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USAFA Discovery

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USAFA Discovery is published quarterly by the faculty of the US Air Force Academy (USAFA). It contains reports on USAFA cadet and faculty research, a complete list of current USAFA research points of contact, and a summary of recent awards and publications. All written material contained within reflects the opinions of the authors and editors and does not necessarily reflect current US Air Force or USAFA policy.

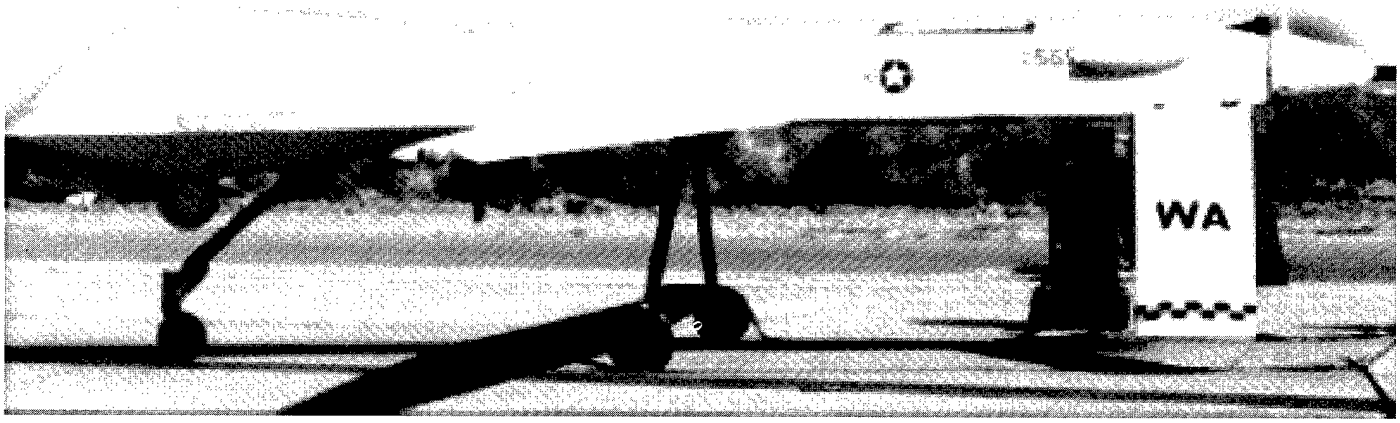
Research Activity in Support of Unmanned Aerial Vehicles (UAV) at the Aeronautics Research Center

The future of air warfare is undergoing a fundamental transformation with the move toward the increased use of Unmanned Aerial Vehicles (UAV's). UAV's are capable of performing a number of missions in high-threat environments while minimizing the risk of human life. An example of an important mission particularly well suited for a UAV is the provision of information superiority for in-theater commanders. **Information superiority** is defined in *Joint Vision 2010*, the official vision statement of the Joint Chiefs of Staff, as

> "the ability to collect, process, and disseminate an uninterrupted flow of information while denying the enemy's ability to do the same".

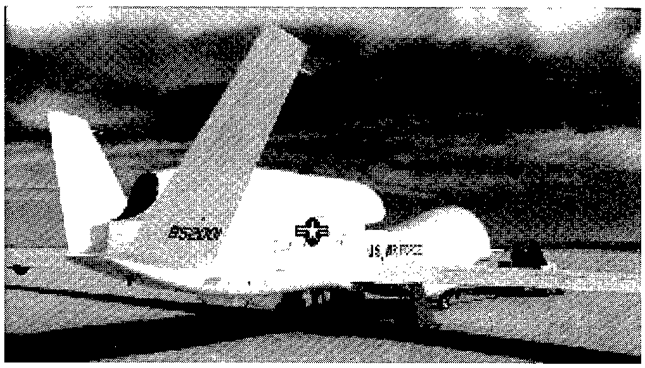
The USAF is currently operating the Predator, a medium-altitude, medium-range, high-endurance (20 hours) UAV that was used in Kosovo to provide near-real-time reconnaissance, target acquisition, and battle-damage assessment. The sensors allowed for effective operation during the day and night and in bad weather conditions.

