United States Air Force Academy

Annual Research Report

July 2003 to June 2004

USAFA RESEARCH

THE FACULTY

USAFA TR 04-05 — Approved for Public Release — Distribution Unlimited

Overview of Research at USAFA - Academic Year 2003-2004

External Sources of Research Funding — 16.4M

Department of Defense	$ 6,140K
AFRL (including AFOSR)	$ 3,635K
Other USAF	$ 4,305K
Visiting Researchers (other than ESEP)	$ 644K
Other US Government	$ 613K
USAFA provided	$ 391K
NASA	$ 227K
INSS	$ 60K
AF Reserve	$ 45K
Industry	$ 35K
Other	$ 269K

USAFA personnel involved in Research

Department faculty and staff:	327
Cadets:	216

Publications and Presentations

Publications:	185
Presentations:	210

Connections outside USAFA

Active MOAs/MOUs:	17
Active Cooperative R&D Agreements:	31
Other agreements:	15

US Air Force Academy

Research Report
Period of Report: 1 July 2003 to 30 June 2004

DIRECTORATE OF EDUCATION
DEAN OF THE FACULTY
UNITED STATES AIR FORCE ACADEMY

The Department of Defense, Federal Government, and non-government agencies supported the work reported herein.

This document was edited and produced by Lt Col William J. Mandeville, Director of Faculty Research, USAFA/DFER.

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Or visit the USAFA research website: www.usafa.af.mil/dfe/dfer/index.htm

About the Cover

Top Left: Researchers from the Space and Atmospheric Research Center enjoy a scholarly moment.

Top Right: Cadet working on an independent study research project sorts plant specimens.

Second Row Left: Technicians inspect the 4-meter adaptive optics telescope bound for USAFA.

Second Row Middle: Engineers work with electronics designed for the Falcon Sat program.

Second Row Right: V-22 simulation from Modeling and Simulation Research Center (M&SRC).

Third Row Left: Cadet working in a chemistry lab.

Third Row Middle: Cadet examining an engine in the Aeronautics Lab.

Third Row Right: Cadet inspects a sample during a chemistry project.

Bottom Center: Two cadets assemble an uninhabited aerial vehicle (UAV) used in a research project.

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Letter from the Dean

The Air Force Academy provides undergraduate education and military training to more than 4,000 cadets each year. The USAFA mission is to educate, train, and inspire men and women to become officers of character motivated to lead the United States Air Force in service to our nation. Research experience is an essential element of a quality military academy education that complements and enhances the Academy mission through the training and education of cadets. More than any other single activity, research develops the skills our cadets need to be independent learners and critical thinkers.

Research at the Air Force Academy has three primary purposes. First, research enhances undergraduate learning by teaching cadets that learning and the acquisition of knowledge are dynamic, living processes. Second, scholarly activity sharpens and enhances the professional qualifications of our faculty, many of whom will follow their assignments here with other Air Force assignments. Finally, research aids U.S. national defense by finding workable solutions to real Air Force problems.

This research report is prepared annually to record the significant research contributions of the Air Force Academy.

JAMES H. HEAD, Colonel, USAF
Acting Dean of the Faculty
United States Air Force Academy

1. Synopsis

This annual report provides an overview of research at the United States Air Force Academy (USAFA) conducted under the purview of the Dean of Faculty. USAFA research covers a variety of topics of interest to the US Air Force and other US agencies. Funding provided to USAFA by these agencies was at an all time high of 16 million dollars for this academic year. The *Funding* section details monetary sources, disbursements, and trends. Research at the Academy spans a broad range from basic sciences to humanities. Specific projects are spotlighted in the *Research Highlights* section. Researchers at the Academy include faculty, cadets, and staff, many of whom have been recognized for their achievements with distinguished awards and honors, as detailed in the *Awards* section. Their research is documented and exhibited in hundreds of publications and presentations each year. Examples of these products and a complete listing of the publications and presentations for this academic year can be found in the *Publications* section. Questions concerning the content of this report can be directed to the Director of Faculty Research, Lt Col William J. Mandeville by phone at (719) 333-4195 or email at director_faculty_research@usafa.af.mil.

2. Year in Review

USAFA research covers a wide variety of technical and non-technical topics of interest to the U.S. Air Force and other U.S. government agencies. USAFA research focuses on topics that faculty members believe will provide research opportunities for cadets while having an impact on the Air Force and our nation. The research program at USAFA has just completed its most successful year on record.

The research at USAFA is performed by all 19 academic departments, eight Air Force Office of Scientific Research sponsored research centers, and three institutes. The Air Force Academy continues to find new research customers and partners. For the 2003-2004 academic year there were 17 active Memoranda of Agreements/Understanding (MOA/MOU) and 31 active Cooperative Research and Development Agreements (CRADA).

Total value of the research program at USAFA for the 2003-2004 academic year was $31,422,000. This amount is divided into external funding support of $16,364,000 and USAFA provided support of $15,058,000. The external funding was a combination of monetary support and in-kind supercomputer time valued at $5,000,000. The external funding support expanded nearly 20% over the previous year. The USAFA provided support consists of labor, lab space, and depreciation of capital equipment.

During the 2003-2004 academic year, 216 cadets and 327 faculty and staff actively performed research. This group of researchers produced 185 publications and gave 210 presentations on their research. They were also recognized with several awards including the prestigious Air Force Science and Engineering Award presented to Lt Col Jerry Sellers.

The dramatic growth of external funding for research over the last several years has created some key challenges. Within the past year indirect cost fees were implemented on all incoming funds. The largest challenge research faces during the upcoming year is establishing a way to use these indirect costs to build an infrastructure capable of managing the large volume of equipment and researcher procurement. Additionally, as with any research program of this size, there is a great deal of support work. Other university research programs hire undergraduate, graduate, and post-doctoral students as assistants to help perform the lower-level support work, such as data acquisition, data entry and programming. Currently, USAFA has no system in-place to allow easy hiring of research assistants. Establishing a research assistant program is a key challenge USAFA faces currently, as it is an integral part of any research program of this size and caliber.

3. Research Centers and Institutes

The Air Force Academy has eight research centers and three institutes. This section provides descriptions for each as well as contact information of the directors of each center.

Aeronautics Research Center

Director: Dr. Tom McLaughlin, tom.mclaughlin@usafa.af.mil
Website: http://www.usafa.af.mil/dfan/

The Aeronautics Research Center (ARC) is the research arm of the Department of Aeronautics (DFAN). DFAN provides an Accreditation Board for Engineering and Technology (ABET) accredited program for cadets working towards a B.S. in Aeronautical Engineering. An important element in the DFAN program is our cadet-centered research program. Cadets are provided opportunities to work on actual research projects that support current U.S. aerospace research objectives while under the close supervision of senior faculty members. The ARC is located in the Aeronautics Laboratory, a 5100 square meter building, which houses world-class experimental and computational facilities.

The staff includes 20 researchers and seven technicians. The USAF Office of Scientific Research is a major contributor in terms of both funding and technical direction. The ARC also receives funding from other Air Force Research Lab (AFRL) directorates, the National Aeronautics and Space Administration (NASA), and the U.S. Army. The Aeronautics Research Center actively seeks sponsored research projects that match our experimental and computational capabilities and interests, allow for cadet and faculty involvement, fit within a semester and/or summer schedule, and bring in funding to support laboratory operations. Research that spans the spectrum between basic to applied is currently being conducted. Arrangements can also be made with private industry through Cooperative Research and Development Agreements (CRADA). Opportunities for collaboration with researchers from other universities are also desired.

Center for Aircraft Structural Life Extension

Director: Lt Col Scott Fawaz, scott.fawaz@usafa.af.mil
Website: www.usafa.af.mil/dfem/castle

The Center for Aircraft Structural Life Extension (CAStLE) brings together cadets, 11 full time engineers, and three engineering technicians to provide aircraft structural integrity technology to the aerospace community. Current customers are the Aging Aircraft Division of the Aeronautical Enterprise Program Office, C-5 System Program Directorate (SPD), KC-135 System Program Directorate, A-10 System Program Directorate, Materials Directorate of the Air Force Research Laboratory, and the Air Force Office of Scientific Research. The Air Vehicle Health Management (AVHM) program is at the core of the Aeronautical Enterprise Program Office's aging aircraft technology transition portfolio. As part of the AVHM program, CAStLE is conducting fatigue, corrosion fatigue, static stability, static strength, residual strength, bonded repair, and flight data acquisition test and analysis programs to provide more robust aircraft fleet management tools to the MAJCOMs, Air Logistic Centers, and acquisition activities. The breadth of experimental and analytical investigations is wide ranging from coupon to component to full scale aircraft. For the C-5 SPD, CAStLE is conducting failure analysis of a C-5A aircraft. For the KC-135 SPD, CAStLE is determining the effect of dents in the fuselage skins on the structural integrity of the aircraft. For the A-10 SPD, CAStLE is investigating the effects of coldworking holes in multi-layer stack-ups.

Chemistry Research Center

Director: Dr. John Wilkes, john.wilkes@usafa.af.mil
Website: www.usafa.af.mil/dfc/

The Chemistry Research Center does basic and applied research primarily in the area of materials chemistry. The projects cover all chemical disciplines: biochemistry, analytical chemistry, organic chemistry, inorganic chemistry, physical chemistry. Most of the research is designed to support the Department of Defense technology base. Examples of the topics currently under investigation are Hydrogen Storage Materials, Nonlinear Optical Materials, Aerospace Battery Materials, Chemical Warfare Agent Countermeasures, Photovoltaics, and Rocket Propellants.

