

Graduate School of Engineering and Management
ANNUAL REPORT 2010

Air Force Institute of Technology



Center for Operational Analysis

AFIT's First Fulbright Scholar

Research Highlights



AFIT HISTORY

What started in 1919 as a school for select officers has grown into a premier educational institution for both officer and enlisted students, international students, Department of Defense civilians, and members of all branches of the armed services. The Air Force Institute of Technology accomplishes its mission through three resident schools—the Graduate School of Engineering and Management, the School of Systems and Logistics, and the Civil Engineer School—as well as through its Office of Civilian Institution Programs and the Center for Systems Engineering.

As AFIT continues its ninth decade of operation, faculty and staff members reflect with pride upon the contributions the institute's graduates have made in engineering, science, technology, medicine, logistics, and management. These immeasurable contributions have been vital to national security. The future promises to be even more challenging than the past, and AFIT is prepared to continue providing the environment and opportunity for our students to develop the professional and technical skills needed to sustain effective U.S. air, space, and cyberspace forces.



MESSAGE FROM THE DEAN

Dr. Marlin U. Thomas, Dean

This 2010 Annual Report of the Air Force Institute of Technology (AFIT) Graduate School of Engineering and Management highlights the research efforts of the Center for Operational Analysis (COA) and the Department of Operational Sciences. The featured projects are good examples of how AFIT graduate students actively participate in meaningful defense-related research efforts under the leadership of experienced military and civilian faculty. AFIT's curricula and research programs are intentionally integrated to effectively educate tomorrow's military and civilian leaders for the Department of Defense (DOD) and allied nations.

The COA and other AFIT centers solve everyday technical, operational, and logistical problems saving U.S. taxpayers hundreds of millions of dollars each year. Whether refining deployment and distribution models to reduce the number of required missions, improving experimental design strategies to reduce testing costs, or effectively modeling aircraft maintenance programs, the COA has provided major benefits to our Air Force and DOD sponsors in this time of shrinking budgets. AFIT is also developing critical new technologies, including indoor navigation and laser tracking techniques, to increase the effectiveness and safety of our warfighters. Due to the significance of these developments, AFIT is increasingly engaged in technology transfer efforts with the private sector.

AFIT's academic and research programs directly support Chief of Staff of the Air Force (CSAF) Vector 2010 initiatives and continue to serve the needs of the Air Force. Our robust nuclear engineering program will be key to strengthening the Air Force Nuclear Enterprise. Our research in the area of satellites will ensure the U.S. continues to have the communications network necessary to preserve global security. The research results from our Center for Cyberspace Research (CCR) have become the foundation for developing cyber security education throughout the Air Force. Finally, AFIT researchers and their collaborators and partners are poised to make key contributions to the Air Force Acquisition Improvement Plan (AIP), building upon years of research conducted by the AFIT systems engineering faculty and students.

I am also pleased to report that AFIT's academic quality was reaffirmed this year when ABET, the accrediting agency for college programs in applied sciences, computing, engineering and technology, once again recognized the quality of our curricula by accrediting our eight engineering programs for the maximum allowable six years. This is a testament to our faculty members, staff, and students' commitment to "excellence in all we do," and provides a sound basis for our educational and research efforts as we move into 2011 and beyond.

Respectfully,
Marlin U. Thomas, PhD, PE
Dean, Graduate School of Engineering and Management
Air Force Institute of Technology



For more information about AFIT, visit www.afit.edu

CENTER FOR OPERATIONAL ANALYSIS

The Center for Operational Analysis (COA) Research Connects Students with Operations and Logistics Communities

Since its inception in 2003, the Center for Operational Analysis (COA) has realized its vision through collaborative relationships with more than 30 operational sponsors within the DOD and Intelligence communities. The COA's mission is to provide, within the Graduate School's Department of Operational Sciences, a channel for its faculty members and students to conduct research, and to develop tools and techniques in order to directly impact and improve the Air Force, DOD, and the National Security Structure of the U.S. The COA faculty members take pride in their research, focusing on improving the efficiency and effectiveness of the war-fighter through research in mobility modeling, test and evaluation, logistics modeling and analysis, automatic target recognition/ combat identification, and decision support systems. The COA aspires to provide its sponsors with the highest quality decision information, and superior analysts, as well as access to senior Air Force leaders. These efforts have resulted in increased sponsor funding—growing from approximately \$300K to over \$4 million in the past three years.

The Department of Operational Sciences, the COA's parent organization, is one of six academic departments in the AFIT Graduate School of Engineering and Management, offering nine world-class doctoral, masters, and certificate graduate programs in Operations Research, Logistics & Supply Chain Management, and Mobility Management. Looking to the future, the departmental vision is to be acknowledged as the Air Force DOD preferred provider for graduate education, research, and technology transfer in the field of logistics and operations analysis. With an emphasis on defense-focused graduate education, the department's mission is to produce exceptionally qualified forward planners and managers who will generate quality on-target research and analysis for the Air Force and U.S. allied partners.

The department and the center work together to provide a rich educational experience by offering a robust curriculum, which is enhanced by mentoring and opportunities for student and faculty member collaboration on research efforts. Together, they contribute to the academic and professional development of the students. The director of the Center for Operational Analysis, Lt Col Stephen Chambal, PhD, strongly believes "AFIT and the Center for Operational Analysis' chief goal is to provide significant and applicable research that will greatly impact the DOD in the current environment of continued combat operations and challenging budgets." With the sharing of expertise, intelligence and insight, the COA and the department are joined in the mutual pursuit of generating essential mission ready research and applications, while producing graduates with the appropriate skills and vision to be tomorrow's leaders.



Lt Col Stephen Chambal, Director, Center for Operational Analysis



Dr. Jeffery K. Cochran, Professor and Head, Department of Operational Sciences

For more information about COA, visit www.afit.edu/en/COA/index.cfm

For more information about the Department of Operational Sciences, visit www.afit.edu/en/ens/index.cfm

COA Leadership, Staff and Students



Top Left: Dr. Jeffrey K. Cochran (Head, Department of Operational Sciences), Alex Gutman, Brian Caldwell, Joanne Karras, Tiffany Harper, and Carl Parson
Bottom Left: David Peyton, Jessica Leslie, Haley Perry, Karen Shannon, Jordan Goldmeier, and Lt Col Stephen Chambal (Director, Center for Operational Analysis). Not pictured: Gavin Anderson, Trevor Bihl, Ben Clapp, Mark Fryman, Paul Hartman, Megan Leiter, Matthew McConville, Jodi Tinney, and Chad Wynkoop

COA Impact

- Performs significant research for more than 30 organizations including Joint Functional Component Command for Intelligence, Surveillance and Reconnaissance, U.S. Transportation Command, F-22 Program Office, Air Force Global Logistics Support Center, U.S. European Command/J3, and National Air and Space Intelligence Center
 - Sponsored funding increased from \$300K to \$4 million in the past 3 years
 - Provides research and outbriefs to over 50 GO/SES per year
- Provides direct support to the warfighter providing reachback analysis capabilities to Iraq/Afghanistan
- Saved millions of dollars for USTRANSCOM by optimizing operations

COA Vision

To be operationally relevant by providing a conduit for leading edge research which directly impacts the Air Force, DOD, and the national security structure of the U.S.

COA Research Areas

Mobility Modeling, Test and Evaluation, Logistics Modeling and Analysis, Automatic Target Recognition/Combat Identification, and Decision Support Systems

"Under the direction of Lt Col Stephen Chambal, the COA plays a critical role in supporting the Department of Operational Sciences. The Center provides a laboratory for students and is a vehicle for further development of "proof of concept" thesis/dissertation research—making it field-useful for the DOD and other government and civilian agencies. Through its advisory board and extensive network of contacts, COA plays a key role in creating awareness of AFIT research capabilities, fostering collaborations and partnerships and attracting grants and sponsored funding."

- Dr. Jeffery Cochran, Professor and Head, Department of Operational Sciences



CENTER FOR OPERATIONAL ANALYSIS

Mobility Modeling Saves Millions for USTRANSCOM

The U.S. Transportation Command (USTRANSCOM) is responsible for the complex and complicated problem of deployment and distribution for the DOD. As of April 2009, 11 million tons of cargo, 5.5 million passengers, and 5.88 billion gallons of fuel had been transported by USTRANSCOM's air and sea assets in support of Operations Enduring Freedom and Iraqi Freedom. Just recently, AFIT's Department of Operational Sciences' research team, led by Dr. James Moore, has begun to support USTRANSCOM within this broad-based area of responsibility.

USTRANSCOM's primary mission of efficiently delivering cargo and passengers to their destinations has proven to be a mission with many twists and turns. AFIT's Department of Operational Sciences' research team members eagerly took on the challenge of supporting this mission by modeling the many intricate aspects of this deployment and distribution operation. The potential exists for mission reductions up to as much as 10 percent as the AFIT team provides in-depth modeling of the many diverse facets of this complex issue. Furthermore, extensive investigation has been done on the issues surrounding reduction of fuel consumption and improvement of loading airlift aircraft. These research results have driven a decrease in the number of missions required to deliver assets to forward operating bases and reduced the variance in delivery times, dramatically improving mission success. Additionally, the research findings have provided unique concepts of operations for new transportation assets and improved the distribution of supplies in the theater of operations. To date, significant financial savings have been realized as USTRANSCOM has improved efficiency in optimizing operations and has been able to cancel chartered commercial flights. This efficiency through targeted research has saved USTRANSCOM over \$1 million in the first month and will continue to save resources moving forward. This was achieved through optimization of pallet height, width, and loading for cargo aircraft. Field testing of the feasibility of increasing pallet height is being conducted throughout the DOD. This has the potential to decrease costs across our mobility fleet, including both civilian and military carriers.

AFIT research is also having an impact on field operations. At Joint Base Balad in Iraq, a spreadsheet inventory model developed by AFIT students is currently being used to determine reorder points and order size. This inventory model, leveraging desktop spreadsheets, is being shared across organizations and is moving to other units within Iraq and Afghanistan.

The continued collaboration between AFIT and USTRANSCOM will improve the situation of our warfighters significantly.



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"I feel like I'm part of a bigger community...while obtaining a degree I am making friends, learning OR concepts with context to real world applications, gaining career contacts, enhancing teamwork skills, and bettering the Air Force." – Tiffany Harper, PhD Student in Operations Research

Improving Test and Evaluation Efficiency Across the Air Force

For more than 18 months, AFIT's Test and Evaluation (T&E) Certificate Program has played a prominent role in the workforce development plans for the Air Force T&E career field. This highly respected one-year certificate program, led by Dr. Raymond Hill, involves a sequence of four courses, including Probability and Statistics; Regression Modeling and Analysis; Statistical Design of Experiments; and Reliability, Maintainability, Supportability, tailored to issues in the T&E arena. Furthermore, the individual capstone projects required for this program are targeted for operational relevance to the sponsoring organizations and focus on aspects of advanced statistical knowledge and application understanding to address the modern challenges of the T&E field today.

AFIT's Department of Operational Sciences is actively involved in basic research in support of the Air Force T&E enterprise. One exciting area of research is focused on wind tunnel test campaigns. These campaigns are critical in the developmental process for aeronautical systems. In the past, this testing was approached in the classical manner, testing one factor at a time and sweeping the factor across its range. Once testing was completed for all factors, the resulting data described the response surface of the system being tested. This method proved to be expensive on many levels, including time and resources. The student team of researchers decided to experiment with applying modern experimental design approaches, such as factorial designs, optimal designs, and face-centered designs. By doing this, the team employed advanced approaches by varying multiple factors simultaneously and they were able to achieve results similar to the previous test methodology. They also identified a significant savings in the number of experimental design points required to achieve similar surface characterizations when applied to a classical legacy wind tunnel test. The 90 percent savings provided a method to increase test emphasis in areas such as high-risk, reducing resource requirements, and shortening developmental schedules.

AFIT is also involved in two other initiatives within the T&E enterprise. The first is investigating how to apply statistical experimental designs to Live, Virtual, and Constructive (LVS) simulations, especially when the models are used to generate information for system acquisition decisions. The second, along with the LVC simulations, has the AFIT team exploring various methods to use constructive Modeling and Simulation (M&S) within an acquisition program to develop effective and more efficient operational tests. Overall, this research is proving to have a positive and important impact on the defense acquisition and test communities across the Air Force T&E enterprise.



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CENTER FOR OPERATIONAL ANALYSIS

Increasing Aircraft Availability Through High Velocity Maintenance

"Old age is like flying through a storm. Once you're aboard, there's nothing you can do." ~ Golda Meir

Doing nothing is not acceptable, especially at the Air Force Institute of Technology. Dr. J.O Miller is leading a highly motivated student operational sciences research team to do something about the U. S. Air Force's fleet of aging aircraft. As Air Force aircraft age, the ability to maintain them is rapidly decreasing resulting in a declining rate of aircraft availability.

