2020
RESEARCH DIRECTORY

UNITED STATES
AIR FORCE ACADEMY
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INTRODUCTION

The Future is uncertain and ill-defined. We need no better reminder of this than the crisis our country and world encountered this year. Whether our future leaders face a pandemic or a military conflict, they must be prepared to make difficult decisions using reliable data, sound scientific principles, and innovative best practices. This is what the research program at the United States Air Force Academy provides.

We are proud to be one of the nations’ leading undergraduate research institutions. Our research program has grown in recent years and is a critical component of officer development. Whether cadets are involved in laboratory research in one of our 27 research centers and institutes, participate in a capstone research project, take part in the Cadet Summer Research Program, or present their research at a scientific conference, every single cadet now has the opportunity to participate in research during their four year program.

Our Faculty and staff are critical facilitators in this process. They challenge cadets with difficult, complex problems and shepherd them through the empirical process. They are dispersed worldwide presenting their research, authoring books, and collecting data that help us understand the world and how the modern Air and Space Forces contribute to global Peace.

Research is a critical component of the innovative spirit our cadets must foster when they graduate. We need future leaders who are adept at viewing problems from new perspectives. Our leaders must ensure that our organizations’ innovators have the resources and support to question our current processes and provide novel solutions.

The skills cadets learn at the Air Force Academy will prepare them to be more adaptive, innovative, and successful leaders. Our Air and Space Forces will be better as a result.

Jay B. Silveria  
Lieutenant General, USAF  
Superintendent, United State Air Force Academy
Air Force Academy Observatory Beams into the 21st Century with $1.2 Million Telescope

BY: DR. DEVIN DELLA-ROSE AND DR. FRANCIS CHUN

Generous Donations Provide Cutting-Edge Observatory Upgrades

Dr. Devin Della-Rose, Observatory/Argo Director/Department of Physics

Since the late 1970’s, faculty from the Air Force Academy Physics Department have used telescopes and other equipment at the Air Force Academy Observatory to support innumerable space science research projects for cadets, faculty and civilian students.

Two telescopes, atmospheric sensors, and even a laser aimed at Earth’s upper atmosphere have enabled studies ranging from space domain awareness of Earth-orbiting objects to the search for planets orbiting other stars. The main telescope, built in 1964, was becoming obsolete, and couldn’t keep pace with the high-precision needs of modern research. However, $1.2 million in funding from the Air Force Office of Scientific Research (through a Defense University Research Instrumentation Program grant), Air Force Academy Dean of Faculty Research Office, and generous Academy graduate and civilian donors, has resulted in a state-of-the-art telescope and camera system, installed in fall 2019.

The new system has a one-meter primary mirror, making it the largest in Colorado that is accessible to the general public. It gathers light at least seven times faster than the old Apollo-era telescope, is remotely controllable, capable of tracking low-Earth orbiting spacecraft, and features a unique, large-format cryo-cooled camera.

$1.2 Million Ritchey-Chretien reflecting telescope. Funding provided by the Air Force Office of Scientific Research, the USAFA Office of Research and several Academy graduate and civilian donors.
A high-resolution spectrograph will join this formidable research arsenal in fall 2020. Without doubt, this new telescope system will support cutting-edge space science research at the Academy for generations to come.

In the spring of 2020, four senior physics majors participated in NASA research to search for Earth-sized planets orbiting “nearby” stars in our galaxy. They used data from the Transiting Exoplanet Survey Satellite (TESS) to identify potential planet candidates for study.

One of these cadet researchers, now Second Lieutenant Gabrielle McClelland, commented that “TESS finds potential exoplanet candidates, and we take more detailed pictures with a specific focus on a single star. We actually had good enough data on one of our observations that NASA moved one of the candidates from questionable to probable.”

The suspected exoplanet identified by the cadet researchers is 90 light years from Earth and is believed to be about 20% larger. McClelland's research partner, now Second Lieutenant Kayla Brown, who is training to serve as an Air Force physicist, also feels fortunate to have done research with the one-meter telescope. "It is quite awesome to see it in action and get information from stars that are very far away and dim," Brown says. “I believe it is to the point where new and exciting research will happen at the observatory.”
Physics Department Prepares for Space Force Research Support

Dr. Francis Chun, Director for the Center for Space Situational Awareness Research/Department of Physics

AFA’s Department of Physics has been preparing for the Space Force for a number of years now. With an existing AFA global system of 0.5-meter telescopes called the Falcon Telescope Network or FTN, combined with a smaller 0.4-meter telescope on campus, cadets have conducted innovative research characterizing satellite from their unresolved optical signature. The new 1-meter telescope with its suite of exquisite instruments combined with the smaller AFA telescopes, will usher in an era of multi-modal optical measurements of a satellite, simultaneously from a variety of locations and under different lighting conditions.

2nd Lt McClelland, who commissioned into the new U.S. Space Force, says her observatory research will be beneficial to her career. “Space domain awareness is becoming extremely important, and being able to image and characterize various satellites undoubtedly will be a focus in the coming years,” she says. “Understanding the limitations and capabilities of a telescope in order to take those images will be invaluable in the coming age of the Space Force.”

Recently graduated cadets from the Class of 2020, Second Lieutenant Marco Pirozzoli, Second Lieutenant Lucy Zimmerman, and Second Lieutenant Sequoia Chun (no relation), spent this past academic year developing and demonstrating a new instrument on the smaller 0.4-meter telescope to measure the polarization signature of geosynchronous satellites. They combined the polarization data with spectral data taken at the same time.