Human Environmental Research Center

Director: Dr. David Westmoreland, david.westmoreland@usafa.af.mil
Website: www.usafa.af.mil/dfb/herc/index.htm

The Human-Environment Research Center is devoted to cadet education, faculty development, and Air Force mission support through research. It conducts high-quality basic and applied research in the life sciences, with focused emphasis in biology & human performance to further contribute to the understanding of warfighting effectiveness. Currently there are three research emphases: biomimetics, the adaptation of animal neural models to develop real-time machine processing of visual images for weapons development; laser bioeffects, the study of cell damage resulting from exposure to lasers; and spatial disorientation, a search for physiological signals that are indicative of Type I and Type II disorientation experienced in flight.

Laser and Optics Research Center

Director: Dr. Randy Knize, randy.knize@usafa.af.mil
Website: www.usafa.af.mil/dfp/research/lorc/lorchome.htm

The Laser and Optics Research Center works on a variety of problems involving lasers and optics. Current research projects include: holographic correction of large telescopes, laser cooling and trapping of cold atoms, nonlinear optical polymers, wavelength conversion of fiber lasers, mid IR laser development and sodium guide star laser development. The Center has a wide variety of optics and lasers that span from the UV to IR and from femtosecond to CW.

Modeling and Simulation Research Center

Director: Lt Col (s) Scott Morton, scott.morton@usafa.af.mil
Website: www.usafa.af.mil/dfan/Research/modeling_and_simulation_center.htm

The Modeling and Simulation Research Center is a multidisciplinary center created to help faculty and cadets perform cutting-edge research in high performance computing physics based simulations, as well as, traditional wargaming simulations. The goals of the center are to expand research in the area of high performance computing to all of the science and engineering departments, take the burden of computer system administration away from the researchers, enhance productivity of faculty modeling and simulation work by providing computational infrastructure and support, and increase basic research in modeling and simulation.

Space Physics and Atmospheric Research Center

Director: Dr. Geoff McHarg, matthew.mcharg@usafa.af.mil

Website: www.usafa.af.mil/dfp/research/spacephys/index.htm

In 2003, the physics department established a new research center, the Space Physics and Atmospheric Research Center (SPARC). SPARC serves as an umbrella organization for departmental activities concerning space physics and astronomy with a core focus on the study of how stellar and near-earth-environment plasmas affect the Earth in general and Air Force systems in particular. This expertise ranges from theory and modeling to designing and building instruments for measuring plasma characteristics and integrating our instruments into satellite payloads. SPARC members engage in three main activities: developing payloads for the Academy's small satellite program, applied plasma physics, and modeling upper atmospheric response to solar and space weather events.

Space Systems Research Center

Director: Lt Col Tim Lawrence, timothy.lawrence@usafa.af.mil

Website: www.usafa.af.mil/dfas/research/index.htm

The Space Systems Research Center conducts systems engineering research in small satellites and sounding rockets. The satellites consist of FalconSat-2, a 30 kg satellite that is ready for launch on the Space Shuttle, FalconSat-3, a 50 kg satellite that will fly on an Atlas V in Fall 2006, and EyaSat, a 5 kg educational satellite that has been used in USAFA courses and for Air Force Space Command's Space 200 course. The primary mission of these satellites is to conduct research in space weather, investigating space plasma and its impact on satellite communication. All of these satellites are built by cadets so they can "understand space by doing space". All of the satellites flown will be controlled by cadets at a groundstation located at USAFA. The sounding rocket program has a goal of launching a 2.5 kg payload to an altitude of 100 km. FalconLaunch I achieved an altitude of 32,000 ft, FalconLaunch II broke the speed of sound, and FalconLaunch III is planned to go to 60,000 ft. Both programs employ approximately 70 cadets and 23 faculty per year and support researchers at an approximate budget of $500K per year.

Institute for Information Technology Applications

Deputy Director of Operations: Lt Col Jim Harper, james.harper@usafa.af.mil

Website: www.usafa.af.mil/iita

The Institute for Information Technology Applications (IITA) coordinates and focuses multidisciplinary teams on information technology application research issues of interest to the Department of Defense (DoD), the Air Force, and the U.S. Air Force Academy (USAFA). IITA is an independent research center supported by the Assistant Secretary of the Air Force for Acquisition (SAF/AQ), the Air Force Office of Scientific Research (AFOSR), and USAFA. The Institute helps to develop research topics, selects researchers, administers sponsored research, publicizes results, and hosts conferences and workshops that facilitate the dissemination of research findings to a wide range of private and government organizations. In addition, IITA seeks to help prepare USAFA graduates for a high technology Air Force.

IITA collaborates with numerous outside agencies in supporting applied research efforts. These outside agencies include Office of the Secretary of Defense, SAF/AQ, HQ USAF, HQ USAFR, Air Education and Training Command, Air Force Space Command, Air Force Communications Agency, Air Force Research Laboratory, Air Force Office of Scientific Research, Air Force

Safety Center, Bird Aircraft Strike Hazard Team, National Science Foundation, and the Department of Homeland Security. From its inception, IITA has offered several advantages to our sponsors. These advantages include providing maximum return for scarce research dollars, providing an objective and multidisciplinary perspective, tapping the skills and knowledge within the military academic community, and acting as a networking locus to bring together people and ideas.

The Institute for National Security Studies

Director: Dr. James M. Smith, James.Smith@usafa.af.mil
Website: http://www.usafa.af.mil/inss/

The Institute for National Security Studies (INSS) promotes national security research for the Department of Defense within the military-academic community and supports the Air Force national security education program, promoting, coordinating, and disseminating vital national security research that influences Department of Defense policy development. INSS is an independent research center supported by various DoD organizations. The INSS mission is "to promote national security research for the Department of Defense within the military academic community, to foster the development of strategic perspective within the United States Armed Forces, and to support national security discourse through outreach and education." Its research focuses on the areas of greatest interest to our organizational sponsors: arms control and strategic security; counterproliferation and force protection; homeland defense, military assistance to civil authorities, and combating terrorism; air and space issues and planning; information operations and warfare; and regional and emerging national security issues. INSS coordinates and focuses outside thinking in various disciplines and across the military services to develop new ideas for defense policy making. To that end, the Institute develops topics, selects researchers from within the military academic community, and administers sponsored research. It reaches out to and partners with education and research organizations across and beyond the military academic community to bring broad focus to issues of national security interest. And it hosts conferences and workshops and facilitates the dissemination of information to a wide range of private and government organizations. In these ways, INSS facilitates valuable, cost-effective research to meet the needs of our sponsors.

The Humanities Institute

Director: Lt Col Tom Krise, Thomas.Krise@usafa.af.mil

The Air Force Humanities Institute (AFHI) is sponsored by the Humanities Division of the Air Force Academy faculty as a service to the Academy and the Air Force providing a mechanism for promoting interdisciplinary education and research, demonstrating the centrality of humanities education to the mission of the Academy and of the Air Force, and enabling productive interaction and outreach among the Academy, the Air Force, and the local and national communities. AFHI sponsors interdisciplinary courses, conferences, and research, graduate scholarships in the humanities and communication, speakers' programs, an awards program, and an executive leadership program, among other activities.

4. Funding

The total value of research funding for USAFA totaled $31.4 million for the academic year 2003-2004. This funding can be broken into two main categories: USAFA provided and externally provided support. Figure 4.1 depicts the relative size of these contributions.

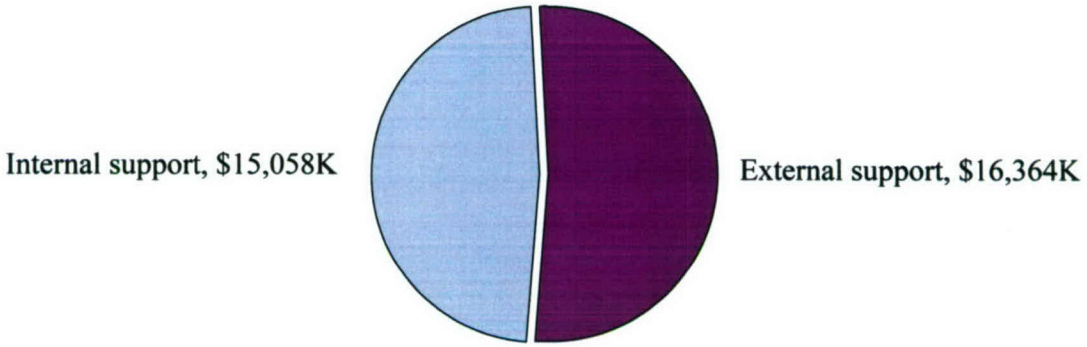


Figure 4.1. Econometric value of research program.

The value of the USAFA provided funding is determined by an econometric evaluation to be $15.1 million worth of laboratory facilities, equipment depreciation and personnel time. To arrive at this amount, laboratory space dedicated to research was valued at $11 per square foot per year, while a simplified 15-year accelerated straight-line depreciation was applied to the replacement value of research capital equipment. Figure 4.2 shows the relative sizes of these components.

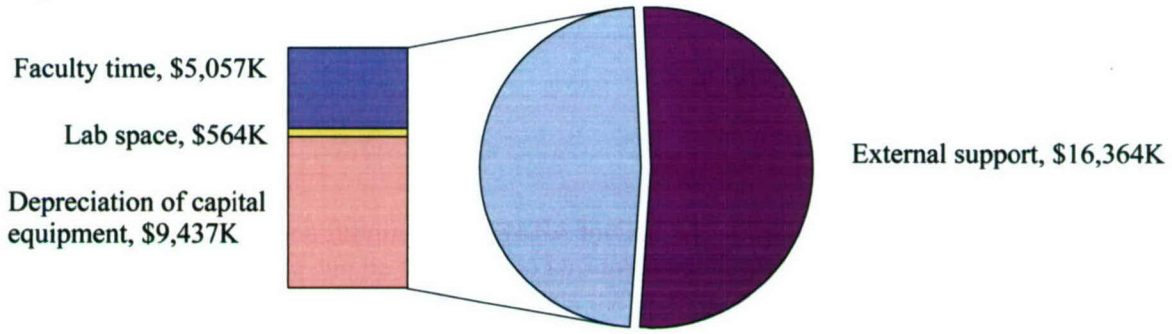


Figure 4.2. Breakout of internal contributions toward research.

