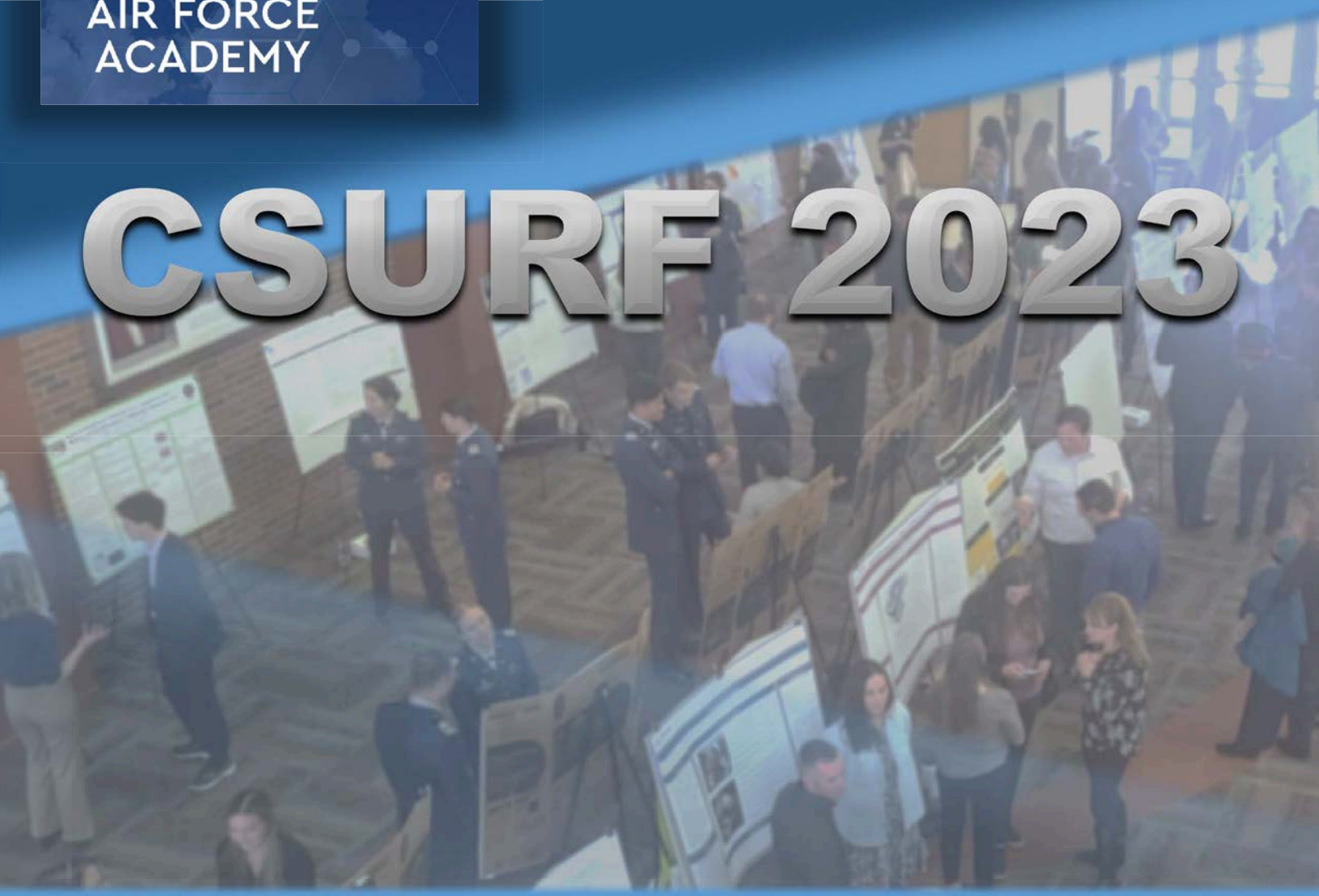
UNITED STATES AIR FORCE ACADEMY

CSURF 2023



USAFA BOOK OF ABSTRACTS

COLORADO SPRINGS UNDERGRADUATE RESEARCH FORUM

2022-2023 Academic Year

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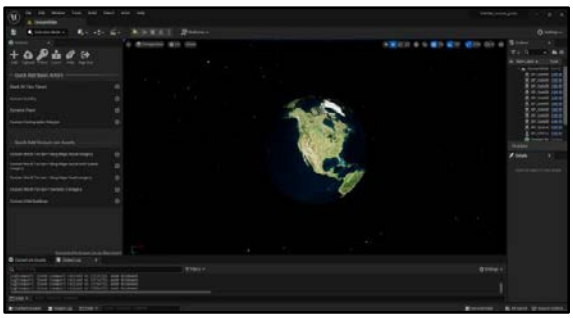
The annual Colorado Springs Undergraduate Research Forum (CSURF) event is a collaborative venture designed to highlight the accomplishments of undergraduate students in all academic disciplines from Colorado College, the University of Colorado at Colorado Springs, Pikes Peak State College and USAFA. CSURF 2023 was hosted at Colorado College on Saturday, 22 April 2023.

Department of Astronautical Engineering

Virtual Immersion System in Orbital Navigation
C1C Christopher Zareck and C2C Casey Dutro
Faculty Mentor: Col Luke Sauter

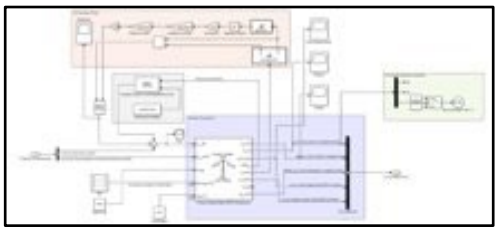
Abstract:
Being able to intuitively visualize a satellite's orbit or how constellations of spacecraft interact with each other is a skill that takes time to understand. Certain graphical tools have helped people gain more intuition, but they are still restricting a 3-dimensional problem to a 2-deminsional landscape. VISION, or Virtual Immersion System in Orbital Navigation, will help overcome that challenge and will be implemented into USAFA's Astronautical Engineering department. A team of two cadets and a mentor, in collaboration with the Kansas State University Computer Science and Data Science departments, have developed a virtual-reality based application for experiencing astrodynamics. This interactive simulator is based in Unreal Engine 5, has a high-fidelity globe through Cesium, and interacts directly with Celestrak for real time satellite information. The applications of this program are numerous: integration into an entry level astronautics course, enhancing military space operator's situational awareness, lessons learned for future USAFA based virtual reality programs, and many more.



Research in Reusable Solid Propellant Rockets
C3C Carter Van Hammond
Faculty Mentor: Col Luke Sauter

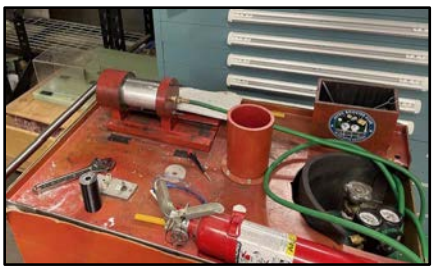
Abstract:
Modern space exploration is highly expensive and often wasteful. Recent advances in rocket technology have worked to limit this wastefulness by creating rockets that are capable of landing themselves. This experiment plans to demonstrate the ability to land a solid-fueled rocket as opposed to the industry standard in liquid-fueled rockets. In contrast to liquid-fueled rockets, solid rocket motors have known characteristics but unknown dynamics at the time of firing. Using a system of computers in a computer-actuator-plant-sensor (CAPS) loop, proper guidance, navigation, and control of the rocket body can be achieved and maintained. In this paper, a computer simulation of a self-landing model rocket has been built and tested using 6 degree of freedom (6DOF) quaternions. Initially, this simulation was designed with some convenient assumptions in mind. Over time, the as-built rocket was used to eliminate some

of these assumptions leading to a dynamic simulation of reusability. Ultimately, when provided a rocket's thrust curve, mass, and other natural properties, the 6DOF rocket-drop simulation was able to consistently and accurately land a simulated rocket body when exposed to a multitude of initial conditions and environments.



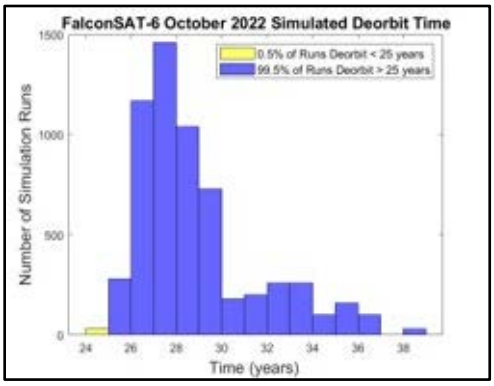
Research in Optimizing Hybrid Rocket Fuel
C3C Bryce R. Foshee, C3C Lino D. De Ros, and C4C Grant K. Becker
Faculty Mentor: Col Luke Sauter

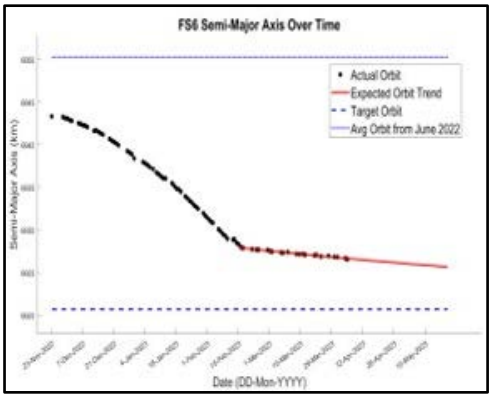
Abstract:
Hydroxyl-terminated polybutadiene hybrid rockets have been well-studied in the past This research serves to optimize the casting and burn procedures of HTPB hybrid rocket propellant. This research investigated the properties of small-scale HTPB fuel grains, an area of research with little available literature but may provide several useful applications. Previous research has failed to yield occlusionfree fuel grains, a known problem for casting HTPB on a small-scale. In order to achieve HTPB fuel grains with the highest purity and specific impulse, experimentation with mold manufacturing processes to include casting under high pressures was tested. Upon testing, a regression rate in the fuel grain was determined to be 0.5 mm/s. Occlusion was reduced through curing the grains under pressure to collapse any gases trapped inside of the fuel, which yielded positive results. Occlusion within the grain creates unpredictable burn fronts within the grain adding many variables that affect the chamber pressure, flame temperature, regression rate, as well as exit velocity. By reducing the amount of trapped air within the grain, a much better burn was achieved yielding values close to their theoretical values. Additionally, nozzle design was tweaked to adequately choke the flow of exhaust while expanding the exhaust to an optimal degree. Future research in this area will focus on the pre and post combustion chamber design to further optimize HTPB fuel performance in preparation for a flight model.

