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2006 Annual Report of the Graduate School of Engineering and Management, Air Force Institute of Technology

Office of Research and Sponsored Programs, Graduate School of Engineering and Management, AFIT

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AIR FORCE INSTITUTE OF TECHNOLOGY

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Graduate School of Engineering and Management
ANNUAL REPORT 2006

AFIT Overview

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. AFIT accomplishes its mission through three resident schools – the Graduate School of Engineering and Management, the School of Systems and Logistics, and the Civil Engineer and Services School – as well as through its office of Civilian Institution Programs.

As the Air Force Institute of Technology continues its ninth decade of operation, faculty and staff members reflect with pride on the contributions the Institute's graduates have made on 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 the opportunity for our students to develop the professional and technological skills needed to sustain the supremacy of America's air and space forces.

MISSION
Provide responsive, defense-focused graduate and continuing education, research, and consultation to improve Air Force and joint operational capability

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Dr. Thomas, Dean

Message from the Dean

I am pleased to share with you the AFIT Graduate School of Engineering and Management Annual Report 2006. The faculty and I are proud of the accomplishments summarized here, and of AFIT's long tradition of providing leading edge technical education to our nation's finest military officers.

AFIT's tradition of excellence continues through our education and research programs delivered through our centers. This report highlights the ongoing activities in the emerging area of cyberwarfare; primarily through our Center for Information Security Education and Research (CISER). CISER's computer engineering–based initiatives address important Air Force and Department of Defense needs to advance new technologies for operations in air and space. These efforts will be in direct support of the Air Force's new Cyberspace Command.

AFIT ranks 19th in the number of master's degrees awarded by U.S. engineering colleges, according to the 2006 American Society of Engineering Education survey. While these graduates will provide immediate benefit to the U.S. Air Force and Department of Defense, they will also contribute to the nation's technical workforce and economic strength for decades following their military service. AFIT's research funding from U.S. military and intelligence agencies continues to increase, reflecting the value of our research products to our sponsors.

Force transformation presents a multitude of challenges for us as we move to a smaller but more effective force with enhanced capabilities including the Global War on Terror (GWOT). AFIT will continue to promote and execute programs and initiatives to leverage technology and improve processes as directed by Air Force Smart Operations for the 21st Century (AFSO21).

As I complete my first year at AFIT, I am enthusiastic about leading the innovations required to continue the fine AFIT tradition of relevant, high quality graduate education and research in an ever-changing world.

Marlin U. Thomas, Ph.D.
Dean, Graduate School of Engineering and Management
Air Force Institute of Technology

Dr. Thomas' biography is available at
http://www.afit.edu/p/dean_en.cfm
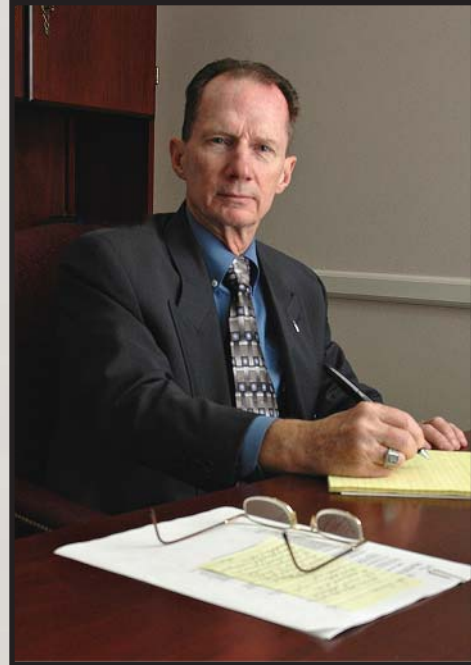
The Cyberspace Vision: Developing Capabilities to Deliver Sovereign Options in Cyberspace

On Pearl Harbor Day, December 7, 2005, the Secretary of the Air Force (SECAF), Mr. Michael W. Wynne, added cyberspace to the Air Force mission. This addition to the Air Force mission was due in large part to the growing threats to national security originating in cyberspace. In his statement, the SECAF envisioned the Air Force as being the service leader in cyberspace operations due to the service's global reach and force projection capabilities. Since that day in 2005, the Air Force has been working at cyber speeds to ensure capabilities development for delivery of sovereign options in cyberspace. In January 2006, the Air Force Chief of Staff (CSAF), General T. Michael Moseley stood-up the Cyber Task Force to investigate current capabilities, identify unfulfilled needs, and promote the growth of cyberspace capabilities. In November 2006, the CSAF named and tasked the Eighth Air Force (8AF) with a "Go Do" letter to provide the way ahead for Air Force cyberspace. Since then, on-going efforts have been to develop a cyberspace Organize, Train, and Equip (OT&E) plan for the cyber workforce as a precursor for the establishment of a Cyberspace Command.

Cyberspace operations are inherently technical in nature. As a result, the Air Force must grow and maintain a technical workforce capable of mitigating the threats posed in cyberspace. AFIT is playing an integral role in the development of the cyberspace workforce. Since the early 1990s, AFIT has been producing graduates who possess the skillsets necessary for the Department of Defense and Air Force success in cyberspace. These graduates understand capabilities as they relate to digital forensics; systems attack, defense, and exploitation; and in general, network warfare and operations. These educational and research skillsets will prove to be invaluable for the cyber warrior.

With fiscal restrictions and manpower reductions continuing to affect the Air Force, the Air Force is faced with a cultural change for successful operations in cyberspace. New cyberspace capabilities must seamlessly integrate with existing air and space capabilities. The cyber workforce will be lean and blended to form a synergistic air, space, and cyberspace service. AFIT is working closely with the 8AF to develop education and training requirements for the cyberspace command. In January 2007, AFIT hosted, on behalf of the 8AF, the first ever Cyberspace Forces Education and Training (E&T) workshop. This workshop brought together 49 experts from the operational, education, training, and policy/personnel communities to develop E&T Courses of Action (COAs) for the AFCYBER Commander, Lt Gen Robert Elder, as part of the OT&E plan.

AFIT and CISER are forward-looking institutions, responsive to the changing educational needs of the Air Force, the DoD, and the federal government. The CISER was designated as a National Security Agency (NSA) National Center of Academic Excellence in Information Assurance Education (CAE/IAE) in 2002 and recertified in 2005 by the NSA and the Department of Homeland Security. In 2005, we also received a national CyberCorp Institution status from the National Science Foundation.

The CISER conducts defense focused research at the Master's and PhD levels. We currently have strong research ties with the Anti Tamper Software Protection Initiative Technology Office of AFRL, the NSA, the Defense Advanced Research Projects Agency (DARPA), the Air Force Information Operations Center (AFIOC), and the Air Force Communications Agency (AFCA). The CISER conducts both classified and unclassified research; faculty and students hold security clearances capable of supporting research at the Top Secret level. The CISER faculty possesses a wealth of knowledge and experience in communications, networking, and information security gained through DoD operational assignments before joining the faculty. Recent research topics include extensive investigations into the vulnerabilities of IEEE 802.11 and Bluetooth networks, interference characteristics of ultra wideband systems on third and fourth generation communication systems, wireless traffic analysis, steganography and steganalysis, Internet Protocol Version 6 (IPv6) capabilities and security limitations, Intrusion Detection System exploitation and evasion, security in remote sensor networks, and routing security in ad hoc communication networks.

