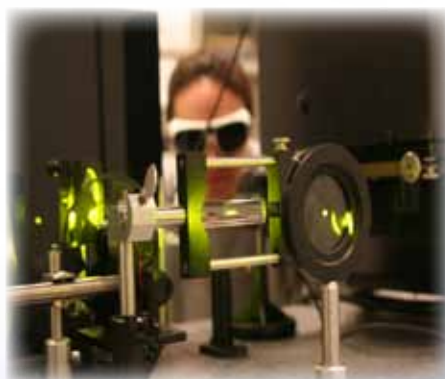


Graduate School of Engineering and Management



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## AFIT Research Centers

The Air Force Institute of Technology is home to many centers, which bring together experts from diverse disciplines to focus efforts on specific interdisciplinary challenges. By sharing expertise, facilities, and equipment, centers provide the synergy required to solve difficult problems.

### **Advanced Navigation Technology Center**

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

Dr. John Raquet

### **Air Force Center for Cyberspace Technical Excellence**

Center for Cyberspace Research

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

Dr. Richard Raines

### **Center for Directed Energy**

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

Dr. Steven Fiorino

### **Center for Space Research and Assurance**

Dr. Jonathan Black

### **Center for Technical Intelligence Studies & Research**

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

Dr. David Bunker

### **The Office of the Secretary of Defense Scientific Test and Analysis Techniques Test and Evaluation Center of Excellence**

Dr. Darryl Ahner, PE

### **Center for Operational Analysis**

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

Dr. Darryl Ahner, PE

# Message from the Dean



The excellence and relevance of AFIT's Graduate School of Engineering and Management was highlighted this year by the establishment of the OSD's Scientific Test and Analysis Techniques in Test & Evaluation Center of Excellence (STAT T&E COE), and by the Graduate School's receipt of five awards at the 2012 Air Force Science, Technology, Engineering and Mathematics Awards Banquet.

In addition to providing details of the above honors, this 2012 Annual Report features the Department of Systems and Engineering Management. The department has long served the civil engineering and acquisition communities with graduate programs in Engineering Management, Environmental Engineering, Cost Analysis, and others. In recent years, the department also took lead responsibility for the interdisciplinary Systems Engineering program, serving a broad range of Air Force, DOD and other federal constituents. The faculty developed Human Systems specialty tracks and a

certificate program to meet the needs of the 711th Human Performance Wing, and established an Industrial Hygiene master's program at the request of the Air Force Medical Service's Bioenvironmental Engineering Career Field.

The Department of Systems and Engineering Management's research in constructed wetlands to treat groundwater contamination has resulted in a successful field demonstration of a technique that will save the Air Force millions of dollars, and has generated commercial interest. Other research projects in the department including Unmanned Airborne Systems (UAS), acquisition efficiency, burn pit emissions, and nano-sensors for chemical agent detection also have significant potential for broad application.

The Graduate School achievements described in this 2012 Annual Report are the culmination of many years of effort by our faculty, staff and students. We have had many other notable accomplishments since I joined AFIT in 2006:

- Research program growth of 300% to over \$23M
- Designation of the Air Force's Cyberspace Technical Center of Excellence (CyTCoE)
- First Patent License Agreement and increasing numbers of patents
- First international Cooperative Research and Development Agreement (CRADA) and record numbers of domestic CRADAs
- First ranking in US News & World Report: 35th nationally in Industrial/Manufacturing, 2010
- AFIT's first Fulbright scholar
- Expansion of distance learning offerings and certificate programs to satisfy broader range of educational requirements

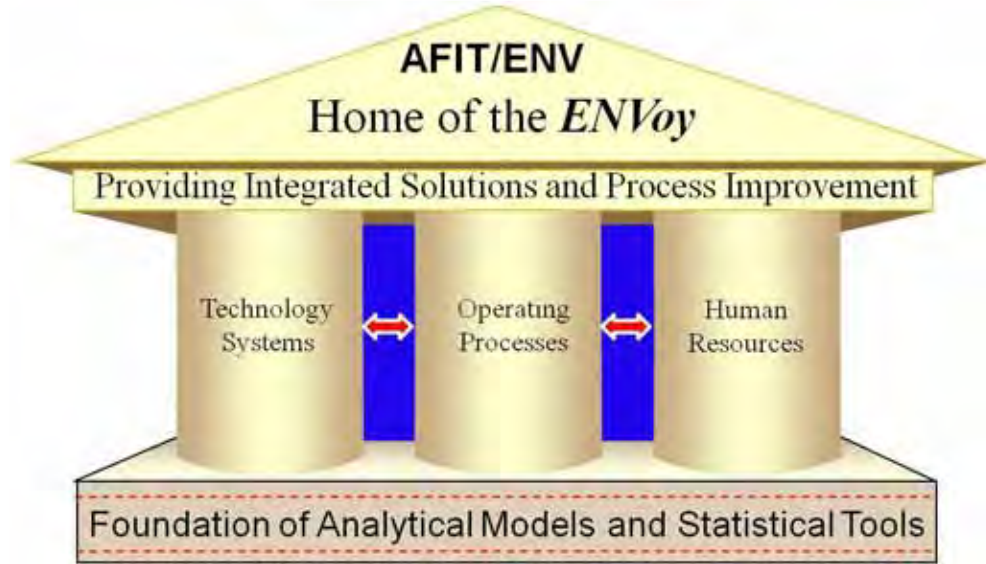
As I prepare to retire in January 2013, I reflect with particular pride on these and other significant accomplishments that demonstrate the increasing quality of the unique defense-focused, research-based graduate education programs at AFIT. I am confident that the Graduate School's outstanding faculty and staff will continue to carefully align AFIT's research and educational efforts with DOD and USAF priorities to ensure maximum value to our nation.

Respectfully,  
M.U. Thomas, PhD, PE  
Dean, Graduate School of Engineering and Management

## FEATURED DEPARTMENT

# Department of Systems and Engineering Management

The Department of Systems and Engineering Management (ENV) is a multi-disciplinary academic department with a rich history of delivering education programs to meet the diverse needs of the Air Force. The department promotes a “Systems View,” linking many factors of Air Force operations rationally together to support Warfighter requirements. The diversity of programs in the department and the research versatility of our faculty provide numerous opportunities to address current and emerging Air Force and DOD science and technology priorities. Major areas of departmental emphasis are:



Visit the Department of Systems and Engineering Management's website:  
<http://www.afit.edu/en/ENV/>

**Technology Systems** – encompasses environmental engineering, engineering control systems, contemporary product development, embedded technical systems and human systems integration.

**Operating Processes** – encompasses cost analysis, work process design, enhancement of operating structures, and organizational structures.

**Human Resources** – encompasses engineering management, organizational behavior, interpersonal relationships, human-machine interface, industrial hygiene, and human performance assessment.

## Degree Programs

Academic programs in the department focus on integrating technological systems, operating processes and human resources to achieve more efficient and effective operational outcomes. The themes of AFSO21 (Air Force Smart Operations for the 21st Century) are embodied in all the programs offered by the department.

The following master of science degrees are offered:

- Cost Analysis
- Engineering Management
- Environmental Engineering and Science
- Industrial Hygiene
- Systems Engineering

In addition, a doctorate degree is offered in systems engineering, and the systems engineering master's program is available via distance learning (see article on page 8).



## Research Highlights

A few of the department's many research projects, including an artificial wetland system for lower cost groundwater remediation, small Unmanned Aerial Systems demonstrations, and inexpensive chemical warfare agent sensors, are described on pages 6-11.

## Systems Engineering Research and Analysis Group

Recently, the department of ENV launched the Systems Engineering Research and Analysis Group (SERAG), which will directly provide research and consultation services to address specific Air Force concerns. The group will provide benefits to the Air Force with respect to product design, evaluation, justification, and integration. This integrative process is presently lacking in many Air Force product development processes. With the strategic activities of SERAG, the ENV department can fill the void created by the recent elimination of the Air Force Center for Systems Engineering. Sponsored research growth in the department has averaged over 10% per year, over the past five years.

### MISSION STATEMENT:

Provide defense-focused graduate education and engage in interdisciplinary research to achieve integrated solutions to contemporary Air Force challenges and enhance the interface between technology and human resources by focusing on systems, processes, and human resources.

### VISION STATEMENT:

Be recognized as a multidisciplinary intellectual asset to the Air Force for providing integrated solutions to operational challenges and enhancing the interface between technology and management by focusing on systems, processes, and human resources.



Department of Systems and Engineering Management Faculty and Staff

## DEPARTMENT OF SYSTEMS AND ENGINEERING MANAGEMENT

# Artificial Wetland System Provides Insight on Contaminated Groundwater Remediation

A field-scale upward flow artificial wetland system has been constructed under the direction of Dr. Michael Shelley, Department of Systems and Engineering Management, to clean up an actual groundwater plume of tetrachloroethylene (PCE) (Figure 1). Previously, modeling efforts using systems analysis of natural ecosystem processes demonstrated how the unique conditions within wetlands (plant species and soil conditions) could be used to remediate chlorinated solvent contamination. The modeled conditions were initially reproduced physically in the laboratory and in pilot scale columns, which led to the successful field demonstration.

Over 10 years of study with the artificial wetland system have demonstrated destruction of all contaminants and hazardous by-products, and have posed new research questions to optimize this technology for routine groundwater treatment. This state-of-the-art wetland laboratory allows experimentation with various environmental media to explore new technology designs arising from computer analysis. This patent-pending technology will save millions of dollars across the Air Force and billions nationally, by using free metabolic energy of the microbes for contaminated destruction, as opposed to passing the water through engineered processes which uses expensive thermal techniques to accomplish the same task.



Figure 1: Artificial wetland system constructed by ENV for the cleanup of a groundwater plume of tetrachloroethylene located at Wright-Patterson AFB.

Figure 2: Piezometer tubes are placed at varying depths of the constructed wetland to sample developing processes relevant to contaminant destruction.



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## Small Unmanned Airborne Systems Research

For the past 5-10 years, faculty and students at AFIT have been involved in ground-breaking research with small, tactical Unmanned Airborne Systems (UAS). This interdisciplinary research area has brought together researchers from the Systems, Aeronautical, and Electrical Engineering programs, typically teaming multiple students and faculty members to support System-of-System (SoS) level design, build and flight test. As part of the Systems Engineering focus, the teams have been asked to define user needs, conceptualize a solution using readily available hardware/software components, and demonstrate the military utility of the concept through flight test, all within a 12 month cycle time.