“Observing with the 0.4-meter telescope was part of my culminating senior research at AFA,” says Zimmerman. “The telescope’s capabilities allowed us to track geosynchronous communications satellites and capture unresolved images of them. Following this, we used a variety of analysis methods to glean more information about these unresolved images and ultimately learn more about the satellite. These observation and analysis techniques are important to the mission of the Space Force.”

This work with the 0.4-meter telescope will directly apply to new capabilities for the 1-meter telescope. Pirozzoli agrees, “The new 1-meter telescope will allow cadets and faculty to gather more precise data and help keep the Air and Space Forces at the forefront of space domain awareness research.” A starry future indeed for space science at the USAFA Observatory!
CCLD Implements Several Research Project To Develop Leaders of Character

BY: DR. JOHN ABBATIELLO – Chief, Research & Scholarship Division, CCLD

In support of its mission statement—"to serve USAFA by advancing character & leadership development in preparation for service to the nation"—the Center for Character and Leadership Development (CCLD) conducts research in cutting-edge methods and concepts related to developing leaders of character. Additional research areas include defining the modern military profession, grit and resiliency, and the heritage of the Air Force.

Several ongoing research projects by CCLD staff highlight these efforts. One project seeks to examine the impact of outdoor leadership training and education on cadets, specifically on awareness of their own emotions and those of their fellow trainees. During the summer of 2019, CCLD staff conducted pre- and post-training surveys of third-class cadets enrolled in Adventure and Experiential Based Learning, part of the Commandant’s Expeditionary Survival and Evasion Training summer program. Collected data demonstrated that participants experienced a significant positive shift in awareness of their own emotions and of those of their small-group teammates during outdoor challenges.

Another project, making use of AFWERX funding, is piloting the use and potential benefits of online technologies as tools for mentoring cadets. Using video-based instruction to impact the efficacy of cadet moral decision-making is yet another study under way.
Our flagship publication is the Journal of Character and Leadership Development (JCLD), with three issues per year as well as an occasional paper series. The purpose of the JCLD is to examine the intersection of character and leadership and research-based techniques for developing leaders of character; it typically includes scholarly articles related to these topics as well as interviews of senior practitioners from across military, academic, business, athletic, philanthropic, and government domains. The JCLD’s winter edition is aligned with the theme of our annual National Character and Leadership Symposium, which in February 2021 will be “Warrior Ethos.”

CCLD also enjoys the expertise of three senior scholars, funded by the Air Force Academy Foundation, who conduct research into the current state of the profession of arms and the impact of the strategic and societal environments on its future. One project by CCLD’s and Arthur Johnson Chair, Lt Gen (Ret) Chris Miller, is a monograph aiming to redefine the modern American military profession.

Dr Steve Randolph, former US State Department Historian, occupies the Rokke-Fox Chair. Dr Randolph’s recent research efforts have focused on how the USAF Academy has reacted institutionally to cadet attrition rates over time.
Lt Gen (Ret) Dave Deptula serves as the Risner-Perot Chair and writes often about current strategic challenges and air and space defense issues. All three senior scholars regularly interact with cadets both inside and outside of academic classes.

CCLD’s senior scholars teamed with USAF Academy staff and leaders from the Air Force Academy Foundation to produce a summer seminar on the Warrior Ethos. Organized by the Institute for Future Conflict, the seminar examined current and historical definitions of the term “warrior” and challenged cadets to reflect on their own identity as military professionals in a technologically challenging environment.

Finally, the recent COVID19 outbreak drove a request from USAF Academy senior leaders to develop coping materials for both cadets and permanent party. Harnessing in-house research expertise in mindfulness, grit and resiliency, CCLD staff produced a weekly newsletter highlighting strategies for individuals to remain resilient and mentally and physically healthy during periods of quarantine and physical isolation.

A key aspect of CCLD’s research is its operational focus. All efforts are designed to provide direct answers to important questions regarding how to best develop cadets into officers and to guide senior leaders in policy decisions. CCLD is committed to this approach of using and producing research to inform decision-makers.
The top research official at the Air Force Academy said it takes more than a global pandemic to stop summertime research at the school. Despite the effects of the COVID-19 pandemic on universities across the U.S., cadet researchers are busier than ever, said Col. Chris McClernon, the Academy’s Associate Dean for Research. McClernon oversees all research at the school. “Our research programs are not slowing,” he said.

The Academy never entertained cancelling its Cadet Summer Research Program, McClernon said, and “herculean” efforts were made by the faculty and the Academy’s tech-transfer partners to schedule research projects while keeping cadets safe from the coronavirus.

Traditionally, the program supports approximately 200 cadets selected for in-person research experiences nationwide. Efforts resulting from the COVID pandemic increased participation to more than 450 remote cadet research experiences for the summer. “It really paid off,” he said. “This is an excellent example of our Academy not only surviving, but thriving amid COVID-19. The coronavirus forces us to rethink how we provide research opportunities.”

In March, as the coronavirus spiraled around the U.S., Academy Superintendent Lt. Gen. Jay Silveria authorized underclassmen to leave the Academy and continue their studies online.

Silveria’s decision to evacuate most cadets from the campus placed a few cadets close to their research hubs, including Cadet 1st Class Kylie Stronko of Woodbridge, Virginia.
Stronko worked at the Aerospace Corporation Center, a nonprofit near Chantilly, Virginia, that advises the U.S. government on space-enterprise issues and space-systems engineering. The center is just more than 20 miles from Stronko's family home in Woodbridge.

Stronko worked with the Aerospace Corporation Center’s head of government relations to monitor progress on next year’s National Defense Authorization Act. She also studied space policies shared by Brazil and the U.S to “develop policy recommendations for U.S. government and military leaders for further collaboration with their Brazilian counterparts.”