To ensure that our cyber education and research programs prepare graduates to meet the needs of the federal government, an external Distinguished Review Board (DRB) of Cyber Operations and security experts and senior leaders oversees program direction. This DRB is chaired by Major General John Maluda, Vice Commander of the 8th Air Force, and has a permanent member in Mr. Tony Sager, the Senior Executive Academic Liaison from the NSA. The DRB solicits feedback on the quality of course instruction, the focus and conduct of research, and the adequacy of laboratory and student support resources.

Our graduate Cyber Operations and Cyber Warfare programs are designed to support one of the federal government's and DoD's critical missions—Computer Network Operations (CNO). As DoD component element missions require rapid deployment and response on a global scale, our graduates must understand the technical and managerial roles associated with these complex cyber mission requirements.

www.afit.edu/ciser

Center for Information Security Education & Research
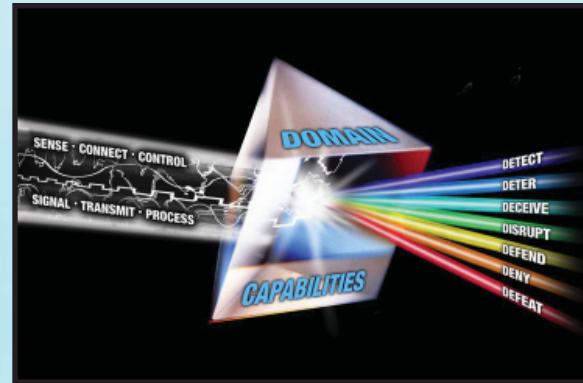
Cyber at AFIT

Viruses, Worms, and Trojan Horses Welcome Here

The Center for Information Security Education and Research (CISER) will soon unveil a powerful network-emulation facility. The Cyber OpeRations Emulator (CORE) is a global-scale network-emulation test bed that provides DoD researchers and students a unified, efficient, and flexible framework for studying malicious code and DoD network operations.

The CORE architecture is based on the proven and fielded Emulab emulation environment which enables CORE to configure and control hundreds of rack-mounted PCs and network devices. The CORE's users can precisely specify a network configuration to emulate, including network-topology and packet-transmission characteristics such as line speed, packet loss, and latency.

When fully operational, the CORE will possess unique capabilities making it valuable for defense research. CORE will support 1) research into malicious activities such as the introduction of viruses, worms, and Trojan horses into networks and network nodes; 2) simultaneous operation in two distinct modes, "research mode" for high-fidelity study of networks, and as a planned later enhancement, a "network-simulator mode" for realistic network-operations training. Furthermore CORE has a Graphical User Interface (GUI) to quickly and efficiently specify a network topology, workload, and operating characteristics.

The CORE provides an invaluable platform for research-related education in a wide range of areas. Each year, approximately 90 students take our courses in Distributed Software Systems, Introduction to Computer Networking, and Computer Communications Networks. The most effective learning takes place by observing and interacting with real systems in operation. Using the CORE as a virtual laboratory will significantly enhance the learning experience in these courses. Each student will be able to simultaneously implement and change the configuration of actual networks and distributed systems, observing the results of their changes in real time.

The most significant impact the CORE will have on current research efforts is the unified, efficient, and easily reconfigurable environment it provides; enabling multiple researchers to focus on the research problem rather than on unique instrumentation for a particular effort. The CORE will make a unique contribution to the research-related educational areas of secure software design, computer security, analysis of malicious code, and computer attack tools and techniques. Such code and applications must be studied in a controlled environment to understand how they operate, to determine their attack profiles, and to devise effective and efficient detection and prevention countermeasures. The CORE provides the ideal environment for such education and research.

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Removing "Security through Obscurity" from Software Watermarking

Software piracy, the act of illegally copying and distributing software, is an ongoing problem for software vendors within the United States and internationally, costing nearly $15 billion dollars each year. Security professionals are researching various software watermarking techniques as one of many means to combat software piracy. Software watermarking involves inserting controlled information or data into the software that cannot be removed or altered. In some cases, a unique fingerprint, often taking the form of a customer ID number, can be used.

Current watermarking systems protect the watermark by hiding it, using "security through obscurity." AFIT research, sponsored by the Anti-Tamper Software Protection Initiative (AT/SPI) Technology Office, has proposed a different approach that instead uses cryptographic style security. Cryptographic style security does not attempt to hide the watermark; instead, the watermark is made as robust and unbreakable as possible. There is no attempt to hide the fact that the watermark is present.

A valid watermarking system proves ownership rather than simply identifying the author, and as such an attacker is less likely to claim it as his own. An accepted standard for a watermark's attack resistance is that any removal or modification of the watermark will "break" the program, rendering it unusable. Instead of relying on the security of the algorithm itself, modern cryptographic algorithms depend on the security of the encryption keys and the rigorous mathematical difficulty of reverse engineering one way functions for the security of those keys. Little or no effort is expended in hiding that encryption occurs or in hiding the actual method of encryption. The important thing is to keep the keys secure.

The watermarking scheme and the watermark values should be publishable without compromising the security of the watermark. A model similar to modern cryptography is desirable. The watermarking algorithm can be published, even the actual watermark. The security of the watermark is then dependent on the robustness of the embedding of the watermark and the difficulty of its removal while maintaining program integrity, not finding the watermark.

History has shown that "security through obscurity" really does not provide security. Current watermarking research depends on a secret key for security, hiding the watermark for protection. If the key is discovered, then the watermark is vulnerable. AFIT research shows the focus should instead be nonstealthy, robust techniques. This shift would lead to increased robustness and security in future software watermarking methods.
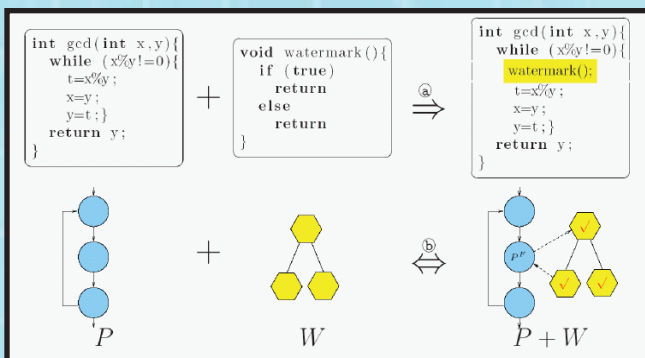
Digital forensics education gives students a distinct advantage over our potential adversaries, be it nation states or malicious hackers. AFIT offers a digital forensics class that examines the technical details of media analysis, including proper media duplication, and methods for locating hidden information.