Most recent AFIT UAS research has focused on simplifying operator tasks and automating UAS functions to support single operator, multi-vehicle operations. AFIT students have flown as many as four UAS vehicles controlled by a single ground station in order to demonstrate cooperative reconnaissance and surveillance tasks. Additionally, research involving Human Systems Integration (HSI) for UAS has become a major thrust area in recent years. Students have developed a mission planning module that predicts when added benefit will be achieved by increasing numbers of vehicles given battery life, power consumption, and operator workload considerations; helping to avoid the situation where the operator is consumed with servicing vehicles as opposed to assessing the imagery that the vehicles are intended to provide.

AFIT maintains a “fleet” of 10-15 air vehicles to support the UAS research. Most vehicles are heavily modified RQ-11 Raven air vehicles that have been decommissioned by operational units. Students and technicians typically gut the Ravens and rebuild them with all new avionics, propulsion, and communication systems. The rebuilt vehicles, designated as AFIT OWLs, can then be modified further according to the individual research objectives. In addition to the OWLs, AFIT also operates several Sig Rascal vehicles, a commercially available system with a weight of 15-20 pounds and a wingspan of approximately nine feet. A custom design vehicle with a 12-foot wing span (the CONDOR) was also developed recently to demonstrate the potential for long loiter, near silent operations using a novel, student designed, hybrid electric propulsion system. The propulsion system is capable of transitioning from high power hybrid mode to gas only mode for cruise/ingress, and electric only mode for loiter operations.



The AFIT small UAS research program, and the associated academic programs in Systems, Aeronautical and Electrical Engineering, are providing directly relevant research for current tactical operations. In addition, the students performing the research gain valuable experience in small UAS operations, as well as rapid prototype design, demonstration, and flight test operations.

<http://www.youtube.com/>

Search for the video titled, “Overhead Watch & Loiter (OWL) System”.

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**DEPARTMENT OF SYSTEMS AND ENGINEERING MANAGEMENT**

## Systems Engineering Distance Learning Program at AFIT

Over 100 students have pursued their AFIT Systems Engineering degree ... remotely. Distance or Distributed Learning (DL) is now common place at many universities. But now Air Force military and civilians located at Creech AFB, Edwards AFB, Hill AFB, Kirtland AFB, Los Angeles AFB and Patrick AFB; Washington DC, Afghanistan, Italy, Japan, Korea, and many other places are pursuing the AFIT Master's degree in Systems Engineering (SE) part-time through DL modalities. The SE degree program has been offered through DL since 2006 and is ABET accredited. DL modalities include the use of webinars, VTC, teleconferences, email, recorded multimedia lectures, chat-room discussions and on-line course management (like Blackboard).

The master's degree program was initiated in response to the needs of students who completed AFIT's Systems Engineering Certificate program via DL. Many of those Certificate students wanted to continue their studies towards the completion of a Master's degree. Four of those students would be pathfinders beginning in the Fall of 2006. They defended their team thesis in 2008 entitled "Operationally Responsive Space (ORS): An Architecture and Enterprise Model for Adaptive Integration, Test and Logistics."



AFIT distance learning locations

To expand its offerings, the DL SE Master's program has leveraged existing DL Certificates specialty tracks offered by the Department of Aeronautics and Astronautics, the Department of Engineering Physics and the Department of Operational Sciences. This allowed students to complete a specialization in Space Systems, MASINT (AGI), Test and Evaluation and Logistics Systems. In 2012, the Department of Systems and Engineering Management began offering an SE Analytics specialty track as another option for these students. As of September 2012, there have been 37 students who have graduated from the SE Master's program via the DL modality.

While many students are not organizationally funded, Space and Missile Center (SMC) at Los Angeles AFB and their detached units have their employees compete annually for scholarships into the DL SE program, often with a Space Systems specialty. SMC values the importance of the graduate Systems Engineering experience and fully funds up to 12 new students each year to pursue an AFIT degree. We are proud to be able to offer this AFIT degree to so many military and civilians located around the world.

Additional program information is available at:  
<http://www.afit.edu/en/env/systemsengineering.cfm>

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## Human Systems Certificate and Specialization



The image above shows a human subject research topic involving helmet-mounted displays (HMD). This helmet is equipped with a binocular HMD and an integrated eye imaging system, the image of his eye, which is used for eye direction tracking, is shown on the display.

We are often reminded that the Air Force is a military branch born of technology. However, advances in technology can be accompanied by increased complexity, making systems more difficult to build, operate, maintain, and support. This complexity can increase manpower requirements and decrease the ratio of system effectiveness to cost. In recent years, the DOD has responded to this issue by emphasizing Human Systems Integration (HSI) and the Air Force has consolidated much of the human-centered research and application knowledge into the 711th Human Performance Wing at Wright-Patterson AFB to provide a strong focal point for research and development within HSI.

To complement these initiatives, AFIT has created a certificate program in Human Systems as well as Human Systems specializations within both our Systems Engineering and Engineering Management degree programs. Students in these programs study Human Systems Integration, Human Factors Engineering, and related concepts; and conduct research to understand human requirements and improve system effectiveness. Research topics have included: the development of models to understand the impact of controlling multiple unmanned aircraft on the workload of a single pilot; 3D interfaces for air traffic control; and technologies for helmet-mounted displays (HMD).

The Human Systems specialization within the Engineering Management program has also exposed Civil Engineering and Environmental Science students to additional system effectiveness considerations, resulting in a new stream of research topics. Our students are asking questions such as, “Can we create easy to use, simple methods for water purification in deployed environments which reduce our reliance on a steady supply of fresh bottled water?” or “As we deploy advanced LED lighting, can we provide better quality of light to affect human biorhythms and improve effectiveness while simultaneously improving energy efficiency?” Human Systems research is a burgeoning area for AFIT, and we are excited to see where the multidisciplinary environment within our graduate school will help to effectively integrate technology with our human needs.

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## AFIT Supports Systems Engineering Research Center

AFIT is one of the original university partners in the Systems Engineering Research Center (SERC), a virtual consortium of 20 universities led by the Stevens Institute of Technology and the University of Southern California. The SERC was founded in 2008 with sponsorship of the Office of the Deputy Assistant Secretary of Defense for Systems Engineering (OSD/ASD(SE)) and the National Security Agency. It is one of only thirteen University Affiliated Research Centers (UARCs) that have been created by the DOD since 1996.

## DEPARTMENT OF SYSTEMS AND ENGINEERING MANAGEMENT

# AFIT's First International Collaborative Research and Development Agreement Established

AFIT entered into its first research collaboration with international and state universities. The collaboration, involving AFIT, the University of Toledo, and Kwangwoon University in Seoul, South Korea, aims to build an international research and education program based on nano-sensors and nano-materials. The program focuses on a research and learning center called the Nano-STAR Center (Nano-Sensor Technology Advancement and Research Center), that will be established at Kwangwoon University. AFIT was the final entity to sign the Cooperative Research and Development Agreement (CRADA). Dean Thomas signed the document on August 16, 2011.

The international CRADA sets a nice precedent for AFIT and provides good collaboration in an area of importance. Particularly, it is hoped the collaboration will result in the development of lightweight, fast, accurate, and inexpensive chemical warfare agent sensors for our troops to use in the field. An article describing the research goal, to apply nanotechnology to detect nerve agents, was published in the Air and Space Power Journal Summer 2011 issue. The Air Force Office of Scientific Research was partly responsible for the agreement being forged by supporting post-doctoral associates and summer faculty at AFIT. It was an initial visit by summer faculty from the University of Toledo that ultimately resulted in the CRADA. Research into sensor development is currently ongoing between all three CRADA partners. At AFIT, the research is being accomplished by environmental engineering and science students in the Department of Systems and Engineering Management.

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AFIT has entered into its first international research collaboration with the University of Toledo, and Kwangwoon University in Seoul, South Korea.

## Reducing Burn Pit Emissions

An AFIT study sponsored by the Air Force Surgeon General's Force Health Protection Research and Development office (AF/SG5) helped increase understanding of the emission from the burning of waste in deployment zones and its effects on human health. In October 2011, a Government Accountability Office (GAO) document entitled, "Afghanistan and Iraq: DOD Should Improve Adherence to its Guidance on Open Pit Burning and Solid Waste Management," focused considerable attention on the DOD and its failure to properly monitor and analyze waste management and resulting emissions. The AF/SG5-funded research included two phases: 1) small-scale burns at the US Environmental Protection Agency (EPA) (Research Triangle Park, NC) and 2) large-scale burns at Tooele Army Depot (Tooele, UT). Small-scale burns determined key pollutants, concentrations, and resulting emissions from representative military deployed waste. Large-scale burns compared emissions from open burns vs. air curtain burners.

Completed in June 2011, Phase 1 research expands the body of knowledge regarding solid waste emissions. This research was perhaps the first to study military waste-focused emissions, providing what may be the largest list of emission factors for research involving municipal solid waste. Limited testing suggests that targeted removal of plastic water bottles, which are hypothesized as providing energy content to promote more complete combustion, has no apparent effect on reducing pollutants and may promote increased emissions. This suggests that targeted removal of polyethylene terephthalate (PET #1) drinking water bottles, if pursued, is best for volume reduction and not for health-related purposes.

Conducted in late 2011, Phase 2 research indicated that smoldering conditions in the air curtain burner and open burns led to similar emissions. However, periodic waste charging of the air curtain burner improved the burn quality, resulting in considerable decreases in emissions for particulate matter with 2.5 micron diameter (PM2.5), volatile organic compounds (VOCs), polyaromatic hydrocarbons (PAHs), and dioxins/furans.

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## Systems Engineering Efficiency Research Project

The Department of Systems and Engineering Management has entered the second phase of a 2-phase, 18-month study on Systems Engineering Efficiency Research (SEER). The first phase of this effort involved participants from the Department of Systems and Engineering Management, the Center for Rapid Product Development (CRPD) (part of the Air Force Research Laboratory), and Arizona State University. Phase 1 research explored the organizational values of the USAF as they relate to the acquisition of weapon systems, aircrafts, infrastructure, and manpower. The result was a 70-page report detailing USAF acquisition over decades as well as a detailed look at acquisition in both commercial fields and foreign militaries. The report has served as a foundation for Phase 2 of the project, which seeks to apply what researchers learned in Phase 1's historical analysis. Researchers from the Department of Systems and Engineering Management are currently studying various decision-making processes that will efficiently determine what asset to acquire and how best to do so. Researchers will make recommendations to the sponsor of the possible methods available, streamlining the acquisition process in an array of USAF operations.

