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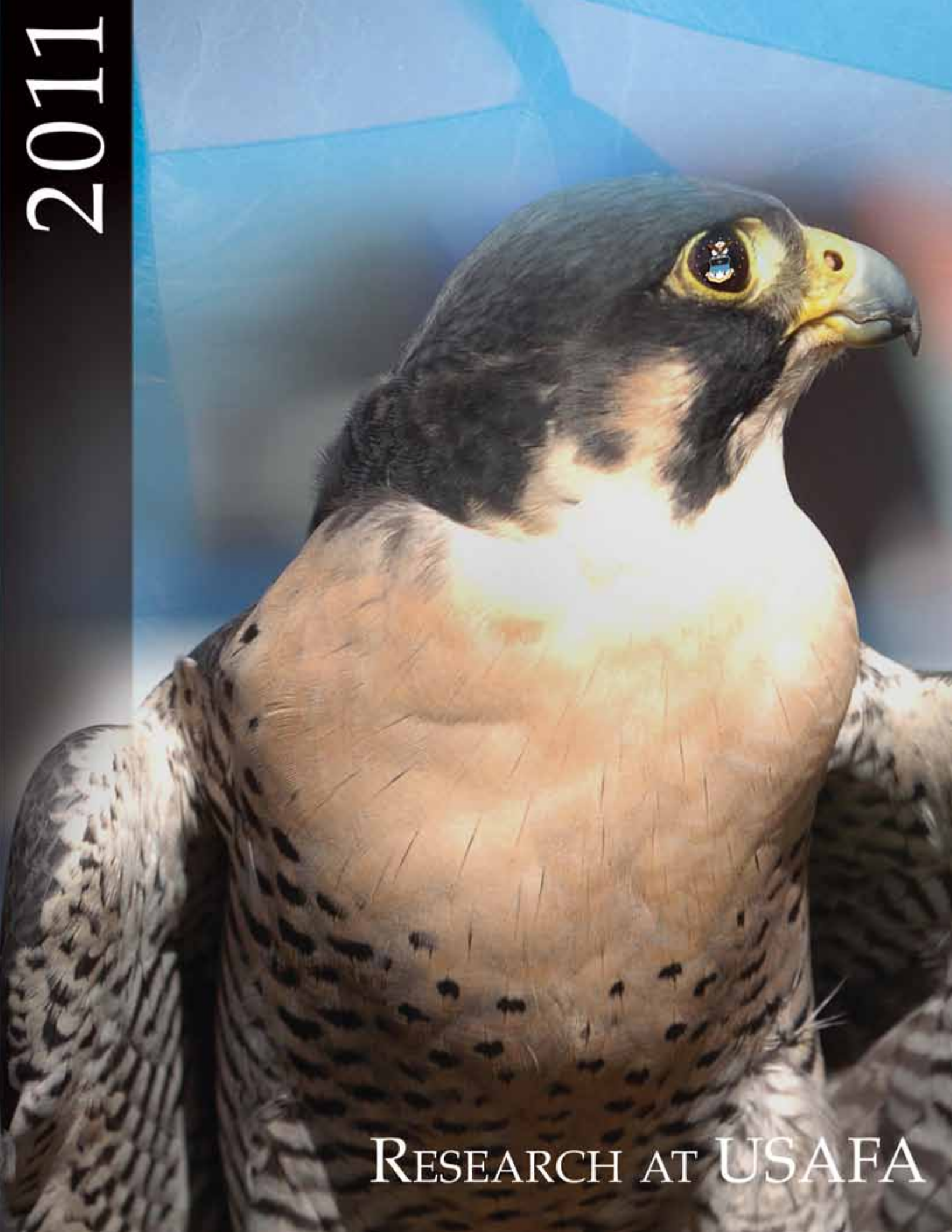

RESEARCH AT USAFA

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Pictured on the front cover:

Oblio

Oblio is one of the Academy's falcon mascots. He was gifted to the Academy in 2004 when he was a few years old. Oblio is from the Peregrine species of falcon, and the Tundra subspecies. The Peregrine falcon is the world's fastest animal: some Peregrines have been spotted going more than 200 miles per hour! The Peregrine's speed allows it to chase and capture any of its prey in the air. Peregrine falcons hunt other birds, ranging in size from sparrows to ducks. The Tundra Peregrines are native to the northern United States and Canada, but winter in the southeastern U.S. and Latin America.

Pictured on the back cover:

Apollo

Apollo is one of the Academy's falcon mascots. He came to the Academy in 2004 when he was just a few weeks old. He is now a trained flying performer and takes to the air for falconry demonstrations at halftime of Air Force Academy home football games. Apollo is a hybrid Black Gyr/Peregrine falcon, known for his aggressiveness when flying. This blend of Black Gyr and Peregrine species allows him to combine the size and power of the Gyrfalcon with the speed and agility of the Peregrine.

Gyrfalcons can be found in Alaska, Canada, and the extreme north of the Continental United States, while Peregrines are native to the northern United States and Canada, and can be found in Colorado during winter months.

Falconry fact sheet:

http://www.usafa.af.mil/information/factsheets/factsheet.asp?id=9425

We're also one of only two schools in the NCAA that has a performing mascot.

– Auburn University is the other with their war eagle.

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RESEARCH AT USAFA 2011

The falcon is not just the feathered mascot of the U.S. Air Force Academy. Known as a symbol of single-mindedness, prowess, and of readiness to serve, the falcon is synonymous with all of the critical values of this institution's fundamental mission 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.

The symbolism of the falcon has not only led us to success on the athletic field, but it has led generations of officers through rigorous academic challenges, decorated careers of service, and guided heart-felt outreach to the communities served by Airmen around the globe. The skills the falcon represents – far-sightedness, aerodynamic execution, efficiency, and discipline – are ingrained into cadets' educational and military experiences. The result is a cadre of officers with character, critical thinking skills, and visionary leadership; which on today's complex battlefields, will help them to anticipate and respond to evolving missions in air, space, and cyberspace; to emerging, game-changing technologies; and to new forms of asymmetrical warfare.

With more than a $70 million annual budget, the U.S. Air Force Academy's sponsored research program is on the front-lines of this evolution. Representing 18 research centers and two Air Force institutes, cadets have a diverse choice of research opportunities. In addition to the centers and institutes within the Dean of Faculty, cadets also benefit from the research efforts within the USAFA Center for Character and Leadership Development, under the Commandant of Cadets, and the USAF Academy's Human Performance Lab in the Department of Athletics. The newly established K-12 STEM (Science, Technology, Engineering and Mathematics) Outreach Center is dedicated to providing support for vetted STEM programs in and after school, continuing education opportunities for educators, and via regional partnerships, to inspire or spark an interest of K-12 students in STEM-related topics and professions. The Outreach Center is currently supporting these types of programs in Districts 11, 20, 49, Teller County, and other school districts across southern Colorado.

Research at USAFA is **education** when cadets like 2Lt Craig Porter, Class of 2011, are immersed in complex cadet summer research projects, national student paper competitions, and priceless one-on-one mentoring from leading experts and faculty.

Research at USAFA is **training** when 2Lt Jack Fitzgerald, also another Class of 2011 graduate, is the cadet lead on a complex NASA project – CANARY – and is responsible for leading his team through NASA briefings, pre-flight tests of this multi-million dollar sensor, and coordinating in-flight space operations as CANARY is launched on the second to last shuttle mission and mounted on the International Space Station by veteran astronauts.

Research at USAFA is **inspiration** by Department of Civil Engineering member 2Lt David Pool, a graduate of the Class of 2010. An active member of the USAFA Engineers Without Borders chapter as a cadet and now as an officer, Pool contributed to a joint project with Tufts University and Washington University in St. Louis, to do an energy audit and provide green energy alternatives for the Agahozo Shalom Youth Village in Rwanda, which houses up to 500 orphans who lost family during the Rwandan genocide.

Research at USAFA is all of this and more.

DYNAMIC OUTREACH AND RESEARCH REINFORCES INTEGRATED INTELLECTUAL, WARRIOR SKILLS

As the leader of the United States Air Force Academy, I know the critical importance of our mission to develop officers of character who possess the knowledge and skills required by today's 21st century Air Force.

The research programs at the Academy promote a deep and life-resonating passion for our profession of arms and for the science, leadership, innovation, and character that will propel us as a nation. As the nation's number one undergraduate-only educational institution for research expenditures, now over $70 million per year, cadets and faculty at the Academy have a unique opportunity to integrate, through research, the rich diversity of the Academy experience. This includes military discipline and heritage; a broad perspective of the social sciences, humanities, language, and cultures; and cutting-edge technologies in well-equipped, state-of-the-art laboratories both here at the Academy and with private and government partners around the world. As a result, when our cadets are commissioned as future Air Force leaders, they will have the critical thinking skills and technological background to innovate and lead—wherever the Air Force assigns them.

To fly, fight, and win in air, space, and cyberspace, we have to prepare our cadets to hit the ground running—to be able to quickly integrate new information and methodologies, and to successfully apply that knowledge in dynamic environments. Through research, we have taken definitive steps to help our cadets meet these challenges. For example, in our Center for Unmanned Aerial Systems Research, cadets are working with real-world Unmanned Aerial Systems such as the Scan Eagle and conducting critical design research on the Air Force Research Lab CAMPUS vehicle and the Fighter Size Target project.

We continue to be proud of the fact that our cadets frequently achieve great success. For example, cadets in the Computer Science Department recently took first place in the National Collegiate Cyber Defense "At Large" Regional Competition. Before long, these same cadets, as Air Force officers, will contribute to the Air Force's broad cyber security efforts, crucial for both day-to-day operations and long-term national cyber security. In the aerospace arena, NASA's next generation of manned space operations vehicles have directly benefited from cadet research. In fact, NASA has so valued the research conducted by cadets on the Orion Crew Exploration Vehicle that they invited cadets to brief them on the safety-of-flight recommendation they uncovered in their research. More importantly, and reflective of the quality of research being conducted by our cadets, NASA decided to implement many of the cadets' recommendations into the design of the Orion.

The United States Air Force Academy's Center for Character and Leadership Development (CCLD) is a dynamic organization, under the Commandant of Cadets, which synergistically focuses on inspiring lifelong habits of honorable living. Through seminars, core value training, and capstone annual events such

as the National Character and Leadership Symposium and the Falcon Heritage Forum, the CCLD links the theory of leadership and character with leading-edge practices and application.

Today's Air Force and Department of Defense also require leaders who are committed to the communities where they serve and who embrace the mission to win the hearts and minds of the people in regions of the world like Iraq and Afghanistan. This commitment ranges from volunteer service here at home to education and cultural outreach across the globe. To promote this commitment, I have made it a top priority for the Academy to consistently reach out to our neighbors here in Colorado.

Cadets participating in research played critical community outreach roles in 2011. For example, cadets in our Civil Engineering Department engineered, built, and delivered Navajo Hogans for the Navajo Nation. Other cadets, led by Chemistry Department professor Dr. Ron Furstenau, donated their time to engage and encourage local students to get excited about science, technology, engineering, and mathematics (STEM) through events such as Cool Science workshops for Girl Scouts. Similarly, several hundred local teachers have benefited directly from our partnerships with regional STEM education programs. Funded by the National Defense Education Program, we have now provided teacher training and continuing education credit opportunities to teachers who will directly impact thousands of K-12 students in classrooms throughout the region.

Another community and Academy partnership can be seen right outside the South Gate, where a new six megawatt solar array was built through a joint partnership with Colorado Springs Utilities (CSU). This new array clearly benefits the Academy, helping us save $1 million annually in energy costs. However, it also helps augment communities who are CSU customers and will provide a unique opportunity for cadets to conduct further research into solar energy technologies.

Internationally, more than 550 cadets participated in cultural immersion and international program opportunities by visiting with foreign lawmakers and leaders, sharing cultural experiences with foreign military colleagues, and immersing themselves in languages and cultures in nearly 50 different countries. International study opportunities offer cadets the chance to develop key cultural awareness perspectives that will assist them as officers.

This annual research report is but a snapshot of our diverse, dynamic, and critically important research programs. I invite you to explore our research centers and institutes, and become acquainted with our research partnership opportunities and community outreach efforts. I also congratulate our cadet researchers on a job well done.

Lt Gen Mike Gould
Superintendent, USAFA

DYNAMIC, LEARNING-FOCUSED RESEARCH IS MISSION CRITICAL

The Academy's mission to educate, train, and inspire men and women to become officers of character extends far beyond the summit of Eagle's Peak and the Academy grounds in its shadow. This mission is not to simply educate cadets as undergraduates, but to empower them in the classrooms, in research laboratories, and as officers throughout our Air Force and civilian communities.

Our dedicated faculty strives to provide intellectual guidance to cadets and continues to provide relevant, real-world research opportunities. This dynamic combination of dedicated faculty and undergraduate core studies supporting meaningful research has proven itself as an incubator of dedicated officers who are well-equipped to identify and address critical needs in today's Air Force.

In less than ten years, we have seen colossal growth within the sponsored research program at the United States Air Force Academy (USAFA). In 2003, internally and externally sponsored funding at the Academy totaled $13.3 million. Today, we are home to 16 established research centers and two Air Force research institutes and manage more than $70 million in undergraduate research expenditures. This considerable investment underscores the quality of the research conducted by our cadets. The quality, reliability, intellectual, and scientific value of our undergraduate research program speaks for itself, and I am proud to lead such dedicated and professional faculty and cadets.

Research is an essential element throughout all of our centers, departments, and across disciplines. Reflective of our National Science Foundation status as the number one funded undergraduate-only research institution in the nation, this year's research report is a collection highlighting some of the remarkable real-world research conducted by cadets during the 2010-2011 academic year. All cadets who have participated in the Academy's unique research programs come out with a deeper appreciation for the scientific process and recognize the value that comes from working side-by-side with our Air Force's scientists and private industry partners. They are able to face unknowns with a determination to find solutions to today's multi-faceted problems, the ultimate value of bringing the research laboratory into the learning environment.

Our cadets are helping to write the next chapter of the space race at a critical time in our nation's space history. In the Aeronautics Research Center and the Modeling and Simulation Research Center, cadets are conducting safety-of-flight research on NASA's Orion Crew Exploration Vehicle, NASA's only manned spacecraft in development after the 2011 retirement of the shuttle program. NASA has also extended a five-year project agreement with USAFA. In a continuation of one of our nation's most successful university small satellite programs, FalconSAT successfully launched its FalconSAT-5 on November 19, 2010 from Kodiak Island, Alaska. This small satellite carried multiple payloads for both the Department of Defense and private industry, and was the most technologically advanced satellite to be designed, tested, and launched by our cadets. The FalconOPS program, which continues to operate the four-year old FalconSAT-3 and now FalconSAT-5, also added to its already advanced

ground station with two, four-meter S-Band dish antennas enclosed by large 18-foot radomes.

Renewable energy is another focus which has been reinforced by the Department of Defense and Air Force mandate to drastically change the way we use energy. The Academy is working to become a net-zero facility and has dedicated staff and resources to exploring and implementing renewable energy solutions. Construction of the six megawatt solar array near the South Gate entrance of the Academy, funded by the American Recovery and Reinvestment Act and constructed in partnership with Colorado Springs Utilities, was completed in 2011. This project will also serve as an opportunity for cadets to study, research, and learn from today's solar technologies.

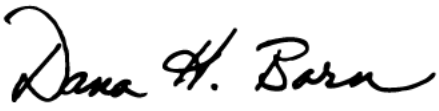
In partnership with one of our 90+ Cooperative Research and Development Agreement (CRADA) partners, Cool Clean Technologies, cadets in the Life Sciences Research Center are conducting research on algae lipid bio-fuels to identify the best strains of algae for the creation of a new bio-fuel that may someday run our vehicles or aircraft. Research into portable roll-up solar panels is occurring in the Department of Electrical and Computer Engineering, with cadets briefing their research to members of the Secretary of Defense's office.

Commitment to the communities in which all Airmen serve is another key component for officers of character. Whether in Colorado Springs or supporting operations in Kandahar, Afghanistan, taking pride and a sense of responsibility for community has become an integral part of the cadet experience. Not only do cadets participate in dozens of international cultural and language opportunities during an academic year, they also give back in support of a wide variety of outreach efforts from building homes for the Navajo Nation or Habitat for Humanity; to volunteering as judges at local schools' science fairs and supporting Science, Technology, Engineering and Mathematics (STEM) programs; to working with Engineers Without Borders in Africa.

This year, the Academy once again took a decisive step in supporting regional STEM education efforts. Putting money where our hearts and minds are via generous funding from the Office of the Secretary of Defense's National Defense Education Program, the Academy paired up with established local organizations such as the Challenger Learning Center of Colorado, the University of Colorado at Colorado Springs, and Cool Science as well as with national organizations such as the American Institute of Aeronautics and Astronautics and NASA. With our partners, we provided teacher training and continuing education credits for elementary, middle, and high school science teachers. With the assistance of dedicated faculty and volunteer cadets, we brought thousands of students through our labs for tours and for our Summer Seminar, and we have continued to bring science to the classroom through outreach efforts like the Chemistry Magic Show and Physics is Phun demonstrations.

A research program of this size and depth would not be possible without the many federal organizations supporting our cadets' efforts. Despite DoD-wide belt tightening, organizations such as the Air Force Office of Scientific Research, the Oklahoma Air Logistics Center, and the Air Force Research Laboratory have continued to offer their financial support of research at the Academy. For their continued support, I am extremely grateful.

I invite you to explore the pages of this report and read some of the many success stories happening within our sponsored research programs. In our classrooms and laboratories we are growing capable, technologically advanced, and intellectually flexible officers of character. These cadets will be our nation's next great generation—willing and ready to lead us with new technologies not yet realized, to lead us through new challenges abroad and at home, and to build strong foundations within the Air Force and the communities in which they will serve.



Dana H. Born, Brigadier General, USAF
Dean of the Faculty

Center For Character & Leadership Development

BUILDING LEADERSHIP FROM THE GROUND UP

The Center for Character & Leadership Development (CCLD) fosters the growth of character and leadership in the cadets and staff at the United States Air Force Academy through the many programs it facilitates. Its mission is to advance the understanding, practice, and integration of character and leadership development in preparation for service to the nation in the profession of arms. The CCLD staff are committed to creating and shaping a culture at USAFA that celebrates this development and promotes the integration of this development across the broader Air Force. The Center provides world-class education and experiences for USAFA cadets and staff. It enlightens and equips future officers to advance lifelong habits of honorable living.

Comprised of four directorates: Cadet Development, Honor, Integration & Outreach, and Scholarship, the CCLD provides purposeful, engaging experiences to challenge and support cadet development through all four years of their USAFA program.