Hands-on laboratory activities give students practical experience with conducting a search and seizure; maintaining a live network without loss of service while identifying and reversing a problem; regaining reentry by circumventing the computer's security when locked out of the machine; analyzing network capture logs and tracking the individuals attacking back to their ISP; and other topics. Subject matter experts are regularly invited to describe their real life experiences in digital forensics, providing a robust learning experience.

Through a grant sponsored by the National Science Foundation, we are partnering with Sinclair Community College to develop courseware appropriately structured for first-responders attending classes at the community

college level. AFIT digital forensics education also serves the local community by offering local law enforcement officers the opportunity to attend the course without charge. The officers have enjoyed the course, commenting that the level of complexity on the media analysis required more of them than most of the cases that they work on a regular basis.

Our digital forensics course is offered once a year and 48 students have completed the class to date. In the future we plan to extend the digital forensics offerings at AFIT, adding courses that offer more depth in the Network Forensics, Digital Device Analysis, and the Data Analysis topic areas. Some of the topics in Data Analysis will be expanded, including a more in depth coverage of information hiding and its role in steganalysis, metadata, and network protocols.

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Network Intrusion Detection

Intrusion detection is the art and science of finding compromises or attempts to compromise a network or computer system's integrity. A Network Intrusion Detection System (NIDS) monitors the traffic on an entire network to determine if an attack or intrusion has occurred. AFIT researchers are striving to minimize the manpower required to operate these systems, while reducing the risks of attack.

One weakness of NIDSs is that they identify attacks but rarely identify whether the attacks succeed or fail; the success–failure determination is left to the analyst or system administrator. Each method for determining whether to trust the response has its own strengths and weaknesses.

The first method, cataloging of known exploit shellcode, is perfectly suited for public exploits, which comprise the majority of attacks. The code's "payload" size is irrelevant because the code is mostly static, so the analyst can account for any minor changes in the payload—changing ports or backdoor names and passwords. This method is the most straightforward and requires the least technical research; however, it fails with randomly encoded payloads.

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The payload-size analysis method is designed for optimized payloads that are randomly encoded. With the overall trend of payload development toward small, optimized code, we expect this method to increase in effectiveness. In the unlikely case that the payload is both unknown and too large, the analyst should either reverse engineer it or check the patches and logs.

An attacker could purposefully create large encoded payloads to render the above defense methods ineffective. Ultimately, the widespread knowledge of the possibility of response forging, combined with methods to correctly determine response validity, makes forging attacks too risky for the attacker. Nevertheless, it's useful to determine the result with polymorphic overflows in which the payload size is either too large or can't be easily calculated.

AFIT research is currently testing large encoded payload attacks against Windows and Linux using the Metasploit Framework. Additionally, we're developing payload-size and shellcode-matching filters for Snort, a widely used Network Intrusion Detection System. On the response-matching side, several real-world issues exist that need additional research—we've found some exploits that have several different patched responses based on the exploit vector, requiring a better matching method than simply using the flowbits plug-in, for example. Further research into these ideas should prove even more beneficial in reducing both the analyst workload and the risk from evasion attacks.

Bomb Damage Assessment
... Near Real-Time

A recent project demonstrating architecture based concept formulation and evaluation focused on a near real-time, net-centric approach to Bomb Damage Assessment (BDA). This project looked at the potential benefit from capturing information from weapon-borne BDA sensors for a rapid probabilistic assessment of weapon effects. The concept was defined parametrically based on bomb effectiveness; aircraft carry capacity, network reliability and BDA algorithm accuracy. The concept was evaluated against mission level metrics associated with sortie effectiveness (e.g., average kills/sortie) and sorties required to service specified targets. Both spreadsheet analysis tools and discrete event simulations were constructed based directly on a system architecture defining the concept. The system architecture correctly captured system of systems level interactions between targets, strike elements, and both ground and airborne command and control elements. An important point that came out of this research is the importance of targeting doctrine to the overall concept. The near real-time approach to BDA did not achieve the desired improvements in sortie effectiveness unless changes were made to traditional weapon-target pairing and targeting doctrine.

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Avoiding Friendly Fire Incidents

Another major thrust within the Center for Systems Engineering has been to support the Core Process III initiatives within the Air Force Research Lab (AFRL). These initiatives look to accelerate support to the warfighter by combining mature technologies in useful concepts that can be rapidly prototyped and demonstrated to support urgent needs. An example of this is the recently completed effort to demonstrate and evaluate friendly marking devices to avoid friendly fire incidences while conducting close air support missions. AFIT students provided the Systems Engineering analysis and test planning as part of a cross directorate effort in AFRL. The group evaluated and tested a wide range of devices, and selected the most promising candidates based on user validated needs.

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Imaging Ground Forces
... Real-Time

Over the past 2 years, AFIT graduate students worked with partners at the Los Alamos National Labs to develop project Angel Fire, a persistent city-sized surveillance program. Intended to help counter the threat posed by improvised explosive devices (IEDs), Angel Fire is an airborne high-resolution imaging and dissemination system. By providing real-time imaging capabilities, IEDs and other threats to ground forces can be detected, prevented, and/or negated. Angel Fire is particularly well suited to provide enhanced situational awareness to forces operating in an urban environment, convoy operations, or other ground operations. The Angel Fire system was successfully demonstrated to the U.S. Marine Corps during various training exercises. The Marines were so impressed with the system that they asked for it to be deployed as quickly as possible. Developed in an incubator-type setting, Angel Fire has been transferred to the Air Force Research Laboratory for further development and establishment as an official program.

For more information
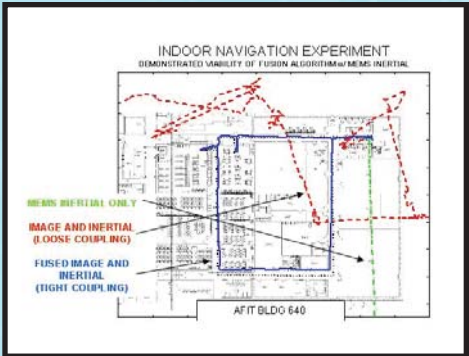Dr Alfred Thal
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AFIT team wins 2006 Air Force Systems Engineering Award: AFIT Satellite Modeling Tool Increases AF Space Intelligence Mission Effectiveness by 400%

The space intelligence community must quickly and effectively evaluate the design and capabilities of foreign satellite systems, to include potential threat systems. In response to this need, a team of AFIT systems engineering students designed, developed and tested a software-based parametric satellite model to be used by the AF space intelligence community for threat modeling and analysis. The final product allowed the user to: 1) alter orbital parameters and space environment variables; 2) plug and play different subsystem component models; 3) alter key design parameters of subsystems and environments; and 4) view system responses to internal/external events and/or environmental changes. The completed effort provided a new capability to the space intelligence community and increased their mission effectiveness by an estimated 400%. In recognition for this outstanding accomplishment, the AFIT team won the 2006 Air Force Systems Engineering Award.