In collaboration with the Air Force Global Logistics Support Center (AFGLSC) Warfighter Support Center, AFIT students are providing in-depth research on the impact of the High Velocity Maintenance (HVM) program which is currently being implemented for the Rockwell B1-B Lancer Weapon System at Ellsworth AFB, South Dakota. Critical features of the HVM include the ability of the mechanics to better identify the condition of the equipment, facilitating better lead times to engineer a plan, obtain appropriate parts, provide training, and develop infrastructure to increase depot efficiency. In essence, the HVM program is able to reduce aircraft out-of-service duration by decreasing the amount of time aircraft spend at the depot center. The students' research efforts are focused primarily on Discrete-Event Simulations within ARENA 12, modeling Total Not Mission Capable due to Supply (TNMCS) and Combat Mission Readiness (CMR). These simulations are used to explore the effects and impact of High Velocity Maintenance on base operations regarding Supply Chain flow and aircraft maintenance rates. The AFIT research has demonstrated system behavior and depicted a significant decrease in TNMCS rates linked to an increase in efficiency of parts stocking effectiveness at the depot. This could ultimately improve aircraft availability by approximately 20 percent leading to a decrease in funding requirements. In addition, the simulation studies are providing a top-level view of the scheduled maintenance and supply processes at the base levels that are greatly impacted by the HVM model. The outcome of AFIT's comprehensive research will help support the U.S. Air Force in maintaining its aging aircraft fleets to ensure air superiority for years to come.

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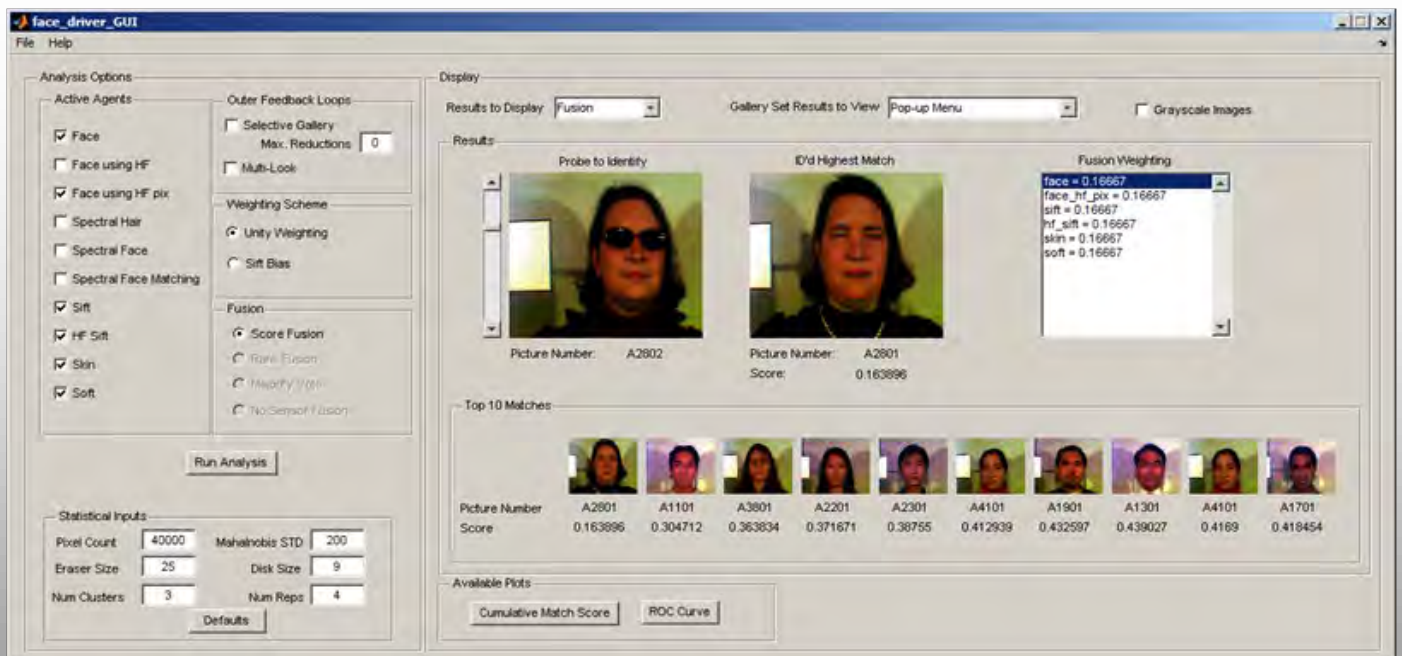
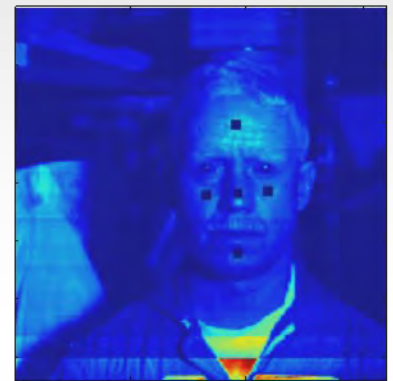


Automatic Target Recognition System Enhancement

While creating an intellectually stimulating environment for its students, AFIT's Sensor Fusion Laboratory is focusing much of its research on the creation and optimization of Automatic Target Recognition (ATR) systems. Two of the primary applications of this effort are Hyperspectral Imagery (HSI) and Synthetic Aperture Radar (SAR) data processing.

The laboratory's quest into the design and sensitivity of ATR systems is centered on optimizing performance based on warfighter and intelligence analyst preference. Advancements are being made through an approach called Robust Parameter Design (RPD), where input parameters are selected to provide optimal ATR results. An ongoing project of the Sensor Fusion Laboratory into the improvement, evaluation, and selection of ATR systems has developed methods of increasing algorithmic processing speed through improved heuristics, approximations methods, parallelization, and syntactic representations. For more than five years, the Sensor Fusion Laboratory has been examining ways to produce robust operating points and has been doing extensive research into classifier feature selection as well. While moving an optimization and processing framework from SAR to HSI, the laboratory's research through its iterative design approach is leveraging real-world sensor data and user needs. The results of this effort will transition into supporting the Air Force DOD warfighter, and applies to facial recognition studies as seen below.

The team, led by Dr. Kenneth Bauer, generates the necessary theoretical research contributions to make advancements in ATR systems, RPD, and the HSI area feasible and able to adapt to the end-user, namely Air Force Research Laboratory and National Air and Space Information Center. The Department of Operational Sciences has received recognition at the national level through the thesis work of one of its students, Capt Robert Johnson, who was awarded the Geospatial Intelligence Award for Academic Research in 2008. The AutoGad code that was designed to find anomalies in HSI has been adapted as a part of an analysis software suite to support the R&D system, TacSat-3, at NASIC. While integrating a host of complex operational problems into student research projects, the focus on delivering transactional capability to both AFRL and NASIC to advance ATR capability within the DOD has been successful and will be implemented into future, high visibility Air Force programs.



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DEPARTMENT OF OPERATIONAL SCIENCES

The Department of Operational Sciences offers world-class graduate programs in Operations Research, Logistics & Supply Chain Management, and Mobility Management. One of six cutting-edge departments in the graduate school, the department faculty members are experts in all major areas of operations research and logistics management. Their research has been substantially funded by the DOD, government, and industry sources. Members of the department hold PhD's, and are recognized leaders in the advancement of the methodology and application of operations research and logistics management.

New PhD in Logistics Launched

The Department of Operational Sciences launched a new doctoral program in logistics this year in response to the growing interest from organizations such as the Air Force Logistics Management Agency (AFLMA) and Aeronautical Systems Center (ASC). The new doctoral program expands the value of the department and the Center for Operational Analysis (COA) to the DOD by attracting and retaining top researchers and advancing the body of knowledge needed to solve the tough logistics problems faced by the DOD. Although AFIT has historically offered rigorous logistics master's degree programs, the Air Force doctoral logistics degree requirements were previously only met by civilian institutions—a missed opportunity to focus strongly on military specific research that addresses DOD and Air Force requirements. The new doctoral degree complements recent logistics research funding levels for department faculty members. Many of the sponsored projects are best addressed by multi-year, in-depth investigations achievable by dissertation research.

The logistics doctoral program's fall quarter 2010 inaugural class was comprised of a diverse cohort of five students: a U.S. Air Force officer, a Greek Air Force officer, and three civilian students. The curriculum develops a strong logistics grounding with emphasis on quantitative analysis. In essence, it combines an analytical core with a flexible program that can accommodate defense-focused supply chain management, acquisition, inventory theory, transportation, and operations management thrust areas.

The program is designed to prepare graduates for senior DOD positions. A secondary objective is to mentor students pursuing faculty appointments at military institutions and elsewhere by exploring teaching, publishing and grant-writing opportunities.

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2010 Inaugural Logistics PhD Class

Left to right: Mr. Paul Hartman, Capt Christos Chalyvidis, Mr. Matthew McConville, and Maj Joseph Elkins.
Not shown: Mr. David Morrow



Five State Area Benefits from Logistics Class Field Experience

An exciting aspect of the Department of Operational Sciences Master of Science logistics degree programs is the incorporation of a variety of corporate site visits and field experiences designed to prepare students to become tomorrow's leaders. This year, at the invitation of the Ohio Department of Homeland Security Office, a team of eight Air Force, civilian, and international officer students worked with faculty members, Dr. Tim Pettit, Dr. Ben Skipper, and Dr. Ned Sandlin to research the financial impact of a terrorist attack on the Great Lakes region. When natural or manmade disasters strike, transportation disruptions can be immediate and severe, threatening both life and property. Using readily available open source information, the team created computer modeled simulations designed to analyze disruptions to ship, rail, and truck arteries at multiple locations throughout the region. Their data show a \$23 million impact to local, state, and regional economies during the first 48 hours post-disaster, not including clean-up, reconstruction, and recovery, which, when added, could potentially double the amount. Research results were presented in a simulated terrorism scenario at this year's spring meeting of the Great Lakes Hazards Coalition held in Oregon, Ohio, which was chaired by National Guard Brig Gen Don Dunbar, Adjunct Gen for the State of Wisconsin. Brig Gen Dunbar commended AFIT's scenario presentation as "outstanding work," commenting that spotlighting such vulnerabilities, costs, and economic impact was exactly the type of information the newly formed five-state consortium needed to energize them to further protective evaluations and actions. Attendees from civilian agencies, the U.S. Coast Guard, the Environmental Protection Agency, and the Department of Homeland Security participated in the discussions. The event provided a rich educational experience for the students, while benefiting from the AFIT team's valuable insights into the effects of disruptions to supply chain operations.

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Department of Operational Sciences Data

- Master's Degree Students: 123
- Doctoral Degree Students: 16
- Certificate Students: 31
- Faculty: 21
- Professional Society Fellows: 2
- Refereed Journals: 27
- Dissertations: 1



Front row (left to right): Mr. David Winn (Ohio Homeland Security), Dr. Tim Pettit, Capt Kesia Gomes (Brazil), Brig Gen Don Dunbar, Maj Francisco Leguiza (Argentina), and Ms. Rachel Ghai. Back row: Maj Mohammed Al-Zaben (Saudi Arabia), Capt Sungtae Jung (Korea), Capt Andy Hackleman, Capt Vince Cammarano, Dr. Ben Skipper, and Capt John Dickens

"The key difference to me between an AFIT PhD (Logistics) and other leading universities is the combined academic excellence, credentials, and experience of the faculty. The Logistic programs are built on a strong quantitative foundation including relevant logistics theory and current industry best practices." – Paul Hartman, AFIT, PhD Student

DEPARTMENT OF OPERATIONAL SCIENCES

AFIT Students Learn Lean Six Sigma

A commercial setting became a classroom for 19 students in LOGM 567 Lean Management Operations and LOGM 569 Maintenance and Production Management courses. Along with four faculty members from the Logistics and Supply Chain Management, Operations Research, Cost Analysis, and Systems Engineering master's programs, they visited the General Electric Aircraft Engines' Customer Education and Training Center (CTEC), in Springdale, Ohio. Mr. Rick Kind, GE's Air Force Programs manager, led a variety of presentations on Lean Six Sigma training, deployment, and supply chain management. Completing the visit was a tour of the training center where the students saw first-hand the progression of engine technology from 1960s military helicopter engines to the newest commercial engine, the GENx. Lean Six Sigma is a key tenet of Air Force Smart Operations for the 21st Century (AFSO 21), and AFIT researchers are using these methodologies to explore ways to reduce waste through disciplined efforts to understand and reduce variation while increasing the speed and flow in the supply chain. Working hand-in-hand with private sector companies ensures AFIT research has wide applicability beyond the DOD.



