of fiber lasers offering high beam quality and single-mode, high-power outputs. Manufacturers can use the approach as a building block for producing weapons-class fiber lasers for use on aircraft. AFRL is currently fabricating this new fiber design for testing.



Two-Color Semiconductor Laser



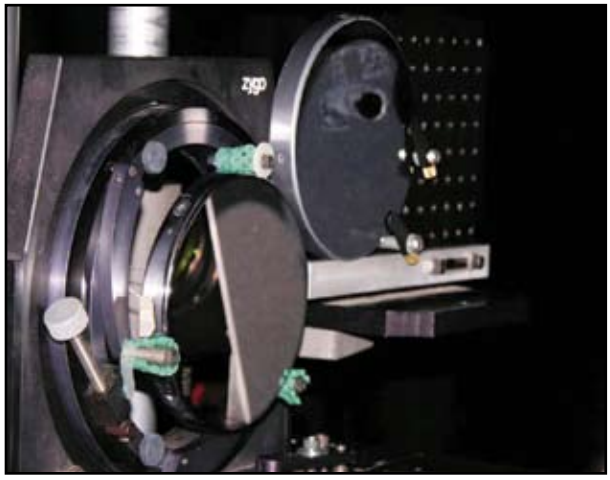
An AFRL team designed, fabricated, assembled, and characterized semiconductor lasers that simultaneously emit at two different midinfrared wavelengths. The team used the Molecular Beam Epitaxy process to grow, process, and characterize a two-color semiconductor laser. This represents a technology wherein a single semiconductor device can produce multiple laser beams of different wavelengths simultaneously.

For this particular device, the AFRL team observed simultaneous laser emissions of ~4100 and ~5400 nm. This accomplishment warrants further investigation to explore the possibility of producing lasers of acceptable power, wavelengths, and quality. If such production is indeed possible, the lasers will fill an immediate market demand, because this technology reduces the laser infrastructure—including beam forming optics and cooling components—of current multicolor systems by nearly one-half.

Compact, efficient infrared countermeasure systems that offer increased counterthreat capability at reduced life-cycle costs will be available for a variety of platforms, including large aircraft. Because of their unique two-color feature, these new lasers can provide a robust infrared countermeasure capability, while resulting in a long-term cost savings for the government.

AFRL expects semiconductor lasers to meet the majority of Air Force tactical requirements, in the low to middle power range, over the next decade. Other potential semiconductor laser applications include remote sensing of chemical and biological agents, as well as tracker, illuminator, designator, combat identification, optical augmentation, and sensor kill capabilities.

AFRL Tests Lightweight Mirror for High-Energy Laser Applications

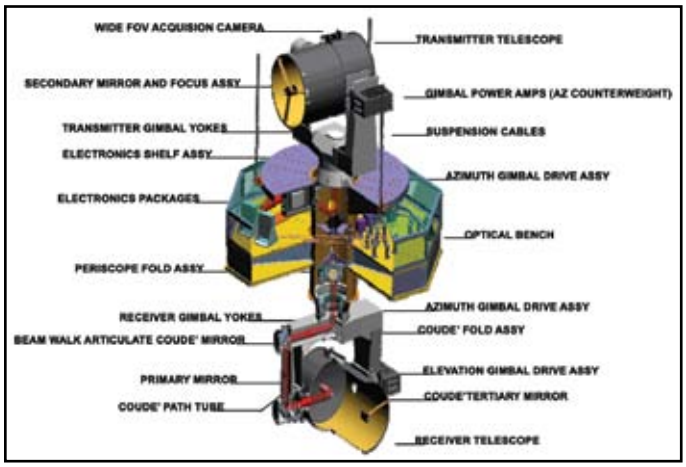


AFRL teamed with the Optical Coatings Evaluation Laboratory and Schafer Corporation (Albuquerque, New Mexico) engineers to perform a live-fire laser test on a 5 in. diameter silicon carbide-silicon lightweight mirror system (SiC-SLMS) weighing less than 1/2 lb. The test simulated high-energy laser (HEL) irradiation of 220 kW distributed over an approximate elliptical footprint of 51 cm^2 with a Gaussian-like intensity distribution. The test consisted of multiple runs, which encompassed up to 166 sec. of lasing. The team checked the laser test setup using a gold-coated BK7 glass mirror, subjecting that mirror to only 13% as much power absorption as the SiC-SLMS.

The test results indicate that the SiC-SLMS with HEL coatings can handle HEL irradiation with minimal thermally induced higher-order distortion. While absorbing almost an order of magnitude greater power than the glass mirror, the SiC-SLMS exhibited less distortion, displaying higher-order distortions of only 0.2 waves and lowering the requirements for the deformable mirrors. Additionally, the tests confirmed that the SiC-SLMS reaches thermal equilibrium seconds after the laser turns off, a critical feature for rapid retargeting. Finally, the tests demonstrated the SiC-SLMS' asymptotic heating, wherein distortion does worsen after the laser reaches a certain point and is still operating.

HELs for airborne applications have strict weight requirements for all system components. Conventional lightweight mirrors use a ribbed-back structure to reduce overall mass. However, extreme temperatures due to the thermal gradient introduced by these ribs cause these mirrors to have print-through. Schafer Corporation developed an innovative design approach for an ultralightweight mirror that eliminates the rib structure and drastically reduces the print-through for both cryogenic and HEL environments. Schafer Corporation engineers are developing a 50 cm diameter SiC-SLMS based on airborne-tactical-laser-like primary mirror specifications under an AFRL Phase II Small Business Innovation Research agreement.

AFRL Completes Aerospace Relay Mirror System Demonstration

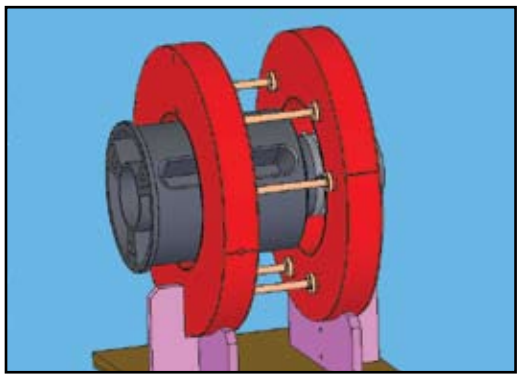


AFRL's Aerospace Relay Mirror System (ARMS) program successfully completed a formal review of laboratory test results. ARMS is a prototype laser relay system designed to redirect and focus the beam of a ground-based or airborne high-energy laser (HEL) onto a target, significantly increasing the HEL's range and lethality. Compared to a regular laser system, a redirected energy beam offers several advantages, including improved beam quality and the ability to hit beyond-line-of-sight targets. Relay systems will improve the engagement timeline, while increasing the standoff range for manned systems and serving as a low-cost force multiplier for HEL systems.

ARMS is a subscale prototype of a future laser relay weapon system. The ARMS technology includes dual line-of-sight pointing, energy capture and transfer, payload integration, and relay system operation and integration. The prototype system serves as a risk reduction test bed for relay system development, including airborne laser performance enhancement; active track; precision strike of time-critical targets; and persistent intelligence, surveillance, and reconnaissance.

AFRL's ARMS program met all hardware and software objectives and received approval to initiate its move to the Starfire Optical Range (Kirtland Air Force Base, New Mexico) for field tests. AFRL demonstrated the payload by performing tracking and pointing in several modes, characterizing all payload functions within the limitations of the laboratory environment. The laboratory tests' major achievement was the refinement of the cooperative tracking between the laser source and the relay receiver. Data analysis provided numerous details about system performance, including sensor performance, tracking overshoots, and settling time.

AFRL Researcher Granted All-Cavity Magnetron Axial Extractor Patent



AFRL directed energy expert Dr. Andrew Greenwood earned a US patent entitled "All-Cavity Magnetron Axial Extractor." The patented technology is a key enabler for packaging a relativistic magnetron high-power microwave (HPM) source into a compact, airborne platform.

Previous schemes for extracting microwave energy from a magnetron source required radially directed waveguides, which do not fit into existing airborne platforms. The all-cavity magnetron axial extractor solves this problem, bringing the relativistic magnetron to the forefront of technologies enabling compact airborne electronic attack systems. This emerging technology provides the means to attack enemy electronics in a nonlethal manner using HPM energy, a method with potential application to attacks against enemy command and control facilities when collateral damage is unacceptable.

Dr. Greenwood's all-cavity magnetron axial extractor design underwent initial test via high-performance computer simulation using ICEPIC—an AFRL-developed improved concurrent electromagnetic particle-in-cell code for massively parallel virtual prototyping of HPM systems. The simulation revealed that the scheme, in addition to being compact, improved the relativistic magnetron operation by equally loading each cavity of the device. The success of the initially simulated device prompted AFRL to employ ICEPIC code for further enhancements, and laboratory experiments are now underway to assess the improved, optimized device.

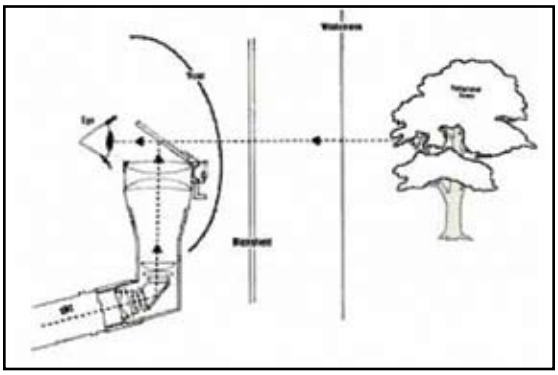
AFRL Researcher Earns Patent for Speech-Based Audio Distance Display System

Users of virtual auditory displays can experience a virtual hearing impairment since current displays do not produce robust distance cues. However, an AFRL researcher has earned a patent for a speech-based audio system that gives listeners the ability to accurately judge the distance of sound sources.

Dr. Douglas Brungart, an AFRL senior computer engineer, earned a patent entitled "Speech-Based Audio Distance Display." The AFRL speech-based audio display is a system that uses vocal effort to manipulate the apparent distances of sound sources in a virtual audio display. For example, a whisper would simulate a nearby sound source, and a shout would simulate a more distant sound source.

AFRL research has shown that the speech-based audio display's distance cues are intuitive enough for listeners with little or no training to use. The laboratory's research has also shown that these distance cues are superior to all other types of distance cues in listening environments where high levels of background noise prevent the use of room reverberation-based audio distance cues. These cues are particularly useful in systems that use spatial audio cues to provide navigation information to dismounted soldiers. With the ability to accurately determine the distance of a sound source, pilots, air traffic controllers, remote vehicle operators, and rescue and recovery personnel can navigate and perform tasks more effectively.

AFRL Develops a Unified Taxonomy for Assessing Visionic Devices



A cooperative effort between scientists at AFRL's Wright-Patterson Air Force Base, Ohio, facilities and the US Army's Aeromedical Research Laboratory, Fort Rucker, Alabama, produced more than 40 test methodologies for conducting laboratory evaluations of visionic devices. The key to properly applying these methodologies lies in the associated, newly developed taxonomic approach. This collaborative endeavor was part of a larger effort conducted under the auspices of the North Atlantic Treaty Organization's Research and Technology Organization panel on Human Factors and Medicine. The working group documented the guidelines for selecting and implementing various methodologies for measuring the performance of prototype and production visionic devices. For its purposes, the group replaced the commonly used term "helmet-mounted display" with the more generic term "visionic device."

Using various kinds of electronic sensors, visionic devices provide warfighters a visual (i.e., pictorial) image of their surroundings; symbolic information may or may not augment these images. The team developed a new taxonomy that not only enables classification of a given visionic device based on optical design and display type, but also provides recommendations regarding specific test parameters that should be measured to ensure the final product delivers expected operational performance.

The new classification scheme is based on both a visionic device's optical design and its display type. The first step in classifying a device requires identifying it (under test) as either non-see-through or see-through. Non-see-through optical designs allow users to view only sensor-provided imagery; they do not provide users a direct, unaided view of the external scene. Conversely, devices built according to the see-through premise permit users to view sensor-provided imagery overlaid upon the external scene.

The second step in the taxonomic approach requires identification of the display type. The choice is between image intensification systems, wherein the sensor and display are integrated into a single component, and stand-alone displays (e.g., cathode-ray tubes and liquid crystal displays).

The third step involves revisiting the optical design to determine if the device uses a monocular or biocular/binocular presentation mode. Biocular/binocular systems require additional testing for alignment disparities between imagery presented to the two eyes. Once these three taxonomic determinations have effectively classified the visionic device under test, researchers can consult tables containing recommended test parameters and corresponding methodologies.

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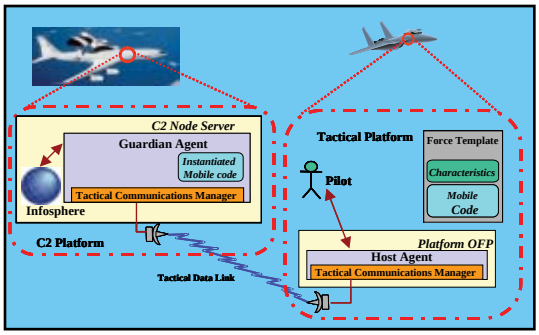
Network-Centric Technologies Connect Warfighters to the Global Information Grid



The advent of network-centric technologies offers enormous improvement in useful information available to command and control (C2) and warfighter participants in both hostile battlefield and peace-keeping situations. AFRL is addressing the problem of affordably integrating current and future systems into the battlefield infosphere.

AFRL and Boeing are pursuing an initiative called the Insertion of Embedded Infosphere Support Technology (IEIST). The premise of IEIST is to develop concepts allowing current and future platforms, such as tactical strike fighters, to become clients of the Global Information Grid (GIG). IEIST demonstrates technologies that efficiently express the information needs and collection capabilities of each platform and also links each platform with corresponding information sources and destinations throughout the GIG.