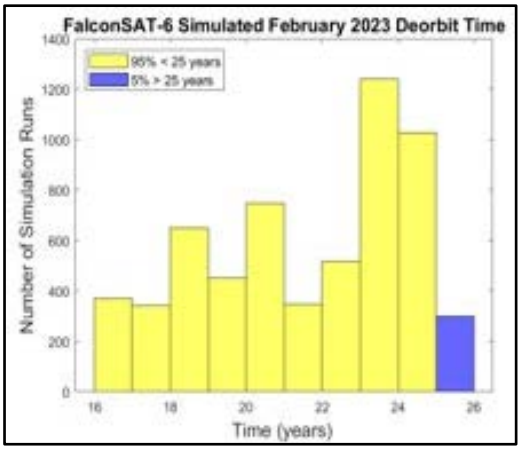


FalconSAT Decommissioning Analysis and Planning
C1C Abigail Spitler, C1C Erica Rivera, and C1C Will Florence
Faculty Mentor: Lt Col Daniel Showalter

Abstract:
The United States Air Force Academy designs, builds, tests, and operates ESPA class satellites. Currently, there are two operational satellites in Low-Earth Orbit (LEO): FalconSAT-6 and FalconSAT-8. The U.S. Orbital Debris Mitigation Standard Practice (ODMSP) requires satellites in LEO to deorbit in less than 25 years after the end of operational lifetime. Using a Two-Line Element (TLE) set, a model was developed to analyze satellite deorbit lifetime incorporating cross-sectional area, coefficient of drag, various atmospheric density models, and solar activity models. A Monte Carlo simulation was implemented varying these parameters which resulted in estimates for a satellite deorbit lifetime. Based on this analysis, FalconSAT-8 would deorbit in 1.9 years and FalconSAT-6 only 5% of the simulation runs would deorbit in 25 years, with a maximum of 38.1 years. Retrograde deorbit maneuvers are necessary to decrease the orbital altitude of FalconSAT-6. Starting in November 2022 retrograde deorbit maneuvers were implemented every 12 hours. As of January 2023, the percentage of simulations resulting below 25 years increased from 5% to 70%. By the end of March 2023, it is estimated that 95% of simulation runs will result in less than 25 years to deorbit.







Utilizing Highly Motile Genetically Engineered Bacteria to
C1C Kailyn Hobbs
Faculty Mentors: Dr. David Hale

Abstract:
The objective of the field study was to determine the existing diversity of small mammals in the relatively undisturbed area now being developed for the True North Commons complex at the U.S. Air Force Academy. The True North Commons development, which is being constructed on 39 acres between the USAFA North Gate and I-25, will consist of a hotel, a theater, glass-enclosed atrium, shops, and restaurants. Live-trapping of small mammals at the actual development site (Spring 2018) and adjacent undisturbed sites (Spring 2023) yielded three rodent species: *Peromyscus maniculatus* (deer mouse); *Reithrodontomys megalotis* (western harvest mouse); and, *Microtus pennsylvanicus* (meadow vole). These results from pre-disturbed and undisturbed sites provide a baseline for comparison to the post-development diversity in future studies, which can yield insights on the faunal impacts of such development along the Colorado Front Rage.

60 *Peromyscus maniculatus* (deer mouse)

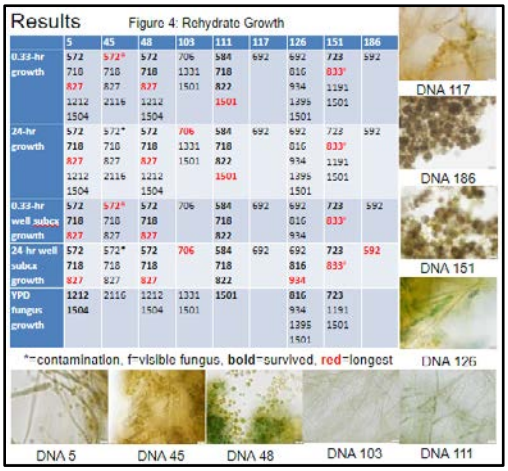
15 *Microtus pennsylvanicus* (meadow vole)

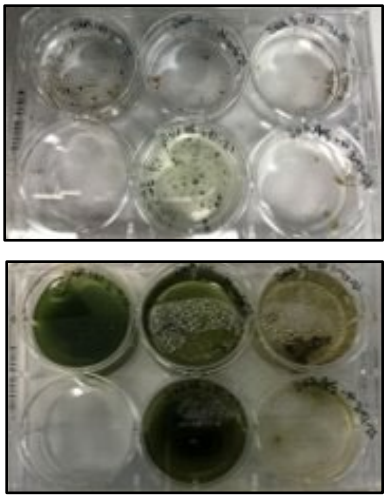
3 *Reithrodontomys megalotis* (western harvest mouse)

Investigation of Cyanobacterial Desiccation Tolerance
C2C Nathaniel LaBarre
Faculty Mentors: Dr. Catherine Jarriel, Dr. Melanie Grogger, and Dr. Armand Balboni

Abstract:
To examine desiccation tolerance in cyanobacteria, we have rehydrated 32 cyanobacteria cultures with varying times of anhydrobiosis spanning 572 to 2116 days. Inoculation in BG11 and BG11-N media occurred after 0.33 and 24 hours to examine differences in desiccation tolerance based on rehydration times. Visual observation and optical density measurements at 750 and 685 nm were utilized to determine growth following rehydration. The presence of fungus was determined by inoculation of YPD with the culture and PCR followed by gel electrophoresis and Sanger Sequencing. We found that the general limit of desiccation tolerance under our lab conditions was <1000 days. Differences in desiccation tolerance based on the 0.33 and 24 hour rehydration times was negligible. Fungus may play a role in desiccation tolerance, having been found in *Staneria* sp. and *Fischerella* sp. cultures displaying the ability, but a definitive conclusion cannot be made since *Calothrix* sp., *Scytonema* sp., *Gloe* sp., and

Leptolyngbya sp. cultures display desiccation tolerance without fungus determination. A *Gloe* sp. culture contained *Penicillium citrinumi, Penicillium steckii*, or *Penicillium* sp., previously implicated in inhibition of decay in wood.

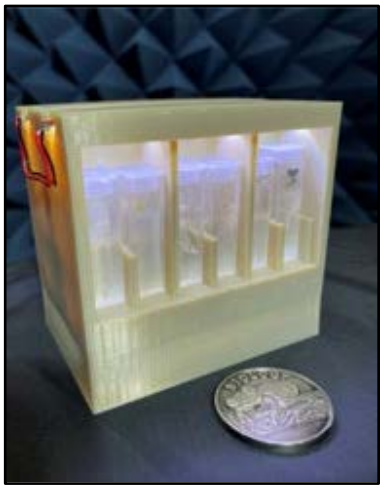


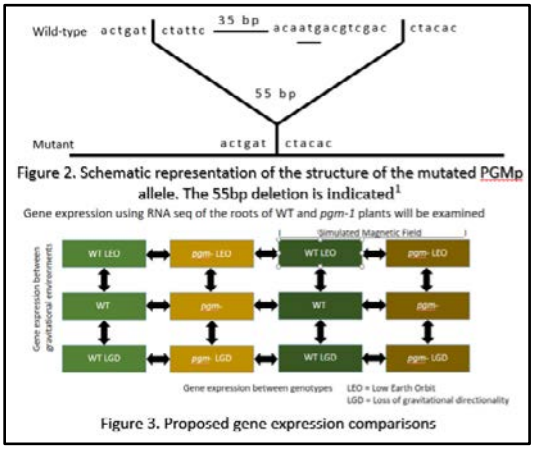


Arabidopsis Gravitational Gene Expression Analysis

C2C Jordyn Wagner
Faculty Mentors: Maj Travis Tubbs and Dr. Katherine Bates

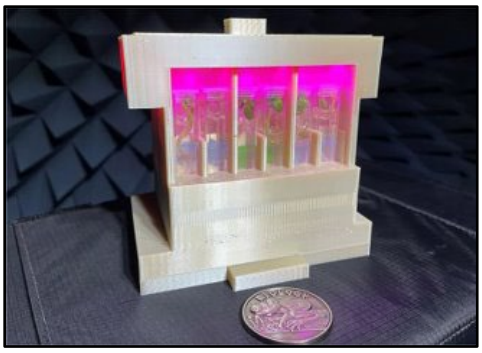
Abstract:
Arabidopsis thaliana is a highly versatile plant for research because it has a high turnover rate and can be easily mutated. It is a member of the mustard family and was the first plant genome to be completely sequenced. Comparing the mutant type (pgm-1) and wild type (col) will help further the understanding of growth patterns and behaviors in a microgravity environment. The mutant type affects the starch synthesis used by the Arabidopsis to determine gravity and which way to grow. Omitting starch synthesis poses the question-- Can one make *Arabidopsis thaliana* grow normally if it cannot sense gravity? This leads to the creation of the hypothesis that if *Arabidopsis thaliana* is cultured using Phytagel and MS Plant Cell Culture, then there will be a noticeable difference in the roots between the wild type and the mutant type. Specifically, the Arabidopsis' genes will be sequenced and compared between the mutant and wild types on Earth and from space.