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AFIT Researchers Brief AFGLSC

On March 5, Dr. J.O. Miller, Lt Col Tim Pettit, and Lt Col Stephen Chambal of the Department of Operational Sciences traveled to the headquarters of the Air Force Global Logistics Support Center (AFGLSC) at Scott AFB to brief Maj Gen Gary T. McCoy and his staff on AFIT research projects currently being conducted for AFGLSC. These include, but are not limited to, TNMCS Simulation, Supply Chain Resilience, F-22/AFGLSC Supply Chain Management Initiative, High Velocity Maintenance Simulation, the Supply Chain Certificate Program, Graduate Education at AFIT and the interfacing AFGLSC role, AFGLSC Advanced Academic Degree military positions and potential for education for civilian workforce development. AFGLSC leadership cite collaboration between AFIT and AFGLSC as key to AFGLSC research capabilities and for providing workforce education opportunities.



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Leading Edge Survey Supply Chain Management Support

Supply Chain Management is a constantly evolving field within the DOD and commercial sector. Many commercial organizations are charging ahead with management initiatives, including improved processes, more efficient business practices, and metrics with increased effectiveness. While the environment in which the U.S. Air Force operates may be slightly different, the supply chain activities performed are very similar to our civilian counterparts, and there is much to be learned from observing how leading edge supply chain organizations conduct their operations.

AFIT's Department of Operational Sciences' Logistics Management Division is leading a two-year study on emerging logistics and supply chain management trends for Air Force Research Laboratory's ManTech division. The AFIT team will conduct surveys and on-site interviews with executives of manufacturers, wholesalers, retailers, and third party service providers in both the private sector and defense industry. Data provided from the surveys and interviews will be analyzed to discover emerging practices, processes, and metrics in logistics and supply chain management that could potentially be adapted and implemented by the Air Force. Through an extensive literature review, a number of supply chain management trends were identified, such as the implementation of supplier Internet portals, improvements in forecasting practices, and virtual integration, to name a few. The AFIT team will compare trends presented by academia to those gleaned from interviews to determine if a link does indeed exist between commercial sector business practices and those presented by academics. In turn, this information will be used to develop applications that provide operational commanders with sustainable and maintainable logistics processes to support our current inventory of weapons systems.



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AFIT Research Supports ECSS Transition Success

The Global War on Terrorism made weaknesses in the military's logistics processes very evident. To help overcome these problems, the Air Force launched the eLog21 transformation campaign. The eLog21 initiative aims to tear down the traditional stove-piped logistics processes currently in use and replace them with a cross-functional, integrated, enterprise-wide set of processes. Perhaps the most critical program to help meet this eLog21 goal is the Expeditionary Combat Support System (ECSS). ECSS is an enterprise resource planning (ERP) system that will enhance the Air Force supply chain management processes, performance metrics, training, and systems by replacing over 250 disparate information systems with one unified system. With a projected end-state in excess of 750,000 primary, secondary, and tertiary users, ECSS is the largest ERP implementation in the world.

Sponsored by the Air Force Logistics Transformation Office (HQ USAF/A4IT), AFIT student researchers, under the supervision of Dr. Jeff Ogden in AFIT's Operational Sciences Department, have been conducting ECSS-related research since the initial blue-printing stages of this transformational effort in 2007. These research results have helped predict and, therefore, avoid implementation barriers, facilitated the creation of a governance structure to oversee the implementation effort, and served to discover ways to minimize productivity disruptions during implementation. These research efforts have also led to a better understanding of both the risks and requirements associated with ERP education and training processes and helped determine where training should take place in order to minimize travel costs. Both data quality and maintenance metrics have also been improved as a direct result of these research efforts. While the initial rollout of ECSS began earlier this year, its full implementation is expected to last through 2013. AFIT continues to play a role for HQ USAF/A4IT in this ongoing effort to help ensure that ECSS is a success.

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RESEARCH AND EDUCATION HIGHLIGHTS

Monocular Vision Localization for Indoor Navigation and Mapping

Urban warfare has become a primary characteristic of modern combat operations. One of the most volatile and dangerous situations occurs when soldiers must enter and explore an unknown building or other enclosed area. In these situations, Global Positioning System (GPS) information is often unavailable or unreliable. In cooperation with AFRL, AFIT researchers are working to develop non-GPS navigation systems for micro-air vehicles to use when exploring these buildings.

One research path that showed promise combined a standard inertial navigation system (gyroscopes, accelerometers, etc.) with a monocular camera and a gimbaled laser range finder. The camera is used to autonomously select a few objects of interest, and then the laser range finder provides an accurate distance measurement to each object. By tracking the objects over time and coupling this information with the inertial navigation system, a stable position, velocity, and attitude solution may be obtained without using a GPS. Finally, since this navigation system operates without any previous knowledge of the surrounding environment, it is ideal for exploration and mapping missions.

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Effective Skills Training for the Millennial Generation

Technologies, such as computers, video games, and MP3 players, have become so ubiquitous in society that their influences are felt in almost every aspect of life. This is particularly true of the millennial generation, those born between 1980 and 2001, who have been raised in a high-tech environment. However, the resulting constant bombardment of stimulation and information provided by these technologies has caused some concern in the education community. In fact, the Air Education and Training Command (AETC) issued a white paper on the topic and stated, "The Air Force must be able to understand the millennial generation and provide a training and education infrastructure that leverages their life-long exposure and aptitude with technology. As learning changes, so must our education and training approaches."

Researchers at AFIT subsequently investigated the learning styles of Airmen undergoing initial skills training at Sheppard AFB, Texas. Using survey data from 866 trainees across various career fields, the researchers examined video gaming experience, preferred learning style, goal orientation, motivation to learn, and performance self-assessment. Contrary to their original hypothesis, the researchers found that gaming experience had no significant impact on an individual's learning style (visual, auditory, read/write, and kinesthetic). Additionally, all learners expressed a lack of motivation to learn in the current training environment with kinesthetic and read/write learners significantly less motivated. The most significant finding to emerge from the research was that increased goal orientation appeared to have a direct influence on motivation to learn. Early research in the field indicated that students who find a particular subject to be interesting, and those who enjoy increasing their mastery, are more motivated to learn in a self-regulated fashion. Using this same rationale, increasing the students' understanding of how they fit into the overall Air Force mission and explaining how the classroom information contributes to their future Air Force success should directly influence the students' learning goal orientation by increasing the value of the information being taught.

To facilitate this process, students can be encouraged to conduct realistic self-assessments to better understand their strengths and weaknesses. Past research at AFIT and elsewhere had found that students with "high levels of career exploration are likely to have high training motivation, because they can more clearly see the link between learning and the development of their strengths and weaknesses." Additionally, students can be taught the importance of career planning—the development of specific plans for achieving career goals. This contributes to learning motivation, because it helps the student understand the importance of training and its role in realizing their career aspirations. Therefore, increased goal orientation will have a profound influence on training motivation, and the Air Force should realize improved training effectiveness and lay the foundation for further excellence.

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The Center for Directed Energy Successfully Tests a Laser/Tracker System

The Center for Directed Energy (CDE) successfully tested the AFIT Active Pointer Tracker (AAPT), a laser pointing and tracking system, in-flight on January 27, 2010. The AAPT is a key component of the Airborne Aero-Optics Laboratory (AAOL) Multidisciplinary-Research Initiative (MRI) sponsored by the High Energy Laser Joint Technology Office (HEL JTO). The CDE has partnered with the University of Notre Dame in this MRI. The power of a laser weapon is due to its coherence; that is, the property of a laser beam that gives it its pencil-beam-like propagation with all rays traveling in the same direction. Likewise, the laser beam's coherence allows one to focus all of its energy with a single lens to a single point, achieving very high levels of energy density. This, of course, leads to rapid heating or even the melting of most targets. The atmosphere causes a reduction in a laser beam's coherence, and when the laser beam is propagating through the air flowing around an airborne platform, the effect is even more severe. The AAOL project will, for the first time, characterize this air flow disturbance, called aero-optical turbulence. If we can better understand the physics of aero-optical turbulence, we can improve the effectiveness of current and future laser weapons through range extension and quicker kills. The project will directly measure the aero-optical flow under actual flight conditions. The AAOL will fly two Cessna Citation aircraft in close formation; the lead aircraft has a telescope mounted to its side for collecting a laser beam pointed at it with the AAPT mounted on the chase aircraft. The instrumentation on-board the lead aircraft is designed for very high bandwidths and resolution for detailed analysis. Matthew Krizo, the project lead from CDE, performed the initial check of the AAPT in January 2010. Other contributors to this project were Rick Bartell, CDE's Lead Research Engineer, and Joshua Brown, the mechanical engineer for the project. Initial findings by the HEL JTO have determined this research is of such importance that it will provide an additional two years of funding to 2012.

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The laser pointing and tracking system installed in the Cessna Citation B aircraft



The laser pointing and tracking system operating in-flight on January 27, 2010

RESEARCH AND EDUCATION HIGHLIGHTS

Distinguishing Suicide Bombers

For the last two years, the Center for MASINT Studies and Research (CMSR) has worked on an experiment called INSPIRE (Integration of a Sensor Package for Identification of Radical Extremists). INSPIRE was designed to investigate whether there are specific gait signatures that can be detected from features and used to distinguish between potential suicide bombers wearing a relatively heavy simulated explosives vest and regular people. Features can include vectors and images. Examples of vectors are time histories of rows of pixels in an image; cross correlations between silhouettes; and time histories of angles of body parts, such as the torso and limbs. Examples of single and multiple images are time averaged over silhouettes and principal component images.

Gait video was acquired of about 90 subjects recruited from AFIT, Wright State University, the University of Dayton, Cedarville University, and local ROTC detachments. The subjects walked a “gait track” that included a set of steps and a ramp in one direction then turning in the opposite direction. The subjects walked in regular attire, attire with a vest, a long coat, and a long coat with a vest. The vests weighed between 5 and 10 kilograms (approximately 11 and 22 pounds) and could be adjusted for each individual. Two cam-

eras were used to cover the gait track, and several hours of video were collected over a number of time periods under different light conditions.

Using a program called PointLight, provided by Dr. Adam Fullenkamp from AFRL/SN, videos were analyzed by hand to extract limb locations and angles from a few subjects. As the gait video data grew to over 700 videos and 1.4 TB in size, it became clear that automatic methods would be needed. To analyze this massive amount of data, programs were written in the Interactive Data Language (IDL) to track and extract sub-images of the walking, ramp ascension/descension, and stair climbing in full color and

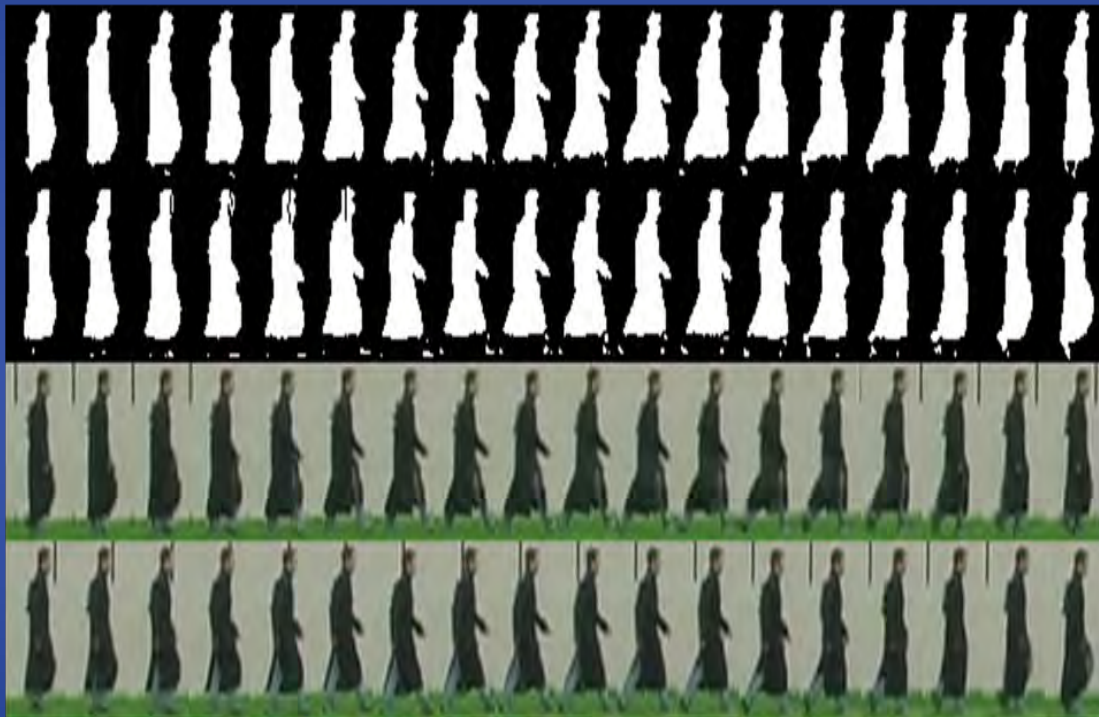


Figure 1 Sample gait signature data

binary masks showing the silhouette of the moving subject. The leg section of the binary mask images was used to extract the gait cycle parameters of gait frequency and velocity for the flat ground sequences (see Figure 1). Teaching a computer to “see” and analyze human gait remains a challenge. Given the relatively light vests used, a clear signature to distinguish “load” from “no load” has not been found. AFIT researchers, Dr. Ronald Tuttle (Principal Investigator), Dr. Kimberly Kendricks (Central State University), Dr. Christoph Borel-Donohue, Mr. Jonathan Juhl, and Mr. Robert McGrellis, have all contributed to this project, which is geared to protect innocent populations from radical suicide bombers.