In providing weapon systems with access to global information and allowing users to coordinate and pair these systems with time-critical targets to better leverage capabilities, IEIST offers two unique technical innovations: the Force Template (FT) and the Guardian Agent (GA). FTs characterize weapon systems and enable a standard means for weapon systems to communicate with GIG elements. The FT "knows" the particular details of its corresponding weapon system, recognizing such aspects as weapon load, available fuel, location, operational capabilities, crew experience, and interface requirements. The GA resides off the aircraft, adding capability to the weapon system without straining available onboard resources. Essentially, a weapon system's FT creates its unique GA.

The GA reviews, filters, and formats information that is relevant to the warfighter. It also publishes time-critical, warfighter-discovered information to the C2. The FT provides a vehicle for characterizing legacy warfighting systems and enhancing their potential for meaningful participation in network-centric engagements. For information flowing from the platform, the GA provides a bridge to publish platform data to the infosphere. Such information could include mission updates, weapon status, and/or other platform state data or state changes. The GA's knowledge of its mission platform includes the mission route; therefore, for each sensor report it receives, the GA is able to make evaluations based on the route and signature of the platform.

AFRL Develops New Video Imaging Technology

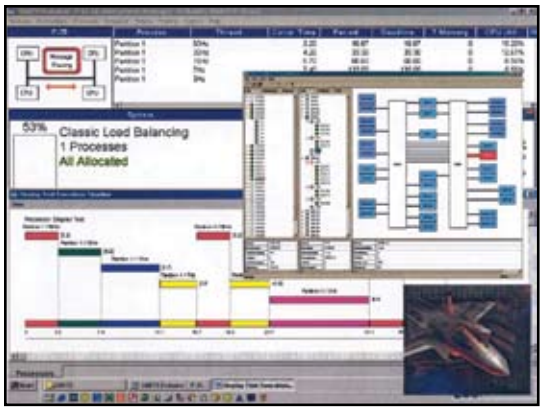
AFRL engineers improved battlefield communications with the development of an advanced video encoder that will increase the transportation speed, quality, and quantity of images that unmanned air vehicles supply while surveying battlefields. The technology will enhance the flow of video information from the battlefield through the use of commercial off-the-shelf products, including software.

AFRL teamed with FastVDO, a video imaging technology company based in Columbia, Maryland, to produce a new and improved video encoder. FastVDO is one of 46 companies—including commercial entities such as Motorola, Nokia, Sharp, Sony, and Texas Instruments—who belong to the Advanced Video Coding (AVC) Alliance, a nonprofit community of like-minded companies committed to the active promotion and the industry-wide success of AVC technology. AFRL and FastVDO began their team effort in 2002 under the Dual-Use Science and Technology program, which encourages Air Force and industry collaboration in a 50-50 technology development cost-share to contribute to military capabilities and commercial markets. The highly successful program has enabled the military and its commercial partners to quickly advance technological innovations in a cost-effective manner.

The new video encoding technology appeared in an exhibit during a National Association of Broadcasters convention held in Las Vegas, Nevada. AFRL supplied military funding, and FastVDO supplied commercial money—with both organizations hoping to reap the benefits of an advanced video encoder that converts traditional video to digital format for subsequent transmission to a distant user.

The new video encoder complies with the new AVC standard that the International Organization for Standardization (ISO) and the International Telecommunication Union (ITU) jointly developed. ISO and ITU are two international standards organizations that set broad interoperability and design criteria for world manufacturers to employ while producing ISO and ITU products. The new standard allows the advanced video encoder to transport better-quality information using less bandwidth and frequency spectrum.

AFRL Analysis Tool Provides Over 10 Years of Real-Time Scheduling Solutions



Under AFRL's Dynamic Avionics Real-Time Scheduling (DARTS) program, Lockheed Martin has performed over 10 years of embedded hardware and software resource allocation trade studies for embedded information weapon systems such as the F-16, F/A-22, and the F-35 Joint Strike Fighter (JSF). In particular, the DARTS schedulability analysis tool analyzes tasks allocated to available processors using rate monotonic scheduling techniques, ensuring the completion of all task deadlines under mission conditions.

The DARTS program introduced dynamic allocation technologies into the domain of embedded, resource-constrained real-time avionics systems, a subject area in which scientists rarely use these technologies. DARTS has supported successful in-context JSF demonstrations of dynamic binding and scheduling technology, analysis of F/A-22 avionics stability problems, and initial schedulability tests for production F-35 mission systems designs. Using DARTS' distributed, multiprocessor resource management capabilities as a foundation, the Defense Advanced Research Projects Agency's Adaptive Software Technology Demonstration project added features to assess embedded applications with time-varying loads.

DARTS' numerous technology benefits are applicable throughout the system design and implementation process. Releasing system designers from the requirement of binding tasks to processors too early in the design process—long before the formulation of realistic resource estimates—allows the designers to focus on solving domain problems. Likewise, delaying the time at which designers must make task-to-processor binding decisions allows the system to automatically cope with the additional task interactions that are not in the original design. Dynamic binding simplifies subsequent system upgrades by building into the platform the ability to relocate tasks as other tasks grow or diminish in priority.

The DARTS schedulability analysis tool has continued to evolve. It forms the basis for DARTS Architect, which offers the capability to rapidly and accurately perform systemwide allocation trade studies by integrating models of network throughput, node-level rate monotonic central processing unit utilization, hardware memory, and bus bandwidths. The DARTS program's resulting products continue to lead in the demand for advanced middleware and scheduling theory for embedded information systems.

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AFRL Develops Network-Centric Monitor for Multiple Heterogeneous Data Streams

Engineers from AFRL and ITCN, Inc. (Dayton, Ohio), are developing a Real-Time Data Monitoring and Correlation (RTDMC) system to acquire data from multiple heterogeneous data streams simultaneously, and time-correlate events contained in the data content. This data acquisition is controllable and distributable over local or global networks.

The team is expanding ITCN's SystemTrace™ product line to include Ethernet capability. This expands the SystemTrace capabilities to include real-time nonintrusive monitoring of concurrent VersaModule Eurocard (VME), MIL-STD-1553B, and Ethernet data buses.

The RTDMC system allows monitoring of data streams on individual buses and/or simultaneous monitoring of data on multiple heterogeneous data buses. The new Ethernet probe is capable of monitoring and recording application-level data variables on 10/100/1000 Mb Ethernet networks. This allows data stream analysis between all devices on the network during data transfers.

The system supports up to 256 unique filters to be monitored per probe per session. Monitored symbols may be defined from a single bit size to double-precision floating-point values. For time stamping, the architecture uses an Interrange Instrumentation Group-based time stamp, allowing monitored data streams to be miles apart. This networked instrumentation architecture addresses the need for system-level instrumentation that can trace "data flow" by monitoring key points throughout the target system with absolute time correlation of the captured data for analysis, performance monitoring, diagnostics, or prognostics.

The RTDMC system allows developers, integrators, users, and maintainers to nonintrusively monitor real-time VME, MIL-STD-1553B, and Ethernet data streams distributed throughout embedded and/or physically dispersed networked systems. The system will significantly aid software test and evaluation, system integration, maintenance, performance monitoring, mission monitoring, and diagnostic/prognostic performance arenas, reducing system development and maintenance costs throughout.

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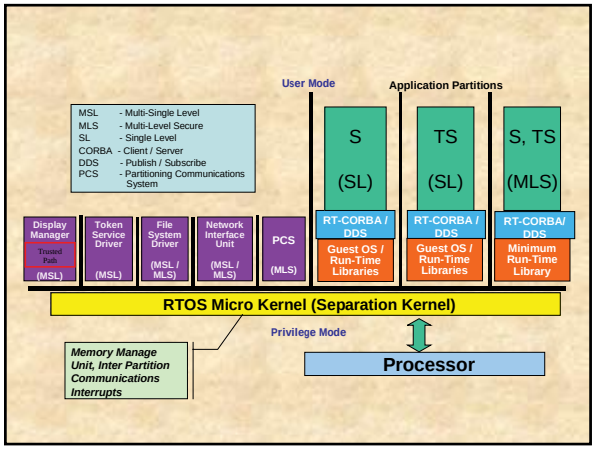
AFRL Successfully Demonstrates High-Assurance Security Architecture

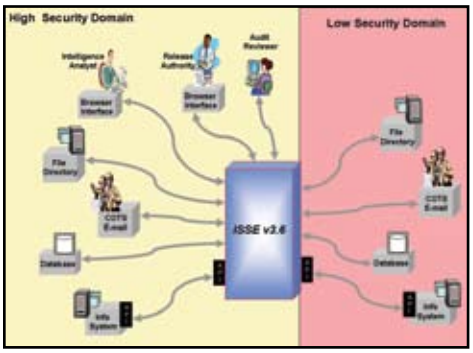


AFRL is working with industry under the High-Assurance Security Architecture for Embedded Systems program to develop and advance the Multiple Independent Levels of Security/Safety (MILS) architecture, an enabling technology offering an affordable near-term solution to building high-assurance systems such as multilevel security systems. AFRL successfully demonstrated the MILS architecture by integrating products from competing commercial off-the-shelf (COTS) vendors to showcase the benefits of the MILS architecture applied to warfighter nodes and connected to the Global Information Grid (GIG).

Raytheon, under contract with AFRL, provided the application software and orchestrated the MILS demonstration, which presented a simulated airborne reconnaissance mission scenario using MILS products supplied by leading software vendors and running on networked processors and workstations. The simulated scenario included control and sensor applications running at different levels of security on the same processor and featured an animated display of aircraft and targets on a MILS workstation. The reconnaissance aircraft were simulated on embedded processors running MILS separation kernels from three COTS vendors: Green Hills® Software, LynuxWorks™, and Wind River Systems. A Linux® workstation represented the reachback into the GIG. The MILS communications software, developed by Objective Interface Systems, ensured the separation of multiple levels of data across platforms through the use of COTS hardware and software.

AFRL and its industry partners successfully demonstrated a capability to affordably ensure the separation of multiple levels of data using COTS components. This technology provides the Air Force (AF) and other services with a capability to protect warfighter data, thereby contributing significantly to the AF's position as a leader in the global information systems technologies defense arena. Furthermore, the MILS architecture is not only applicable to the Department of Defense, but is directly transferable to other domains involving a critical infrastructure, including supervisory control and data acquisition, financial, medical, intelligent transportation systems, and consumer electronics applications--all of which require secure, high-assurance performance.

AFRL Engineers Complete ISSE V3.6 Critical Design Review



AFRL engineers successfully completed a critical design review (CDR) of the Information Support Server Environment (ISSE) version 3.6. Upon completion of the CDR, AFRL received approval to proceed with implementation from major stakeholders, which include the Air Force Command and Control Intelligence, Surveillance, and Reconnaissance Center (AFC2ISRC); Director of National Intelligence Chief Information Office; Defense Intelligence Agency; Defense Information Systems Agency; and National Security Administration. ISSE v3.6 is an AFC2ISRC-sponsored controlled interface (CI) capable of connecting multiple security domains and facilitating the secure transfer of various formatted and unformatted data types between those domains.

AFRL is developing ISSE v3.6 to provide intelligence analysts and operational users a cross-domain data transfer solution that complies with Director of Central Intelligence Directive 6/3. The new version represents a complete overhaul of the previous version and provides increased flexibility, expands input/output options, dramatically improves throughput, centralizes audit collection and analysis, uses public key infrastructure (PKI) encryption, and automates transfer of highly structured data. The new architecture extends the system to allow bidirectional data transfers between a single, controlling security domain (such as a Joint Worldwide Intelligence Communication System network) and multiple, noncontrolling security domains (such as the Secret Internet Protocol Router Network and coalition networks).

AFRL designed the new version's highly extensible architecture to be the first CI to provide cross-domain transfer of unstructured data input from commercial off-the-shelf (COTS) e-mail applications, COTS browsers, and file directory drops. ISSE v3.6 will simultaneously accommodate automated transfer of structured data from information systems through the ISSE application programming interface. The new version has advanced file-type checking, virus scanning, malicious code inspection, and Microsoft® Office hidden-content inspection capabilities to protect the connected networks and prevent spillage of highly classified information to lower-security domains. PKI mechanisms maintain data integrity. ISSE v3.6 will provide operational users within the Air Force, Department of Defense Intelligence Information System, and intelligence community an increased ability to share information across security domains, while simultaneously reducing the risk associated with allowing connections to classified security domains.

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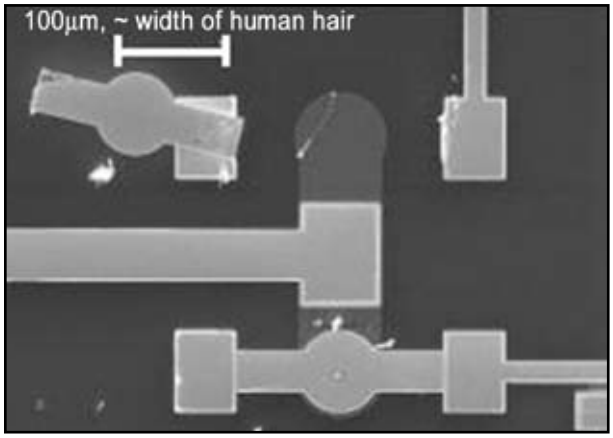
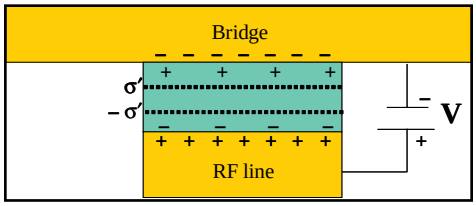
AFRL Research Provides Valuable Data for Improving MEMS RF Switches



AFRL scientists explored and documented the relationships between bias voltage, dielectric charging, microscale adhesion, and surface roughness during switch operation. They collected all data under precisely controlled operating conditions in a well-defined environment. Their findings improve the Air Force's (AF) understanding of capacitive microelectromechanical systems (MEMS) radio frequency (RF) switch failure mechanisms, an essential step in the quest for advancements in wireless systems, radar, aviation instrumentation, automotive technology, and secure communications.