External support comes from monetary contributions, externally funded researchers, and in-kind supercomputer time. External support totaled $16.4 million for the 2003-2004 academic year, of which approximately $10M was actual monetary contributions, $1M was the value of externally funded researchers, and $5M was the value of in-kind supercomputer time. (Note: Approximately $400K of these "external" funds are USAFA gift funds, Dean's small grant funds, and other USAFA provided funds.) The relative portions of external funding are depicted in Figure 4.3, followed by descriptions of each of these three funding sources.

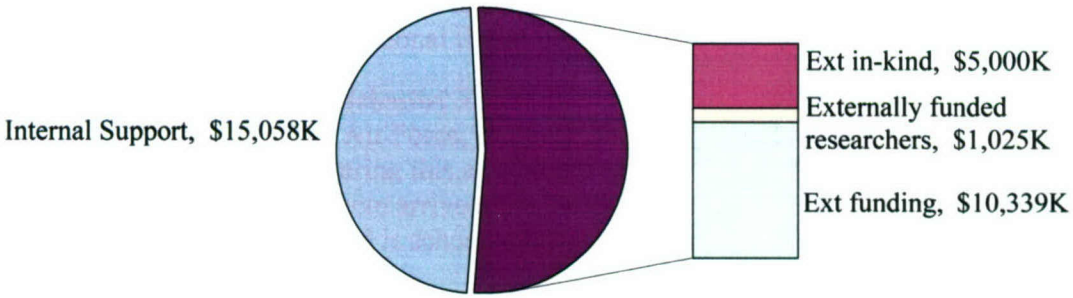


Figure 4.3. Breakout of external contributions toward research.

Monetary contributions for the 2003-2004 academic year totaled $10,339K. This funding arrives at USAFA through two primary vehicles: Memoranda of Understanding/Memoranda of Agreement, and Cooperative Research and Development Agreements.

- **Memoranda of Understanding (MOU) and Memoranda of Agreement (MOA)** are typically between government organizations. During the 2003-2004 academic year, USAFA had 17 active MOUs and MOAs with other agencies. Most notably, USAFA has an MOA with the Air Force Office of Scientific Research (AFOSR) for annual support of approximately $2 million which provides core funding for the eight USAFA research centers and IITA.

- **Cooperative Research and Development Agreement (CRADA)** allows government agencies to work closely with civilian agencies or industry. During the 2003-2004 academic year, USAFA had 31 active CRADAs.

Externally funded researchers account for just over one million dollars worth of the external funding received by USAFA for research during the 2003-2004 academic year. External researchers are provided to USAFA through two primary vehicles: the Engineer and Scientist Exchange Program and the National Research Council.

- **The Engineer and Scientist Exchange Program (ESEP)**, administered by AFOSR for the Secretary of the Air Force, provides visiting researchers to USAFA whose salaries are paid by AFOSR. During this academic year USAFA hosted six ESEP researchers from Germany. Five of them arrived in August 2003 and departed August 2004. One arrived in December 2003 and is scheduled to depart January 2005.

- **The National Research Council (NRC) Research Associates Program** contributes funds to USAFA which are specifically designated for hiring research associates. During this academic year USAFA hosted two NRC researchers. Both of them worked in the Aeronautics department. One was from the United Kingdom, and the other was from Russia.

In-kind supercomputer time accounts for $5 million of the external funding for the 2003-2004 academic year. Under an agreement with other DoD installations, USAFA researchers use off-site supercomputers. In exchange, researchers at the other DoD installations use the

supercomputers at USAFA. The computer time is traded so no money exchanges hands. The monetary value is assigned based on $2.00 per CPU hour.

Total external support varies from year to year. In recent years external funding has increased dramatically. External funding for the 2003-2004 academic year continues this growth trend, experiencing an increase of almost 20 percent, from $13.5 million to almost $16.4 million. Figure 4.4 shows the explosive funding growth that has occurred.

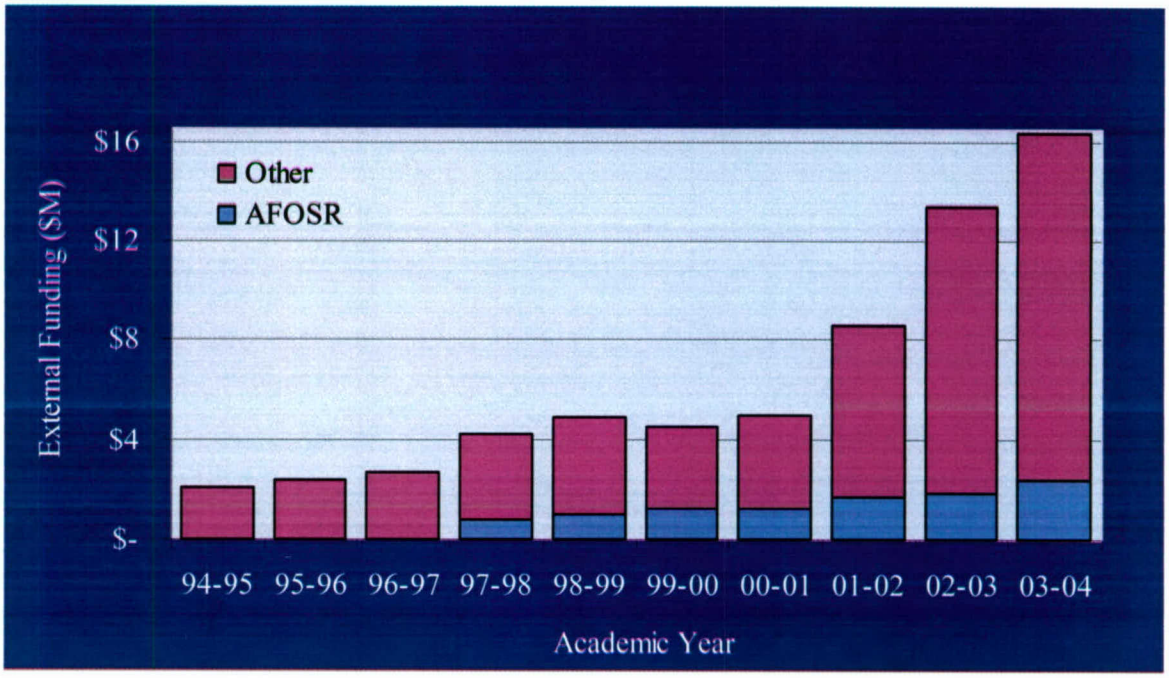


Figure 4.4. External funding trends at USAFA.

Table 4.1 is a listing of funding sources which accounts for the $16.4 million of external funds received by USAFA for the 2003-2004 academic year.

Table 4.1. External sources of research support in thousands of dollars

Dept of Defense	$ 6,140.20	37.5%
other USAF (not AFRL)	$ 4,304.62	26.3%
AFOSR (including ESEP)	$ 2,692.06	16.5%
other AFRL	$ 942.50	5.8%
other Visiting Researchers	$ 643.95	3.9%
other U.S. Government	$ 613.30	3.7%
USAFA provided	$ 391.03	2.4%
NASA	$ 226.90	1.4%
INSS	$ 60.24	0.4%
AF Reserve	$ 45.00	0.3%
Industry	$ 35.00	0.2%
other	$ 268.74	1.6%
Total	**$ 16,363.54**	**100.0%**

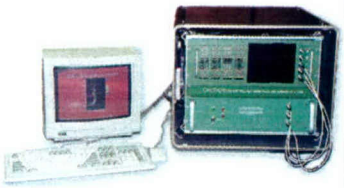
A complete listing of the recipients of the external funding is provided in Table 4.2.

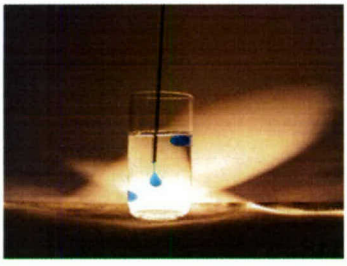
Table 4.2. Allocation of External Funding

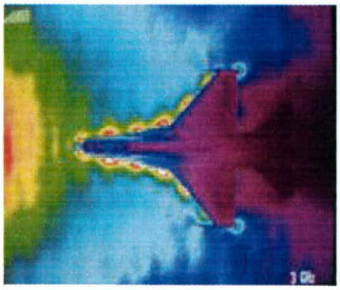
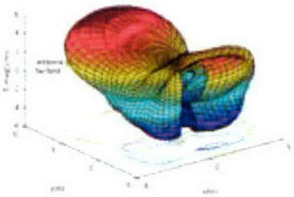
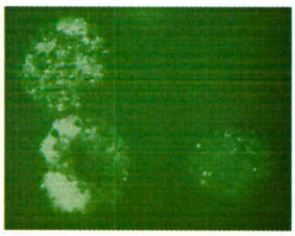
Basic Sciences	
Biology	$ 342,800
Chemistry	$ 224,200
Computer Science	$ 325,100
Mathematical Sciences	$ 69,000
Physics	$ 1,482,300
Total Basic Sciences	**$ 2,443,300**
Engineering Sciences	
Aeronautics	$ 7,237,500
Astronautics	$ 1,052,400
Civil and Environmental Engineering	$ 48,900
Electrical Engineering	$ 163,100
Engineering Mechanics	$ 1,401,600
Total Engineering	**$ 9,903,600**
Humanities	
English and Fine Arts	$ 17,700
Foreign Languages	$ 10,000
History	$ 17,300
Philosophy	$ 18,000
Total Humanities	**$ 63,000**
Social Sciences	
Behavioral Sciences and Leadership	$ 230,000
Economics and Geography	$ 75,300
Law	$ 26,500
Management	$ 45,200
Political Science	$ 82,200
Total Social Sciences	**$ 459,200**
Other	
National Security Studies	$ 330,000
Information Technology Applications	$ 3,151,400
34 EDG	$ 12,900
Total Other	**$ 3,494,300**
USAFA-provided	$ 391,000
Total External Funding	$15,972,500
Grand Total	**$16,363,500**