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## TECHNOLOGY TRANSFER

## Flare Test Accuracy Improvements Delivered to Joint Base McGuire-Dix-Lakehurst



Flares are a key component of the overall survivability systems in many aircraft. The Air Mobility Command Test and Evaluation Squadron (AMCTES) at Joint Base McGuire-Dix-Lakehurst, New Jersey conducts tests to determine the effectiveness of new flare patterns to be employed on C-5s, C-17s, and C-130s flying in high-threat areas of responsibility. Updated statistical techniques recommended by an AFIT student have increased the reliability of the tests used to determine if the new flare patterns demonstrate an improvement over the currently employed flare pattern.

Accurate statistical analysis requires an appropriate match between the technique used and the characteristics of the test data. The data collected from the flare tests is considered binomially distributed because each data point is either a success or failure. Historically, AMCTES used a normal approximation to the binomial distribution to complete the statistical analysis of data. The normal approximation is appropriate for a binomially distributed data set when there is a large amount of data, and when the expected number of failures and successes observed is at least greater than five. In the case of the flare tests, these conditions for the normal approximation do not hold for several critical comparisons, resulting in inaccuracy in the analysis.

Maj Michael Cook, AMCTES Chief Scientist, employed the help of Capt Katherine Batterton, a current AFIT student working towards a PhD in Statistics, to identify a better data analysis approach. Capt Batterton researched several alternative statistical methods and briefed the test squadron on her findings. The Fisher Exact Test was implemented for current and future testing. This statistical test can be used to compare different groups which both have binomial responses, without making any additional distributional assumptions. The Fisher Exact Test allows the test squadron to determine exact confidence levels for their tests, a significant improvement over their previous approximate confidence levels. By using a more appropriate analysis method AMCTES has a better evaluation methodology for 3,000+ open-air flare dispense data points and a more efficient use of \$450K test dollars per test period (about twice a year). This allows AMCTES to make better informed decisions on survivability assets protecting 52 C-5, 213 C-17, and 428 C-130 aircrafts.

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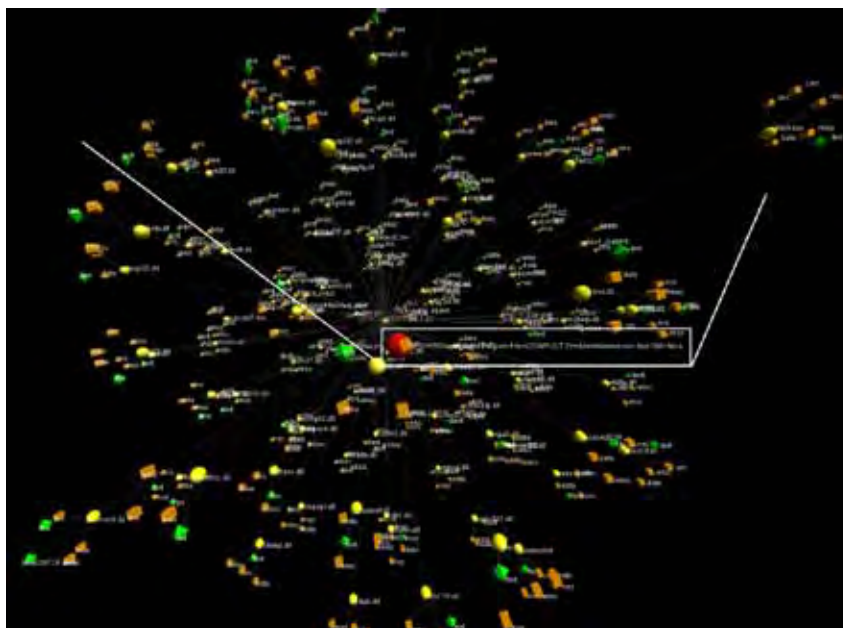
# AFIT Technology Enhances Commercial Cyber Security Product

AFIT successfully transferred an operating system protection technology to SCADA Security Innovation (SSI) Inc. of Ballardvale, MA, who will include the technology in new products designed to protect critical U.S. infrastructure from cyber attack. The patent-pending technology, Enhanced Signed Code Application for Page-level Execution (ESCAPE), was developed by Mr. William Kimball, an AFIT civilian employee and doctoral candidate. Once fully integrated by SSI, ESCAPE-enabled technology will protect SCADA (Supervisor Control and Data Acquisition) computer systems that control and monitor the operation of critical processes including power generation and distribution, wastewater treatment, and petroleum refinement.

ESCAPE technology is unique as it prevents unauthorized programs from ever executing in the first place. Traditional antivirus systems 'blacklist' known malicious software (i.e., viruses, worms, etc.) scan for known malware signatures. Thus, new or modified malware often can evade such signature-based protection mechanisms. ESCAPE uses 'white listing,' which restricts system operations to an approved set of code sequences, thus reducing or eliminating exposure to risk resulting from computer and network code injection attacks.

SSI will initially incorporate the ESCAPE technology into security solutions targeted at industrial device manufacturers, operators of power production and distribution, oil and gas refineries, wastewater treatment, and water purification systems. Other industries expected to benefit include those providing environmental management for heating, ventilation and air conditioning systems, fire control systems, and energy management systems. AFIT's ESCAPE technology is an important contribution that will help safeguard vital utilities and services that are a hallmark of American life.

The graph represents code tracked by ESCAPE in real-time. Green nodes represent cryptographically signed non-malicious code ESCAPE allowed to run. The red node represents unsigned malicious code (HiddenMalware.ocx) ESCAPE detected and prevented from being executed, thus protecting the computer system.



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## TECHNOLOGY TRANSFER



Aircrew are vulnerable to laser exposure during flight, and models are needed to better evaluate the risk to the flight crew for various levels of laser exposure.

### Modeling Laser Damage to the Human Retina

Demand for laser systems has skyrocketed in the 21st-century due to an increased understanding of the capabilities and technologies they make available within our society. In parallel, an important field of physics, Laser Bio-effects, has emerged to study how lasers interact with biological cells, tissues, organs, and whole-body systems. A solid understanding of Laser Bio-effects is critical for laser applications utilized in medicine, the establishment of safe exposure limits for industry standards and academia, and the investigation of laser light effects on living organisms.

AFIT researchers are developing improved models of the eye to support the Bio-effects community. At present, deterministic modeling and simulation tools are typically used to support experimental research into damage thresholds and laser effects. Risk management and analyses methodologies require a probabilistic model approach, but previous efforts suffered from largely biased assumptions due to limited sampling and reporting techniques. AFIT's Probabilistic Model for Laser Damage research is focused on constructing the first-ever population based Probabilistic Model for retinal damage by means of creating a statistical model of the optical properties and dimensions of the human eye. Simulated population distributions will be utilized as input to propagation and thermal damage models for analysis.

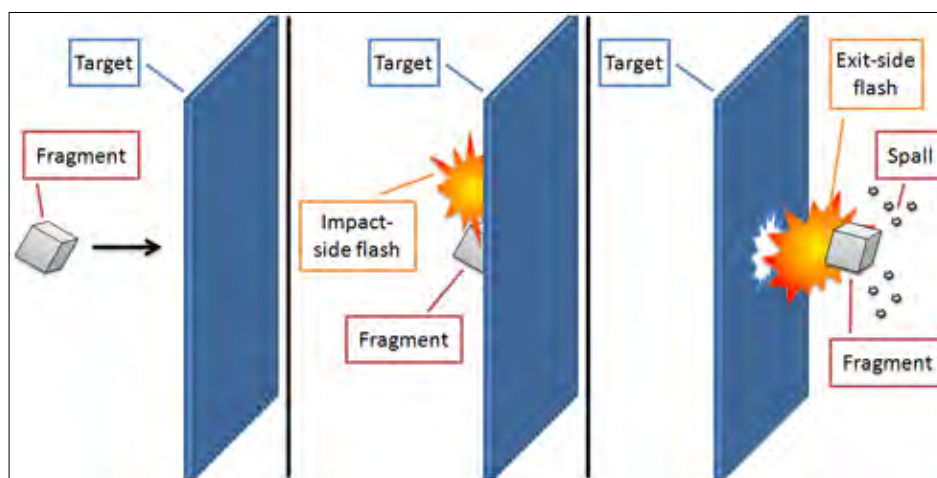
Once complete, this exciting research will yield more accurate models of potential laser damage to the human retina. The results will also provide a solid foundation for new probabilistic models with broader biological and other applications on the horizon.



# Ballistic Impact Flash Characterization Improves Survivability Modeling

Ballistic impact flash occurs when a projectile impacts an object at high speed and causes a fire or flash. Such impact events play a pivotal role in the ignition of fires in military vehicles. Flash duration, geometry, and energy profiles are critical variables in the assessment of ballistic-induced fires. The survivability community has identified a need for a standardized data collection methodology and corresponding valid, community-verified models. The capabilities of high-speed video coupled with the image processing capabilities of modern software provide a means to develop empirical measures of flash size (as measured by encapsulating the flash image in a bounding ellipse), movement of the flash (by noting the position of the bounding ellipse with respect to impact point) and angle of movement of the flash (by noting the trajectory of flash movement away from the impact point). These measures, when developed based on a frame-by-frame analysis of the flash event, provide a time series data set of the flash that can then be estimated using an empirical model.

The Department of Operational Sciences at AFIT has developed a methodology for modeling these time series and then abstracting those time series models into a meta-model capable of predicting the boundary of a flash event and its movement as a function of the parameters of that particular event. The resulting model, the first such model of its kind, has been transitioned to the Joint Survivability modeling community and is implemented in Computation of Vulnerable Area (COVART) as AFITFlash. The model implemented is version 1 while updates are being made to further improve the predictive capabilities of the model. The AFITFlash represents the first model of ballistic impact flash beyond those based on expert opinion.



The figure above shows three time intervals in a Ballistic Flash Sequence. From left to right, the fragment about to impact the target, the initial impact with resulting entry side flash, and the penetration of the fragment through the target with resulting exit side flash.