Exoatmospheric Space Culture Adaptability Pattern Experiment (ESCAPE)
C2C Abigail Ryan
Faculty Mentors: Maj Travis Tubbs

Abstract:
This experimental investigation aims to analyze the physical and genetic adaptability of various model organisms from different environments, including those with high salinity, high acidity, low light, and anaerobic conditions, along with a control sample from Colorado Springs pond water. The success of these organisms in microgravity will be monitored and compared to control samples on Earth to gather vital data on the characteristics, which aid in prolonged exposure to microgravity during space flight. Optical observations will be collected, processed using onboard hardware systems, and transmitted to on Earth using the United States Air Force Academy' FalconSAT program. The results of this investigation may provide insights into how various microscopic organisms from different environments exhibit physiological traits to aid in microgravity survival during spaceflight. This study may have implications for human space travel and serve as an educational resource for enhancing STEM outreach and education.

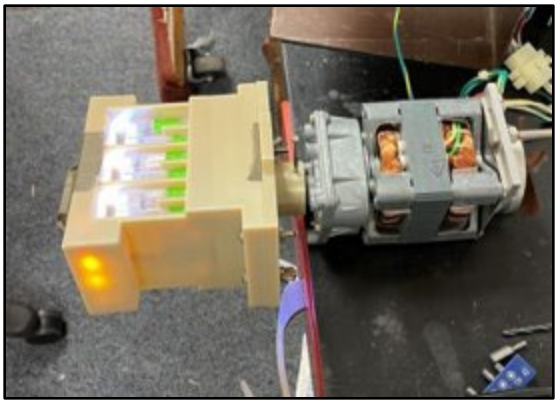


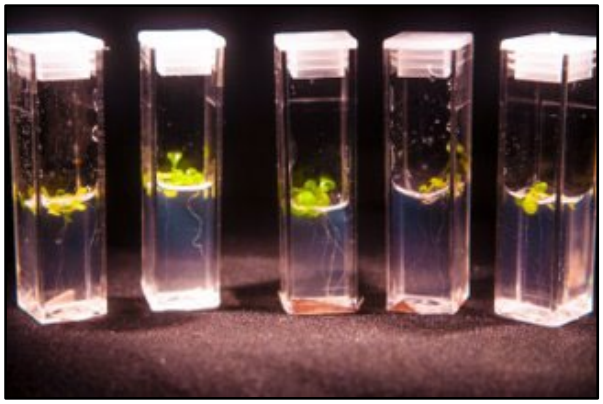
Mushroom and Mycelium Growing for Applications (MAGMA)
C4C Jordan Moore
Faculty Mentor: Maj Travis Tubbs

Abstract:
This study aims to investigate the potential of various growing substrates for edible mushrooms in space. Using a wide spectrum of mycological techniques, the research will determine the efficacy and potency of mushrooms grown in space, their adaptability to extreme environments, and the effects of space on mycelial and fruit growth. The study also explores the potential for breeding space-positive mycelium and using custom mushroom-growing chambers to create a sustainable food source for long-term space flights. Furthermore, the ability of *Pestalotiopsis microspora* mushrooms to digest polyethylene plastics for waste management on new planets will be examined. This study offers a promising solution to the challenges of space travel and provides valuable insights into the potential for Astro-mycology as a means to sustain life in space.

LEO, Integrated, Floriculture, Experiment (LIFE)-Trichoderma
C2C Jacqueline Kelly
Faculty Mentor: Maj Travis Tubbs

Abstract:
This scientific project aims to compare the DNA expressions of the Arabidopsis Thaliana wild type (Col) and Arabidopsis Thaliana mutant (pgm-1) grown on Earth with exposure to Trichoderma Harzianum, and the DNA expressions of these plants grown in a low earth orbit environment without exposure to Trichoderma Harzianum. The pgm-1 mutant is particularly useful as it lacks the statoliths necessary to detect gravity, which makes it a representative model for studying plant growth in a low gravity environment. Trichoderma Harzianum, a beneficial fungus, is introduced to plants to increase growth and root colonization. The main research question is how the DNA expression of Arabidopsis Thaliana mutant and wild type exposed to Trichoderma Harzianum compares to DNA expression of Arabidopsis Thaliana mutant and wild type grown in a low earth orbit. The hypothesis of this project is that exposure to Trichoderma Harzianum will increase the DNA expression and phenotypic response of both Arabidopsis Thaliana's root growth and colonization. The project will compare the genetic and phenotypic responses to the control group of Arabidopsis Thaliana mutant and wild type grown on Earth. This project will test the hypothesis both on Earth and in a low earth orbit environment to provide a logical comparison between the two very different variables.

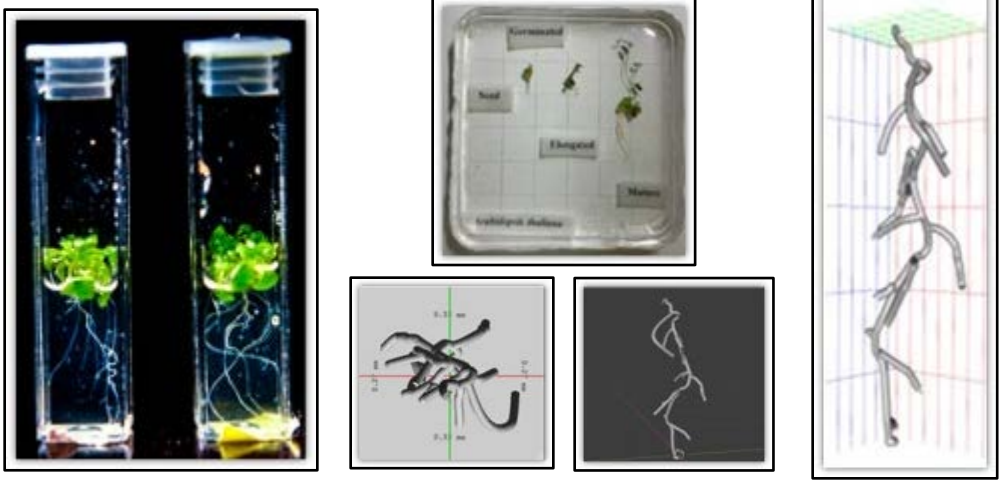




LEO, Integrated, Floriculture, Experiment (LIFE)-Root Structure
C1C Madison Martin
Faculty Mentor: Maj Travis Tubbs

Abstract:
The purpose of this project is to investigate the effects of a Low Earth Orbit environment on root growth response of two types of *Arabidopsis Thaliana*, wild type (Col) and mutant (pgm-1), exposed to other factors such as a fungus *Trichoderma harzianum* (strain T-22), and magnetic conditions. The experiment will use 3-D imaging to collect data on root growth responses on Earth and in Low Earth Orbit. The use of a mutant *Arabidopsis Thaliana* with silenced Amyloplast allows researchers to determine how the plant will grow in microgravity environments. The 3-D imaging will enable precise measurements of root system architecture, which is vital for plant survival, development, and performance. The experiment's hypothesis is that if the root growth of both wild and mutant types of *Arabidopsis Thaliana* grow in response to a Low Earth Orbit environment while exposed to other factors, then 3-D imaging protocols will be able to test various parameters of root growth. The experiment will use controls to grow plants on Earth and in Low Earth Orbit, and 3-D imaging equipment will be used to analyze the data. The

findings of this experiment will provide insights into how plants respond to microgravity environments, which can have implications for future space exploration and food production.



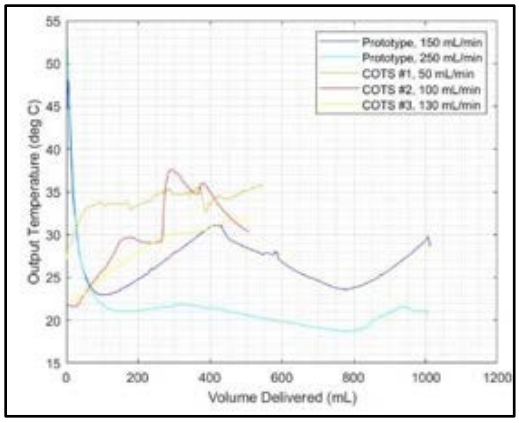
Performance of Prototype Blood Warmer for Rapid Field Transfusion

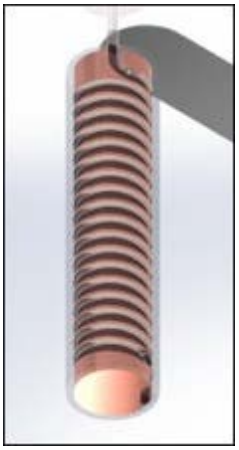
C2C Kelly Yoon, C2C Emma Dershem, C2C Elizabeth Cassidy, C1C William Mockel, and C1C Matthew Lee

Faculty Mentors: Lt Col Ilea Heft and Capt. Damon Kirkpatrick

Abstract:

When an individual has lost large volumes of blood due to injury, rapid transfusion of whole blood or blood products is required to keep that individual alive. One factor that slows the ability of medics to provide this lifesaving treatment is the temperature of the blood. Blood is stored at about 4 degrees Celsius to maintain its viability in storage. However, transfusing cold blood into a patient can cause hypothermia and death. Therefore, the blood needs to be warmed to approximately 37 degrees Celsius prior to transfusion. There are multiple products on the market that warm blood, but each has its limitations for rapid field use by military medics. As a result, representatives from Air Force Special Operations Command identified a need for an improved blood warming device. We have developed a prototype device to rapidly warm blood and carried out testing to assess the effectiveness of the device and to ensure the blood is still viable after passing through the device. We also compared the performance of o ur prototype the performance of cur rently available comme rcial products.





Synthesis, Characterization, and Cytotoxicity of Perfluoropyridine Polymers
C1C Zachary J. Auleciems, C1C Ian M. Geniza, and C3C Ashley Lin
Faculty Mentor(s): Dr. Jordan Steel and Dr. Abby Jennings

Abstract:
Fluorinated polymers are widely used in pharmaceutical, industry, and textile applications. Synthesis of these compounds has relied heavily on incorporating perfluorinated carbon chains into the polymer structure, however, perfluorinated carbon chains have recently been associated with human and environmental health concerns. There is growing need for alternative perfluorinated compounds that mitigate potential toxicity whilst maintaining the desired properties of the polymer. Alternatives have included shorter fluorinated chains and fluorocyclic structures, with the latter being less utilized. We have synthesized a perfluoropyridine (PFPy)-based monomer, which has been used in the preparation of a variety of fluorinated polymers, via RAFT polymerization techniques. The polymers are fully characterized using TGA, DSC, GPC, MALDI, FT-IR spectroscopy, and multinuclear NMR spectroscopy. Furthermore, after performing solubility tests, cell viability studies have been performed to analyze these novel perfluorinated polymers for cytotoxicity. The results of these studies and future directions will be discussed.

