

RESEARCH DIRECTORY

AY 2017 – 2018



UNITED STATES
AIR FORCE ACADEMY

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SUPERINTENDENT LETTER

JAY B. SILVERIA, LT GEN, USAF



RESEARCH AT USAFA

The United States Air Force Academy is a cutting edge academic and military institution where innovation, warrior ethos and character development are a foundation of our heritage and the guiding priorities of our future. These pillars of our transformative experience make it possible to train and educate the future leaders of our Air Force to meet the challenges of a complex, sophisticated and fast-paced modern profession of arms.

At the heart of the Academy's innovative spirit is our research enterprise. Research at USAFA is unparalleled among undergraduate institutions, regularly bringing in more than \$40 million each year. These efforts are central to our curriculum and vital to our faculty development, and provide high-impact practice to augment our cadets' growth in becoming informed, critical-thinking officers. Research plays a major role in the way we develop future officers of the highest caliber, capable of shaping the future of modern warfare, and making our Air Force their own.

We are preparing cadets to lead in battlespaces more complicated and volatile than they have ever been. Warfighting in this century relies as heavily on innovation and collaboration as it does on strength and firepower. To meet these challenges, our academy must continue to be a place of creative freedom and constant innovation. This includes an emphasis on technical disciplines and centers, but our Academy is also a place where research in the humanities, social sciences, and leadership are making direct impacts to Air Force readiness and the lethality of our military.

Through the coordination and facilitation of our entire research enterprise, from our cadets to the nationally acclaimed research experts among our faculty and staff, we can and will continue to maintain the advantages necessary to outpace our adversaries. Enclosed are the people and centers that help make our many successes happen. I hope you will take an interest in the great work they're all doing.

A handwritten signature in black ink that reads "Jay B. Silveria". The signature is written in a cursive, slightly stylized font.

JAY B. SILVERIA, Lt Gen, USAF

Superintendent, United States Air Force Academy

'MAD SCIENTIST' AT AFA USES BUTTERFLY WINGS TO FIND CHEMICAL WEAPONS

BY: TOM ROEDER

The Air Force Academy has always had the perfect backdrop for mad scientists.

Lasers, wind tunnels and bubbling chemistry labs are all part of the scenery at the academy, nationally renowned for its science and engineering programs.

Now the school also might have the perfect character for that set: Lt. Col. Joshua Kittle, who uses the wings of dead butterflies to detect chemical weapons.

“You just take one of the wings,” Kittle explained, showing off the translucent wings of the insect.

The wings, it seems, are nearly as reliable as spectral analysis to show the presence of chemical weapons. It just takes a specialized light and the wings do the rest.

It’s all thanks to specialized structures within the wing that filter light differently in the presence of chemicals. And if Kittle can make it work, the butterfly wings could save lives on battlefields.

“This is basic research,” he said. “It’s still not ready to be fielded, but it’s close.”

The homeland defense and battlespace operation communities need portable and reliable sensors for chemical warfare agent detection. These natural detectors on butterfly wings can enhance synthetic detectors.

Kittle’s work is part of a wide effort at the academy that puts the brains of the school’s 4,000 cadets to work solving real-world problems for the Air Force. The \$38 million undergraduate research

program has come up with new ideas for body armor, launched swarms of drones, and helped combat rust in aging planes.

It's the best-funded such program in America, and leaders hope to make more strides this year, including advances for Kittle's butterfly work.

Most of the heavy lifting to test Kittle's idea was carried out last year by cadets, and work continues this fall.

The wings have been used to detect chemicals similar to those used in mustard gas and the chemical weapon sarin.

Now, Kittle is hoping to come up with something better than butterfly wings that will allow him to find the presence of minuscule quantities of the chemicals.

This year, cadets are working with silicon structures that simulate the translucent wing to see if they'll do the job.

What makes the wing so attractive is not just that it detects chemicals. The wing is something that could be used rapidly and easily on the battlefield putting detection technology that would normally require a full chemistry lab into the hands of Airmen on the battlefield.

Kittle didn't start studying butterfly wings on a whim. Instead, the career Air Force chemist adapted something he spotted in a scientific paper a decade ago to fit a military mission.

Lt. Col. Don Rhymer, the school's associate dean of research, said letting cadets and professors follow their curiosity is part of what makes the academy's research arm successful.

"The academy never wants to get in the game of directed research," said Rhymer.

Kittle and his cadet team this year will try to refine their chemical detection tools. He knows what the battlefield will require.

"We certainly want small, cheap and robust," he said.



Lt. Col. Joshua Kittle, a professor of physical chemistry at the Air Force Academy, holds a butterfly in a case. (Photo by Kelsy Brunner/The Gazette)

ENHANCING THE CYBER ECOSYSTEM AT USAFA

USAFA AOG & USAFA ENDOWMENT SUMMER 2018

With a planned new building focused solely on cyber, the U.S. Air Force Academy is poised to prepare cadets for important cyber careers while addressing strategic Air Force goals.

The building, which is in the design phase, would bring together each of the Academy's cyber-related programs to increase the strength of its cyber ecosystem.

"A single facility will enable us to bring the various components of our cyber research and education enterprise under one roof. This will allow us to provide a world-class cyber education experience for our cadets by leveraging state-of-the-art research and design activities," says Brig. Gen. Andy Armacost, dean of the faculty.

The programs included in the planning are the Department of Computer and Cyber Sciences (DFCS), the Academy Center for Cyberspace Research (ACCR), AF CyberWorx and the Department of Homeland Security's Center of Innovation (CoI).

"The new building is critical to our ability to develop leaders in the dynamic technical environment," says Col. David Caswell, head of DFCS. "This new building will create a set of creative spaces that will become a learning laboratory where cadets can be immersed in the latest technology."

EARLY SUCCESSES

Each of the cyber areas has achieved its own separate successes in the past, yet collaboration has been growing across the programs and academic disciplines. Dr. John Riley, assistant professor in the Department of Political Science, partnered with CyberWorx to lead two cadet projects solving problems in the humanitarian space.

Dr. Riley's cadets collaborated with industry to prototype an application that helps predict mass atrocities. His current cadets are working on another application to help refugees

plan for their futures away from the tragedies that drove them from their homelands.

DFCS, in collaboration with CyberWorx, deployed a team of faculty and cadets to Andrews and Nellis Air Force Bases for STEM outreach at their respective airshows. These events gave more than 4,800 local visitors access to hands-on robotic and cybersecurity demonstrations. Additionally, the Cyber Competition Team, mentored by faculty, participated in 11 events during the fall of 2017 maintaining a ranking in the top 10 percent of the world.

Capstone teams within ACCR are conducting research that ranges from assessing the cybersecurity of a combatant command's network to building a virtual reality simulation that assists cadets in overcoming their fear of heights as they prepare to jump off the 10-meter board in water survival training.

BENEFITS FOR MULTIPLE AUDIENCES

“We must continually work to help cadets think differently about problems and prepare them to rapidly create solutions,” Caswell says. “This innovation ecosystem is intended to provide unique tools for both cadets and faculty to continually push the technological edge.”