5. Research Highlights

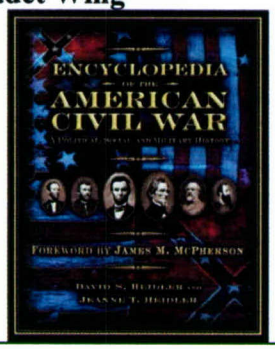
Customer	Department	Impact
Electronic Systems Center (ESC), Hanscom AFB, MA 	Aeronautics Research Center (DFAN)	Wind tunnel investigations conducted at the Academy have aided in the development of the Advanced Remote Ground Unattended Sensor (ARGUS). Previous research had shown that initial designs of ARGUS configurations were not able to achieve stable flight since "coning" or spiraling was experienced. Investigations at the Aeronautics Research Center determined that placing perforations in the drag brakes greatly reduced the coning and ensured the desired normal impact with the ground. Cadets were key participants in this investigation and their results were presented to ESC in June 2004.
Air Force Research Lab (AFRL) Propulsion Directorate 	Astronautics (DFAS)	The Astronautics research group launched and successfully recovered an 11.5 foot rocket using a 700 lbf solid propellant motor to an altitude of 17,000 feet at the Army Pinion Test Range. The program produced the following successful results: fastest rocket in Academy history (~ Mach 2); first ever real-time stored three-dimensional avionics readings of location, altitude, and velocity; revalidation of an eclipse grain for solid propellants; use of a new Thiokol composite case for the rocket body, propellant grain and avionics package.
The National Science Foundation (NSF)	Physics (DFP)	Just-in-Time Teaching Digital Library (JiTTDL) is a three-year project to create a shareable collection of resources and materials for the Just-in-Time Teaching (JiTT, www.jitt.org) initiative, funded by an $850,000 grant from the National Science Foundation (NSF). JiTT is a teaching and learning strategy pioneered at the U.S. Air Force Academy and Indiana University-Purdue University at Indianapolis (IUPUI), in which students respond electronically to carefully constructed web-based assignments. Students' assignments are due shortly before class, enabling the instructor to access the web-based assignment submissions "just-in-time" to adjust the classroom lesson to suit the students' needs. Now adopted by over 300 faculty in some 25 disciplines at over 100 colleges and universities across the US and abroad, JiTT has achieved national recognition in various science and pedagogical circles. The JiTTDL project will interconnect and grow the multidisciplinary JiTT community.

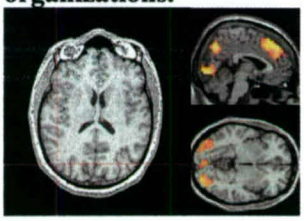
United States Air Force Academy (USAFA), and Air Force Research Lab (AFRL) 	Physics (DFP)	The USAFA Digisonde is a sounding device used to characterize both quiescent and unstable plasma in the bottomside ionosphere. The Digisonde Portable Sounder (DPS) unit consists of a transmitter, receiver, antennas, and a single computer system to manage data acquisition, control, signal processing, display, storage, and automatic data analysis functions. This sounder will be primarily utilized to support active ionospheric experiments with High Frequency (HF) heaters, including those associated with the HF Active Auroral Research Project (HAARP), the HIgh Power Auroral Stimulation (HIPAS) observatory, and the planned Arecibo facility. Cadet Loren Jones-Harris successfully completed the Air Force sponsored Polar Aeronomy and Radio Science Summer Workshop in Gakona, Alaska, last summer (August 2003), and he is now in the process of developing a radio wave propagation model as a participant of the Cadet Summer Research Program at Hanscom AFB. Once the Digisonde is installed on site at USAFA and is operational, cadets and faculty will have access to the data. The Digisonde serves as both an educational tool for learning about the fundamentals in ionospheric measurement, and as a source of data for cutting edge research.
Air Force Research Laboratory (AFRL), and Air Education and Training Command (AETC) 	Behavioral Sciences (DFBL)	Behavioral Science conducted research to evaluate the efficacy of "Chair Flying," a technique pilots can use to prepare for a flight, in which they mentally rehearse the information they need during the flight, and go through every sequence of the flight. This includes simulating the movements during the mission, such as the work pilots have to do with their arms, hands, and feet as they interact with various controls. Three groups were evaluated in the study: a group that prepared with an actual flight simulator; a group that used the "Chair Flying" technique; and a "control group" that simply memorized the instructions. Both test groups exhibited better performance on the simulator mission than the control group. Further, the "Chair Flying" group showed less time to accomplish the mission, a more precise take-off speed, and a better situational awareness. The results suggest that Chair Flying can be beneficial as a special technique to prepare student pilots for a mission.

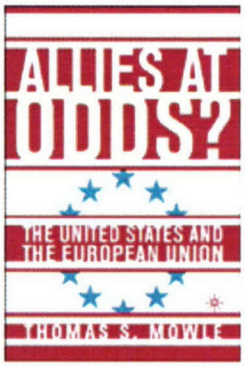
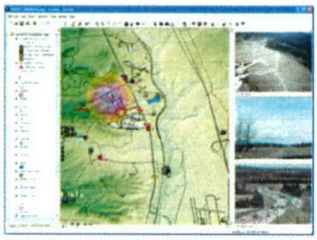
Air Force Research Lab (AFRL) Materials and Manufacturing Directorate, and Sensors Directorate 	Chemistry (DFC) and Physics (DFP)	Photonic-Ionic liquids are a new class of materials designed to protect sensors and people's eyes from high intensity laser light. The ionic liquids have numerous advantages over typical molecular liquids or solids. They are liquid at or below room temperature, and are stable up to several hundred degrees Celsius. As salts, they have no detectable vapor pressure, and their thermal stability is unmatched by all other common liquids. They were designed by chemists at USAFA and AFRL/Materials Directorate to have nonlinear optical properties, which should result in the ability to absorb high intensity light, as from a laser beam, but transmit light from normal sources (images, thermal signatures, etc.). About twenty examples of the new liquids were synthesized in the USAFA Chemistry Department, and the optical properties are being measured in the USAFA Physics Department and at AFRL, Wright-Patterson AFB.
The Air Force Civil Engineer and USAFA Cadets 	Civil and Environmental Engineering (DFCE)	The Civil and Environmental Engineering Department developed specialized software based on AutoCad that is used in a contingency support exercise scenario for the culmination of the core course "Airbase Design and Performance." DFCE upgraded a version of this exercise based on "Geobase" GIS software which is coming into use throughout the Air Force. The upgrade not only gives cadets a better tool for the exercise, but introduces them to something they will likely use in the Air Force.
Predator SPO, UAV Battlelab, Air Force Research Lab (AFRL) 	Computer Science (DFCS), and other academic departments	The Department of Computer Science supported the UAV program at USAFA in cooperation with several other USAFA academic departments. In the Computer Science capstone courses, cadets developed a ground station for the UAVs. In Systems Engineering 495, cadets from DFCS and three other departments used the UAVs to investigate a pine beetle infestation problem. Although DFCS received under $10K direct funding related to this project, it managed the lab and provided officers and cadets to fly the UAVs, which included one Silver Fox, two Desert Hawks, and two Xtra Easy II.

Air Force Space Office of Scientific Research (AFOSR), and Air Force Research Lab (AFRL)  	Electrical Engineering (DFEE)	The Computational Electromagnetics (CEM) research project in the department of Electrical Engineering is performing hyper-accurate Radar Cross Section (RCS) simulations on aircraft in deployable configurations. In addition, the CEM project is modeling the interaction of onboard antennas with the rest of the airframe, as well as the mutual interaction with other onboard antennas. This is especially important as more sensors are continually being located closer together on aircraft. These simulations take into account advanced materials including frequency-selective material. CEM researchers are validating these simulation results using infrared (IR) thermographic measurement techniques where the actual radar energy is displayed and characterized via IR as it scatters off the airframe.
Air Force Research Laboratory (AFRL/HEDO) 	Biology (DFB)	As one of the Human-Environmental Research Center (HERC) thrusts, Lt Col Erick Snellman (DFB) is studying the effects of pulsed laser light on human and porcine pigmented epithelium tissue (h/pRPE). This tissue layer rests behind the retina in the eye and performs a nutritive function for the retina. Exposure to pulsed laser light has been shown to cause changes in gene expression, protein manufacture, and DNA damage. Lt Col Snellman along with staff scientist Dr. Mike Wilcox (DFB), Martin Johnson (DFP, LORC), Cadet Stephanie King, and Dr. Tom Giddings (University or Colorado, Boulder) has been investigating changes in cellular lipids and lipid signaling in cells exposed to pulsed green laser light. This work supports AFRL objectives in determining safety standards for laser exposure. The micrograph shows active lipid signaling centers probed with green fluorescent dyes in laser-exposed porcine pRPE cells.
	Economics & Geography (DFEG)	Dr. Kate Carson was awarded $62,486 (100% funding of the requested amount) for *Investigations of Value Elicitation Mechanisms* by the National Science Foundation (NSF) jointly funded by Decision, Risk, and Management Sciences and Measurement, Methodology, and Statistics divisions of the Social and Economic Sciences Directorate. Results from experiments to determine how people assign value to their use of public lands have important public policy implications.