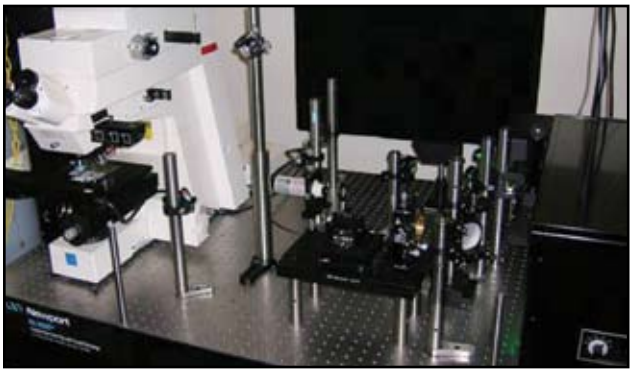
AFRL scientists conducted fundamental studies of gold-on-silicon nitride contacts at various bias voltages using the switch simulator to measure and/or control fundamental parameters such as contact force and adhesion, which they cannot measure with actual switches. The studies demonstrated that excessive adhesion was the primary failure mechanism and that both mechanical and electrical effects were contributing factors. Excessive adhesion can explain decreased lifetime at the high bias voltage previously reported with actual capacitive MEMS switches. The experimental results explained the switch's sticking, self-actuation, failure to actuate, and self-release.

Surface analysis data from the research revealed the presence and growth of a film containing carbon and oxygen. The film is responsible for aging-related adhesion reduction by increasing surface separation and/or reducing surface energy. Also noted, junction growth did not occur with capacitive switch contacts in simple loading experiments, as previously observed with gold MEMS direct current contacts at low current.



MEMS RF switches offer tremendous potential for a myriad of commercial, aerospace, and military applications. They also have significant advantages over conventional switches, including high linearity, low insertion loss, low power consumption, reduced size, wider temperature range, good isolation, high shock resistance, and low cost. Performance and reliability enhancements will facilitate dramatic improvements in military technologies directly supporting the AF warfighter.

AFRL Scientists Refine 3-D Mapping Capabilities



AFRL scientists refined three-dimensional (3-D) mapping capabilities, successfully producing 3-D maps of mechanical and thermal material properties with 1 μ resolution. AFRL combined Brillouin spectroscopy, which measures small energy shifts of scattered light from material, with a confocal laser scanning microscope (CLSM) to extend 3-D mapping and laser scanning capabilities.

Engineers can use this unique and powerful tool for nondestructive evaluation of a variety of materials systems. The system determines discrete material properties for each constituent from the scattering point, a useful feature in exploring macro- and nanocomposites. For structured materials such as devices and coatings, the system gathers this information from multiple points, not only providing valuable information on the discrete regions, but also indicating how the various materials and interfaces affect the properties of other regions.

Coupling CLSM usage with Brillouin spectroscopy expands the utility of the instruments, enabling the creation of 3-D high-resolution (spatial) maps of material properties. The CLSM provides the 3-D mapping ability, while the Brillouin spectroscopy analyzes the tiny changes in light frequency coming from the confocal microscope. The 3-D mapping and reconstruction of the physical properties of materials provides valuable information on materials systems and interfaces, as well as the ability to perform Brillouin spectroscopy on a single point embedded within the material. This gives researchers more accurate and in-depth information. It also provides the ability to obtain both mechanical measurements on extremely small samples (~1 μm) without physical contact and thermal measurements without heating the sample.

Nanomaterials research relies on the capability to directly measure mechanical, optical, and thermal properties at the material surface, in bulk, and across an interface. Therefore, the availability of this information is invaluable in most basic research, device manufacturing, and failure analysis efforts.

AFRL Develops Biofuel-Powered Heated Vest

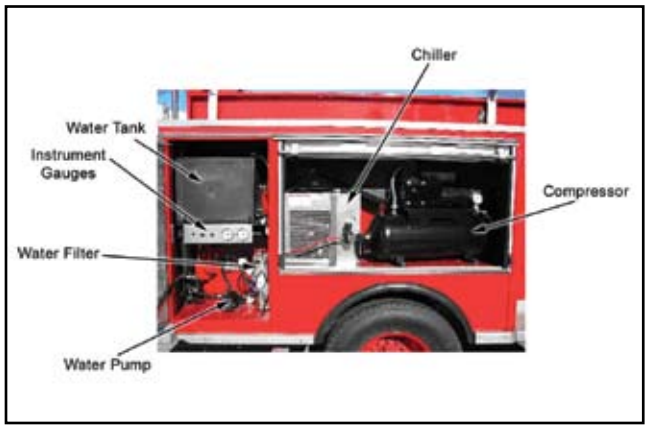
AFRL and Vacca, Inc. (Cincinnati, Ohio)—with consultation from the Army Natick Soldier Center (Massachusetts)—financed the development of a low-cost, lightweight heated vest. The heated vest allows an individual to reduce cold-weather gear by as much as 50%, increasing his or her agility in the field. The vest aids a person's ability to maintain normal body temperature in harsh winter environments.

Today's military personnel wear 15-piece cold-weather uniforms, which can be bulky and cumbersome to wear and carry. Additionally, these individuals are at greater risk when they must take off body armor to add or remove clothing layers. To meet the cold-weather needs of military personnel, AFRL conducted market research and evaluated several methods for maintaining a healthy body temperature in colder climates. As a result, the laboratory funded the integration of Vacca's biofuel-powered flameless catalytic heaters into a vest. The lightweight, easy-to-use prototype combines a standard work vest with two biofuel-powered heaters (located in the vest's two front panels). Using fuel cell concepts developed at Los Alamos National Laboratories, Vacca developed heaters that pass methanol or ethanol across a catalyst membrane. The reaction by-products are heat, carbon dioxide, and small traces of water. The prototype currently weighs 12 oz, with the potential to weigh 8 oz in future designs. The existing prototype's weight is dramatically less than the 1.7 lb commercial products on the market today.

Commercially introduced lithium-ion-heated jackets provide heat for 2.5-3 hrs before the user must recharge the battery. In contrast, Vacca's revolutionary prototype, according to the company's final report, can last 22 hrs with 100 cc of fuel in low-heat mode (22 W) and 12 hrs in high-heat mode (42 W). Users can adjust the vest's internal fuel supply to high, low, and off settings for increased control.

Vacca's lightweight heated vest and the fuel it uses are more affordable for the Department of Defense compared to current commercial products. AFRL purchased biofueled prototypes, which are currently in use to demonstrate the technology's feasibility. With additional funding to develop flexible heaters, user-friendly fuel storage, and a robust heat distribution system, scientists could debut this product in 2007, ultimately revolutionizing weight and efficiency for the heated-garment market.

AFRL Evaluates Lifesaving Body Cooling Technology for Firefighters

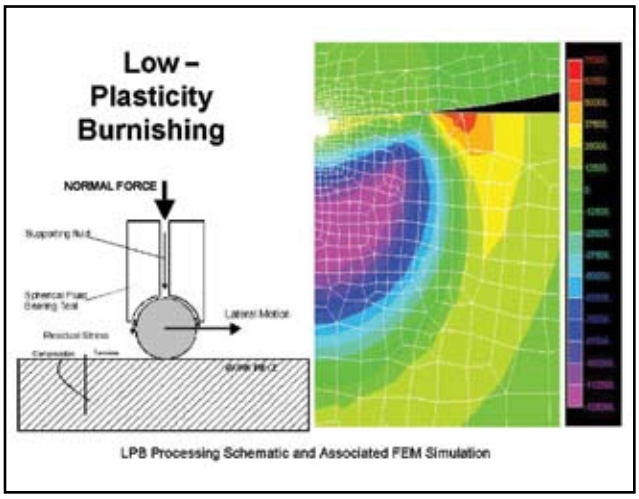


AFRL's Fire Research Group is evaluating the Vapor Relief™ System (VRS), a new, commercial off-the-shelf technology that is leading the way in providing firefighters with the means to stay cool in extreme heat conditions. The VRS has potential uses throughout the Department of Defense and the civilian firefighting community. This cooling technology is particularly useful in the desert and other hot climates, and it is also an effective apparatus for chemical and biological decontamination purposes. AFRL integrated the VRS into a standard P-27 firefighting vehicle and performed preliminary evaluations to determine the initial benefits that this type of cooling system may provide firefighters in the field.

At the request of the Air Force Fire Protection program, AFRL performed a series of 26 evaluations in which 18 firefighters observed the VRS' effectiveness in preventing heat exhaustion. The VRS is a humidification technology in which a combination of chilled water and pressurized air creates atomized water vapor (mist) that decreases the surrounding area's air temperature. The evaporating water droplets lower the ambient air temperature, and preliminary research shows that the cool mist causes test subjects to experience a decreased body temperature and a refreshing interlude from the intense heat conditions. AFRL designed the evaluations to determine the effects of the atomized mist as it surrounds the body, as well as the length of time required to cool a person and/or return the individual to a fully functional level. During the tests, a radio frequency telemetry sensor on each firefighter recorded heart rate, activity level, and skin temperature. The firefighters performed physical labor for approximately 12 minutes; they then received a 5-minute exposure to the cooling system while cooling down. Scientists obtained baseline data by performing a second set of tests in which the firefighters did not receive exposure to the cooling system during the cooldown period.

The overall performance of the VRS in firefighter applications is still under study; however, these preliminary findings indicate that this innovative concept may have future potential to prevent firefighters from suffering the effects of heat stress brought on by the severe conditions in which they fight fires. When the evaluations are complete, the Air Force may consider the cooling vapor technology for installation on its future fire trucks.

AFRL Tests Low-Plasticity Burnishing on 300M Aircraft Landing Gear



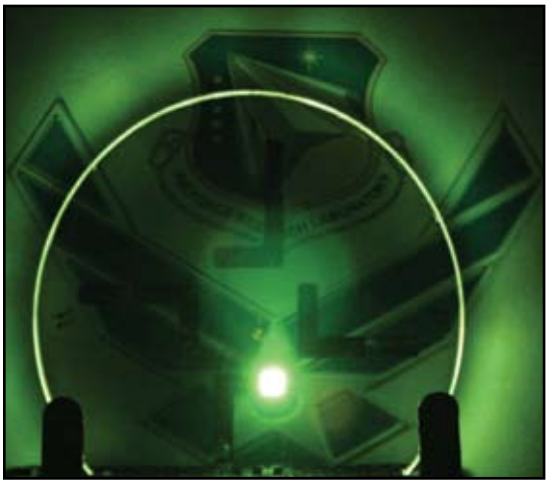
LPB Processing Schematic and Associated FEM Simulation

Engineers extensively use high strength steels, such as 4340 and 300M, for aircraft landing gear because these alloys' high strength and other desirable properties. Unfortunately, high-strength steels tend to be vulnerable to corrosion fatigue and stress corrosion cracking (SCC), which can lead to catastrophic failure if left unchecked. AFRL engineers studied the effect of low-plasticity burnishing (LPB) on several 300M steel specimens to determine whether the treatment could improve the durability of high strength steel components in adverse conditions. They used LPB to mechanically suppress stress-sensitive corrosion failure mechanisms present in a 3.5% salt solution, studied simulated foreign object damage (FOD) conditions, and compared their findings with baseline shot-peened (SP) and low-stress ground conditions.

AFRL's tests indicated that LPB imparts persistent compressive residual stresses in 300M steel surfaces and that LPB-treated specimens withstand fatigue, FOD-related damage, and SCC. In all cases the LPB's articles outperformed the baseline conditions by a large margin. AFRL engineers are now working with industry to tranisition the application of LPB into service on an Air Force platform. Continuing research efforts could result in more durable steel components for military and commercial aircraft landing gear.

LPB is a process that Lambda Technologies (Cincinnati, Ohio) conceived and patented to introduce deep, high magnitude compressive residual stresses into the surfaces of metallic components. LPB was first used to substantially increasing the FOD tolerance and fretting fatigue resistance of turbine engine components. LPB offers greater depth and stability of compression and, in most circumstances, higher performance than conventional SP permits. Additionally, users can perform LPB during manufacturing using standard computer numeric control machine tools, eliminating the need to ship components to other facilities for surface treatments. The process design for test samples and actual hardware is critical for optimized performance. In addition to ensuring that the design has sufficient compression to meet performance requirements, the design process must accommodate potential redistribution of the induced compression through thermal and mechanical means, as well as the location and magnitude of compensatory tensile stresses.

AFRL Scientist Leads Revolutionary Polymer Research, Development, and Application Efforts



AFRL is making significant contributions to bioengineering through the investigation of a new class of polymer, or "biopolymer," based on DNA (deoxyribonucleic acid) derived from biowaste materials. Dr. James G. Grote, of AFRL's Materials and Manufacturing Directorate, assembled and led a team to investigate this new biopolymer and its potential applications. The team has members from AFRL and also includes international collaborators, a number of major universities, government research institutions, and industry. The team demonstrated the new material's unique optical and electromagnetic properties, including the tunable conductivity and ultralow optical and microwave loss that make it optimal for high-speed applications.

Electro-optic (EO) and electronic devices fabricated from the new biopolymer demonstrate enhanced performance compared to state-of-the-art devices fabricated from current, organic-based materials. This new class of polymer has the potential to compete with—or even replace—many fossil-fuel-based plastics for applications ranging from eyeglasses and food containers to higher-technology applications such as light-emitting diodes (LED) and transistors. Continuing research and development efforts could have profound impact on the Air Force (AF) and Department of Defense (DoD), as well as commercial industry.