Cadet 1st Class Kathleen Medill enrolled in the Robotics Institute Summer Scholars Program, hosted by Carnegie Mellon University, from her home in Lincoln, Nebraska. “The goal is to develop a deep-learning [artificial intelligence] model that makes it easier to use a robotic arm,” she said, referring to the AI algorithms used to predict human movement. “I'm excited to apply that knowledge to my capstone project.”

Cadet 1st Class John Byrne of Chesterfield, Missouri, updated the Aerospace Corporation's Space Policy Primer for industry newcomers.

Byrne began his research in Chesterfield, but will continue his projects at the Academy later this summer. “The Academy provides a much more in-depth opportunity for cadets interested in specific subjects like space policy," he said.

The Cadet Summer Research Program also allows cadets to participate in a variety of research internships across Congress, the Defense Department, the State Department, the U.N., NATO, and other organizations.

McClernon, an Academy graduate, said the research opportunities the school provides cadets are a critical component of officer development. “This is a formative transition from when I was a cadet 20 year ago and research was secondary or extracurricular," he said. “Now, every cadet has the opportunity to participate in research during their 4-year program. This aspect of the Academy's officer development curriculum trains our future leaders for the complex, ill-defined problems they will face when they lead our country.”

Byrne, Medill and Stronko expect to begin their senior year in September.
RESEARCH AT A GLANCE

27 Research Centers and Institutes

450+ cadets in Cadet Summer Research Program (CSRP)

217 active national and international research agreements

12 recent patents*

995 recent research publications*

146k PreK-12 students, 900 teachers in STEM Outreach Program

*2018 - 2020
### New Agreements Academic Year 2019-2020

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### 2020 Cadet Summer Research Program

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The Air Force T3 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). The Office of Research provides T3 guidance and support for USAFA researchers. The USAFA Office of Research is a designated Air Force Laboratory and ORTA (Office of Research Technology Applications).
Energetic Composites from Metallized Fluoropolymer Melt-Processed Blends  
**PATENT NUMBER:** US 10,676,409 **DATE:** 9 June 2020  
**Inventors:** Scott Iacono and Jena McCollum  
An energetic composite comprises a metal powder; poly (vinylidene fluoride) (PVDF); and poly(lactic acid) (PLA). The metal powder comprises micrometer or nanometersized particles, and the ratio of PVDF to PLA is between about 1:3 to 3:1. The metal powder comprises between about 4-32% wt of the energetic composite, and the metal powder consists of aluminum (Al), magnesium (Mg), or boron (B). A method of making an energetic composite material, comprises melt-blending a metal powder with poly(vinylidene fluoride) (PVDF) and poly(lactic acid) (PLA). The present invention overcomes the foregoing problems and other shortcomings, drawbacks, and challenges of energetic compounds suitable for manufacturing parts by extrusion-based techniques, i.e. FDM (fused deposition modeling), 3D printing, and injection molding.

Cascade Wind Tunnel Turbulence Grid  
**PATENT NUMBER:** US 10,545,069 B1 **DATE:** 28 January 2020  
**Inventors:** Conner Wiese and Kurt Rouser  
A cascade wind tunnel T-bar turbulence generating grid for creating a turbulence intensity in an air flow having an air flow volume for testing at least two turbine blades having a turbine blade dimension and a pitch-wise location, the turbulence generating grid comprising a plurality of cross bars having a front surface and a cross bar gap, a plurality of vertical bars having a vertical bar front surface and a cross bar gap and at least two support bars assembled to form a plurality of air flow. The support bar at an angle 90 to the air flow and about parallel to the turbine blades. The cross bars mounted to the support bar such that the cross bar front surface is perpendicular to the air flow. The vertical bars are mounted to the support bar such that the vertical bar front surface is perpendicular to the air flow and wherein the vertical bar gap and a horizontal gap provide the turbulence intensity about constant across the pitch-wise location.

Hockey Puck Passing Machine and Shooting Trainer  
**PATENT NUMBER:** US 10,406,417 B1 **DATE:** 10 September 2019  
**Inventors:** Nicholas Le Tourneau and Ricardo Arocho  
A training device for hockey players includes a puck sorting system for holding and orienting hockey pucks. The puck sorting system includes a puck drum having bottom and side portions and configured to hold therein a plurality of hockey pucks. The bottom portion of the puck drum has rotatably mounted thereon a conical puck agitation device configured to orient the plurality of hockey pucks into a predefined position. The training device further includes a puck launching system attached to the puck sorting system. The puck launching system includes a sloped tube operable to receive oriented hockey pucks and convey hockey pucks to a puck launcher. The puck launcher is configured to shoot hockey pucks via a spinning launching wheel driven by a launching motor.

Flowing Gas, Laser Pumped, Alkali Metal Laser with Thermal Confinement of Alkali Metal  
**PATENT NUMBER:** US 10,276,999 B1 **DATE:** 30 April 2019  
**Inventors:** Matthew D. Rotondaro, Randal J. Knize, and Boris Zhdanov  
An optically pumped, flowing gas, alkali metal laser includes a gas passageway transporting an alkali metal vapor and a hydrocarbon buffer gas, and a laser propagation passageway intersects the gas passageway and forms a main cell at the intersection. A pump laser is directed into the main cell and produces a main laser beam in the laser propagation passageway. The flowing hydrocarbon buffer gas is disposed in the main cell with a density to induce spin-orbit relaxation in the alkali metal vapor. At least one window is disposed in the laser propagation passageway, and the window is protected from deposits of alkali metal or carbon by a heated leading edge in the laser propagation passageway that re-vaporizes alkali metal and returns it to the gas passageway via a convective gas flow. The window is further protected by a cold block that liquefies alkali metal and by a colder block that solidifies alkali metal in the laser propagation passageway.