Faculty participation improves their ability to mentor cadets while enhancing their leadership skills as they prepare for future assignments in the Air Force.

“It is an exciting time as our cyber enterprise continues to grow from the founding leadership of retired Brig. Gen. David Gibson, Dr. Marty Carlisle and Col. Jeff Collins. With the current team of Col. Caswell as the department head and Lt. Col. Michael Chiamonte as the CyberWorx director, I foresee great things for the Air Force, USAFA and our cadets,” Armacost says.

“Cyber harnesses the ingenuity of our more than 4,000 digital native cadets, innovating ways to revolutionize our employment of cyber technologies and directly influence the capabilities that our Air Force employs,” says Lt. Gen. Jay Silveria, superintendent of the Air Force Academy. “The future of cyber is bright with possibilities.”



Air Force Academy cadets, Morgan Cisna and Harry Andriantavy, demonstrate the Sphero robot in their prototype computer science core class during the spring 2018 semester. Cadets build an algorithm for the robot to sense its surroundings and determine a path out of the maze. (U.S. Air Force Photo/USAFA Association of Graduates)

CADET AND FACULTY RESEARCH



"I get to work with cadets every day and do the things I love doing, conducting research with my students who will hopefully be my peers in the future. I want to try and get as many people to come with me and hopefully we all learn something from it."

Lt Col Jimmy Do, 2018 McDermott Award winner for Faculty Research Excellence in the Social Sciences



"By the end of my research, I had reported over 650 new employees, written 8 reports that were published into the intel community to be used by other agencies, and I was able to find the research university where these people were being sent to learn how to use the weapons system."

C1C Molly Phillips, 2018 Thomas D. Moore Award Overall winner

"All research is a challenge. It's always a challenge, not knowing what the end result is going to look like."

Dr. Randall Musselman, 2018 Seiler Award winner for Faculty Research in Engineering





C1C Prayant Hanjra was selected to pitch his research work at the Space Foundation's 34th Space Symposium NASA iTech "Ignite the Night" event on April 17, 2018 at the Broadmoor Luxury Resort in Colorado Springs, CO. Cadet Hanjra was the first Air Force Academy cadet to present his research at the annual event and the Space Foundation hopes to continue the tradition.

(NASA photo, Kira A. Blackwell)

"I like to choose research activities that are accessible for cadets, that they can participate in and take ownership in and really make a primary contribution to the research."

Lt Col Michael Anderson, 2018 McDermott Award winner for Technology Transfer



"The adversarial state starts off by seeking to create an environment of public uncertainty, fanning elements such as dissent through methods such as information operations, propaganda campaigns, economic coercion, and sponsorship of political protests."

C1C Courtney Kunselman, 2018 Thomas D. Moore Award for Outstanding Cadet Summer Research, Basic Sciences Division and author of *A Shifting Puzzle: Understanding and Countering Russian Hybrid Warfare* (Air Force Photo by Staff Sgt. Charles Rivezzo)

"I learned to put myself out there and not be afraid to fail, just like in the lab, you have to be able to try new things. I returned from Lincoln Labs motivated to learn more in the classroom and to keep exploring what I can."

C1C Jinan Andrews, 2018 Thomas D. Moore Award Winner, Engineering Division and 2017-2018 Mountain West Female Scholar-Athlete of the Year



STEM OUTREACH

CONNECTING WITH THE K-12 COMMUNITY

The United States Air Force Academy K-12 Science, Technology, Engineering and Math (STEM) Outreach Program mission is to offer a variety of programs and services that effectively engage, inspire and attract the next generation of STEM talent. Faculty, cadets and the STEM Outreach Coordinator work to support the local community, schools, events and teachers professional development to increase the effectiveness of the Air Force's investment in STEM. Cadets have the opportunity to mentor the next generation of potential cadets through involvement in these efforts.

EDUCATIONAL OUTREACH

Science Pals

Chemistry Magic Shows

Physics is Phun Shows

Science Fair Support

Junior Botball

Student Visits to Research Centers

Lending Library

Cadet Clubs – STEM Support

STEM Fridays

STEM Teacher Workshops

Hour of Code

Girls in the Middle

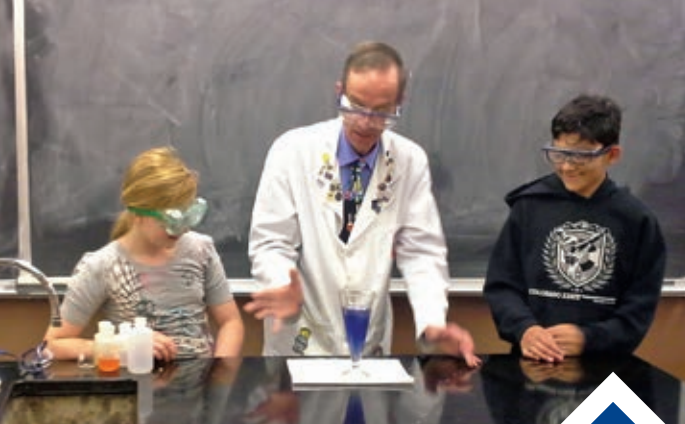
Audience with an Astronaut

LEGACY Craftsman Camps

WeDo Robotics Challenges

Computer Science Robot Interactions

Planetarium Tours



Dr. Ron Furstenau, Academy professor of chemistry, provides STEM Outreach to elementary school students and Brownie and Daisy Girl Scout troops. Dr. Furstenau teaches the magic of chemistry through fun and interactive demonstrations.

(Air Force Photos)



Academy cadets assist faculty with STEM Outreach events for Girls in the Middle (GIM) and Guys Reaching Incredible Potential (GRIP). Local middle school students get hands-on experience with STEM projects and can ask cadets questions about attending the Air Force Academy.

(Air Force Photos, Capt Jessica Ullom)