Dr. Grote's biopolymer has not only transferred successfully to industry, but has also transitioned directly to AF and DoD development programs. The technology is being (or will soon be) used for optical interconnects, LEDs, lasers, electronics, and biomolecular electronics and photonics.

The team is also transitioning the new biopolymer material within AFRL for radio frequency polymer-based EO modulator work. In addition, the laboratory transferred the material to Lockheed Martin and IBM for optical interconnect applications. The research led by Dr. Grote demonstrates that while biotechnology is applicable to genomic sequencing and clinical diagnosis and treatment, it can also have a major impact on applications outside the biotech arena—photonics and electronics, for example. This potential influence opens up a whole new field for bioengineering.

AFRL Develops Novel Ceramic-Based Body Armor

AFRL materials scientists worked with Excera Materials Group (Columbus, Ohio) to develop a novel metal-ceramic hybrid material for use in high-performance, lightweight, low-cost small arms protective inserts (SAPI) for body armor vests. Excera Materials Group is the manufacturer of a unique ceramic material called ONNEX, which the company develops by infusing a ceramic material with liquid aluminum. This material offers the high hardness of boron carbide, but it also provides fracture toughness 10 times that of other pressed ceramic materials. The hardness of an ONNEX armor plate will shatter and stop a striking bullet, and because the material's fracture toughness confines damage to a small area, the armor can tolerate multiple strikes to the same region.

The AFRL/Excera team reinforced the ONNEX material with a ballistic fiber backing made from Dyneema® polyethylene fiber and Rhino Linings®, an elastomeric polyurethane coating that is also widely used in truck bed liners. The ONNEX-based SAPI system is lighter and less expensive than currently deployed systems. During a 6-month deployment to Iraq, the 88th Security Forces Squadron field-tested the armor to evaluate its strengths and weaknesses. Upon their return, squadron members provided feedback, including recommendations related to fit and "wearability."

AFRL is now evaluating ways to improve the product's comfort level. Engineers will begin scanning several representative body types to determine the basic body shapes of military personnel (both male and female). They will work with Excera to create molds and armor to fit these shapes and thus accommodate the body types of most people. Materials scientists will incorporate the team's findings into the strike plates so that critical body areas remain protected regardless of a person's body size.

In just 18 months, this low-cost, high-payoff technology development program evolved from initial laboratory research and development work into a technology system that exceeds the capabilities of most current SAPI plates. The technology's manufacture requires lower temperatures and shorter processing times, leading to substantial cost savings.

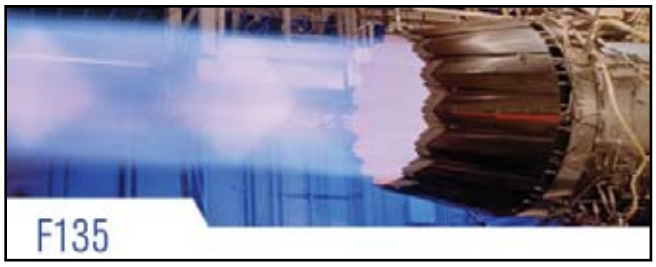
High-Speed Testing Capabilities Enhanced

AFRL's Research Cell 18, located at Wright-Patterson Air Force Base, Ohio, is now classified as a world-class continuous-flow supersonic combustion ramjet (scramjet) component research facility. This classification culminated in the completion of a heated-air system upgrade and successful operational check runs.

AFRL conducts research and development programs in advanced air-breathing engine science and technology. The laboratory places emphasis on developing high-speed engine concepts and merging discrete propulsion cycles into combined-cycle engines that operate over a very broad flight regime, extending from sea-level takeoff to hypersonic velocities. These engine cycles represent enabling technology for military space operational missions and high-speed global reach missions.

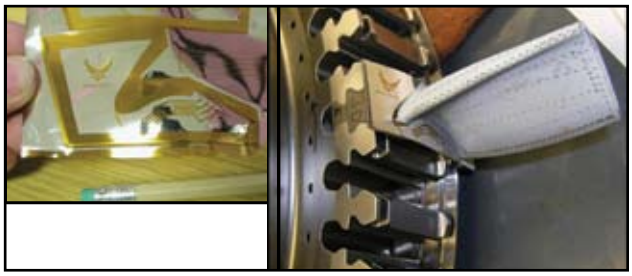
Research Cell 18 can provide a continuous source of furnace-heated air (i.e., indirect heat) to any of the laboratory's three wind tunnels, where temperatures can reach 1100°F at 750 psia. With completion of this air system upgrade, the supersonic combustion rig in Research Cell 18 can simulate Mach 3.5-5 flight speeds and flight dynamic pressures between 500 and 2000 lbf/ft^2. This increased capability, combined with new combustor hardware, will allow AFRL to explore alternate scramjet combustor ignition devices, active combustion methodologies, diode-laser-based flowpath diagnostics, and fuel injection and mixing techniques in a realistic, reacting flow environment.

AFRL Develops New Instrumentation for F135 Turbine Blade Measurements



AFRL researchers developed new double-sided platinum thin-film arrays to solve problems in the measurement of turbine blade heat flux. The unique thin-film instrumentation's design and fabrication allow the arrays to measure the surface heat flux on a critical area of the F135 high-pressure turbine (HPT) blade surface. The nonintrusive sensors are made of 600 Å thick platinum film patterns deposited onto both sides of a flexible, 50 μ thick sheet of polyimide.

Researchers were able to apply the double-sided film arrays to the HPT surface without causing disruption to the flow surface and without any machining of the test blade. AFRL's Heat Flux Instrumentation Laboratory, located at Wright-Patterson Air Force Base (WPAFB), Ohio, allows researchers to produce custom thin-film sensors suited to perform different types of measurements. Scientists will test these sensors in a fully rotating, transient HPT rig test in AFRL's Turbine Research Facility (WPAFB).



Traditional measurement techniques required single-sided gauges and a single-layer, semi-infinite heat transfer calculation that is insufficient for the three-dimensional heat transfer problem on complexly cooled turbine rotor blades. The new technology originated from AFRL-sponsored research with the University of Oxford and Syracuse University. This technique provides a nonintrusive measurement in a critical and complex flow area, and the instrumentation provides a new capability to investigate immediate challenges for the Joint Strike Fighter's engine and other advanced military propulsion systems.

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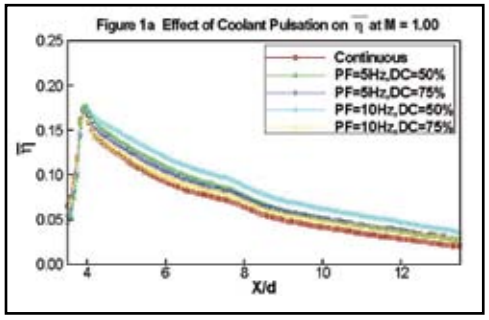
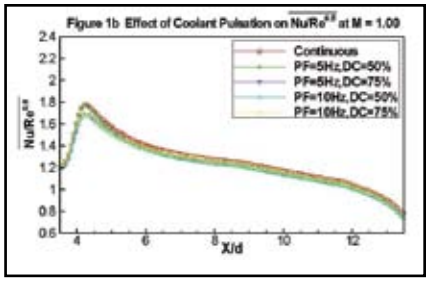
AFRL Researches Use of Pulsed Coolant for Film Cooling



Coolant flow reduction is an important design goal in the development of advanced turbine engines. Turbine engine designers routinely use film cooling to cool engine components in the hot-gas flowpaths. Film cooling is the process of injecting coolant fluid at one or more discrete locations along surfaces regularly exposed to a harsh, high-temperature environment. The film cools and thus protects turbine engine components, enabling the engine to operate at higher turbine engine inlet temperatures and increasing its thermal efficiency. Current turbine engine designs employ a continuous coolant flow to cool turbine airfoils. AFRL researchers are working to reduce the volume of high-pressure air needed for turbine blade cooling, which will allow designers to proportionately increase the airflow available for combustion and thus increase thrust.

The AFRL researchers controlled coolant pulsation by adjusting the opening and closing times of two synchronized pulsed valves, installed in the coolant supply line, to create a combination of pulsing frequency (PF) and duty cycle (DC). To conduct the study, the researchers applied hot mainstream air to the test model as they injected coolant through a cylindrical hole in the model. They released both flows onto the ambient-temperature surface of the model simultaneously in a transient mode. The goal of film cooling is to obtain both a higher film effectiveness to better protect the turbine blade/vane and a lower heat transfer coefficient to prevent the hot-gas stream from transferring heat to the turbine blade/vane.



The results show that compared to the continuous coolant, the pulsed coolant provides greater film coverage, which contributes to the higher spanwise-averaged film effectiveness. The results also indicate that the pulsed coolant generates heat transfer coefficients lower than those generated by the continuous coolant in dimensionless form.

This research effort demonstrates that turbine engine designers can significantly reduce film cooling flow requirements by substituting pulsed coolant flow for continuous blowing methods. Using pulsed flow, designers can reduce film cooling flow ranges by 18% to 41%—depending on DC and PF—while improving film effectiveness and lowering heat transfer coefficients. These important findings will contribute to the design of higher-performing turbine engines.

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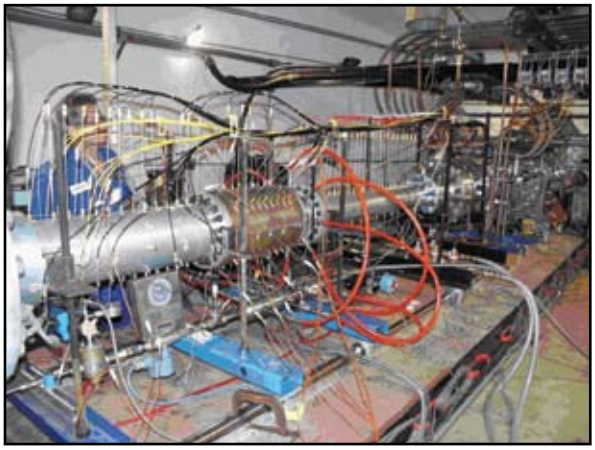
Successful Scramjet Combustor Testing

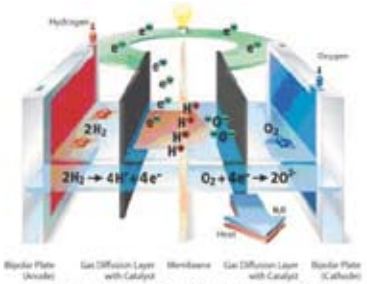


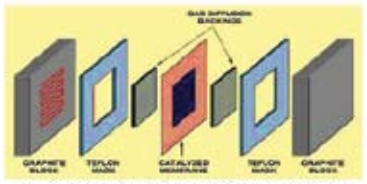
AFRL's Robust Scramjet [supersonic combustion ramjet] program establishes new and improved capability in dual-mode scramjet combustors along three major pillars: scalability, operability, and durability. Working under the Robust Scramjet program, Aerojet (Orange, Virginia) successfully completed the initial test series on a missile-scale round scramjet combustor. Round combustor geometries are favorable due to their ability to withstand internal pressure. Eliminating the inherent corner effects of two-dimensional geometries reduces both the surface area and the overall weight of the combustor.

Engineers conducted the tests at enthalpies typical for Mach 2.7 to Mach 5 flight. The tests demonstrated the use of technologies for increasing the operability of scramjet engines over the current baseline. They also established a baseline dataset to support the structurally efficient round combustor's scalability for engines suitable for cruiser aircraft and space applications.

The engineers employed a variety of fuel injector arrangements, fueling levels, and other test conditions. They collected data related to thrust, combustor pressures and temperatures, and flow. The results of their analysis exceed the goals set forth by the Air Force for improved dual-mode scramjet engines. AFRL engineers provided Aerojet with technical support, test article design, computational flow modeling, and data analysis support. These tests will help pave the way for the development of larger combustors.

AFRL Advances Proton Exchange Membrane Fuel Cell Research





Schematic showing the construction of the Proton Exchange Membrane Fuel Cell

AFRL manages and conducts exploratory and advanced development programs to provide power systems and cooling technologies for aircraft, missile, terrestrial, and special applications. AFRL researchers are conducting in-house proton exchange membrane (PEM) fuel cell research to help these fuel cells become viable power sources for Air Force applications.

AFRL's investigation of critical fuel cell materials, including their reliability and issues with energy density, has resulted in new polymer systems. For instance, scientists synthesized and characterized a low-cost hydrocarbon-based 6F-SPTES [sulfonated polyarylenethioethersulfone]-50 polymeric system with endcapping groups for potential application as fuel cell membranes. In addition, they synthesized and fabricated high-molecular-weight polymers into tough films exhibiting high intrinsic proton conductivity.

AFRL researchers have now successfully fabricated operational membrane electrode assemblies, or single fuel cells, with this material. The demonstrated overall performance is similar to that of the state-of-the-art Nafion® at both low and high temperatures (100°C). The high thermal stability and high intrinsic proton conductivities of 6F-SPTES-50 qualify these polymers as potential cost-effective alternatives to Nafion as electrolyte separators for PEM fuel cells. AFRL researchers presented their results at the 3rd International Energy Conversion Engineering Conference, held in San Francisco, California.

AFRL Deploys Oil-Filled Switch Technology

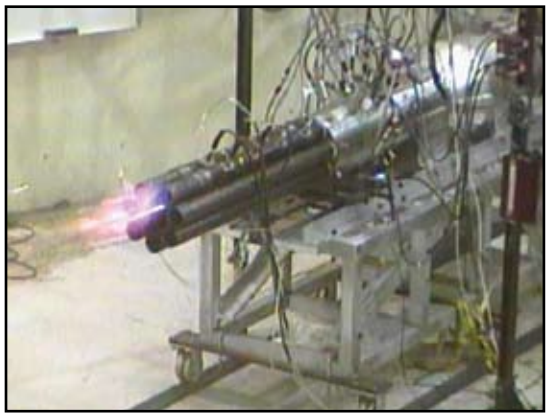
AFRL researchers deployed a novel oil-filled switch technology developed over the last 3 years. This device incorporates advances in switching technology made at the University of Missouri-Columbia and Alpha-Omega Power Technologies.