The Commandant of Cadets, Brigadier General Richard Clark said, "CCLD is our catalyst for elevating a culture of honorable living at USAFA. The Center's developmental programs, assessments, and scholarship impact every aspect of the Academy experience and challenge the cadets, faculty and staff to tirelessly pursue leading with character."

The Cadet Development directorate designs and delivers character and leadership development events and programs which include four character seminars and core values training for the cadets that help cadets take ownership over their development with an intentional focus on values, courage, respect for others, servant leadership and ethical dilemmas. Additionally, this directorate conducts the annual National Character & Leadership Symposium (NCLS) and the Falcon Heritage Forum (FHF) events. NCLS brings together distinguished scholars, military and corporate leaders, athletes, and others to share knowledge and insight which enhance the understanding and challenges of sound moral character in the exercise of leadership. FHF links cadets with the wealth of knowledge and experience embodied in our distinguished veterans. This interaction facilitates practical and honest answers to operational Air Force issues.

The Honor directorate works to foster in every USAFA graduate, the habits of honorable living and a relentless pursuit of an identity of a leader of character. This directorate oversees the cadet-owned honor education program, as well as the administration of the process by which the cadets implement their cherished honor code and oath: "We will not lie, steal or cheat, nor tolerate among us anyone who does. Furthermore, I resolve to do my duty in all things and live honorably, so help me God."

The Scholarship directorate, recently created to generate diversity of thought and innovation, takes theory into practice and helps CCLD and USAFA to assess, challenge, and support the character and leadership development process. This directorate assesses, analyzes, and refines the effectiveness of developmental programs and examines "the big Character & Leadership questions that matter" through research, scholarship and outreach. Directorate staff facilitate practical evaluation of character and leadership education to ensure CCLD's programs reach USAFA's stated objectives, to understand the impact of events on development and learning, and is also responsible for publishing the Journal of Character & Leadership Integration (JCLI). This peer-reviewed publication, released in print and electronic copy biannually, serves to advance the integrative study and development of character and leadership for academic and practitioner audiences alike, and provides opportunities for leading edge scholarship and connecting diverging worldviews. Finally, this directorate supports the character and leadership-related interests of USAFA and the Air Force through exploratory research, theoretically-grounded frameworks, targeted scholarship, pilot testing and partnerships with internal and external agencies.

"There have been many changes in the 21st century – militarily, culturally, technically, politically and operationally, along with the attendant demand for global and strategic thinkers with a solid ethical foundation. These changes generate requirements for new approaches to developing character and leadership. The aim of the Journal is to promote relevant scholarship and discourse on the "big questions" in character and leadership, and to foster international engagement on the subject," said Col Joe Sanders, the Permanent Professor and Director of the CCLD.

The Integration and Outreach directorate provides focus on the alignment of CCLD efforts within the Center, across USAFA and beyond. This focus on strategic partnerships and efficiencies enhances the reach and impact of CCLD initiatives, and brings external perspectives and best practices to our processes and programs. One particular area of outreach is to our cadet community, to ensure they have the opportunity to engage in character and leadership activities that support their development and connect with their commitments.

In addition to attendance at USAFA sponsored character events, CCLD staff members and cadets from the CCLD advance their knowledge and development by attending and presenting at leadership conferences around the country at universities and other military institutions such as the International Society for Military Ethics Conference, Association of Leadership Educators, Military Academies Honor Conference, and the University of San Diego Character Development Leadership Conference. In 2011, CCLD members presented or were invited to present papers and seminars to the Association of Leadership Educators annual conference, the American Association of Colleges & Universities (AAC&U) Conference on Personal and Social Responsibility, and the NYU International Symposium on Emerging Pedagogies.

Some of the CCLD's efforts internally included various professional development opportunities to both its own staff and for all of USAFA. The center hosts various professional development days during which notable guests speak with the staff about ways to advance our training techniques and methods. In 2010-2011, a number of strategic partnerships were formed to expand the capacities of the Center. For example, CCLD members have co-authored publications on Behavioral Integrity and a book chapter on trust development with colleagues from Cornell and NY University. CCLD initiatives have created partnerships with Stanford's Center for Leadership Development, Fort Carson's Wounded Warrior Transition Unit, and have led to a large scale project on technology-based situational judgment tests with the other federal service academies.

The CCLD has many future goals for its programs, events, and scholarship expansion – and is always striving for innovative instruction and research into the disciplines of character and leadership, to continuously learn and adjust to the demands of change, and to challenge established worldviews about character and leadership.

"The CCLD will endeavor to be a global epicenter for developing leaders of character who…live honorably, lift others to be their best possible selves, and elevate performance toward a common and noble purpose," said Col Sanders.

Space Systems Research Center

LEARNING SPACE BY DOING SPACE

The crowd held its collective breath as the countdown to launch began and the video display showed the Minotaur IV taking off from Kodiak, Alaska. The rocket carried the Space Systems Research Center's (SSRC) FalconSAT-5 payload and its successful launch brought whoops and applause from more than 300 attendees watching the live video feed at the Academy. It was one more successful learning moment on the center's impressive success story resumé.

The cutting-edge SSRC FalconSAT and FalconLAUNCH programs, allowing cadets to design, build, test, launch and operate DoD and private payloads, are the sole undergraduate-only efforts of this kind in the world. Married with the center's FalconOPS "Space for All" program and its fully-capable ground operating system and two new 18-foot radomes housing two four-meter S-band dish antennae, a world-class commercial-grade clean room, and a bevy of USAFA faculty and research experts from the space and launch industry, these "Learning Space by Doing Space" efforts offer cadets of all majors the chance to participate in an established aerospace company with real-world clients, budgets, launch deadlines, and all of the accompanying challenges.

"The real, long-term value of programs like FalconSAT in the SSRC is the connection between our cadets and faculty and the DoD research and development community. Our work has great academic worth because it applies the lessons learned in the classroom to real-life scenarios with hands-on experience for our cadets developing capabilities for the researcher that will benefit the warfighter," said Col Marty France, Permanent Professor and Head, Department of Astronautics.

Cadet teams in the SSRC are currently operating two orbiting satellites, FalconSAT-3 and FalconSAT-5, as well as coordinating the development of the FalconSAT-6, FalconSAT-7, and FalconLAUNCH-T1 projects. Participation in one of the Astronautics capstone projects is a requirement for all Astronautical Engineering and Space Operations majors but cadets majoring in other fields also have the opportunity to participate, making the program truly multi-disciplinary.

One example of a cadet research effort in the SSRC was Cadets Justin Landseadel and Adrianna Eaton's FalconSAT-3 Primary Housekeeping Task Executable (PHTX2) code. These cadets tackled an operating issue that had plagued FalconSAT-3 since its launch in 2007. The problem was the satellite's low sample rate for data, which was supposed to have been 2 Hz but was only operating at 0.2 Hz. The cadets wrote the upgrade code with mentoring from the SSRC's Professor Steve Hart and the end result was a system that now operates at 4 Hz – revolutionizing the entire system and breathing new life into FalconSAT-3 operations.

"They are the only cadets I've seen get an impromptu standing ovation in class, and not by my or the faculty's prompting but by their cadet peers, due to their PHTX2 work. This effort was truly remarkable. They rescued our satellite," said SSRC Director Lt Col David Richie, who had led cadets during a previous USAFA assignment during FalconSAT-3's design phase.

The FalconSAT-3 cadet teams are also teaching current Air Force officers and other DoD partners what they have learned. With the resounding success of the PHTX2 code, the Air Force Institute of Technology (AFIT) and the US Military Academy at West Point joined the project as DoD partners. In the spring of 2011, AFIT and the SSRC partnered to conduct a one-of-a-kind space tasking exercise. Cadet FalconSAT-3 ground station teams guided 10 three-person AFIT crews through 10 missions executing FalconSAT-3 advanced tasks and simulated anomalies similar to Emergency Procedure Simulations used by the Air Force in real-time missions. West Point also worked with the SSRC to establish a USMA ground operations center at the New York installation.

FalconSAT-5 has been in orbit since November 2010. Following its launch, cadets have performed dozens of operations with the satellite, tested the Space Plasma Characterization Source (SPCS) Hall Effect Thruster, and are performing its Air Force Research Lab (AFRL) research mission to measure space weather phenomena. There are multiple payloads on board including the Academy's own Space Physics and Atmospheric Research Center's Integrated Miniaturized Electrostatic Analyzer (iMESA) and the Radio Frequency (RF) Signal Strength (RUSS) payload.

FalconLAUNCH-T1 had a successful static test fire in spring 2011 and the cadets were able to evaluate the propulsion system and test the rocket's subsystems such as avionics and ground station subsystems. This precursor to the larger FalconLAUNCH-9, under development and sponsored by AFRL's Propulsion Directorate at Edwards AFB, will allow cadets to fly suborbital missions with DoD payloads.

The center has established itself as a breeding ground for graduate school candidates, with eight of its 2011 graduates headed to prestigious graduate schools including the Massachusetts Institute of Technology, Stanford University, Rice Universtiy, and AFIT. This extraordinary center is now positioned to not only contribute a generation of space professionals to the industry but also to become a greater part of our nation's next chapter in space operations. SSRC cadets and graduates will have the opportunity to conduct research critical to continuing the Air Force space mission and to developing the new technologies to drive our nation's space industry.

Social Sciences & Humanities

CHANGING WORLD NEEDS THREE DIMENSIONAL LEADERS

From the villages of Afghanistan, where language and cultural knowledge can literally save lives, to well-developed management skills that will ensure delivery of critical assets in both military and humanitarian operations, the social sciences and humanities are essential. Taken as a collective, the diversity and texture of solid education in the social sciences and humanities adds depth and substance to a cadet's experience and development as a leader of character. History, Law, English, Language, and Politics act as bridges to the technical and strategic worlds—and have become critical to success on the 21st century battlefields of the Air Force and DoD.

With 10 majors within the Social Sciences and Humanities Divisions, cadets have the opportunity to develop the skills and knowledge they will need to interact successfully, as officers, with our allies abroad. In addition to a classical curriculum within the divisions, cadets have unique opportunities for professional, cultural, and language exchanges; cadet summer research projects with a wide range of government and private organizations including internships with the U.S. Congress and the National Security Agency; and opportunities to participate in multi-disciplinary research projects combining project management with technical programs such as the Astronautics FalconSAT and FalconLAUNCH programs.

"Research is about discovery and sharing results with others. This is a fundamentally important activity among our faculty and something we encourage with our cadets. The research process is consistent with our institutional focus on lifelong learning, development, and contribution. As with other disciplines, research in the field of management requires a scientific approach to testing and analyzing new hypotheses. It is truly an exciting endeavor that not only enhances the field, but brings an added dimension to the classroom," said Col

Andrew Armacost, Permanent Professor and Head of the Academy's Department of Management.

The Academy's Department of Management has been part of a growing trend in schools of management and business to promote student innovation and creativity through new venture plans or nascent project development. Cadets' efforts span a wide spectrum of management topics that include military applications and those directed purely at the private sector. Projects have included defense-related technologies, energy-related projects, medical therapy applications, and additional for-profit ideas that have yielded novel concepts and organizations.

One example of this effort was a bio-fuels project for the US Department of Agriculture and the Air Force Research Lab. Working with Dr. Don Veverka, director of the Academy's Life Sciences Research Center (LSRC), and Biology cadets, Management cadets were recognized for their involvement in the LSRC's algae lipids bio-fuels project. Capitalizing on work done through a CRADA with CoolClean Technologies, cadets Matt Alva, Sean Christy, and Tyler Dallas worked to develop several possible DoD applications for renewable energies. Their proposals were selected to compete in the final round of the National Security Innovation Competition sponsored by the Colorado Homeland Defense Alliance, and they presented their work at the Keith Memorial Capstone Conference and Competition at West Point—also held at USAFA.

Another project within the Management Department is the NuAge Trainer. This project, led by cadets Derrick Luken, Benson Oldmixon, and Ryan Rogl, is a new venture plan for a web-based algorithm and supporting enterprise that scientifically matches the right trainer for anyone wanting or needing physical development or training. This work advanced to the second round of the University of Nebraska's New Venture Innovation Competition in Lincoln, Nebraska.

In the Department of English and Fine Arts, cadets contributed to the "Journeys and Journals: Cadet and Faculty Travel," gallery exhibit in the recently remodeled Permanent Professors' Art Gallery. Faculty members published dozens of papers and conference presentations such as Dr. Donald Anderson's "Soldier-Artists: Preserving the World," introductory essay for a special feature on "Veterans of War" in the *Connecticut Review* 22.2 in the fall of 2010. Dr. Anderson's essay has been nominated for the prestigious Pushcart Prize.

The department also organized and hosted the inaugural *War, Literature & the Arts* Conference which more than 1,300 scholars attended. The event featured 34 panels, five keynote speakers, and two war-art exhibits and was a huge success. The conference focused on the "Reporting and Representation of America's Wars since 1990," and featured presentations from world-renowned experts in such genres as journalism, fiction, poetry, critical essay, film studies, film screenings, and photography.

The Department of Behavioral Sciences and Leadership has been playing a critical role in the USAF Academy's leadership and leadership education arenas. One example of this effort can be seen in the work of Dr. R. Jeffrey Jackson. Dr. Jackson played a pivotal research role in the analysis of the Academy's AOC Master's program to include assessment of the program's value to cadets and the on-going transfer of training to the Cadet Wing. His research encompassed the assessment and evaluation of the cadet wing climate from more than 2,500 participating cadets and the results will have a great impact on future leadership development within the cadet wing and across the Academy. Dr. Jackson's externally sponsored research included a DoD project about the critical issues of leading in harm's way and the benefits of a combat stress team, and a funded research project examining factors that contribute to the resilience of those serving in the Army National Guard.

Space Physics & Atmospheric Research Center

SUCCESS MIXED WITH A TOUCH OF FAILURE TEACHES LIFE LESSONS

The Space Physics and Atmospheric Research Center (SPARC), led by Dr. Geoff McHarg, has a track record of providing cadets with real-world research opportunities. Whether they are working on the development of cutting-edge space weather, atmospheric instrumentation, or payloads that support the FalconSAT program, cadets in the SPARC are given the opportunity to embark on projects that cultivate the research skills that go with the science. The cadets acquire an appreciation for the realities of research – how to deal with failures, the need to go back to the drawing board to discover what went wrong, and how to try again.

One such project was the NASA Sounding Rocket Program 40.026RENU "Rocket Experiment for Atmospheric Neutral Upwelling." Led by Dr. Marc Lessard of the University of New Hampshire, USAFA co-investigators Dr. Geoff McHarg and Dr. Parris Neal, 2Lt Shane Fink, a 2010 grad, and C1C Hal Schmidt, designed the Miniature Analyzer for Neutral Gas density (MANG) instrument.

The design of the MANG instrument began nearly two years ago as a capstone course and was completed this past academic year. The instrument is a small device, less than 600 grams, mounted on an extendible boom on the rocket payload. The goal of the project was to measure atmospheric neutral particle density as a function of altitude both during the rocket ascent and descent. These measurements will help form a more complete model of how high-altitude atmospheric neutral particle density changes with different heating mechanisms and the subsequent impact on atmospheric drag on polar orbiting satellites.

Shipped to Andøya, Norway, for a December 2010 launch, the team was dealt a setback on the project. After several delays, the launch was a failure. The rocket's nose cone did not separate cleanly and the project was unable to collect any data. However disappointing the failed launch was, the lessons learned by the team were invaluable and are being applied to future SPARC projects.

As for the lessons that failure teaches old and new researchers alike, McHarg said, tongue in cheek, "An expert is the person who has most recently screwed up the experiment." Mistakes, failures, and re-examination are constant elements in research. The lesson of

perseverance is critical in the lab and in life; it will help sharpen and guide these cadets in their future careers, according to McHarg.

The center's primary projects had very successful research accomplishments including two successful launches during the 2010 – 2011 Academic Year. The cadet-led project, Materials International Space Station Experiment-7 (MISSE-7), was removed from the International Space Station (ISS), and replaced by the Endeavor mission crew with the Canary project. Named after the proverbial canary in a coal mine, Canary will measure interactions of thrusters from spacecraft visiting ISS with the ISS local plasma environment. The project was successfully mounted externally on the ISS. MISSE-7 was designed to run tests to determine the effects of the space atmosphere (i.e. ultraviolet, direct sunlight, radiation, and other space weather elements) on different materials and coatings. The Canary project also gives cadets the opportunity to work and learn first-hand from the nation's top space professionals. Canary is one experiment on the STPH3 mission to the ISS. STPH3 is integrated and flown under the direction of DoD's Space Test Program (STP). Funded and supported by the STP, Canary project cadets worked with STP and the team at the Johnson Space Center on integration efforts. In the future SPARC cadets will work with STP and NASA from a ground operations center in the SPARC to retrieve data and send commands to the Canary.

More than a dozen cadets in SPARC worked on projects for government and corporate organizations to include the DoD, Air Force Institute of Technology (AFIT), Ball Aerospace, Naval Research Laboratory, and NASA.

In November 2010, two other SPARC projects , the Wafer Integrated Spectrometers (WISPERS) sensor and the Integrated Miniaturized Electrostatic Analyzer (iMESA) payloads, were successfully launched aboard the Academy's Space Systems Research Center's FalconSAT-5 small satellite. Both survived the launch and data collection is ongoing.

A second iMESA was delivered to Ball Aerospace and STP for a joint project to measure background temperature and density of the low earth orbit (LEO) environment, and cadets played a major role in pre-delivery and pre-flight tests. The project was included on the STPSAT3 satellite. The Naval Research Laboratory is also working with cadets to design an iMESA for their first miniaturized CubeSat which will measure the background temperature and density of electrons in the LEO.

Dr. McHarg's team of researchers and cadets is also preparing for the next FalconSAT project. Coming on the heels of the most advanced cadet-designed, built, and launched satellite, FalconSAT-5, SPARC has taken on even more in-depth projects. The center embarked on a project for the National Reconnaissance Office (NRO). In coordination with several other organizations including Boeing, AFIT, the Air Force Research Laboratory (AFRL), NASA, and MMA (a small Colorado aerospace company), the SPARC will work to develop the Peregrine payload to fly on FalconSAT-7. The payload will include a "photon-sieve" telescope to observe the Sun. The sieve, a polyimide flexible membrane developed by USAFA physicist Dr. Geoff Andersen, will be the first of its kind to be flown in space. When deployed, it will be the first imaging optic that is larger than the satellite.