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## EDUCATION HIGHLIGHTS

# Nuclear Weapons Effects, Policy and Proliferation Graduate Certificate Program

Over the past several years, the Air Force recognized that much of the nuclear weapons education that Air Force personnel received during the Cold War had eroded. As a result, AETC/A10 tasked AFIT to develop a graduate Nuclear Weapons Effects, Policy, and Proliferation (NWEPP) certificate program that could be delivered via distance learning to Air Force personnel who work in the nuclear enterprise. The purpose of the NWEPP program is to provide formal graduate education in the areas of nuclear weapon effects, nuclear proliferation and technologies, and nuclear weapon strategy and policy to the Air Force's operational nuclear weapon community. In the first year of operation (FY12), the program awarded 21 certificates, and is currently standing up to a full operating capacity of 120 students in FY13. The program has received outstanding reviews, and was identified as one of the top educational priorities for the Air Force in FY12. Entrance into the program is currently a selective process that requires consent from AETC/A10 and AFGSC/A1.

Additional program information is available at:  
<http://www.afit.edu/en/enp/nwepp.cfm>

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## Local Students Visit AFIT During National Engineers Week

Approximately 160 students from Dayton Public Schools and the Dayton Regional STEM School visited AFIT on February 21-22 to celebrate National Engineers Week. Students were given an introduction to AFIT's mission and participated in laboratory demonstrations of the defense-related research conducted by our faculty and students.

During their visit, students learned about infrared and terahertz cameras with the Department of Engineering Physics, built and tested a soda straw rocket with the Department of Aeronautics & Astronautics, viewed items through a Scanning Electron Microscope with the Department of Systems & Engineering Management, and controlled Advanced Navigation Technology robots with the Department of Electrical & Computer Engineering.

The theme of the 2012 National Engineers Week was, "7 Billion People, 7 Billion Dreams". There are many challenges facing our world that require immediate engineering solutions, however, the U.S. faces a critical shortage of students who choose to pursue careers in Science, Technology, Engineering, and Mathematics (STEM). AFIT's participation focused on encouraging the next generation of talent to meet and overcome these challenges.



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## ACE Program for ROTC Boasts Many Learning Opportunities



Advanced Cyber Education (ACE) is the nation's only cyber security program for ROTC cadets that combines cyber warfare education, hands-on training, research internships with Air Force scientist and engineers, and leadership development activities.

The program has deep technical foundations and is organized into several components. One component comprises cyber warfare lectures on topics that include security concepts, cyber attacks, computer network defense, digital forensics, reverse software engineering and cryptography. All classes are taught by faculty from the Department of Electrical and Computer Engineering and affiliated Center for Cyberspace Research (CCR) researchers.

Another component of the ACE program is research experience through internships with leading cyber professionals at AFIT and other Wright-Patterson organizations to include the 711th Human Performance Wing (HPW), Air Force Research Laboratory's (AFRL) Virtual Combat Laboratory, and the 88th Communications Group.

In addition to academics and research, ACE participants engage in leadership development activities with their active duty counterparts. Organized unit physical training sessions and staff rides to the National Museum of the United States Air Force, Micro Air Vehicle Laboratory and wind tunnels at AFRL, AFIT Research Centers, US Transportation Command, AF Network Integration Center, and the Defense Information Systems Agency provide a full slate of leadership development activities.

The CCR hosted the program this summer for its second year. Participants included 38 cadets and midshipmen from the Air Force, Army and Navy ROTC detachments from 30 different schools and 22 states.

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## OSD CENTER OF EXCELLENCE

# Establishment of New Center of Excellence at AFIT

In April 2012, the Office of the Secretary of Defense Scientific Test and Analysis Techniques in Test and Evaluation Center of Excellence (OSD STAT T&E COE) was established at AFIT's Graduate School of Engineering and Management by the Deputy Assistant Secretary of Defense for Developmental Test and Evaluation (DASD DT&E) in coordination with the Commander, Air Training and Education Command, and Director, Air Force Test and Evaluation.

Programs are nominated for partnering with the new center by each Service Component's Test and Evaluation Executives and accepted for partnering by DASD DT&E. The OSD STAT T&E COE works directly with the Program Manager and the program's Chief Developmental Tester to improve test effectiveness and ensure efficient use of scarce resources. Utilizing a combination of rigorous scientific methods and best practices, the OSD STAT T&E COE determines where test designs can be improved and efficiencies gained, and then applies this knowledge to the program's T&E strategy development. The end results of incorporating STAT in T&E are the development of more efficient and cost effective Test and Evaluation Master Plans and test plans, and more accurate evaluations of test results. These results provide the program manager with improved information to underpin decisions and understand program risk areas. The OSD STAT T&E COE serves as a reach-back capability and a T&E force multiplier for the overall acquisition community.



The establishment of the OSD STAT T&E COE at AFIT was a logical choice as AFIT's Center for Operational Analysis (COA), within the Department of Operational Sciences, is recognized as a leader for T&E. The COA focuses on collaboration with various test organizations to dramatically improve the application of experimental design principles, and by developing and leveraging state-of-the-art experimental methods and analytical techniques through its research program. These efforts are highlighted through the development of robust designs and models for the KC-46 Program Office via funding from the Director, Operational Test & Evaluation and the Test Resource Management Center, along with the Air Force wide development and delivery of Design of Experiments and Reliability Growth workforce development courses sponsored by the Air Force Material Command A3 Operations.

The OSD STAT T&E COE consists of an interdisciplinary group of T&E professionals that possess knowledge and experience of DOD T&E planning, execution and assessment; knowledge and experience in warfare areas (land, air, sea, space and information systems); and statistical expertise. In addition to injecting more STAT into program test strategy planning, the OSD STAT T&E COE experts ensure the organic test and evaluation team gain a better understanding of STAT and how it should be executed within developing testing methodologies.

The OSD STAT T&E COE's initial major acquisition programs across the Services include:

- Air Force: B-61 Mod 12 Life Extension Program, Space-Based Infrared System Program, Combat Rescue Helicopter, KC-46 Tanker Modernization, Space Fence, and Air and Space Operations Center - Weapon System initiative 10.2
- Army: Armored Multipurpose Vehicle, Stryker ECP, Indirect Fire Protection Capability Increment 2-Intercept, Common Infrared Countermeasures, and Integrated Air and Missile Defense

- Navy: DDG-51 Flight III Guided Missile Destroyer, LHA-R Amphibious Assault Ship, Ship to Shore Connector hovercraft, and Joint Precision Approach and Landing System (JPALS)
- Information technology and space systems: Next Generation Enterprise Network, Distributed Common Ground System-Navy Increment 2, Next Generation Diagnostics System, Logistics Modernization Program, and Air Force Integrated Personnel and Pay System

In addition to directly supporting acquisition programs, the OSD STAT T&E COE also provides the development of case studies; collects, develops, and promotes best practices; identifies student research topics, and supports workforce development through input to course development on scientific and statistical approaches within T&E planning, execution and assessment.

“The establishment of the OSD STAT T&E COE is a testament to the DOD’s commitment to acquisition excellence,” said Mr. Ricky Peters, Director of Test and Evaluation, HQ USAF. “The increased scientific rigor within the T&E community will provide senior leaders defensible information to make informed and timely decisions.”

The OSD STAT T&E COE attained full operational compatibility in July 2012 and celebrated with an official ribbon cutting ceremony on October 18, 2012.



Left to right: Mr. Ricky Peters, Director of Test and Evaluation, HQ USAF; Dr. Steven Hutchinson, Principal Deputy, Developmental Test and Evaluation; Dr. Marlin Thomas, Dean, AFIT Graduate School of Engineering and Management; Dr. Steven Butler, Executive Director, AFMC; Dr. Darryl Ahner, Director, OSD STAT T&E COE and COA

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## RESEARCH HIGHLIGHTS

### F-16 Ventral Fin Buffet Alleviation



Structural fatigue and damage due to buffeting is a common problem in high performance aircraft and over the years numerous methods to alleviate vibrations have been studied. The F-16 ventral fin was one such structure prone to in-flight failures from excessive vibrations attributed to buffeting. Historically, structural modifications are made to provide passive vibration control by altering the design and/or incorporating different materials. While such solutions have been successfully applied, they typically result in an increase in structural mass and cost.

For the F-16 ventral fin, the implemented fix was to redesign the ventral fin and add material to passively suppress the buffeting. However, the use of active control techniques offer the promise of reducing the vibration levels without significantly increasing structural mass and cost. To achieve this, the Department of Aeronautics and Astronautics is conducting research to reduce buffet induced vibrations through the use of active structural control. The research involves embedding a combination of piezo-electric actuators and sensors into the ventral fin to facilitate active vibration control.

During the initial phase of the project called ACTIVE FIN, AFIT in conjunction with the Air Force Test Pilot School, designed and flew an experimental ventral fin to obtain in-flight data. Using the flight test results, the current effort seeks to improve upon the initial design by increasing the number of actuator layers to increase control authority, and by incorporating multi-input/multi-output (MIMO) control algorithms. The research involved experimental modal identification of the ventral fin along with determination of the principle strain directions, followed by selection of system components, determination of a mathematical plant model, and design and test of candidate control algorithms.

AFIT's research resulted in a control system hardware and software design suitable for flight, with the ability to test several different control algorithms to include single-input/single-output (SISO) positive position feedback (PPF), multivariable PPF, two-input two-output linear quadratic Gaussian (LQG), and two input four-output LQG. To date, the laboratory results of this study show significant reductions in buffeting at the first four structural modes of the ventral fin using the MIMO LQG controller. These bench-level laboratory results will be validated during wind tunnel testing conducted by AFRL at Wright-Patterson AFB, followed by flight tests on the F-16 at Edwards AFB in California.

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## Sensing for Conditioned-Based Maintenance

The need to improve the safety and reliability of rotary wing aircraft is a high priority for the DOD and civilian operators. The large number of complex rotating parts in a helicopter drivetrain provides numerous locations for faults to occur, sometimes resulting in catastrophic consequences. Historically, rotorcraft manufacturers, operators, and maintainers have relied upon time-based metrics to perform preventative maintenance actions on these aircraft. Time-based metrics specify predetermined time intervals for inspection and replacement of aircraft components. While effective in preserving safety and reliability, the time-based process often results in unnecessary, costly maintenance being performed. To combat these ever growing costs, the DOD has mandated a transition to Condition-Based Maintenance (CBM). The premise of CBM is that maintenance actions will be performed based on the actual needs of the components rather than at predetermined time intervals. The CBM program is expected to reduce operating costs of helicopter fleets while increasing readiness for operational tasking.