The newly deployed high-voltage switch utilizes the polyaolefin dielectric coolant already resident on most airframes as the switching medium, enabling the operation of a high-power microwave (HPM) system through the aircraft's existing hydraulic fluid. This feature offers significant advantages over gas-filled switches.

HPM sources typically require the generation of electron beams with energies in excess of 500 keV and currents of many tens of kA. Therefore, employment of an HPM source on an aircraft presents challenges related to space, weight, and power requirements. The oil-filled switch overcomes most of these difficulties with its unique compact design, which utilizes high-pressure, flowing hydraulic fluid as the medium for repetitive, high-voltage switching. Since hydraulic fluid is already present on most airframes, the new switch does not necessitate that a new material be incorporated into air platforms. Furthermore, the switch has the advantage of being far more compact than the standard blown-gas switches that AFRL commonly employs.

AFRL researchers integrated the novel oil-filled switch technology into the laboratory's general repetition-rate universal multipurpose pulser system, and they are collecting extended lifetime data. This data collection effort includes the development of specifications necessary for operating the switch in an HPM system. Once such protocols become available, the switch could become a standard laboratory component.

Revolutionary Rotary Airflow Controller

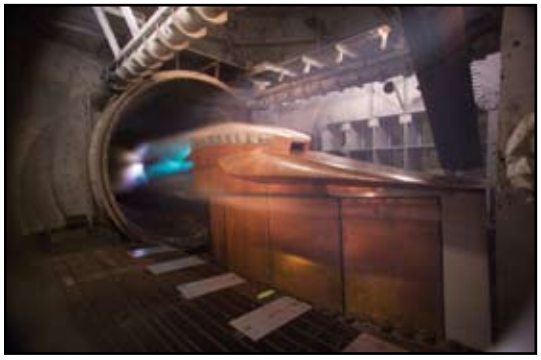


The cyclic (on/off) characteristics of pulsed detonation engine (PDE) airflow requirements impose a difficult airflow matching problem for the integration of an unsteady PDE with a high speed limit. Therefore, AFRL engineers developed a revolutionary airflow controller and isolator to (1) control the detonation chamber airflow, (2) provide sealing, and (3) isolate the inlet from the severe airflow disturbances that could be imposed by PDE operation.

TechLand Research, Inc. (North Olmsted, Ohio), designed and fabricated the controller under a Phase II Small Business Innovation Research project. AFRL technicians installed the unit in the laboratory's Pulsed Detonation Research Facility, which was instrumented to assess the airflow controller's operation. During testing, the controller successfully isolated the upstream inlet conditions from the downstream pressure oscillations associated with PDE operation. In addition, the device significantly reduced pressure losses through the engine, making the fill process more efficient and consequently boosting performance.

Test efforts also demonstrated continuous operation of one tube and two adjacent tubes. The high performance achieved with this rotary airflow controller demonstrates a revolutionary pulsed detonation propulsion technology.

AFRL Successfully Completes GDE-2 Testing



AFRL engineers completed testing of the second-generation Ground Demonstration Engine, known as GDE-2, at the National Aeronautics and Space Administration (NASA) Langley Research Center's 8 ft high-temperature tunnel (Hampton, Virginia). The GDE-2 is a hydrocarbon-fueled supersonic combustion ramjet (scramjet) engine featuring a single integrated flowpath, fuel control system, and closed-loop thermal management system. AFRL successfully completed the final test series, which included an assessment of the engine's inlet performance and operability as a function of cowl lip position and angle of attack.

Previously completed tests involved the assessment of a closed-loop hydrocarbon fuel system utilizing JP-7 fuel; demonstration of engine light sequence; verification of various design tools (e.g., aerothermal, structural, and control); and evaluation of engine structural integrity, hot gas valve operational characteristics, and engine thrust and performance at Mach 5. A collaborative effort between the Air Force, NASA, and GDE-2 builder Pratt & Whitney Rocketdyne, this test program is developing technologies for future hypersonic propulsion systems, which have application to rapid response strike and space access missions. The program also serves as an invaluable risk reduction activity for the scramjet engine that will power the X-51A flight test vehicle, currently scheduled to fly in December 2008.

New Rocket Engine Combustion Cycle Technology Testing Reaches 100% Power Level

America's rocket propulsion capabilities recently achieved an important milestone. During tests conducted at the National Aeronautics and Space Administration's (NASA) Stennis Space Center (near Bay Saint Louis, Mississippi), the nation's only staged-combustion liquid booster rocket engine now in development reached "steady-state" operation at 100% power level, providing "mainstage" performance for the first time. The engine cycle demonstrator, dubbed the Integrated Powerhead Demonstrator (IPD), is a ground demonstrator engine that combines the latest innovations in rocket engine propulsion technologies.

Engineers from Pratt & Whitney Rocketdyne, Inc., and Aerojet designed, developed, and tested the IPD engine under AFRL's program direction and NASA's technical direction. The new engine technology, designed to achieve 250,000 lbs of thrust, used liquid oxygen and liquid hydrogen to achieve the first US demonstration of the full-flow staged-combustion (FFSC) cycle. With a goal as a reusable rocket engine system capable of up to 200 flights, the engine design utilizes high-performance, long-life technologies and materials.

The FFSC cycle uses a fuel-rich preburner to drive the fuel turbopump and an oxidizer-rich preburner to drive the oxygen turbopump. Because the preburners utilize and burn all of the propellants, more mass flow is available to drive the respective turbines than in a conventional staged-combustion cycle engine. The additional power enables lower turbine temperatures and hence less stress, translating into longer turbine life, a key factor for reusable rocket engine life.

In addition, the use of oxidizer-rich gas in the oxidizer turbine and fuel-rich gas in the fuel turbine eliminates the need for a complex propellant seal in the pumps, prevents inadvertent propellant mixing, and increases engine system reliability. The innovative engine cycle and turbopump design also includes a hydrostatic bearing technology that literally floats the turbine shaft on rocket propellants, alleviating wear and enabling high reusability.

Although the IPD engine will not fly, its technologies will make their way into future rocket engines. This program provides a cost-effective manner in which high-payoff technologies can be demonstrated at component and engine system levels.

AFRL Completes Dual-Use Initiative for Nonintrusive Stress Measurement

AFRL, in partnership with Williams International and Hood Technology Corporation, managed a Dual-Use Science and Technology initiative to advance Nonintrusive Stress Measurement System (NSMS) technology for small turbine engines. Exploiting initial NSMS research conducted by the Arnold Engineering Development Center, the team developed and demonstrated a suitable NSMS for use in current and future generations of small gas turbine engines. The team used the high-pressure compressor of the XTL-87 Joint Expendable Turbine Engine Concept technology demonstrator engine to baseline system design requirements for the effort.

The primary goal was to apply a version of Hood Technology's successful large-engine turbine blade measurement system to Williams International's smaller gas turbine engines. Hood expanded the system's sensor capability by decreasing the sensor's size, improving its resolution, and expanding its operational temperature range, enabling the measurement system to detect the position of extremely small airfoils at the high shaft speeds and discharge temperatures typical for small turbine engines. The resulting small-engine NSMS can detect damaging resonance conditions and provide accurate data related to blade stress.

The system uses case-mounted laser probes to measure a blade's time of arrival to the probe location. Engineers compare the recorded arrival time to a known disk rotational position to infer the blade deflection. They can then relate the deflection to a blade's vibration mode shape and its associated stress. AFRL's secondary program objective was to develop a blade stress measurement system with a service life longer than that of the surface-mounted strain gage and slip ring system currently used in turbine engine blade measurements. A key aspect of this NSMS capability is that it may be capable of providing data throughout the entire service life of a typical unmanned air vehicle application.

Engineers conducted a number of rig and engine tests to characterize the performance of the small-engine NSMS, including consecutive tests of the strain gages, slip rings, and optical probes. With this technology now sufficiently proven, Williams International includes it as a standard practice for the development and certification of both military and commercial engines, with or without parallel strain gage corroboration.

AFRL Successfully Demonstrates Lightweight Modular Support Jammer

AFRL engineers successfully demonstrated several support jamming techniques at the Naval Air Weapons Center, California. The lightweight modular support jammer (LMSJ) is a scalable-architecture, digitally controlled support jammer based upon digital common modules and highly integrated transmitters and apertures. The total end-to-end system will incorporate affordable technologies for enhanced detection, location, and identification of hostile, friendly, and advanced-threat radar and communications signals for existing and future aircraft. The LMSJ electronic attack (EA) system embodies countermeasure techniques and waveforms intended to defeat or degrade modern radar and communications threats. These technologies will increase the survivability and lethality of combat aircraft against advanced, integrated radio frequency and communications air defense networks.

AFRL engineers installed a demonstration jammer system equipped with LMSJ capabilities on a Naval Air Systems Command AeroStar unmanned air vehicle. The ground test provided an opportunity both to optimize the jamming waveforms used against the test subject radar and to complete an all-systems check before flight. The two flight tests demonstrated the effectiveness of the selected jamming modulations against each of the radar's modes of operation.

The Advanced Threat Alert and Response (ATAR)/LMSJ program has designed, developed, and demonstrated a modular digital receiver electronic surveillance (ES) system that can concurrently perform all tasks for generating (the receiver portion of) warning, targeting, EA management, and countermeasures techniques. The combined ATAR/LMSJ program utilizes the ATAR software-reconfigurable digital receiver as the EA system front end, while the LMSJ uses the solid-state radio frequency power modules to drive the apertures (consisting of arrayed antenna elements) as the back end. The integration of the dual ATAR and LMSJ efforts will develop a modular, scalable, and affordable end-to-end ES/EA advanced architecture capable of countering the entire integrated air defense threat.

SBIR Company Advances Future Space Computers

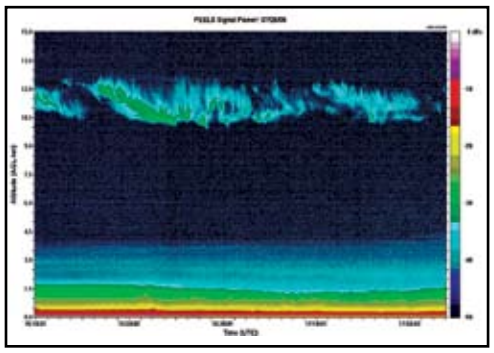
Onboard computers are the primary means of operating satellites that cost millions of dollars to build and launch; once in orbit, however, these computers are not easily repaired if problems arise. Furthermore, space-deployed hardware cannot tolerate data errors, since ordinary microchip performance degrades considerably outside the earth's atmosphere. The traditional method of building spacecraft computers therefore involves the fabrication of very expensive, specialized chips, which result in slow, power-hungry processors. Consequently, the Air Force's Military Satellite Communications program tasked AFRL with finding innovative solutions to these challenges. Under an AFRL Small Business Innovation Research (SBIR) contract, Space Micro, Inc. (San Diego, California), developed a strategy for using commercial microprocessors in space.

To address the issues surrounding a commercial microprocessor's usage in space, Space Micro focused on the dual problems of single-event upsets (a type of radiation-induced data error) and single-event functional interrupt hang-ups, both of which contribute to the unreliable performance of commercial chips exposed to high-energy cosmic radiation. To resolve initial difficulties, the company investigated a way to utilize existing circuitry to perform on-the-fly recalculation (and checking) of computations associated with critical operations. This straightforward approach beats the alternative of running three processors in parallel and voting their outputs. In addition, it uses less hardware and power, because the necessary level of redundancy is easily activated and deactivated as needed.

Space Micro also incorporated a radiation-hardened watchdog chip, which triggers an automatic processor reset if it detects a hang-up in the apparatus. This innovative solution simplifies the architecture by eliminating the need to synchronize multiple processors. The company's final product consists of a high-performance, fault-tolerant computer—known as Proton—that employs low-cost, commercially available parts.

To date, over 50 satellite programs have inquired about this commercially based, inexpensive, low-power approach to space computing systems, with nine various delivery contracts awarded from the Air Force, Missile Defense Agency, National Aeronautics and Space Administration, and Defense Advanced Research Projects Agency. Space Micro's groundbreaking prototype has thus established its legacy as one of AFRL's most successful SBIR efforts.

Cirrus Cloud Study Shows Laser Beam Impact

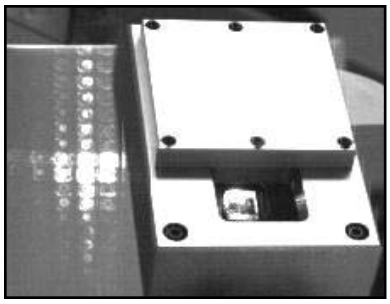


AFRL scientists completed a study on the potential impacts that cirrus clouds have on airborne defensive laser systems. These laser systems have envisioned potential both in missile defense and in the engagement of theater ballistic missiles during their boost phase. However, high-energy lasers are subject to optical turbulence that may diffract the beam, causing it to spread and thus reducing the power directed towards the target. Another atmospheric effect is the absorption and scattering of laser light by ice crystals in cirrus clouds. The AFRL study quantified the effects that observed cirrus layers might have on laser transmission from a high-altitude laser source.

AFRL scientists conducted an 11-month field campaign at Hanscom Air Force Base, Massachusetts, to collect cirrus cloud measurements. Ground-based cloud profiling radar and light detection and ranging (lidar), radiosondes, satellite imagery, and a surface observer collected data throughout more than 26 different 3-hour cirrus episodes occurring between February and December. Radar and lidar data specified the top and base altitudes of the cirrus layer, and satellite data provided an estimate of effective ice particle size and ice water content. The research team found that radiosonde relative humidity soundings must supplement satellite imagery to ensure accurate top and base height estimates, with respect to radar and lidar measurements. Additionally, the research confirmed that radiosondes can infer the presence of very thin cirrus layers that escape satellite detection.