"This project has cadets involved from Physics, Electrical and Computer Engineering, and Systems Engineering Management. With this project, I hope that cadets will get an end-to-end feel of how to incorporate new technology into an experimental spacecraft, and radically improve the state of the art in small satellite optical imaging," said McHarg.

Critical thinking, developing and integrating new technologies, and good old fashioned elbow grease have become mission essential skills in today's Air Force and SPARC cadets will be ready to utilize these skills on day one of their careers as officers.

Center of Innovation

THE ART OF THE POSSIBLE

The United States Government, Department of Homeland Security, and the Department of Defense are at a critical inflection point in efforts to adopt emerging technologies and create advanced capabilities to accomplish its mission in the second decade of the 21st Century. The Center of Innovation's (CoI) approach is to leverage the creative minds of the millennial generation U.S. Air Force Academy cadets. The Center of Innovation is building upon USAFA Superintendent Lt Gen Mike Gould's statement, "We have to be big enough to acknowledge that they [cadets] have some skill sets and some knowledge that we don't." The future of emerging warfare and security sits squarely on the shoulders of today's cadets. The CoI harnesses these core capabilities and combines them with cutting-edge private industry research technologies to create game-changing innovations which will enable the 'art of the possible.'

The CoI has forged an innovation ecosystem driven by Public/Private partnerships including industry titans such as Intel Corporation, Cisco Systems, and the IBM Watson Research Center. Through the use of Cooperative Agreements, the CoI leverages leading technology innovators' cutting-edge research technologies. The CoI is creating novel linkages among the discrete private industry innovations to create a new layered approach to national cyber protection – Flexible Distributed Security.

The Flexible Distributed Security framework realizes the vulnerability of networks, assumes end devices are intrinsically compromised, and recognizes the danger

of attacks originating internally. Flexible Distributed Security research is designed to enable security against multiple points of attack, encompassing internal and external threat origins. By presuming that modern malware will penetrate our outer defenses, Flexible Distributed Security creates a self-healing system much like the body's biological defense.

The Cadets will field test Flexible Distributed Security this year in a 3-D virtual environment, conducting research on game-changing private sector prototypes and field test them within a framework of social collaboration experiments called Rare Event Scenarios, which are designed to improve distributed collaboration among stovepipe organizations.

In the Rare Event Scenario framework, cadets mimic members of Operations Centers, Fusion Centers, and edge responders, collaborating in a distributed environment. The purpose of these field tests is to prevent a simulated "Rare Event" such as large scale terrorist events including 9/11, the bombing of the Murray Federal building in Oklahoma City, and Black Swan-like incidents.

"Cadets bring critical social networking skills that are inherent to their generation. As tomorrow's leaders, we will rely on cadets to blend these skill sets with game-changing technologies to create novel capabilities," said CoI director Dr. Terry Pierce.

During the 2010-2011 academic year, CoI's Rare Event Scenario Framework included three major field experiments. These field experiments focused on the value of virtual environments for distributed collaboration and decision making. The IBM Watson Center for Social Software analyzed cadet collaboration effectiveness using 2-D and 3-D Virtual Environments.

Cadet involvement is critical and is a prerequisite for every relationship the CoI cultivates with its private industry research partners. Cadets are mentored by world-class innovators conducting cutting-edge research. Upon graduation, the CoI hopes the cadets can leverage their research experiences to champion solutions to tomorrow's threats.

During the 2010-2011 academic year, the CoI sponsored C2C Carmella Burruss to conduct research with Intel Corporation's Futurist, Brian David Johnson. As Intel's Futurist, Brian developed a model called 'future casting' which helps Intel Corporation anticipate how people and devices will interact in the year 2020. Cadet Burruss is working with Brian to translate this construct into a Federal Innovation Model to predict emerging threats and security solutions. During the year, Cadet Burruss had the opportunity to brief her efforts to a graduate-level class at the University of Washington, the Harvard Security Fellows, and the Associate Director of the Central Intelligence Agency. In the summer of 2011, Cadet Burruss worked with Mr. David Johnson at the Intel Corp Research headquarters in Hillsboro, Oregon, and will continue working on the project through her senior year at USAFA.

"One of the most exciting things the Center of Innovation has to offer are these one-of-a-kind experiences for USAFA cadets. For example, the only undergraduate students in the nation conducting research at Intel Labs are USAFA cadets." Dr. Pierce sums up "for me, it is very rewarding to see these cadets being mentored by and working alongside leading researchers who are focused on changing the world."

Department of Civil & Environmental Engineering

ENGINEERING A BETTER AIR FORCE AND WORLD

When 2Lt David Pool returned to the States from a recent Engineers Without Borders (EWB) project in Rwanda, he came home with more than a PowerPoint briefing. Professionally, as a 2010 graduate and a new Air Force officer, he learned some critical lessons on the relationship between classroom civil engineering, the challenges on how to engineer energy solutions in a remote Third World nation, and most importantly, an understanding and a new respect for the challenges impoverished nations and leaders face.

The Department of Civil & Environmental Engineering plays a critical role in preparing future officers like Pool for the demands and needs of a dynamic Air Force. Civil engineers provide essential infrastructure the Air Force needs to be a cohesive and responsive force, and if well laid out plans don't come together as planned, it is the job of civil engineers to make it right. From operation systems such as water and utilities, to roads and building plans, to mobile battlefield systems, to the energy solutions for tomorrow, Air Force civil engineers are mission critical for today's evolving infrastructure needs.

Cadets doing research in civil engineering have to develop multiple skills ranging from mathematics to management in order to be effective. Led by Lt Col Jeff Heiderscheidt, cadets have a chance to not only develop these skills with faculty mentors in the classroom but they get the chance to put their knowledge to work through a variety of real-world challenges.

"The Air Force, USAFA, and the cadets reap huge benefits from opportunities to perform research on real problems. For example, our cadets have been able to take what they've learned in the classroom and develop a rapid soils analysis kit for use by deployed civil engineers, and to develop and patent a field repair technique for enamel-coated steel used in reinforcing concrete structures. In addition to solving real problems, these efforts provide excellent teaching examples in our courses. The result is that our cadets get valuable experience tackling and solving problems that don't have textbook solutions," added Heiderscheidt.

Sponsored funding in the department includes projects for the National Science Foundation in learning strategies & modeling for engineering students and research on multiphase porous media. Another large project partnership with the Strategic Environmental

Research and Development Program has offered cadets the opportunity to conduct research characterizing Dense Nonaqueous Phase Liquid (DNAPL) source zone architecture plumes. DNAPL source zone architecture is broadly defined as groundwater contamination often linked to industrial contaminants such as chemical solvents and polychlorinated biphenyls (PCB). Cadets are working on identifying and developing protocols for characterizing these areas of contamination and how they travel through groundwater sources.

Energy research is also an interest for the department. Faculty and cadets are involved in research to evaluate an energy foundation for buildings and alternative window insulation technologies.

Energy foundations combine the structural supports for a building with a heat pump so that the foundations can be used as ground-source heat exchangers to provide heating and cooling for a building. This provides a cost-efficient approach to conserve energy, reduce carbon emissions, and reduce installation costs. The objectives of this project, which is being conducted in collaboration with the University of Colorado-Boulder, include cadets' assistance in the installation of an energy foundation system and associated monitoring equipment in a shower/shave facility planned for construction at the USAFA, as well as a cadet project to monitor the system performance with respect to energy consumption, maintenance, temperatures in the ground, foundation, and building, and the heat pump coefficient of performance (ratio of heat generated to electricity required) and to compare measured performance indicators including construction and life-cycle costs with those expected for conventional building heating and cooling systems.

Cadets also have an opportunity to participate in overseas engineering opportunities and to work with civil engineering professionals outside of the Air Force. One example of this is the cadet chapter of the international non-governmental organization Engineers Without Borders. The partnership with the local professional chapter has allowed the cadets the opportunity to work on several projects in Bolivia, Rwanda, and Morocco.

As part of a joint capstone project with Tufts University and Washington University in St. Louis, Pool went to the Agahozo Shalom Youth Village in Rwanda, which houses up to 500 orphans who lost family during the Rwandan genocide, to do an energy audit and help them to identify energy alternatives. Pool said the village, whose mantra is "restoring the rhythm of life," has to pay for electricity per unit and the village leadership did not have a good idea of where their energy was going. The result was multiple power shortages which ultimately affected their education and medical care programs. After conducting an in-depth energy audit and providing easy and cheap energy solutions, Pool and his fellow researchers also worked on a plan to develop inexpensive and easy to maintain solar and bio-waste energy sources for the village.

In addition to the research element, civil engineering cadets also participate in a wide variety of events and activities that put their engineering knowledge to the test. The Academy hosted the 2011 American Society of Civil Engineers (ASCE) Rocky Mountain Student Conference which brought together hundreds of students and faculty from schools across the Rocky Mountain region. Participants had a chance to design and race a concrete canoe, present papers and student research, and compete in other civil engineering challenges.

Another such challenge is the Civ Engr 351—Civil Engineering Practices—Field Engineering course. This course combines a two-week operational Air Force experience as well as a three-week Field Engineering and Readiness Laboratory (FERL). During FERL cadets participate in a wide variety of civil engineering activities such as learning surveying and construction methods and skills, heavy equipment use and operations, and site management. One of the projects during FERL is for cadets to build Navajo hogans which are then donated to the Navajo Nation. The goal of the five-week experience is to give cadets broad exposure to the civil engineering field and to have them see how the skills they are learning at the Academy will be applied in their careers as Air Force officers.

Human Performance Lab

SPORTS SCIENCE RESEARCH CONTRIBUTES TO AIRMAN SAFETY

The body of the airman is as important to mission success as technology and weapons. The USAF Academy's Human Performance Lab (HPL) is a key element to identifying how the Air Force can keep our airmen physically safe as they complete their missions in a wide variety of terrains and environments.

Under the direction of the USAFA Athletic Department and retired Brigadier General Hans Mueh, the HPL applies sports science principles to improve Academy athletic teams and individual cadet performance. Coaches, cadet athletes, and cadets receive specific physiological information by way of testing, research, training, and education.

The lab also provides subject matter expertise on the Air Force fitness program and human performance, offering scientific data through research and exercise science principles. As a result, the HPL offers a venue for cadet researchers and qualified exercise physiology interns to complete independent study research in the fields of exercise physiology, biology, biochemistry, and biomechanics.

The HPL tests and trains more than 1,000 cadets and approximately 100 faculty and staff members annually.

Some of the projects undertaken by the HPL are joint efforts with the Air Force Research Lab (AFRL), Air Force Special Operations Personnel, Air Force Security Forces, the Injury Prevention Research Laboratory, and the Academy's Life Sciences Research Center. Most HPL projects offer cadet research components as well as direct Air Force or Department of Defense field applications.

HPL has several ongoing or recently completed research projects for 2010-11. Data collection on an Institutional Review Board-approved study entitled: "Genome-Wide Association to Human Physiological and Cognition

Performance-Related Genes" started in Fall 2010. This is a joint study with AFRL, with the primary objective to identify genetic single nucleotide polymorphism (SNP) associations to the described physiological performance and psychological cognition parameters. In addition, the center is examining physiological performance and cognition parameters and their relationship to successful completion of the combat controller program (Hurlburt AFB) to provide data in support of categorization of 'optimal' phenotype.

Researchers for the HPL recently completed data collection on a study entitled "Comparison of the 1.5 Mile Run Times at 7,200 Feet and Simulated 850 Feet in a Hyperoxic Room." This study investigated if a significant difference in aerobic performance exists between moderate altitude and sea level and, if it does exist, to what extent. Fifty-five subjects were tested and found to have a 30-second difference in running times between the two altitudes. These differences were mainly due to decreased hemoglobin oxygen saturation. This information was presented to the Air Force Fitness panel as evidence of support if an altitude adjustment for the Air Force fitness test will be reinstated for airmen testing at moderate altitude bases. Lt Col Michael Zupan also presented the results at the 2011 AFMS Medical Research Symposium.

Working jointly with Combat Controllers at the 23rd Special Tactics Squadron, the center's researchers investigated using intermittent hypoxic exposures (IHE) to improve performance at moderate altitude. This study looked at the benefits of six weeks of intermittent hypoxic exposures (IHE) on increased physical performances (max VO_2), anaerobic endurance, and eye-hand speed coordination at moderate altitude. Rapid deployment of unacclimatized airmen to moderate altitudes can compromise mission success by producing debilitating effects on fighting capabilities and force health. These rapid deployments do not give airmen the opportunity to slowly ascend to the higher altitudes, so pre-deployment strategies using hypoxic tents need to be developed.

Another study that was completed this year looked at the effect of class year and exercise on moderate altitude de- and re-acclimatization following USAFA winter break at sea level. Principle investigators Lt Col Michael Brothers and Dr. Jeff Nelson were supported by the work of seven cadets as a cadet research project. Cadets C2C Joshua Stanley, C2C Anthony Pompa, C2C Robert Blank, C2C Elvira Chiccarelli, C1C Patrick Ryan, C1C Kevin Wright, and C1C Trevor Symalla assessed the effect of sojourning to sea level during winter break on total hemoglobin mass, running economy, and lactate measures. The Independent study was a direct extension of the leadership opportunities at the academy, providing cadets incredible, hands-on opportunities to become involved in cutting edge research, and learn the challenges and rewards of scientific research.

The HPL is also conducting a joint study with the Injury Prevention Research Laboratory at the Uniformed Services University of the Health Sciences (USUHS) in Bethesda, MD. The study, entitled "Randomized Controlled Trial of a Lower-Extremity Injury Prevention Program in Air Force Academy Cadets (JUMP-ACL)" is investigating the effect of a Dynamic Integrated Movement Exercise (DIME) warm-up on subsequent injury rate of USAFA cadets. About 1,300 new cadets underwent baseline movement screening using the Landing Error Scoring System (LESS) during the start of Basic Cadet Training. The data is currently being analyzed.

Institute for National Security Studies

STRATEGIC KNOWLEDGE CRITICAL TO SECURITY

In 2010, the world saw the firm establishment of strategic security issues at the top of the United States security policy agenda: a New Strategic Arms Reductions Treaty (START) was signed with Russia, the Nuclear Posture Review policy guidance was issued, a global Nuclear Security Summit was hosted, and the Lisbon Summit issued a new Strategic Concept to guide the NATO alliance into the near- and mid-term future. The story continued to unfold into 2011with the ratification and entry into force of the new START, substantial work toward implementation of the Nuclear Posture Review and the NATO new Strategic Concept, and follow-on discussions to monitor implementation of the pledges and agreements toward global nuclear materials security. But work in these areas has just begun. Strategic engagement with Russia is addressing issues toward further bilateral agreement and nuclear forces reductions, and study has been initiated on how and when to multilateralize strategic arms control and address further force reductions. After more than a decade residing on the policy, research, and education back burners, strategic issues and nuclear weapons are back at center stage.

Led by Dr. Jim Smith, the Air Force Institute for National Security Studies (INSS) has focused research, published reports, and developed leaders with strategic knowledge and perspective for 19 years, and it is well-postured to continue to support Air Force and DoD programs in these national priority areas as well as related areas of emerging security issues, environmental security and sustainability, and the changing face of Twenty-First Century conflict. Housed within the faculty at USAFA, INSS reaches out across the faculty and the broader military academic community to conduct research, enhance education, and bridge

together all sectors of the strategic policy community. In doing so it seeks to develop policy knowledge and analytical skills to help develop a next generation of military officers, and the faculty that educate them, with strategic perspective and vision. INSS partners with others, including the Defense Threat Reduction Agency, the National Defense University's Center for the Study of Weapons of Mass Destruction, the Army Environmental Policy Institute, the Army Foreign Military Studies Office, and the Naval Postgraduate School in these efforts.

INSS has an ongoing research focus on strategic issues associated with reducing roles and numbers of nuclear weapons and future arms control issues. In 2010 INSS focused on framing the nuclear drawdown and understanding the renewed threat of limited nuclear conflict in this emerging environment. INSS has now finalized those reports, including input to an edited text on the re-emerging dangers of limited nuclear war. The Institute also initiated a summer seminar in 2010 engaging young military and civilian scholars to study and teach strategic topics. INSS continued that seminar series with a 2011 session.

A major INSS theme of continuing focus is the emerging and innovative concepts of deterrence, strategic stability, and assurance. A primary INSS focus across 2011 and 2012 is on constructs of extended deterrence to NATO/Europe, Northeast Asia, and the Middle East and implications for arms control, non-proliferation and counterproliferation, missile defenses, and USAF programs. A second and related focus is on innovative applications of deterrence constructs to violent non-state actors and specifically to weapons of mass destruction terrorism. On a closely linked and parallel track, INSS is sponsoring small-group expert discussions on a full range of emerging and changing deterrence constructs. One goal of this effort is the preparation of an edited volume capturing the new and innovative thinking in these areas that could be used as an anchor text for upper-level undergraduate and graduate strategic and security studies education across the military and civilian academic communities.

INSS is continuing its support of the development of officers with strategic perspective and vision by developing texts and other written materials for the classroom as noted above, and now by developing academic programs to renew strategic knowledge and enhance strategic perspective. The Institute presented a short survey course on nuclear and strategic policy and strategy in 2011 as part of the orientation education for officers and civilians assigned to global USAF arms control program positions. That survey course will also be offered in early 2012 in Colorado for other members of the USAF strategic community. INSS is dedicated to advancing strategic knowledge and to developing strategic leaders for the USAF and DoD, and that goal will continue to guide INSS efforts.

Aeronautics Research Center

LAUNCHING THE NEXT GENERATION OF AERONAUTICAL ENGINEERS

How many undergraduates can say they have briefed NASA on critical design needs for the next generation of America's manned space vehicles? Better yet, how many can say NASA agreed with their research and made critical design and safety-of-flight changes? The answer can be found in the wind tunnels and labs of the U.S. Air Force Academy's Aeronautics Research Center (ARC).

The center, which is housed in one of the world's longest-running aeronautics programs, insists that cadet involvement is not a nice-to-have element of research but a must-have element. Dr. Tom McLaughlin, director of the ARC, has consistently set the bar for accepting only real-world research projects that allow cadets the maximum benefit of involvement while contributing to USAF, DoD, NASA, and industry needs.

"Our cadets get the best opportunity to develop real-world knowledge and experience in the engineering process and the chance to develop critical skills they and the Air Force will need in the future. It is a win-win for the Academy, for cadets, and for our DoD, Air Force and commercial partners," said McLaughlin.

The center's laboratory is home to four operational jet engines including turbojet and turbofan engines, a rocket test cell, a wide variety of smaller facilities and five large wind tunnels. The center is also making

facilities improvements to accommodate a new testing tunnel scheduled to be delivered in 2012. Through a Defense University Research Instrumentation Program (DURIP) grant of $930K, the center is procuring a Ludwieg Tube, a supersonic test tunnel capable of operation at Mach 6 for short durations. The tunnel will be a significant enhancement to DoD's ability to understand vehicle behavior at hypersonic speeds.