In order to realize anticipated gains through CBM, Health and Usage Monitoring Systems (HUMS) were developed and incorporated by various manufacturers. Where time-based preventive maintenance uses historical averages and qualitative inspections by trained personnel to determine the lifespan of a component, HUMS sensors such as accelerometers and temperature gauges allow real-time monitoring of the states of specific components. Using the principles of CBM and HUMS data, components can be replaced or repaired when indications of potential malfunctions are detected.

This research, under the direction of Dr. Donald Kunz of the Department of Aeronautics and Astronautics, seeks to interpret the vibration data from the CH-47D rotor system in order to create models from which component servicing or replacement can be determined. Using the Rotorcraft Comprehensive Analysis System (RCAS) software to model the CH-47D, faults are introduced into the model in order to observe and analyze resulting vibration characteristics. These vibrations are first compared to limited vibration data obtained from aircraft which have experienced identical or nearly identical faults. If vibration models can be accurately determined for known faults, these models can be used to train diagnostic

and prognostic systems, in order to enhance the efficiency of maintenance operations, safety of flight, and operational readiness.



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## RESEARCH HIGHLIGHTS

# Mitigating Unintentional Information Leakage from Integrated Circuits

The information leakage of electronic devices, especially those used in cryptographic applications or other vital system functions, represents a serious practical threat to secure systems. The content of the unintentional emissions produced by “secure” devices is frequently sufficient to allow inference of precise details about the operations the device is performing and data it is processing, to include extremely sensitive information such as cryptographic key material. Furthermore, such information leakage can lead to more refined attacks such as reverse engineering of critical technologies or cloning of secure tokens. Such attacks allow competitors or adversaries to bypass years of research and development through counterfeiting, cloning, or theft of intellectual property.

Recent research conducted in the Department of Electrical and Computer Engineering developed the first known technique, known as leakage mapping, to provide a comprehensive picture of leakage risks. The leakage mapping technique can be used to assess systematic risk as well as to make well-informed decisions when implementing mitigation strategies to protect secure systems. A second technique, known as “Distinctive Narrative Attribute” RF-DNA fingerprinting, allows identification of microchips in a manner analogous to biometric human identification. The RF-DNA fingerprinting technique can be used to detect cloned smart-card based ID cards, counterfeit microchips, or unauthorized modifications to critical system components. Both techniques have broad applicability to both military and commercial applications.

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# Measuring Atmosphere Turbulence Using Cell Phone Signals

In the Department of Engineering Physics, research has recently been conducted to investigate a new method for measuring the intensity of turbulence in the planetary boundary layer. This method takes measurements of cell phone signal strength and uses scintillation in the signal to estimate the strength of local turbulence. Using cell phone signals provides unique measurement advantages: it is a passive measurement method, it is not strongly affected by precipitation, and one device can potentially measure several paths at once. The measurements were taken using a custom built application. The strength of turbulence was quantified using the index of refraction structure constant ( $C_n^2$ ). The goal of the investigation was to determine if  $C_n^2$  values calculated from the cell phone signal power show a relationship to  $C_n^2$  measurements taken using clear air radar returns for a given path. The strength of the agreement between measurements made by the method and those done with an established method lead to a conclusion that turbulence changes can be measured using cell phone signals. Such passively obtained  $C_n^2$  values could then be used in techniques to improve laser communication or laser weapon system propagation in the atmosphere.

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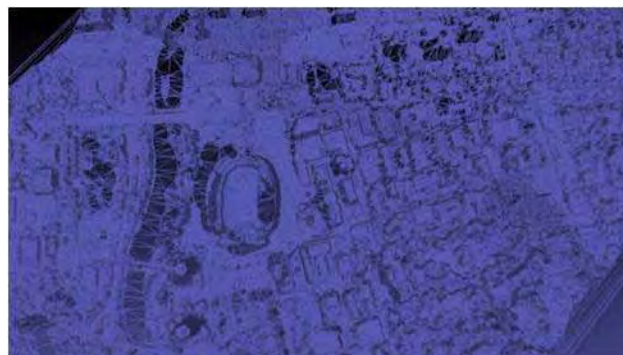
## 3-D Site Modeling from Imagery

Using imagery from airborne or satellite sensors, the Department of Engineering Physics was able to successfully demonstrate accurate 3-D reconstruction of buildings and terrain with large AFRL Sensors Directorate datasets within a couple of hours. Recent student research by Capt Jared Ekholm, defines the optimal flight paths and collection geometries required for accurate scene reconstruction using advanced computer vision techniques. These techniques allow for the automated reconstruction of 3-D site models from 2-D imagery which can then be used for warfighter training, targeting, or intelligence analysis. Capt Ekholm's thesis entitled, "3-D Scene Reconstruction from Aerial Imagery" sets the bar for the academic quality desired at AFIT. This recent success, using AFRL airborne imagery collection will surely drive additional research at AFIT and within the intelligence community into the exciting areas of computer vision, autonomous navigation, and 3-D change detection (graphic below).

Of special note is the comparison of the 3-D models generated from passive imagery compared to that of active Light Detection and Ranging (LIDAR) 3-D products that have recently gained popularity within the geospatial community. The computer vision techniques have the potential to offer comparable quality at a fraction of the cost of current LIDAR collection systems and so could become the 3-D product of choice due to the availability of high-resolution imagery over most areas of military interest. Current and future research proposals will utilize these 3-D products for advanced physics modeling of a site to predict and relate various types of remotely sensed data for fusion and archival purposes.



Stage 1



Stage 2



Stage 3

Stage 1: Initial Dense Point Cloud of the Ohio State University Stadium obtained from image feature correspondences using Epipolar Geometry constraints.

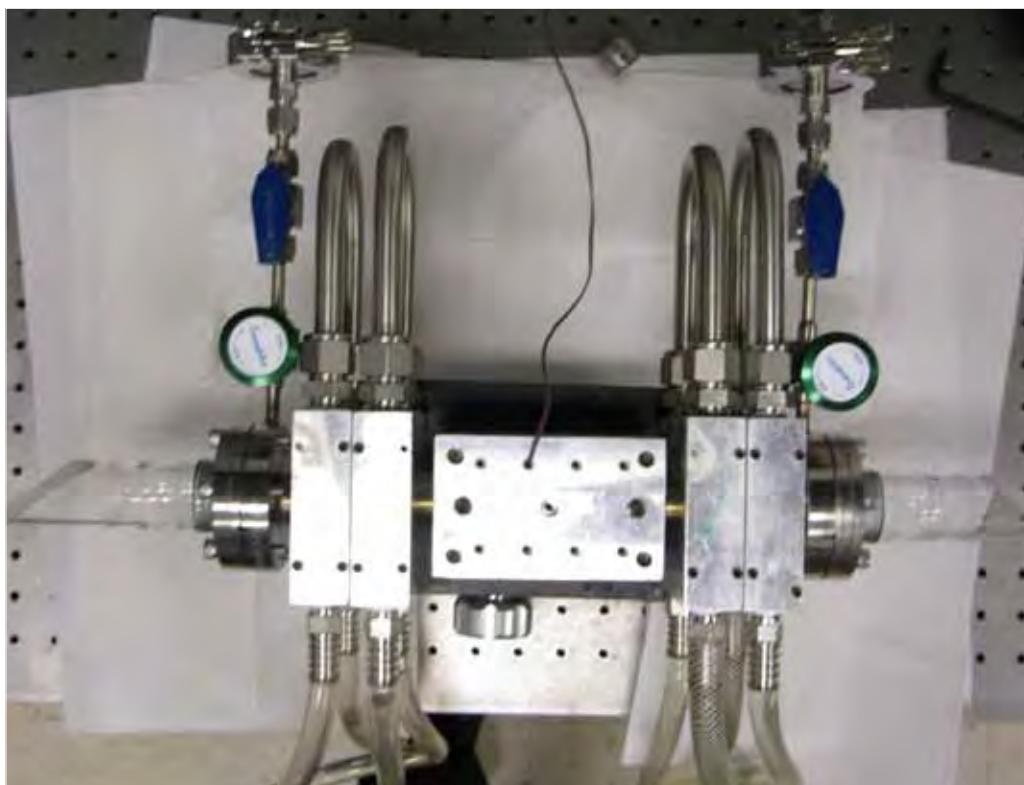
Stage 2: A facetized model can then be created from the Dense Point Cloud to simulate the stadium. This can then be imported into visualization programs (such as MESHLAB) for model interaction.

Stage 3: The faceted models can also be textured with information from the images for more realistic site representation or for 3-D archival of the imagery.

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## RESEARCH HIGHLIGHTS

# High Power Diode-Pumped Alkali Lasers



Diode-pumped alkali metal vapor laser (DPAL) heat pipe for a cesium laser

The quest for a high-power, electrically driven laser with excellent thermal management, lightweight packaging and high brightness for tactical military applications, may be realized with the advent of the diode-pumped alkali laser (DPAL). The DPAL is being scaled to powers exceeding 1 kW for laser weapon applications. This DPAL system combines efficient electrical pumping from solid-state lasers with the excellent beam quality and thermal management characteristics of gas lasers. However, localized heating in the DPAL system can lead to spatial variations in metal vapor density, which affects the absorbance and results in reduced performance. The AFIT team has studied the temperature gradients induced in the DPAL heat pipe (pictured). A significant radial dependence of the absorbance has been observed for experimentally simulated, high power DPAL conditions. The absorbance is modulated by up to a factor of two, when the pump beam is blocked. High efficiency performance can be restored by properly tailoring the alkali concentration in the presence of the heat load. The conclusions derived from the DPAL systems in this project will enable the further research of temperature gradients in high-powered DPAL devices.

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## Overhead Persistent Infrared Research

Overhead Persistent Infrared (OPIR) research capabilities are evolving as new sensors and analysis techniques are developed and understanding of phenomenologies improves. The Center for Technical Intelligence Studies & Research (CTISR) is working with a number of organizations to advance capabilities to detect and track infrared targets and enhance knowledge of underlying physics associated with spectral emissions of targets. To accomplish the OPIR research, the CTISR first established a classified OPIR computational capability within AFIT secure facilities. This capability consists of a high-end workstation with multiple OPIR analysis software packages used by the community, and acquisition of actual datasets collected by operational OPIR sensors for use in evaluating new analysis methods.