Air Force Major Command Flying Units, Air Logistics Centers, and the Air Force Research Laboratory (AFRL) 	Engineering Mechanics (DFEM)	The focus of the Center for Aircraft Structural Life Extension (CAStLE) is to provide structural integrity technology to the Aerospace Community. CAStLE directly addresses the most pressing structural problems (fatigue, corrosion, damage, and repair) facing the Air Force's fleet of 5,800+ aircraft. Currently, about 30 projects are under CAStLE's purview, many of them being performed in-house using the superb facilities of DFEM's Applied Mechanics Laboratory. One such project is the analysis of a major C-5 structural component: the horizontal stabilizer tie-box fitting. Cracking problems with this large aluminum forging are being investigated by a team of engineers from around the Air Force and NASA, including six USAFA cadets. The goal of this test effort is to improve understanding of the loads and environment experienced by the tie-box fitting during flight and ground operations, and to use this information to develop methods to avoid tie-box cracking in the C-5 fleet.
The United States Air Force Academy (USAFA) 	Law (DFL)	Col Paul Pirog created and led a research project during the Spring 2004 semester involving an interdisciplinary approach to solving a real-world problem at USAFA. The project involved seven faculty, eighteen cadets from six different majors, and an $11,500 budget. It addressed the problem of infestation of USAFA Ponderosa Pine trees by the Mountain Pine and Ips beetles, which, in conjunction with recent sustained drought conditions, renders the trees susceptible to disease and death. The goal of this project was to design, plan and conduct surveillance of a typical section of Ponderosa Pines at USAFA to identify those trees which are most stressed, and then to propose solutions to minimize loss of the trees and/or to ensure their future health. A flyable Unmanned Aerial Vehicle, which could be fitted to carry an infrared camera, was proposed and purchased, but was unable to be flown due to weather and time restrictions. The US Department of the Interior Assistant Secretary for Fish, Wildlife and Parks, and the Air Mobility Command Director of Operations, were briefed on the research during the course of the project.

Society for the Interdisciplinary Study of Social Imagery 	English and Fine Arts (DFENG)	The Society for the Interdisciplinary Study of Social Imagery hosted a conference on the image of the hero in literature, media, and society. The Department of English and Fine Arts presented four papers at this conference: Robert Burns on Philip Caputo's In the Forest of the Laughing Elephant, William Newmiller on the history of Navajo code talkers, Dr. Thomas Vargish on Shakespeare's Henry V and Gabriel Garcia Marquez's The Autumn of the Patriarch, and Dr. Richard Lemp on Roch Carrier. In addition, Professor Donald Anderson served as the conference's plenary speaker. Robert Burns' paper has been accepted for publication in War, Literature, and the Arts.
AFRL, Air Force Center for Distributed Learning 	Foreign Languages (DFF)	The Department of Foreign Language designed and developed instructional tools that apply situated cognition theories to the Foreign Language Classroom. Using a real Joint Task Force (JTF) Deployment as a model, a simulation was designed to place cadets as members of a JTF facing a critical situation in a South American country that required US intervention. The cadets assumed the roles of the JTF Commander, Intelligence Officer, Operations Officer, etc., to frame and resolve several ill-defined problems. All of the communications took place in the Target Language in a computer-mediated environment. The results of these efforts have direct applicability to distance education programs in the U.S. Air Force and throughout the United States. Papers related to this research have been published in the peer-reviewed journal Quarterly Review of Distance Education, and have also been accepted for presentation at an international conference on the innovative use of technology in the classroom.
The United States Air Force Academy (USAFA) Cadet Wing 	History (DFH)	The 2003 Society For Military History Distinguished Book Award was awarded for The Encyclopedia of the American Civil War co-authored by Dr. Jeanne Heidler, Professor and Deputy for American History. In addition, a new book by Dr. Heidler, Manifest Destiny, was released, and Dr. Heidler was named to Marquis' Who's Who in America.

AF Chief of Staff, Air Force Management and Innovations Agency (AFMIA)	Management (DFM)	Under the direction of the Air Force Chief of Staff, the 2003 Air Force Climate Survey was administered across the Air Force and, for the first time, the Air Force Reserve and Air National Guard. The results of the survey provide information to each AF unit regarding its member commitment, performance, satisfaction, and intent to remain in the Air Force. The 102 question survey yielded more than 310,000 respondents encompassing active duty military and civilian personnel. A team of researchers from USAFA's Department of Management provided the data analysis, modeling, and interpretation of over 31 million data points. Their analysis provides commanders with feedback to address and improve the operations of individual units. The DFM team also developed a multimedia briefing for the Secretary of the Air Force and the Air Force Chief of Staff outlining significant findings, actionable feedback for commanders, and suggestions for improvement and future research.
Air Force Institute for Information Technology 	Department of Mathematical Sciences (DFMS) and Air Force Institute for Information Technology (AFIIT)	As math curriculums throughout the country evolve to incorporate technology such as portable computers, Major Lem Myers, PhD, and Mr. Eric Hamilton propose the use of Tablet PCs so students can interact with technology in a more flexible and natural environment than the keyboard-only notebook PC currently allows. Specifically, the stylus input device allows students to electronically annotate their on-line textbooks and note pages. These Tablet PCs also allow the instructor to interact with the students in real-time via wireless networks as the students work through math problems, creating a shared computer workspace. The performance of students in experimental sections of various undergraduate mathematics courses will be compared to control groups to determine the effectiveness of this interaction paradigm.
Air Force OXI, Defense Modeling and Simulation Office, Baylor Medical College, miscellaneous Department of Defense organizations. 	Department of Philosophy (DFPY) and Department of Engineering Mechanics (DFEM)	Maj Bill Casebeer (DFPY) and Capt Jake Bartolomei (DFEM) continue refining their computer simulations of terrorist group growth. In addition to systems-level methodologies and tools briefed or in use at multiple Department of Defense agencies (Northern Command, the Joint Warfare Analysis Center, DIA, CIA, RAND, etc.), the team has partnered with the Human Neuroimaging Lab at the Baylor College of Medicine to understand how terrorist recruitment stories and narratives affect the brains of disaffected members of vulnerable populations. This work promises to yield innovative new tools for understanding and effectively prosecuting the war on terrorism, and subjects are already being evaluated at the Lab in Houston.

NATO 	Department of Political Science (DFPS)	In 2004, Maj Thomas Mowle delivered the final manuscript for his book on the transatlantic alliance, Allies at Odds. Given the recent debates between leading countries in the European Union and the United States on several international issues, including military cooperation, Maj Mowle's work comes at an opportune time for policy makers. Transatlantic cooperation is important for the future of NATO as well as US missions in Afghanistan and Iraq. By looking at multiple cases across substantive issue areas, Allies at Odds provides a sweeping view and a powerful explanation for why countries in the European Union continue to pursue competing policies even while they share many fundamental values with the United States. Research on this book and related articles has influenced courses in the DFPS curriculum, including "International Relations Theory" and "Model NATO." In fact, the latter class now participates in both Model NATO and Model EU competitions. Maj Mowle's work has helped to clarify the interaction between these two organizations that continue to influence calculations for US national security and defense policy. In recent years, the "Model NATO/EU" class has become one of the most popular electives offered by DFPS.
  	**Institute for Information Technology Applications (IITA)**	IITA continues to be the research arm of the HQ USAF Geospatial Integration Office and IITA researchers are conducting a variety of GeoBase-related research projects. The new Cadet Homepage was fielded proving cadets a single web page source for vital information such as command alerts, multi-source notices, airfield status, uniform of the day, weather conditions and Mitchell Hall menus. The cadet's Microsoft Outlook calendar is integrated into the Homepage providing the cadets an individualized, easy to read daily planner. IITA researchers fielded the first version of an automated flight briefing room replacing the dry-erase boards and single screen display with interactive, multiple display capability that also provide digital editing tools. IITA researchers received an outside grant to perform time-sensitive but modest evaluative research support for one of secondary and undergraduate education's most promising and readily adoptable technology developments of recent years, Just in Time Teaching (JiTT). The core features of JiTT involve problem-solving assignments students complete shortly before class that the instructor reviews and grades, resulting in class sessions that are much more attuned to student understandings.

Department of Defense 	Institute for National Security Studies (INSS)	INSS provided critical support to the Global War on Terrorism. The Institute published INSS Occasional Paper #52, Violent Systems: Defeating Terrorists, Insurgents, and Other Non-State Adversaries, by Maj William Casebeer (DFPY) and Maj Troy Thomas (Research Fellow at DIA's Center for Strategic Intelligence Research, formerly of DFPS). This study outlined a framework for understanding violent non-state actors as dynamic biological systems. This allows for the development of various means of deterring and defeating such groups that are appropriate at different points in their life cycle. The authors briefed their results to MG Brooks of the Joint Staff J-5 (Plans and Policy) directorate, who is responsible for pursuing the Global War on Terror. MG Brooks subsequently asked the authors to contribute to the development of the DoD's strategy for combating terrorism. They later briefed their results to the Joint Warfighting Analysis Center, which invited them to return and teach a 3-day course to the analysts there. Their research has also been used extensively by Gen Ralph Eberhart, the Commander of US Northern Command, and by the New Mexico Department of Homeland Security and New Mexico National Guard.