Between 1 January 2020 and 30 June 2020, DFRO submitted 6 additional Invention Disclosures to AFMCLO/JAZ.
FY 2019 RESEARCH FUNDING

$43,941,000
TOTAL

*All values are rounded to the nearest thousand.
RESEARCH CENTERS AND INSTITUTES
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 best-equipped aeronautics 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
- Aircraft Stability and Control
- Supersonic/hypersonic experiment and computation
- Gas turbine and combustion research
- Small air vehicle design/build/fly
- Parachute canopy development/computation

**MAJOR PROJECTS**
- A-10 degraded configuration flight worthiness
- 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
- NASA Orion vehicle dynamic stability
The Center for Aircraft Structural Life Extension 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 for 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
- Aircraft Structural Integrity Program (ASIP) 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.
- Short courses, videos, science center exhibits, design challenges, college readiness programs, etc.

### MAJOR PROJECTS
- Structural testing and analysis (full-scale, component level, and coupon)
- Material degradation (corrosion, cracking, etc.)
- Material processing, testing, and development
- Structural teardown analysis and root-cause analysis
- Measurement and impact analysis of operational loads, stress, and environment
- Educational outreach & curricula development

The Hypersonic Vehicle Simulation Institute, sponsored by the DOD High Performance Computing Modernization Program, is a national effort managed from the USAFA. The vision of this effort is to bring together disparate DOD, DOE, NASA, academic and industry hypersonic researchers 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 the 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

### 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.
The Astronomical Research Group and Observatory, based at the USAFA Observatory, houses a 41-cm Ritchey–Chrétien telescope, and supports the worldwide Falcon Telescope Network (FTN). A state-of-the-art 1-meter Ritchey–Chrétien telescope and large-format camera system was installed in fall 2019 (pictured above), and is now fully operational. A high-resolution echelle spectrograph is scheduled for integration into the 1-meter system in fall 2020. ARGO conducts deep-space research including asteroid tracking, astronomical spectroscopy and photometry and exoplanet studies, as well as SDA research including resolved and non-resolved space object tracking. ARGO also supports the other Department of Physics research centers and grant work. Finally, ARGO hosts STEM outreach activities at the observatory for Scout groups, school groups and teachers, in partnership with the newly-reopened USAFA Planetarium.

**OVERVIEW**

The Astronomical Research Group and Observatory, based at the USAFA Observatory, houses a 41-cm Ritchey–Chrétien telescope, and supports the worldwide Falcon Telescope Network (FTN). A state-of-the-art 1-meter Ritchey–Chrétien telescope and large-format camera system was installed in fall 2019 (pictured above), and is now fully operational. A high-resolution echelle spectrograph is scheduled for integration into the 1-meter system in fall 2020. ARGO conducts deep-space research including asteroid tracking, astronomical spectroscopy and photometry and exoplanet studies, as well as SDA research including resolved and non-resolved space object tracking. ARGO also supports the other Department of Physics research centers and grant work. Finally, ARGO hosts STEM outreach activities at the observatory for Scout groups, school groups and teachers, in partnership with the newly-reopened USAFA Planetarium.

**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 in support of NASA TESS Mission
- Spectroscopy of exoplanetary host stars
- SDA research with the new 1-meter telescope
- Hazardous near-Earth asteroid tracking

**Center for Space Situational Awareness Research (CSSAR)**

**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.

**MAJOR PROJECTS**

- Development of the Academy’s global Falcon Telescope Network and new 1-meter telescope
- Spectral and polarization measurements of solar panel glints from geosynchronous satellites
- Four-channel polarimeter to determine linear polarization states from un-resolved satellite optical signatures
Laser and Optics Research Center (LORC)

DR. RANDY KNIZE
Randy.Knizee@usafa.edu | 719-333-2579

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 Systems Research Center (SSRC)

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OVERVIEW

The Space Systems Research Center 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
- FalconSAT-X
- EyasSAT Technology Demonstrator
- Cadet Space Operations Squadron
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

- Analysis of data from the first ever Air Force Academy Space Weather satellite constellation. Cadets analyze data from six plasma instruments flown by the Department of Defense Space Test Program (STP)
- Delivery of the Falcon Solid State Energetic Electron Detector in collaboration with the Air Force Research Laboratory
- Designing Falcon Neuro, the first ever flight in space of a neuromorphic camera. Falcon Neuro will be hosted on the International Space Station (ISS) by STP, and will be used to study lightning and sprites in the atmosphere below the ISS.
The Academy Center for Cyberspace Research (ACCR) is the research center for the USAFA's Department of Computer and Cyber Sciences (DFCS). Through deliberate development, the faculty in the DFCS is prepared to conduct high-impact research driven by partnerships with internal research centers, operational Air Force entities, and industry. All of the ACCR projects are designed to match operational needs, industry partners, faculty expertise and cadet interest. Through this pairing we are able to create powerful capabilities that are targeted for providing a direct capability to USAF operations.