Cadets had the opportunity to perform a wide range of A-10 sustainability aerodynamic investigations including tail surface patch impact investigation, engine/airframe compatibility, Pitot-static replacement investigation, the effect of no gear doors, accident investigation support, and the effect of non-flush rivets upstream of speed brakes. This test program began in the spring of 2011 and efforts are anticipated to extend through 2012.

The center also received DoD and State Department approval for a three-year program between USAFA and the Republic of Korea. The lab is recognized as an expert in closed loop flow control, which is an aerodynamics problem of interest to both the United States and Korea. A cadet team began working on the joint Feedback Flow Control for a Tangent Ogive Body at High Angles of Attack project in early 2011 and the center anticipates cadet involvement to continue through the duration of the project. In addition to ongoing cadet involvement, the center also hosted two Korean engineers for several months to work on this project.

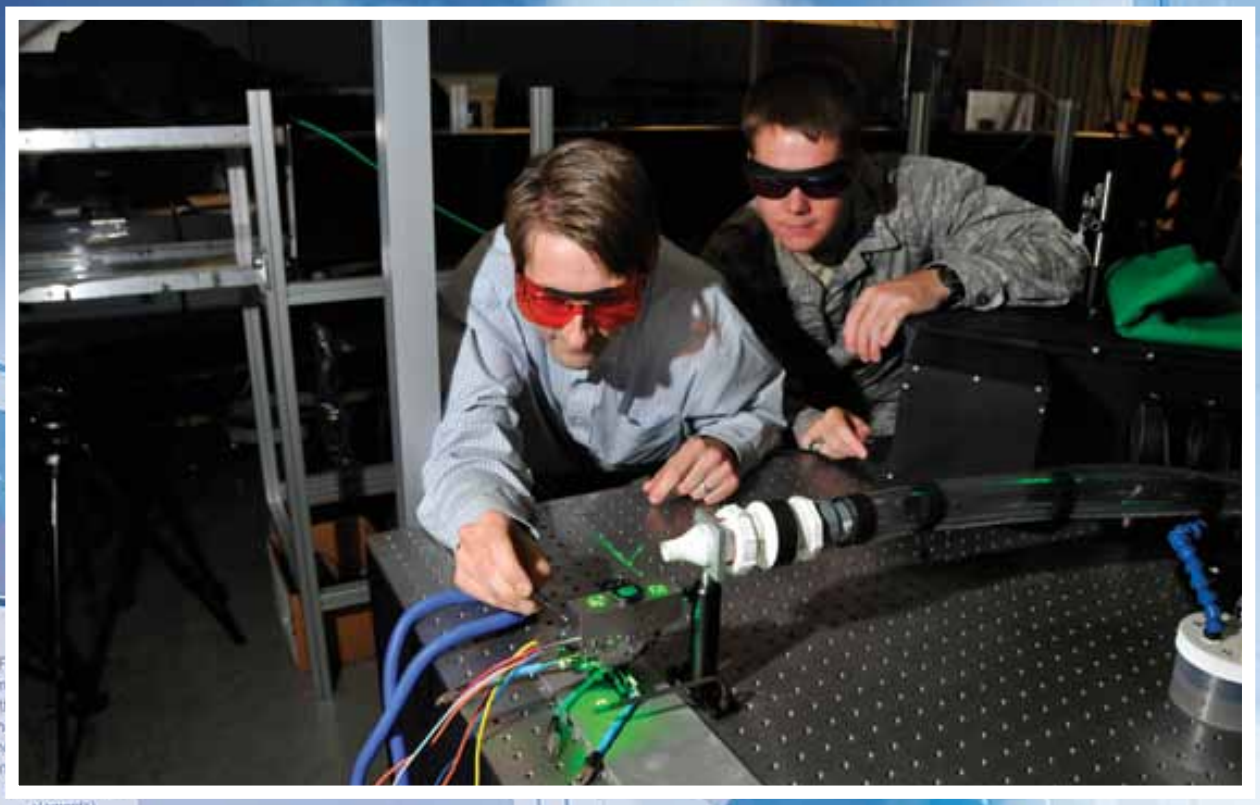
Following the lead and the needs of the greater Air Force for Unmanned Aerial Vehicle/System testing, the center has undertaken a long-term partnership with the AFRL Munitions Directorate. Utilizing ARC's low speed wind tunnel, a cadet team was able to fully characterize a working UAV at full scale. In addition to characterizing the vehicle's performance, the experiment validated a new methodology of wind tunnel investigation: "modern design of experiments," which seeks to reduce wind tunnel test time through selected test points, instead of the the classical "one factor at a time" test methodology.

Another long-term project stems from a more than 15-year relationship with NASA. Cadets have had the opportunity to be involved in a wide range of NASA projects including the X-38, Crew Exploration Vehicle (CEV) and return-to-flight efforts after the Columbia shuttle disaster in 2003. In 2011, NASA committed $200K for the next five years towards the CEV project, which is now the forerunner of the nation's next manned space vehicle. Cadets have worked on a variety of projects related to the CEV including a launch abort tower and the parachute recovery system. Cadets' efforts on the parachute recovery system include performance issues and separation characteristics of the bay cover. In fall 2010, now 2Lts Darren Montes and TJ West won the American Institute of Aeronautics and Astronautics International Student Competition for their technical paper and presentation, "Experimental Aerodynamic Investigation of NASA Orion Forward Bay Modifications," which addressed research performed in the ARC's Subsonic Wind Tunnel. NASA has used these findings to rethink some of its operations and drive design changes to the CEV.

It was the fifth time in recent years that related research was so honored at this industry competition that attracts student researchers from the likes of MIT and Purdue, as well as teams from as far away as Australia and Europe. The competition and the NASA work have also become a springboard for cadets to pursue advanced degrees after graduation: Lieutenant West is now pursuing a master's degree in aeronautical engineering at the University of Washington, and Lieutenant Montes is pursing the same degree at Rice University.

"Our cadets are producing reliable, timely and accurate data that is firmly supported by scientific research, testing and facts," said Col Neal Barlow, Permanent Professor and Head of the Department of Aeronautics. "Our cadets' level of success is indicative that we are doing a unique job of integrating real-world research and education."

Cadet Summer Research Program



LEADING BEYOND THE LABS

Leadership is a quality that extends far beyond the halls of power or the commanders on the battlefield. When dedicated leadership meets and overcomes the challenges of the research laboratory, our nation benefits. When our research leads to innovation in critical technologies and industries, our nation benefits and when we combine the best of those worlds into a dedicated education campaign to ensure a long blue line of Air Force scientists and innovators, the world benefits.

This equation is played out year after year through the Cadet Summer Research Program (CSRP) and the entrepreneurial efforts of the USAFA research program's Cooperative Research and Development Agreements (CRADAs).

Through CSRP, rising senior cadets participate in real-world research projects both here and abroad with a wide range of government and private sector research partners. In the past and currently, these partners include Congress, the Pentagon, the Air Force Research Laboratory, NASA, Intel, Google, Boeing, and other university partners such as the Massachusetts Institute of Technology, the Naval Postgraduate School, and the University of Colorado at Colorado Springs. Every summer, participating cadets report to their pre-selected research site and under the guidance of mentors, spend three to five weeks conducting and presenting their research. Upon returning to the Academy, some cadets will also continue to work on their project during their senior year as a senior capstone or independent study project.

"CSRP benefits cadet and sponsor participants as well as the DoD and Air Force. Sponsors gain skilled manpower, a 'fresh' perspective that cadets often bring to research challenges, and lasting relationships with the Academy and the Air Force. Cadets gain academically and professionally from their work with some of the world's foremost experts who give them the gift of knowledge. As future officers, cadets who master applying classroom

principles to the laboratory will be better prepared to develop and utilize research driven skills and knowledge in the variable operational world of the Air Force," said CSRP director Capt David Ratliff.

More than 190 cadets participated during the summer of 2011 on projects including advanced cyber and computational modeling, robotics and nanotechnology research, unmanned aerial vehicles and systems engineering, and defense management and public policy to name a few. There have been countless success stories of cadets' CSRP research. Some have been successfully patented, some have fielded and are helping to save lives today, and cadets have consistently communicated the value their research has had on their development as students and how it will benefit them as officers.

C1C Cole Stegeman, a Systems Engineering Management major, spent his 2011 summer CSRP at Los Angeles AFB working on the Space Based Infrared System (SBIRS) missile defense project. His work helped to complete a portion of the project ensuring block delivery of contractor requirements.

"CSRP gave me real world experience as to how an acquisitions officer works with civilian contractors to make sure systems are delivered in a way that the Air Force needs," said Stegeman, who was already considering acquisitions as a potential career field prior to his internship and stated that he now knows first-hand what he could expect from that career track. Stegeman also felt his experience gave him added leadership experience. "In terms of leadership development, I saw how Lieutenants and Captains had a lot of responsibility put on them. They volunteer for extra duty and I know I can count on working hard for promotions. I will take that away and use it in my Air Force career."

CRADAs have helped to drive the significant growth of the USAFA research program over the past decade. A CRADA allows non-federal organizations such as another university or a private sector company to leverage their investments and R&D projects, allowing them to tap into the significant research assets of the Academy including lab technology and space, cadet research, and faculty research. During 2010-2011, our

CRADA partners continued to grow and the Academy welcomed the addition of Intel and Google to our list of research partners. There are currently more than 100 active CRADA partners with more anticipated by the end of 2011. While some CRADAs are specific to supporting CSRP, many are with long-term research partners such as the MITRE Corporation, ZettaCore, Cool Clean Technologies, Boeing, Stanford University and the Massachusetts Institute of Technology. Long term research partnerships have led to the development of new solar technologies, algae bio-fuel research, critical technical and computer-based applications, and highly competitive graduate school opportunities for cadets upon graduation from the Academy.

The Academy is also striving to be a community partner in Colorado, offering undergraduates the opportunity to showcase their research every year during the Colorado Springs Undergraduate Research Forum which is jointly hosted by the Academy, the University of Colorado at Colorado Springs and Colorado College.

Chemistry Research Center

FASTER, STRONGER, LIGHTER – NANOTECHNOLOGY IN THE SPOTLIGHT

The Chemistry Research Center (CRC) at the Academy has a long and storied history starting with the center's genesis in the original Frank J. Seiler Laboratory founded in 1962. Over that period of time the center has remained a bastion of classic scientific education and research for cadets long after the original Seiler Lab was closed. Today, the center, led by Dr. John Wilkes, has metamorphosed into a national leader in ionic liquids, energy, and battery research as well as in the burgeoning area of nanotechnology. The research in the CRC is driven by cadets and faculty working intimately with the Center's active researchers, university partners, and other DoD and DoE laboratories such as the Air Force Research Laboratory (AFRL).

Nanotechnology allows scientists and researchers to build new materials from the molecular level, such as complex structures or systems. In chemistry, this emerging research area encompasses a broad range of subtopics including bio devices, polymers, composites, etc.

As a full partner of the National Nanotechnology Initiative, the CRC is currently involved in focused research to advance high-performance nanomaterials. USAFA researcher Dr. Cassie Kettwich and faculty member Capt Scott Iacono are conducting AFRL-sponsored research in advanced materials to include high energy munitions, nanocomposites for propulsion components and alternative fuel cell technology. With cutting-edge capabilities, the CRC is able to synthesize and engineer materials by manipulation at a nanometer level, one atom at a time.

"Nanotechnology is really at the forefront of research important to the Air Force and US industry. The faculty's ability to expose and guide cadets to that kind of

technology and research early in their education experience is of great benefit to them regardless of what they choose to pursue their degree in," said Dr. Don Bird, the acting head for the Department of Chemistry.

Cadets are currently working on several nanotechnology projects. One such project focuses on fluoropolymers, which possess high thermal and chemical resistance, and are widely known as the key ingredient in Teflon non-stick cookware products and water-resistant Gore-Tex™ jackets. The potential development of new energetic fluoropolymer nanomaterials with potential uses in aerospace and high-performance space applications is one area cadets are researching.

Another key CRC initiative with AFRL focuses on polymer nanocomposites that mimic the water repellent nature of the lotus leaf. By synthesizing flurosilicon-based nanostructures within another polymer, researchers and cadets are transforming what is considered the most liquid repellent molecules known to date and is a class of fluorinated polyhedral oligomeric silisesquioxanes known as F-POSS. The hope is the research will eventually lead to the fabrication of omniphobic (liquid hating) materials which could lead to a wide variety of space and aeronautics applications including preventing seal fatigue in engines and mitigation of solid rocket motor insulation degradation.

As technology advances are transforming the traditional perception of chemistry, biology, robotics and more - cadets are once again being given an opportunity to help lead the way for new Air Force applications.

According to Iacono, "One distinctive characteristic of nanoparticles is that they may display size-related properties that can differ significantly from those observed in bulk materials of the same substance. Material properties such as optical, mechanical (elasticity, hardness, corrosive resistance, etc.), electronic, energetic and magnetic qualities can perform very differently below the material's critical size. The use of nanoparticles in the scientific fields exploits these intrinsic materialistic aberrations to create desired effects in the bulk material for a vast range of applications."

This range is allowing cadets and faculty to conduct diverse research that bridges multiple disciplines such as biology, engineering, and chemistry. Examples of research in this area includes integrated circuit packaging to synthesizing durable and capable energetic materials in fuel cells, cryogenics, water and grease resistance fabrics, and materials coatings. The CRC is breaking new ground on synthesizing and modifying select nanoparticles with the best stability, sensitivity, and reactivity. This is allowing cadets to research applying these new materials to light emission and electrical/magnetic capabilities for potential use in optics, space coating, and fuel cell proton exchange membranes.

Under faculty mentorship, cadets at USAFA are using all of these ideas to synthesize novel energetic materials in order to appreciate their potential applications or limitations for use as energetic materials for the DoD. Ionic liquids containing nanoparticles are being developed and the energetic properties of these novel solutions are being investigated for the first time.

Eisenhower Center for Space & Defense Studies

DEFENSE POLICY FOR AIR, SPACE, & CYBERSPACE

The Eisenhower Center for Space and Defense Studies is the research center for the Department of Political Science, giving renewed focus to the Department's fifty-year tradition of defense policy studies. The Center provides cadets and faculty the opportunity to contribute innovative space policy research to new and emerging challenges in assuring the security of the nation in the 21st Century. The Center serves to increase the Academy's teaching capabilities and presents cadets with opportunities to learn first-hand from national and international leaders about the issues and problems that will confront them in their Air Force careers. The Eisenhower Center develops and promotes educational resources to understand the role space systems play in overall U.S. defense and strategic policy, contributing not only to enhancing military capability but also to achieving overall U.S. foreign and strategic policy goals. Over the past year, the Center also responded to the call from national security leaders to apply this same rigorous intellectual foundation of inquiry from the defense policy studies discipline to thinking about challenges in the cyber domain.

Led by Ambassador Roger Harrison, the Eisenhower Center has greatly increased the resources the Academy devotes to space and security studies, including the publication of its Space Defense Policy textbook, expansion of graduate study opportunities in space policy for cadets, funding cadet and faculty research projects and internships, and bringing cadets together with senior officials and other experts in workshops on key space policy issues facing the

United States. These workshops have included a series of discussions on topics ranging from improving space situational awareness, the dynamics of US-Chinese strategy and security in space, and trans-Atlantic space cooperation.

The Center has recently been designated as the recipient of a multi-year grant from the Office of the Secretary of Defense to establish a Minerva Research Fellowship program at the Air Force Academy. The Minerva research grant will concentrate on exploring ways to improve our understanding of the evolving strategic relationship between the United States and China. Specifically, the Minerva Fellows sponsored under this program will apply contemporary political, historical, and cultural scholarship to an analysis of the options for the United States in dealing with China as a nation of rapidly rising economic influence on the international stage that is confronted with domestic challenges to its sustained growth and stability.

The Center is named in honor of Dwight D. Eisenhower. Eisenhower was the first American president to establish a national policy on the use of space for both military and civilian purposes. His legacy – the creation of both the National Reconnaissance Office and NASA– laid the foundation for the manned space program, the use of space to bolster national security, and the infrastructure which led to revolutions in battle management and global communications. This foundation remains the benchmark against which all successive policies are measured.

The Eisenhower Center has also fostered inter-service education, highlighted by the Summer Space Seminar, a selective two-week program for cadets from the U.S. Air Force Academy, U.S. Naval Academy (Annapolis) and U.S. Military Academy (West Point), along with selected civilian colleges. Cadets have the chance to visit and learn about the key issues and institutions of the industrial, civil and military space sectors.

This year marked the first year of teaching by the Brent Scowcroft Professor in National Security Studies. The Scowcroft Professorship is held by Dr. Schuyler Foerster and recognizes the contributions to national security made during the military and civilian career of Lieutenant General Brent Scowcroft, who served as a faculty member of the Department of Political Science when he was a field grade officer. Dr. Foerster is leading the effort with faculty from the Department of Political Science to produce a new edition of its textbook American Defense Policy, designed to reach every cadet graduating from the Air Force Academy through the core political science course and provide them with a foundation for thinking critically about national security and the military profession.

Like other research centers at the Academy, the Eisenhower Center also makes significant contributions to the needs of the Air Force and Department of Defense at large. The Center has conducted studies on behalf of the Office of the Undersecretary of Defense for Policy which have provided the first clear intellectual framework for adapting deterrence theory to space systems and addressed the political and technical challenges of verifying agreements on activity in space. The Center's landmark deterrence study was subsequently used in Washington, DC, for discussions leading to the Quadrennial Defense Review and the new national space policy. In the coming year, the Center will complete its study of space governance and begin a new exploration of cross-domain deterrence.

Under the leadership of Ambassador Harrison, the Eisenhower Center remains focused on its goal to mentor cadets in both technical and non-technical majors interested in defense policy, encourage research and publication on space, cyber, and security topics, and to ensure the Air Force has a cadre of future leaders familiar with and inspired by the challenges of operations in space.

"When we think about space, we tend to think about it technically. We need to think about it politically and strategically. The space domain confronts the war fighter with distinct challenges, both operationally and in terms of policy. The Center's task is to prepare them for those challenges, giving them the opportunity for cutting edge research and to nurture them as future leaders of the greatest aero-space force in the world," said Harrison.

Center for Physics Education Research

CRITICAL ENGAGEMENT IN PHYSICS EDUCATION

The Center for Physics Education Research (CPER) is on the frontlines of transforming the Academy's learning and teaching environment. It provides a platform on which faculty and students can become fully engaged in physics and on a broader scale, other intellectual endeavors.