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Accurate Navigation without GPS

Autonomous navigation is often needed for military operations in environments where external navigation reference sources (such as the Global Positioning System) are unavailable. AFIT is exploring new ways of fusing optical and inertial sensors to achieve robust, self-contained, passive, autonomous navigation – without GPS. The overall objective of this research is to combine image and inertial sensor data at a fundamental level to exploit the natural synergy between imaging and inertial sensors. At the heart of this approach is a rigorous method to combine previous image information with inertial navigation system measurements to predict feature locations in new images. Using this approach yields a robust, efficient algorithm that can be applied in real-time. An experimental test set-up at AFIT has demonstrated the ability of this system to use the predicted feature locations to navigate in an aircraft and indoors without maps or other prior knowledge of the environment.

INDOOR NAVIGATION EXPERIMENT
DEMONSTRATED VIABILITY OF FUSION ALGORITHM w/ MEMS INERTIAL

MEMS INERTIAL ONLY

IMAGE AND INERTIAL
(LOOSE COUPLING)

FUSED IMAGE AND
INERTIAL
(TIGHT COUPLING)

AFIT BLDG 640

For more information
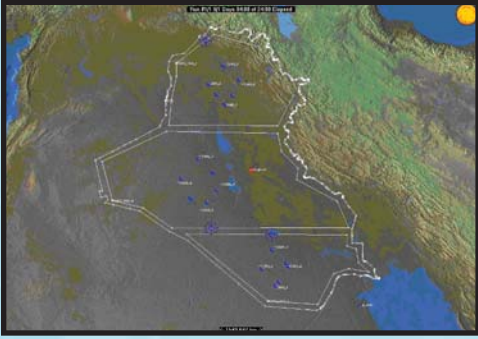Maj Michael Veth
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Precision Air-to-Air Navigation for UAV Refueling

With sponsorship from AFRL, the Advanced Navigation Technology (ANT) Center at AFIT developed and successfully demonstrated both a real-time relative navigation system and flight control algorithms for UAV refueling. There is currently no operational capability to refuel UAVs in flight, because all current approaches require a person in the loop. The new relative navigation system developed at AFIT used GPS carrier-phase ambiguity resolution techniques to solve for centimeter-level accuracy relative position between two moving aircraft in real-time at a 20 Hz rate. The flight control algorithms were developed via simulation but then implemented on the Variable Stability System (VSS) autopilot in a Learjet owned by Calspan. A flight test was conducted in fall 2005 by the USAF Test Pilot School, in which the Calspan Learjet flew in full six degree-of-freedom autonomous formation flight with a lead C-12 (representing a tanker) for several hours. The system performed well in both straight-and-level flight and in turns, and also demonstrated the ability to transition between commonly used positions in a refueling sequence. Ongoing research is investigating the use of imaging sensors to augment the GPS-based approach for increased robustness.

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Combat Modeling for Current and Future Operations

The Center for Operational Analysis continues its combat modeling research and analysis using models from the Air Force Standard Analysis Toolkit (AFSAT). The System Effectiveness Analysis Simulation (SEAS) mission-level model was selected to examine various mixes of sensor coverage for high value fleeting targets for Air Combat Command. SEAS was also used in an effort to define, model, and evaluate Network Centric Warfare concepts for Aeronautical Systems Center's Simulation and Analysis Facility. As the only agent based model in the AFSAT, SEAS also provides a perfect platform for future ABM research in collaboration with the Naval Postgraduate School and follow on efforts to Project Albert. Another effort demonstrated significant variance reduction in a campaign level combat model (THUNDER) using traditional variance reduction techniques, the most successful being control variates.

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AFSO21 at AFIT: Improving USAF Operations

AFIT is an active participant in the ramp-up of Air Force Smart Operations for the 21st Century (also called Air Force Smart Ops or AFSO21), a coordinated effort to improve operations throughout the rank and file of the US Air Force. AFSO21 is an integrative process using Lean Principles, Theory of Constraints, Six Sigma, BPI, MBO, TQM, 6s, Project Management, and other classical management tools. AFSO21 will streamline operations, optimize processes, reduce overhead operations, and achieve a lean workforce. These improvements will have direct, long-term contributions to both military and civilian organizations, enabling a more effective US Air Force. With three trained AFSO21 facilitators and a wealth of knowledge resident in its faculty, AFIT is incorporating AFSO21 content and tools into graduate program course work and is applying AFSO21 to improve its internal processes. The first AFIT rapid improvement effort resulted in a reduction of the time to produce systems engineering case studies by 36% (11 months) while also improving the value of the case studies to the final customer at no additional cost. AFSO21 is expected to be the catalyst for sustainable organizational improvement within the Air Force, and AFIT's Department of Systems and Engineering Management is playing a crucial role in the Air Force's transition to AFSO21.

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Nuclear Weapons Studies and Research

Our weapons effects based research includes fallout prediction, computational modeling, radiation effects on electronics and materials, and radiation detection. Fallout modeling research is done as part of the national nuclear forensics program, and contributes to real time analysis of debris and air sampling for treaty verification, detonation monitoring, and prediction of fallout patterns. Computational modeling is oriented on developing state-of-the-art transport codes. Radiation effects research encompasses transient and long term radiation damage effects to a variety of electronics materials used in DoD applications. Recent work is oriented on survivability of high speed and high energy components in the natural space and nuclear weapons enhanced environments, and includes ionizing interactions, electrostatic discharge and EMP. Radiation detection research has been the mainstay for many decades and currently is oriented on developing high efficiency, high resolution spectrometers for use in detection of special nuclear materials in closed unknown configurations or at great distances.

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Research Highlights

New Airbag Designs

An AFIT doctoral student has conducted one of the first experiments with low pressure airbags, an important step in the development of new systems to reduce helicopter fatalities and minimize damage from collisions with large trucks. The experiments successfully validated computational models that allow engineers to simulate thousands of airbag design configurations quickly on the computer, using the resulting performance data to choose the best airbag design. The range of experiments covers many potential uses of low pressure airbags, including helicopter crash landing protection, heavy vehicle bumpers, and bomb bay ejectors. The bomb bay airbags would reduce bomb ejection point loads on the airplane structure, as well as noise due to trapped vortices in the open bomb bay. Civil applications include reducing fatalities by mounting on bumpers of heavy trucks; external airbags that would deploy when collision with a smaller vehicle or pedestrian was imminent. The photo shows the gondola hitting an airbag at a fatal helicopter speed of 30 mph. The airbag kept the decelerations below 12 G's. Collisions slowed to this level would allow helicopter pilots to walk away from an otherwise fatal crash.