USAFA TECHNOLOGY TRANSFER

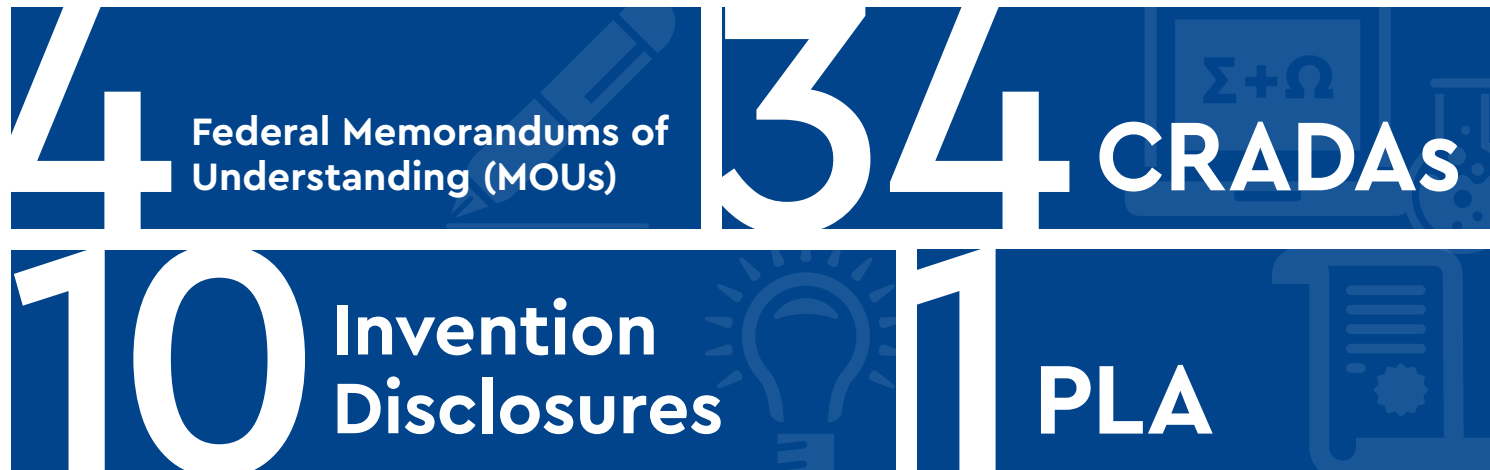
OFFICE OF RESEARCH AND TECHNOLOGY TRANSFER

Overall



The Air Force T2 program was created to ensure Air Force science and engineering activities are transferred or internally shared with state and local governments, academia and industry. The exchange of knowledge, expertise, equipment and testing facilities leverages research and development investment made by the Department of Defense (DOD).

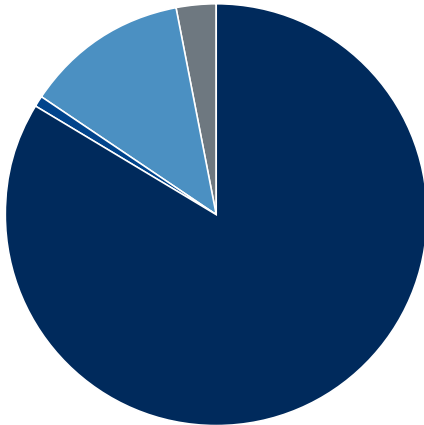
Academic Year 2017–2018



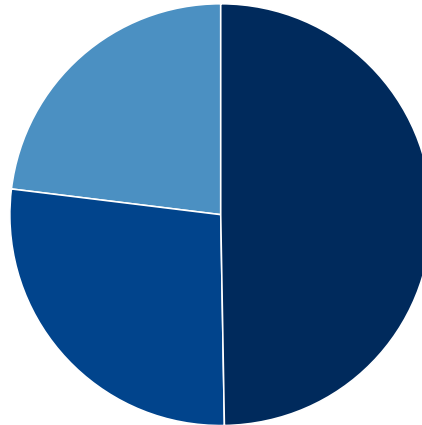
Cadet Summer Research Program



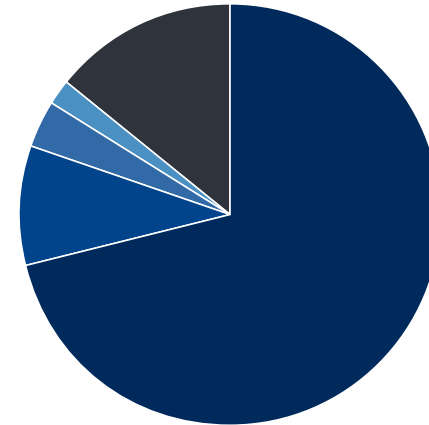
FY 2017 RESEARCH FUNDING



- Federal | \$40,491,000
- Nonfederal | \$520,000
- Internal (USAFA) | \$6,030,000
- Misc. (e.g. gift funds) | \$1,366,000



- Applied Research | \$24,192,000
- Development | \$13,113,000
- Basic Research | \$11,102,000



- Engineering | \$34,534,000
- Basic Sciences | \$4,428,000
- Social Sciences | \$1,673,000
- Humanities | \$1,016,000
- Other Centers & Institutes | \$6,756,000

*All values are rounded to the nearest thousand.

\$48,407,000
TOTAL

A photograph of two men in military uniforms in a laboratory setting. The man on the left is wearing glasses and a camouflage uniform with a name tag that reads "FRANK". The man on the right is wearing safety glasses and a camouflage uniform with "U.S. AIR FORCE" visible. They are both looking at a red, geometric, lattice-like object held by the man on the right. The background shows laboratory equipment and windows. The text "RESEARCH DIRECTORY" is overlaid in white, bold, sans-serif font in the center of the image.

RESEARCH
DIRECTORY

Department of Aeronautics (DFAN)

DR. TOM MCLAUGHLIN

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OVERVIEW

The Aeronautics Research Center in the Department of Aeronautics seeks to provide every Aeronautical Engineering cadet with a meaningful research experience, employing projects supporting customers in the Air Force, DOD, other government agencies and commercial partners. The center makes use of the USAFA Aeronautics Laboratory, the most well-equipped facility in all of academia. It is complemented by a broad range of faculty and researcher expertise in aerodynamics, flight control, propulsion and flight test. These capabilities combine to produce highly motivational cadet learning experiences, quality research products for the customers, and faculty/researcher technical currency.

CORE COMPETENCIES

- Aerodynamic flow control
- Subsonic wind tunnel testing in five different facilities
- Supersonic/hypersonic experiment and computation
- Gas turbine and internal combustion research
- Small air vehicle design/build/fly

MAJOR PROJECTS

- A-10 Rocket Pod Aerodynamic Characteristics
- Parachute Design and Optimization
- Flight demonstration of innovative flight control effectors
- Multiple UAV design/build/fly programs
- Quiet propellers and propulsive ejectors
- Supersonic vehicle aerodynamic actuators



Center for Aircraft Structural Life Extension (CAStLE)

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OVERVIEW

The Center for Aircraft Structural Life Extension (CAStLE) has a two-fold research mission in support of the safe sustainment of aging structures. First, to perform a wide range of research and technology development projects focused on delivering critical science and technology (S&T) data, tools and other products required to understand the impact of material degradation in structural systems to various government, academic, and commercial sponsors. Second, but no less important, to educate, train, inspire, and otherwise prepare future generations that might become the core of the S&T community within the government and the general professional population. CAStLE's core competencies, developed over more than two decades of successful research product delivery to our sponsors, fully address all aspects of the mission.

CORE COMPETENCIES

- Structural testing and analysis (full-scale, component level, and coupon)
- Material degradation (corrosion, cracking, etc.)
- Material processing, testing, and development
- Measurement and impact analysis of operational loads, stress, and environment

MAJOR PROJECTS

- USAF Aircraft Structural Integrity Program support; component & full-scale testing, teardown analysis, flight data acquisition, root-cause analysis, modeling, etc.
- Structural re-design, material substitution, prototyping, and validation testing
- Basic research in material degradation prevention and control, OSD sponsored Technical Corrosion Collaboration between university, DOD, and commercial research groups
- Multiple educational outreach programs: courses, videos, science center exhibits, student design challenges, college readiness programs, etc.