The CTISR recently completed a project sponsored by the Space Innovation Development Center of Air Force Space Command (AFSPC/SIDC) which involved the independent review and assessment of an OPIR tracking algorithm



Figure 1: Target Tracking Techniques (inset) of dim target in highly cluttered background sample scene

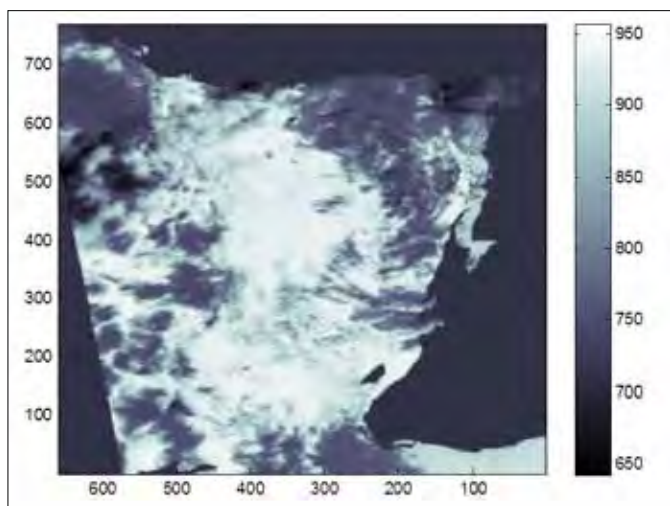


Figure 2: Sample Output from NGA provided OPIR Sensor Model

developed by a contractor. Lt Col Karl Walli, the project Principal Investigator, worked with student Devin Todd, to exercise the algorithm under an assortment of scenarios. Because the code was not complete and no user manual or help functions had been developed yet, Devin generated an initial user's manual which was made available to SIDC. Results of the study indicated that the tracking algorithm was able to track dim targets in a highly cluttered scene as required; however, a priori knowledge of target class was necessary to ensure the algorithm parameters were properly configured. Based on this result, SIDC was able to conclude that multiple instances of the algorithm would be required to run simultaneously to provide real-time target tracking. Working with this data, a technique was developed to easily detect the low signal-to-noise ratio target using an open source image analysis software package called 'Fiji' (Figure 1).

Currently, AFIT Researchers, Drs. Chris Borel and Dave Bunker, along with Mr. Don Hemminger, are partnered with the National Geospatial-Intelligence Agency (NGA) to enhance a simple-to-use OPIR sensor model to simulate OPIR data. The objective is to be able to model various target types, background scene conditions, and sensor configurations to assess sensor capabilities to detect targets. The model would also allow comparison of results from different types of OPIR sensors to aid sensor operators in selecting the optimal sensor for a given mission.

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## RESEARCH HIGHLIGHTS

## Satellite Relative Motion Control

Autonomous formation flight concepts and algorithms have great potential to revolutionize spacecraft operations enabling missions to perform autonomous docking, in-space refueling, in-space robotic assembly, and space debris removal. Such tasks require the implementation of speed and path control algorithms to maneuver satellites along relative paths with specified rates along those paths. Research conducted in the Department of Aeronautics and Astronautics has designed and simulated control algorithms capable of providing relative speed and path control between satellites with a pointing error of less than two degrees, a position error of less than two millimeters, and less than a millimeter per second of velocity error. One such control algorithm, developed by master's student 1st Lt Samuel Barbaro, is to be used on board the International Space Station as part of MIT's Synchronized Position Hold Engage Reorient Experimental Satellites (SPHERES) program. SPHERES is designed to provide a practical intermediate step toward validating autonomous formation spaceflight algorithms. Furthermore, AFIT's simulation tool used to develop control algorithms also allows for a greater community of control engineers to interact with SPHERES purely in the MATLAB® development environment.

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## Nanocomposites Lower the Cost of Space Systems

Since the mid-1990s, the unusual properties of carbon nanotubes and their potential for inclusion in low-cost, low-weight, high-performance composite materials have caught the attention of many researchers. AFIT researchers are now investigating the reactions of such carbon nanotube composite materials to the space environment in order to better understand the possible uses of the new materials in a variety of space applications.

The unique structure of carbon nanotube results in extraordinary strength for a given mass. Thus, composite materials made with carbon nanotubes can meet the demanding structural space system requirements, while reducing overall weight and volume. This means that satellites and spacecraft containing carbon nanotube composites potentially cost less and have added functionality when compared to traditional space materials. Additionally, the effect of temperature on expansion and contraction is nearly nonexistent in carbon nanotubes, hence the materials are not affected as severely by the temperature extremes of space compared to other composite materials. However, before carbon nanotubes can be widely used in space applications, a better understanding of the interactions between the carbon nanotubes and other materials must be achieved.

AFIT's Department of Engineering Physics, in conjunction with the Department of Aeronautics and Astronautics and AFRL's Materials and Manufacturing Directorate, is conducting experiments to understand the effects of the space environment on carbon nanotube-based composite materials. Measurements ranging from mechanical stress and conductivity to spectrographic measures (e.g. Electron Paramagnetic Resonance) are then used to analyze whether changes in bulk properties can be related to the primary component in the composite material. Eventually the material will be incorporated into rockets and satellites to provide a robust, low-cost option for a new generation of space systems.

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## Design, Build, and Test CubeSats

Creating satellites is a profoundly difficult, expensive, and high risk-activity because it requires a dedicated team with a wide range of engineering disciplines such as mechanical, electrical, thermal, and astronautical, working together. The Department of Aeronautics and Astronautics has been requiring students to design satellites on paper for over a decade; however, over the last 5 years, AFIT students have been building engineering development unit (EDU) CubeSats so they can experience a low-risk, but high payback satellite build opportunity that will not easily be forgotten.

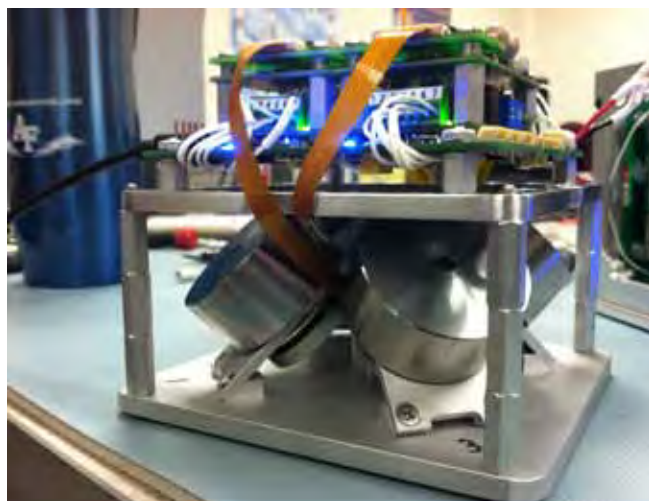
A CubeSat is a nano-satellite developed from combining approximately 10 cm by 10 cm by 10 cm cubes or units also called a “U” which can each weigh as much as 1.3 kg each, typically created from inexpensive commercial off the shelf (COTS) components or custom designed components.

CubeSats are selected because they are much smaller and less expensive than typical satellites and normally have most of the typical satellite subsystems such as payload, power, structural, communications, and command and control. The student’s CubeSats must pass common satellite tests, such as thermal vacuum, vibration, and functional to demonstrate that their design can survive launch and successfully operate in space. Each student serves as an individual subsystem specialist who must work closely with all other subsystem specialists to ensure design decisions made by one specialist will not impact other subsystems in adverse ways.



AFIT CubeSat Bus

By providing the students a scaled down experience that has all of the same processes of developing real satellite hardware, the students not only receive nearly immediate feedback in learning what works and does not work, they develop real hands-on experiences critical to aerospace workforce development. It is important to note that the impact of this type of educational experience can be profound when considering the typical AF officer or civilian project manager can be placed in charge of a multi-million dollar satellite program shortly after graduation. Over the past five years, over eighty students have designed, built, and tested eleven different CubeSats for organizations such as AFRL, SMC, USAFA and ORS. Because flight-worthy CubeSats typically cost over \$1M, these EDU CubeSats have proven themselves as a great value to the customers because they can make very well informed decisions based on what the students have learned.



AFIT CubeSat Reaction Wheel Array and Attitude Control Subsystem

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## RESEARCH HIGHLIGHTS

### State of the Art AFIT Cleanroom

AFIT's Cleanroom capabilities have been expanded via facility modifications, equipment upgrades, and new equipment installations to support a wider range of research projects. The improvements enable increased research collaboration with organizations such as the AFRL.

Facility modifications yielded a Class upgrade from 10,000 to 1,000, an order of magnitude improvement in cleanliness. The cleanliness improvement has resulted in smaller, higher quality devices now being reliably fabricated. An external 1500 gallon liquid nitrogen tank (donated by AFRL) was installed to replace a Dewar system, resulting in increased equipment utilization tempo and over \$9,000 annual operating cost savings.

Equipment upgrades include improvements to the Denton Discover 18 plasma-based, thin film sputter deposition system (Figure 1). The system was upgraded with an RF power supply for dielectric film depositions, a co-sputtering capability for depositing metal alloys, a loadlock for improved timelines (15 minutes vs. 4 hours), and a reactive sputtering capability for in-situ chemical reaction-based depositions.

New equipment installations enable AFIT to conduct research using an expanded range of materials and devices. An oxidation/diffusion furnace, the only one on Wright-Patterson AFB, was acquired to grow thermal oxides and vary material resistivity for transistor development. In addition, a new hydrofluoric (HF) acid vapor etching system (Figure 2), used for precisely etching sacrificial layers for micro-mechanical components, is one of only four in the nation.

The recent expansion of Cleanroom capability allowed AFIT to support AFRL's Devices for Sensing Branch with device processing while their lab was being reconstructed last year. This has led to significantly increased collaboration between these organizations.