Housed in the Physics Department and led by Lt Col Steven Novotny and Distinguished Scholar Dr. Gregor Novak, the center made considerable progress during the 2010-2011 AY. The biggest success story was the continued innovation in the Just-in-Time Teaching (JiTT) program. The focus has been on further implementation, development and expansion of this successful program. The JiTT pedagogy has been augmented over the past four years by the creation and classroom testing of research-based pre-instruction learning resources for our introductory physics courses. With this effort we are expanding and standardizing the proven advantages of a JiTT-based classroom. The resource development has been based on the worked-examples and self-explanation paradigms. Both of these pedagogies have an extensive education research foundation. The worked-examples paradigm represents a powerful instruction strategy, but there is a major barrier that must be overcome by any instructor desiring to implement it. Creating effective worked examples requires both an understanding of the best practices involved (and the pitfalls to avoid) and a large investment of time and

effort in crafting the examples and support materials.

"CPER researchers lead the way in providing the necessary expertise to author and develop these resources, bringing all of the benefits of the research-based pedagogy into the classroom," said Novotny.

Currently JiTT products are being widely utilized across USAFA, with up to 60% of all cadets using the JiTT Preflight server. This curriculum emphasizes the students' efforts at self-explanation, a class experience built around the students' current understanding, and an interactive classroom experience—all of which are methods proven to enhance student learning. This approach has proven so successful that both physics core courses at USAFA, as well as some in other disciplines, are firmly founded on the CPER Just-In-Time Teaching/Worked Examples pedagogy.

"We have used our successes as a foundation for seeking further funding to expand the program in such a way that these techniques will become a permanent part of the teaching philosophy in the physics department at USAFA and beyond," he added.

Comprehensive assessments of the project for the past seven semesters are underway and the center is embarking on a project to assess and understand the classroom impacts of JiTT and other CPER programs.

Another successful effort was the implementation of the center's Do-It-Yourself Modeling program. This multi-disciplinary effort is a cross-collaboration partnership with the U.S. Military Academy at West Point, NASA, and six civilian universities and colleges. The project, led by Drs. Brian Patterson and Gregor Novak, includes using simulation and gaming software to construct an environment in which students hypothesize solutions to problems, construct models to simulate their hypotheses, and then compare the results of those models to observations. The students use standard mathematical notation rather than software-specific notation for their modeling tasks. Thus, the emphasis is on the science modeled rather than on programming skills. This software, professionally developed by programmers who also develop NASA simulation tools, is a powerful tool for exploring challenging and realistic problems.

Exploiting the strengths of the Do-It-Yourself program, the CPER is leveraging this National Science Foundation funded research to further expand the worked examples impact by initiating an effort to combine the Do-It-Yourself modeling software with current pre-class exercises. This effort enhances the pre-class experience by allowing students to not just read about, but actually explore text-book examples through the use of computer simulations with video-game quality graphics.

The USAF Academy currently ranks fifth in the most accessible professors category in the annual Princeton Review of universities and colleges nation-wide. One way this is accomplished is through extra instruction opportunities for cadets. The CPER is looking to improve upon this model with Alternative forms of structured extra instruction (EI) periods. This project is being led by cadet researcher C1C Nolan Sweeney. Sweeney's project offers students additional EI periods centered on unique mathematical learning exercises specific to the physics they are currently using. Furthermore, to assist their success in Physics 215, *General Physics II, Electricity and Magnetism*, C1C Sweeney is actively searching for areas to improve student visualization abilities. As part of this research, Sweeney has tracked which students attend the EI periods, and gives this information to the course director so that participation in these special EI sessions can be evaluated against student performance on graded events. A short feedback form is also given to students at the end of the sessions to gather feedback about the immediate perceived effectiveness of the activities.

With workshops and brown-bags the CPER provides faculty with opportunities to develop expertise in active learning techniques, designed to help students deal with physics questions as an expert physicist would deal with them.

"Starting with 'decoding the disciplines' techniques that help faculty identify the conceptual bottlenecks and develop scenarios and activities that model the expert's handling of these, participants were taught to construct in-class and out-of-class student assignments and activities, following the "Just-in-Time Teaching" paradigms that guarantee a high level of timely interactions between students and instructors," said Novotny.

Center for Aircraft Structural Life Extension

TECHNOLOGY FOR AGING AIRCRAFT MAINTENANCE IS MISSION CRITICAL

According to the *Air Force Times* in 2010, the average age of aircraft in the Air Force is 24 years old and some of the senior citizen aircraft such as the KC-135 tanker aircraft are today in excess of 50 years old. And the fleet is not getting any younger.

To keep the Air Force fleet in the safest and best operational shape, the researchers and cadets in the Academy's Center for Aircraft Structural Life Extension (CAStLE) are working on the front lines of critical structural integrity, analysis, and maintenance programs. Led by Dr. Gregory Shoales (Director) and Dr. James Greer (Technical Director), the CAStLE lab is a flurry of activity in its multi-million dollar laboratory which houses a diverse range of machinery and the newest technologies such as a new nano-laboratory for micro-machining and surface analysis, an advanced X-ray computed tomography machine, two types of electric discharge machines (EDM), a laser Computer Numerically Controlled (CNC) cutter, a rapid prototyper, and a coordinate measuring machine for reverse engineering. The lab is also home to a new composites development lab.

The CAStLE is currently involved in projects ranging from new materials research to multiple aging aircraft structural teardown analysis, corrosion, and energy harvesting projects. Funding for these efforts comes from a variety of sources including the Air Force Office of Scientific Research (AFOSR) and other DoD and Air Force organizations such as the C/KC-135 Sustainment Division at Tinker AFB.

"CAStLE supports our cadets' education by giving them hands-on, real-world structural sustainment experiences. Many USAF aircraft are seeing their third generation

of pilots—some of our cadets will be flying airplanes their grandfathers flew. They are seeing first-hand the breadth and depth of the technical problems that must be addressed to keep these 'mature' aircraft flying for decades to come," said Greer. "Our cadets get to work with the Government and contractor teams charged with solving today's aircraft structural issues and, upon graduation, will head off to their Air Force jobs with a deeper appreciation of what's needed to sustain our warfighting capabilities."

The center works to carve out cadet projects from every project the center undertakes. Structural teardown analysis programs, designed, planned and executed by CAStLE engineers with various aspects assisted by cadet projects, are used to destructively analyze retired USAF airframes to gain insight as to their condition not possible by any other means. Such insight in turn yields answers as to suitability of the entire fleet for extended safe service beyond original design service goals. Due to its previous record of successful research, CAStLE authored the USAF manual for Teardown Analysis Programs and is currently considered to be the world's expert on the subject. Current teardown programs encompass the C/KC-135 Tanker, the B-1B Bomber, and the C-130 Transport empennage.

An example of the work conducted in the center can be seen in the C/KC-135 Tanker project, a partnership with Tinker AFB, involving three complete aircraft undergoing the most comprehensive nose-to-tail and wingtip-to-wingtip teardown analysis of any aircraft ever undertaken world-wide. Project researchers anticipate the inspection of more than 25,000 parts by multiple techniques, and it is expected to yield more than 30,000 inspection results to help fleet managers reach the current service requirement beyond 2040. Cadets have been intimately involved in the evaluation of the fatigue residual life of fuselage lap joint panels and the evaluation of the static residual strength of similar fuselage lap joint panels. In Engineering Mechanics 445, *Failure Analysis*, cadets gain real-life root cause analysis experience as members of the analysis teams. Multiple cadets have accomplished full analyses of inspection indications which have become part of the formal report and data to be used by the KC-135 fleet managers.

Another major thrust in the center's mission is its USAF Aircraft Structural Integrity Program Support. Due to the center's recognized structural integrity expertise, researchers and cadets provide continuous support to multiple aircraft fleet managers at Hill AFB (A-10 and T-38 aircraft) and Tinker AFB (KC-135 tankers). The projects are varied and range from designing and validating repairs, performing residual life analysis, augmenting the current crack growth prediction database, and exploring material substitutions of legacy alloys.

The 2010-2011 Academic Year also saw the completion of a six year project for the U.S. Coast Guard collecting critical flight data and analysis. This project not only resulted in a cadet-developed temperature correction equations for a strain measurement device and the validation of CAStLE developed structural models but also resulted in the safe extension of the life of the U.S. Coast Guard HC-130H fleet by several thousand flight hours.

"Our faculty's professional development is enhanced in much the same way, by providing them with state-of-the-art tools to address current sustainment problems for the Air Force. Working with other DoD professionals in the field, our faculty are able to bring the most current and relevant technical issues into the classroom. This obviously benefits the cadets, but also has a 're-bluing' effect on the faculty, fostering their professional development, and increasing their value to the cadets and the Air Force," added Greer.

This can be seen in the Center's energy harvesting capstone project to design, build, and test systems that can harvest energy to power structural health monitoring systems for use on bridges and other DoD infrastructure as well as the University Corrosion Collaboration efforts. Cadets and faculty have the chance to work with the Office of the Secretary of Defense on these projects as well as with other university partners who jointly work to address the needs of aging aircraft and infrastructure globally.

USAF Academy K-12 STEM Outreach Center

SCIENCE FOR A NEW GENERATION OF STUDENTS

Renewed investment in today's students of science, technology, engineering and mathematics (STEM) is crucial to America's place in the world as a leader in innovation and productivity. A crisis in America's STEM workforce has been brewing since the end of the Apollo program in the 1970s, and the tipping point has come and gone. In 2009, the majority of US patents were awarded to non-US entities and majority of PhDs in STEM disciplines went to non-US citizens. It will take at least a decade (or longer) to solve this problem.

The front lines in this battle for the young minds of today are in K-12 classrooms across America. There, teachers bring engaging STEM education to students who need to see the vast potential for personal satisfaction and income that STEM professions offer. Faculty and cadets at the United States Air Force Academy have been reaching out to the Colorado Springs community for decades to support STEM education. However, in 2009, the USAF Academy Office of Research began formalizing establishment of a single center to support

and expand these diverse STEM outreach efforts, and in February 2011 the Dean of the Faculty, Brigadier General Dana Born, established the Academy's K-12 STEM Outreach Center.

Dr. Billy Crisler teaches aircraft design at the Academy and is the Center's first Director. "For years, the Academy viewed itself as a STEM consumer, taking the cream of each year's high school class from around the nation. We know now that we must become a STEM supplier and do our share in our community to broaden the stream of young people preparing themselves for STEM careers in civilian government and industry and in the military."

The Center expresses the Academy's strategy of effective, local, grassroots solutions to this national STEM workforce crisis and has already captured more than $600,000 in funding via the Secretary of Defense's National Defense Education Program (NDEP). In addition to supporting and expanding existing Academy STEM outreach efforts, the center serves as a coordinator and clearinghouse to match STEM resources from inside and outside the Colorado Springs community to STEM needs. The Center also builds partnerships with local STEM industry and STEM professionals to support STEM activities in the schools. Efforts range from hands-on events for students in Academy labs to teacher training opportunities like the annual STEM Bootcamps. Examples of the former include the year-round Cool Science activities, which bring hundreds of Girl Scouts through the Chemistry labs for exciting science activities such as Bungie Barbies, Pin Hole Cameras, and the always-popular Chemistry Magic Show. The Center's keystone K-12 STEM Educator Bootcamps offer teachers new and exciting STEM teaching methods. During 2011, more than 80 teachers from across the country spent 6 days building robots, building and testing underwater remotely operated vehicles, building and launching rockets, and listening to keynote and guest speakers from across the country, including NASA astronaut Clayton Anderson, Federal Aviation Administration (FAA) Deputy Regional Administrator David Suomi, and FAA Ambassador for Aviation and Education Jamail Larkins. Participants took valuable experience and hardware (e.g., Garmin GPS units, LEGO Mindstorms, Sea Perch kits, etc.) back to their classrooms and earned credit towards continuing education.

The Center has partnered with the Colorado Consortium for Earth and Space Science Education (CCESSE) to support a growing team of organizations that includes Challenger Learning Center, Project Lead the Way, the American Institute of Aeronautics and Astronautics, Cool Science, and For Inspiration and Recognition of Science Technology (FIRST) Robotics. All of these programs work directly with students and teachers to first spark interest in STEM and then sustain that interest with a variety of in-class and after-school programs. The Center currently supports programs in School Districts 11, 20, 38, 49, near-by Teller County, and other smaller districts and home school networks across southern Colorado. Peak Area Leadership in Science, a local teacher association and social network, is part of CCESSE and has been crucial to engaging with teachers.

For those on Twitter and Facebook, Ms. Aurora PhD is a falcon character who visits with students and STEM educators. She also partners with other STEM characters across the country such as Stanford's Solar Dynamics Lab's Camilla Sdo and American Institute of Aeronautics and Astronautics' Skye Bleu. The characters undertake STEM education adventures, including witnessing the final Space Shuttle Atlantis launch in July 2011, and share their adventures on-line.

Dr. Crisler is optimistic, "The Colorado Springs community is poised to create a great example of effective local STEM collaboration to help solve the national STEM workforce crisis. Our strategy is to bring the Academy's core values of Integrity First, Service Before Self, and Excellence in All We Do to coordinating the goodwill we see in the Colorado Springs community. We have all the pieces in place here to help solve this crisis, and once we as a community do the job right, we hope to reach out to other communities who want to create their own solutions."

Note: all minors featured have DoD images release forms on file with the USAFA Research office.

Scholarship of Teaching and Learning

TEACHING THE EDUCATORS RESULTS IN STUDENT SUCCESS

Much like a plant needs water to grow to its full potential, the Academy's Scholarship for Teaching and Learning (SoTL) Program is working to ensure educators get all of the tools they need to grow as teachers and to pass that growth on to their respective students. Via the latest research, technological tools, and well-developed best practices for teaching and learning models, faculty at the USAF Academy have an unlimited chance to not only better themselves as educators but to shape the national dialogue on the profession of teaching.

Under the guidance of SoTL Director Dr. Lauren Scharff, and made possible by a generous gift of funding from Mr. John Martinson, the SoTL Program implemented more than 20 SoTL research projects during the 2010/2011 academic year, involving faculty from all four academic divisions. While many of these projects involved a single instructor systematically investigating the results of a new pedagogy in his/her classroom, several of the projects involved multiple instructors and were multi-disciplinary in nature.

For the first time, two SoTL projects had cadets leading the investigation as part of independent study courses experiences. One of these projects focused on a mathematics and physics challenge and the other focused on language acquisition between two similar languages, Portuguese and Spanish. Additionally,

several of the projects addressed topics linked with USAFA strategic outcomes such as Respect for Human Dignity, Critical Thinking, and Intercultural Competence.

"A key goal of the SoTL Program is the later implementation and further use of the findings from the projects. I'm happy to report that is indeed happening," said Dr. Scharff.

Technology and its use as a teaching and learning tool was one area of particular focus during the 2010-2011 academic year. An e-reader project co-led by Dr. Scharff and the director for the Center for Cadet IT Research, Carolyn Dull, studied the impact of e-published textbooks and a variety of types of e-readers on cadets' learning behavior, both inside and outside the classroom, across an entire semester. This study represents one of the first multi-disciplinary, academic studies investigating the impact of e-readers on student behaviors such as note-taking, reading assigned texts, and study habits.

At the beginning of the Spring semester in 2011, the SoTL Program and the Institute for Information Technology Applications (IITA) distributed a small number of the more versatile e-reader devices such as the Apple iPad and the HP Slate to some participating cadets, with an additional eleven cadets participating by using e-reader applications on their standard-issue laptops. These particular devices were targeted because they have expanded e-reader functions such as detailed color displays for images, connection to the internet via wi-fi, and the ability to both download and develop interactive user applications to better connect with material. Each cadet had texts for at least two of their courses available on their designated e-reader device. How cadets utilized the technology and their attitudes towards the devices was also studied, with information about their text reading, note taking, and the timing and type of use collected.

Ultimately, said Dr. Scharff, using new technologies comes with costs, both for the equipment itself and often with respect to the time and effort to learn how to effectively use the new technology. Initial data suggest that the smaller, more portable devices were likely to lead to significant increases in reading, due to the increased accessibility of the e-text material compared to the need to carry around large textbooks or the heavier laptop. However, all the devices, especially the smaller ones, had drawbacks with respect to screen space and cadet ability to type notes in a separate document while reading the e-text. However, cadets reported a strong interest in continued studies as the technologies improve and as e-texts add extra e-resources to enhance learning (e.g. online mastery quizzes, interactive demonstrations).

Overall, instructors from across the Academy have worked with the SoTL Program to test a variety of new approaches, all with the goal of improving the cadet experience and, ultimately, cadet learning. For example, Capt Frank Echeverria and Dr. James Rolf developed video tutorials to use as part of pre-flight activities in Engineering Math. The videos were so helpful that students in other instructors' sections started using them. Lt Col Richard Dabrowski examined the impact of different types of mural displays in the Spanish classrooms in order to better understand how to motivate cadets to learn Spanish. Capt Tim Frank and colleagues from across several engineering departments studied the impact of learning contracts. Early data suggested that, for students who had performed poorly on the first exam, making a commitment to study and attend extra instruction via a contract made a significant positive impact on their learning behaviors and final course grade. Dr. Sarah Robinson in Geosciences assessed the impact of a new lab submission format on student mastery of course content and preparation for the final project.

SoTL researchers share their projects and inspire other Academy instructors at the annual SoTL Forum, held in September of each year. They additionally share their ideas and findings via monthly SoTL Circle discussions and departmental brown bag presentations. During the 2010-2011 academic year, ten SoTL projects were presented at conferences, several of which had international audiences, and three project papers were accepted for publication.

"The enthusiasm for supporting and enhancing cadet learning is apparent in the steady stream of instructors who come to the SoTL Program," says Dr. Scharff. "It's a win-win approach to teaching, because it is these types of experiences and research opportunities that will directly benefit the cadet learning experience and will contribute to a better teaching environment as well."

Center for Space Situational Awareness Research

AWARENESS = SUCCESS IN SPACE MISSION

The mission of the Center for Space Situational Awareness Research (CSSAR) is to develop world-class space situational awareness education and research programs for cadets, faculty, and the Air Force. In August 2011, NASA and the astronauts on the International Space Station had a close call with a piece of space junk that missed impacting the station by less than 1,000 feet and forced the crew to take refuge in the Soyuz escape pod. This is just one example of the importance of space situational awareness in the U.S. Air Force (AF) and Department of Defense (DoD) space missions. With numerous pieces of orbital space junk monitored by NASA and many nations' space assets, keeping track of what is where and how it could impact any space mission is critical. Developing future leaders who can anticipate and respond to the needs of the AF space mission is one of the goals at the U.S. Air Force Academy.