Hypersonic Vehicle Simulation Institute (HVSI)

DR. RUSS CUMMINGS

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OVERVIEW

The Hypersonic Vehicle Simulation Institute (HVSI), sponsored by the Department of Defense High Performance Computing Modernization Program, is a national effort managed from the U.S. Air Force Academy. The vision of this effort is to bring together disparate DOD, DOE, NASA, academic and industry hypersonic research to address current shortcomings and advance the state-of-the-art in hypersonic vehicle simulation. This program will enable academic and research institutions around the country to pursue advances in the ability to simulate the challenging aerothermodynamic and propulsion system phenomena—such as boundary layer transition, shock-shock and shock-boundary layer interactions, ablation, non-equilibrium chemistry and fluid/thermal/structural interactions—of hypersonic flight in order to accelerate technology development and transition into superior defense capabilities for the United States. Faculty and cadets associated with USAFA Research Centers may compete for funding through this effort in areas such as development and evaluation of hypersonic turbulence models, and creation of experimental data sets to enable verification and validation of new simulation capabilities.

CORE COMPETENCIES

- Access to DOD supercomputing resources
- High-speed network access and local storage systems
- Partnerships with universities throughout the country for hypersonics research
- Supersonic/hypersonic experiment and computation
- Gas turbine and internal combustion research

MAJOR PROJECTS

- The first area for funding was chosen to be development of improved turbulence models for use in hypersonic flight simulations, including design and conduct of experiments that could provide validation data for these models.



Space Systems Research Center (SSRC)

MAJ DANIEL SHOWALTER

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OVERVIEW

The Space Systems Research Center (SSRC) designs, builds, tests, and flies cadet-built, DOD-backed satellites. It focuses on cadet education while achieving real DOD objectives and supports national Science, Technology, Engineering and Mathematics (STEM) educational objectives.

CORE COMPETENCIES

- Designing, building, testing and flying small spacecraft
- Systems engineering
- Avionics testing and simulation

MAJOR PROJECTS

- FalconSAT-6
- FalconSAT-8
- EyasSAT Technology Demonstrator
- Cadet Space Operations Squadron



Astronomical Research Group and Observatory (ARGO)

DR. DEVINDELLA-ROSE

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OVERVIEW

The Astronomical Research Group and Observatory, based at the USAFA Observatory, houses the 41-cm telescope, and supports the worldwide Falcon Telescope Network (FTN). We now have the funding for a state-of-the-art 1-meter telescope to replace our existing, 54-year-old 61-cm telescope, and we are pursuing the acquisition of this new telescope. ARGO conducts near-Earth research including resolved and non-resolved space object tracking deep-space research including asteroid tracking, astronomical spectroscopy and photometry and exoplanet studies. ARGO also supports the other DFP research centers and grant work. Finally, ARGO hosts STEM outreach activities at the observatory for Scout groups, school groups and teachers.

CORE COMPETENCIES

- Deep space photometry and spectroscopy
- Space object identification and tracking
- Space object photometry and spectroscopy
- STEM education and outreach in astronomy and space science

MAJOR PROJECTS

- Search for exoplanets using the FTN
- Spectroscopy of exoplanetary host stars
- Light curve photometry of binary stars and supernovae
- Hazardous near-Earth asteroid tracking
- One-meter telescope acquisition



Center for Space Situational Awareness (CSSAR)

DR. FRANCIS CHUN

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OVERVIEW

The Center for Space Situational Awareness Research provides cadets and faculty at the United States Air Force Academy an education and research program in space situational awareness (SSA) using world-class facilities and capabilities.

CORE COMPETENCIES

- Small aperture optical telescopes for satellite characterization
- Non-imaging photometric, spectral and polarimetric techniques for characterization of un-resolved space objects.
- Data fusion and modeling

MAJOR PROJECTS

- Development of the Academy's global Falcon Telescope Network
- Spectral measurements of solar panel glints from geosynchronous satellites
- Two-channel polarimetry to determine horizontal/vertical polarization states from un-resolved satellite optical signatures
- Long-term photometric observations of inactive geosynchronous satellites for debris monitoring

Laser Optics Research Center (LORC)

DR. RANDY KNIZE

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OVERVIEW

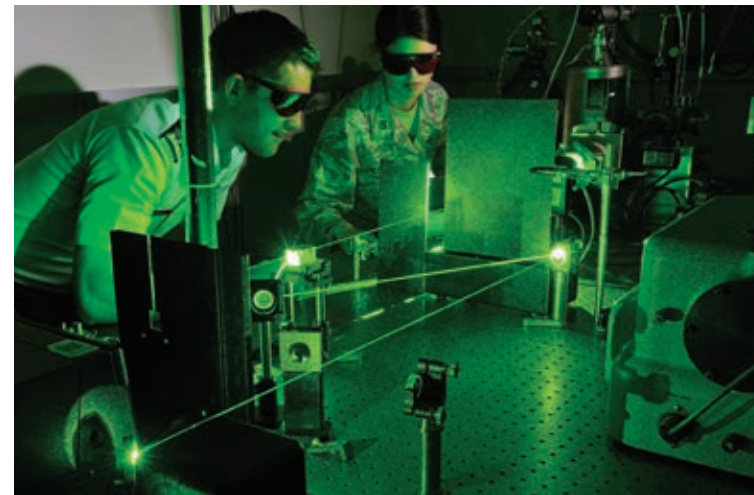
The Laser and Optics Research Center performs research in laser development, laser applications and large optics for space with cadets, faculty and contractors using a well-equipped laboratory. Lasers and large optics are increasingly used by the military for directed energy weapons, precision munitions, communications and surveillance.

CORE COMPETENCIES

- Pulsed tunable lasers
- Laser and optical test equipment
- Laser and optical modelling
- Design and fabrication of unique laboratory apparatus
- High power continuous wave lasers

MAJOR PROJECTS

- Diode pumped alkali lasers
- Fiber lasers
- Atomic and nuclear physics
- Novel materials
- Photon sieves and wavefront sensors



Space Physics and Atmospheric Research Center (SPARC)

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OVERVIEW

The Space Physics and Atmospheric Research Center faculty and cadets perform basic research in the solar terrestrial environment and investigate how perturbations in that environment can negatively impact the performance and longevity of U.S. Air Force space assets. SPARC specializes in development of aggressively miniaturized payloads that fly on experimental spacecraft to make observations of the ionosphere. SPARC then works with cadets to incorporate these measurements into the broader framework of the ionospheric system, with the long-term goal of developing physics-based predictive models eventually leading to the ability to forecast the geospace environment.