The USAF is currently developing the Global Hawk, a high-altitude, aerial reconnaissance UAV. The Global Hawk will have a maximum operating altitude of 65,000 feet and endurance of 24 hours. It will be able to provide imagery with one-meter resolution over an area of 40,000 square nautical miles, an area roughly the size of the state of Illinois, in one day.



Predator long-endurance UAV

The technical breakthroughs that support UAV design and development have taken place in the areas of unsteady aerodynamics, controls, aerospace materials, sensors, secure communications, and microcomputers. Research currently underway in the Aeronautics Research Center is adding to this important technology base.



Global Hawk high altitude UAV

In this issue:

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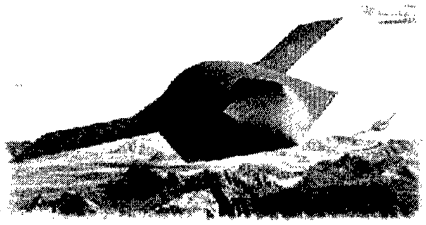
The USAF, NASA, and the Defense Advanced Research Projects Agency (DARPA) are jointly developing the Boeing X-45, the first U.S. unmanned combat aerial vehicle (UCAV) which is set to fly in early 2001. The UCAV, pictured below, features stealth technology and will carry multiple, advanced, precision-guided munitions to be used in the suppression of enemy air defenses.



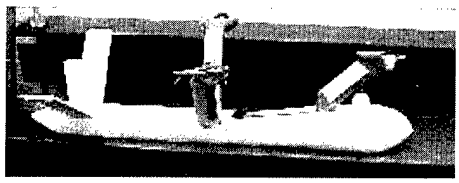
Boeing X-45a Unmanned Combat Aerial Vehicle

USAFA UAV Research

Drag Reduction Studies on Predator UAV

In 1998 a series of experimental investigations to evaluate the drag-reducing potential of several proposed modifications to the Predator UAV were conducted in support of the Air Combat Command's UAV Battle Lab. Wind tunnel studies conducted by three cadet teams evaluated numerous gear and fairing configurations and determined that the configuration with fixed and faired main gear and a retracted nose gear gave the best tradeoff of low drag, low maintenance, and minimal obstruction of sensor fields of view. This configuration had only slightly more drag than the current retracted-gear configuration, and offered the important advantages of reduced actuator monitoring and maintenance costs, plus increased internal fuselage volume available for sensors or fuel. The success of these studies prompted the UAV Battle Lab to request further landing gear studies in FY 2001. They also asked USAFA to study shapes for drag-reducing fairings for Predator's "skyball" optical sensor turret.

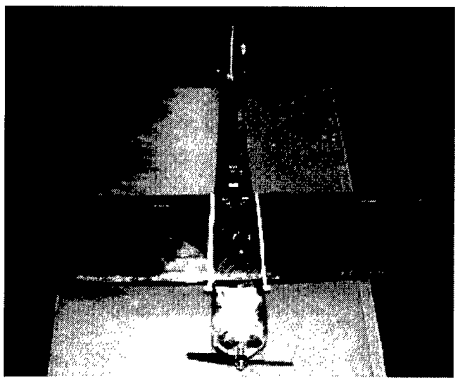
The Predator drag-reduction studies gave rise to questions about the stability and control implications of proposed modifications. Wind tunnel tests performed by two USAFA cadets indicated that the fixed and faired landing gear would not cause Predator any stability and control problems. These studies prompted requests by the UAV Battle Lab to study in FY 2001 the stability and control implications of a variety of proposed external stores for Predator.



Predator Drag Reduction Wind Tunnel Model

Advanced UAV Design

In November 1999, the UAV Battle Lab asked the Department of Aeronautics aircraft design classes to design, build, and fly two small UAV's suitable for use by soldiers in the field. These small aircraft were required to fit, when folded into a compact configuration, into a standard infantryman's backpack, and to be light enough to be carried by an average soldier in addition to their normal field gear and supplies. Both aircraft were required to be deployed in total darkness in field conditions and to operate in near silence for 30 minutes.