Synthesis, Thermal Analysis and Molecular Weight Summary

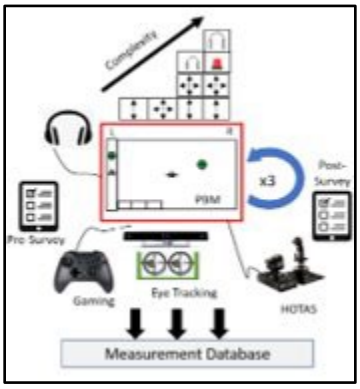
Polymer Sample[a]	T_g (°C)[b]	$T_{5\%}$ (°C)[c]	M_n (g/mol)[d]	M_w (g/mol)[d]	$Đ$[e]	R group (wt%)	Yield (%)	RAFT Agent
Poly1	102	155	7,200	15,610	2.17	Me (100)	46	CPBT
Poly15	122	154	670	1,050	1.56	H (100)	100	CPBT
Poly16	120	169	7,020	11,410	1.63	H (75)	96	CPBT
Poly17	121	215	20,070	60,730	3.03	H (50)	94	CPBT
Poly18	122	232	28,370	121,610	4.29	H (25)	78	CPBT

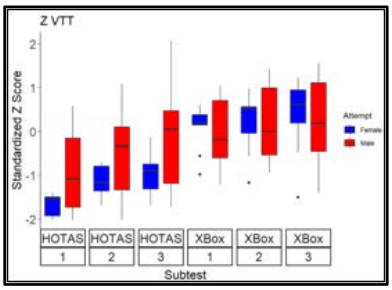
Department of Behavioral Sciences and Leadership

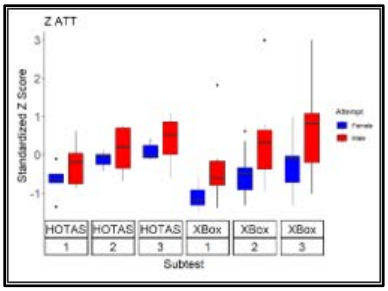
Making the skies more inclusive: Modernizing Pilot Selection Methods & Technologies at the United States Air Force Academy
C2C Adedapo Adeboyejo, C1C Hannah Silvestro, C1C Bethany Duggan, C1C Kory Beach, and C1C Hank Scholes
Faculty Mentor(s): Lt Col Chad Tossell and LCDR USN Kenneth King

Abstract:
The United States Air Force (USAF) is modernizing the method used to select military pilots in order to promote diversity and improve prediction of success in pilot training. As part of this effort, the United States Air Force Academy (USAFA) is evaluating new technologies and methods to modernize the operational Test of Basic Aviation Skills (TBAS). The current TBAS system includes 10 subtests, such as

spatial ability, multi-tasking, and psychomotor skills. The psychomotor portion entails tracking a moving target utilizing a flight control stick and rudder pedals. As part of a redesign, we are examining the use of a gaming controller to provide candidates with more natural ways to interact with the system. We expect performance on the gaming controller to be better relative to the flight control stick and throttle and especially for those with gaming experience and without flight experience. We also suspect gender differences to be more pronounced on the flight control stick and throttle. Performance scores, preferences, and usability will be compared. Additionally, we are exploring the predictive validity of allowing more practice. Data collection is ongoing and initial results will be analyzed and discussed.



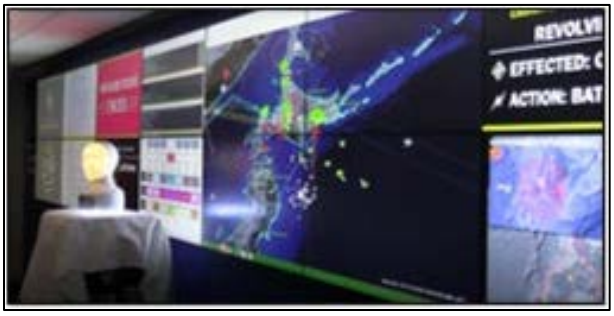


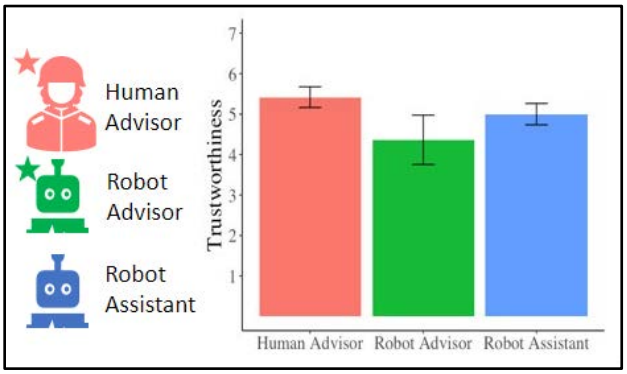


Robot Moral Advice in a High Stakes Military Environment

C1C Jonah Nascimento, C1C Niyah Martinez, C1C Amiyah Breeding, C1C Benjamin Pederson, C1C Harley Anez, C1C Kekoa Gross, C1C Spenser Schwalm,
Faculty Mentor(s): Dr. Steven Hadfield, MSgt Bonnie Rushing, Lt Col Chad Tossell, Lt Col Christopher Gausepohl, Maj Melissa Mclain, Dr. Ewart de Visser, Dr. Ali Momen

Abstract:
In the future, social robots could advise and assist human military leadership towards making ethical and effective decisions in command-and-control scenarios. Ethical decisions are sensitive, however, and it is unclear whether humans trust robots with them. This study examines the influence of a Furhat robot in senior advisor and junior assistant roles on a decision to launch a strike in a simulated moral dilemma.





Degradation of Heating, Ventilation, and Air Conditioning Components at locations across the United States

C3C Michelle Cabonce, C3C Sophie Boulware
Faculty Mentors: Lt Col Tim Frank, Dr. Justin White, and Lt Col Josh Aldred

Abstract:
Materials degrade at different rates in different environments depending on factors such as temperature, aridity, salinity, and solar radiation. Therefore, predicting asset longevity depends, in part, on the environmental conditions to which the asset is exposed. Heating, ventilation, and air conditioning (HVAC) systems are critical to building operations yet are responsible for a significant proportion of their energy consumption, and their operation is imperative to mission critical Air Force and Space Force missions. Understanding the environmental influences on HVAC degradation in detail will inform maintenance schedules and capital investment, reduce energy use, and increase lifecycle management efficiency. HVAC inspection records spanning 10 years from 21 geographically diverse Air Force or Space Force Bases across the United States were compiled and a score indicating average degradation over time was computed. Six environmental variables were explored in this study, and weather conditions associated with those variables were collected for the same 21 bases. Correlations between individual environmental variables and average HVAC degradation were explored as well as differences in degradation by location. Using a non-parametric feature selection method, the most critical environmental variables were identified. Results indicate that environmental harshness plays a meaningful role in HVAC system degradation.

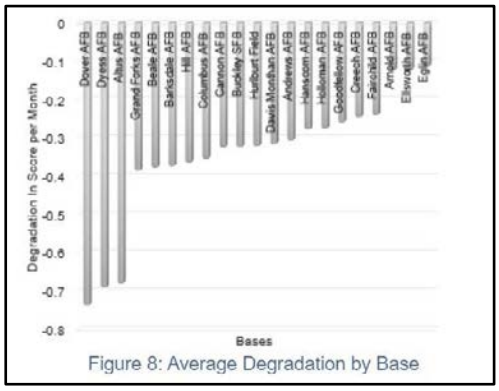


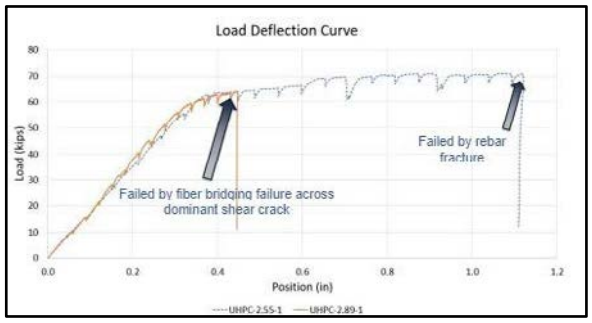
Figure 8: Average Degradation by Base

Pilot Study of Ultra-High-Performance Concrete Beam Performance

C2C Alexis Tri, C2C Elizabeth Decko, C2C Darcy Farrell, C2C Cole Landes
Faculty Mentors: Lt Col Tim Frank and Capt Peter Amaddio

Abstract:
Ultra-high-performance-concrete (UHPC) is a class of cementitious composites with a relatively large percentage of cement generating high compressive strength. Additionally, UHPC contains randomly disbursed steel fibers, which control crack width, carry tensile load, and limit spalling. These characteristics lend themselves to a wide range of structural applications when UHPC members are reinforced with longitudinal steel. The amount of fibers and longitudinal steel need to be varied according to other design parameters in order to fully utilize both the compressive and tensile qualities

of the reinforced cementitious composite and gain the benefits of UHPC. The objective of this pilot study is to investigate the shear response of steel reinforced UHPC beams and inform future studies. Two beams were constructed and experimentally tested with varying longitudinal bar diameters and similar reinforcement ratios. Transverse and longitudinal bar spacing was above and below limits specified by the traditional reinforced concrete code, respectively. Fewer steel fibers were included than most traditional UHPC mixes in order to observe the effectiveness of the fibers to prevent shear cracking and avert an abrupt failure. One specimen failed gradually in shear and the other failed abruptly due to reinforcement bar fracture. Results indicate shear demand in short UHPC beams may not be fully met by steel fibers in certain configurations. Additionally, longitudinal bar spacing requirements may be relaxed in UHPC beams.