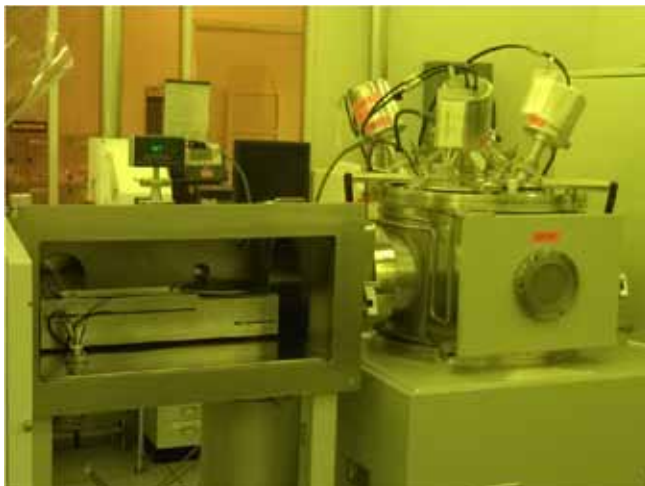


Figure 1: Denton Discover 18 plasma sputtering system upgraded with loadlock, RF, co-sputtering and reactive sputtering capabilities.



Figure 2: HF vapor etching system for etching silicon dioxide without damaging metal contacts as well as enabling high-aspect MEMS and NEMS releases – only 4 in the USA.

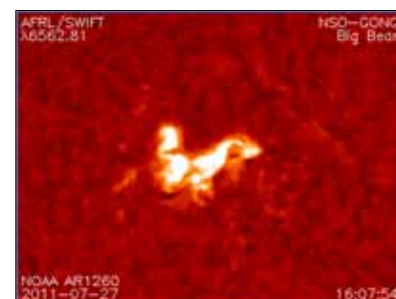
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# Space Weather Education Improves Operations

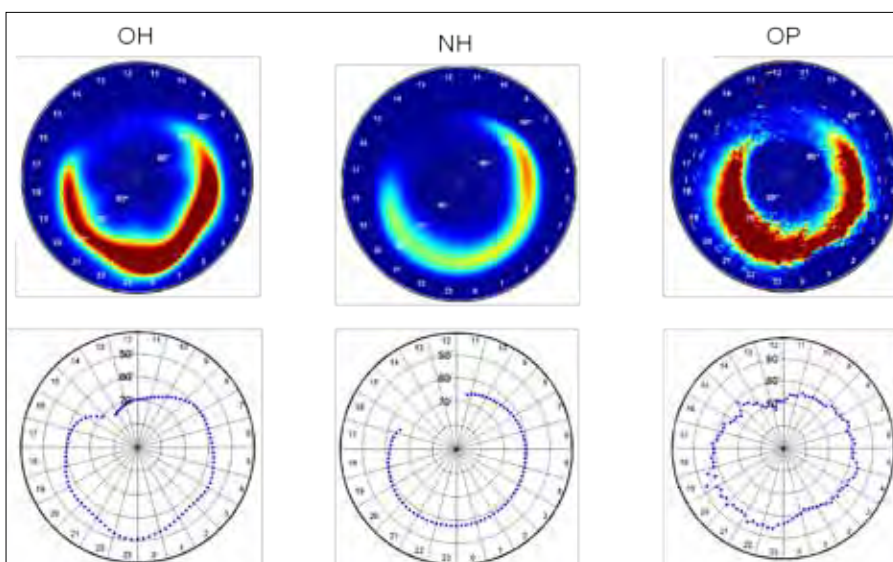
The Department of Engineering Physics provides space physics education for weather officers, addressing phenomena on the Sun, in interplanetary space, and within Earth's atmosphere that can impact DOD and civilian operations. Upon graduation, these officers are responsible for providing space weather support to all DOD agencies as well as a host of other government agencies.

The research of two recent space weather graduates, Capt Lindon H. Steadman and Capt Thomas M. Wittman, has had direct operational impact, attracting praise from Dr. Fred P. Lewis, the Director of Weather, Deputy Chief of Staff for Operations, Plans & Requirements, Headquarters USAF. Capt Steadman used the Global Assimilation of Ionospheric Measurements (GAIM) computer simulation to establish how many ground Global Positioning System (GPS) receivers are needed in CONUS in order to provide reliable GPS/total electron content (TEC) correction maps during geomagnetic storms. He established the need for 110 receivers to provide optimal accuracy, and a more economical solution of 40 stations with moderately degraded results. He also concluded that strategic placement of GPS stations has a greater impact on accuracy than the number of receivers, enabling future system expansions to be deployed with maximum effectiveness.



Capt Wittman analyzed GONG and SOON h-alpha flare images and determined GONG imagery was a suitable replacement for SOON's h-alpha flare intensity and size classification mission.

Capt Wittman's research objective was to examine imagery from the Air Force's Solar Observing Optical Network (SOON) and the civilian Global Oscillation Network Group (GONG) observatories to compare coverage and consistency of characterization of solar flares. He concluded that observations and characterization were consistent, providing assurance that adequate flare monitoring capability could be achieved with the GONG observatory alone when SOON is undergoing maintenance.



Maj Lane compared auroral oval boundary models to Defense Meteorology Satellite Program data to determine their performance during varying geophysical conditions.

The current research of other AFIT weather officers maintains an operational focus. This research includes: automated ensemble forecasts for coronal mass ejections (CME) which has shown a significant improvement over traditional forecasting techniques used by the Air Force; a collaboration with Utah State University to test and verify the accuracy of a new version of GAIM Full Physics Model slated to be delivered to the Air Force Weather Agency in 2013; work with NASA to investigate the best available auroral oval models to be used in various situations; and studies of atmospheric drag on satellites.

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## ALUMNI HIGHLIGHTS



### Richard T. Devereaux, Major General, USAF (Retired)

Maj Gen Richard T. Devereaux retired July 1, 2012 after an impressive 34 year career covering a wide variety of command and staff positions. He held five commands including a C-5 flying squadron, an air mobility operations group, an air refueling wing, the Air Force's largest technical training wing, and the USAF Expeditionary Center.

Maj Gen Devereaux's career was marked with his ability to set himself apart. He is a 1978 honor graduate of the United States Air Force Academy, a Distinguished Graduate of AFIT, Air Command and Staff College, and National War College. While at AFIT, he was the top graduate in his class, earning the General Edwin W. Rawlings award. His thesis on the Air

Force's Officer-Enlisted Fraternization Policy provided a base for future policy decisions. Dr. Carl Davis and Dr. Charles R. (Dick) Fenno, Maj Gen Devereaux's thesis advisors, helped him shape a theoretical topic into something that would make a difference for the Air Force. Maj Gen Devereaux's thesis was so influential at the time of Air Force developing their policy on the issue of fraternization; he was able to brief the results of his study to the Director of Personnel Policy at the Pentagon. He describes his time at AFIT as "stimulating, engaging, and fun".

"I'm convinced I would not have become a general officer without my AFIT experience. The program broadened me in a way that allowed me to surpass the potential I had envisioned for myself."



### John Thomas, Colonel, USAF (Retired)

Col John Thomas began his Air Force career in 1979 as a graduate of the United States Air Force Academy. In 1985, Col Thomas received a Master's of Science in Logistics Management from AFIT.

Of the many career opportunities that presented themselves throughout his career, several have resulted directly from his degree through AFIT. Some of those opportunities include time as a Logistics Officer for the Intermediate Nuclear Forces Treaty and an assignment as the Deputy Chief of Logistics for the F-22 stealth fighter during its development in the mid 1990's. Col Thomas also served as the Assistant Chief of Logistics for the Airborne Laser Program and the Chief of Logistics for 15 Airbases while serving at the Air Staff. Rounding out his career, Col Thomas occupied a high visibility assignment as the Air Force's first acquisition Program Manager for the new C-27J Spartan Joint Cargo Aircraft (JCA) program. Currently, Col Thomas is the President of the National Aerospace Organization (NAO), managing educational technology symposiums for DOD and NASA agencies.

## FACULTY HIGHLIGHTS

### IN MEMORIAM Dr. James T. Moore, 1952-2011



Dr. James T. Moore, a highly-regarded Professor of Operations Research, Department of Operational Sciences, Graduate School of Engineering and Management, passed away on November 15, 2011. Dr. Moore distinguished himself through exceptional achievements during 24 years of active duty service in the Air Force, as research advisor to over 100 graduate students, and as a teacher who prepared and mentored hundreds of forward-thinking students, officers and leaders. Dr. Moore also served as interim Head of the Department of Operational Sciences on two separate occasions during his tenure at AFIT.

In September of 2011, Dr. Moore was selected to receive the Analytic and Lessons Learned (A2L2) Community's Lifetime Achievement Award due to his profound and lasting contributions to our Air Force and the broader national defense community. The award acknowledged his outstanding leadership and expert execution of studies critical to the development, acquisition, and fielding of systems, tools, and weapons to improve warfighter capabilities. His contributions included improved models for aircraft loading and distribution routing, and a high profile analysis of proposed Federal Aviation Administration rules for flight crew member duty and rest requirements that was cited in H.R. 1540: National Defense Authorization Act for Fiscal Year 2012.