**CORE COMPETENCIES**
- System Security Analysis
- Artificial Intelligence and Autonomy
- Immersive Environments
- Business Process Automation

**MAJOR PROJECTS**
- Modern Cyber Security Operations
- Autonomous Drone Swarms
- Robotic Process Automation

Air Force Cyber Worx collaborates with Airmen, academic, and industry experts to solve operational problems using human-centered and agile design methods. Cyber Worx aims to resolve challenges for the Air Force with forward-looking solutions. Partnering with AF Cyber Worx provides airmen and cadets with the opportunity to work with real-world practitioners, creating teaming environments that will help with their leadership skills in their Air Force careers. Cyber Worx is based at the Air Force Academy to harness the ingenuity of 4,000 digital-native airmen and cadets and more than 100 Ph.D. faculty members, its vibrant

**CORE COMPETENCIES**
- Use industry best practices
- Collaborative design groups
- Create impactful solutions
- Rapid, low-fidelity prototyping
- Collaboration with public and private partnerships
- Educating Airmen to be innovators

**MAJOR PROJECTS**
- Cyber Risk Ecosystem (CRE): An AI/ML multi-domain command and control tool
- Program Unified Combat Coordinator (PUCC): A web-based application that mimics existing AF flight scheduling puck boards
- Position Navigation Timing (PNT) without GPS
- Readiness Dashboard (COP): A web application that consolidates numerous data sources into one dashboard
- Self-Healing Drone Swarm: Algorithms to establish an autonomous drone swarm
- Optimis (Flight Evaluation App): An app-based training management program that can be accessed on issued government iPads with real-time inputs that sync wirelessly to a central database.
- Software Guard Extensions (SGX)
High Performance Computing Research Center (HPCRC)

**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 (CFD)

**MAJOR PROJECTS**

- Computational aerodynamic modeling of full-aircraft for USAF and DOD
- High fidelity modeling of propeller flow interactions with aircraft bodies
- Reduced-order modeling for stability and 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

Institute for Information Technology Application (IITA)

**OVERVIEW**

The Institute for Information Technology Applications (IITA), funded by the Air Force Research Laboratory Information Directorate (AFRL/RI), engages in multidisciplinary research at the US Air Force Academy to develop products and technology benefiting education and operations at the Academy, the Air Force, and the DOD. IITA fosters collaborative efforts between AFRL (all technical directorates) and the Academy by supporting research proposal development, funding, and execution; and the exchange of personnel through summer internships, sabbaticals, and working TDYs.

**CORE COMPETENCIES**

- USAFA Liaison to AFRL Technical Directorates
- Research project development and growth

**MAJOR PROJECTS**

- Power grid system simulator to research methods to detect and mitigate cyber-attacks and anomalies.
- Multi-disciplinary, autonomy, robotics, vision & learning duality (MARVL), is a cross-discipline research effort focused on operational air and space forces.
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 and Worked-Example pedagogies

**MAJOR PROJECTS**

- Open Educational Resources
- Retention of STEM Majors
- Math Interventions to Improve Success Rates in Introductory Physics
- Physics Modules that Incorporate Engineering Design Scenarios
- Automation of CAD & CFD from the JET Aircraft Design Tool

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 athlete 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**

- Physiological tests to aid athletes and cadets to improve their performance, nutritional habits, and overall fitness level, including: Dual Energy X-ray Absorptiometry (DXA) scans for body composition, Resting Metabolic Rate, VO2max, Anaerobic Endurance, Anaerobic Power and Anaerobic Threshold
- Testing and training of more than 1,800 cadets and approximately 100 faculty and staff members annually
- Hyperoxic tent to simulate sea level, used for interval or maximal effort training events to further adapt the skeletal muscle and improve athletic performance

**MAJOR PROJECTS**

- Conducting a three-year study investigating the physiological, neurological and respiratory benefits offered by PX3’s Bite Regulator technologies in reducing concussions among Academy athletes
- 1.5-mile Altitude Dose research study to determine if a significant difference in aerobic performance exists between five different altitudes and if it does, to what extent and if possible, determine a regression equation for each altitude to aid the Air Force in determining an appropriate correction factor at bases around the world
- Falcon Fuel finished its first year in fueling all cadets before, during and after intense physical activity
Office of Labor and Economic Analysis (OLEA)

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OVERVIEW

The Office of Labor and Economic Analysis is dedicated to providing labor economic analysis with the rigor necessary to define, develop, shape, sustain, and deliver an Air Force and Space Force workforce with efficiency. Products from OLEA provide senior leaders responsible for managing the Department of the Air Force’s human capital portfolio with critical information in the development of strategic guidance. OLEA addresses unmet needs in personnel policy identified by senior leadership, with a focus on the application of labor economics principles and econometric analysis to understand the impacts of policy and incentive structures on the behavior of Airmen and members of the Space Force.

CORE COMPETENCIES

- Labor economic theory
- Causal empirical analysis
- Market design
- Personnel policy development and analysis
- Econometric data processing

MAJOR PROJECTS

- IOC for OLEA is projected for Summer of 2021

Scholarship of Teaching and Learning (SoTL)

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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

- Use of lecture capture technology to support CHEM instruction and flipped classes in ASTRO
- Multi-disciplinary investigation of knowledge surveys to develop student self-assessment of learning
- Interventions to promote civil discourse and gender inclusiveness in Political Science
Center for Air Power Studies (CAPS)

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OVERVIEW
CAPS and the Department of Military and Strategic Studies (DFMI) facilitate cognitively agile and action-oriented thinkers' education and leading research on joint warfighting in multi-domain operations. Developing future leaders that can meet the challenges of the 21st century and beyond. Providing new ways of thinking on translating strategic guidance into operational and tactical successes to meet national security policy goals. CAPS facilitates research in a conducive academic environment to develop strategic and critical thinking through cutting edge educational. CAPS' mission is crucial for USAF's future needs as various violent and nonviolent contexts increasingly require new, creative uses of U.S. and coalition forces. CAPS' approach to education and research helps understand how human and economic resources are used best in multi-domain operations involving air, space, and cyberspace.

CORE COMPETENCIES
- Research initiatives bring together expert faculty and cadets to further their mutual and individual warfighting interests.
- Research on the success, failure, and effectiveness of multi/all-domain warfare for continued U.S. dominance in the international system.
- CAPS exercises oversight of DFMI's graduate school programs, Cadet Summer Research Programs (CSRP), internships, and unique academic opportunities.