Scientists also used the cirrus altitudes and crystal properties in laser transmission models. They computed the transmittance, or fraction of initial laser power, incident on a hypothetical missile as a function of ascent altitude. The results indicate that cirrus clouds can have a profound impact on a propagating laser beam. This study suggests that passing through even thin cirrus will result in a reduction of power. State-of-the-art radiosondes can detect the presence and altitude of cirrus layers of varying optical thicknesses. The radiosonde can provide critical support to high-altitude laser system field tests when complemented by satellite imagery for aerial coverage to avoid cirrus clouds. This will greatly reduce the cost of cirrus detection over expensive shipment and operation of ground-based radars and lidars.

AFRL Demonstrates High-Rate Laser Communications Using Optical Phased Arrays



AFRL scientists used an actively operating optical phased array (OPA) to demonstrate a 10 Gb per second laser communication link. The liquid-crystal-based OPA steered the laser beam while recording laser power levels, communication signal eye diagrams, and overall link error levels.

Like liquid crystal display (LCD) monitors and televisions, OPAs are pixelated devices wherein electrical charges applied to each pixel across the array determine the direction a laser beam will be steered. Researchers are interested in using OPAs for a number of beam-steering applications due to their light weight and rapid switching abilities. However, when OPA pixels switch from one steering angle to the next, individual LCD molecules rotate in an uncontrolled fashion and can disrupt the transmitted beam.

To determine if OPAs are suitable components for future laser communication systems, AFRL engineers tested how this disruption affects a high-data-rate communication signal being passed via a laser beam. The experiment proved that while the switching can occur with no interruption to the communication signal, overall power levels are somewhat affected. Future work will focus on optimizing the switching process to minimize resulting power reductions. This successful demonstration leads the way to replacing large, heavy, and expensive mechanical mirror systems with lightweight, fast OPAs as beam-steering elements in future free-space laser communication systems.

Instruments Installed in Greenland Will Enhance Space Weather Forecasts

Under an international cooperative research project between the US Air Force (AF), Denmark's Ministry of Defence and Ministry of Transport and Energy, and the Greenland Home Rule government, AFRL researchers deployed a suite of five ionospheric monitoring instruments at Station Nord, located in far northeast Greenland. With assistance from the Danish site crew, AFRL scientists installed a digital ionosonde for determining ionospheric density profiles; an all-sky imager for observing aurora and ionospheric plasma clouds; and three additional systems for detecting ionospheric scintillation via fluctuations in the strength of signals from various satellites, including the Global Positioning System (GPS).

Despite the 3 ft of snow and ice still on the ground at the site even in late summer, the deployment team prevailed over the remnants of the region's harsh arctic weather to successfully construct the approximately 82 x 200 ft ionosonde transmit antenna. AFRL researchers and their Danish counterparts will use the data to generate realistic maps and models of the highly variable polar ionosphere, which will enhance space weather forecast capabilities and also facilitate development of algorithms for improving systems affected by the ionosphere. Station Nord occupies a key location midway between major ionospheric investigation facilities in Svalbard, Norway, and AF operational and research capabilities in Thule, Greenland.

Space weather information collected at the new site will advance the development of algorithms capable of detecting, correcting, or mitigating ionospheric effects on radio-based systems, including the upgraded early-warning radars in Thule and other high-latitude sites; the GPS; and AF satellite communications, high-frequency communications, geolocation, and space-based radar systems. In addition, a real-time data link from the location will provide information for "nowcasts" and short-range forecasts of space weather impacts on communications, navigation, and surveillance systems.

Technology Transfer

Page

AFRL Develops Open-Source National Imagery Transmission Format Library

AFRL and Stellar Science, a computer software development company, developed and published an open-source C++ library capable of reading National Imagery Transmission Format (NITF) 2.0 and 2.1 image files. NITF is the formatting standard for digital imagery and imagery-related products. The Department of Defense (DoD), the intelligence community, and other US government agencies use NITF to exchange images between organizations. NITF is also the standard for image sharing among North Atlantic Treaty Organization (NATO) member countries, with NITF 2.1 known as the NATO Secondary Image Format. NITF is highly flexible and very complex, supporting various bit rates, compression schemes, blocking schemes, subimages, and graphical overlays.

The NITF specification includes an extensible framework for representing file- and image-level electronic support data. This support data varies depending on the source and type of imagery present in the file and contains information that can aid the exploitation process. There are many support data extensions officially registered for various imagery types, and many unregistered extensions exist as well.

This new open-source library conforms to the basic NITF 2.0 and 2.1 specifications and includes a framework for defining and parsing tagged record extensions. The framework allows C++ application developers to easily define extensions by writing a succinct code that resembles the tabular specification within a NITF controlled extensions document.

A number of proprietary NITF readers are available; until now, however, there has been no freely available, robust software library capable of processing NITF files. The AFRL-developed library is freely available based on both the potential improvements to DoD interagency image exchange processes and the costs saved by eliminating repeated NITF implementations.

AFRL Significantly Increases Avionics Bandwidth

AFRL, in partnership with Edgewater Computer Systems, Inc. (Ottawa, Canada), increased avionics bandwidth by a factor of 200, enabling the transition of advanced displays and network-centric warfare capabilities. The team developed an expanded MIL-STD-1553B capability that removes defense-wide roadblocks preventing required upgrades to current air fleets.

Manufacturers install MIL-STD-1553B bus cables deep inside tens of thousands of aircraft, tanks, ships, and satellites, as well as in the space shuttle. The growth of weapon system capability requires electronics upgrades in the cockpit area as well as in sensors and onboard computer suites. However, defense system and logistics program offices cannot accept these component technologies due to bandwidth limitations and the prohibitive costs associated with installing fiber-optic or copper-based cabling in local area networks and disassembling aircraft to access the cables.

The bandwidth required for legacy platforms warrants an increase of the current 1 Mbps MIL-STD-1553B to at least 30 Mbps, and preferably to >100 Mbps; AFRL managed the Air Force Dual-Use Science and Technology effort to develop technology for increasing available bandwidth on installed MIL-STD-1553B avionics cable from 1 Mbps to >200 Mbps. The program was an integral part of other extended MIL-STD-1553 development efforts with both Ogden Air Logistics Center (OO-ALC) and the Aeronautical Systems Center (ASC).

This 200x bandwidth increase enables legacy platforms to accommodate technology upgrades in displays, sensors, and processors across AFRL. A specific technology example is the F-16 Block 30 fleet's ongoing instrument panel upgrade and planned adoption of panoramic night vision goggles. Neither activity would be a possibility without AFRL's improved bandwidth avionics bus transceivers. AFRL transferred this technology both to OO-ALC for the F-16 upgrade program and to ASC.

In this effort, AFRL successfully moved data over MIL-STD-1553B bus cables at a rate of 204 Mbps, with just one error per trillion bits—the bit error rate required in critical real-time avionics. AFRL's technology clearly exceeds the current requirement and provides sufficient bandwidth for the remaining (20-30 year) service life of aging air fleets. Manufacturers can affordably install this technology by simply replacing existing bus terminals.

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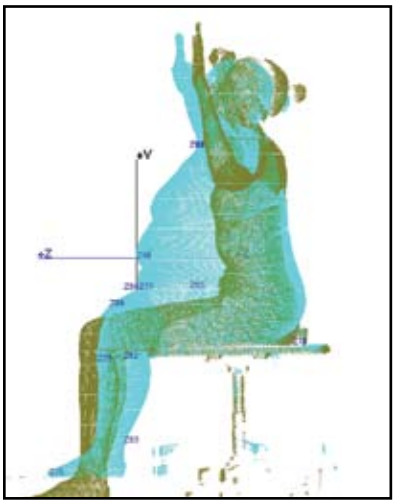
Virtual Mannequins Help Improve Ergonomic Design of Future Automobiles



Ford Motor Company has adopted an AFRL-developed multivariate case method to establish an automotive-industry first—a set of nine computer-aided design (CAD)-created virtual mannequins modeled after representative human body characteristics. Ford is using the virtual human mannequins to assist its automotive ergonomists in meeting the demands of a physically larger public.

Ford used data and three-dimensional (3-D) scans from AFRL's Civilian American and European Surface Anthropometry Resource (CAESAR) database to create the 3-D models. The CAD-created mannequins represent males and females with varying body shapes and sizes, including characteristics such as high body mass index (a measurement that takes into account a person's age and weight), wide hips and shoulders, long legs, short legs, long arms, short arms, and various combinations. Designers are able to position the virtual mannequins to examine their interactions with the environment and adjust accordingly.

AFRL first used CAESAR in designing the T-1 and T-6 aircraft and achieved the greatest range of accommodation ever realized for an ejection seat aircraft. Ford ergonomists have already used the virtual mannequins to evaluate the cabin of the new 2007 Ford Edge to better accommodate more generously proportioned drivers. Transitions such as this will not only help the nation but also promote recognition of the world-class research being accomplished by the men and women of AFRL.

Bonded Composite Wing Surpasses All Expectations

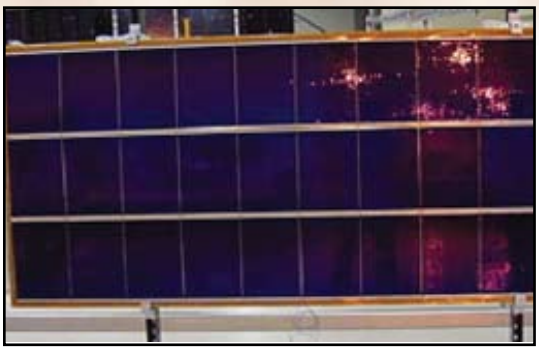
AFRL researchers successfully demonstrated the ultimate load-carrying capacity of a bonded fighter aircraft wing constructed mostly of composite materials. Developed under the Composites Affordability Initiative (CAI) X-45C Technology Transition project, the bonded composite wing surpassed engineering expectations despite undergoing intentional damage, along with simulated stresses and wear representing two aircraft lifetimes of fatigue, during the tests. The CAI is a focused effort to develop the technologies and tools necessary for reducing the acquisition cost of composite structures used in airframe structures and transition these capabilities to future weapons systems. The CAI team includes members from AFRL, Navy Manufacturing Technology, Bell Helicopter Textron, Boeing, Lockheed Martin, and Northrop Grumman.

The CAI team designed, fabricated, and conducted extensive testing of the bonded composite X-45C wing, which demonstrated exceptional performance. Boeing designed the wing as an alternative to the aircraft's baseline, mechanically fastened wing to meet or exceed X-45C performance requirements. The team constructed the 26-foot-long wing, which was projected to cost 29% less than the baseline wing, using standard layup techniques for the skins and a bonded pi-joint structure. The team's fully matured, bonded pi-joint design improves the original manufacturing method, which entails drilling holes and using fasteners to assemble the X-45C aircraft.

By bonding the wing, the team completed the assembly effort in days as opposed to the weeks needed for conventional construction. The new design eliminates about 2,000 fasteners with respect to the baseline wing design. The bonded structure could reduce life-cycle costs, which dominate total ownership costs for weapon systems, approximately 75% as compared to fastened structures.

The CAI team's lengthy test series—which included efforts ranging from coupon testing for the effects of defects to ballistic survivability—corroborated the robustness of the pi-joint design for bonded aircraft structures, as well as the design's capability to meet all current performance requirements. The team fatigue-tested the pi-bonded structures twice, with the bonded joint remaining intact both times. With the designs, process controls, and quality assurance techniques in place to support future aircraft designs using bonded pi joints, advanced weapon system designs can now leverage this extensively tested technology for increased performance, reduced cost, and decreased cycle time.

AFRL Transitions Thin-Film Solar Cells



The Missile Defense Agency (MDA) selected AFRL's thin-film solar cell technology to meet the power generation requirements of its High-Altitude Airship (HAA) Advanced Concept Technology Demonstration program. The MDA will demonstrate the laboratory-developed technology in the deployed structures experiment (DSX), which will establish the viability of thin-film solar arrays and deployment mechanisms while increasing technical maturity. The DSX will also demonstrate a lightweight rollout array >200 W/kg. The array will contain solar cells from at least three different vendors and will include experiments on protective coatings for thin-film solar cells, high-voltage solar modules, and high-temperature annealing.

Scientists fabricate thin-film solar cells using amorphous silicon or polycrystalline copper-indium-gallium-diselenide materials. These solar cells have lower efficiencies than state-of-the-art crystalline multijunction solar cells, but their flexible, lightweight nature allows them to grow on 1 mm thick metal foils or polymer substrates.

AFRL's work targeted the adaptation of thin-film solar cells from heavy, rigid substrates (e.g., glass) to flexible, lightweight substrates (e.g., stainless steel and polymer foils). Additional work focused on modifying the cells to withstand the extreme space environment and increasing their efficiency in the blue-light-rich space solar spectrum. When paired with a lightweight support structure, thin-film solar cells produce satellite solar arrays that are 4 times less expensive and have 7 times higher specific power, 10 times greater stowed volume, and better radiation resistance than state-of-the-art rigid panel solar arrays that use crystalline multijunction solar cells.

Thin-film solar cells are the only technology capable of meeting the HAA's high specific power requirements (>750 W/kg) without the use of fragile, brittle crystalline silicon or crystalline multijunction solar cells. The low mass of HAA thin-film solar arrays reduces the volume of lifting gas as well as the HAA's size, since each additional pound allocated to the solar array requires hundreds of additional cubic feet of lifting gas. As a result, scientists identified thin-film solar cell technology as a leading candidate for the HAA. Thin-film solar arrays are the next generation of power technology that will enable satellites by reducing the mass, stowed volume, and cost requirements for solar arrays. Increased solar array radiation resistance will allow easier access to high-radiation orbits.