CORE COMPETENCIES

- Miniaturized payloads
- Space physics
- Applied physics

MAJOR PROJECTS

- Delivery of the final of six Integrated Miniaturized Electrostatic Analyzer (iMESA) instruments for the DOD Space Test Program (STP)
- Delivery of the Falcon Solid State Energetic Electron Detector in collaboration with the Air Force Research Laboratory Designing the Falcon Orbital Debris Experiment (Falcon ODE) in collaboration with NASA for the Air Force Operational Test and Evaluation Center (AFOTEC)
- Designing the Falcon ODE in collaboration with NASA for the AFOTEC. Falcon ODE will provide calibrated radar and optical targets for the new Air Force Space Fence and the NASA Orbital Debris office





Academy Center for Cyberspace Research (ACCR)

MAJ JUD DRESSLER

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OVERVIEW

The Academy Center for Cyberspace Research conducts research in a wide range of research areas within the field of Computer Science in support of the Air Force, Department of Defense and other government and commercial sponsors. ACCR seeks to develop cadets as cyber innovators by participation in and exposure to research projects in the domain of cyberspace. Current research focus areas for ACCR include cyberspace education and training, cyber-warfare topics and information assurance.

CORE COMPETENCIES

- Cybersecurity education
- Malware analysis
- Provably secure internet software

MAJOR PROJECTS

- Malware Similarity Detection
- Cyberdeception
- Intrusion Detection for SCADA Systems
- IRONSIDES – A provably secure DNS server

High Performance Computing Research Center (HPCRC)

LT COL ROGER GREENWOOD

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OVERVIEW

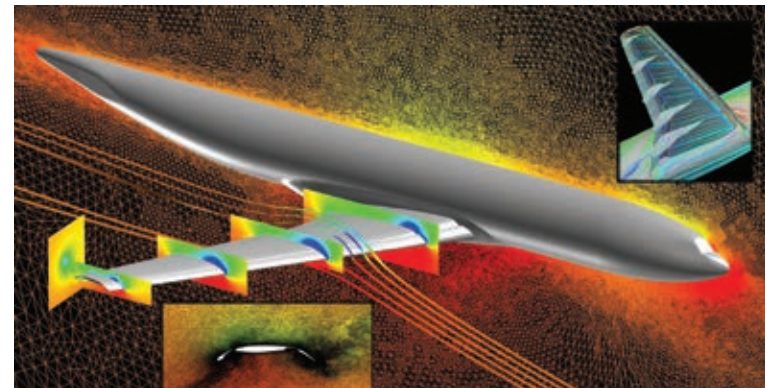
The High Performance Computing Research Center provides access to high performance computing resources (local and remote), high speed network access to those resources and the expertise to use them efficiently. These resources are available to all faculty, staff and cadets, regardless of academic department or discipline. As part of the Department of Aeronautics, HPCRC researchers assist aeronautical engineering majors to conduct research in computational modeling of aerodynamics and high-speed gas dynamics.

CORE COMPETENCIES

- Access to DOD supercomputing resources
- High-speed network access and local storage systems
- Partnerships with local universities for HPC research
- Expertise in Computational Fluid Dynamics

MAJOR PROJECTS

- Computational aerodynamic modeling of full-aircraft for Air Force and DOD
- High fidelity modeling of propeller flow interactions with aircraft bodies
- Reduced-order modeling for stability & control characteristics for NATO air vehicles
- Computational modeling of hypersonic vehicles
- Development of Fluid-Structure-Interaction (FSI) capabilities in the Kestrel CFD code
- Modeling of FSI, to include fluid-surface heat exchange, on several geometries
- Automation of CAD & CFD from the JET Aircraft Design Tool



Air Force CyberWorx

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Center of Innovation (CoI)

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OVERVIEW

AF CyberWorx is a partnership of Airmen, industry and academia reimagining how technology enriches and protects our nation, businesses and lives. CyberWorx is primarily a human-centric design center that seeks out unique ways to apply current and future technologies to create desirable experiences for Airmen prosecuting the fight in Air, Space and Cyberspace. Within CyberWorx, the Center of Innovation conducts research and proofs of concepts with large market shaping companies on disruptive technologies. Together the design and research efforts of CyberWorx accelerate the agility of the AF, DOD and DHS by driving creative solutions and preparing the government to leverage technology before it hits the open market.

AF CyberWorx and the CoI provide unique immersive opportunities for cadets to interact with industry and government experts through design projects, internships and travel opportunities. The center expends almost \$250K annually, creating high-impact experiential learning environments for cadets that have produced scientific papers, CORONA discussion topics, research awards and motivational experiences that have transformed cadet performances.



CORE COMPETENCIES

- Design Thinking
- Cadet Education
- Public/Private Partnerships
- Basic and Applied Research with Market Shaping Companies

MAJOR PROJECTS

- Designing a 21st Century Cyber Training Model to improve the sustainment of the AF Cyber workforce
- Designing a Cyber Risk Ecosystem to quickly and effectively convey mission risks from cyberspace to non-cyber commanders
- Rewriting AF Cyber Command and Control policy to create an intuitive and effecting structure to organize and operate in Cyberspace
- Design a “Smart Base” using modern technology to simplify the lives of Airmen.
- Anti-malware research focused on code reuse versus variant detection. The defining features of this research have been speed and accuracy
- Research on open source and government legacy software to fully leverage a new capability called Software Guard Extensions, new microcode embedded in Intel Corporation’s 7th generation microprocessor. This new capability provides a hardware solution for safe computing on compromised machines and over unprotected networks



Center for Physics Education Research (CPER)

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OVERVIEW

The Center for Physics Education Research engages in pedagogical innovation and the thoughtful application of technology to the learning experience by developing and evaluating effective teaching strategies using research-based approaches.

CORE COMPETENCIES

- Developing research-based educational resources
- Assessing effectiveness of educational approaches
- Providing resources and support for the Just-in-Time Teaching pedagogy

MAJOR PROJECTS

- Innovative Classroom Pedagogies
- Just-in-Time Teaching
- Flipped Learning
- Worked-Examples

Department of Management (DFM)

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OVERVIEW

The Department of Management develops and inspires Air Force leaders to manage complex systems of people, resources and technology. DFM strives to be the renowned center of management education and expertise for the Air Force.

CORE COMPETENCIES

- Strategic planning
- Diversity and inclusion
- Organizational behavior
- Operations research
- Investment management

MAJOR PROJECTS

- Review and evaluate institutional marketing strategies to bolster the USAFA brand
- Use Appreciative Inquiry to build upon organizational strengths in multiple key areas
- Collaboration with local government organizations and nonprofits to improve processes and provide decision support
- Curricular support to the Quad program, a cooperative innovation initiative consisting of the USAFA, University of Colorado Colorado Springs, Colorado College and Pikes Peak Community College



Eisenhower Center

COL KRIS BAUMAN

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OVERVIEW

Named after President Dwight Eisenhower, the first American president to establish a national policy shaping U.S. engagement in space for both military and peaceful purposes, the Eisenhower Center is the research center of the Department of Political Science. It provides cadets and faculty with unique opportunities to participate in research and policy discussions on the future of American security through first-hand contact with senior leaders and experts in the military, civilian government and private sector from the United States and major space-faring nations. In addition to its founding interest in space policy, the Eisenhower Center examines challenges to America's national security across other frontiers of technology development, to include cyber security and developments in hypersonic delivery vehicles. Through its journal, *Space and Defense*, the Eisenhower Center promotes an ongoing discussion of space and security policy issues from a broad range of professional and intellectual perspectives among academic experts and defense policy makers.