### Air Force STEM Awards

**On August 23, 2012, five AFIT faculty members were presented with awards at the Air Force STEM (Science, Technology, Engineering and Mathematics) Awards Banquet:**

- Lt Col John S. Bommer Jr. - Senior Military; AF Outstanding Scientists/Engineers
- Dr. Julie A. Jackson - Junior Civilian; AF Outstanding Scientists/Engineers
- Dr. William F. Bailey - Educator; AF Outstanding Scientists/Engineers
- Capt A. Wooddell - AFIT Systems Engineering Award
- Dr. Michael J. Havrilla - John L. McLucas Basic Research Award; Honorable Mention

### Excellence in Education Honorees

**Ohio Magazine recognizes outstanding teachers at colleges and universities around the state. The following AFIT faculty members were recognized in the December 2011 issue:**

- Lt Col Ariel Acebal, PhD, Department of Engineering Physics
- John M. Colombi, PhD, Department of Systems and Engineering Management
- Matthew Fickus, PhD, Department of Mathematics and Statistics
- Lt Col Mark Friend, PhD, Department of Operational Sciences
- Eric Swenson, PhD, Department of Aeronautics and Astronautics

## RESEARCH DATA

## Selected Large Awards FY12

**OSD - \$2,710,000**

“Test and Evaluation Center of Excellence”

Dr. Darryl Ahner

**TRICARE - \$1,790,000**

“Joint Integrated Electronic Health Record (iEHR) Initial Operating Capability Support”

Dr. Rusty Baldwin

**478th AESG - \$785,000**

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

Maj Daniel Mattioda

**711 HPW/RH - \$770,120**

“Dismount Modeling and Detection”

Lt Col Jeffrey Clark

**NSF - \$697,710**

“Federal Cyber Service: Scholarship for Service (SFS)”

Dr. Rusty Baldwin

**HELJTO - \$525,000**

“CY2012 HEL JTO M&amp;S TAWG Product Development”

Dr. Steven Fiorino

**AFRL/RV - \$500,000**

“Persistent TT&amp;C using LEO SatComm (PTLS)”

Dr. Eric Swenson

**ORSO - \$493,000**

“Tactical Electronic Support 2 Spaceflight Experiment”

Dr. Jonathan Black

**NGA - \$454,000**

“Overhead Persistent Infrared (OPIR) R&amp;D”

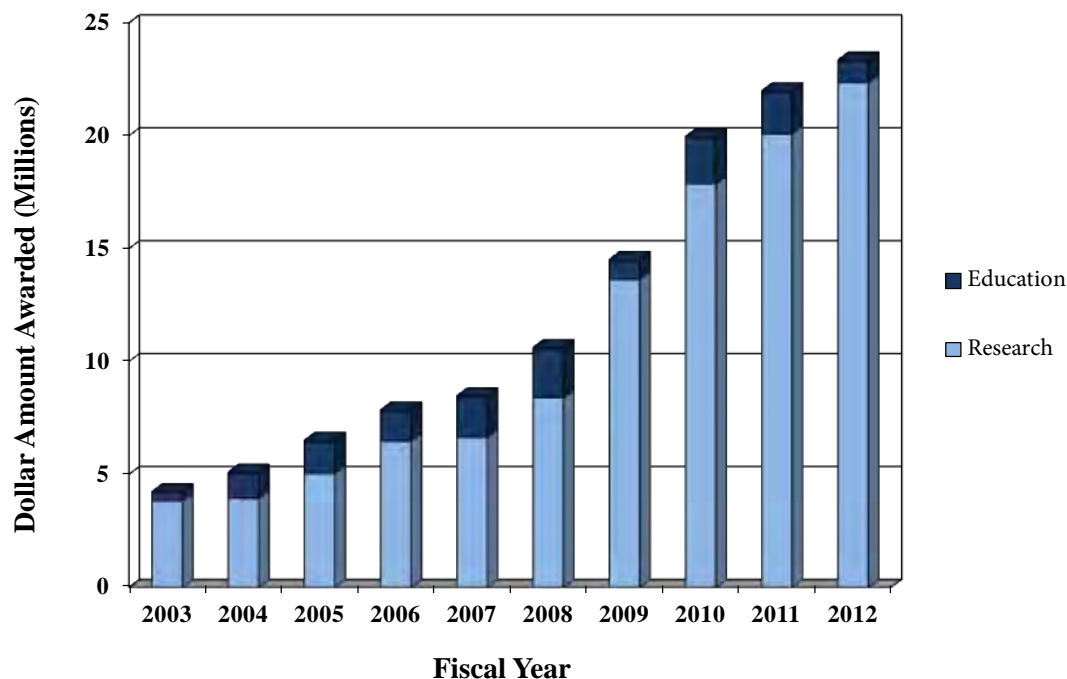
Dr. David Bunker

**CAA - \$400,000**

“A System of Equations to Capture SSTRO Dynamics”

Dr. Darryl Ahner

## New Award History FY03-FY12



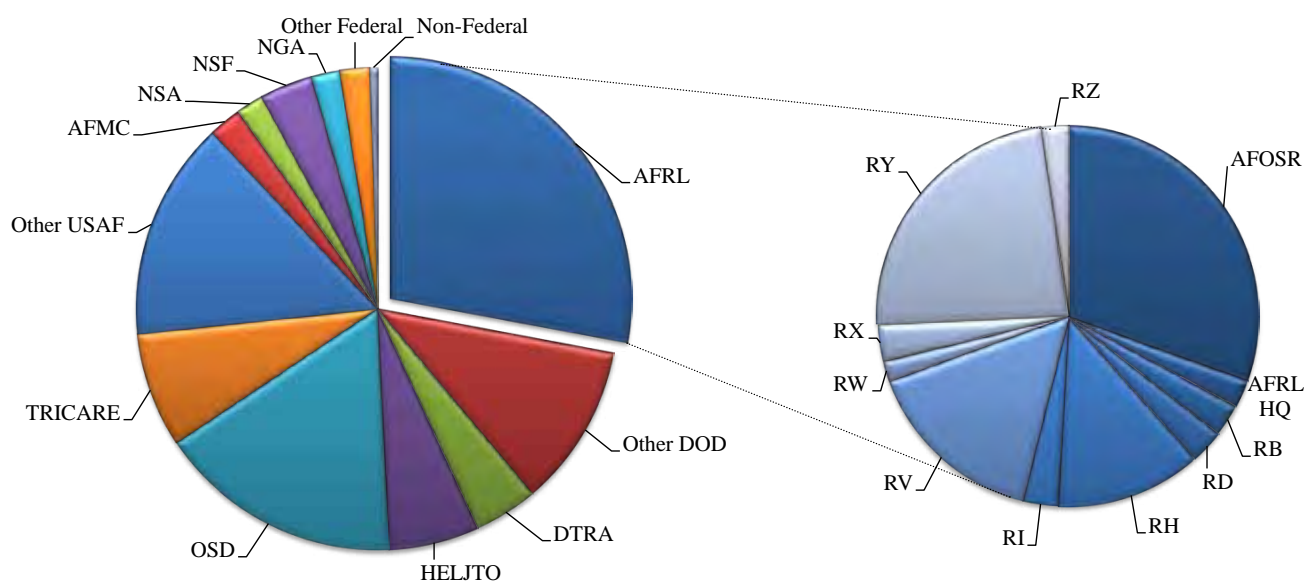


## New FY12 Awards to Academic Departments and Research Centers

Department	Newly Awarded Research Projects		Newly Awarded Education Projects		Total FY12 Newly Awarded Projects		Total FY12 Research Expenditures
	#	\$k	#	\$k	#	\$k	\$k
Mathematics & Statistics (ENC)	13	587	-	-	13	587	562
Electrical & Computer Engineering (ENG)	59	6,044	3	844	62	6,888	8,348
Engineering Physics (ENP)	41	5,177	2	64	43	5,242	6,151
Research & Sponsored Programs (ENR)	1	19	1	36	2	55	17
Operational Sciences (ENS)	13	6,089	-	-	13	6,089	5,250
Systems & Engineering Management (ENV)	14	1,019	-	-	14	1,019	1,547
Aeronautics & Astronautics (ENY)	49	3,433	2	40	51	3,473	5,180
<b>TOTAL</b>	<b>190</b>	<b>22,369</b>	<b>8</b>	<b>984</b>	<b>198</b>	<b>23,353</b>	<b>27,055</b>
Center							
	#	\$k	#	\$k	#	\$k	\$k
Advanced Navigation Technology (ANT)	20	1,214	-	-	20	1,214	2,179
Center for Cyberspace Research (CCR)	11	2,694	2	839	13	3,533	2,331
Center for Directed Energy (CDE)	17	2,533	1	19	18	2,552	3,297
Center for Technical Intelligence Studies & Research (CTISR)	8	1,341	-	-	8	1,341	1,140
Center for Operational Analysis (COA)	12	6,004	-	-	12	6,004	5,212
<b>TOTAL</b>	<b>68</b>	<b>13,786</b>	<b>3</b>	<b>858</b>	<b>71</b>	<b>14,644</b>	<b>14,159</b>

Note: Total research expenditures reported include institutional cost sharing, which is not included in newly awarded projects. Numbers reported to the ASEE and NSF research expenditure surveys vary somewhat due to differences in definitions. All Center funds are also included in departmental funding.

## Sponsors of FY12 Projects



\*Pie chart on the right shows breakdown by AFRL Technology Directorates.

## ENROLLMENT INFORMATION

### Enrolling at AFIT for Graduate Studies

The Graduate School of Engineering and Management offers multiple graduate and doctoral degree opportunities that focus on high-quality graduate education and research. We serve the Air Force as its graduate institution of choice for engineering, applied sciences, and selected areas of management. The appeal for our distinct educational opportunities is widespread and attracts high-quality students from other United States armed services, Government agencies both inside and outside the Department of Defense, and international military students. Of particular note, under the National Defense Authorization Act for Fiscal Year 2011, the Graduate School may enroll defense industry employees seeking a defense-related masters or doctoral degree.

Our automated application system at <http://www.afit.edu/en/admissions/index.cfm> provides immediate application information to the Office of Admissions; an admission counselor usually contacts the applicant within 24 hours of submitting an application. In addition, there is no application fee. Because of our highly automated admission processes, the Office of Admissions usually renders an admission decision within 15 days.

Prospective students will join a robust and energetic student body focused on learning and research. The Accreditation Board for Engineering and Technology (ABET) accredits most of our engineering programs, not a common factor among graduate schools of engineering. Students usually finish their master's programs within two years and the doctoral programs within three years. Enrollment averages around 664 full- and part-time students with a student to faculty ratio of 5:1. In academic year 2011-2012, 383 master's and doctoral degrees were awarded to 310 Air Force officers, 12 sister services, 43 civilians, and 18 international military officers. Our campus consists of 8 buildings, 23 class laboratories, 67 research/laboratory areas, and the D'Azzo Research Library.

For more information, visit [www.afit.edu/EN/admissions/index.cfm](http://www.afit.edu/EN/admissions/index.cfm).

### AFIT Internship Opportunities

Internship opportunities are available for undergraduate and graduate science, technology, engineering, and mathematics (STEM) students through the Southwestern Ohio Council for Higher Education (SOCHE). Students have the opportunity to work at the AFIT through the Summer Internship Program, the Student Research Program, or both. Students benefit both academically and financially by working in state-of-the-art laboratories with top professionals in their field. Additionally, they can use this experience for senior projects, cooperative education and graduate research. AFIT receives the benefit of top students who bring new energy and ideas to the research projects.

For additional information regarding AFIT internship opportunities, please visit: <http://www.socheintern.org/>.

## ACKNOWLEDGEMENTS

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