6. Awards

Faculty and cadets together form the core of the USAFA research community. USAFA academic departments reported that 216 cadets were involved in research for the 2003-2004 academic year, and a total of 327 faculty members were counted as active researchers. The academic excellence of this impressive group of cadet and faculty researchers is illustrated by the numerous honors and awards granted:

- Lt Col Jerry Sellers won the highly prestigious Air Force Science and Engineering Award for Exploratory or Advanced Technology Development for his work leading the FalconSat research program. Lt Col Sellers was also named the Rocky Mountain Section AIAA Engineer of the Year.

- Maj John Grenier won the McDermott Award for social sciences and humanities for his research in colonial-era military history. His manuscript, The First Way of War: American Warmaking on the Frontier, 1607-1814, will be published by Cambridge University Press.

- Lt Col Scott Fawaz and his team won the Frank J. Seiler Award for Engineering Research for their work in the finite element analysis of high-aspect ratio cracks. The Director of AFOSR described their efforts as "the best work I've seen in this area."

- Maj Kurt Brueske won the Frank J. Seiler Award for Research in Basic Sciences. Major Brueske spearheaded the development of a new technique to estimate the intensity of tropical cyclones using polar orbiting weather satellites, and successfully transitioned it into operations at the National Hurricane Center Tropical Prediction Center (NHC/TPC) in 2003.

- Special recognition for sustained excellence in research in basic sciences was awarded to Dr. Mike Wilcox, Dept of Biology. Since 1997 Dr. Wilcox has directed a phenomenally wide-ranging research program in biocybernetics--from glaucoma implants, to treatment of central nervous system trauma, to a semiconductor-based, biologically-inspired, machine vision system. His work is addressing a "high interest" area within the Office of Naval Research (ONR) and Defense Advanced Research Projects Agency (DARPA). Dr. Wilcox is a previous winner of the Seiler and Air Force Science and Engineering research awards.

- The INSS Outstanding USAFA Researcher Award was presented to Col Thomas A. Drohan, Commander 34th Education Group for his work titled "Effects, Targets, and Tools: A Primer for US Strategy and an Application Examining the Security Dynamics of Northeast Asia."

- The Maj Gen Robert E. Linhard Award was presented to Lt Col (select) S. Didi Kuo for his work titled "High Ground over the Homeland: Issues in the Use of Space Assets for Homeland Security."

- Dr. Steve Hadfield won the IITA Outstanding Researcher Award for developing the initial operational implementation of the USAFA Cadet Portal. Dr. Hadfield conducted

research into Oracle-to-Outlook data synchronization and modified existing programs to provide an initial calendar course scheduling capability and secured funding for the initial development from multiple sources.

- The Thomas D. Moore Award for outstanding cadet summer research went to Cadet Lindsey Bauer for her work in Basic Sciences. Cadet Bauer is a physics major who, while performing research at Hanscom AFB, discovered the existence of very intense plasma bubbles during a time of year that they were previously thought to be non-existent. Her data were published in a special issue of *Annales Geophysicae.*

- Cadet Matthew Munska won first place in the 2004 AIAA Region V Competition with his paper and presentation titled "Plasma Induced Flow on a Circular Cylinder," AIAA Region V Conference, Minneapolis, MN, April 2004.

- The Abrupt Wing Stall (AWS) Team, led by Jim Forsythe and supported by Lt Col Scott Morton and the Modeling and Simulations Research Center, received the trophy for the "Turning Goals Into Reality 2004 Partnership Award for Exceptional Progress toward the Partnerships for National Security Objective."

- Dr. John Wilkes received the American Chemical Society Colorado Section Award, consisting of a medal, a certificate, and $1,000. Dr. Wilkes was recognized specifically for his work in hydrogen storage chemistry and the development of personal electric power technology.

7. Publications

Publications and presentations are some of the key products of an active research program. USAFA researchers produced 185 publications and 210 presentations during the 2003-2004 academic year. Included in the number of publications were 74 journal articles (37 peer-reviewed) as well as seven books and ten chapters authored or edited. Included in the number of presentations are 53 international conferences/workshops and 79 national conferences/workshops. The number of publications and presentations for each of the last five academic years is shown in Figure 7.1.

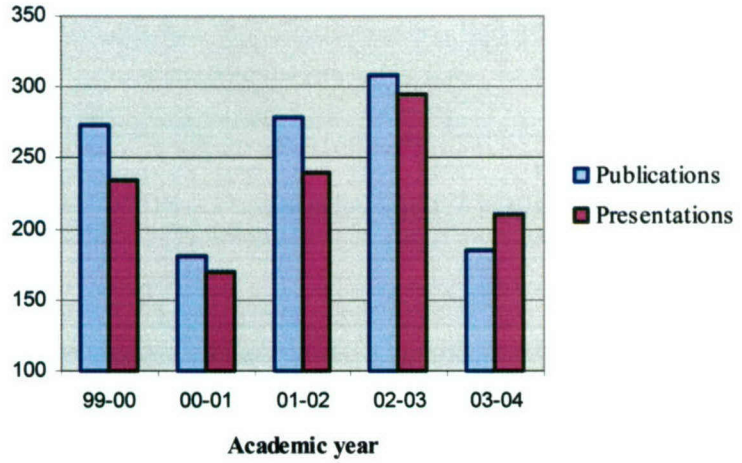


Figure 7.1. Trends in publications and presentations by USAFA faculty

The following is a sampling of key research articles submitted for publication in our research newsletter, *Discovery* followed by a complete list of publications and presentations produced by USAFA researchers during the 2003-2004 academic year. This list is organized by academic department.

7.1 Discovery Articles (www.usafa.af.mil/dfe/)

Academy Plans Upgraded, World-Class Observatory

by

Academy Spirit staff

(Reprinted with permission)

Cadets and professors at the Academy can look forward to becoming extremely far-sighted, but the change in eyesight has nothing to do with aging. A $50 million surplus mirror is expected to arrive here soon after graduation and, once funding is approved, the four-meter diameter optics would become the heart of the 12th largest observatory in the world.

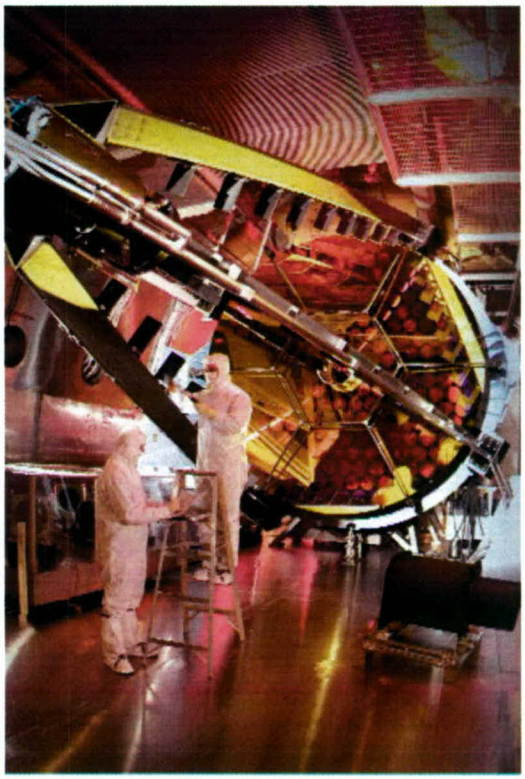
"We have USAFA approval to proceed with the project planning, but we don't yet have all the funding that we need to make this a reality," said Dr. Derek Buzasi of the physics department. "We will be moving the optics to Colorado by early summer 2005. We're working logistics at this point." Air Force Deputy Assistant Secretary, Technology and Engineering, Mr. James Engle expressed enthusiasm for the telescope concept during a recent visit here as a way to increase cadet awareness of space.

The new equipment comes from the Air Force's former Space Based Laser Program and will greatly extend the Academy's vision, according to Dr. Buzasi. The system provides a 50-fold increase in light-gathering power over the largest current telescope here, he said. "The satellite surveillance capabilities of this telescope will greatly enhance cadet education towards the goal of achieving a technical air and space force," said Dr. Geoff Andersen of the physics department. "The new observatory could also provide a facility for DoD courses in subjects as diverse as adaptive optics, lasers, optical communications, space physics and space operations."

Adaptive optics is a technique which allows a telescope to compensate for image distortions introduced by the atmosphere, and can produce images which rival in quality those available from space-based observatories.

Planned observatory modifications include an expansion of the existing structure to accommodate improved support facilities and construction of a new building and dome for the telescope. "The telescope would also require the construction and installation of a rapid-slew mount which would enable tracking and imaging of satellites in low Earth orbit," Dr. Buzasi said.

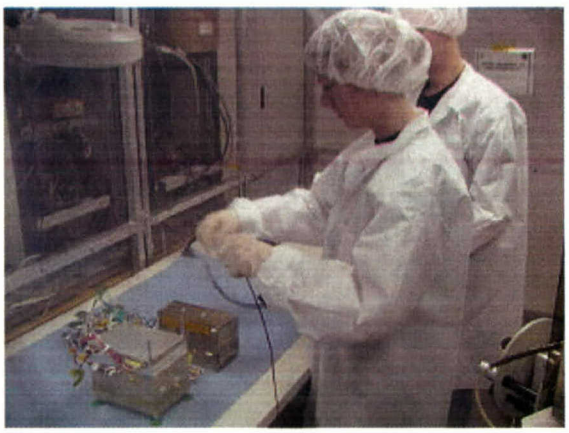
Several potential DoD users have already expressed support and interest in using the telescope in collaboration with cadets. The new observatory could be operational as early as July 2006. Currently, the project is being reviewed and sources of funding for the $7.5 – 10 million necessary for completion are being explored.



Workers make adjustments to the giant telescope faculty members hope is destined for the Academy.

FalconSat & FalconLaunch: Hands-on Space Education and Research

Jomia Quan



Capt Barnhart and C1C Nicola Hill are shown "grounding themselves," to prevent damaging hardware.