"Peeping Tom" Backpack

Two different payloads were specified, so that the Battle Lab could know how payload size and weight influences aircraft size. The first payload was a tiny 1-ounce visual spectrum video camera and associated downlink transmitter. The aircraft designed to carry this payload was the "Peeping Tom" as shown below center

The second payload was a 2-pound infrared video camera and data downlink, the smallest IR video system available at the time. The aircraft designed to carry this system was called " M.O.T.H.R.A" for Mobile Over-The-Hill Reconnaissance Aircraft. The figure below shows an artist's concept of MOTHRA flying over the USAF Academy.

Artist's Concept of MOTHRA Backpack

Whereas the Peeping Tom was relatively small, spanning only 28 inches and weighing less than 2 pounds, MOTHRA was significantly larger, with a 5-foot wingspan and weighing 5 pounds. Both aircraft were electric powered and were constructed of carbon fiber-epoxy skins over styrene foam cores. At this writing, the Peeping Tom has flown only once and MOTHRA has not flown at all. Flight tests of both aircraft will be performed as part of Spring 2001 design course requirements.

Unsteady Aerodynamics of Rapidly Pitching UCAV

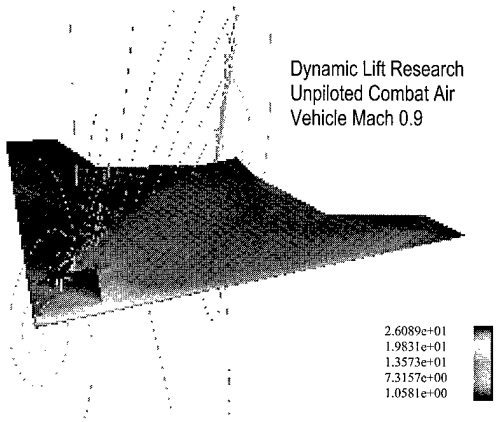
This project investigates the characteristics and potential benefits

achieved through control of the dynamic lift generated during a rapid pitch-up maneuver of a generic unmanned combat air vehicle (UCAV) configuration pictured on the following page.

By precisely controlling the maneuver, it is possible to avoid dynamic stall and to produce, for a short duration, lift coefficients higher than the static stall lift coefficient. This increased lift can be exploited for increased aircraft maneuverability that can lead to increased lethality and survivability. Because UCAV's are unmanned, they are particularly well suited to such increases in maneuverability since they can sustain high "g" loads without human factor concerns.

Experimental investigations are focused on understanding the dynamic lift due to unsteady symmetric pitch motions and the performance benefits gained from these maneuvers. The program will eventually transition these wind tunnel experiments to flight tests. There are significant changes in velocity during unsteady maneuvers that cannot be duplicated correctly in a wind tunnel, so flight-testing becomes important. Furthermore, flight tests eliminate wind tunnel effects due to walls and blockage caused by the model. In addition, the aircraft center of rotation can change during maneuver, leading to changes in pitch-induced camber and aircraft performance. To date the dynamic pitch mechanism has been constructed and successfully tested in the Low Speed Wind Tunnel, allowing force and moment measurements of the UCAV model under dynamic conditions. This effort will take advantage of a separate UAV Battlelab-Aeronautics Research Center program to develop a flight control and telemetry system for in-flight experiments.

Computational investigations of the UCAV are also being performed to complement the experimental invest-



Generic Unmanned Combat Air

igation of the dynamic lift phenomena. Computational predictions provide a view of the important three dimensional flowfield events that are taking place. The fluid motion over the UCAV can be "seen" thereby allowing detailed analysis of the underlying flow physics. It is the combination of experiment, computational simulation, and flight test that make this a unique program.

Flight Control Laws and Flying Test Bed

Currently an analytical and computational investigation of the flight control laws that is particularly well suited for small, highly maneuverable UAV's is underway. This project will include the development of a hardware-in-the-loop UAV simulator that will allow a "virtual" flight test using newly developed flight control algorithms and hardware. Finally, a radio-controlled aircraft that will serve as a "flying wind tunnel" UAV test bed will be developed to support the testing of new flow control devices such as rapidly pitching control surfaces and pulsed jet actuators. The on-board flight control system will provide telemetry so that a ground station will be able to monitor the influence of the flow control devices on aircraft performance.