MAJOR PROJECTS
- Construction of a Multi-Domain Laboratory (MDL), and its incorporation into the existing DFMI curriculum (planned completion Spring 2021).
- MDL will host flight simulators, Remotely Piloted Aircraft (RPA) simulators, Air Battle Management workstations, and a functional Air Operations Center (AOC).
- Development of the sixth version of the Correlates of War Project’s Militarized Interstate Dispute (MID) dataset.
Institute for Future Conflict (IFC)

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OVERVIEW

The USAFA Institute for Future Conflict (IFC) is an integrative concept designed to enhance the capabilities and skills of all USAFA cadets and faculty in thinking about and waging the future fight. The IFC helps USAFA produce leaders of character not only versed in emerging technology, but also able to think critically about the social, historical, and philosophical implications of these developments. The IFC supports and integrates existing USAFA programs and provides resources for cadets, faculty and senior leaders to pursue high-impact learning opportunities and build deeper roots in the technological and socio-cultural demands of modern/future conflict.

CORE COMPETENCIES

- Understanding of emerging technologies: advanced computing, “big data” analytics, artificial intelligence, autonomy, robotics, directed energy, hypersonics, and biotechnology
- Implications of emerging technologies on strategic policy, arms control and deterrence
- Collaborates with United States Space Force, NORAD/NORTHCOM, and other external partners (MIT, Johns Hopkins, Los Alamos National Laboratory (LANL), MITRE Corp., etc.)
- Generates, cultivates, and advances scholarship on technology and the future fight
- Helps educate faculty, staff, cadets, and the wider Air Force on emerging technology and security issues

MAJOR PROJECTS

- Summer Seminars on emerging technologies, warrior ethos, diversity/demography, and the humanities
- United States Space Force Fellowship
- Visiting scholar/scientist program with LANL
- Support of MyMajors academic and career assessment program

Above: Cadets participate in the IFC Summer Seminar “Diversity, Demography, and Leadership in a 21st Century Military” in June of 2020. https://echo360.org/media/7d746aa1-a0d7-4b12-a33d-524f121f7b8a/public
Institute for National Security Studies (INSS)

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OVERVIEW

The USAF Institute for National Security Studies (INSS) is located within the USAFA facility. From its inception in 1992, INSS has focused on strategic security, arms control, and strategic stability, advising the Air Force strategic policy and arms control communities on current and emerging issues of interest. The mission of INSS is to promote national security policy research for the Department of Defense within the military academic community, to foster the development of strategic perspective within the United States Armed Forces, and to support national security discourse through outreach and education. Air Force sponsorship to INSS comes from the HAF/A10, Deputy Chief of Staff for Strategic Deterrence and Nuclear Integration. Other core sponsors include the Defense Threat Reduction Agency (DTRA) and the broader Defense strategic research community.

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
• 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

Nuclear Enterprise Research Center (NERC)

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OVERVIEW

The Academy Nuclear Enterprise Research Center, hosted by the Department of Physics, focuses on interdisciplinary research in support of the nuclear weapons complex. The center utilizes partnerships across the nuclear enterprise to perform cutting edge research across the nuclear science and policy spectrum. The center supports the Nuclear Weapons and Strategy Minor, and provides research opportunities for cadets of all academic backgrounds and majors.

CORE COMPETENCIES

• Ability to due Classified Research
• Nuclear Detection
• Nuclear Weapon Effects
• Countering Nuclear Proliferation
• Radiation Health Physics

MAJOR PROJECTS

• Third-Offset Deterrence
• Space Dosimetry on the iMESA and FalconSEED instruments
• Material Characterization using X-Ray Scattering
• Noble Gas Detection for Counter Proliferation
Academy Center for Unmanned Aircraft Systems Research (ACUASR)

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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 UAS
• 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 Service Academy Swarm Challenge Competition, a drone war fielding 25 autonomous USAFA UASs vs 25 USMA/USNA UASs

Center for Character and Leadership Development (CCLD)

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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

• Publication of the Journal of Character and Leadership Development
• Executed the annual National Character & Leadership Symposium and Scholars Forum
• Continuing the “Living Honorably” Study and follow-on research activities
• Developed and delivered Permanent Party Professional Development Seminar Series and expanded offerings to include sessions on emotional intelligence, communication and feedback
Chemistry Research Center (CRC)

OVERVIEW
The research team in the Chemistry Research Center at the U.S. Air Force Academy focuses on new chemical discoveries from to meet operational Air Force and DOD mission partner needs as well as private partnerships with academia and industry. CRC and the Department of Chemistry faculty have proven success through 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

Life Sciences Research Center (LSRC)

OVERVIEW
The Life Sciences Research Center's primary mission is to support the Air Force Office of Scientific Research (AFOSR) and the Defense Health Agency (DHA) though 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 two main research thrusts which include biomedical and Natural Materials and Systems.

CORE COMPETENCIES
- Interrogating select cell lines for microbiome research
- Cultivating/isolating select extremophile organisms as a source of alternative energy production for biosensing capabilities
- International Genetically Engineered Machine (iGEMs) competition

MAJOR PROJECTS
- Natural Materials and Systems – isolate extremophiles with interesting and robust extracellular electron transfer capabilities to potentially power remote sensing devices
- Biomedical – iGEMs research, develop an inexpensive synthetically (genetically engineered) modified E. coli organism based system to detect Perfluorinated Compound contamination in area water supplies. Microbiome research, investigating candidate intestinal short chain fatty acids and their potential utility in studies of gut-brain interactions as it pertains to PTSD intervention.
Warfighter's Edge (WEdge)
Advanced Development Lab

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OVERVIEW
Warfighter's Edge (WEdge) is an advanced development lab activity with sponsorship from various commands. The lab is hosted in Colorado Springs, CO on the campus of the USAF Academy. WEdge leverages GOTS and COTS software with custom modifications to meet the urgent or emerging needs of unit-level warfighters. Established in 2005, WEdge has contributed over 20 innovative software products used throughout the DoD with an average eight-month delivery time.