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Center for Rapid Product Development Established

AFIT graduate students will have the unique opportunity to apply knowledge and principles learned in coursework to real-world product development efforts while being guided by AFIT faculty and AFRL researchers. This framework builds on the concept of Conceive-Design-Build-Operate to take a product development effort from initial idea to implementation, and provide feedback to the designer. This strategic partnership builds on the foundation to instruct officers, engineers, and scientists to develop new products and systems quickly. Through collaborative relationships, the center's purpose is to develop and demonstrate rapid solutions to urgent operational needs through the application of maturing technologies.

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CMSR Research for Air Force, DoD, and the Intelligence Community

The Center for MASINT Studies and Research (CMSR) continues to break new ground with research into Multispectral and Hyperspectral Imaging, imaging and non-imaging IR, radar sensing, specifically SAR, passive bistatics, and non-cooperative target recognition using multi-static techniques. The NSA is sponsoring advanced biometric research, investigating the relationships between body gesture, speech and nonverbal information. Current research involves Radiant Brass conventional munitions signatures and rocket plume detection, measurement, and characterization; bomb detonation characterization using MASINT sensors will provide greater understanding of threat explosive types and destructive potential. Focused on the Air Force, Department of Defense, and the intelligence community, the CMSR is a unique national resource for educating the future generation of MASINT and AGI professionals in the scientific, technical, and operational activities necessary to develop, operationalize, and sustain MASINT methods and capabilities.

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AFIT Investigates Zero-Fuel Disposal Options for Retired Spacecraft

Orbit disposal of aging spacecraft has become a significant concern over the past few years, as the increasing number of orbiting objects in high-value orbits (e.g. geosynchronous) threatens to limit the launching of future satellites and spacecraft. AFIT researchers have demonstrated through high fidelity modeling that the transfer to safe disposal orbits can be done with little or no fuel, using only the sun's radiation. By controlling the projected area of a spacecraft with respect to the sun, the tiny force exerted by solar radiation can be harnessed to slowly raise the orbit of spacecraft in geosynchronous orbits. The time required depends strongly on the physical configuration of each spacecraft. For satellites currently on orbit, researchers estimate it could take 30 years to reach a safe disposal orbit, but it is hoped that future satellites could be designed to take advantage of this "free ride", and make their final transfer in far less time.

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CDE: A Leader in the Modeling and Simulation of Laser Weapons

Accurate representation of the performance characteristics of a new weapon system is essential, not only for analysis, but also for the successful training, evaluation, and planning by the WarFighter. AFIT's Center for Directed Energy has partnered with the High Energy Laser Joint Technology Office (HEL JTO) in the development of laser weapons' performance models and simulations. The High Energy Laser End-to-End Operational Simulation (HELEEOS) is a cornerstone model that captures HEL performance over a wide variety of devices, wavelengths, and atmospheric conditions. A premier model that includes effects of turbulence, aerosols, and clouds, HELEEOS has been incorporated into many recognized JTO-performance and Air Force codes, such as Brawler. Working with the Center for Operational Analysis, HELEEOS is being slated for intergration with WarFighter-in-the-loop and EADSIM simulations.

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Enhancing Hyperspectral Image Analysis
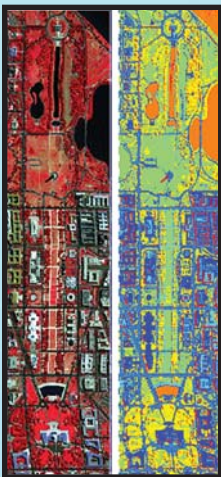
As lead on a collaborative Air Force sponsored research project ($300K annually) with the Naval Postgraduate School (NPS) and Pacific Northwest National Laboratory (PNNL), researchers in the Center for Operational Analysis are using multivariate statistical techniques such as Principal Component Analysis, Multivariate Trimming, and the Iterative RX method to detect anomalies in Hyperspectral (HS) images. The goal is to develop a HS target detection methodology that increases the probability of detection, minimizes false alarms, and reduces the need for user interaction and technical knowledge. Specific efforts include determining the most robust clustering algorithm for HS data, with or without outliers. Also, the suitability and effectiveness of variable reduction methods for HS data is being investigated in order to recommend appropriate feature extraction and selection techniques. Synthetic imagery is being used to create a family of hyperspectral images to provide insight into which scene conditions most influence the performance of the anomaly detectors. This research will also fuse AFIT anomaly detection results with PNNL results using contextual processing.

For more information
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Research Highlights

**Dr Mark Goltz Receives
Society of American Military Engineers
Award**

Dr Mark Goltz, Professor of Engineering and Environmental Management, was awarded The Society of American Military Engineers' Regional Vice-President's Medal; in recognition of his contributions to the Kittyhawk Post Education Committee.

**Dr Jeff Kharoufeh Receives
Operations Research Award**

Dr Jeff Kharoufeh, Associate Professor of Operations Research, has been awarded the Outstanding Young Member Award by the Cincinnati/Dayton Chapter of The Institute for Operations Research and the Management Sciences (INFORMS); this award recognizes outstanding contributions to operations research by an active member under the age of 35.
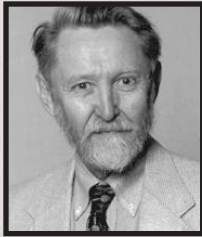
**Dr Peter Torvik Honored
as Fellow by Ohio Academy of Science**

Dr Peter Torvik, Professor Emeritus, has been named an honorary Fellow; fellows are those that have rendered some special service to the Ohio Academy of Science or have made extensive, productive scientific, technological contributions to society.

**Dr Marlin Thomas
Receives 2006 Wellington Award**

Dr Marlin U. Thomas, Dean of AFIT's Graduate School of Engineering and Management, was recently selected by the Institute of Industrial Engineers as the winner of the 2006 Wellington Award; in recognition of his pioneering contributions in warranty planning and estimation of warranty cost.

**Maj Daniel Holt
Awarded Bronze Star**

Maj Daniel T. Holt, Assistant Professor of Management, was awarded the Bronze Star Medal for meritorious service while engaged in ground operations against the enemy at Al Udeid Air Base, Qatar. While exposed to extreme danger from hostile activities and mortar attacks, Maj Holt managed $973M worth of construction at 15 bases in 12 countries across the Central Command's Area of Responsibility.

**Dr Anthony Palazotto
Elected Fellow of Two Societies**

Dr Anthony N. Palazotto, Professor of Aerospace Engineering, was elected to be Fellow in two prestigious engineering societies: the American Academy of Mechanics (AAM) and the American Institute of Aeronautics and Astronautics (AIAA). AAM Fellows have made major contributions to the field of Engineering Mechanics over an extended period of time; AIAA Fellows have made notable and valuable contributions to the art, sciences, or technology of aeronautics or astronautics.