Summary

A wide range of research activity is currently being conducted in the Aeronautics Research Center in support of Unmanned Aerial Vehicles. The research is supporting both existing systems such as the Predator and new systems that are being considered for future air warfare roles such as the "backpack UAV's." In addition to applied research, the Aeronautics Research Center is also conducting basic research on the unsteady aerodynamic phenomena associated with rapidly pitching UAV's. Finally, investigations that involve wind tunnel experiments, flight testing, and computational predictions will be used to evaluate new flow control devices to increase the maneuverability of future UAV systems. All of this work is adding to the technology base supporting UAV's while providing cadets and faculty with meaningful research experience and opportunities for professional development.

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WESLEY W. POSVAR CENTER FOR AMERICAN AND COMPARATIVE DEFENSE STUDIES

On 30 August 2000, the Dean of the Faculty formally approved the establishment of the Posvar Center. The Center's mission is:

To develop, sustain, and enhance America's future Air Force leaders' understanding and appreciation of American and comparative defense and national security policy through education and research.

Department Research News

A twofold process integrating faculty and students, teaching and research will distinguish the Posvar Center's programs. The centerpiece of these programs will be the endowed General Wesley W. Posvar Chair in Political Science.

The Center's goal is to be a part of the mainstream of the Air Force Academy's cadet and academic life. This will be accomplished through Center-sponsored lectures, conferences, independent studies and summer research projects, as well as interaction with other USAFA Centers.

Immediate goals for the Center include the hiring of a recognized expert and scholar in the field of American and comparative defense studies to fill the Posvar Chair. The Center also is working on co-sponsoring, with the Central Intelligence Agency, a conference on "Intelligence: Policy and Process in the New Century" tentatively scheduled for Fall 2001. If you would like more information on the Posvar Center, feel free to contact Lt Col Brenda Vallance in DFPS.

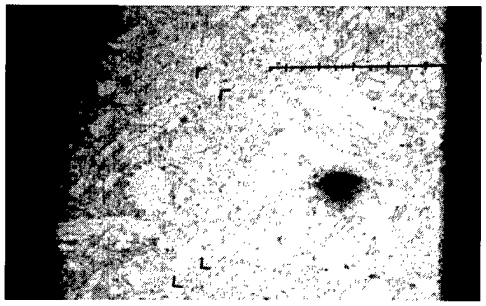
Department of Biology

Scanning Electron Microscopy now available at USAFA

LtCol Edward T. Unangst, Jr. and Dr. Michael Wilcox

On 8 September 2000, Col Klayton, USAFA Vice-Dean, dedicated the new USAFA scanning electron microscope in ribbon cutting ceremonies held in the Department of Biology.

A JEOL 2000FX Scanning/ Transmission Electron Microscope (STEM), retired by the Materials Lab AFRL-WPAFB, was procured and transported to USAFA by Dr. Mike Wilcox and Lt Col Pat Bradshaw, DFB. To meet strict environmental constraints, a specially-designed room (GP133) was constructed by 10 ABW CE through support by both AFOSR and Brig Gen Wagie. With maintenance funding provided by DF, the microscope was brought on-line after a two-year effort.



Magnification of a fly's brain taken with the Scanning/Transmission Electron Microscope (STEM)

The resolution limit for this instrument is the width of a single carbon atom, 2.3 Å. An Angstrom (Å) is 10^{-10} meters, which equates to one ten billionth of a meter! With this device, one can see individual atoms. However, the real strength of the instrument is in its analytical capability. The device is now operational and being used for within-institution projects. Cadets and faculty are currently imaging the smallest of objects, individual atoms, and viewing the world through 200,000 Volts. Ideally, the microscope will be available as government-furnished equipment for faculty and cadets to accomplish DoD-related research. Examples of current and potential use of the instrument include glaucoma research by Dr. Wilcox and C1C Omar Kadri, laser damage assessment by Dr. John Obringer and C2C Jared Paslay,

C1C Omar Kadri using STEM

and biomimetics modeling of the eye by Dr. Wilcox and C1C Tim Lamabie. The Department of Biology invites all prospective researchers and faculty members to come view the newest USAFA technology. Only the researcher limits its potential applications.