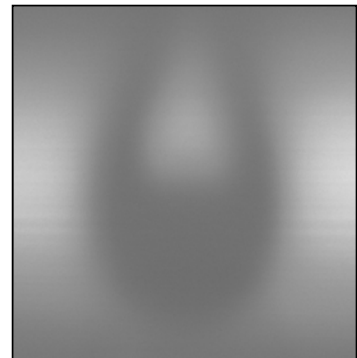
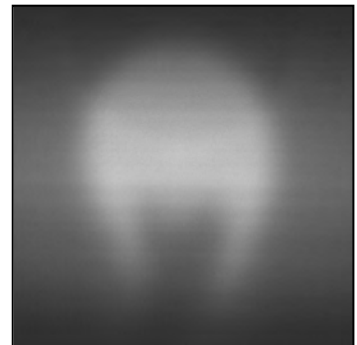
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Advanced Laser Diagnostics Improve Understanding of Aircraft Engines

Modern aircraft engines require high efficiency, yet must also be manufactured to be as light and compact as possible in order to improve performance. In traditional engines, combustors can take up considerable space in order to ensure the necessary residence time for the fuel to mix with air and fully react. Newer designs have sought to take advantage of fluid mixing driven by density gradients, brought about by large temperature differences in the combustor region, in order to reduce the size of the combustor while maintaining and even improving efficiency.

In order to better understand the effect of density differences on mixing, an experiment was conducted using filtered Rayleigh scattering (FRS) in combination with a horizontal buoyant jet. Using a powerful narrow linewidth, continuous wave laser in the Combustion Optimization and Analysis Laser (COAL) Laboratory at AFIT, our research team was able to demonstrate that mixing was greatly enhanced when the density gradient led to instability. The experiments were performed using helium, which has a low value for the molecular cross-section and appears dark when compared to air, and carbon dioxide, which has a large molecular cross-section and appears bright when compared to air, as the primary fluid. Sample images collected with a scientific grade (PCO 4000) camera are shown (figure to the right). By placing a molecular iodine filter between the camera and the image plane, frontal cross-sectional views of jets were collected while background light was suppressed. This led to the capture of the jet cross section for a wide variety of locations and flow conditions. The trajectory and mixing behavior of the jet was demonstrated to depend mainly on Froude number, as opposed to Reynolds number or Schmidt number, for the conditions investigated. The results were summarized in a research article which has been accepted by the highly esteemed journal, *Experiments in Fluids*. These results confirm that the Froude number is of primary importance in characterizing migration of hot combustion products in a real aircraft engine.

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Rapid Detection of Nuclear Material

Protecting the U.S. and its allies from the threat of an improvised nuclear device detonation is one of the highest priority missions for the DOD and Department of Homeland Security. The early detection of the presence of fissile material, such as enriched uranium or plutonium, at ports of entry or in transit, is one of the most effective means of countering this threat. There are several approaches for detecting fissile materials, including gamma scintillation detectors, neutron scintillation detectors, and Helium-3 detectors. Many of these detection systems are not sensitive enough, too bulky, and too expensive, based on the materials and systems currently used, to be widely applicable in many of the proposed concepts for intercepting fissile material.

To address this need, LTC John McClory (Assistant Professor) and the Nuclear Engineering faculty have developed a research program in solid-state neutron detection systems to develop alternatives that are cheaper, lighter, faster, and more sensitive than the currently available systems. AFIT students and faculty members have built and tested devices containing neutron-sensitive materials, such as boron carbide, lithium tetraborate, gadolinium oxide, and uranium oxide, for the Defense Threat Reduction Agency (DTRA). The boron carbide research has resulted in a patent application for a neutron spectrometer. The work on lithium tetraborate and gadolinium oxide has pushed the boundaries of current research and reoriented thinking in the neutron detection community. The work has led to extensive collaborations with scientists and engineers at the University of Nebraska, University of Missouri, and West Virginia University. The ultimate goal is a neutron detection system that is portable, inexpensive, highly sensitive, reliable, and easy to operate.

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RESEARCH AND EDUCATION HIGHLIGHTS

Center for Directed Energy Products Meeting DOD Needs

Faculty members in the Department of Engineering Physics and Center for Directed Energy (CDE) have developed industry leading atmospheric effects modeling and simulation and high energy laser (HEL) operational decision aid tools. These tools have become the DOD standard, filling a void left as legacy Government models become proprietary. Used primarily by the Army, Navy, Air Force, and Academia in engineering performance modeling, the tools are currently being adapted for mission planning and operational use.

In terms of laser weapons modeling, the CDE is a partner in the Modeling and Simulation Technical Working Group of the High Energy Laser Joint Technology Office (HEL JTO). The High Energy Laser End-to-End Operational Simulation (HELEEOS) is a Government-owned engagement-level directed energy modeling MATLAB code developed by AFIT under HEL JTO funding. HELEEOS is the only fast-running HEL engagement code to couple industry standard Scaling for High Energy Laser and Relay Engagement (SHaRE) scaling laws with a worldwide climatic database of atmospheric effects and incorporate an off-axis irradiance due to atmospheric scatter calculator.

Atmospheric effects information can be defined and exported separately with the CDE's Laser Environmental Effects Definition and Reference (LEEDR) code. LEEDR is a freestanding MATLAB executable product, derived from the HELEEOS engine, that calculates and characterizes the effects of the atmosphere and its constituent components on directed energy and electromagnetic energy propagation between 0.4 μm and 8.6 μm . It includes a unique air-to-air, air-to-ground, and ground-to-air worldwide cloud free line of sight database and full access to the probabilistic Extreme and Percentile Environmental Reference Tables (ExPERT) climatic database.

To facilitate implementation of these tools and better serve the high energy laser community, CDE, with the support of the Directed Energy Professional Society (DEPS) and HEL JTO, has also developed three distinctive short courses: a Laser Weapons Systems Short Course (LWSSC) with textbook, an Atmospheric Effects Short Course, and a HELEEOS Short Course. These courses are offered on an on-going basis throughout the year through 2011.



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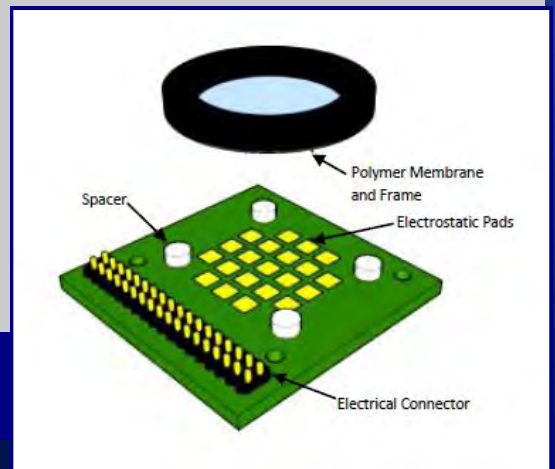
Advanced Beam Control for Tactical Scenarios

The Center for Directed Energy (CDE) is a major partner in this multidisciplinary research effort sponsored by the Joint Technology Office (JTO) to explore creative approaches for reducing volume and weight of a tactical beam control system without a loss of performance. In early 2010, this project was awarded two option years. Other team members include the University of California, Los Angeles (UCLA); the Naval Postgraduate School; and MZA Associates. The CDE has conducted extensive analyses of the expected utility of adaptive optics, used to correct for errors introduced by the atmospheric path, across a wide range of high-interest tactical scenarios. These scenarios, which include precision strike, aircraft self-defense, area defense, and ship defense, span the interests of all the services. As part of this project, the CDE has also analyzed expected performance differences between on-axis and off-axis beam director optical designs. In addition, the CDE is characterizing the performance of low-cost, state-of-the-art micro-electro-mechanical systems (MEMS) deformable mirrors, which may play a role in an advanced tactical beam control architecture. Future plans include analyzing the effects of realistic sensor noise levels and using state-of-the-art tiled fiber laser sources on overall system performance, using a high-fidelity wave optics model of a hypothetical advanced tactical design. This research will continue through 2012.



Artist's conception of an air-to-surface precision strike scenario

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“Optical Cloak” Materials Characterization

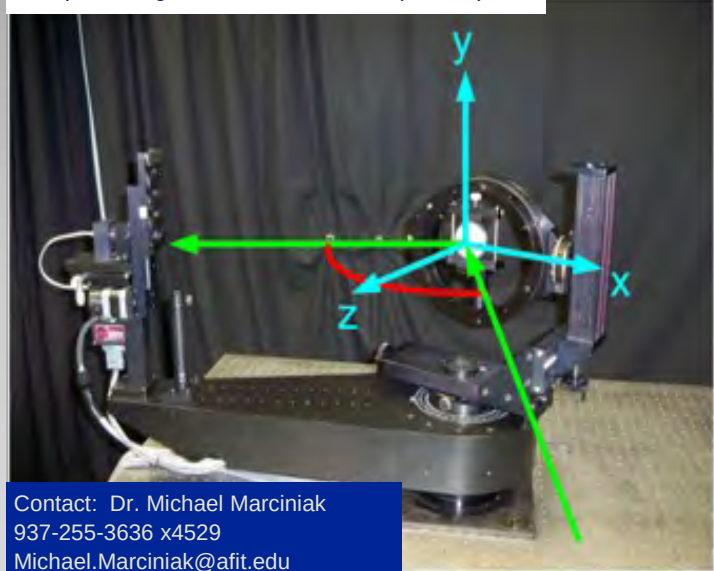
Novel materials with structures fabricated into them on the nanometer and micrometer scale have been designed with the potential to manipulate light in a manner not found in nature. One of the most publicized applications is the possibility of developing an optical cloak that can bend light around itself making it and any object hidden inside invisible. These optical “meta-materials” require feature sizes much less than the wavelength of the light for which they are intended (thus, the small scale) and, therefore, are very difficult to fabricate. Of the relatively few successfully fabricated structures reported, even fewer have had more than a cursory optical characterization to demonstrate their unique optical performance. It is very important to fully understand how fabricated materials interact with light to assess whether they are living up to their design potential.

A recent thrust for AFIT’s Optical Scatter Measurements Laboratory in the Department of Engineering Physics has been to develop a complete optical characterization capability for optical meta-materials and other novel nano- and micro-structured materials such as photonic crystals. At the heart of AFIT’s system is a Schmitt Measurement Systems Complete-Angle Scatter Instrument (CASI®), which measures the bidirectional transmission of light through and reflection of light from a sample at optical wavelengths of military interest: green and red in the visible and in the mid-wave infrared (MWIR) and long-wave infrared (LWIR). Here, “bidirectional” means that a ray of light incident on the sample from any direction is then measured at each and every spatial position in both the transmission and reflection hemispheres around that sample.

The lasers used to provide the incident light in the MWIR and LWIR are continuously tunable with respect to wavelength. This is very important, since optical nano- and micro-structured materials often display their unique properties over only a very narrow range of wavelengths about the “resonant” wavelength for which they were designed. Most instruments similar to AFIT’s CASI only use lasers at discreet wavelengths. AFIT’s ability to characterize novel materials both at and away from their resonant wavelengths is a clear advantage. AFIT’s CASI also features full polarimetric capability. This means that, at any of the CASI wavelengths, any polarization state of the laser light incident on the sample can be prepared, and that all polarization states that the light may be scattered into are measured.

To accommodate the enormous directional, spectral, and polarimetric data-generating capability of this impressive system, AFIT’s CASI features unique automation, sample positioning/orientation, and data collection/analysis interfaces and software. To then analyze this potentially huge volume of collected data, AFIT uses a variety of computational codes to predict the electromagnetic performance of the novel material studied. Other instruments available at AFIT, such as the atomic-force microscope or scanning-electron microscope, are also used to study the samples and provide supplemental information for the analysis.

Complete-Angle Scatter Instrument (CASI®),



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Service Life Predictions for Polymer-Matrix Composite Air Vehicle Components

AFIT researchers are developing new models for aging effects on polymer-matrix materials to enable accurate predictions of component service life. High-temperature polymer-matrix composites (HTPMCs) are currently in use in a variety of aircraft structural components that require light weight, high temperature tolerance and in some situations, transparency to radio frequency energy. Typical examples include external engine components on the HH-60G and F-18 along with the radar nose fairings of several high-speed aircraft.

Before HTPMCs can be more widely used in critical aerospace applications, their long-term durability and structural integrity must be assured. To provide that assurance, experimentally-based, durability-driven design and analysis methodologies must be developed.