"Learn space by doing space"— this is the primary mission of FalconSat and FalconLaunch, two undergraduate space programs which provide "hands-on" space experience to cadets. This year-long course is built around the notion that in order for cadets to truly understand and appreciate the academics that take up most of their time at the Academy, the best learning experience stems from allowing them to apply that knowledge and contribute towards producing a real-life product that will further their understanding and provide insight into what they have been taught. These two programs are made up of an interdisciplinary group of cadets from Astronautics, Physics, Computer Science and Management, who are guided and led by faculty members and various contractors. While the more advanced members in the space realm aid in the form of advice, supervision and instruction, the cadets perform almost 90 percent of the work.

Through the years, the program has formed many strategic partnerships with very well-established and premier organizations, such as Air Force Office of Space and Research (AFOSR), Air Force Research Lab (AFRL/VS), Space and Missile Command/Space Test Program (SMC/STP), and the United States Naval Academy (USNA). The cadets and faculty also work extensively with contractors to acquire cutting-edge space hardware such as SpaceQuest, ATK/Thiokol and SSTL.

Cadets are an integral part of research conducted within the Depart of Astronautics Space Systems Research Center (SSRC). The SSRC is under the direction of Lt Col Jerry Sellers, who actively oversees the FalconSat and FalconLaunch programs. The FalconSat-2 project, is under the direction of Capt David Barnhart, the FalconSat-3 project under Capt David Richie, and the FalconLaunch project, whose goal is develop sounding rockets, is headed by Maj Dan Miller. Together, these programs provide a learning experience for cadets while contributing towards real-life Air Force science and engineering objectives.

FalconSat

The cadets working on FalconSat, spend a significant amount of time developing engineering and qualification models for the satellites they build, underscoring the fact that FalconSat does not use a simple proto-flight approach. Their system development approach is very complex and consists of:

- the FalconSat avionics simulation and test bed, which form the foundation of the satellite and provide an environment for software, subsystem, and payload development and testing,

- the engineering model, which is subjected to the most rigorous and extensive environmental and functional testing,
- the qualification model, which undergoes the qualification-level environmental test conditions,
- and lastly the flight model, which is subjected to acceptance-level testing and final integration onto the launch vehicle.

The program began the production of a series of satellites in 1997, when it first launched a "barnacle" satellite on the Atlas-Centaur. FalconGold, was the first success of the program and made its contribution to the Air Force by relaying GPS data for fifteen days above the GPS constellation. This was a significant achievement because it showed that useful GPS can be received at these orbits.

The next product in the series of satellite production was FalconSat-1, which carried the CHAWS-LD Experiment as its primary payload and assessed the hazards for spacecraft operations in the wakes of larger bodies. This DoD SERB Experiment was successfully launched on the launch vehicle, OSP-1, in January 2000.

Following FalconSat-1, the team began work on FalconSat-2, the next satellite in the line-up. This spacecraft was successfully assembled and is currently awaiting a launch date on the Space Shuttle using the Hitchhiker Ejection System. Assembly and integration was completed in June 2002, the acceptance testing was done in July 2002, and the ground station and cadet operations team are ready to go. FalconSat-2's main payload is a mini electro-static analyzer (MESA), which investigates low latitude ionospheric plasma depletions and their effects on radio waves (i.e. GPS signals). The expertise and quality of work has improved over the years and is shown in the fact that FalconSat-2 was ranked 21 out of 34 by the DoD SERB. This amazing accomplishment not only proves the success of the program, but also remains as evidence of the time and energy spent by the cadets and faculty in producing a top-quality product, competitive on an Air Force-wide scale.

C1C Pritchard Keely is shown re-torqueing the hex head bolts on FalconSat-3.

The most current satellite being worked on is FalconSat-3, which carries three different payloads, one for AFRL/PR, and two for AFRL/VS. The three payloads consist of: the micro propulsion attitude control system (MPACS), the flat plasma spectrometer (FLAPS), and the plasma local anomalous noise environment (PLANE). Additionally, FalconSat-3 also consists of a shape-memory alloy boom and shock ring vibration suppression. The tentative launch date for this satellite will be in March 2006, but more important, and perhaps more interesting is that FalconSat-3 is slated to be launched on the first ever EELV/ESPA launch vehicle.

Similar to FalconSat-2, each payload did very well when reviewed by the DoD SERB. In fact, MPACS ranked 18 out of 45, FLAPS ranked 31 out of 45, and PLANE ranked 36 out of 45. Again, these rankings demonstrate the robustness of the program and speak to the quality of the final products that are put together by cadets and faculty.

Last semester was a very busy one for the 30-cadet FalconSat team as they completed many of the programs' major milestones, including the FS-3 payload critical design reviews, the formal FS-3 system-level critical design review and the assembly of the structural engineering model (SEM-2). More recently however, the cadets, staff and faculty have been focused with events such as the FS-2 SEM-2 test campaign, acceptance tests for the qualification model's payloads and avionics, and the FS-2 Flight Readiness Review. But there is more to the program than just these major milestones,

since the cadets must simultaneously perform various tasks, including developing spacecraft assembly, integration and test procedures for FS-3 and satisfying integration requirements. During the rest of Spring semester 2004, the cadets will build the Qualification Model (QM) of FalconSat-3 and perform integrated testing in the USAFA Clean Room. All this is preparation for handing off the program to the Class of 2005 who will have the task of testing the QM and preparing to build the flight model during the next academic year.

FalconLaunch

While FalconSat continues their work in the area of satellites, FalconLaunch is a sister program designed to allow cadets to design, build and launch an affordable, repeatable sounding rocket using existing technology capable of reaching an altitude of 100 km with a 2.5 kg payload. The program is made up of 15 cadets working in teams (mechanical systems, propulsion systems, avionics systems and operations), focused on specific areas of the process. Last year on 12 April 2003 at Fort Carson, Colorado, FalconLaunch-1 carried a payload which included: ashtech G-12 high dynamic missile application GPS, Tattletale TT-8 micro controller flight computer, an airbag-deployed parachute recovery system, and HAM radio packets for telemetry and commands. Similar to the FalconSat program, FalconLaunch strives to establish the capability to fly small Air Force and DoD scientific and engineering payloads (SERB approved) on a yearly basis.

C1C Monessa Catuncan, C1C Ryan Carter, C1C John Matchett, and C1C Dustin Sanders are shown here, integrating the recovery section with the propulsion section of the stubby rocket.

The program rests on a reproducible program plan, which means that the process can be reproduced on a one academic-year cycle. Additionally, the program maintains a high level of engineering practice by establishing specific technical goals including: up-down trajectory from sea-level to space, gross liftoff mass greater than 100 pounds, a useable payload mass greater than five pounds and a few other objectives. As with a satellite, much preparation, planning and problem-solving goes into achieving the goal of building a rocket. Among the many deliverables and steps that must be accounted for, the teams of cadets work diligently to solve problems and concerns regarding system-level and subsystem requirements, dimensions and performance measures for the nosecone, the fin, motor design parameters, and igniter design and interface. In addition to these tasks, the cadets also have to focus on analyzing their test results, such as chamber pressure and thrust profiles.

C1C Kevin Geoffroy is shown loading the stubby rocket onto the launch rail, while C1C Chris Nations, and C1C Dustin Sanders look on.

Recently, the FalconLaunch team successfully completed the static test of their 100 km motor. The results of the test turned out very favorably and after

approximately twelve to fourteen seconds, which is the time it took for the rocket to fire, team FalconLaunch was able to gather thrust, pressure, and temperature data from the rocket. Overall, the case, test stand and insulation all held up very well. And although the test did result in the failure of the silica phenolic, which ultimately caused the aluminum to burn, the cadets successfully identified the problem, and acknowledged the fact that this will give them the opportunity to improve the compression molding process for the flight model and next year's model. In the meantime, the team will look forward to and plan for a launch to approximately 100,000 ft at Fort Carson in April 2004.

Conclusion

While both FalconSat and FalconLaunch have different objectives and deliverables, one thing remains clear—the experience gained by the involvement in such a program is invaluable and affords many of the cadets a once-in-a-lifetime opportunity to "learn space by doing space" while contributing toward Air Force science and technology research. The programs are unique in that no other undergraduate program has such a developed curriculum which allows their students the experience provided here at the U.S. Air Force Academy, and this legacy of academic achievement will continue to develop and prosper because in the academic realm, the sky is truly not the limit.

Note: The FalconSat program is supported by the Air Force Research Laboratory and the Space & Missile Space Test Program. The FalconLaunch program is supported by the Air Force Research Laboratory.

Capt Barnhart, C1C Nicola Hill, and C1C Obadiah Ritchey rearrange items in the clean room to ensure there is enough space for the assembly of the FS-3 qualification model.

The View From Iraq: USAFA Research Applications

Lt Col Dave Bossert

As I reflect upon my return from a 4-month deployment to Kirkuk Airbase, Iraq, I realize that there is much we can do at USAFA to help our comrades in arms. My job was the Deputy Group Commander for Support for the 506 Air Expeditionary Group, where I was responsible for support activities for ~1000 personnel in a 1200 person group. While I was stationed there, we were attacked 26 times by 107 mm rockets, rocket-propelled grenades, and mortars. We were co-located with the 173rd Airborne Brigade – the unit that conducted the largest airdrop in over 50 years at the start of Operation Iraqi Freedom. Figure 1 shows some proof that Kirkuk Airbase was indeed in a war zone – a hole from a 107mm rocket that detonated underground.