**Dr Theodore Nicholas Honored
with ASME's Nadai Medal**

Dr Theodore Nicholas, visiting Professor, is the recipient of the American Society of Mechanical Engineers' (ASME's) prestigious Nadai Medal. The medal was presented at ASME's Annual Meeting, where Dr Nicholas presented the Nadai Award winning lecture, entitled "High Cycle Fatigue of Metals."

**AFIT Graduate
Michael W. Wynne Sworn in as SECAF**

Michael W. Wynne was sworn in as the 21st secretary of the Air Force. As head of the Department of the Air Force, Secretary Wynne is responsible for its functioning and efficiency, the formulation of its policies and programs, and the timely implementation of decisions and instructions of the president of the United States and the secretary of defense.

**Drs Heil and Jacques Honored
with AIAA Associate Fellow Status**

The American Institute of Aeronautics and Astronautics (AIAA) bestows the prestigious grade of Fellow upon Dr Michael L. Heil, Director, Center for Space Studies and Research, and Dr David R. Jacques, Chair of the Systems Engineering Program; in recognition for notable and valuable contributions to the arts, sciences, or technology areas of aeronautics or astronautics.

AFIT Bids Farewell to Director of Academic Affairs, Former Dean

Dr. Robert A. Calico Jr. joined the AFIT family in June 1972, when he was hired as an assistant professor of aerospace engineering in the Graduate School of Engineering and Management. In July 1990, he was appointed Dean of the Graduate School, a position he held for nearly 16 years; in January 2006, Dr Calico assumed the role of Director of Academic Affairs for AFIT, until his retirement on July 21, 2006. Dr Calico's tenure at AFIT was distinguished, a fact reflected in his current status as Dean Emeritus and Professor Emeritus.

New Department Head

Dr Adedeji Badiru joined AFIT on October 2, 2006 as head of the Systems & Engineering Management Department. He was previously the department head of Industrial & Information Engineering at the University of Tennessee in Knoxville. He is a registered professional engineer, a fellow of the Institute of Industrial Engineers, a fellow of the Nigerian Academy of Engineering, and a member of several professional associations. His areas of expertise and courses taught cover mathematical modeling, project systems modeling, systems analysis, simulation, and economic analysis. He is the author of several technical papers and books; he is the editor of the Handbook of Industrial & Systems Engineering and series editor for CRC Press Series on Industrial Innovation.

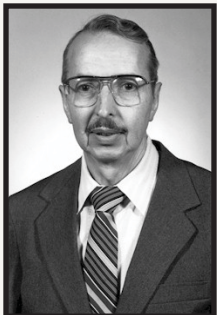### Dr Jeffrey Kharoufeh Beginning a Stellar Career at AFIT

In only five years, Dr Jeff Kharoufeh has already impressed his peers. Since receiving his Ph.D. in 2001, he has published sixteen refereed journal articles, and is currently serving as an Associate Editor for Operations Research Letters and the IEEE Transactions on Reliability. In 2006, he was the Air Force Office of Scientific Research, Optimization and Discrete Mathematics division nominee for the Presidential Early Career Award for Scientists and Engineers (PECASE), the highest honor bestowed by the U.S. government on outstanding scientists and engineers beginning their independent research careers. This nomination followed his 2006, three-year grant from AFOSR to develop queueing models for analyzing complex computer network systems suffering from unreliability, congestion and information processing delays. In 2005, he was promoted to associate professor, and tenured in 2006 a full year early. Dr Kharoufeh has garnered several awards including the Outstanding Young Chapter Member Award by the Cincinnati/Dayton Chapter of INFORMS in 2006, and in 2003, the Norton Teaching Excellence Award, the top teaching award in the Graduate School of Engineering and Management at AFIT.

In Memoriam ...

Professor John J. D'Azzo

Following WWII and his honorable discharge from the military, Dr John J. D'Azzo took a position as an educator at the Air Force Institute of Technology. Dr D'Azzo's expertise was in the areas of Control Theory and Aircraft Flight Control Systems, until his retirement in 1998. Dr D'Azzo died on September 30, 2006, and will be fondly remembered by faculty and students for his contributions at AFIT.

Professor Won B. Roh

Dr Won B. Roh, Professor of Engineering Physics, received his Ph.D. in electrical engineering from the Ohio State University in 1973 and joined the AFIT faculty in 1978. He taught and advised students in the areas of optics, lasers, nonlinear optics, and optical diagnostics. Dr Roh died on July 6, 2006, and will be greatly missed by all who knew him, particularly by his fellow faculty and former students.

Faculty Focus

The Graduate School of Engineering & Management is continually cognizant of its unique responsibility – the technical and management education of Air Force officers so they can fulfill their roles in serving their country to the greatest degree possible.

For a complete program listing, please visit
http://www.afit.edu/en/ener/catalog.cfm

For admissions information, please visit
http://www.afit.edu/en/Admissions/

Master's Degree in Environmental Engineering and Science

AFIT offers a Master's Degree Program in Environmental Engineering and Science. The Graduate Environmental Engineering and Science (GES) program was developed at the request of, and in concert with, Air Force leaders representing the BioEnvironmental Engineering (BEE) career field. The program provides military officers, noncommissioned officers, and civilian career professionals with relevant graduate education in the disciplines of environmental engineering and science (encompassing air, water, soil media) consistent with future duties across the spectrum of military environmental consulting and management duties. The core curriculum includes course offerings in statistics, chemistry, risk assessment, chemical fate and transport in the environment, physiology and toxicology, and environmental sampling, along with design classes in air, water, and solid waste pollution control. A recent addition to the program is Physiologic Effects of Nuclear, Biological and Chemical (NBC) Agents. This course was developed to address the growing threat of use of these types of agents and the increasing responsibility placed on the BEE regarding preparation for and response and recovery following NBC agent use. The program complies with guidelines established by the Accreditation Board for Engineering and Technology and subject areas from the Professional Engineering Exam for Environmental Engineering.

For more information
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Master's Degree in Industrial Hygiene

The Department of Systems and Engineering Management has launched a new Master of Science degree program in Industrial Hygiene. US civilian, US government, and allied government students entering this program will be actively engaged in studies and research in environment, safety, and occupational health (ESOH) as they apply to civilian industry, the Air Force and Department of Defense. The program coursework is structured on the classical industrial hygiene paradigm of "anticipation, recognition, evaluation, and control" of chemical (gas, vapor, liquid, aerosol), biological, and physical (noise, thermal, ergonomics, ionizing & non-ionizing radiation) health hazards to ensure occupational efficiency and worker health and safety. Students will also study statistics, epidemiology, and environmental sciences to add breadth and understanding of workplace health operational risk management. Graduating students should be well-prepared to sit for professional certification examinations and excel in ESOH jobs such as consultant, researcher, hazardous materials/weapons of mass destruction response advisor, and staff ESOH professional within government or private industry. Research thrusts include engineering noise control, exposure assessment, and industrial ventilation.