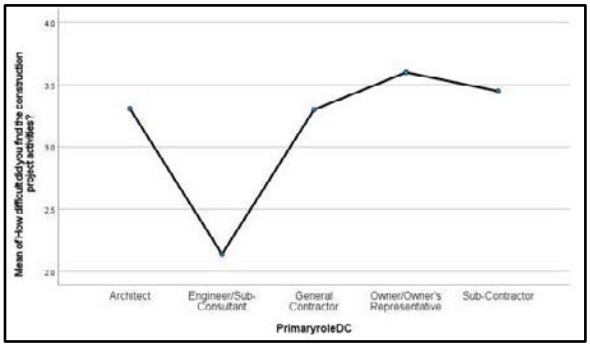
Construction Project Teams: Perceptions of Effort Amongst Project Participants in Highly Collaborative Environments

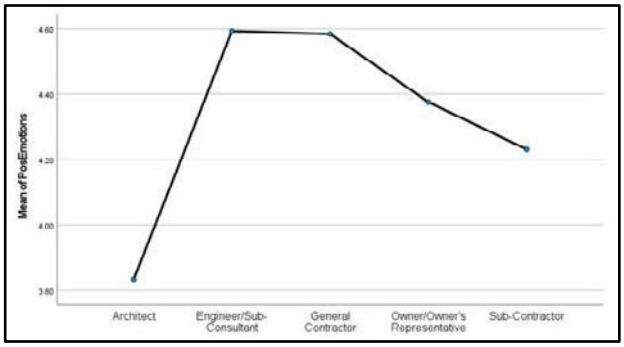
C1C Sophia Hirtle

Faculty Mentors: Dr. Sean Mulholland, Dr. Elissa Hack, and Dr. Caroline Clevenger

Abstract:

The construction industry is in the process of transitioning to more collaborative and integrated project teams. This transition is from a traditional procurement and contracting method of employing fragmented and siloed teams based on contribution of specific design or construction elements. As the construction industry moves to this more collaborative format, the industry has experienced varying results in team dynamics. Construction project teams are a mix of design (architects and engineers) and construction professionals. These professionals vary in age, experience, and gender. Goal of case study is to evaluate what, if any, differences of the self-evaluated level of effort are present in construction project teams. Study will utilize results from a survey, and semi-structured interviews.





Sensitivity Analysis of Airfield Pavement Design Methodologies
C1C Alan Kobylik
Faculty Mentor: Lt Col Vincent Bongioanni

Abstract:
New developments in the field of airport pavement design were seen with the release of FAA Rigid and Flexible Iterative Elastic Layered Design (FAARFIELD) and Pavement-Transportation Computer Assisted Structural Engineering (PCASE). These computer programs mark major improvements in designing airport runways as the newest updates of these programs bring a multitude of new variables and improved prediction capabilities. However, with the relative newness of this program there is still some uncertainty of the effect of some variables. In order to rectify this, a sensitivity analysis will be conducted on shared variables between both programs to identify key factors that affect pavement performance. This data will allow for designs to be more accurate as they will be less sensitive to the considered inputs. All results will be presented in graphs to allow to for easy analysis of any trends between the two programs.

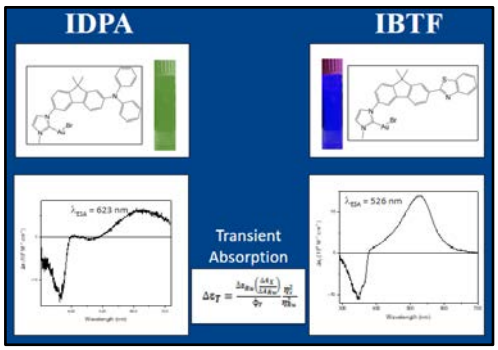
Methodology	Design Method	Design Life
Military (DoD-USA) PCASE	Flexible: CBR or LED Rigid: Westergaard or LED	20
Civilian (FAA-USA) FAARFIELD	Flexible: LED Rigid: LED+FEM	20
Civilian ALIZE-France	Flexible: LED Rigid: LED	10
Civilian APSDS-Australia	Only Flexible: LED	20

Department of Chemistry

Excited State Dynamics in Gold(I) N-Heterocyclic Carbene Complexes
C2C Mikhail Stiffler and C2C Emily Hofmann
Faculty Mentor: Lt Col Ethan Holt and Dr. Kimberly de La Harpe

Abstract:
Due to their tailorable emission properties, gold(I) complexes are exciting options for OLEDs and non-linear optical materials. In collaboration with the Air Force Research Lab and Case Western Reserve University, the photophysical properties of two gold(I) complexes bearing electronreleasing (diphenylamino) and electron-withdrawing (benzothiazolyl) ligands were studied. With observed room-

temperature phosphorescence, intersystem crossing quantum yields above 50%, and triplet lifetimes ranging from 300-1000 µs, further exploration is warranted into the excited state dynamics of these molecules. Initial results show evidence of triplet-triplet annihilation, which likely competes with thermally activated delayed fluorescence as the dominant decay pathway from the triplet state, due to the close proximity in energy of fluorescence and phosphorescence peaks. To better understand the competing decay pathways of triplet states in these molecules, the excited state dynamics were studied through energy-dependent delayed fluorescence and timedependent triplet decay measurements



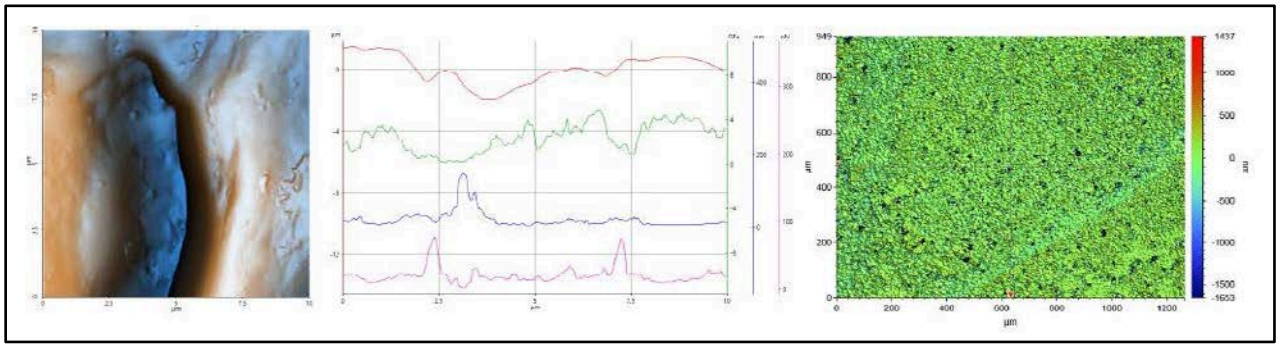
Photophysical Properties

	λ_{ABS} (nm)	ε (10^4 $M^{-1}cm^{-1}$)	λ_{FL} (nm)	λ_{PHOS} (nm)	ΔE_{ST} (eV)	Φ_F	Φ_{ISC}	Φ_P
IDPA-AuBr	367	8.7	398	497, 537	0.63	0.15 ±0.02	0.53 ±0.03	0.01
IBTF-AuBr	330, 346, 364	4.8	374, 395, 415	531, 576	0.99	0.17 ±0.01	0.56 ±0.04	0.004

	τ_F (ns)	τ_P (µs)	$k_{r,F}$ (s^{-1})	$k_{nr,F}$ (s^{-1})	k_{ISC} (s^{-1})	$k_{r,P}$ (s^{-1})	$k_{nr,P}$ (s^{-1})	k_{TT} (s^{-1})
IDPA-AuBr	1.19 ±0.04	320 ±20	$1.26x10^8$	$2.69x10^8$	$4.45x10^8$	31	3,094	
IBTF-AuBr	0.77 ±0.13	1010 ±40	$2.21x10^8$	$3.51x10^8$	$7.27x10^8$	4	986	

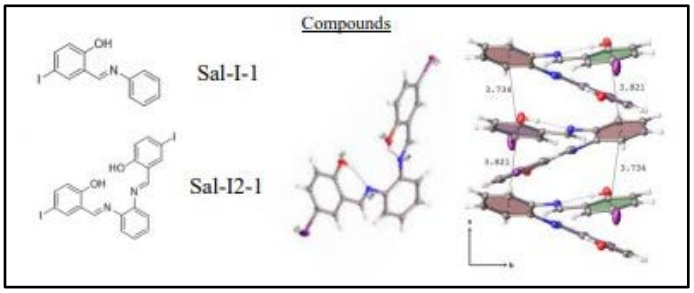
Synthesis and Characterization of a Novel Monomer for Additive Manufacturing
C2C Joshua Quarterman
Faculty Mentor: Dr. Abby R. Jennings

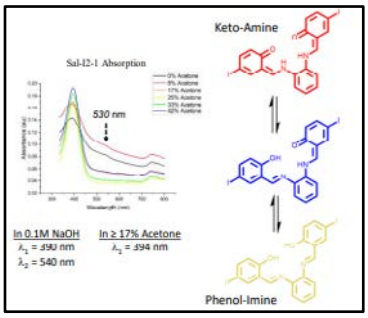
Abstract:
As the field of additive manufacturing, or 3D printing, continues to mature, the drive for more functional matrices increases. In this work, a new monomer, containing an alkyl bromide group, was designed. With this functional group being reactive towards substitution and elimination reactions, the ability to chemically tune the properties of the material used for 3D printing is achievable. Furthermore, with the terminal methacrylate groups, the monomer can easily be cured during 3D printing using UV light. This presentation aims to summarize the reaction optimization and characterization of the monomer. Furthermore, the ability to use the monomer as a feedstock for additive manufacturing was investigated. The results of these studies and future work will be further discussed.