CORE COMPETENCIES

- National security policy, with an emphasis on deterrence theory, particularly in the space and cyber domains
- Supports research and scholarship related to challenges to U.S. security

MAJOR PROJECTS

- First-ever cyber forum in April 2016
- Celebrated the tenth anniversary of its Space Forum in December 2016
- Collaborated with the 59th Air Force Academy Assembly which focused on the future of American Defense Policy
- Hosted the Space Forum in September 2017 with a focus on the Air Force's role in space security and the future of conflict
- Working to produce the ninth edition of the Department's classic textbook, *American Defense Policy*

Scholarship of Teaching and Learning (SoTL)

DR. LAUREN SCHARFF

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OVERVIEW

The Scholarship of Teaching and Learning Program represents a growing national and international professional movement that recognizes, publicizes, funds and advocates the scholarly approach to understanding factors that impact student learning. These factors include specific teaching techniques, incorporation of technology, organization of materials and use of group work.

CORE COMPETENCIES

Support an academic culture of innovation and educational research by providing:

- Resources for evidence-based teaching approaches,
- Opportunities to discuss and share evidence-based practices,
- Guidance on research method design and ethics approval for educational research,
- Support for educational research project presentation at conferences

MAJOR PROJECTS

- Investigation of the impact of participation in the USAFA forensics for Air Force officers
- Teaching and assessing Respect for Human Dignity (RFHD) in behavioral sciences courses
- Characterization of capstone design experiences in engineering



Human Performance Lab (HPL)

MS. DYANA BULLINGER

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OVERVIEW

The Human Performance Laboratory 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 Human Performance Lab also provides subject matter expertise on the Air Force fitness program and human performance, offering scientific data through research and exercise physiology principles. Through the use of various physiological tests, to include Dual Energy X-ray Absorptiometry (DXA) scans for body composition, Resting Metabolic Rate, VO₂max, Anaerobic Endurance, Anaerobic Power and Anaerobic Threshold, the HPL can aid athletes and cadets to improve their performance, nutritional habits and overall fitness levels. The HPL tests and trains more than 2,000 cadets and approximately 200 faculty, staff and active duty members annually while also hosting and conducting informational and educational tours for more than 150 high schools, college universities, elite athletes, professional sport teams and military personnel from all over the world.

CORE COMPETENCIES

- Training and enhancing vision for sports performance
- Interval and maximal effort training to further adapt the skeletal muscle and improve athletic performance

MAJOR PROJECTS

- 1.5 mile Altitude Dose research study to determine if a significant difference in aerobic performance exists between five different altitudes
- A three year study to investigate the benefits offered by PX₃'s Bite Regulator technologies in reducing concussions among USAFA athletes
- Falcon Fuel
- An internship program for senior level undergraduate or graduate students, in the field of exercise physiology, from around the country



Air Force Humanities Institute (AFHI)

DR. TOM MCGUIRE

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OVERVIEW

This organization offers a wide array of programs, lectures, interviews, art exhibits, seminars and discussions aimed at fostering interdisciplinary conversation and exchange. AFHI allows USAFA faculty and cadets a forum for exploring a broad range of intellectual traditions and paradigms that enrich our understanding the human condition.

CORE COMPETENCIES

- Examining the intersections of art, literature, technology, science and ethics
- Promoting interdisciplinary dialogue about perennial questions in the humanities
- Fostering creativity and ethical reflection through fine art, imaginative literature, history, philosophy and foreign language
- Providing professional development and research opportunities for faculty and cadets

MAJOR PROJECTS

- Lectures
- Speakers
- Interdisciplinary conversations
- Performing arts presentations
- Faculty development seminars



Department of Foreign Languages (DFF)

LT COL DARIN EARNEST

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OVERVIEW

Research and faculty development in the Department of Foreign Languages is about encouraging innovative, interdisciplinary research and teaching at once, while paying due attention to the details of a particular topic without losing sight of the larger questions raised by history, literature, philosophy and the study of language and cultures.

CORE COMPETENCIES

- Educational and developmental resources for teachers and cadets
- Research publications and scholarly presentations for teachers and cadets

MAJOR PROJECTS

- Cadet 1st Class Susan Hurtado, Cadet 2nd Class Samuel Burton, and Cadets 3rd Class Nestor Hernandez and Kimberly Soltero presented a research paper at the XXI International Conference of Hispanic Studies in Merida Mexico; coached and mentored by Dr. Ismenia de Souza (March 2016)



Center for Air Power Studies (CAPS)

LT COL JOEL HIGLEY

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OVERVIEW

The Department of Military and Strategic Studies Center for Airpower Studies produces cognitively agile, action-oriented thinkers to meet the challenges in translating strategic guidance into operational and tactical successes to meet national security policy goals with the military instrument of national power. The center develops strategic and critical thinking through education in the rational, responsible and restrained use of military power in a variety of violent and nonviolent contexts and conducts innovative research into the effective use of air, space and cyberspace powers in the joint warfighting environment.

CORE COMPETENCIES

- Cadet Battle Laboratory (CBL) - The primary focus of the CBL is to provide warfare simulation for education, research and analysis in an interactive educational environment aimed at individual and/or collaborative learning.
- Air Warfare Laboratory (AWL) - The primary focus of the AWL is to provide airpower simulation in an interactive educational environment for individual and collaborative learning

MAJOR PROJECTS

- Investigate options to improve Air Force pilot throughput and inspire potential future pilots through aircraft simulation.
- Test and evaluate appropriate modeling and simulation software to allow replicable strategy analysis and data gathering on key airpower variables.
- Develop strategies to defeat 5th generation aircraft with 3rd generation fighters.
- Investigate Command and Control concepts to support the Combat Cloud/ Fusion Warfare concepts.

Department of Philosophy (DFPY)

DR. CARLOS BERTHA

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OVERVIEW

The Department of Philosophy takes great pride in being the only stand-alone philosophy department among U.S. service academies. Like nearly all philosophy departments, DFPY emphasizes critical thinking in several domains, including aesthetics, ethics, applied ethics (e.g. military and STEM ethics), philosophy of language and mind, logic, metaphysics and philosophy of religion. In addition to the philosophy major, the department administers the philosophy minor and religion studies minor.