AFRL Develops High-Efficiency Multijunction Solar Cells

AFRL worked with Spectrolab, Inc. (a Boeing subsidiary in Sylmar, California), through the Dual-Use Science and Technology program to develop ultra-triple-junction (UTJ) solar cells. These cells subsequently powered the solar arrays aboard two National Aeronautics and Space Administration (NASA) Mars rovers. The rovers *Spirit* and *Opportunity* landed on Mars in early 2004 to continue NASA's quest to explore the role of water on the planet. Once on the Martian surface, the solar panels deployed to form a total area of 1.3 m^2 of UTJ solar cells that powered all spacecraft activities and instruments.

The Mars Exploration Rover (MER) program posed significant engineering and technology challenges due to many design and operational constraints, including limited available panel area, changing illumination levels and temperatures, variable shadowing and atmospheric conditions, and dust accumulation on the rovers. As highly efficient collectors of the sun's energy, single-crystal multijunction (MJ) solar cells maximize solar panel electrical output. These solar arrays provide nearly a 50% improvement in cell efficiency compared to the single-junction solar cells used on the earlier, Mars Pathfinder mission. The UTJ cells employ a three-layered structure to more effectively capture and convert solar energy into electricity. Each of the junction cells converts a different portion of the solar spectrum into electricity, greatly improving energy conversion efficiency.

The MJ solar cells used for the MER program were UTJ solar cells with a 27.5% beginning-of-life efficiency. By directly replacing lower-efficiency cells, they permit increases in solar array power output without increasing solar panel size or number, thereby minimizing costs in programs such as NASA's Global Positioning System effort, wherein engineers accommodated the power needs of an additional payload by switching to high-efficiency cells. By maintaining the power level of a legacy spacecraft design, these cells reduce both deployed array area and stowed volume, a critical reduction for programs required to downsize from a Titan IV launch vehicle to an evolved expendable launch vehicle, which has 33% less shroud volume.

NASA also used MJ solar cells successfully in other interplanetary missions: the Mars Global Surveyor, which monitored Martian weather patterns; the Beagle 2, which served as another Mars exploration spacecraft, and the Near Earth Asteroid Rendezvous spacecraft, which reached a distance from the sun marking the farthest travel of any solar array.

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Awards and Recognition

Page

Continued on next page

Awards and Recognition

Page

Four AFRL Innovators Receive Modern-Day Technology Leadership Honors

US Black Engineer & Information Technology magazine editors selected four AFRL innovators to receive Modern-Day Technology Leadership honors. AFRL's honorees include Captain Catercia Isaac (pictured top left), a researcher in the Directed Energy Directorate; First Lieutenant Robert W. Patton (pictured top right), a program manager in the Information Directorate; Mr. Douglas K. Simpson (pictured bottom left), an integration team leader in the Munitions Directorate; and Ms. Krystal M. Thomas (pictured bottom right), an industrial engineer in the Human Effectiveness Directorate.

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AFRL Names Seven New Fellows for 2006

The AFRL Fellows program annually honors the laboratory's most outstanding scientists and engineers for their achievements and technical excellence that support our nation's air and space forces. This year's honorees, all of whom are internationally recognized experts in their respective fields, are as follows: Dr. Paul Barnes (pictured top left), Propulsion Directorate; Dr. Hugh DeLong (pictured top center), Air Force Office of Scientific Research; Dr. Dennis Goldstein (pictured top right), Munitions Directorate; Dr. Kumar Jata (pictured middle left), Materials and Manufacturing Directorate; Mr. Frank Marcos (pictured middle right), Space Vehicles Directorate; Dr. Michael Murphy (pictured bottom left), Human Effectiveness Directorate; and Mr. Carl Snyder (pictured bottom right), Materials and Manufacturing Directorate.

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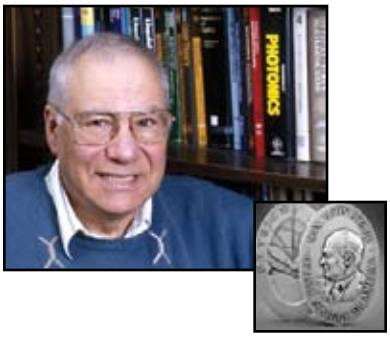

AFRL-Funded Scientist Receives Max Born Award

Dr. Alexander E. Kaplan, an AFRL Air Force Office of Scientific Research-funded professor, received the Max Born Award from the Optical Society of America. Dr. Kaplan, a professor in the Electrical and Computer Engineering department at Johns Hopkins University, received this honor for his pioneering contributions to nonlinear interface, optical bistability effects, hysteretic resonances of a single electron, and physics of subfemtosecond pulses.

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AFRL Basic Research Program Manager Receives Special Honor at International Exhibition

Dr. Gerald L. Witt, a basic research program manager in AFRL's Air Force Office of Scientific Research, received honors from the International Society for Optical Engineering, otherwise known as SPIE [the Society of Photo-Optical Instrumentation Engineers]. These honors recognize Dr. Witt's 26 years of exemplary federal service and guidance in the electronic and optoelectronic research communities.

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AFRL Scientist Receives IEEE Fellow Status

The Institute of Electrical and Electronics Engineers (IEEE) named Dr. Gerald L. Witt, a basic research program manager in AFRL's Air Force Office of Scientific Research, a Fellow for his promotion of research in compound semiconductor devices. This distinction signifies his extraordinary record of accomplishments in the advancement of engineering science and technology.

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publicaffairs@afosr.af.mil • (703)696-7797

AFRL Director of Physics and Electronics Receives Professional of the Year Award

The Capitol Chapter of the Association of Old Crows (AOC) awarded Dr. Forrest (Jack) Agee, director of physics and electronics at AFRL's Air Force Office of Scientific Research, with the Professional of the Year Award in the Lifetime Achievement category. Dr. Agee received this honor for his exemplary service to the AOC in the field of electronic warfare and information operations.

For more information contact
publicaffairs@afosr.af.mil • (703)696-7797

AFRL-Funded Researcher Receives International Award

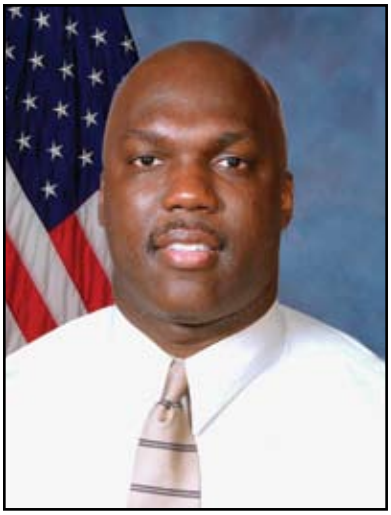
Dr. Nancy Lynch, an AFRL-funded basic researcher in computer science, earned the first Van Wijngaarden Award during the 60th anniversary celebration for Centrum voor Wiskunde en Informatica—also known as the National Research Institute for Mathematics and Computer Science—held in Amsterdam (the Netherlands).

For more information contact
publicaffairs@afosr.af.mil • (703)696-7797

AFRL Senior Aerospace Engineer Honored for Contributions to AIAA

The American Institute of Aeronautics and Astronautics (AIAA) presented AFRL's Dr. Carl P. Tilmann with the AIAA Special Service Citation for outstanding service to the aerospace community. Dr. Tilmann volunteered substantial time and effort as the executive chair for the 30th annual Dayton-Cincinnati Aerospace Science Symposium.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074



Mr. Mark Derriso Wins Hans-Juergen Schmidt Award

AFRL's Mr. Mark M. Derriso rose above a pool of highly qualified international candidates to win the 2005 Hans-Juergen Schmidt Award, the most prestigious award presented at the 5th International Workshop on SHM [structural health monitoring], held at Stanford University. This award recognizes his outstanding leadership in advancing SHM technologies in industry and government.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074

AFRL Researchers Earn Star Team Award

An AFRL research team earned the Star Team Award for world-class contributions to the field of computational fluid dynamics. This award honors teamwork, research excellence, and contributions to the Air Force and national defense in the areas of science and engineering.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074

AFRL Engineer Earns AIAA Aerodynamics Award

The American Institute of Aeronautics and Astronautics (AIAA) honored Mr. William Blake, an AFRL aerospace engineer, with the AIAA 2006 Aerodynamics Award. Mr. Blake earned this prestigious award both for his contributions to developing and applying aerodynamic prediction programs and for his solutions to flight test problems.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074

Dr. Raymond Gordnier and Dr. Miguel Visbal Receive Royal Aeronautical Society Silver Award and Busk Prize

The Royal Aeronautical Society awarded its Silver Award and Busk Prize to two engineers at AFRL's Air Vehicles Directorate. Dr. Raymond Gordnier (pictured top), a senior research aerospace engineer, and Dr. Miguel Visbal (pictured bottom), a principal research aerospace engineer, received the honors for their work in coupling computational fluid dynamics code with structural simulation software to study how fluid and structure interact.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074

Dr. Jonathan Poggie Receives General Benjamin D. Foulois Award

Dr. Jonathan Poggie, of AFRL's Air Vehicles Directorate, received the General Benjamin D. Foulois Award for his pioneering work in modeling and characterizing plasma actuators in hypersonic vehicles. This award honors AFRL engineers and scientists who made significant contributions to aerospace technology during the previous year.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074

AFRL Engineers Receive Courtland D. Perkins Award

Dr. Larry Byrd (pictured right) and Mr. Mark Haney (pictured left), research engineers with AFRL's Air Vehicles Directorate, received the Courtland D. Perkins In-House Engineering Award for their research towards developing solutions and repair techniques for the B-2 aft deck cracking problem. The award honors engineers and scientists making the most significant in-house contributions to aerospace technology.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074

AFRL Research Team Earns AFOSR Star Team Award

Researchers from the Air Vehicles Directorate's Computational Aeroelasticity team earned the Air Force Office of Scientific Research (AFOSR) Star Team Award for their noteworthy scientific advancements. The core team members are Dr. Philip Beran, Dr. Maxwell Blair, Dr. Ned Lindsley, Major Gregory Parker (PhD), and Dr. Richard Snyder. The collaboration also includes a significant number of on-site contractors, university faculty, and students.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074

Mr. Jess Sponable Receives Commander's Cup Award

AFRL awarded Mr. Jess Sponable, of the Air Vehicles Directorate, the Commander's Cup for his efforts in developing new space access technologies enabling low-cost space access. The annual Commander's Cup award recognizes a senior-level person whose efforts have contributed significantly to the laboratory's mission or public image and whose accomplishments have enormously impacted and increased AFRL's credibility.

For more information contact
afrl.va.marketing@wpafb.af.mil • (937)255-2074

Dr. Hendrick W. Ruck Elected American Psychological Association Fellow

Dr. Hendrick W. Ruck, director of AFRL's Human Effectiveness Directorate, received Fellow status from the American Psychological Association. Dr. Ruck's nomination recognizes his outstanding contributions to the field of psychology.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Supervisory Research Medical Officer Earns Lifetime Achievement Award

The Air Force Studies and Analysis Agency selected Dr. Richard A. Albanese, a supervisory research medical officer at AFRL's Human Effectiveness Directorate, to receive the prestigious Air Force Analytic Community's Analyst Lifetime Achievement Award. The honor recognizes Dr. Albanese for his contributions to revolutionary Air Force technologies and capabilities during his 35 years of service.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

Dr. Glenn F. Wilson Named HFES Fellow

The Human Factors and Ergonomics Society (HFES) named Dr. Glenn F. Wilson, a principal research psychologist in AFRL's Human Effectiveness Directorate, an HFES Fellow. Dr. Wilson earned the honor for his significant engineering achievements and contributions to both the engineering profession and the US Air Force for more than 20 years.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Chief Named FLC Laboratory Director of the Year

The Federal Laboratory Consortium (FLC) for Technology Transfer's National Advisory Council selected Dr. Hendrick W. Ruck, director of the AFRL Human Effectiveness Directorate, to receive the 2005 Laboratory Director of the Year Award. The FLC recognized Dr. Ruck's outstanding contributions supporting technology transfer activities in the laboratory throughout 2005, as well as his strategic vision and contributions towards AFRL's collaborations with universities and industry that highlight the laboratory's focus on biotechnology and cognitive sciences.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Researcher Wins Esteemed Optometrist of the Year Award

Major Laura Barnes won the Armed Forces Optometric Society's (AFOS) Optometrist of the Year Award. Maj Barnes is the deputy branch chief and program manager for the AFRL Human Effectiveness Directorate's Vision Science program. She earned this elite award upon her first sponsored submission—an uncommon accomplishment among AFOS members.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Second Lieutenant Receives Membership to the 35th Student Squadron

Second Lieutenant Jeffery Gray, of the AFRL Human Effectiveness Directorate, became a member of the Air and Space Basic Course's 35th Student Squadron (also known as the Eagles). He received honors for his outstanding team effort, warrior ethos, dedication, and commitment.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Establishes Educational Partnership With MIT

AFRL and the Massachusetts Institute of Technology (MIT) established an educational partnership to facilitate collaborative research, teaching opportunities, and information exchange between MIT faculty and AFRL personnel. The partnership will stimulate student interest in science, mathematics, and engineering, as well as promote the education of future scientists and engineers.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL's ACCES® Takes 2006 Award for Excellence in Technology Transfer

AFRL developed the Attenuating Custom Communications Earpiece System (ACCES), a state-of-the-art hearing protection system that improves audio communications in the cockpit and simultaneously protects the ear from damage that audio frequencies can cause. The Federal Laboratory Consortium for Technology Transfer (T^2) honored AFRL for clearing the way for commercial customers to acquire ACCES by means of a one-of-a-kind T^2 process that is quicker and less expensive and also uses far less paper than other acquisition methods.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Researcher Wins Harold Brown Award

Dr. John A. Caldwell, a principal research psychologist with AFRL's Human Effectiveness Directorate, received the 2005 Harold Brown Award, Air Force Materiel Command's highest honor for significant contributions in the field of research and development. This prestigious award honors Dr. Caldwell's accomplishments and vast expertise in the field of experimental psychology and confirms the world-class talents of AFRL's scientists and engineers.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

IEEE and SID Elect Dr. Darrel Hopper as Senior Member

Senior membership within the Institute of Electrical and Electronics Engineers (IEEE) and the Society for Information Display (SID) is reserved for professionals who demonstrate active, significant, and sustained performance within a scientific or technical discipline. Both organizations elected Dr. Darrel Hopper, of AFRL's Human Effectiveness Directorate, to senior member status.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Researchers Receive AFMC Awards

Air Force Materiel Command (AFMC) awarded five representatives from the AFRL Human Effectiveness Directorate with medical service awards. The honorees are Major Drew Widing (pictured top left), Maj Mark Pomerinke (pictured top center), Maj Tammy Savoie (pictured top right), Master Sergeant Marcus Williams (pictured bottom left), and Senior Airman Andre Scott (pictured bottom right).