For more information
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Master's Degree in Combating Weapons of Mass Destruction

AFIT now offers a Professional Science Master's (PSM) Degree Program in Combating Weapons of Mass Destruction through the Department of Engineering Physics. This PSM program provides an innovative and flexible approach to achieving a level of proficiency in an interdisciplinary subject of vital international interest and importance. This program is cohort-based and closely integrated with future employers to provide both a teamwork environment and a focused research path. Achieving the conflicting goals of breadth versus depth of knowledge in the broad area of combating weapons of mass destruction is met by students completing a core foundational curriculum in nuclear, chemical and biological weapons technologies along with fundamental statistical, modeling and risk analysis skills followed by a flexible specialization in a specific area of expertise and research. Graduates of the program will be qualified to fill a variety of scientific and engineering positions in the WMD arena, such as technical advisor, analyst, physical scientist, or program manager. Employment opportunities lie within the Department of Defense and the U.S. Government as well as select positions in the private sector. On-going research areas include nuclear detection technology, post-WMD attack analysis, radiation effects on electronics, and biological agent detection.

For more information
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New Programs

New FY06 Awards to Academic Departments & Research Centers by Type

Department	Research #	Research Dollars	Education #	Education Dollars	Total #	Total Dollars
Mathematics & Statistics (ENC)	6	102,345	-	-	6	102,345
Electrical & Computer Eng (ENG)	49	2,716,614	2	401,469	51	3,118,083
Engineering Physics (ENP)	29	1,842,940	5	915,875	34	2,758,815
Research & Sponsored Programs (ENR)	1	9,800	-	-	1	9,800
Operations Sciences (ENS)	17	751,821	-	-	17	751,821
Systems & Eng Management (ENV)	3	136,540	-	-	3	136,540
Aeronautical & Astronautical Eng (ENY)	55	960,827	1	15,391	56	976,218
TOTAL	**160**	**6,520,887 ***	**8**	**1,332,735**	**168**	**7,853,622**

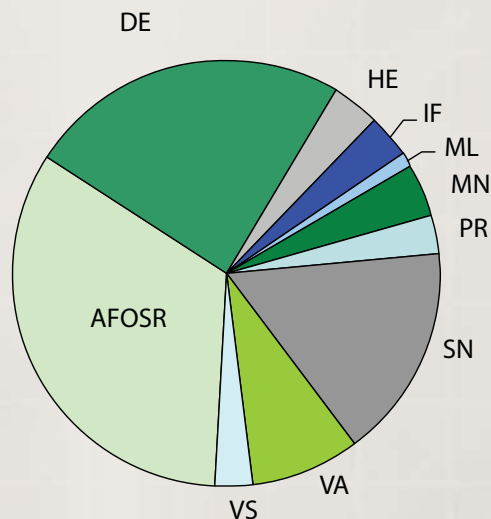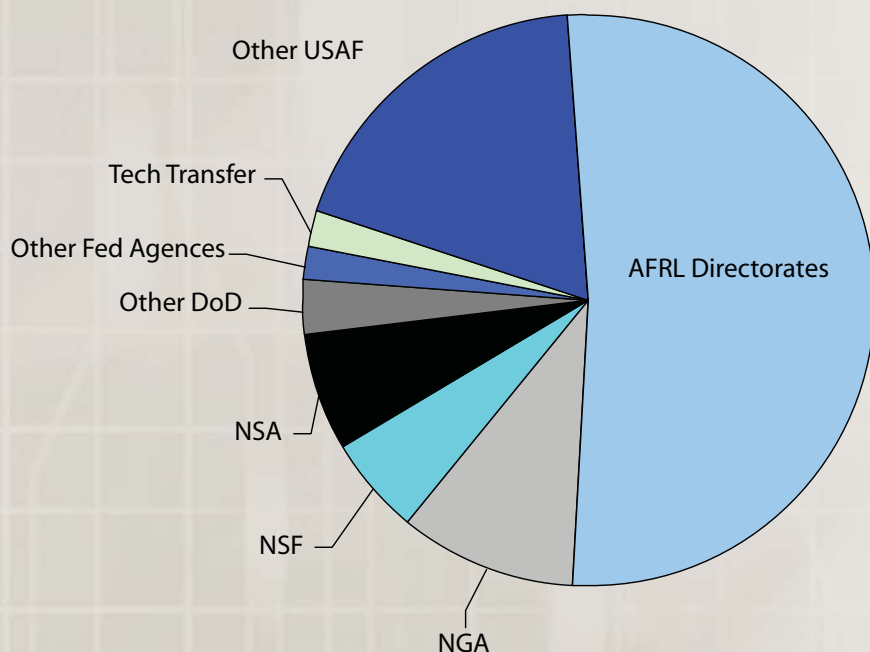| Research Center **	Research #	Research Dollars	Education #	Education Dollars	Total #	Total Dollars
Advanced Navigation Technology Center (ANT)	20	1,017,127	-	-	20	1,017,127
Center for Directed Energy (CDE)	18	1,426,353	2	65,875	20	1,492,228
Center for Info Security Edu & Research (CISER)	9	915,658	2	401,469	11	1,317,127
Center for MASINT Studies and Research (CMSR)	-	-	3	850,000	3	850,000
Center for Operational Analysis (COA)	13	655,310	-	-	13	655,310
TOTAL	**60**	**4,014,448**	**7**	**1,317,344**	**67**	**5,331,792**

* DoD regulations limit AFIT's charges to DoD organizations. Accounting for these nonchargeable items, the
   cost of our research program at a comparable civilian university would have been approximately $15 million.
** All Center funds are also included in departmental funding

New Award History FY00-FY06
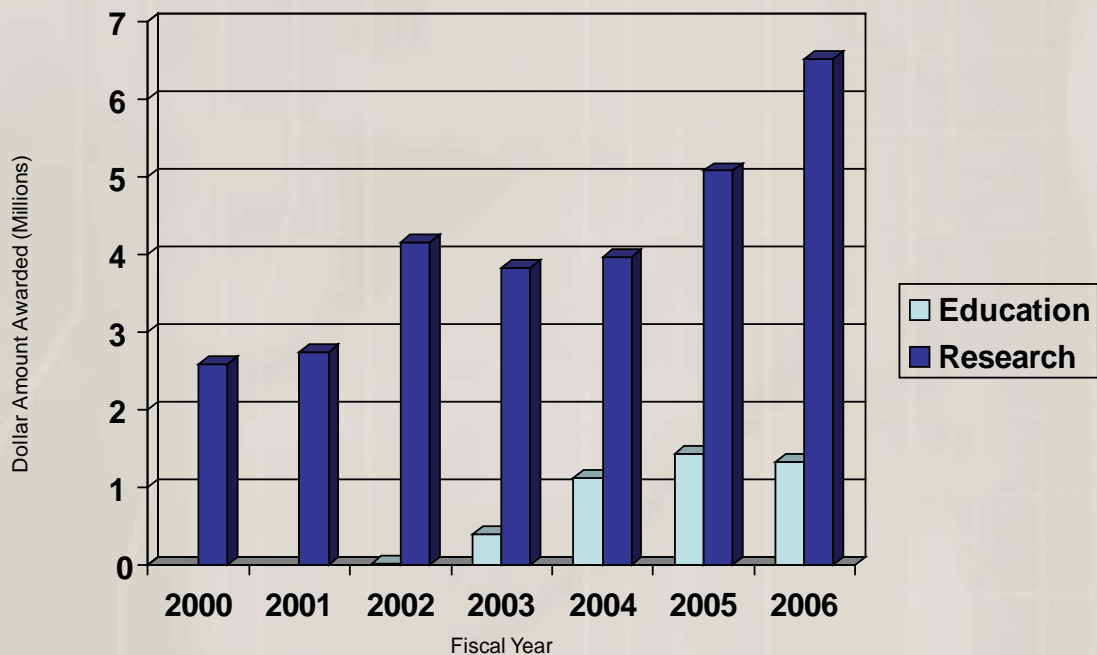
Sponsors of FY06 Funded Research