Synthesis and Photophysical Characterization of Salophen Complexes
C2C Abigail Worley, C2C Johnnay Martin, and C4C Gavin Unterreiner
Faculty Mentors: Lt Col Ethan Holt, Dr. Kimberly De la Harpe, and Dr. Latisha Jefferies
Abstract:

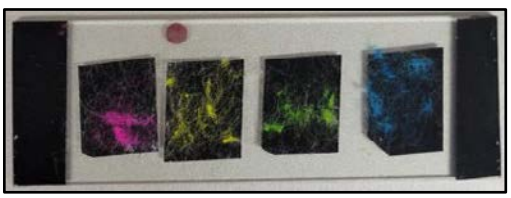
Due to their tailorable emission properties, gold(I) complexes are exciting options for OLEDs and non-linear optical materials. In collaboration with the Air Force Research Lab and Case Western Reserve University, the photophysical properties of a series of diphenylamine-substituted fluorenyl moieties with gold(I) s-alkynyl or s-triazole linkages were studied. The complexes all exhibit ultraviolet absorption and room temperature dual luminescence in the visible range, with an emission color dependent on the ancillary ligand and gold-ligand attachment. The observed room temperature phosphorescence of these complexes prompted a further study of their excited state dynamics. Notable features include a broad excited state absorption centered near 600 nm and triplet lifetimes ranging from 170-500 ms. The presence of triplet-triplet annihilation in these complexes was shown through energy-dependent delayed fluorescence and time-dependent triplet decay measurements.





Characterization of Dyes and Fabric Identification by MALDI Imaging Mass Spectrometry
C2C Hannah G. Castellan
Faculty Mentors: Dr. Andrea R. Kelley

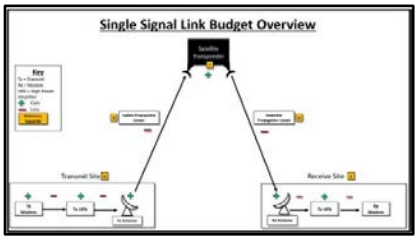
Abstract:
In the analysis of trace constituents, primarily in the field of forensic science, there remains a need for an informative, robust, relatively non-destructive, method of identification and characterization. This is of particular interest in the analysis of fibers and fabrics (determination of the dyes within and distinguishing between different types). This project focused on using MALDI mass spectrometry to produce distinguishable, characteristic mass spec profiles of the dyes in different colors of highlighter. Highlighters act as a cost-effective representative model system for method development toward being able to differentiate between fibers without having to destroy them or directly extract the dye components. The methods developed in this project will serve as a basis for the eventual imaging of intact fibers and fabrics. The results of these studies and specifics of method development will be further discussed.

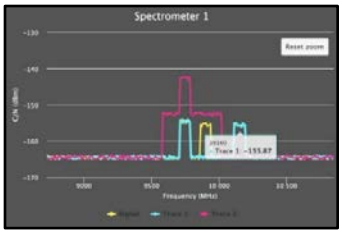


Department of Computer and Cyber Sciences

ChURROS
C1C Eric Kenes, C1C Anna Little, C1C Daniel Simonds, C1C Josiah Stearns, and C1C Jason Tilley
Faculty Mentor: Dr. Joel Coffman

Abstract:
The future fight will be accomplished not only in well-studied domains, but also in the contested domains of space and cyberspace. There are two ways to improve our performance in the space domain: technology and competency. Our capstone targets competency, as working with the Space Force Weapons School we are developing the newest version of a training simulation to prepare warfighters. This project, called Channelized Uplink/Downlink Realistic Operations Simulation (ChURROS), will prepare space warfighters to participate in electronic warfare by learning the skills of electronic attack. In the course of this project, the team developed a web application using the JavaScript frontend framework Vue and the Python backend framework FastAPI. The software engineering process reinforced practice of Agile development and use of a CI/CD pipeline. This poster will summarize our design decisions, lessons learned, and potential for future work on this project.





Bug Bounty Project
C1C Madison Gillan, C1C Peter Ye, C1C Matthew Dickerman, C1C Alison Thompson, and C1C Krittawata Su-uthai
Faculty Mentor: Dr. Steven Fulton

Abstract:
Our research focuses on identifying and exploiting vulnerabilities in the computing systems of our corporate partner. Our initial emphasis was an understanding of the technical environment of the computing environment. Through an analysis of DNS records and IP Network Address Ownership, we have identified and mapped more than 150 IP addresses located in the US and abroad. Once the associated IP addresses were identified, we began a 2-pronged attack to perform both a technical attack as well as a software engineering attack. Our ongoing testing results expect success with attack methodologies.

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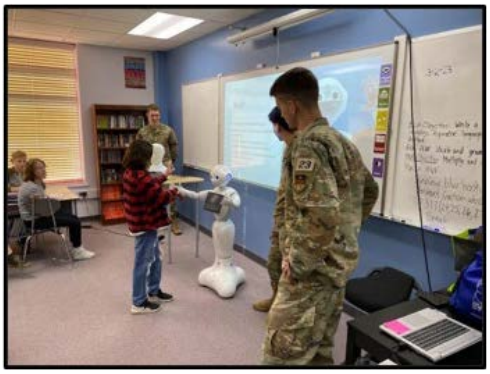
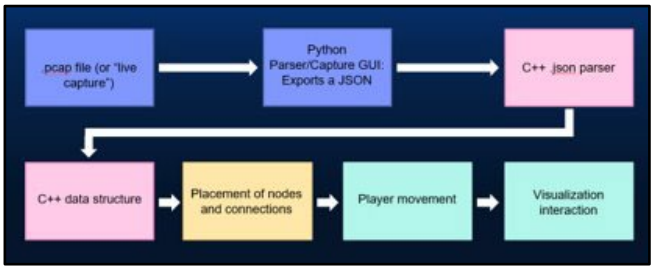
Furhat and Human-Robot Interactions
C1C Ben Pederson, C1C Kekoa Gross, and C1C Jonah Nascimento
Faculty Mentor: Dr. Steven Hadfield

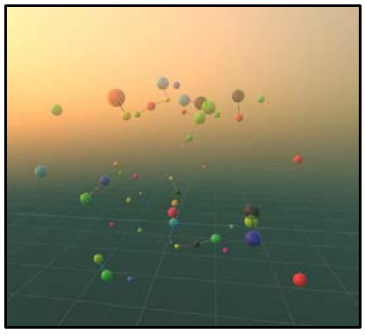
Abstract:
The Furhat robot is a social robot with the ability to engage in conversation using human-like faces and emotions. The USAFA Humanoid Robotics capstone team has utilized Furhat to explore how human-like robots, using ethical and conversational artificial intelligence (AI), might interact with humans in military command operations and in conducting negotiations. The capstone team has partnered in an interdisciplinary effort to understand the impact of incorporating Furhat into a Military Strategic Studies course's wargaming scenario in USAFA's Multi-Domain Lab. The study looked into how Furhat could serve as a trusted ethical adviser for military command and control applications and whether humans would trust the Furhat robot in this role. Additionally, the capstone team explored using Furhat to conduct negotiations with humans. The USAFA team wants to be a leading force in our increasingly common interactions between humans and AI-controlled social robots.



VR Network Visualization
C1C Samuel Lowery, C1C Andy Ledbetter, C1C Finnian Westenfelder, and C1C Taylor Metzger
Faculty Mentor: Major Benjamin McGraw

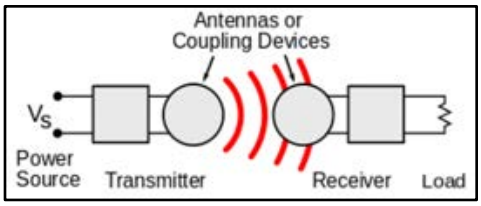
Abstract:
Our capstone project is network visualization using virtual reality. Visualizing computer networks requires significant processing due to the scale of modern computer networks in private, commercial, and government applications. With this many end nodes and packet connections, our project's goal is to create a 3D space with all nodes in a given computer network condensed into simplified subnets. Our focus is to create a simple and intuitive interface for users to understand computer networks with a planned user group of computer science educators as well as network administrators.

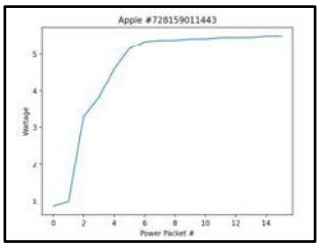




Wireless Power Transfer
C1C Quinn Henry, C1C Cole Hermanson, C1C Nathan Pak, and C1C Alexander Singh
Faculty Mentors: Dr. Shannon Beck and Dr. Kelly Hughes

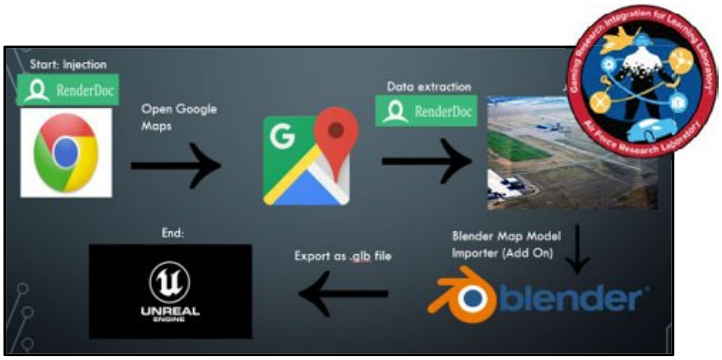
Abstract:
Wireless power transfer is a relatively new technology that is being implemented in most handheld devices today. Not only is wireless charging considered a premium feature on most devices, but it is also critical for larger-scale technologies such as pacemakers and electronic cars. With its novelty, however, comes a lack of understanding of how it works and potential vulnerabilities that can be exploited. This capstone project has focused on discovering these exploitations to be able to mitigate them and create a safer technology in the long run. Currently, there are two feasible exploitations for wireless power transfer: hijacking and eavesdropping. Hijacking involves crafting a malicious message in a form that matches the Qi protocol the power transmitter (charger) and receiver (phone, headphones, etc.) use to communicate with each other. Doing this allows a user to stop the charging of the device, overcharge the device, or accomplish denial of service. Eavesdropping is like wiretapping and allows critical information about the device to be discovered. This attack vector can give a user charge status of the phone, a unique serial number, the manufacturer of the device, and all the power the phone has received over time. This combination of information can be used to predict what the device is doing. Overall, this project has deemed a potential risk of using wireless power transfer technology and research will continue in following years.