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Audiologist Receives Research Award

Mr. John Hall, of AFRL's Human Effectiveness Directorate, received the Military Audiology Association's 2006 Auditory Research Award for his outstanding contributions to audiology research, hearing science, and hearing conservation. Mr. Hall has been a leader in the Air Force's (AF) fight against hearing loss. His work is helping to define current and future hearing protection throughout the AF.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

Major Stephen Steele Named Outstanding Air Force Audiologist/Speech Pathologist of the Year

Air Force Materiel Command named Major Stephen D. Steele, operations chief at the AFRL Human Effectiveness Directorate's Warfighter Interface Division, Outstanding Air Force Audiologist/Speech Pathologist of the Year. Each year, the Air Force (AF) awards an AF audiologist or speech pathologist for superior leadership, professional achievements, and officership in support of the AF Medical Service and the profession of audiology or speech pathology.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Researcher Wins Charles S. Gersoni Military Psychology Award

The American Psychological Association honored Dr. Dee H. Andrews, senior scientist at AFRL's Human Effectiveness Directorate, with the Charles S. Gersoni Military Psychology Award (Division 19). The award recognizes Dr. Andrews' outstanding and unusual contributions to psychology through the development of innovative training concepts and technologies, as well as his technical leadership both in developing the concept of distributed mission training into a multi-million-dollar synthetic battlefield for Air Force combat aircrews and in developing the multiship simulator fighter training program, which is on the leading edge of technology and will permit aircrews to simulate combat using more realistic combat mission scenarios.

For more information contact
afrl.he.tech.info@wpafb.af.mil • (937)255-2423 ext 253

AFRL Scientist Elected President of Material and Process Engineering Society

The Society for the Advancement of Material and Process Engineering (SAMPE®) selected AFRL's Dr. Tia Benson Tolle as its president. This honor recognizes her individual achievement and also highlights the talent, professionalism, and dedication of the men and women of AFRL. SAMPE is an international organization with 43 professional chapters, 60 student chapters, and more than 4,000 members, all dedicated to the advancement of new materials and processes.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

AFRL Scientists Receive John L. McLucas Basic Research Award Honorable Mentions

Dr. Andrey A. Voevodin (pictured top) and Dr. James L. Blackshire (pictured bottom), of AFRL's Materials and Manufacturing Directorate, received honorable mentions for the John L. McLucas Basic Research Award based on their individual achievements, technical expertise, professionalism, and dedication. Dr. Blackshire received an honorable mention for his current research contributions towards the development of advanced nondestructive evaluation methods for detecting, characterizing, and imaging structural microcracks in aerospace systems. Dr. Voevodin received an honorable mention for his outstanding basic research and development of nanocomposite tribological materials and hybrid plasma technologies.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

AFRL Metallic Glasses Researcher Receives Air Force Basic Research Award

Dr. Daniel B. Miracle, of the AFRL Materials and Manufacturing Directorate, won the Air Force Basic Research Award for his outstanding scientific achievement. The award recognizes his highly creative and original research that led to the discovery of the atomic structure of metallic glasses.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

AFRL Engineer Receives Air Force Science and Engineering Award

Mr. Doug Carter, of the AFRL Materials and Manufacturing Directorate, received the Air Force Science and Engineering Award in the Manufacturing Technology category. This award honors his expertise, professionalism, and commitment in the field of manufacturing technology.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

Two AFRL Scientists Receive International Achievement Awards

Mr. Gerald Petrak (pictured top) and Dr. Michael Shepard (pictured bottom), of the AFRL Materials and Manufacturing Directorate, received The Technical Cooperation Program (TTCP) Achievement Award for their work in the maturation of the low-plasticity burnishing process. Their selection for this team achievement award recognizes their participation in a TTCP operating assignment between allied nations.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

Dr. James Larsen Wins 2006 Outstanding Engineers and Scientists Award

The Affiliate Societies Council of Dayton, Ohio, selected Dr. James Larsen, a senior scientist in AFRL's Materials and Manufacturing Directorate, to receive the 2006 Outstanding Engineers and Scientists Award. This award honors Dr. Larsen's career achievements and recognizes his wisdom, leadership, and motivation.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

Dr. Richard Vaia Wins 2006 Outstanding Engineers and Scientists Award

The Affiliate Societies Council of Dayton, Ohio, selected Dr. Richard Vaia, a principal materials scientist in AFRL's Materials and Manufacturing Directorate, to receive the 2006 Outstanding Engineers and Scientists Award. The honor recognizes Dr. Vaia's work and exceptional expertise in the field of nanomaterials.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

LAIRCM Team Awarded 2005 Defense Manufacturing Technology Achievement Award

The Large Aircraft Infrared Countermeasures (LAIRCM) team was a cowinner of the 2005 Defense Manufacturing Technology Achievement Award. LAIRCM team members include engineers from AFRL and the Aeronautical Systems Center's Mobility Systems Wing, as well as support contractors from Northrop Grumman Corporation. The team's selection for this award recognizes the hard work and dedication of its members, which resulted in significant production rate, reliability, and cost improvements that are vital for protecting large aircraft from terrorist threats.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

Dr. Lee Semiatin Receives ASM International Award

ASM International, formerly the American Society for Metals, selected Dr. Lee Semiatin, a senior scientist in AFRL's Materials and Manufacturing Directorate, to receive the ASM International 2007 Gold Medal. Dr. Semiatin received this honor for his outstanding contributions to processes—particularly thermomechanical processes—for aerospace materials including both conventional metallic and emerging intermetallic alloys.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

OSD Honors AFRL Team With Acquisition Innovation Award

The Office of the Secretary of Defense (OSD) honored team members from AFRL's Materials and Manufacturing Directorate with the Defense Acquisition Executive Certificate of Recognition for Acquisition Innovation. The award recognizes the team's achievements in executing a very complex initiative with a simultaneous capital expansion and various science and technology development efforts.

For more information contact
techinfo@afrl.af.mil • (937)255-6469

AFRL Engineer Receives Volunteer Excellence Award

Dr. Craig Ewing, an engineer at AFRL's Munitions Directorate, Eglin Air Force Base, Florida, was named the Eglin Volunteer Excellence Award winner for 2005. Dr. Ewing serves as the technical advisor for the AFRL Advanced Guidance Division's Guidance Simulation Branch yet still finds time to volunteer for a variety of outside activities.

For more information contact
AFRL.MN.Marketing@eglin.af.mil • (850)882-3009

Dr. Bob Sierakowski Named Composite Award Winner

Dr. Bob Sierakowski, chief scientist at AFRL's Munitions Directorate, received the American Society for Composites Outstanding Research Award for 2006. This award recognizes distinguished members of the composites community who have significantly impacted the science and technology of composite materials through research efforts sustained over a number of years.

For more information contact
AFRL.MN.Marketing@eglin.af.mil • (850)882-3009

HERD Team Wins Award for Exploratory Development

The High Explosives Research and Development (HERD) team of munitions experts received the 2006 Air Force Science and Engineering Award in Exploratory Development. This prestigious award is given to less than 1% of Air Force research teams. The HERD team received the honor in recognition of its excellent progress in advancing the development of three highly synergistic technologies with significant potential for enabling much safer—yet higher-performing—warheads.

For more information contact
AFRL.MN.Marketing@eglin.af.mil • (850)882-3009

AFRL Superconductivity Group Awarded Third Consecutive Star Team Award

AFRL's Superconductivity Group earned its third consecutive Star Team Award. Dr. Paul Barnes leads the group, whose selection for the award is based on research accomplishments in the areas of magnetic flux pinning and alternating current losses in the yttrium barium copper oxide superconductor.

For more information contact
techinfo@pr.wpafb.af.mil • (937)255-3428

AFRL Propulsion Scientists Named AIAA Fellows

The American Institute of Aeronautics and Astronautics (AIAA) bestowed respective Fellow and Associate Fellow status upon Dr. Sivaram Gogineni (pictured top) and Dr. Michael Heil (pictured bottom), of the AFRL Propulsion Directorate, for their valuable contribution to the sciences. Dr. Gogineni's election to Fellow status honors his accomplishments in turbine engine technology. Dr. Heil (Colonel, US Air Force, Retired) received his Associate Fellow nomination in recognition of his outstanding accomplishments and leadership contributions in the science and technology of aeronautics and astronautics.

For more information contact
techinfo@pr.wpafb.af.mil • (937)255-3428

Hybrid Piston Engine-Pulsed Detonation Engine Patent Granted to AFRL Combustion Scientist

Dr. Frederick R. Schauer, of the AFRL Propulsion Directorate, earned a US patent entitled "Hybrid Piston-Pulsed Detonation Engine." This patent describes a hybrid piston engine-pulsed detonation engine (PDE) where the piston engine is operatively connected to the PDE for the purpose of extracting shaft power.

For more information contact
techinfo@pr.wpafb.af.mil • (937)255-3428

Dr. James Scofield Wins Technology Transfer Award

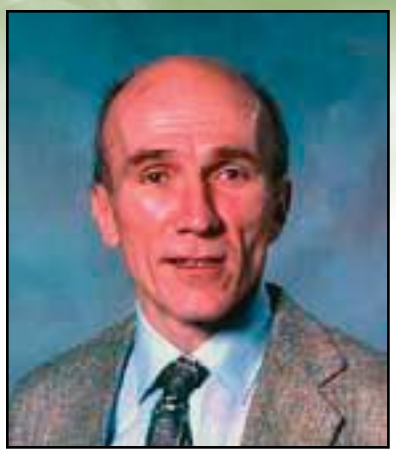
Dr. James Scofield, of AFRL's Propulsion Directorate, received the prestigious 2006 Award for Excellence in Technology Transfer. The Federal Laboratory Consortium for Technology Transfer honored Dr. Scofield for his work in the area of silicon carbide (SiC) power devices—specifically, for his efforts towards transferring the SiC technology and providing leadership, in collaboration with Mississippi State University, to incubate SemiSouth Laboratories, Inc.

For more information contact
techinfo@pr.wpafb.af.mil • (937)255-3428

Ms. Temeca Jones Honored for Creating New Financial Database

The American Society of Military Comptrollers' National Professional Development Institute honored Ms. Temeca Jones, a financial specialist at AFRL's Propulsion Directorate, for her financial, analytical, and problem-solving skills. Ms. Jones received the Secretary of Defense (Comptroller) Individual Award for improving financial management systems within the directorate's Financial Management Division.

For more information contact
techinfo@pr.wpafb.af.mil • (937)255-3428



AFRL Scientist Elected President of International Society for Optical Engineering

The International Society for Optical Engineering, otherwise known as SPIE [the Society of Photo-Optical Instrumentation Engineers], elected AFRL's Dr. Paul F. McManamon its 2006 president. As the chief scientist for AFRL's Sensors Directorate, Dr. McManamon is a member of AFRL's scientific and technical cadre of senior executives, serving as technical lead for more than 500 scientists and engineers.

For more information contact
sn.marketing@wpafb.af.mil • (937)904-9771

AFRL Scientist Receives 2005 Accent on Excellence Award

Dr. Michael Hayduk, branch chief of AFRL's Sensors Directorate, received the 2005. Accent on Excellence Award from the *Observer-Dispatch* (Utica, New York) and Northland Communications (East Syracuse, New York). Dr. Hayduk received the award for leading and encouraging the youth of New York counties Oneida and Herkimer.

For more information contact
sn.marketing@wpafb.af.mil • (937)904-9771

Dr. Stanley Rogers Receives Prestigious Achievement Award

A senior panel of representatives from government, academia, and a national engineering faculty program selected Dr. Stanley Rogers, a nationally recognized professional from AFRL's Sensors Directorate, as the recipient of the 2006 Office of Naval Research Achievement Award. Dr. Rogers' nomination recognizes his career achievements, personal accomplishments, and commitment to helping others succeed in science and engineering.

For more information contact
sn.marketing@wpafb.af.mil • (937)904-9771

Sensors Assistant to the Chief Scientist Earns WSU Institute Award

Dr. Tamara Chelette, assistant to the chief scientist of AFRL's Sensors Directorate, received the Institute Award from Wright State University's (WSU) Biomedical Sciences PhD program. Dr. Chelette, a 1994 WSU graduate, received the award for her accomplishments in the nonacademic/governmental research sector.

For more information contact
sn.marketing@wpafb.af.mil • (937)904-9771

Dr. Stanley Rogers Receives Top Minorities in Science Award

Science Spectrum magazine named Dr. Stanley Rogers, of AFRL's Sensors Directorate, as a recipient of its Top Minorities in Science award. Award winners—known as *Science Spectrum* Trailblazers—contribute exemplary scientific work that extends throughout and beyond their industry.

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