Other USAF

Tech Transfer

Other Fed Agences

Other DoD

NSA

NSF

NGA

AFRL Directorates

DE

HE

IF

ML

MN

PR

SN

AFOSR

VA

VS

Breakdown by AFRL Directorate

New FY06 Awards to Academic Departments & Research Centers by Sponsor

Dept.	AFRL	Other USAF	Other DoD	NGA	NSF	NSA	Other Federal	Non-Federal	Total
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
ENC	35,000	-	-	-	-	-	36,786	30,559	102,345
ENG	1,632,345	388,689	130,000	-	427,976	496,963	-	42,110	3,118,083
ENP	1,305,940	532,000	45,000	750,000	-	-	90,000	35,875	2,758,815
ENR	9,800	-	-	-	-	-	-	-	9,800
ENS	376,424	330,550	-	-	-	10,000	33,000	1,847	751,821
ENV	111,540	-	25,000	-	-	-	-	-	136,540
ENY	741,119	183,364	23,561	-	-	-	-	28,174	976,218
TOTAL	**4,212,168**	**1,434,603**	**223,561**	**750,000**	**427,976**	**506,963**	**159,786**	**138,565**	**7,853,622**
Research Center*	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
ANT	762,064	165,063	90,000	-	-	-	-	-	1,017,127
CDE	1,125,353	296,000	35,000	-	-	-	-	35,875	1,492,228
CISER	328,188	64,000	-	-	427,976	496,963	-	-	1,317,127
CMSR	-	100,000	-	750,000	-	-	-	-	850,000
COA	337,310	275,000	-	-	-	10,000	33,000	-	655,310
TOTAL	**2,552,915**	**900,063**	**125,000**	**750,000**	**427,976**	**506,963**	**33,000**	**35,875**	**5,331,792**

*All Center funds are also included in departmental funding

Air Force Institute of Technology Research-Large Awards* FY06

Department of Aeronautics and Astronautics

"Gouging Mitigation by Considering the Effects of Coatings, Non-equilibrium Thermodynamics and Material Failure"
$102,953 - Air Force Office of Scientific Research (AFOSR)
Principal Investigator: Dr Anthony N. Palazotto

Department of Electrical and Computer Engineering

Advanced Navigation Technology Center (ANT)

"Advanced Navigation Technology (ANT) Center & Laboratory Support per Appendix of the MOA between AFIT and Air Force Research Laboratory (AFRL)"
$152,122 - AFRL Sensors Directorate (AFRL/SN)
Principal Investigator: Dr John F. Raquet

Center for Information Security Education and Research (CISER)

"Anti-Tamper Software Protection Initiative Education, Outreach, and Research (Scope and Budget Revision)"
$257,188 - AFRL Sensors Directorate (AFRL/SN)
Principal Investigator: Dr Richard A. Raines

"Development of a Federal Cyber Force at the Air Force Institute of Technology"
$358,855 - National Science Foundation (NSF)
Principal Investigator: Dr Richard A. Raines

"Secure Communication in a Mobile Wireless Network Environment"
$144,281 - National Security Agency (NSA)
Principal Investigator: Dr Barry E. Mullins

"Tuition & Resource Support for the Air Force Institute of Technology (AFIT) Center for Information Security Education & Research"
$342,682 - National Security Agency (NSA)
Principal Investigator: Dr Richard A. Raines

Other

"Remote Sensing and Communications for Measurement and Signatures Intelligence (MASINT)"
$100,000 - National Air Space Intelligence Center (NASIC)
Principal Investigator: Dr Andrew J. Terzuoli, Jr

"RF Signal Intercept and Collection System (RFSICS)"
$153,268 - Air Force Office of Scientific Research (AFOSR)
Principal Investigator: Dr Michael A. Temple

Department of Engineering Physics

Center for Directed Energy (CDE)

"Delivered Irradiance Assessment Tool (DIAT)"
$191,000 - Directed Energy Test & Evaluation Capability (DETEC)
Principal Investigator: Dr Salvatore J. Cusumano

"High Energy Laser Weapons: Modeling & Simulation Phase III: Apply Modeling & Simulation Capabilities to Weapon & Battlefield Effectiveness"
$460,000 - High Energy Laser Joint Technology Office (HELJTO)
Principal Investigator: Dr Glen P. Perram

Center for MASINT Studies and Research (CMSR)

"Advanced Geospatial Intelligence Education"
$375,000 - National Geospatial Agency (NGA)
Principal Investigator: Dr Ronald F. Tuttle

"Advanced Geospatial Intelligence Education"
$375,000 - National Geospatial Agency (NGA)
Principal Investigator: Dr Ronald F. Tuttle

"MASINT Academic Support"
$100,000 - National Air Space Intelligence Center (NASIC)
Principal Investigator: Dr Ronald F. Tuttle

Other

"Magnetic Properties of Cr- and Mn-implanted in GaN"
$100,000 - Air Force Office of Scientific Research (AFOSR)
Principal Investigator: Dr Yung-Kee Yeo

Department of Operational Sciences

Center for Operational Analysis (COA)

"Classification and Fusion Based Methods for the Analysis of Hyperspectral and Polarimetric Imagery"
$210,000 - Secretary of the Air Force (SAF)
Principal Investigator: Dr Kenneth W. Bauer, Jr

"SNA Behavioral Modeling MOA"
$110,000 - AFRL Human Effectiveness Directorate (AFRL/HE)
Principal Investigator: Dr Richard F. Deckro

*Large Awards are those that earn $100,000 or more for a single proposal in the given fiscal year.

http://www.afit.edu/de

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http://www.afit.edu/ciser

http://www.afit.edu/ant

http://www.afit.edu/coa

http://www.afit.edu/cmsr

http://www.afit.edu/cssr

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