Continues next page

RESEARCH AND EDUCATION HIGHLIGHTS

Continued from previous page

Viscoplastic models which account for the rate-dependent deformation behaviors of polymer resins at elevated temperatures do exist. Although originally developed to describe the behavior of metals, one such model, Viscoplasticity Based on Overstress for Polymers (VBOP), has been specialized to account for various aspects of the deformation behavior of polymers.

Recent experiments at AFIT with PMR-15 neat resin revealed the need for a predictive model that was capable of representing the rate-dependent deformation response as well as accounting for the effects of thermal aging on material behavior. As HTPMCs are exposed to elevated temperatures in the design environment, they suffer thermal aging which slowly changes their material properties. Researchers at AFIT have extended VBOP to represent the effects of prior isothermal aging at 288° C. Several VBOP model parameters were made dependent on prior aging time and the resulting model was used to predict the high-temperature behavior of PMR-15 polymer subjected to prior aging of various durations. However, this extension of VBOP does not represent the effects of temperature (either testing temperature or the temperature of prior aging) on the inelastic behavior.

Current research aims to develop a viscoplastic constitutive model capable of capturing the effects of prior thermal aging time and temperature on inelastic mechanical behavior of high-temperature polymers. First, effects of prior aging temperature on time-dependent material behaviors of PMR-15 are established. Second, analytical capability to account for the effects of prior aging temperature on the time-dependent deformation response of solid polymers will be developed within a constitutive framework of the VBOP. The resulting viscoplastic constitutive model will enable designers and analysts to accurately predict component service life and assure structural integrity and environmental durability of HTPMCs in aerospace applications.

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AFIT Applies Hyperspectral Imaging Expertise to Assist Rose-Hulman's Fuel Efficiency Research

In the spring of 2010, Dr. Kevin Gross (Department of Engineering Physics [ENP]) traveled to Terre Haute, Indiana, to the Rose-Hulman Institute of Technology. The goal was to take spectral images of the detonations of a low-compression ratio (1:3) ethanol-fueled internal combustion engine through a sapphire cylinder (left panel in Figure 1, page 21). Over 14,000 interferogram cubes were gathered in one day of experiments. The instrument used was the Telops Hyper-Cam midwave (InSb 1.5–5.5µm) Imaging Fourier Transform Spectrometer (IFTS). FTSs are designed to look at static scenes by building up an interferogram by moving a mirror back and forth. The measured interferogram is then Fourier transformed into a radiance spectrum. Therefore, it seemed far-fetched at the time to create usable spectra, since the temperature of the detonation varies by almost 1,000° C during each engine stroke.

Previous work performed by Dr. Gross' Remote Sensing Group on jet engine exhaust and a plume from a coal fired power plant stack indicated that it might be possible to create interferograms by sorting them according to baseline shifts, which are a function of source temperature. Dr. Christoph Borel-Donohue (ENP) devised a signal processing algorithm that creates a low-pass baseline for each interferogram by spectral smoothing (see right panel in Figure 1). The over 8,000 interferograms are then grouped into similar shapes based on simple measures, such as slope and maximum, as shown in Figure 2. The baseline for each pixel is then compared to a template of the full baseline pulse, which is created interactively by aligning pieces from similar pulse shapes. Only pulses that are a good match to the template are kept. Therefore, it is possible to construct a synthetic interferogram using pieces from similar interferograms but with different phases. When enough pieces are found to create a complete interferogram, the radiance spectrum is computed. A simulation of the measured interferograms showed that the method is indeed capable of reconstructing spectral faithfully for a desired time. With more work, we believe that this novel analysis method can be used to study the combustion process in an internal combustion engine in more detail by retrieving amounts of gases and their temperatures.

See figures next page

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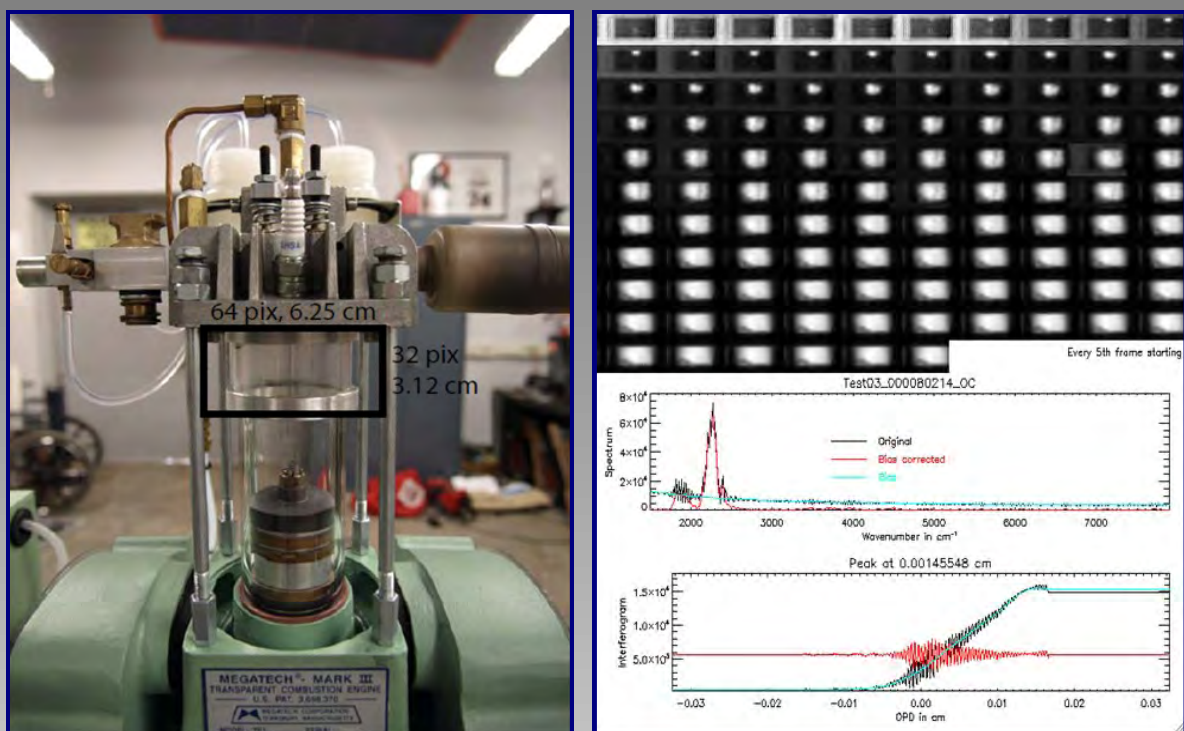


Figure 1 Left panel: Megatech engine with sapphire combustion cylinder. Right panel: Hyperspectral camera sequence (top), spectra (middle), and interferograms (bottom)

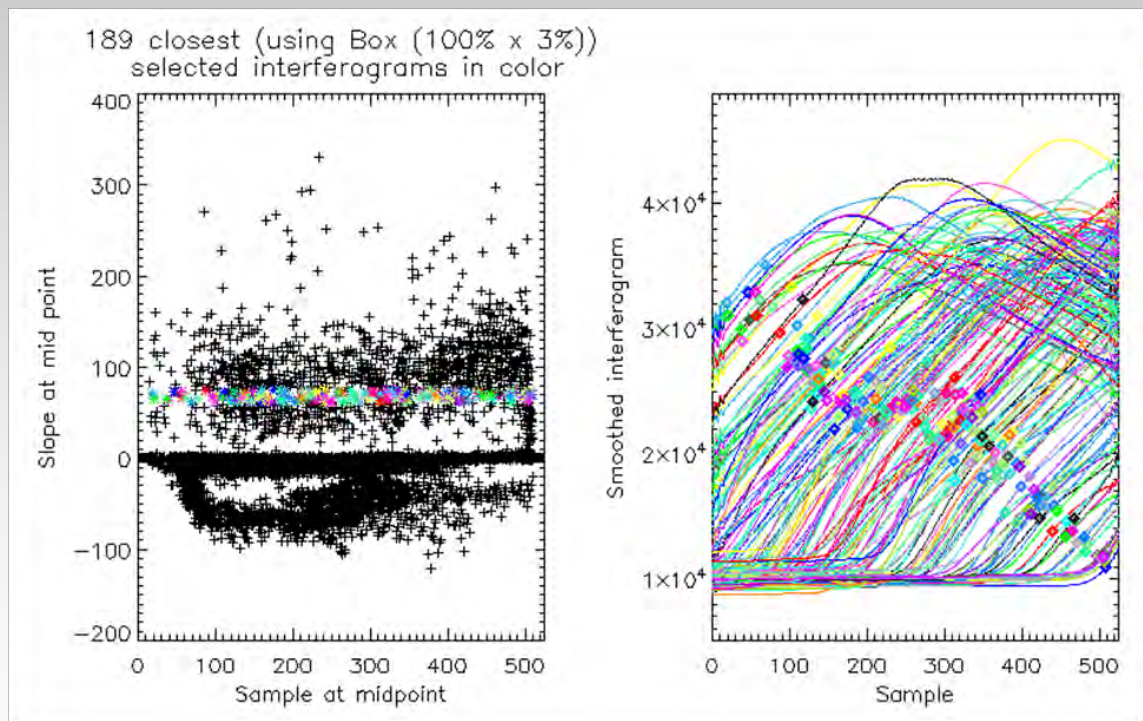
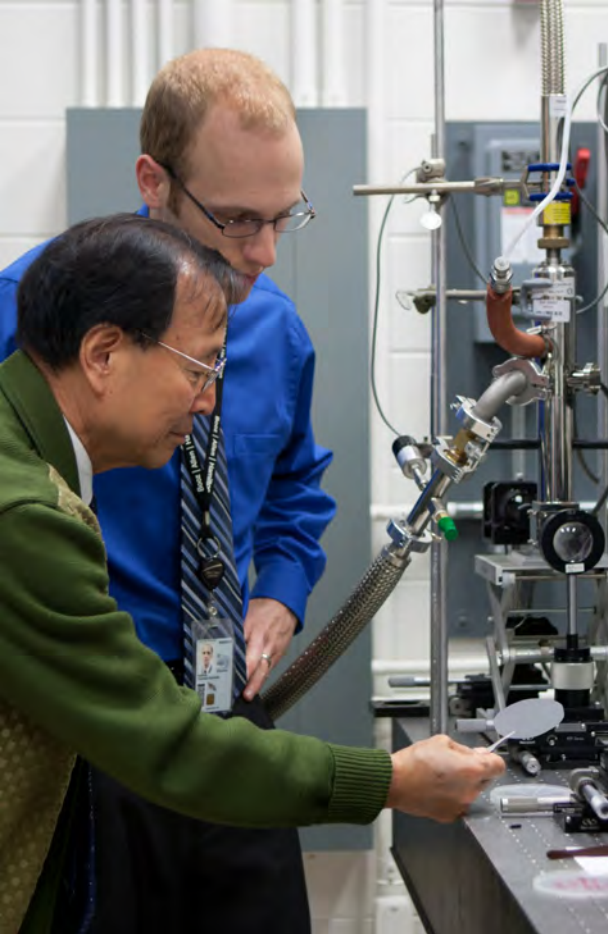


Figure 2 Selection of similar pulse shapes (Diamond symbols) from over 8,000 interferograms represented by + symbols based on mid-point position and mid-point slope

RESEARCH AND EDUCATION HIGHLIGHTS

Optoelectronic and Electronic Devices on a Single Silicon Chip

Silicon (Si) is very well known for its electronic device applications, but there are currently no optoelectronic devices, such as light emitting diodes (LEDs) and laser diodes (LDs), made from Si or germanium (Ge) because of the indirect bandgap nature of these materials. In order to develop new novel Si- and Ge-based LEDs and LDs, the AFIT semiconductor group, in collaboration with Arizona State University and the University of Delaware, is currently studying the optical and electrical properties of newly developed direct bandgap materials, GeSn and SiGeSn alloys, using photoluminescence, electroluminescence, and Hall-effect measurement techniques.



These direct bandgap materials have been grown on Ge or Si substrates by employing a novel crystal growth technique and tuning Si, Ge, and tin (Sn) alloy compositions. It is now possible not only to fabricate Si- and Ge-based LEDs and LDs but also to integrate these optoelectronic devices with the Si-based electronics on a single Si chip. This advance will undoubtedly ignite a major change in future optoelectronic and electronic technology leadership. Furthermore, the ternary SiGeSn alloys will allow effective integration of various devices made from compound semiconductors, such as gallium arsenide (GaAs) and indium phosphide (InP), with Si electronic devices. Many fundamental challenging issues still exist in the development of these new Si- and Ge-based direct bandgap GeSn and SiGeSn alloys and represent the focus of our characterization research. This research project is sponsored by the program manager, Dr. Gernot Pomrenke (1989 AFIT PhD graduate), at the Air Force Office of Scientific Research.

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Atmospheric Effects on Military Systems

Technological innovations in directed energy and remote sensing systems for DOD applications require an accurate characterization of the atmosphere and a solid understanding of how the atmosphere affects transmission of energy across the electronic spectrum. To achieve an adequate understanding, research is required across many disciplines, such as directed energy, remote sensing (ground and airborne platforms), climate change, aerosol radiative effects, and particle dispersion.