In Spring 2011, CSSAR had a number of accomplishments. Physics 375: *Physics of Space Situational Awareness* (SSA), the newest physics course, was taught by Dr. Michael Dearborn to four physics majors. During the academic year, Dr. Dearborn assisted in the training of seven PALACE ACQUIRE engineers and analysts from Air Force Space Command (AFSPC) in the fundamentals of SSA. Dr. Dearborn incorporated a number of laboratories and guest lecturers into the curriculum, adding relevancy and motivation to the course. One guest lecturer from the National Reconnaissance Office offered cadets a classified glimpse into the world of satellite reconnaissance. Another guest lecturer from AFSPC provided cadets an understanding of the natural space environment and its impact to satellite operations. The impact of this course is best summed up by a recent USAFA graduate, 2Lt Daniel Fulcoly,

who took SSA as a special studies course (Physics 495) in Spring 2010. Lt Fulcoly is currently working on a graduate degree at the Massachusetts Institute of Technology and said, "I've definitely had the opportunity to use what I've learned in Physics 495! We had a 90-minute lesson on space-optics and there was nothing I hadn't already seen in 495."

2Lt Fulcoly's paper entitled "Determining Basic Satellite Shape from Photometric Signatures" was accepted for publication by the *Journal of Spacecraft and Rockets*. Fulcoly's co-authors were 1Lt Katharine Kalamaroff, a Class of 2009 physics major, and Dr. Francis Chun, a professor at USAFA. C2C Kody Wilson continued Fulcoly's research project by advancing the optimization of multiple telescope sites for determining satellite shapes solely from photometric light curves. Simply put, he used a larger set of sites to analyze many more combinations. He also analyzed how well various combinations worked in determining satellite shapes compared to a single telescope site.

Dr. Chun said, "Cadet Wilson's work was important in that he, for the first time, confirmed an assumption we and our colleagues in the Air Force Research Laboratory (AFRL) have been using for six years; mainly that multiple telescope sites simultaneously observing the same satellite yielded more information on that satellite than a single telescope site." Cadet Wilson presented his results at the 2011 Non-Resolvable Space Object Identification (NRSOI) Workshop hosted by AFRL in Maui in April.

CSSAR also completed the upgrade of the 16-inch telescope at the USAFA Observatory, converting the system into a fully capable satellite tracking telescope. With this new system in place, CSSAR has observed various satellites orbiting Earth and was the first DoD organization to image FalconSAT-5. In Figure 1, FalconSAT-5 is the bright dot near the center and the stars are the streaks; this is because the telescope was tracking the satellite's orbital motion, not the rotation rate of Earth. Figure 2 is another observation taken by the Academy's 16-inch telescope of the International Space Station on 23 February 2011. Due to its much larger size, the International Space Station is a more clearly resolved object. Using observations taken by the 16-inch telescope, Dr. Chun presented satellite photometric observations at the NRSOI Workshop, while Dr. Roger Tippets presented satellite spectra.

Figure 1. First image of FalconSAT-5 made by CSSAR on 5 January 2011.

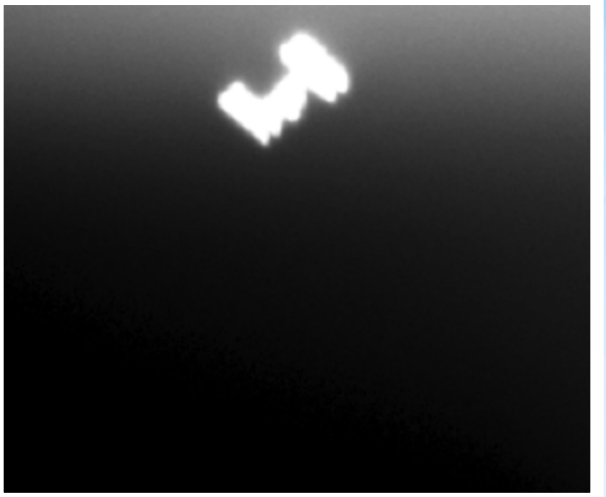


Figure 2. Image of the International Space Station taken on 23 February 2011.

Finally, CSSAR was successful in securing approximately $775K in funding from AFSPC, Space Innovation Development Center, Defense Advanced Research Projects Agency (DARPA), and AFRL. Dr. Chun said, "Clearly the rest of the Air Force and Department of Defense are realizing the importance of cadets learning about SSA and what it brings to the warfighter."

Life Science Research Center

UNLOCKING BIOLOGY'S ENERGY SECRETS

The researchers and cadets in the Life Science Research Center (LSRC) at the USAF Academy are peeling back the curtain on biology's potential renewable energy secrets. The research center, multidisciplinary by nature, focuses on a wide range of critical areas including bioenergy and force health protection.

A part of the center's seminal research efforts include providing detection and mitigation of biological threats and remains a high priority with the LSRC. LSRC researcher Melanie Grogger and Cadet Craig Nowadly completed preliminary research involving the formulation and testing of novel real-time molecular diagnostic reagents that are stable in field conditions. Grogger and Nowadly focused on the design and evaluation of operationally -relevant molecular-based testing reagents to detect pathogens and toxins from environmental sources in potentially adverse (extreme temperatures) field conditions. The challenge of this research is that most real-time PCR reagents are temperature sensitive and are typically not stable outside laboratory conditions. Under a cooperative research and development agreement (CRADA) with molecular biologist Dr. Daniel Atchley of the Harding University College of Pharmacy, LSRC researchers are working towards the creation of a robust PCR master mix that would remain stable in spite of harsh field conditions and will lead to real-time analysis of biological threats.

In yet another intriguing area of biological research, cadets are conducting joint research on various oil producing strains of algae with the U.S. Department of Agriculture (USDA), Brooklyn College, Cool Clean Technologies, the Air Force Research Lab (AFRL) and the University of Dayton. Cadets working with the USDA and CRADA-partner, Dr. Juergen Polle, have done considerable work exploring the optimization of algal media for a variety of algal species through a comprehensive series of experiments configured by a sophisticated software program (STAT-EASE, Design Experiment). The goal of this research is to simultaneously derive the best mix of nutrients and environmental factors for optimal growth and oil accumulation. This experimental method has the potential to accelerate research towards finding the most promising microalgae candidates for commercial

biofuels production. Dr. Polle of Brooklyn College provided select microalgae candidates which were subjected to new media manipulations as a means of providing super-performing strains of algae with greater overall biomass productivity and enhanced lipid production for biofuel production. Dr Simina Vintila, a post-doctoral researcher in the LSRC, made additional arrangements to expand investigations into the area of lipidomics to better understand the lipid characteristics of promising algae strains. Researchers and cadets, using recently acquired state-of-the-art chromatography equipment, will be examining the respective classes and types of lipids produced by selected super-performing algae over multiple semesters. This research will contribute to the algal scientific community through a better understanding of how metabolites are directed towards lipid generation (carbon partitioning).

"Such information is critical towards the eventual commercial production of liquid transportation fuels for ground or aviation uses, in terms of stability, ignition point and cold flow properties. This project is expected to identify and generate strains of microalgae capable of superior biofuel production essential to making renewable fuel sources economically viable," said Dr. Don Veverka, LSRC Director. Concomitantly, this research will provide novel strains and data on strains to other biofuels research efforts currently funded by the Air Force and/or the US Department of Energy, thus complementing and supporting other research groups.

The center also sent several cadets on Cadet Summer Research Programs (CSRP) involving biofuels. Cadet Michael Wojdan worked to improve harvesting methods in algae ponds and bioreactors located at Tyndall AFB, FL. Cadet Kris Morehouse's algal cultivation techniques developed with AFRL partner University of Dayton Research Institute were instrumental for quickly creating replicate stock cultures for experimental purposes. Wojdan and Morehouse conducted preliminary studies involving environmental manipulations (irradiance, temperature, nutrient supplementation, etc.) to help set up the center's new media optimization trials during the Fall 2011 semester. Their scientific leadership inspired other biology majors to engage in this research and the center expanded future CSRP opportunities for this research with AFRL, Brooklyn College, and University of Dayton for follow-up biofuels research projects connected with microalgae. Additionally, their algae research reaches across other disciplines as Department of Management cadets created a comprehensive business plan involving a remote biofuels production facility at a forward deployed location. Developed in coordination with Dr. Kurt Heppard, Department of Management, and Dr. Veverka, the cadets' plan was selected as one of ten finalists in the annual National Security Innovation Competition.

During 2010-2011, the center worked to build a sustained and expanded research program involving algae to biofuels. While the Air Force Office of Scientific Research (AFOSR) and AFRL generously support the research mission of LSRC, Dr. Veverka and his team are working to secure additional funding and to fully leverage the resources at the Academy. Building a substantial alternative energy research program with the requisite equipment, supplies, and research personnel is vital to the educational experiences of our cadets. Conducting biofuels research will result in cadets becoming knowledgeable with the energy issues facing our nation and ultimately assist them in making critical resource decisions in their subsequent Air Force careers.

"The fascinating part about our cadets working on alternative energy research is that it has immediate ramifications for their future. The Air Force has nearly completed its testing on synthetic and green fuels for use in its aircraft fleet and is looking to acquire half of its domestic aviation fuel stocks from alternative fuels by 2016," said Veverka. "Our cadets are an integral part of meeting that goal by working firsthand with one of the algae feedstocks that will help support that requirement." As one cadet has put it, "More than likely, I'll be flying a jet that will hold a JP-8 blend containing one of the algae stocks we are now investigating—our research does not get any more 'real' than that!"

Academy Center for Unmanned Aerial Systems Research

RECONNAISSANCE- KEY TO OPERATIONS SUCCESS

The ability of the Air Force to provide timely, integrated intelligence, surveillance, and reconnaissance (ISR) to Department of Defense assets has become crucial to mission success and to saving lives.

The Academy Center for Unmanned Aerial Systems Research (ACUASR) has been working hard to meet this critical operational need through ground-breaking research on a variety of new technologies using multiple, autonomous unmanned aircraft to support ISR operations, innovative small UAS designs, and covert micro-UAS perching technologies.

Accurate knowledge of ISR requirements and their role in the development of the next generation of UAS are necessary for today's UAS operations and successful use of the technologies in the future. Such knowledge is also crucial for tomorrow's Air Force leaders. In 2010, the Air Force Posture Statement called for greater investment and deployment of RPA (remotely piloted aircraft, also known as UAS) technologies and aircraft as well as for more RPA-only pilots and manpower hours, dedicated to supporting RPA operations and ISR integration.

Led by Dr. Daniel Pack, the center is multi-disciplinary by nature, employing faculty and cadets from Aeronautics, Electrical and Computer Engineering, Engineering Mechanics, and System Engineering. The increasing number of viable UAS applications in both military and civilian communities offers complex classroom and research challenges to faculty and cadets and provides ample opportunities for them to solve relevant problems on multiple levels. "When cadets start a project they are often overwhelmed by its scope, complexity, and competing design requirements. But once finished, their (cadets) belief in their abilities has increased an enormous amount," said Pack. "They are more confident about their ability to make correct decisions and solve difficult problems. The experience will help them to become more versatile officers and stronger leaders."

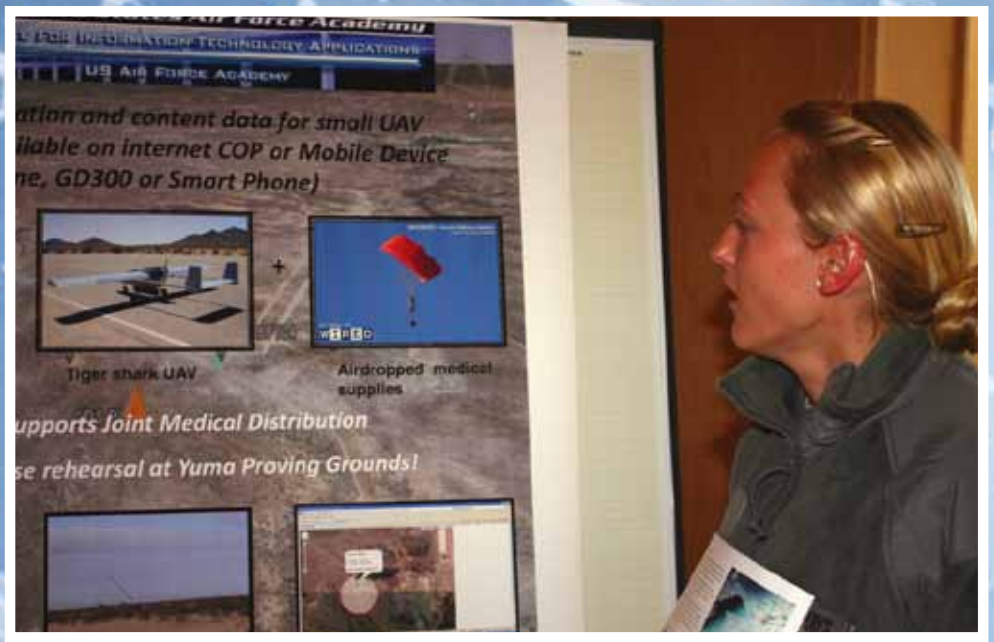
The center seeks to provide solutions to challenging UAS problems. The ACUASR is currently working on research projects with a number of outside academic, government, and industry partners including the Office of the Secretary of Defense, Rapid Reaction Technology Office; the Air Force Research Laboratory directorates for Air Vehicles, Information, and Munitions; the U.S. Military Academy; the U.S. Naval Academy; and the MITRE Corporation. The center's total external research funding received during the past academic year was $865,000.

"Our USAFA core curriculum emphasizes developing critical thinking skills," Dr. Pack points out. "Our research has revealed that UAS operators may have large amounts of information at their disposal. The operator's decision-making process depends heavily on these critical thinking skills, which cadets develop further as they participate in our research."

Ongoing research projects include the continued development of autonomous cooperative technologies for heterogeneous unmanned vehicles to cooperatively perform wide-area ISR missions using heterogeneous sensors as well as to detect and track airborne chemicals. The ACUASR extended their research technologies to small vertical take-off and landing (VTOL) vehicles, improved communications in the dynamic UAS environment, and to develop a UAS that will cooperatively search for and detect intruders in both a naval and land environment in order to protect a harbor. The latter mission capability involves cooperation with the U.S. Naval Academy and the U.S. Military Academy as they develop unmanned surface naval vessels and unmanned ground vehicles, respectively. During 2010-2011, the center successfully demonstrated these capabilities through actual flight testing. For the VTOL platforms, small and light on-board systems and sensors were developed and successfully demonstrated using a fleet of small back-pack UAS obtained from decommissioned Special Forces assets. Cadets majoring in Mechanical Engineering are developing very small UAS (approximately bird sized) that can land in a very small area such as a window ledge, maneuver to support ISR sensors, and re-launch. As part of this work researchers are also developing new design methods to enhance innovation during the concept generation phase of the design process. Such well-defined system engineering design processes are used to design next generation, small unmanned aircraft in a number of senior capstone design projects administered by the Aeronautics department.

During the summer of 2011, a cadet UAS team participated and placed 4th out of 32 in the Association for Unmanned Vehicle Systems International student UAS competition. As for cadets pursing Air Force careers in RPA and unmanned technologies, Pack has no doubt about their futures. "Our efforts in the ACUASR help to prepare our faculty and cadets for the important role that unmanned systems have in modern warfare. It is clear from our experience of using the technologies in recent wars that USAF officers who understand the capabilities and employment of RPA will play an ever increasing role in the success of our future military missions."

Institute for Information Technology Applications



ASYMMETRIC GLOBAL MISSION REQUIRES INNOVATIVE INFORMATION TECHNOLOGY

Information technology has become the core of successful DoD and USAF operations. Without today's modern communication and response capabilities, our warfighters would be hampered in their ability to respond to real and emerging threats.

Spanning an ever complex gamut of information technology applications ranging from cyber security, information accessibility, education, transportation, wireless technology, and research and development, the Institute for Information Technology Applications (IITA) at the Academy has spent more than two decades researching and developing critical tools for today's warfighter.

Led by General (retired) James McCarthy, IITA has become the nucleus to multiple research centers and efforts including the Warfighter's Edge (WEdge), the Geospatial Technology Center, the Scholarship of Teaching and Learning, Unmanned Aerial Systems Remotely Piloted Aircraft (UAS-RPA) Airmanship Program Operations, Reserve Research, and Cadet Technology Research.

"Cadets are in the IITA laboratory developing software that will go into a system used by pilots, flight commanders, and eventually, the whole Air Force," said McCarthy. He added that the level of cadet participation in IITA projects results in highly motivated cadets who eventually will move into wing organizations and command and control positions. To help better prepare cadets for their future roles as officers, McCarthy has initiated an effort to identify and develop information technology capabilities specific to the Cadet Wing's needs.

The projects undertaken by IITA's growing cadre of researchers and program managers are just as diverse.

The Warfighter's Edge (WEdge) center is the largest organization within the institute and supports multiple sofware packages. The WEdge flagship product is the Warfighter's Edge Briefing System (WEBS) which is the only certified and accredited application designed to organize, standardize and enhance mission briefings on DoD networks. The program is currently deployed to more than 10 bases. WEdge has also fielded the Shuttle software which utilizes the WEdge Architecture to synchronize data between disparate groups for planning separate portions of a mission package. The

WEdge Viewer is a customized Google Earth® application that renders mission planning elements in a 3D environment to capture as much of the battle space picture as possible. The WEdge Geospatial Center (WGC) provides a portable Google Earth® service that provides deployed airmen 3D/4D visualization capability in theater. In less than three years, the capabilities provided by the WEdge center have gone from the drawing board to approval for Air Force-wide operations.

According to the WEdge Director, Lt Col Andrew Berry, cadets have been involved in multiple WEdge developments including 3D viewing capabilities using Google Earth®, and interfacing with Joint Mission Planning Software to enable collaborative mission planning throughout the DoD.

Another multi-year program within IITA is the Airdrop Enhanced Logistics Visibility Information System (AELVIS). This project integrates Blue Force Tracking satellite systems with logistics information to provide real time position and contents of airdropped resupply bundles to ground forces, command centers, and logistics centers worldwide. This capability will enable accurate and timely decision-making in hostile, rugged or remote drop zones. Engineering Mechanics cadets designed the mounting system to ruggedize and attach Blue Force Tracking hardware to airdrop bundles. Cadets will also analyze and evaluate the operational function of the AELVIS System.