CORE COMPETENCIES

- Critical thinking in military ethics, especially the just-war tradition; all department members teach and publish in this area

MAJOR PROJECTS

- Publishing textbook in engineering ethics
- Study of the philosophy of religion while growing and sustaining the first religious studies minor at a U.S. service academy
- Publishing and providing editorial assistance in major disciplinary organs such as the international Journal of Military Ethics
- Hosting the biennial meeting of the International Society for the Philosophy of Architecture



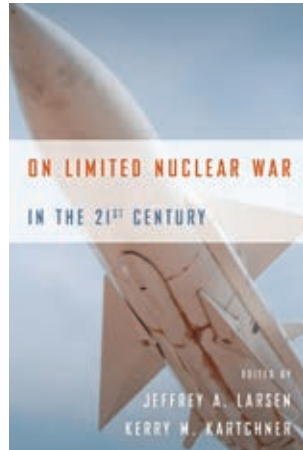
Institute for National Security Studies (INSS)

DR. JIM SMITH

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OVERVIEW

The USAF Institute for National Security Studies (INSS) is located within the Air Force Academy faculty. INSS has focused continuously on arms control, strategic stability and strategic security, advising the USAF and Defense communities on current and emerging issues of interest to them. USAF sponsorship to INSS today comes from HAF/A10P, the Policy Division of the HAF/A10, Deputy Chief of Staff for Strategic Deterrence and Nuclear Integration. Other core sponsors include the Defense Threat Reduction Agency (DTRA) and broader Defense strategic research community. INSS manages the DTRA Project on Advanced Systems and Concepts for Countering WMD and its research portfolio that advises the DTRA strategic planning process. These projects include both cutting-edge strategic security and countering WMD strategy and policy studies, but also a series of Track II (non-official) strategic dialogues with allies, adversaries, and states of WMD concern.



CORE COMPETENCIES

- Strategic policy and strategy research and analysis
- Arms control and strategic stability, strategic deterrence and assurance, proliferation and countering weapons of mass destruction and emerging strategic security challenges

MAJOR PROJECTS

- Re-conceptualizing strategic stability
- Future of arms control
- China's strategic future
- Countering WMD challenges and the emerging strategic environment
- Regional Strategic Challenge: The Day After the Next Nuclear Employment



Institute for Information Technology Applications (IITA)

LT COL BEN CROSSLEY

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OVERVIEW

The Institute for Information Technology Applications, funded by the Air Force Research Laboratory Sensors Directorate (AFRL/RI), engages in multidisciplinary research at the US Air Force Academy to develop products with information technology that would benefit education and operations at the Academy, the Air Force, and the DOD.

CORE COMPETENCIES

- Developing and funding multidisciplinary research opportunities across the academic departments
- Fostering collaborative efforts between AFRL and the Academy
- Remotely Piloted Aircraft (RPA) program teaches cadets tactical airmanship concepts via the RQ-11 Raven unmanned aircraft and operational airpower employment via the Air Operations Center simulator

MAJOR PROJECTS

- Collaborative effort between DFMI and AFRL/RQ (Aerospace Systems Directorate) to purchase and install experimental simulators for integration into the DFMI Air Warfare Laboratory
- Development of a power grid system test bed for detection and mitigation of cyber anomalies and information vulnerabilities in a collaborative effort with DFEC, West Point, the Naval Academy and the Idaho National Laboratory
- DFCE effort to use UAV technology to assess pavement conditions and determine required maintenance for flexible and rigid pavements
- State-of-the-art RPA Operations Center (ROC) provides command and control for all unmanned aircraft operations at USAFA
- USAFA participation in DOD's counter UAS exercise, Black Dart
- Researching methods of mitigating threats from hardened and deeply buried targets through infiltration and underground mapping techniques



Life Sciences Research Center (LSRC)

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OVERVIEW

The Life Sciences Research Center's primary mission is to support the Air Force Office of Scientific Research (AFOSR) and Air Force Surgeon General (AF/SG) through faculty and cadet research efforts. The main objective of the LSRC is to develop basic research within a broad range of biological sciences topics. Multidisciplinary, there are three main research thrusts which include biomedical, biosystems and human health/performance areas.

CORE COMPETENCIES

- Screening methods for detecting bacterial agents that can activate/deactivate avian flu viruses and interrogating select cell lines for microbiome research
- Cultivating/isolating select extremophile organisms as a source of alternative energy production for biosensing capabilities
- Cellular lipid and protein analysis for investigating molecular redox mechanisms

MAJOR PROJECTS

- Biosystems - isolate extremophiles with interesting and robust extracellular electron transfer capabilities to potentially power remote sensing devices
- Human Performance - interrogate known mitochondrial metabolic phenomenon that are still not well understood in terms of electron transfer mechanisms which control organism survival and viability
- Biomedical - identifying secreted proteases from *Aeromonas sobria* that affect avian influenza virus infectivity

Chemistry Research Center (CRC)

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OVERVIEW

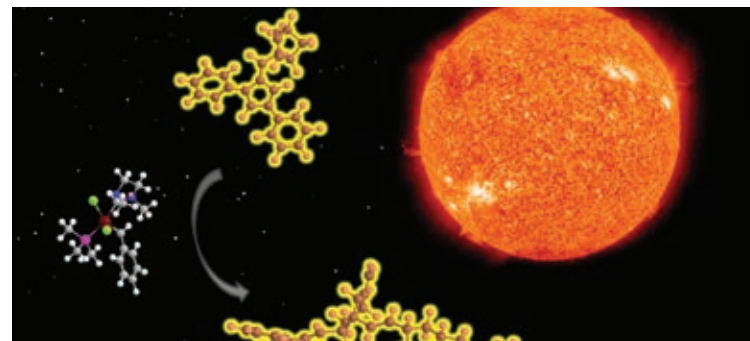
The research team in the Chemistry Research Center at the U.S. Air Force Academy focuses on preparing functionalized polymer and hybrid polymer composites directed toward developing next-generation, high-performance materials to meet operational Air Force and Department of Defense mission partner needs. In order to accomplish a portion of this, the CRC has had proven success by external partnering with academia, industry and national laboratories in order to leverage an expanding technology base.

CORE COMPETENCIES

- Advanced materials and composites processing and fabrication
- Robust small molecule, biomolecular and macromolecular synthesis and characterization
- Molecular computational modeling and simulation for predictive chemical properties
- Senior and post-doctoral associates and faculty with a broad spectrum of specialties to adapt to the ever-changing world of chemistry challenges

MAJOR PROJECTS

- Light harvesting material for new solar/green technologies towards federal zero net energy goals
- Stimuli-responsive coatings for the development of chemical warfare nerve agent detection
- High temperature resins and high strength fibers for next-gen solid rocket motor case composites
- Metallized composites from additive manufacturing towards structural energetics for propellants with tunable energy output



Department of Civil and Environmental Engineering (DFCE)

DR. THOMAS PHELAN

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OVERVIEW

The Department of Civil and Environmental Engineering produces problem solvers, meeting the challenges of environmental degradation, building and improving infrastructure, energy needs, natural disaster responses, sustainable development and community planning by improving the full spectrum of the built environment.

CORE COMPETENCIES

- Fully functional soils laboratory
- Static structural testing capability via a 25-foot-long reaction floor and multiple hydraulic actuators
- A high-bay laboratory space with a 5-ton crane and multiple universal testing machines
- Extensive experience with multiphase flow simulation techniques

MAJOR PROJECTS

- Forest service bridge design and construction
- Screening-level modeling of bioenhanced dissolution in field-scale bioremediation remedies
- Tools for the prediction of PFAS transformation, transport and retention in AFFF source areas
- Use of energy foundations to provide geothermal heating and cooling to buildings
- Integrating responsible engineering and local knowledge to design, implement and evaluate sustainable engineering solutions in Latin America



Academy Center for Unmanned Aircraft Systems (UAS) Research

DR. GEORGE YORK

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OVERVIEW

The Academy Center for Unmanned Aircraft Systems Research, hosted by the Department of Electrical and Computer Engineering, focuses on adding autonomy to UAS, to allow one operator to control multiple UAS that can autonomously search, find, identify and track various targets. UAS serve as an excellent platform for our cadets across various disciplines to conduct meaningful research supporting the warfighter.