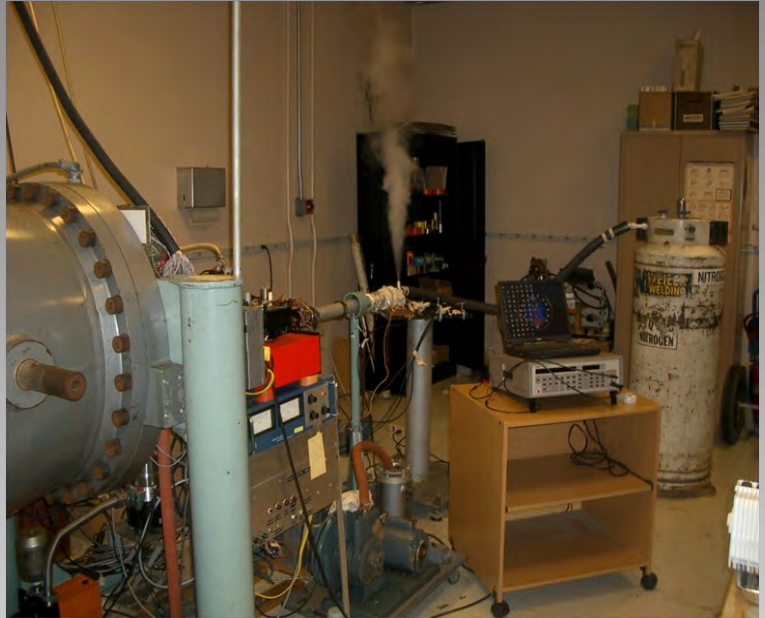
AFIT's Department of Engineering Physics has expertise in these areas and is conducting many interdisciplinary projects to ensure that the DOD remains a world leader in directed energy and remote sensing systems. For example, two recent projects include validating the need for tactical decision aid for the proposed Advanced Tactical Laser (ATAL) and understanding effects of climate change on high energy laser (HEL) weapon systems in maritime environments. The first quantified the effectiveness of the proposed ATL with consideration of simulated engagement scenarios in the lower atmosphere or troposphere. The expected propagation performance was assessed at selected geographically diverse land sites (desert, tropical, subtropical) throughout the world. Seasonal and boundary layer variations and time of day variations for a range of relative humidity percentile conditions were considered. In addition to realistic vertical profiles of molecular and aerosol absorption and scattering, correlated optical turbulence profiles and realistic cloud and rain rate scenarios are considered to complete the realistic engagement environment necessary for comprehensive understanding of ATL operations in the troposphere, validating the need for an ATL High Energy Laser Tactical Decision Aid (HELTDA). Because of the complex nature of the tropospheric effects, the HELTDA will require innovative processes compared to the airborne laser TDA operating in the less complex upper atmosphere or stratosphere. The second study qualified the potential impacts on ship defense HEL performance because of atmospheric effects in the marine boundary layer driven by recent observations and analysis of worldwide sea surface temperatures (SSTs). The atmospheric effects are defined using the worldwide probabilistic climatic database available in the High Energy Laser End-to-End Operational Stimulation (HELEEOS) model. Mean differences and

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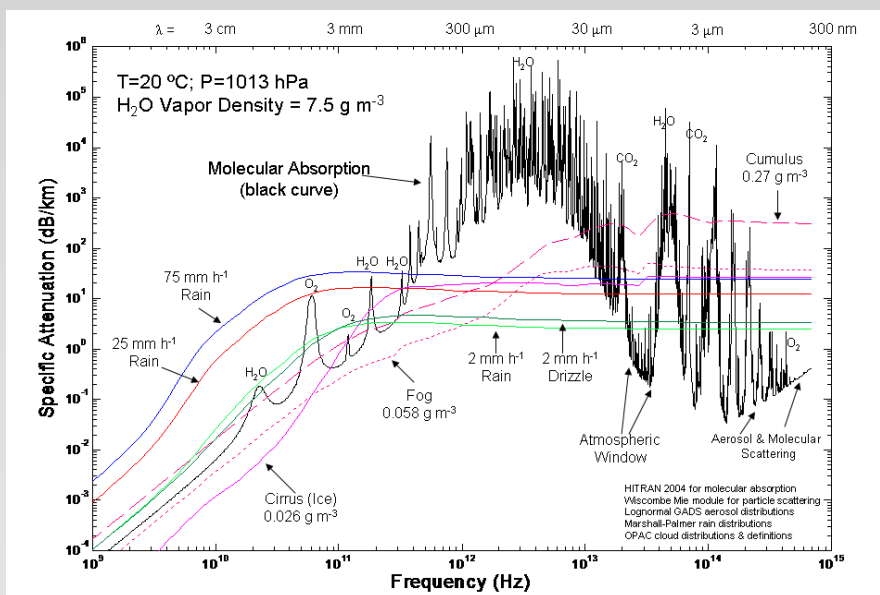
Radiation Effects on Space Electronics and Satellite Materials

U.S. military effectiveness and security depends on reliable space and nuclear assets. These assets are subjected to extreme space and weapons enhanced radiation environments during their life-cycle. AFIT Nuclear Engineering Faculty members, including Assistant Professor LTC John McClory and Associate Professor Dr. James T. Petrosky, have developed an experimental and modeling research program to address the DOD's critical need to test devices for space and nuclear applications. AFIT PhD and MS students have investigated the electronic and mechanical response of advanced materials such as gallium-nitride, silicon carbide, hafnium oxide, and carbon nanotubes to gamma, neutron, electron, and ion radiation. This research has been performed with several organizations including the Air Force Research Laboratory (AFRL), Defense Threat Reduction Agency (DTRA), and the National Nuclear Security Administration (NNSA).

The results of AFIT research into the radiation response of gallium-nitride based transistors have enhanced the AFRL Sensors Directorate's initiative to develop high-speed reliable sensors and electronic components. The research into the radiation response of carbon nanotube-based satellite structural material has resulted in the rejection or acceptance of particular nano-based composite materials for future satellite exoskeletons by the AFRL's Materials Directorate, potentially saving millions of dollars in payload costs for new satellites. Research into the radiation response of hafnium oxide has resulted in new solid-state neutron detectors for the DTRA's Basic and Applied Science Directorate and is a potential component of a standoff nuclear materials detection system. This research has also led to extensive collaborations with Sandia and Los Alamos National Laboratories and universities like The Ohio State University, Wright State University and Indiana University. The goal of these research efforts is to build reliable and robust electronics, using modern semiconductor materials and designs that are deployable on critical national space and nuclear defense assets.



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Broad Spectrum Effects from AFIT HELEEOS Program

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trends between two SST databases are used to deduce possible climate change impacts on simulated maritime HEL engagements. A number of locations indicated a slight decline in expected HEL performance, but most areas showed little discernable change. As technology continues to advance our weapon systems and remote sensing platforms, our understanding of how the atmosphere affects those systems and platforms will continue to evolve and become increasingly complex.

RESEARCH AND EDUCATION HIGHLIGHTS

AFIT Prepares Future Cyberspace Warriors to Meet DOD Needs

Since it was designated as the Air Force Cyberspace Technical Center for Excellence in June 2008, AFIT's Center for Cyberspace Research (CCR) has been at the forefront of providing courses for future cyberspace warriors. "Space and cyberspace bring us the ability to have very small groups of forces act and behave like very large forces," said General Kehler. "Cyberspace is an enabler. It allows warfighters to navigate and call in help with supreme accuracy. It allows warfighters to see the battlefield in real time. This focus on space, and now cyberspace, will allow the United States Air Force to continue the dominance over our adversaries."

On October 28, over a hundred students from across the Air Force and DOD cyber community including the 7th Intelligence Squadron, 83rd Network Operations Squadron, 315th Network Warfare Squadron, 690th Network Support Squadron, 24th Air Force, Air Force Special Operations Command, National Guard Bureau, and U.S. Strategic Command, graduated from AFIT's newest program for cyberspace professionals. Within the curriculum, students were provided a broad background in cyber concepts, including capabilities, limitations and vulnerabilities and their associated application and employment in joint military operations. Working closely with the Air Force Space Command (AFSPC), CCR will continually re-tool its educational programs to keep cyberspace professionals current and at the cutting edge, keeping pace with the quickly changing cyber domain.

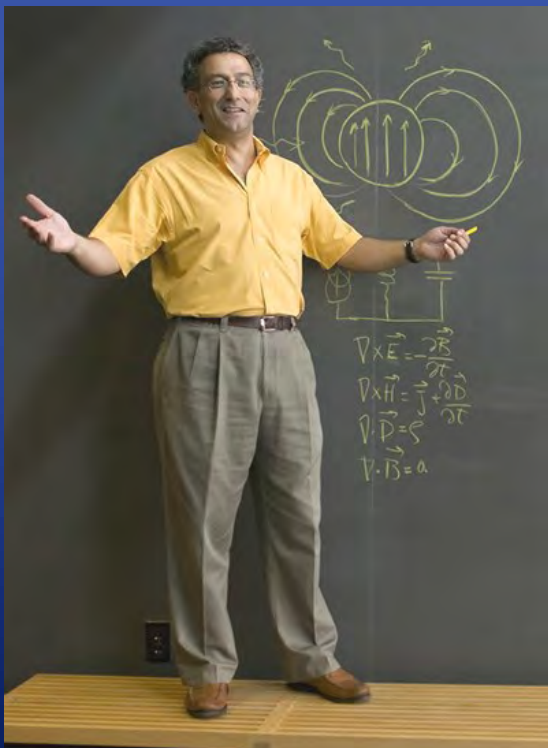
<http://www.afit.edu/en/ccr>

AFOSR Seminar Series Fosters Research Collaboration

The Air Force Office of Scientific Research (AFOSR), the AFRL (Air Force Research Laboratory) and AFIT have teamed together to present a series of seminars designed to foster collaboration between Air Force scientists and researchers at private and public sector colleges and universities. The brainchild of AFOSR Director, Dr. Thomas P. Russell, the series is held in conjunction with the AFIT

Department of Engineering Physics weekly seminar series, offering quarterly lectures and the opportunity to interface with private sector scientists who conduct research in areas closely aligned and sometimes funded by AFOSR and AFRL. Speakers to date have included Dr. Nader Engheta from the University of Pennsylvania, Dr. Kenny Breuer from Brown University, Dr. Kenneth Sandhage from the Georgia Institute of Technology, and Dr. George C. Schatz from Northwestern University.

While at WPAFB, featured lecturers have the opportunity to visit labs, have individual meetings and be briefed about on-going research initiatives and DOD needs.



Upcoming AFOSR Seminar Series Lectures

March 3, 2011	Dr. Mark Lewis, University of Maryland—"What We Still Don't Know About Hypersonic Flight"
May 5, 2011	Dr. Meigan Aronson, Stony Brook University—"Magnetic Materials"

Dr. Nader Engheta was the first AFOSR Seminar Series speaker. His topic was "Taming the Light with Metamaterials"

AFIT Celebrates 50th Anniversary of the Laser

On September 16, 2010, the Center for Directed Energy (CDE) held the AFIT SPIE LaserFest Speaker Series at the Engineers Club of Dayton. LaserFest (www.laserfest.org) is a yearlong celebration of the 50th anniversary of the laser's invention, which was first demonstrated in 1960, and is a collaboration among the American Physical Society, Optical Society of America, SPIE, and IEEE Photonics Society. AFIT was competitively selected and funded by SPIE to host this event.

This lecture series focused on the DOD's role in the development of laser technology and featured two distinguished speakers, Dr. Charles "Barry" Hogge and Dr. Joseph Verdeyen. Dr. Verdeyen, who is currently at the University of Illinois, has a long career in laser research and authored a widely used textbook in laser electronics. He discussed the chemical oxygen-iodine laser (COIL), which was recently used by the Air Force Airborne Laser to shoot down a ballistic missile. Dr. Hogge ascended through the ranks of DOD research and eventually served as the Chief Scientist of AFRL's Directed Energy Directorate. During his talk, he covered the exciting history of laser applications within the DOD. With attendance of nearly 100 staff members, faculty members, and students from AFIT, local universities, and Dayton-area high schools, the event was deemed a success. This lecture series provided an opportunity for the students to further their knowledge on laser devices and allowed them to expand their network of experienced laser researchers.



Left to right: Dr. Heidi R. Ries, Maj Jason D. Schmidt, Dr. Joseph T. Verdeyan, Dr. Salvatore Cusumano, Dr. Marlin U. Thomas, Dr. Glen P. Perram, and Dr. Charles "Barry" Hogge

CCR Hosts ICIW Conference

AFIT's Center for Cyberspace Research (CCR) hosted the International Conference on Information Warfare (ICIW) on April 8-9, 2010. Over a hundred researchers from the U.S., Estonia, Finland, France, India, Portugal, South Africa, Turkey and the United Kingdom attended. The ICIW conference provided a unique venue where researchers and practitioners were able to discuss advances in scientific and technical knowledge as it pertains to information warfare and cyberspace. ICIW goals going forward include putting research into practice and providing researchers with an understanding of real-world problems.