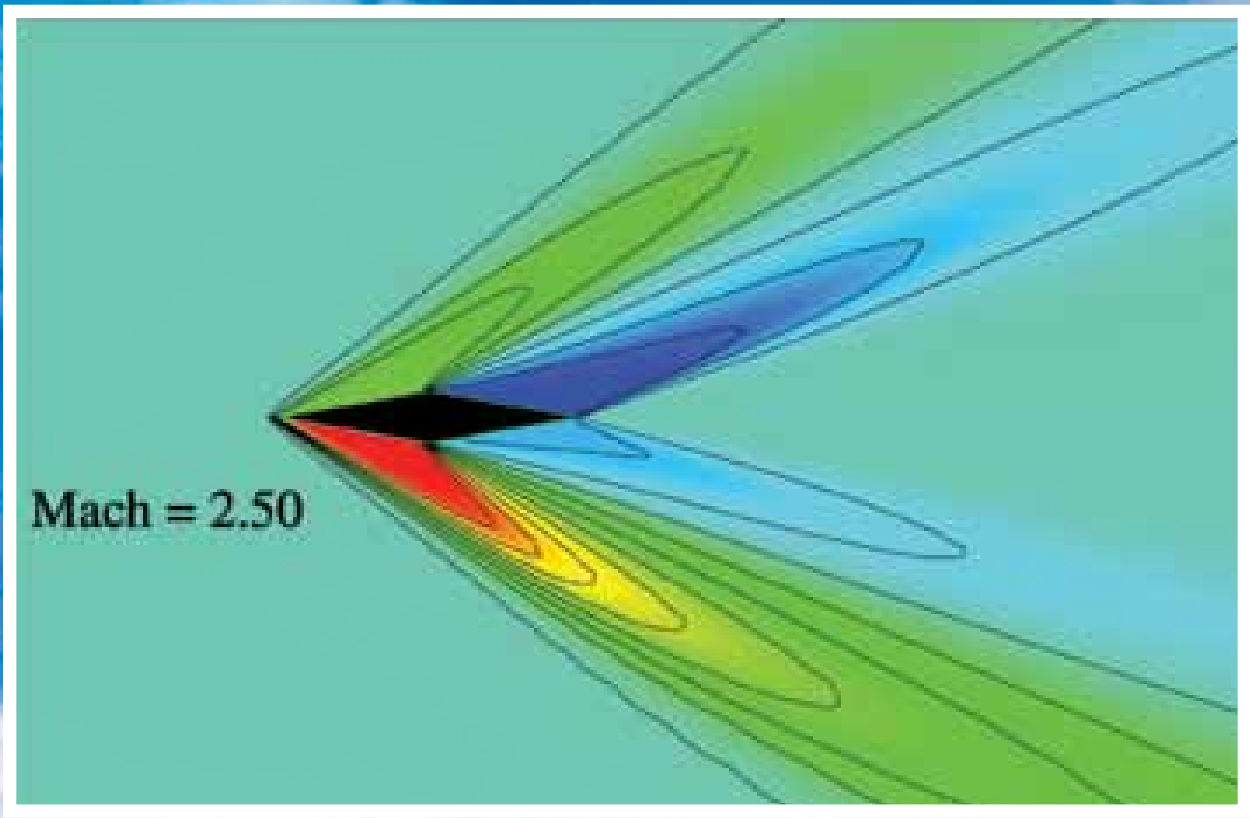
UAS and RPA, with their myriad technological, military doctrinal and "just war" challenges present a unique means to achieve our mission-driven end of producing leaders of character. As such, our UAS-RPA programs very directly and in many ways uniquely support our mission of educating, training and inspiring leaders of character. Coordinated by the Academy Center for UAS Research, several of our academic departments perform UAS research in a number of advanced level courses. Such research programs range from behavioral science programs aimed at developing screening criteria for future UAS-RPA pilots to UAS airframe development and autonomy work. Bringing it all together, the UAS-RPA airmanship program uses operational and mature unmanned aerial systems as a holistic training device incorporating basic airmanship, tactics, command and control issues, and the difficult choices faced by combat RPA operators every day.

The Wing IT Services Engineers (WISE) are a group of tech-savvy cadets led by the Cadet Wing Communications Officer and mentored by IITA's Carolyn Dull. Under her guidance, the cadets have automated several processes and moved the Cadet Wing toward paperless operation using Microsoft SharePoint®. The WISE cadets are also writing software for the Android Operating System (OS) and Apple's iOS mobile devices to enable the cadet wing to leverage mobile computing devices for accountability, communication and evaluations. These talented cadets have also designed an automated bugle call system that is used in the wing operations center on a daily basis. The IITA is proud to mentor and enable these talented cadets as they use their innovative ideas and technical skills to solve Wing IT challenges.

The Geospatial Technology Center's (GTC) mission is to innovate in the areas of geospatial information systems and information technology to provide enhanced situational awareness tools. Over the past several years, the center generated several of the innovations that have been transitioned into WEdge software products including the WEdge viewer and portable Google Earth® globes. Their current innovations use low-cost commercial or government technologies to provide commanders with a common operating picture to help manage multiple first responders during major events. The tools developed by the GTC are being used and evaluated operationally by USAFA and several Air National Guard bases.

The information technology expertise and resources available through the IITA provide cadets the opportunity to develop solutions to real Air Force problems alongside some of today's best engineers, scientists and researchers. The opportunities provided through the IITA have likewise revealed amazing information technology talent in the next generation of Leaders of Character.

Modeling & Simulation Research Center



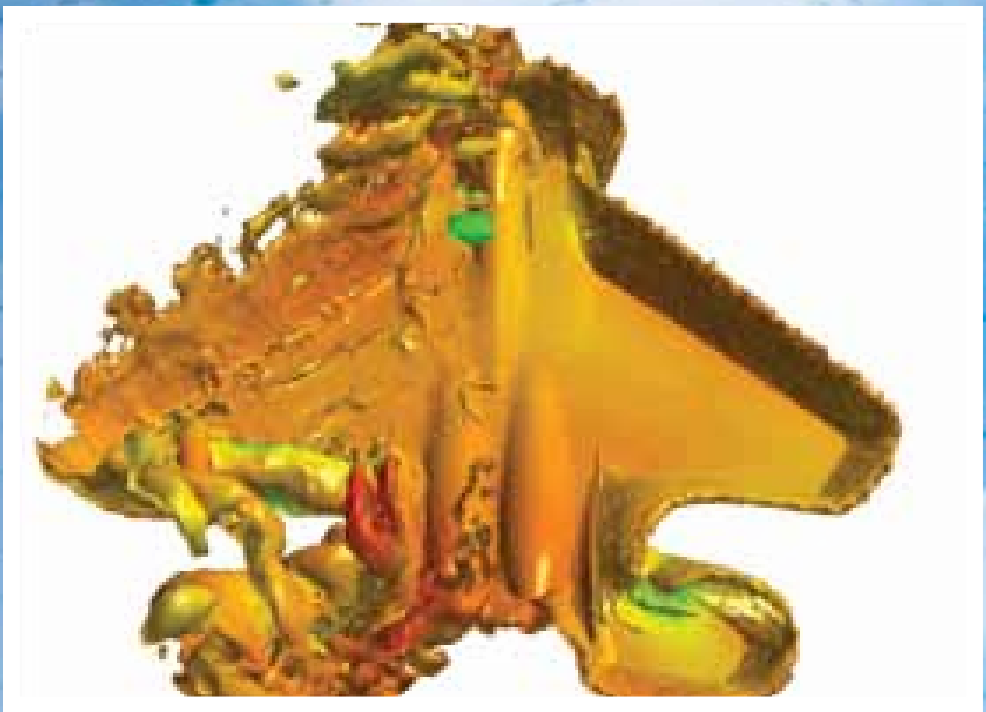
THE EXPERIMENTAL AND COMPUTATIONAL DYNAMIC

In a world of cloud computing, high performance computing (HPC), and ever-advancing modeling and simulation technologies, the Modeling and Simulation Research Center (MSRC) at the USAF Academy stands out from the crowd.

Over the past decade, the center has quietly been providing cutting-edge computational and modeling capability to support research to the nation's top government and private clients including Air Force Office of Scientific Research (AFOSR), the Air Force Institute of Technology (AFIT), Air Force Research Lab (AFRL), NASA, the Department of Homeland Security, and Empirical Systems Aerospace.

The Center is a one-stop research partner across multiple disciplines within the Academy. These joint efforts reflect the Center's core mission of providing advanced computational technologies to faculty and cadets in support of the broader Department of Defense community.

"The thing that sets the Academy apart from other universities is that we have the capability to combine state-of-the-art experimental and computational resources. Most universities will typically focus on one or the other. However, with the complex multi-disciplinary problems facing researchers these days, this is often times not enough. You really need both elements to get a complete understanding. With the MSRC here at the



Academy, the infrastructure and expertise are in place that allows Academy researchers to quickly and cost effectively add a computational component to their research efforts," said Lt Col (retired) Chuck Wisniewski, the director of the MSRC.

In 2010-2011, the center broke new ground not only in its capabilities but also in its support partnerships with other Academy research centers. MSRC added a new layer of local capability with its launch of a cadet academic cluster, which will serve to support the high computing needs of the entire faculty and across departments. This project was supported with $150K from the Dean of Faculty Brig Gen Dana Born and adds to the center's already impressive research remotely accessible cluster, processing workstations, and administration of the Air Force Defense Research and Engineering Network (DREN).

The center had nearly a dozen success stories during the past academic year and has a strong emphasis on cadet project leadership. Of the major projects undertaken or projects that are continuing from previous years, each features cadet researchers with one-on-one faculty mentoring. As an example, 2Lt Craig Porter, a 2011 graduate, under the direction of the MSRC former director Dr. Keith Bergeron, conducted computational fluid dynamic application to virtual flight testing and system identification research for the Air Force Seek Eagle Office (AFSEO).

Another success story is the center's continuing work on the NASA Orion Crew Exploration Vehicle (CEV), the nation's next generation manned space vehicle. Cadets, through multiple years of this research, have presented their findings to NASA on various safety-of-flight research projects and 2011 graduate, 2Lt Jared Becker continued research on drag predictions in the Orion's wake. The relationship with NASA has been cemented by a continuing five year project agreement.

The MSRC is a critical partner supporting other Academy centers' successes. The research the MSRC supports within the various departments ranges from supporting the Center for Aircraft Structural Life Extension's Hi-Fidelity C-130E Center Wing Model project, to the optimization of multiple telescope sites for non-resolvable space object identification for the Academy Center for Space Situational Awareness. The MSRC also supports the FalconSAT program via data transfer, retrieval, and secure storage, and the Institute for Information Technology Applications marquee WEdge project via automated, real-time flow of mission data briefings, 3-D mission data visualization, and collaborative mission planning technologies.

Academy Center for Cyberspace Research

CYBER THREATS TRANSFORMING DoD, US AIR FORCE

With thousands of cyber-attacks daily against the Air Force, DoD, and U.S., the mission to prepare cadets for an ever-evolving cyber battlefield has become critical to our nation's security.

The Academy Center for Cyberspace Research (ACCR), housed within the Department of Computer Science, has been working diligently to prepare cadets for their future as officers on a cyber-centric battlefield. Cyber security today is a combination of offensive strategies and technologies as well as defensive tactics in order to prevent attacks stemming from malware, spyware, and bots and to actively protect our critical systems from larger threats that could damage our financial, infrastructure, or communications systems.

During 2010-2011, the center was overseen by Dr. Dino Schweitzer, with the center's research focus being digital biometrics, jam resistant communication, mobile computing, security visualization, security education tools, and student-led projects. ACCR's mission is to enhance cadet education through research in cyberspace through a variety of avenues including but not limited to basic and applied research projects, multi-disciplinary curriculum development and hands-on activities for cadets such as the Cyber Defense Exercise (CDX), and regional cyber activities and events such as the Front Range Information Security Colloquium (FRISC). Some of the center's sponsors

include the Air Force Research Lab (AFRL), various Air Force organizations, the Defense Advanced Research Projects Agency (DARPA), the Defense Information Assurance Program, the National Security Agency, and the Department of Homeland Security.

One of the center's projects is the Digital Biometric System also known as DiBiS. This project focuses on persistent behavioral biometric authentication. The authentication is based on 'how' a person types on the keyboard and 'asks' if the person typing is really the person logged in. During 2010-2011, ACCR researchers began a pilot study with more than 300 USAFA participants and the research is looking to determine both the accuracy of this authentication method and to identify technical challenges. This technology was developed by Louisiana Technical University and the research at the Academy is sponsored by the 24th Air Force and AFRL. Cadet and researcher efforts on this project have identified data leakage issues affecting user privacy that were previously unrecognized.

Unkeyed jam resistance technology and algorithms are also a critical part of the research efforts in ACCR with both faculty and cadet researcher participation. The free flow of communications is critical for both military and commercial operations. Interference with the flow of communications can be accidental due to environmental or traffic conditions or the disruption can be caused intentionally. A robust communications system that will successfully defend against intentional or accidental jamming while simultaneously communicating critical information without disruption and securely is the ultimate goal of this research. A shared secret approach does not scale well in a net-centric arena, in large networks, or the commercial GPS system. Dr. Leemon Baird is the lead ACCR researcher on jam resistance technology and is the creator of a new type of concurrent coding theory and the BBC algorithm. This new system has been demonstrated successfully and cadets are currently analyzing different implementations and communication defense scenarios.

Cadet contributions to the sponsored research initiatives in ACCR are diverse and allow for cadets to complete a project and often times, test their project results in a real-world environment. In addition to conducting critical research for the DiBiS and jam resistance research, cadets are currently involved in nearly a dozen projects including cross site scripting vulnerabilities, RFID vulnerability, rhyming and graphical password generation, smart card vulnerabilities, social networking, and identification of rogue access points.

In addition to sponsored research, the center also offers cadets a chance to help develop cyber education tools as well as events and opportunities to test their cyber defense skills. Cadets have developed interactive classroom tools in partnership with Regis University. These tools are available to the public and teach security concepts. Some of the tools developed include crypto applets, re-locatable code called Core War, SQL injections, and the GRASP Security Protocol Visualization.

The center also hosts several major events including the annual CDX. Sponsored by the National Security Agency, participating teams are tasked to design a secure network supporting many services including web services, instant messaging, voice over IP (VoIP), email, and file sharing. During the exercise, cadets must defend the networks from attacks by NSA red teams as well as defend against an NSA "Grey Cell," which plays the part of an uneducated user who poses an insider threat. More than a half dozen universities and military academies participate and include USAFA, the U.S. Military Academy, the U.S. Naval Academy, Air Force Institute of Technology (AFIT), and the Royal Military College of Canada. Undergraduate teams representing the U.S. military academies vie for the NSA Information Assurance Director's trophy, a traveling award that resides with the winning academy for the academic year. This award serves to advertise and generate interest among students to learn about cyber security.

"By conducting research on cyberspace topics, cadets not only learn a topic in depth, but, more importantly, they learn to solve challenging problems in a real-world environment," said Schweitzer.

USAFA Center for Oral History

STORIES SHAPE A GENERATION OF LEADERS PAST AND PRESENT

"It was a very emotional period, especially for a few of us who had been very old prisoners. We were closely bonded, so some of most wonderful friends I've ever had came out of those camps. We stayed together and helped each other. None of us feel it was a total dead loss, the experience I mean. A lot of us learned a lot about ourselves, about our limits, and we certainly learned how to get along with other people in difficult circumstances, which is a very important lesson..." said the late Lt Gen A.P. Clark upon his liberation after 33 months from the German POW camp Stalag Luft III and Mooseburg. Gen Clark would go on to serve as the sixth Superintendent of the USAF Academy.

The lessons of history are ones that have a powerful influence on the shaping of tomorrow's leaders. The USAFA Center for Oral History's (COH) mission is to preserve and to share the oral histories of the USAF Academy and of the Air Force and is firmly committed to preserving yesterday for tomorrow's profession of arms. Led by Dr. Bob Wettemann, the center which officially was established in 2010, has made huge

strides in 2010-2011. Like the recollections of Gen Clark, who left a great deal of oral, written, and photographic history of his captivity to the Academy's Special Collections, the experiences and words of personal record being gathered by Dr. Wettemann and participating cadets, will serve a special place and purpose for future cadet classes.

The Center's on-going Operation ALLIED FORCE Research Project was comprised of cadets from the Department of History's 499 and 371 courses exploring modern airpower and an oral project to interview and compile stories of USAF Academy graduates who served during the 78-day long air campaign over Kosovo in 1999. Participating cadets were given guidelines, research material and interview support from the COH. The interviews were also video-recorded and ultimately, the COH and future cadets will compile this work into a cadet-written, book-length manuscript emphasizing the role of USAFA graduates in Operation ALLIED FORCE.

"Using oral histories as the core material for research projects helps advance the cause of history education at the Academy on two levels," explained Dr. Wettemann. "On the one hand recording the experiences of USAFA graduates, pioneers, and distinguished visitors preserves the unique history of the Academy for posterity. On the other hand, using these interviews as a foundation for cadet research projects further increases future officers' understanding of the heritage and application of air power."

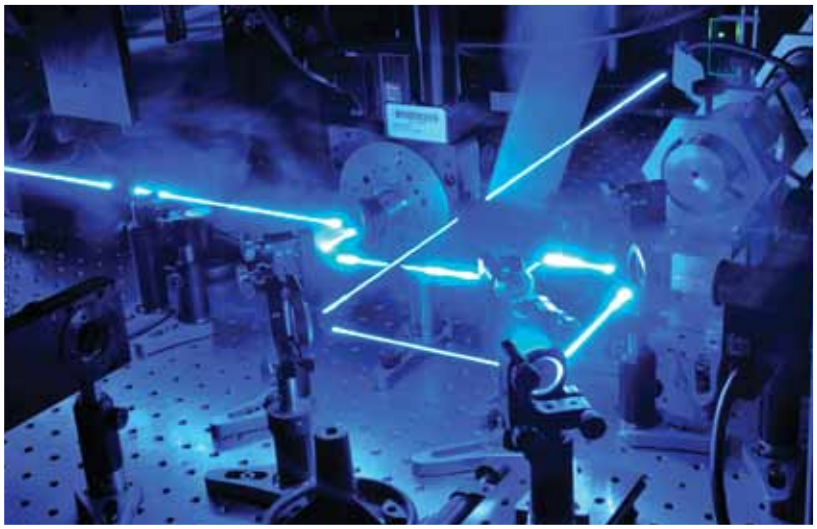
The first full academic year for the center was a huge success. More than 25 interviews with various alumni from a half dozen classes ranging from 1963 to 2010 were completed, as well as interviews with various USAF Academy leaders and visitors of interest including Christopher Graveline, Lead Prosecutor, Abu Ghraib Trial; Michael Clemens, Lead Investigator, Abu Ghraib Trial; and USAFA Pioneers Jack Train, Managing Architect, Skidmore, Owings and Merrill; and the late Richard Coffee, Air Force Academy Construction Agency. The center is also working towards compiling the oral histories of graduates who have served as astronauts, with the goal of publishing their recollections and experiences.