CORE COMPETENCIES
• Leading multi-discipline applied research collaborations with various joint Service customers and contracted partners
• Integrating emerging technologies with legacy systems through collaborative teaming during development phases

MAJOR PROJECTS
• Collaborating with USMA, USAFA, and the Defense Threat Reduction Agency (DTRA) to upgrade and adapt existing complex unmanned systems frameworks by leveraging the Robot Operating System 2 (ROS-2) to deliver open source and GOTS software for achieving coordinated autonomy among unmanned platforms
• Shepherding the R&D efforts of small business partners delivering technology advancements and integration in sensing and analytics, unmanned and autonomous systems, and in fusion/synthesis for tactical situational awareness and command and control
• Deploying sensors for measurement of the ionosphere and predictions of high frequency (HF) propagation

Warfighter Effectiveness Research Center (WERC)

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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
• Basic and applied research in human-machine teaming & readiness
• Diversity and inclusion research
• Evidence-based approaches to understanding leadership development
• Responding to warfighter needs for enhancing operational performance
• Human/Information Domain

MAJOR PROJECTS
• Robots as social agents in human-machine teaming contexts
• Healthy and Respectful Skepticism
• Wearable Technology & Human State Monitoring
• A social scientific approach to brain care (concussion)
• Warfighter Readiness
• Multi-domain command and control / Information Ops
• Autonomous driving and Autonomous Wingmen
OTHER DEPARTMENTAL RESEARCH
Department of Civil and Environmental Engineering (DFCE)

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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

Department of Electrical and Computer Engineering (DFEC)

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OVERVIEW
The Electrical and Computer Engineering Department complements its rigorous and diverse course of study with a wide variety of immersive research projects. Each cadet is required to select a capstone project and contribute meaningfully to the advancement of the state-of-the-art in their chosen depth area. Each of the Department's research projects applies directly to a current challenge within the Department of Defense or commercial sector. These projects both integrate concepts from technical courses, while building systems engineering and project management skills, paving the way for success in the world’s most technologically advanced Air Force, whether as Pilots, Developmental Engineers, or any other career field.

CORE COMPETENCIES
- Electronic Warfare
- Robotics
- Assistive Technology
- Power Electronics and Power Systems
- Target detection and tracking
- Autonomy
- Machine Vision

MAJOR PROJECTS
- Electronic Cyber Warfare
- Cyber Assessment of Critical Infrastructure Vulnerabilities
- IEEE Autonomous Robotics Team
- Detection, Tracking, and Mitigation of small Unmanned Aerial Systems (sUAS)
- Offensive applications of sUAS
Air Force Humanities Institute (AFHI)

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

CORE COMPETENCIES
- Examining the intersections of art, literature, technology, history, culture, science and ethics
- Promoting interdisciplinary dialogue about perennial questions bearing on the human condition
- Fostering cross-talk between STEM and the Humanities
- Facilitating 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
- Critical Conversations for cadets
- Interdisciplinary faculty conversations & colloquia
- Performing arts presentations & studio art exhibits
- Faculty development seminars
- Returning warrior & veteran outreach

Department of English and Fine Arts (DFENG)

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OVERVIEW
Research in the Department of English and Fine Arts takes many forms: Faculty publications and conference presentations, cadet research under faculty mentorship, an international footprint with the journal War, Literature and the Arts, and a new Digital Humanities Center advancing techniques of archival analysis.

CORE COMPETENCIES
- Research and scholarship for professors and cadets
- Digital Humanities

MAJOR PROJECTS
- 2019: Cadet First Class Manzi Masozera conducted research at the Library of Congress, the National Archives, the National Museum of African American History and Culture, and the African American Civil War Museum. Under the guidance of Professor Greg Laski, Cadet Masozera’s research focused on United States Colored Infantry during the Civil War
- 2019: Cadet First Class Sarah Schwartz interned at the Air Force Entertainment Liaison Office in Los Angeles, exploring the intersection of service and public relations
- 2018 Cadet First Class Grace Skidmore conducted archival research in the Vladimir Nabokov Collections at Cornell University, which resulted in her winning the Humanities Division Moore Award for Outstanding Cadet Summer Research
- 2018 Cadet First Class Taylor Yucus attended the American Institute of Political and Economic Systems at Charles University in Prague
- 2018 Cadet First Class Kathleen Kohler researched Samuel Beckett’s manuscripts at the University of Reading (UK)
Department of Law (DFL)

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OVERVIEW
The Department of Law uses the law as a vehicle to fine-tune cadets' critical thinking and communication abilities, preparing them to think through and develop clear solutions for the complex challenges they will encounter throughout their careers. Along with educating cadets, DFL also has two research efforts – the Law, Technology, and Warfare Research Cell (LTWRC) and the Leadership and Appropriate Dispute Resolution (LADR) Program. The LTWRC researches the law related to the use of technology in military operations. The LADR Program is a center for thought leadership in managing and resolving conflict in the mil-mil, mil-civ, and international domains.