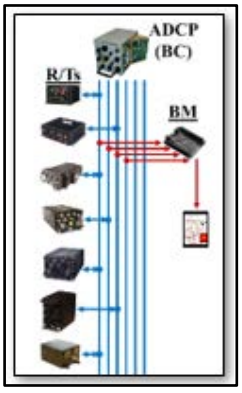
Teams in Danger: GRILL West Project
C1C Tia Kolakowski, C1C Glenn Jones, C1C Alex Bach, C1C Garret Crew
Faculty Mentors: Lt Col Justin Wilson

Abstract:
This research project develops a virtual reality (VR) simulation of a military Foreign Object Debris (FOD) walk using Unreal Engine 4 (UE4). The simulation aims to improve situational awareness and decision-making skills of military personnel during FOD walks. This is a proof of concept for using VR as a training tool to extrapolate for other mission sets. The project uses a multiplayer mode with Google Maps data to generate the environment, providing a more realistic and accurate simulation. Users can navigate the simulated environment, identify potential FOD objects, and interact with other users in the multiplayer mode. The project employs advanced VR technologies to create an immersive and authentic experience. The results of this research can be used to inform future military training practices and improve the safety of military personnel during FOD walks. Overall, this research project presents a significant advancement in the training of military personnel, providing them with a safe and realistic simulation of a FOD walk. The use of VR and Google Maps data demonstrates that this approach can be applied to other military training scenarios, improving the effectiveness of military training and enhancing the safety of military personnel in challenging environments.



Cyber Defense of Satellite Systems
C1C Jonathon Shearer, C1C Colin Seymour, and C1C Ethan Schofield
Faculty Mentor: Dr. Kenneth Sample

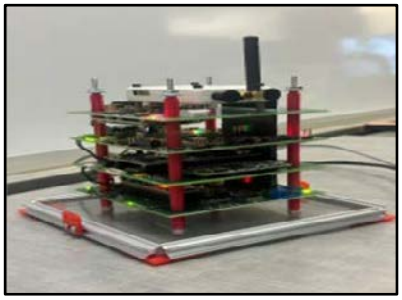
Abstract:
F-15 data normally transcribed to the “black box” and the legacy flight instruments of the aircraft is either not available to the pilot in-flight or is not detailed enough for the pilots, leaving a lot of information inaccessible until after the mission is over. Our project utilizes this live data sent from the four MIL-STD-1553 multiplex buses in the F-15 and then displays the live data on an external IOS tablet. This data included in the systems and sensors of the F-15 is compiled, processed, and transmitted to an external device. This allows the F-15 to utilize more data with minimal hardware modifications to the aircraft. Tablets are already used in the F-15 for offline data such as maps and manuals, which means the only physical modification would be a quick release cable between the tablet and the aircraft. This also means that there will be minimal training required to utilize our project during a flight.



Defense of Satellites
C1C Spencer Anderson, C1C Isabella Gentile, C1C Dalton Paskett, and C1C Max Perkins
Faculty Mentors: Maj Bobby Birrer and Dr Steven Fulton

Abstract:
In 2022, simultaneous with the Russian invasion of Ukraine, cyber-attackers launched malicious software attacks against a United States satellite company, Viasat. The attack highlighted the vulnerability of space systems to cyber-attacks, which could disrupt civilian and military communications and operations. This research evaluates protecting critical space assets with a Linux-based cyber-defense tool, ZeroLock, developed by industry partner Vali Cyber. In conjunction with Vali Cyber, the researchers performed a series of development and testing activities to evaluate the effectiveness of the software in

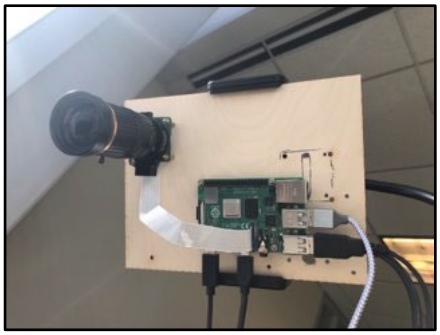
defeating attacks on simulated ground stations and simulated flight applications. The team developed a NASA Core Flight System Application with a command injection vulnerability; exploited the vulnerability to attack the confidentiality, integrity, and availability of the system; and then tested these attacks against the same system with the ZeroLock software. The researchers then used the results of these tests to develop new rules and policies that can be applied to space assets in order to prevent these and similar attacks.



Internet of Things (IoT)

C1C Theodisha Etienne, C1C Taylor Coffey, C1C Eric Fossen, C1C Elizabeth Lopez, and C1C Jay Stearns
Faculty Mentor: Lt Col Adrian de Freitas

Abstract:
Internet of Things (IoT) has become a staple in the everyday lives of people globally and it is transforming the way the world does business, conducts training, educates, socializes, and how humans exist in that environment. Understanding the implications of IoT - such as interoperability, fast tracking data sharing, and increasing convenience - allows institutions and corporations to work towards increasing productivity and improving quality of life for the members of their organizations. This project aims to make cadet lives better by identifying areas of major inconvenience in the lives of cadets and attempting to provide practical solutions through the use of IoT devices and Raspberry Pis. The team developed two use case scenarios with an emphasis on convenience and safety: a parking lot detection use case and a gunshot detector use case. As a result, the team produced an integrated open platform that is capable of facilitating communication between commercial devices and team-produced products via open source technologies. In the end, this project also led to the identification of limitations in IOT involving security and privacy, along with additional capabilities that go beyond the marketed intent for certain devices. The interoperability of IoT devices is unique to this capstone. The team was able to provide several proofs of concept that IoT ca n be used to enhance safety measures and aid in creating convenient solutions for everyday tasks. These proofs of concept include a working AI model that identifies empty parking spots and a ring alarm system that identifies when a room is not secure and displays that information using hue lights.

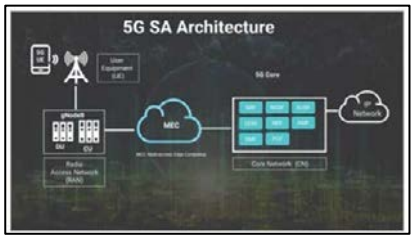


5G Research
Mason Roach and Daniel Sevilla
Faculty Mentor: Dr. Kelly Hughes

Abstract:
5G architecture carries with it the potential to revolutionize the way we communicate with each other. Boasting capabilities like Enhanced Mobile Broadband (eMBB), which grants users download speeds up to 1 Gbps indoors and 300 Mbps outdoors, and Massive Machine Type Communications (mMTC), which utilizes edge computing technology to allow devices in densely populated areas to talk to each other, the only real way forward in the world of mobile communications, where data consumption and cloud computing technologies are growing, is a large-scale adoption of 5G. With this large-scale adoption however comes risks. This capstone intends to look at and study those risks, through either research or through actual implementation of vulnerabilities that exist with 5G architecture. 5G networks are composed primarily of 3 components, the 5G Core (5GC, essential to functionality), the Radio Access Network (RAN), and Multi-edge Computing (MEC). All three of these components interact seamlessly, meaning that, for example, a vulnerability which takes down the 5GC would also have broader impacts on the RAN and MEC as well. Our goal is to gather a greater understanding of such vulnerabilities, through either research or observed effects, and to raise awareness/present potential solutions to the vulnerabilities we find.

5G Vulnerabilities
C1C Joseph Daniel
Faculty Mentor: Dr. Steve Fulton

Abstract:
Internet of Things (IoT) has become a staple in the everyday lives of people globally and it is transforming the way the world does business, conducts training, educates, socializes, and how humans exist in that environment. Understanding the implications of IoT - such as interoperability, fast tracking data sharing, and increasing convenience - allows institutions and corporations to work towards increasing productivity and improving quality of life for the members of their organizations. This project aims to make cadet lives better by identifying areas of major inconvenience in the lives of cadets and attempting to provide practical solutions through the use of IoT devices and Raspberry Pis. The team developed two use case scenarios with an emphasis on convenience and safety: a parking lot detection use case and a gunshot detector use case. As a result, the team produced an integrated open platform that is capable of facilitating communication between commercial devices and team-produced products via open source technologies. In the end, this project also led to the identification of limitations in IOT involving security and privacy, along with additional capabilities that go beyond the marketed intent for certain devices. The interoperability of IoT devices is unique to this capstone. The team was able to provide several proofs of concept that IoT ca n be used to enhance safety measures and aid in creating convenient solutions for everyday tasks. These proofs of concept include a working AI model that identifies empty parking spots and a ring alarm system that identifies when a room is not secure and displays that information using hue lights.



Department of Economics and Geosciences

Exploring the Efficacy of Using Geospatial Techniques to Estimate Building Roof Area
C1C Edwin Kust
Faculty Mentor: Dr. Justin White

Abstract:
Recent advances in the geospatial techniques realm have made estimating metrics such as building footprint and building volume possible, though their precision and accuracy is often marginal and requires relatively sophisticated compute algorithms. Calculating roof area has remained even more elusive and is largely explored in the private/industrial sector using proprietary methods and data. Here, we explore different approaches using geospatial techniques to estimating building roof area in the Rocky Mountain Front Range region using publicly available data. Our explorations involve LiDAR and aerial imagery data, various methods spanning simple spectral or elevational relationships to more complex deep learning techniques. We used ERDAS Imagine, ArcGIS Pro, and Python. We present the results of our explorations, their shortcomings, and suggested paths forward for improved outcomes.