FACULTY HIGHLIGHTS



Raquet Named First AFIT Fulbright Scholar

Dr. John Raquet, director of the Advanced Navigation Technology (ANT) Center, was selected as AFIT's first Fulbright Scholar for his proposal to spend six months conducting research and teaching the fundamentals of Global Positioning Systems at the Tampere University of Technology in Tampere, Finland. As a Fulbright Scholar, he worked with graduate level students in the Department of Computer Systems. Tampere was a natural fit because the research the university conducts is similar to that of the ANT Center; however, with one big difference—while the ANT Center strives to provide navigation solutions for the warfighter, research at Tampere University of Technology focuses on navigation systems for mass-market consumer usage.

Working just across the street from the research facilities of cell phone maker Nokia, Dr. Raquet was able to consider his own research in a new way. He encountered several different research ideas and educational methods that he is working to implement at AFIT. One such concept is the extensive use of in-class exercises and demonstrations to improve student understanding.

During their time in Finland, Dr. Raquet and his family also experienced a different lifestyle, which is as much a part of the Fulbright Scholar program as the research and teaching opportunities. They toured the country, learned to cross-country ski, embraced the Finnish affinity for saunas and winter swimming, and learned to love Finnish food. Dr. Raquet plans to continue the education exchange spawned by his Fulbright experience by keeping in touch with the faculty and researchers in Tampere and using the relationship to support AFIT and the ANT Center.

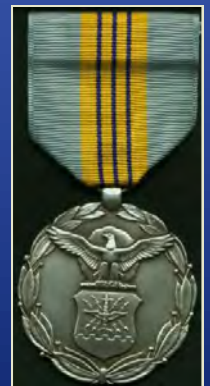
Contact: Dr. John Raquet
937-255-3636 x4580
John.Raquet@afit.edu



Brig Gen Walter D. Givhan and Dr. Jeffery K. Cochran

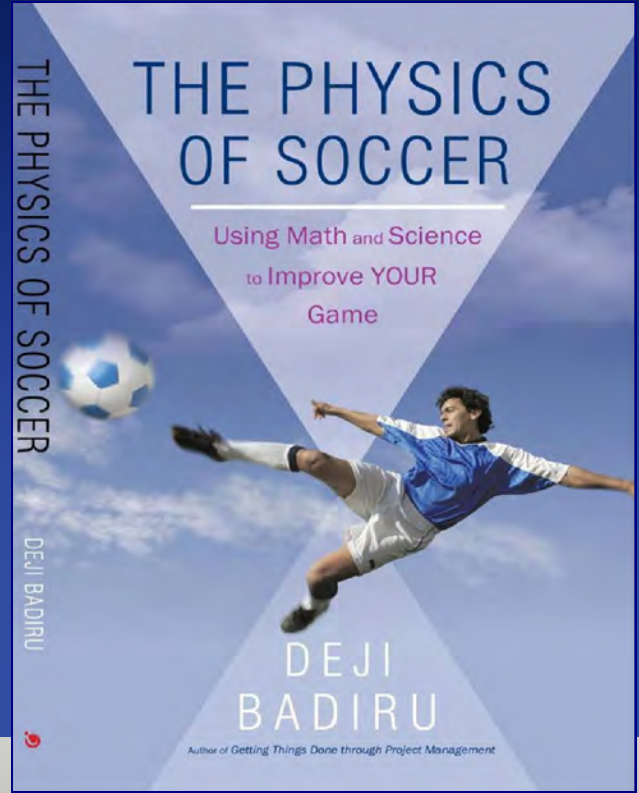
Meritorious Civilian Service Award

Dr. Jeffery K. Cochran was awarded the Civilian Meritorious Service Award by AFIT Commandant Brig Gen Walter D. Givhan in recognition of his exemplary leadership and professional excellence as the Department of Operational Sciences department head. Dr. Cochran joined AFIT after 23 years at Arizona State University where he served as Professor of Engineering and Associate Chair of Graduate Studies. The citation recognized Dr. Cochran's exemplary leadership and relentless energy, noting that he completely revolutionized the organization and culture of the Operational Sciences Department, motivating the faculty through "leadership by example" to be more effective as educators and researchers, significantly impacting both students and sponsors of departmental research. Furthermore, he was recognized as a tireless proponent of positive change and an exemplary role model within AFIT who created an environment where success is expected, tools are provided for the faculty members, staff, and students to excel and remarkable results are championed for others to emulate.



Math, Science and Soccer

Dr. Deji Badiru penned *The Physics of Soccer: Using Math and Science to Improve Your Game* to provide a guide to those who seek to truly comprehend the physics and movements of the game and manipulate them to vastly improve performance. With over 40 years of experience as a soccer player and coach, Dr. Badiru combined his extensive knowledge of science and engineering to break down the core principles of physics as they relate to soccer. The book has received the Editor's Choice Award from IUniverse.



AFIT Vision Statement

"World leader for defense technological education, research, and consultation."

AFIT Remote Sensing Team Wins Air Force-wide Award

The Remote Sensing Group in AFIT's Department of Engineering Physics has won the FY10 Air Force-wide Science and Engineering Team Award for Exploratory or Advanced Technology Development. Since the late 1990s, the group, now led by Dr. Glen Peram, Dr. Kevin Gross, Lt Col Michael Hawks, and Mr. Jeremy Pitz, has worked with the intelligence community to improve phenomenological understanding of transient battlespace combustion events, such as high-explosive detonation fireballs, muzzle flashes, and rocket motors. The group routinely deploys an extensive suite of radiometers, imagers, and spectrometers to various DOD test ranges to observe these rapidly evolving combustion events. Student-driven analysis of these rich data sets has produced scholarly publications and improved intelligence sensor data exploitation.

Contact: Dr. Kevin Gross
937-255-3636 x4558
Kevin.Gross@afit.edu



STUDENT AND ALUMNI HIGHLIGHTS

Maj Mark Friend—AFIT Graduate Joins Operational Sciences Faculty

Q. You completed your PhD program at AFIT in 2007. What have you been doing between your graduation and your return to AFIT?

"After graduation I worked at AMC/A9 Analyses, Assessments, & Lessons Learned as Chief of the Integration Division. AMC/A9I main focuses are to provide support to the Air Mobility Command's capabilities based planning process, serve as the focal point for AMC modeling and simulation needs, and provide reach back support to deployed analysts at the Air Mobility Division (AMD) in the 609th Air and Space Operations Center, Al Udeid Air Base Qatar. As part of our support for the war fighter, everyone in AMC/A9I deploys to the AMD and leads the analyst cell during their AEF cycle. In support of this effort I deployed to Al Udeid Air Base from Jan – Mar of 2009."

Q. How did your AFIT education prepare you for your new role in the Department of Operational Sciences?

"As a graduate of the Operation Sciences PhD program I understand the challenges faced by new students in both the Operational Sciences Master and PhD programs. In addition, AFIT's strong focus on research by both Master and PhD students helped prepare me to start research as a faculty member."

Q. What courses will you be teaching and what areas of research will you be pursuing during the coming year?

"I will be teaching Discrete Event Simulation and Empirical Modeling. My main focus of research will be pattern recognition techniques applied to Synthetic Aperture Radar and Hyper spectral imagery data."



Maj Mark Friend (left) works with a Department of Operational Sciences student

Maj Gen Wendy M. Masiello

Maj Gen Wendy M. Masiello is the Program Executive Officer for Combat and Mission Support, Office of the Assistant Secretary of the Air Force for Acquisition, Washington, D.C. She leads the acquisition of Air Force services and is responsible for more than \$100 billion in existing and planned contracts across the Air Force. She oversees acquisition planning, the competitive selection process and execution of performance-based acquisition, ensuring proper management controls are in place. She obtained her MS degree in logistics management from AFIT in 1984. She was an instructor at AFIT, teaching Quantitative Contract Analysis from 1984-1987.

She has commanded an air base wing, and deployed to Iraq as Principal Assistant for Contracting Forces in Iraq/Afghanistan. Prior to her current assignment, she was the Associate Deputy Assistant Secretary (contracting), Office of the Assistant Secretary of the Air Force for Acquisition.



AFIT Alumni Honored at Heritage Symposium



Dr. Ray O. Johnson

Dr. Ray O. Johnson and the late Gen Robert T. Herres were named Distinguished Alumni at this year's AFIT Heritage Symposium. Dr. Johnson is the Senior Vice President and Chief Technology Officer for Lockheed Martin Corporation. As an Officer of the Corporation and a member of the executive leadership team, Dr. Johnson guides the Corporation's technology vision and provides corporate leadership in the areas of technology and engineering, which includes more than 70,000 people working on more than 4,000 programs. Dr. Johnson also leads the Corporation's Advanced Concepts Organization and the *Center for Innovation*, a world-class laboratory for collaborative experimentation and analysis involving Lockheed Martin, its customers, and industry partners. He currently serves as a member of the Sandia Corporation, National Math and Science Initiative, Hispanic College Fund, and SPIE Boards of Directors and as a member of the Project Lead the Way Advisory Board. Dr. Johnson is a member of the Governing Board of the Indo-US Science and Technology Forum and a sponsor of the DST-Lockheed Martin India Innovation Growth Program. He is on the Board of Directors of the Northern Virginia Technology Council and the Virginia Center for Innovative Technology. He is a member of the Virginia Innovation and Entrepreneurship Investment Authority and the Maryland Federal Facilities Advisory Board. Dr. Johnson is a member of the Board of Visitors for the Clark School of Engineering at the University of Maryland. Born in Kansas City, Missouri, Dr. Johnson holds a BS degree in Electrical Engineering from Oklahoma State University and MS and PhD degrees in Electrical Engineering from AFIT in 1987 and 1993 respectively.



Gen Robert T. Herres (deceased)

The late Gen Robert T. Herres was the first commander in chief of the U.S. Space command and retired as the Vice Chairman, Joint Chiefs of Staff. He was born in Denver, Colorado. In 1954, he graduated from the Naval Academy, later earning master's degrees in electrical engineering and public administration from AFIT (1960) and The George Washington University. His early military assignments were as a pilot and electronic maintenance officer. Following his graduation from AFIT, he served as a technical intelligence analyst and flying training supervisor. In 1965 he became an instructor at Air University. By 1967, he was assigned to the Manned Orbiting Laboratory program, part of the Space Systems Division of the Air Force Systems Command in Los Angeles. Three years later he attended the Industrial College of the Armed Forces and upon graduation became the vice commander of the 449th Bombardment Wing, becoming commander the following year. As his career continued, he was involved with various aspects of command and control until assuming command of the Air Force Communications Command at Scott AFB in 1979, followed by the command of SAC's 8th AF at Barksdale AFB in 1981. By October 1982, he was called upon to direct the control and communications command systems of the Joint Chiefs of Staff—ultimately becoming the first commander in chief of the U.S. Space Command. He culminated his distinguished military career as the first Vice Chairman, Joint Chiefs of Staff. After his retirement from the military, Gen Herres served in various capacities at USAA and retired as their Chief Executive Officer.