34th Education Group

During Summer 2000, the 34th Education Group sponsored two cadets for summer research. C1C Janene L. Drummer spent six weeks at the Air Mobility Command Headquarters Historian's Office located at Scott AFB Illinois. She was assigned and completed her research project, which was to create a chronological history of the C-9A aeromedical evacuation aircraft – part of a series of chronologies on aircraft in the AMC inventory. She also had the opportunity to ride an F-15, a C-9A, and a KC-135. C1C Christopher G. Seaman was assigned to the Air Force Doctrine Center at Maxwell AFB Alabama and participated in the development of the new "Aerospace Commander's Handbook." Both had exceptional research and Air Force experiences to help prepare them for their officer careers.

Department of Mathematical Sciences

Ms. Deborah Arangno, has recently accomplished research worthy of note. The research proposed a new paradigm for universe dynamics based on entropy and Dirac's radical particle theory. The theory proposed contradicts the current conventional thinking that the universe is expanding at an increasing rate by offering the idea of transpired-event phenomenon where time itself is accelerating.

Under this theory, the universe would be expanding at a rate that is getting slower and would eventually reach an equilibrium state. The research combines cosmology, physics, and mathematics with philosophy and theology demonstrating interesting cross-disciplinary ties. Its abstract is included below.

Ms Deborah Arangno

Entropy & A Paradigm Of Universe Dynamics

Abstract for a Creationist's View of Cosmology

A robust theory pertaining to the origins, dynamics, propagation, and future of the Universe is suggested. The radical particle theory, advanced by P.A.M. Dirac in 1928, resulted in the eventual discovery of certain particles, and the evolution of elementary particle physics. Notably, his wave equation, the solutions to which prompted Dirac's discovery of a new particle – the positive electron, or "positron" – involved the relativistic Hamiltonian, which is essential to our formulation of entropy, which the author calls the "intrinsic factor". This paper discusses the dynamics of the Universe, from the generation of the first particle pair as suggested by Dirac, to the implication of the *negative energy space*, known as the "Dirac Sea", to the application of the laws governing *energy-matter duality*, and Peano's *space-filling curve* as a model for the propagation of matter through the void, all within the context of entropy, and the principle of *time-space coupling.*

The scientific community is currently misinterpreting astronomical data to conclude the Universe is expanding at a faster rate. Although initially misled by these empirical observations, cosmologists will eventually realize that measurements – correctly interpreted so as to account for what the author refers to as the *transpired-event phenomenon* – indicate that time itself is that dimension, rather than space, which is accelerating. We will conclude, relativistically, that the Universe is expanding at a slower rate. The paper discusses the dynamics of this process and proposes that a *static state* must be reached, what can be understood as an equilibrium that must occur (taking into account the facts concerning relativistic relation between length contraction and time dilation). The paper also suggests *why* data may be misconstrued to suggest the contrary. The general dynamics of the gravitational processes subsequent to reaching the equilibrium event of the Universal static state is described, and its implications with respect to the future of the Cosmos.

Publications and Presentations

34th Education Group

Publications:

SMITH, J. M. "Aerospace Professionalism Across the Academy: Focusing on USAFA's Four Products." *USAFA Educator*, Fall 2000.

SMITH, J. M. ed. *Searching for National Security in an NBC World.* INSS Book Series, July 2000.

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Presentations

SCHMIDT, M. D. "Iris Closure for LCD Video Projectors." International Planetarium Society, Montreal Conference, Summer 2000.

SMITH, J. M. "USAFA's Contribution to Aerospace Leadership." Executive Commissioning Committee Meeting, Kirtland AFB, NM, 24 July 2000.

SMITH, J. M. "Developing Aerospace Strategists." USAF School of Advanced Aerospace Studies IPT, Washington DC, 18 July 2000.

Department of Aeronautics

Publications:

GUY, Y., J. Morrow, and T. McLaughlin. "Experimental Study of a Delta Wing with Upper and Lower Flaps." 18th AIAA Applied Aerodynamics Conference, AIAA 2000-4003, August 2000.