The center had a presence at the Challenger Shuttle Memorial Dinner with the Space Foundation, the inaugural Black Academy Graduates Super Reunion in Maryland and attended the Oral History Association Conference in Atlanta, GA. Additionally during 2010-2011, the center supported a variety of Academy events including the Falcon Heritage Forum, Heritage to Horizons, and the independent documentary "Wings of Honor: A Year at the Air Force Academy" as well as providing support to several Department of History courses.

The center's forward momentum continued during spring 2011 with a pledge of $5,000 per annum for the next twenty years from the Class of 1980 to support the center's Moral Courage project. This project is a joint initiative with the Academy's Center for Character and Leadership Development. Other COH initiatives underway or planned for the near future include the launch of a new webpage and the launch of a Facebook social networking page in support of the Center's activities, a Class of 1963 History initiative, and multiple cadet-led research projects modeled on the COH Operation ALLIED FORCE Research Project and to include topics such as USAFA on 9/11, Falcon Legacies (parents and children who both attended the Academy), Falcon Love (lifelong relationships that started at USAFA), and Falcon Athletics. A project focusing on the post-deployment experiences of USAFA faculty is also underway.

"The goal of the COH is to become the identifiable and premier resource and Center of Excellence for the oral history of the U.S. Air Force Academy and the U.S. Air Force...," said Wetteman of the program, that after decades of informal efforts now has the opportunity to make an indelible mark on future cadets. "The COH is also interested in the further development of leaders of character for the U.S. Air Force. Additional efforts will also be directed toward those individuals whose integrity, ethics, morality, and character were tested in real life situations, as such examples will be of immense and lasting value in explaining the importance of this trait to USAFA cadets and others interested in leadership and character development."

Laser & Optics Research Center



GAME CHANGING ADVANCES IN TECHNOLOGY

In a world where directed energy and optical information technologies are growing rapidly, the Academy's Laser and Optics Research Center (LORC) is leading the way in developing and understanding new lasers, optical devices and materials. The LORC offers a unique environment where cadets and researchers can together investigate and develop innovative ideas for the Air Force.

The LORC is supported by 12 fulltime researchers and, with over $7 million in advanced research equipment, is one of the most extensive, well-funded undergraduate laboratories in the United States. Led by research director Dr. Randy Knize, the LORC has become a world leader in multiple areas of research in lasers and optics including fiber lasers, holographic and adaptive optics, alkali lasers, atomic physics, and metamaterials and nanotechnology research programs. In 2010-11, the center procured over $2 million in research funds through competitive awards and grants from numerous agencies including but not limited to the National Science Foundation (NSF), Air Force Office of Scientific Research (AFOSR), Air Force Research Laboratory (AFRL), Missile Defense Agency (MDA), High Energy Laser Joint Technology Office (HEL-JTO), and the Defense Advanced Research Projects Agency (DARPA). The expansive resources and advanced technological facilities available in the LORC allow cadets at USAFA to have the opportunity for a unique first rate undergraduate research experience, which includes working various aspects of a research project under the mentorship of the LORC researchers.

"The hands-on research experience cadets gain is invaluable in preparing the cadets for their careers after graduation from the Air Force Academy, whether it be graduate school or another assignment," said Knize. "Cadets find a certain excitement, a sense of pride contributing to innovative projects that can influence the future of Air Force weapons and technology."

Since 2004 the LORC has distinguished itself among the leaders in the world for the understanding, development, and power scaling of diode laser pumped alkali lasers (DPALs). Alkali lasers are gas lasers that exhibit high beam quality with excellent efficiency and have the potential to be power scaled for military applications such as an advanced tactical laser. Recently, the AirBorne Laser (ABL), a chemical oxygen iodine laser flown in a Boeing 747, demonstrated the ability to engage and destroy a live simulated foreign military missile. However, the ABL achieves this at a high logistical and chemically hazardous cost. DPALs are a growing laser technology which show promise in power scaling to become a safer, more reliable alternative to the chemical laser used in theABL. The LORC's alkali laser research efforts, led by Dr. Randy Knize, Dr. Michael Shaffer, and Dr. Boris Zhdanov, continue to investigate the development of new alkali lasers, scaling and control technologies.

A leader in the world of holographic optics technologies, Dr. Geoff Andersen heads up the LORC's

adaptive optics and large space optics program. Using diffraction instead of refraction to collect and focus light, Andersen has developed large diameter, flexible membrane photon-sieve "lenses" to be deployed in space on FalconSAT 7. The light weight of a flexible membrane means for the same payload on a rocket, the optic diameter, and therefore the resolving power, can be much larger than with traditional lenses and mirrors. Andersen also is investigating a fast, close-looped holographic adaptive optics system with recent demonstrations showing his system able to correct for beam distortions, such as atmospheric turbulence, at speeds of 10,000 times a second.

Fiber laser research is another LORC program overseen by researcher Dr. Chad Carlson. Carlson and his team of researchers are investigating a number of fiber laser projects. Under a multi-university research initiative with the University of Michigan, the team is exploring the power and array size scaling of passive coherently combined eye-safe diode pumped fiber lasers. High power eye safe lasers have a diverse range of potential applications from tactical use in neutralization of Improvised Explosive Devices (IEDs) or in remote sensing and communications. In conjunction with Optical Engines, Inc., a small business in Colorado Springs, LORC research has demonstrated a high power 6+1x1 photonic crystal fiber pump/signal - a world record in input power for this type of fiber combiner. Another cooperative effort with the Naval and Army Research Labs and led by Dr. Carlson is researching technologies to develop and simulate novel ultra-large mode area fibers on US soil, in part to alleviate our dependence on foreign production. To simulate the optical and acoustic mode propagation of the fibers Dr. Carlson uses and refined a proprietary, world class, finite element analysis program, with credit to former LORC researcher Lt Col Ben Ward. This program also supports photonic crystal ribbon development with Lawrence Livermore National Labs.

The center's atomic physics program also made headway in cutting-edge atomic research during the past academic year. Under the direction of Dr. Brian Patterson and Dr. Jerry Sell, researchers and cadets investigated the fundamental physics of atomic systems by probing the quantum mechanical properties of various atoms, including atomic radiative lifetimes, absorption and collisional cross sections and fine structure relaxation cross sections and rates. The team made precision measurements of the cesium $6P_{3/2}$ radiative lifetime with unprecedented accuracy; a measurement important to atomic clocks and for testing the validity of the current fundamental theory of physics. Another project investigated the fine structure relaxation rates and cross sections of the alkali rubidium P states in the presence of various buffer gases at various pressures and has important significance to understanding fundamental physics. The results of this effort directly augment the accuracy of the models and performance predictions of alkali lasers.

In the realm of metamaterials and nanotechnology, Dr. Yalin Lu is driving world class research to new levels. His investigations of copper indium gallium selenide (CIGS) devices, a possible alternative to silicon based devices, have shown that writing nanogratings on the device can improve performance characteristics like absorption by a 33% enhancement. Lu's other projects include investigations of tunable intrinsic negative index materials (NIMs) and tunable plasmonic materials. Patterson and Sell are also investigating plasmonics in various materials via an investigation of the effect of plasmonic layers in thin film silicon solar cells. The research is looking at, among other things, the conversion efficiency of solar cells. The potential result of this project could lead to a more efficient and practical solar cell technology. The center's metamaterials and nanotechnology research represents examples of an exciting field that may lead to more efficient solar devices or even materials capable of cloaking or shielding a device (e.g. aircraft) from optical detection.

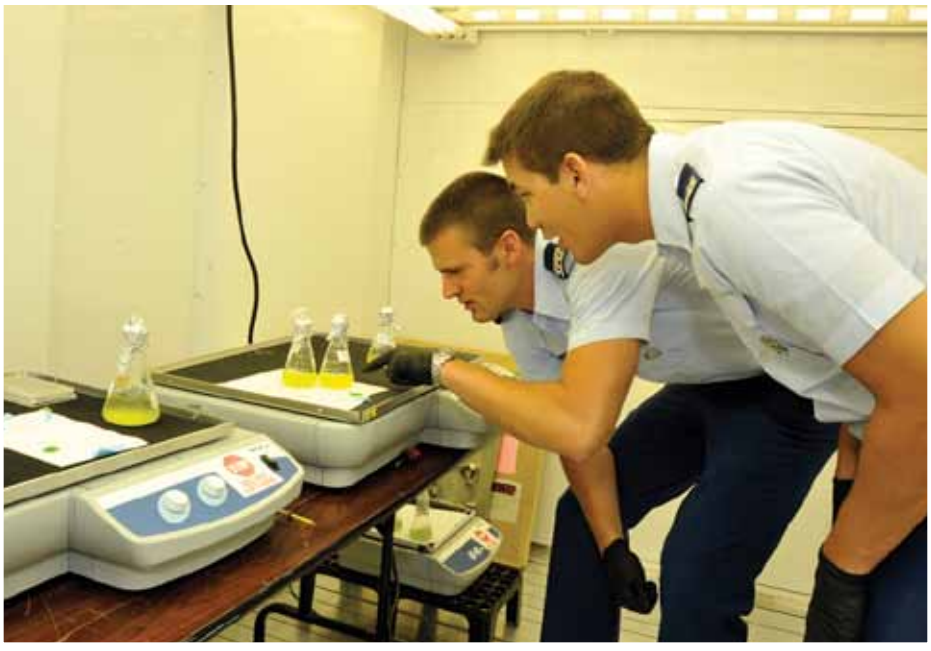
The LORC is truly taking laser and optics research to the next level and its cadet researchers today know they could very well be looking at their futures as AirBorne Laser operators or field operators helping to diffuse IEDs with technologies they helped to develop in our labs.

FUNDING STATUS FOR RESEARCH AT USAF ACADEMY

Research at the United States Air Force Academy has been on a steady uphill climb since 2001. In this case, however, the funding doesn't truly indicate the value for the thousands of cadets exposed to cutting-edge research opportunities in these programs. Officer training happens in the labs as they learn the negotiation and relationship skills required of tenured program managers. The only way for this to take place is in a lab environment with entrepreneurial spirit like the research centers at the Academy. When the funding impacts a cadet's ability to conduct research then he or she quickly absorbs the business mindset from which future officers benefit. Financial support is high, with funding arriving from two primary vehicles – the first vehicle being the Memoranda of Understanding (MOU)/ Memoranda of Agreement (MOA) with Air Force, Department of Defense, and other federal agencies. The second vehicle being the Cooperative Research and Development Agreement (CRADA) through collaboration in research with non-federal entities. Whether it is for a cadet's senior capstone course or an intriguing independent study in their field of interest, these funding vehicles allow every cadet the opportunity for exposure to an array of research projects.

The research programs available are valued at an all-time high of $74 million for the 2010-2011 Academic Year (AY). This can be broken into three main categories: External In-Kind, External Funding, and Internal Support (See Figure 1). External In-Kind support includes the value of visiting researchers and in-kind supercomputer time contributed by the Department of Defense High Performance Computing Modernization Office, which totaled $4.3 million. External funding is the direct monetary funding that research centers receive from outside partners, pulled in from the Department of Defense (DoD), other government sources and non-federal entities. The Internal support value is determined by an evaluation of USAFA-provided laboratory facilities and USAFA personnel time, which totaled $11.1 million.

Figure 2 indicates the sources of external funding. Outside partners contribute to the continued overall growth rate since 2001. An agreement between USAFA's Center for Aircraft Structural Life Extension (CAStLE) and the Oklahoma City Air Logistics Center at Tinker AFB continues to contribute substantially to support research on the KC-135 project. USAFA's Center of Innovation (CoI) and Department of Homeland Security continue in the multi-year partnership to enhance the Rare Event Scenario. USAFA continues to receive core funding from the Air Force Office of Scientific Research (AFOSR), the basic research manager of the Air Force Research Laboratory.



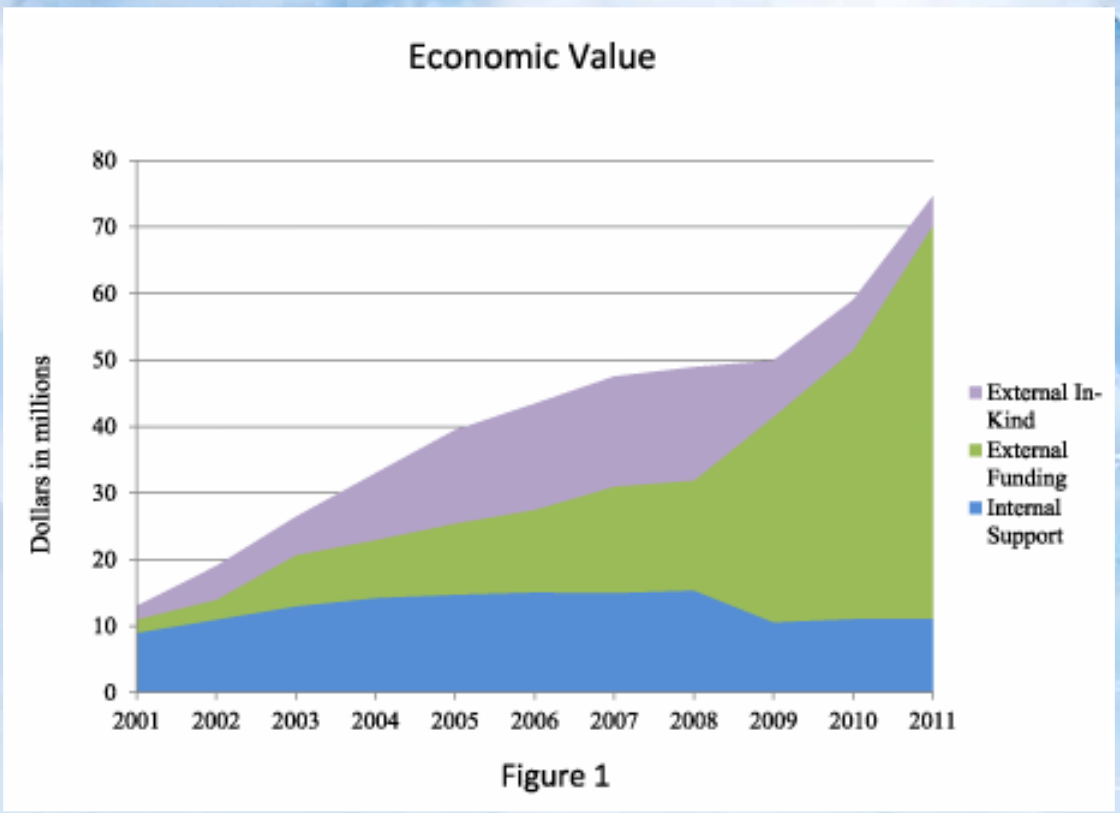

Economic Value
80
70
60
50
40
30
20
10
0
Dollars in millions
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
External In-Kind
External Funding
Internal Support

Figure 1

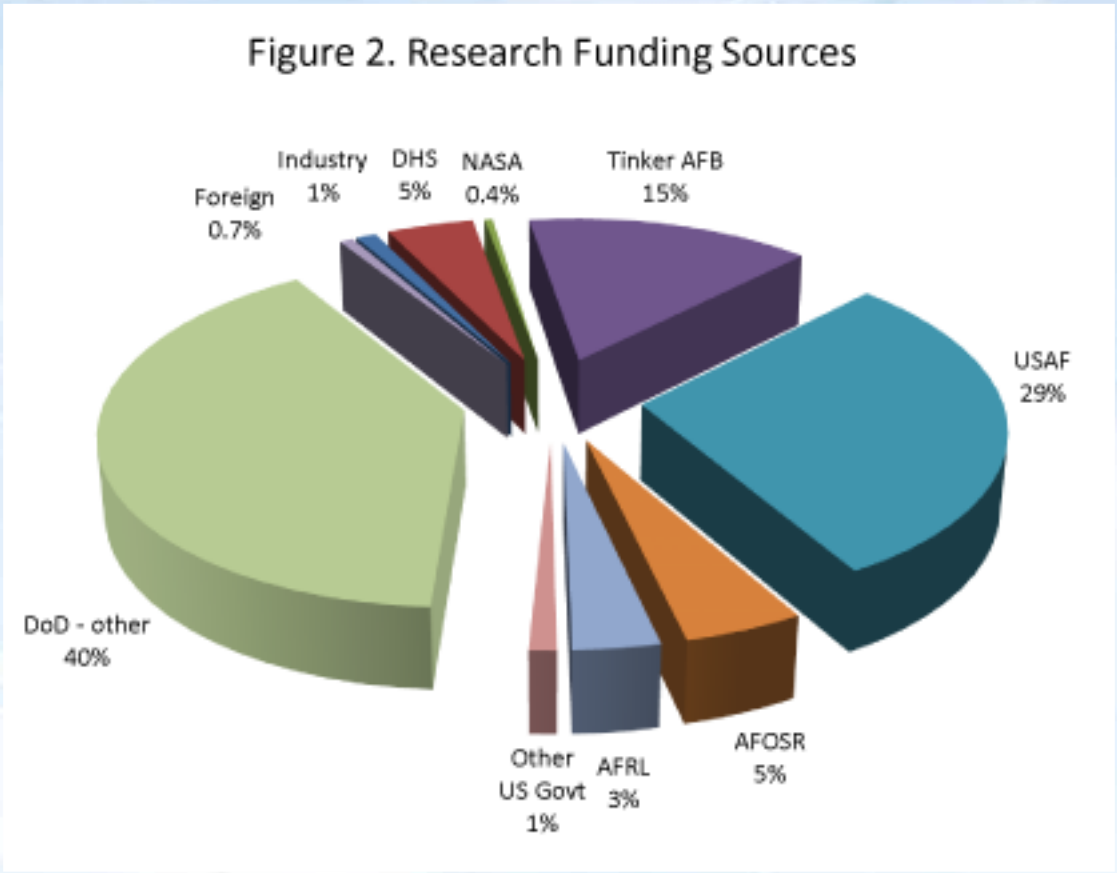


Figure 2. Research Funding Sources
Industry 1%
DHS 5%
NASA 0.4%
Tinker AFB 15%
Foreign 0.7%
USAF 29%
DoD - other 40%
Other US Govt 1%
AFRL 3%
AFOSR 5%

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