AFIT Educational Programs Supporting DOD Initiatives

Responsiveness to emerging challenges has long been one of AFIT's key strengths, and the Graduate School of Engineering and Management has produced a number of education programs to specifically meet critical Air Force needs. These include:

- Degree programs in cyber operations and cyber warfare were developed in direct response to the newest Air Force mission area. The cyber operations program blends coursework from traditional Computer Science/Computer Engineering degree programs with specialized coursework and research designed to give students a solid technical foundation in information assurance issues including computer operating systems, networks and data security, and network design and analysis. The cyber warfare program is a one-year intermediate developmental education program designed to give future leaders a broad background in cyber warfare theory and application to help them better understand, develop, acquire, manage, and employ cyber-based capabilities. POC: Dr. Nat Davis, Department of Electrical and Computer Engineering, 937-255-3636 x7218, Nathaniel.Davis@afit.edu
- Cyber professional continuing education programs were developed and are being taught by the Air Force Cyber Center for Cyberspace Research which is part of the Graduate School of Engineering and Management. Known as Cyber 200 and Cyber 300, these courses provide students with hands-on technical education in cyber operations (cyber 200) and senior leadership issues and responsibilities (cyber 300). POC: Dr. Nat Davis, Department of Electrical and Computer Engineering, 937-255-3636 x7218, Nathaniel.Davis@afit.edu
- AFIT has developed a unique program specializing in the design of nuclear weapons and the analysis of their effects. In this one-of-a-kind program students are introduced to a variety of areas to include detection and characterization of atmospheric effects due to nuclear detonations, nuclear forensics, satellite radiation vulnerability, fallout modeling, and counter-proliferation. POC : Dr. James Petrosky, Department of Engineering Physics 937-255-3636 x4562, James.Petrosky@afit.edu
- To develop technologies and techniques to defeat terrorist threats, and in support of the Department of Homeland Defense counter-terrorism efforts, AFIT offers a three track program that researches target identification of weapons of mass destruction. Students learn how to characterize target identification signatures for either biological, chemical, or nuclear weapons. POC: LTC Eugene Sheely, Department of Engineering Physics 937-255-3636 x4569, Eugene.Sheely@afit.edu
- In response to the Congressional Weapons Systems Acquisition Reform Act, and to help establish DOD standardization for cost estimating and analysis, a cost analysis distance learning Masters degree program is being developed jointly with the Naval Postgraduate School to help improve DOD acquisition capabilities POC: Lt Col Eric Unger, Department of Systems and Engineering Management 937-255-3636 x7402, Eric.Unger@afit.edu
- At the request of the Air Force Medical Service's Bioenvironmental Engineering Career Field, AFIT developed an industrial hygiene program. This program leverages the synergy resulting from AFIT's co-location with the 711th Human Performance Wing and the incoming USAF School of Aerospace Medicine. POC: Lt Col Jeremy Slagley, Department of Systems and Engineering Management 937-255-3636 x4511, Jeremy.Slagley@afit.edu
- At the request of HAF A4 and A10 in direct response to the CSAF initiative to correct nuclear enterprise problems, AFIT developed a nuclear logistics management specialty in the Master of Science in Logistics and Supply Chain Management degree program. Designed for students who manage nuclear munitions, the program includes course work in Nuclear Weapons Strategy and Policy, Nuclear Weapons Effects, Nuclear Technologies, and Reliability, Maintainability, and Sustainability. POC: Lt Col Tim Pettit, Department of Operational Sciences 937-255-3636 x4525, Timothy.Pettit@afit.edu
- A one-year graduate certificate program in Test and Evaluation (T&E) provides students with the tools needed to advance the role of experimental design, and to meet the unique needs of the Air Force T&E enterprise workforce. POC: Dr. Ray Hill, Department of Operational Sciences, 937-255-3636 x7469, Raymond.Hill@afit.edu

Selected Large Awards FY10

Research Analysis and Transition Support to the 478th Aeronautical Systems Group

\$570,000—AFMC

Principal Investigator: Lt Col Timothy Pettit

CY2010 HELJTO M&S Technical Area Working Group Product Development

\$525,000—AFRL/RD

Principal Investigator: Dr. Stephen Fiorino

Joint Distribution Process Analysis Center and AFIT Distribution Research Project

\$500,000—USTRANSCOM

Principal Investigator: Dr. James Moore

Tactical SIGINT Technology Program

\$496,000—NSA

Principal Investigator: Dr. Rusty Baldwin

Ground Truth Support

\$475,000—NASIC

Principal Investigator: Dr. Kevin Gross

Leading Edge Supply Chain: Identifying Ways to Improve Weapon Systems Sustainment & Logistics Support

\$410,000—AFRL/RX

Principal Investigator: Lt Col Joseph Skipper

Squadron Officer College Blended Learning Study

\$400,000—AETC

Principal Investigator: Lt Col Alex Barelka

Characterization of Air Emissions and Geospatial Exposure Modeling from Burning of Waste at Deployed Military Locations

\$290,000—AFMSA

Principal Investigator: Lt Col Jeremy Slagley

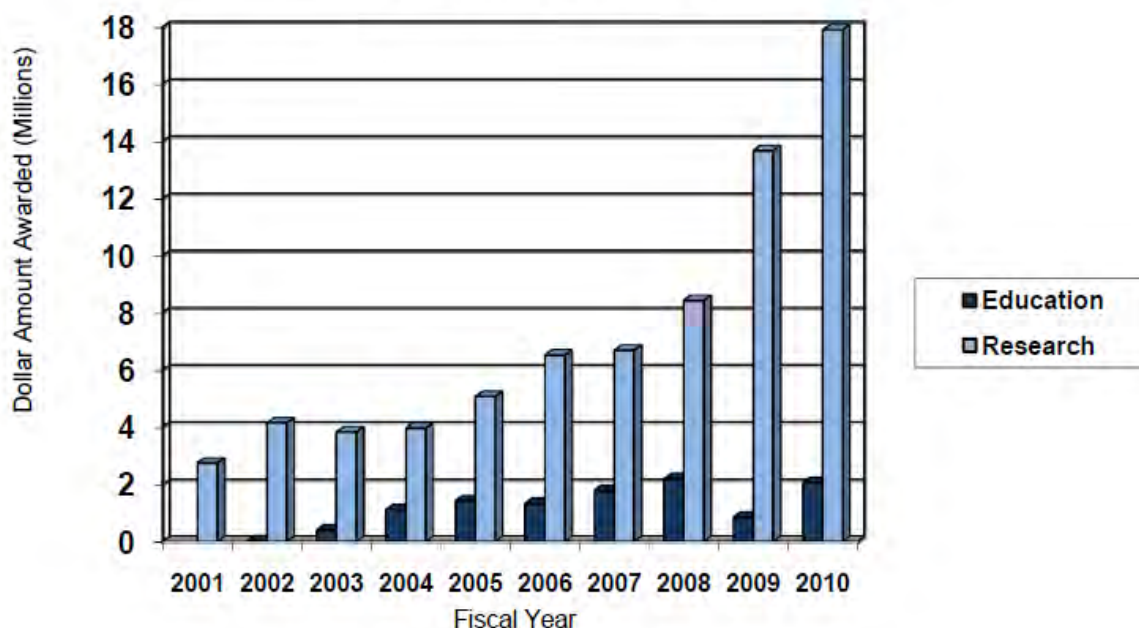
RESEARCH DATA

New FY10 Awards to Academic Departments & Research Centers by Type

FY10 External Funding & Research Expenditures to Academic Departments & Research Centers by Type (\$ 1,000's)	Newly Awarded Research Projects		Newly Awarded Education Projects		Total FY10 Newly Awarded Projects		Total FY10 Research Expenditures
Department	#	\$k	#	\$k	#	\$k	\$k
Mathematics & Statistics (ENC)	11	357	-	-	11	357	389
Electrical & Computer Eng (ENG)	85	4,807	3	475	88	5,282	10,323
Engineering Physics (ENP)	59	5,782	7	603	66	6,385	5,518
Research & Sponsored Programs (ENR)	1	6	1	29	2	35	35
Operational Sciences (ENS)	22	3,631	4	367	26	3,998	5,322
Systems and Eng Management (ENV)	10	1,247	3	590	13	1,837	1,520
Aeronautical & Astronautical Eng (ENY)	56	1,958	-	-	56	1,958	4,357
TOTAL	244	17,788	18	2,064	262	19,852	27,464
Center	#	\$k	#	\$k	#	\$k	\$k
Advanced Navigation Technology (ANT)	23	1,390	-	-	23	1,390	2,081
Center for Cyberspace Research (CCR)	18	1,160	2	471	20	1,631	3,315
Center for Directed Energy (CDE)	27	1,847	3	83	30	1,930	2,427
Center for MASINT Studies and Research (CMSR)	17	2,730	2	465	19	3,195	1,824
Center for Operational Analysis (COA)	26	3,726	6	557	32	4,283	5,438
Center for Systems Engineering (CSE)	2	620	-	-	2	620	437
TOTAL	113	11,473	13	1,576	126	13,049	15,522

Notes: AFIT reports research expenditures annually via the ASEE and NSF surveys. The numbers may differ slightly due to differences in definitions. Institutional cost matching is included in research expenditure column. All Center funds are also included in departmental funding.

New Award History FY01-FY10

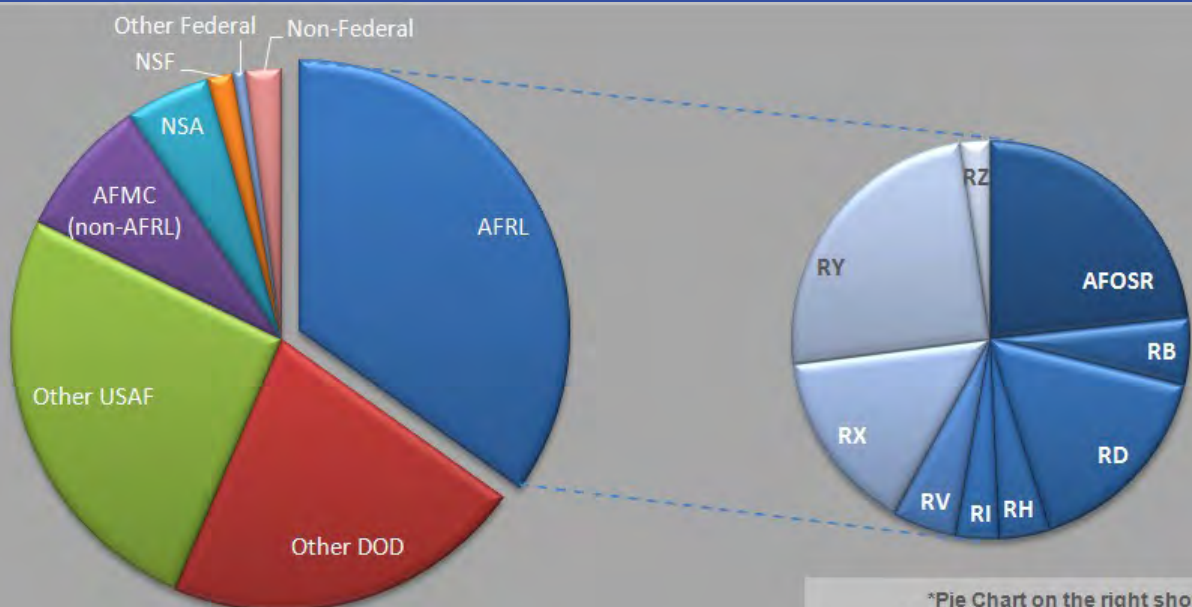


New FY10 Awards to Academic Departments & Research Centers by Sponsor

	AFRL	AFMC (non-AFRL)	Other USAF	NSA	Other DOD	NSF	Other Federal	Non- Federal	Total
Dept.	\$k	\$k	\$k	\$k	\$k	\$k	\$k	\$k	\$k
ENC	342	-	15	-	-	-	-	-	357
ENG	2,540	100	411	1,005	688	223	-	315	5,282
ENP	2,024	50	3,025	-	1,076	50	150	10	6,385
ENR	6	-	-	-	-	29	-	-	35
ENS	510	1,512	764	-	1,212	-	-	-	3,998
ENV	84	-	835	-	860	-	-	58	1,837
ENY	1,411	-	60	-	447	-	-	40	1,958
TOTAL	6,917	1,662	5,110	1,005	4,283	302	150	423	19,852
Research Center	\$k	\$k	\$k	\$k	\$k	\$k	\$k	\$k	\$k
ANT	648	100	25	-	305	-	-	312	1,390
CCR	408	-	111	837	52	223	-	-	1,631
CDE	1,291	50	93	-	436	50	-	10	1,930
CMSR	200	-	2,841	-	154	-	-	-	3,195
COA	590	1,512	778	-	1,403	-	-	-	4,283
CSE	-	-	-	-	600	-	-	20	620
TOTAL	3,137	1,662	3,848	837	2,950	273	-	342	13,049

Note: All Center funds are also included in departmental funding.

Sponsors of FY10 Projects



*Pie Chart on the right shows breakdown by AFRL Directorate

AFIT AT A GLANCE

AFIT CENTERS



Center for Operational Analysis
<http://www.afit.edu/en/coa/>
Lt Col Stephen Chambal



Center for Directed Energy
<http://www.afit.edu/en/de/>
Dr. Salvatore Cusumano



Advanced Navigation Center
<http://www.afit.edu/en/ant/>
Dr. John F. Raquet



Air Force Center for Systems Engineering
<http://www.afit.edu/cse/>
Dr. Tom Christian



Center for Measurement and Signature Intelligence
<http://www.afit.edu/en/cmsr/>
Dr. Ronald F. Tuttle



Center for Cyberspace Research
<http://www.afit.edu/en/ccr/>
Dr. Richard Raines

Current Enrollment

Master's: 602
Doctoral: 122
Certificate: 79
Other: 10

Enrollment by Branch of Service

Air Force Officer: 524
Air Force Enlisted: 14
International: 31
Sister Service: 48
Civilian/Other: 196

Alumni

Total: 18,000+

Scholarly Activity for 2010

Books and Book Chapters: 17
Refereed Journal Articles: 220
Proposals Submitted: 226

Personnel

Faculty: 141
Support Staff: 382

Land and Buildings

Acreage: 35
Gross Square footage: 500,000 sq ft
Buildings: 9

AFIT Directory

For specific information regarding faculty research areas, please see the AFIT Directory at <http://www.afit.edu/directory/Expertlist.cfm>

Sponsoring Thesis Topics

AFIT encourages input from agencies that align with our research and student education. <http://www.afit.edu/>

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