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MCLAUGHLIN, T., S. Morton, J. Morrow, and S. Siegel. "Unsteady Computational and Experimental Investigation of an Unmanned Combat Air Vehicle Experiencing Dynamic Lift." AFOSR Program Review, Monterey, CA, September 2000.

Department of Biology

Publications:

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Department of Chemistry

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GAMMON, S., James F. Blankenship, Mathew J. Sandelier, and Ronald C. Marks. "Implementation and Features of a New Internet Based Homework System." Biennial Chemical Education Conference, Ann Arbor, MI, July 2000.

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NEAL, P. and Linda G. Shapiro. "A Symbolic Representation for 3-D Object Feature Detection." International Conference on Pattern Recognition, September 2000.

Department of History

Publications

ABADI, J. "The Quest for Foreign Policy and National Security of Qatar," under review by Journal of Mideast and South Asian Studies, October 2000.

ABADI, J. "Ethnicity and Religion in Israeli Politics: The Emergence of the Shas Party." Accepted as chapter in edited anthology.

ABADI, J. "Constraints and Adjustments in Portugal's policy toward Israel," accepted by International History Review.

ABADI, J. "Constraints and Adjustments in Greece's Relations with Israel," accepted by Mediterranean Quarterly.

ABADI, J. "Constraints and Adjustments in Sweden's Relations with Israel," accepted by Middle Eastern Studies.

ABADI, J. "Constraints and Adjustments in Libya's Relations with Israel," accepted by Journal of Conflict Studies.

ABADI, J. "The Road to the Israeli-Moroccan Rapproachment," accepted by Journal of North African Studies.

ABADI, J. "Israel's Relations with Azerbaijan and the Muslim States of Central Asia," under review by Central Asian Survey.

RUFFLEY, D.L. "Children of Soviet Victory, Founders of Russian Future: Young Soviet Specialists and the Evolution of Russian Society, 1965-1982" Doctoral Dissertation successfully defended at Ohio State University, August 2000; Ph.D. degree awarded 31 Aug 2000

Conferences
Witzel, M.D., New Faculty Boot Camp, Leadville CO, July 2000

Department of Management

Presentations:

BARKER, J. "Writing Critical Ethnography." Academy of Management Convention, Toronto, ON, August 2000.

HORNYAK, M. "The Affective Side of Learning." Academy of Management National Meeting, August 2000.

Department of Mathematical Sciences

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WARNER, B. and J. Anderson. "Trees, Nets, Matches and Mushrooms." DFMS TR, 00-02, June 2000.

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SCHOOFF, R. "The Consideration of Multiple Objectives in US Engagement Strategies." Int'l Conf on Systems Engr in Decision Making, Charlottesville, VA, June 2000.

Department of Physics

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KRAUSE, L., D. Knipp, B. Dichter, and K. Ray. "The Relationship Between DSCS III Sunlight Surface Charging and Geomagnetic Activity Indices." IEEE 2000 Nuclear and Space Rad Effects Conf, Reno, NV, July 2000.

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Department of Political Science

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MURRAY, D. "Leading University-Wide Change: Defining New Roles for the Department Chair." *The Department Chair*, 11/1, August 2000.

PILCH, F. "Security and Refugees: Dilemmas, Crises, and Debates." *Refuge: Canada's Periodical on Refugees*, 19/1, August 2000.

Presentations:

CARRESE, P. "Montesquieu and the Spirit of Modernity." American Political Science Association, Washington, D.C., September 2000.

COLETTA, D. "A New Solution to the Chain Store Paradox." American Political Science Association, Washington, D.C., September 2000.

MORRISON, J. "James Wilson, Thomism, and the Founding." American Political Science Association, Washington, D.C., September 2000.

USAFA Research Points Of Contact

To learn more about research at the United States Air Force Academy, we encourage you to visit our Web site at www.usafa.af.mil/dfe. If you want to focus on a particular department or effort you might want to contact the associated Department Research Director. Each phone extension is preceded by (719)-333 commercial or 333 DSN. Each e-mail is followed by @usafa.af.mil

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