CORE COMPETENCIES

- Simulating and test flying autonomous algorithms for multiple UASs
- Sensor Fusion (EO, IR, RF)
- GPS-Denied Navigation
- Sense and avoid path planning
- Counter-UAS methods

MAJOR PROJECTS

- Won the Boeing Tri-Service Autonomous MicroUAS Swarm Challenge, defeating USMA and USNA
- Hosted a five University Counter-UAS demonstration at the USAFA
- Developed Range-Sensor and Image-based Navigation for GPS denied environments
- DARPA Unmanned Capture-the-Flag Competition, a drone war fielding 25 autonomous USAFA UASs vs 25 USMA/USNA UASs

Department of Engineering Mechanics (DFEM)

LT COL CORY COOPER

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OVERVIEW

The Department of Engineering Mechanics develops Air Force problem-solvers to meet the needs of the warfighters through innovative design techniques, infrastructure monitoring and improvements, aging aircraft analysis and solutions and aircraft structural integrity improvement. In addition to consistent faculty research, multiple cadet research opportunities are provided via cadet summer research opportunities, senior capstone projects and independent cadet research endeavors.

CORE COMPETENCIES

- Materials characterization including microstructure, properties and corrosion effects
- Mechanical testing including fatigue, corrosion and welding effects
- Composite structures and additive manufacturing laboratories
- Automotive laboratory including chassis and engine dynamometers
- Dynamic testing including vibrational and structural response under transient loading

MAJOR PROJECTS

- Effects of friction stir welding and temperature on microstructure, corrosion resistance and mechanical properties of metals
- Cadet capstone competitions resulting in multiple first place finishes for competitions such as the annual Corrosion Design Competition and the annual Service Academy Challenge
- Thermodynamic analysis of multiple real-world applications, including aircraft icing, athletic stadium field heating for de-icing and airbase petroleum oil and lubricant (POL) storage/distribution systems



Warfighter Effectiveness Research Center (WERC)

LT COL CHAD TOSSELL, PH.D.

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OVERVIEW

The Warfighter Effectiveness Research Center is the research arm of the Department of Behavioral Sciences and Leadership, and is dedicated to facilitating faculty and cadet research in the behavioral sciences that enhances warfighter effectiveness. A trans-disciplinary approach is generally used to address the research areas mentioned below. Current collaborators include government laboratories, academia, industry and military operators— all dedicated to the same warfighter-focused approach to science and technology.

CORE COMPETENCIES

- Cadet development through research and design
- Basic and applied research in human-machine teaming
- Diversity and inclusion research, practice, and policy
- Evidence-based approaches to understanding leadership development
- Responding to warfighter needs

MAJOR PROJECTS

- Robots as social agents in human-machine teaming contexts
- Healthy relationship training as a method for sexual assault prevention
- Novel core leadership education and training synchronized across USAFA
- A social scientific approach to brain care (concussion)
- Pilot screening in Afghanistan
- Multi-domain command and control and operations research support in AFSOUTH
- Autonomous driving
- Supervisory control of multiple RPAs (VR, AR, etc.)

Center for Character & Leadership Development (CCLD)

DR. JOHN ABBATIELLO

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OVERVIEW

The Center for Character and Leadership Development is the Academy's most visible focal point for understanding, enhancing and integrating Academy cadet and staff efforts to achieve the essential mission of developing officers of character. CCLD conducts research and brings scholars and practitioners together to understand the evolving Profession of Arms and the changing demands of military leadership and character development. We support the developmental processes which prepare cadets to serve effectively as leaders.

CORE COMPETENCIES

- Generates and shares research, assessment and understanding of military character and leadership questions of importance
- Designs and coordinates selected professional development activities for Academy-assigned personnel, to provide for their own personal growth and to enhance cadet development
- Leverages the newly-completed Polaris Hall to support both cadet development and USAFA institutional outreach to external (USAF, DOD, national and international) discussants in character and leadership issues
- Publishes print and electronic scholarship in the field of character and leadership integration

MAJOR PROJECTS

- Collection and publication of character- and leadership-related oral history and the Journal of Character and Leadership Integration
- Executed the annual National Character & Leadership Symposium and Scholars Forum
- Continued development of the "Combined Effects Operations" concept for publication, in coordination with the Center of Innovation
- Continuing the "Living Honorably" Study and follow-on research activities
- Developed and delivered Permanent Party Professional Development Seminar Series to include sessions on Accountability (seminar I), Developing Others (seminar II), and Building Trust (seminar III)



THE USAFA OFFICE OF RESEARCH

Supporting Your Research The USAFA Office of Research exists to support the researcher as they develop career officer and operations-ready warfighters through access to federally developed technology, STEM education, national security and job growth.

STEM Outreach The mission of the United States Air Force Academy STEM Outreach Program is to offer a variety of programs and services that effectively engage, inspire and attract the next generation of STEM talent.

VISITING RESEARCHER PROGRAMS

Engineer and Scientist Exchange Program (ESEP) and Administrative Professional Exchange Program (APEP)

A DOD effort to promote international cooperation in military research, development and acquisition through the exchange of defense scientists and engineers. It provides on-site working assignments for U.S. military and civilian engineers, scientists and administrative professionals for a 2 year period.

Air Force Science & Technology Fellowship Program

Provides USAFA labs an opportunity to bring on postdoctoral and senior scientists and engineers for 12–24 month periods to assist with research and contribute to overall efforts of the laboratories.

Summer Faculty Fellowship Program (SFFP) USAFA researchers can bring on SFFP fellows for collaborative research over a summer period of 8–12 weeks.

TECHNOLOGY TRANSFER

Technology Transfer Commercial Test Agreements

Agreements to extend services from a USAFA laboratory to a third party for the testing of materials, equipment, models, computer software and other items for an appropriate fee.

Cooperative Research and Development Agreement (CRADA) Services

Legal agreements between a USAFA laboratory and a nonfederal party to offer both parties the opportunity to leverage each other's resources when conducting research and development; resulting royalty income is shared between the inventors and the laboratory.

Educational Partnership Agreement (EPA)

A formal agreement to transfer equipment from a USAFA laboratory to a K–12 facility or any non-profit institution that is dedicated to improving science, mathematics and engineering education. EPAs increase awareness and visibility of military developed technologies and increase potential for commercialization of military technology.

THE USAFA OFFICE OF RESEARCH

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ENHANCING CADET EDUCATION
DEVELOPING FUTURE PROBLEM SOLVERS
PARTNERING FOR INNOVATION SOLUTIONS



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AIR FORCE ACADEMY