CORE COMPETENCIES
• Critical Thinking
• Effective Communication
• Law of War/International Humanitarian Law
• Legal Use of Technology in Warfare
• Negotiations and Appropriate Dispute Resolution

MAJOR PROJECTS
• Participation in International Humanitarian Law, Negotiation, and Cyber Policy undergraduate competitions
• Collaboration with USSPACECOM and USCYBERCOM on researching the legality of military operations in those domains
• Facilitating undergraduate legal research opportunities
• Leading Air Force wide conflict resolution training and knowledge production

Department of Foreign Languages (DFF)

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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. Today's officers from all Air Force career fields and specialties will find themselves globally engaged. The Department of Foreign Languages & International Programs provides future officers with broad-based, foreign area-related skills for worldwide service commitments.

CORE COMPETENCIES
• Educational and developmental resources for teachers and cadets
• Research publications and scholarly presentations for teachers and cadets
• Faculty hold memberships in various professional organizations including: Colorado Congress of Foreign Language Teachers, Southwest Conference on Language Teaching, American Council on the Teaching of Foreign Languages, and Modern Language Association
• Cadets can study Arabic, Chinese, French, German, Japanese, Portuguese, Russian or Spanish—eight of the most important languages in the world.

MAJOR PROJECTS
• Cadet Summer Language Immersion Program (CSLIP)
• Cadet Semester Exchange Abroad Program (CSEAP)
• Cadet Semester Study Abroad Program (CSSAP)
• Foreign Academy Visit (FAV) Program
• Cultural Immersion Program (CIP)
The Department of Mechanical Engineering 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**

- Developing and teaching innovative design methodologies
- Materials characterization including microstructure, properties and corrosion effects
- Fatigue, corrosion and welding effect testing
- Composite structures and additive manufacturing
- Automotive laboratory including chassis dynamometer
- Vibrational and structural response testing under transient loading
- Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD)

**MAJOR PROJECTS**

- Effects of friction stir welding on metal microstructure, corrosion resistance and mechanical properties
- Fatigue and corrosion characterization and protection, including crack growth and residual stress effects
- Additive manufacturing for ordnance disposal, titanium alloys and supersonic particle deposition for aircraft structural repair
- Cadet capstone competitions resulting in multiple first place finishes for the annual Corrosion Design Competition and the Service Academy Challenge
- Thermodynamic analysis of real-world applications, including aircraft icing, athletic stadium field de-icing, and airbase petroleum oil and lubricant distribution systems
- Dynamic characterization of composite aircraft skin panels
Department of Philosophy (DFPY)

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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
- Cadets hone oral and written communication, critical thinking, and decision-making skills throughout 40 discussion-oriented, writing-intensive lessons

MAJOR PROJECTS
- Publishing textbook in engineering ethics
- Study of the philosophy of religion while growing and sustaining the first 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
- Co-hosting the International Symposium on Military Ethics (ISME) annual meeting with UCCS

Department of Management (DFM)

DR. WILLIAM JENNINGS
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OVERVIEW
The Department of Management produces critical thinkers who are able to adapt quickly in today's dynamic, technologically complex, global environment—skills that are essential for Air Force officers and future community leaders. Depending on their focus, cadets study traditional business topics like accounting, finance, human resource management, marketing, production & operations, information systems, strategy, operations research, systems engineering and other aspects of management.

CORE COMPETENCIES
- Diversity and Inclusion
- Organizational behavior
- Operations research
- Investment oversight
- Strategic planning

MAJOR PROJECTS
- Collaboration with local government organizations and nonprofits to improve processes and provide decision support
- Consultation with local nonprofits and social service organizations on marketing, volunteer retention, social media and management
- Use Appreciative Inquiry to build upon organizational strengths in multiple key areas
- Review and evaluate institutional marketing strategies to bolster the USAFA brand

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THE USAFA OFFICE OF RESEARCH

SUPPORTING YOUR RESEARCH
The USAFA Office of Research exists to support researchers as they develop our nation’s future leaders. The Office of Research does this by enhancing cadet education, providing DOD warfighter support, opportunities for faculty development, and partnership for technology transfer. Contact the DFRO to find out more about additional services offered.

Budget Office
DFRO Budget Analysts are responsible for assisting research centers and departments execute over $40M in annual funding, from providing contract support, accepting and obligating funds, processing purchase requisitions, to funds reconciliation and everything in between.

Public Release
DFRO is responsible for approving the public release of USAFA research publications and other external communications. PA numbers are provided after submissions are cleared for public release.

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

Research Exchange Program
DFRO provides guidance and coordination for the Summer Faculty Fellowship Program (SFFP), Engaging Scientists and Engineers Program (ESEP), Administrative Professional Exchange Program (APEP), and the National Research Council/Research Associate Programs (NCR/RAPs). Research over a summer period of 8-12 weeks.

TECHNOLOGY TRANSFER AND AGREEMENTS

Technology Transfer and Transition Services
The Office of Research offers in-house services to assist researchers in the T3 process. Services include assistance with patents, invention disclosures, agreements, and public releases. The Office of Research also coordinates with industry partners for commercialization opportunities.

Agreement Services
The Office of Research provides guidance and support in processing 13 different Support Agreements. Three of the most common agreements are CRADAs, MOUs/MOAs, and EPAs.

Cooperative Research and Development Agreement (CRADA)
Legal agreement between a USAFA laboratory and a non-federal 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.

Memorandum of Understanding / Agreement (MOU/ MOA)
Legal documents describing a bilateral agreement between parties describing intent to cooperatively work together on an agreed upon project or meet an agreed upon objective. Use of an MOU or MOA is dependent on the mutual obligations of the parties.

Educational Partnership Agreement (EPA)
A formal agreement allowing USAFA and a K-12 facility or any non-profit institution that is dedicated to improving science, mathematics, and engineering education the opportunity to access equipment and resources which may be unavailable at one of the
THE USAFA OFFICE OF RESEARCH

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