What does this have to do with research, you might ask? Well, quite a lot actually. I noticed a lot of things about the warfigher mentality as I was over there which is pertinent to research. When I deployed, one of my objectives was to gain operational insight into Unmanned Aerials Vehicles (UAVs). The Force Protection Aerial Surveillance System (FPASS) and its Desert Hawk airframe were used on a regular basis by our USAF Security Forces. This system is currently on loan to the USAFA UAV Research Group from CENTAF to examine ways to increase system viability. Also there is a senior aircraft design project in the Aeronautics Department to enhance the performance of the plane. Figure 2 is a picture of one of the 6 FPASS Desert Hawk airframes at Kirkuk. The USAF Security Forces FPASS Team Chief TSgt James Crawford, shown with the Desert Hawk, was key to providing operational inputs on the system.

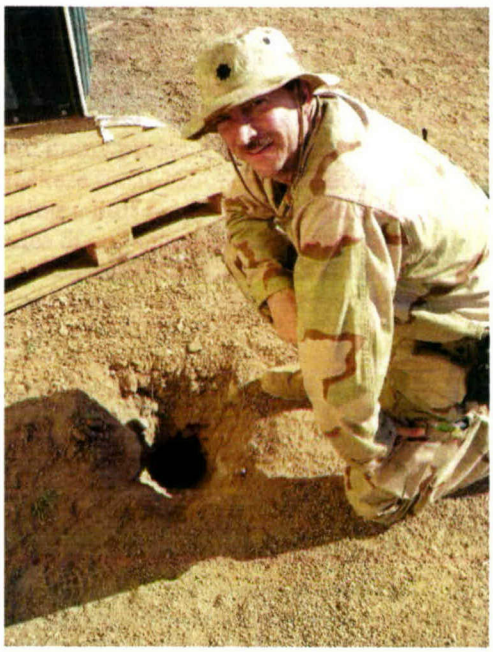


Figure 1. 107 mm Rocket Attack at Kirkuk Airbase

A few of the areas which require improvements with FPASS are the ability to land in "adverse" conditions, extended battery life, and the ability to have about 150 feet of antenna cable so that remote viewing terminals are able to be used in command posts. Figure 3 shows a picture of the "landing strip" where most FPASS crashes occurred due to the skid landing difficulties on rugged terrain.

Figure 2. FPASS Airframe With Operator in Front of "Hangar"

I actually saw excellent case studies for all four divisions during the deployment beyond UAVs. For example, operations research could aid with analysis of gate entry procedures which limited access to the base to about 150 local national vehicles per day. Vehicles and personnel would have to be screened for explosives and contraband before entering the base, and many projects would not have workers until 1100-1200, effectively losing a half a day of work. In addition, rules of engagement interpretations

between the USAF and U.S. Army would make great case studies for law, military studies, and philosophy courses. Since the Air Force was in charge of base defense, while the Army was involved in controlling the area outside the base, perceived threats were quite different. Since the AF/Army had an overlap area immediately outside the base perimeter, there were several conflicts about when to engage personnel.

Figure 3. Austere Landing Strip

Some of the current USAFA research activities, such as aging aircraft, certainly have a play in a war zone as well. Figure 4 shows an A-10 landing strut that failed on landing. When operating older aircraft in austere environments, any technology which can identify potential problems in the field can save lives and also extend the usability of AF assets.

In talking with my 173rd Airborne Brigade counterparts, they liked new technology and wanted it in theater ... with some caveats. Any new technology should serve as a force multiplier, be easy to use, and be very reliable. Also, smaller is better. Even our "high technology" Air Force brethren turned down some high visibility technology programs since they were perceived as not being user friendly. Bottom line is that in a war zone if it takes longer than a week or two for the average infantryman to become competent in the use of a system, it will likely meet with resistance.

One way USAFA can truly take steps to become the Air Force's Academy is to have class projects which address real-world AF problems. And, I am not talking about developing a new weapon system. I am talking little things like making a better user-interface or making a longer lasting battery to help with the endurance of a UAV. If we could focus more of our class projects to the scope of helping make small improvements to existing systems, we can and will help the warfigher. How do we find out what those projects are? The answer is pretty simple – talk to any war fighters you know. You'll find in most cases they'll be thrilled to have USAFA help them with a problem.

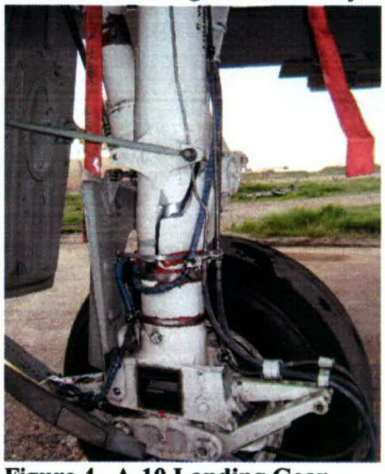


Figure 4. A-10 Landing Gear Damaged on Landing

USAFA Instructor Advances to Final Round of Judging in Invention Competition

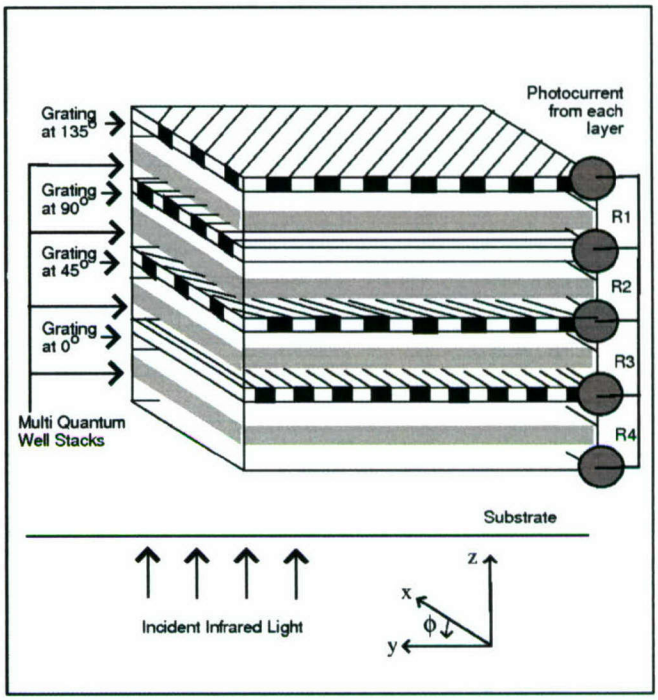
Mario Serna's work will contribute to high-level imaging, surveillance

Capt Mario Serna, a faculty member at the U.S. Air Force Academy, competed recently as a finalist in the Collegiate Inventors Competition, a program of the National Inventors Hall of Fame. Capt Serna traveled to New York along with eight other graduate teams and six undergraduate teams to take part in the competition. Capt Serna, 28, presented his invention to a panel of eight judges, including representatives from the U.S. Patent and Trademark Office and inductees from the National Inventors Hall of Fame. His work, which is a type of imaging polarimeter, came about through research conducted at the University of New Mexico and Kirtland Air Force Base.

Military surveillance aircraft and satellites could use polarized light to analyze images on the ground. Different types of soils, plants, and metals reflect light in unique ways that can be used to determine what the objects are made of from afar.

This kind of technology has been restricted by severe limitations on the sensitivity of the polarimeter, a device that measures polarized light. Capt Serna has created what he calls a "polarimeter in a pixel" to overcome that limitation.

Capt Serna conceived his idea at Kirtland Air Force Base and created it while doing graduate work in electrical engineering in New Mexico. An officer in the U.S. Air Force, he got the initial idea for the invention while attending a conference where high-ranking military officials said they needed higher-quality polarimeter sensors for improved surveillance.



Schematic of Capt Serna's polarization sensitive detector

He began working on the problem and ran into the same obstacles other researchers had encountered in the past. "Then I began to think about it in a more fundamental way," Capt Serna said. That triggered the insight that led him to create a new type of high-resolution sensor capable of measuring polarization of the light striking every single pixel in the detector.

Capt Serna is excited by the practical applications for his work. He noted, "This polarimeter could be used from planes, to study everything from land mines to crop vegetation."

Born in Bogota, Colombia, Capt Serna grew up in Miami and Houston before enrolling as a mathematics and physics student at the USAF Academy, where he is now an instructor. "I really love physics. I am deeply enamored with understanding the universe at the deepest level," he said. A computer science teacher, Scotty Johnson of Langham Creek High School in Houston, inspired Capt Serna to study science. Capt Serna went on to earn a master's degree in high-energy physics at the Massachusetts Institute of Technology before beginning graduate research at the University of New Mexico.

His parents, Mario Jose and Mary Helen Serna, reside in Mexico City. Capt Serna and his wife, Laura Evans, live in Colorado Springs. Air Force officials have expressed an interest in developing Capt Serna's invention into a sensor for military use.

The Collegiate Inventors Competition is an international competition designed to encourage college students to be active in science, engineering, mathematics, technology, and creative invention. This prestigious challenge recognizes and rewards the innovations, discoveries, and research by college and university students and their advisors for projects leading to inventions that can be patented. Introduced by the National Inventors Hall of Fame in 1990, the Collegiate Inventors Competition has annually rewarded individuals or teams for their innovative work and scientific achievement. The competition is now in its fourteenth year.

The National Inventors Hall of Fame is a not-for-profit organization dedicated to recognizing, honoring, and encouraging invention and creativity. The main activity of the Hall is honoring the men and women responsible for the technological advances that make human, social, and economic progress possible. Founded in 1973, the Hall makes its permanent home in Akron, Ohio. In addition to the Collegiate Inventors Competition, another popular program of the Hall of Fame is Camp Invention®, a summer day camp for elementary-aged children.

7.2 List of Publications

The complete list of publications is available upon request. Please view on-line at http://www.usafa.af.mil/dfe/dfer/index.htm or contact Director_Faculty_Research@usaf.af.mil for a hardcopy.