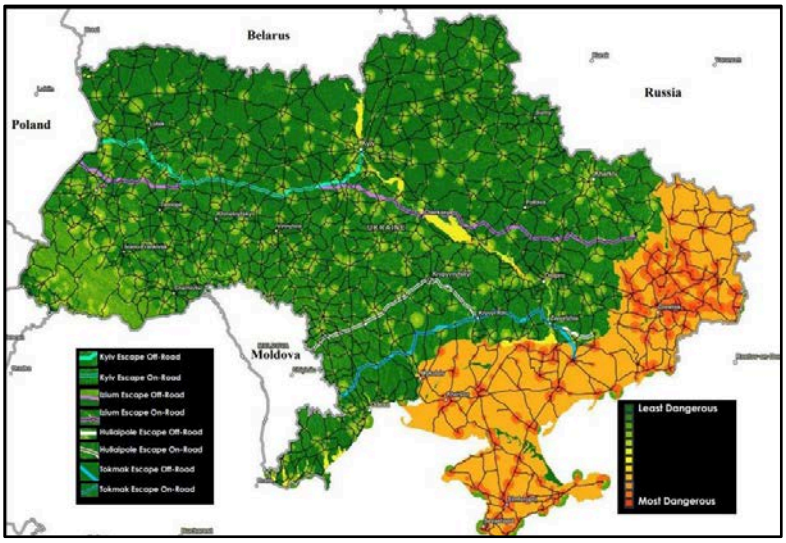
Exploring Methods of Detecting Individual Plant Species Using High Resolution Imagery in an Arid Landscape
C1C Landon Chandler, C1C Jordan Williams, and C1C Blake Bride
Faculty Mentors: Dr. Justin White and Dr. Jennifer Holt

Abstract:
Using remotely sensed techniques to examine general vegetation type, age, and community structure, has been widely explored globally. The same is true for vegetation patterns at >local scales. Data sources such as AVHRR, MODIS, and Landsat have been successfully manipulated into sophisticated indices that can reduce vegetation classification noise by accounting for soil moisture, surface and air temperature, and atmospheric particulate content, while maintaining the benefits of rationing chlorophyll reflectance. However, vegetation exploration in circumstances where the imagery is of high resolution and excludes reflectance longer than near-infrared remains a persistent challenge. Here, we explore various method-data combinations in search of an accurate method of parsing vegetation species in arid Colorado with 2-foot resolution NAIP RGBN imagery. Our approaches include combinations of segmentation, deep learning, and basic raster-vector classification approaches. Data combinations included terrain-based indices such as Heat Load and landform type, duration of direct solar radiation, and various vegetation indices optimized for arid environments such as MSAVI2. We offer recommendations on which combinations of data (essentially indices) are most helpful in parsing vegetation species.

National Scale Exploration of Optimal Evacuation Routes for Ukrainian Civilians from Combat Zones
C2C Keegan Hathaway
Faculty Mentors: Dr. Justin White

Abstract:
Many Ukrainian citizens are actively trying to flee from combat zones to a neighboring country. Our goal is to build a workflow that would generate feasible evacuation routes using optimal cost paths (an

improvement upon the traditional least cost paths) for Ukrainians to flee to access a safer location while avoiding cities, rugged terrain, major bodies of water and the frontlines of the war. We used a logical approach to create a threat map from a static instance in 2022 and at the national scale – as opposed to local - with areas having different weights for threats and rewards. Four cities (Kyiv, Izium, Tohmak, and Huliapole, Ukraine) were chosen as starting points and we calculated the safest route, while considering costs associated with distance and time, to an international border crossing. We discuss our findings from a methodological point of view and aim to demonstrate one approach of innovating in the GEOINT space with geospatial tools.



Department of English and Fine Arts

Lesbian Love In the 18th Century
C2C Emilee Denslow
Faculty Mentor: Davis Perry

Abstract:
Homosexual relationships between women in the long eighteenth century were not discussed in the same language used today, but they certainly existed. One of the problems for modern scholars is distinguishing between two competing artistic movements. On the one hand, platonic 'love and friendship' poems were a popular genre of the period for all women writers, as they highlighted the possibility for intellectually stimulating and emotionally nurturing relationships outside traditional gender norms of marriage. In such friendships, women could express their full capacity as thinking and feeling adults without the male gaze and all that it entailed. On the other hand, erotic and passionate love between and for women was also expressed using similar styles and language. Disentangling the two requires nuance and care. In my paper, I conduct a careful close reading of several pieces in which

the boundaries of platonic love appear to be deliberately breached, and lesbian love both revealed and celebrated.

Interpretations of William Shakespeare's Henry V
C2C Daniel Garza
Faculty Mentor: Unknown

Abstract:
It has been debated as to whether or not King Henry in William Shakespeare's *The Life of King Henry the Fifth,* was meant to represent an ideal monarch or a cunning Machiavel. The textual evidence from the play provides support for both interpretations and critics agree that neither is more correct than the other. And yet, adaptations of the play perform their own interpretation of Henry the Fifth. These various interpretations from Kenneth Branagh's *Henry V* (1989) to David Michôd's *The King* (2019) borrow elements of Henry's character from Shakespeare's play but also make their own additions to Henry's character. These changes make the character more complex and nuanced. Although Henry faces the same conflict with the French in each of these interpretations, the changes to his character make each story and its meaning different. It is impossible to know which of all of these interpretations is most true to the actual Henry the Fifth. However, it is important to study and analyze these different interpretations because they can give modern audiences insight to a variety of things, including the strengths and dangers of nationalism, how different interpretations of actions can affect a narrative, and the importance of metatheatricallity and its effects.

A Story Worth Retelling: A Portfolio of Guided Adaptation of Treasure Planet
C1C Brendan (Neo) Anderson
Faculty Mentor: Dr. Daniel Couch and Dr. Maxwell Sater

Abstract:
his project is a nontraditional capstone that is driven by the creative/theatrical arts and guided by theories of adaptation. The result has been a unique project which I hope will yield future opportunities for interdisciplinary and collaborative projects across the institution. I also hope that this capstone will create opportunities for further study on my part. To elaborate upon the meaning of my project's title, I elected to work under the broad umbrella of adaptation studies and narratology. Of course, the scope of

the project requires further specification, which in turn leads me to classify it under the more precise and emerging focus of "Disneyfication" (i.e., how the Disney Corporation adapts and readapts certain stories for new mediums). I am especially interested in how Disney adapts its animated films for the stage or for live action films. The primary aim of the project is to create a portfolio of physical properties and designs that might be used in a hypothetical theatrical production of the Disney film *Treasure Planet* (2002). This portfolio will consist of materials that are typically found in a technical theatre capstone project. Additionally, this portfolio will feature a textual component in the form of an artist's statement; in this statement, I will describe the research that shaped my creative decisions in an attempt to balance the reflective and analytical components of my project.

Department of Foreign Languages

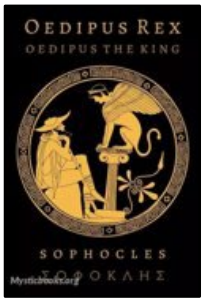
The Sword and the Pen: An Analysis of the different languages and perspectives of conquerors and the Indigenous People in the New World
C1C Sarah Hetzel
Faculty Mentor: Dr. Ismenia De Souza

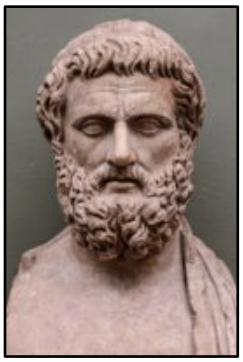
Abstract:
There are a lot of published works in history about the colonial period and the systematic violence that the Spaniards waged against the Indigenous people. However, there are few studies at the intersection of literature and history about the power of words on humans and historical events. Therefore, this essay aims to scrutinize the differences in the Spanish and Indigenous perspectives during the colonial period through the lens of their respective languages. Words and expressions will be studied using the chronicles of selected conquerors such as Hernán Cortés, Francisco Pizarro, and Cristóbal Colón. In addition, the Indigenous perspective will be studied using chronicles by Hernando Alvarado Tezozómoc, Fernando de Alva Ixtlilxóchitl, and Titu Cusi Yupanqui. Finally, this essay will evaluate the posterior effects of the Spaniards' violence and the lack of references regarding genocide, crimes against humanity or justice for the descendants of affected indigenous communities.



A comparative analysis between *Life is a Dream* by Pedro Calderon de la Barca and *Oedipus Rex* by Sophocles
C2C Kristian DeJesus
Faculty Mentor: Dr. Ismenia De Souza

Abstract:
The play *Life is a Dream*, written by Pedro Calderon de la Barca in 1635 CE, has been analyzed a plethora of times over the course of several years. These analyses focused primarily on the representation of the contrast between the real world and our dream worlds, while greatly overlooking the importance and significance of the concept of predestination found throughout the text. At the time of the writing of the text, Spain was undergoing a major renaissance era, during which various new religious ideas arose, resulting in the writing of works like *Life is a Dream* which try to rationalize and explain human life. However, attempted explanations for human life also date back as far as we can date. For instance, in 430 BC, the philosopher Sophocles presented *Oedipus Rex*, which spoke at great lengths about the idea of predestination, and how it is a concept we as mortals cannot escape. Consequently, the purpose of this paper will be to compare how the two different works actively represent predestination in relation to human life. The analysis will aim to provide some general historical context that works to justify why predestination was represented as it was in each time period and bring to light the similarities and differences in predestination present throughout the readings.



"We are Here to Cleanse You of the Dirt": The Question of Genocide in Bucha and Irpin
C2C Luke Hughes
Faculty Mentor: Dr. Nicholas Kupensky

Abstract:
Genocide is an act that has plagued the world for generations and with the modern era of humankind, its prevalence and consequences have only become clearer and bloodier. From the Holocaust during World War Two to various genocides in Africa and former Yugoslavia, genocide has brought out the worst in humanity, bringing with it the destruction of whole cultures by the most horrific means. When the war in Ukraine began in late February of 2022, President Putin made clear his intention and belief that Ukraine was never its own nation, and that the "Nazi regime" there would be eliminated. This research aims to answer the question of the act of genocide taking place in Ukraine, more specifically in the towns of Bucha and Irpin on the outskirts of Kyiv. This research also aims to answer why the atrocities that did take place in Bucha and Irpin happened in those specific places, and not somewhere else. The reason for this research came from both personal connections, having visited both cities while on a two-year religious mission in Ukraine as well as in an effort to determine the aim of Russia's war on

Ukraine, and whether it fulfills the measures for genocide, and not just war. This is an extremely important topic, as genocide is a problem that the human race has still not been able to solve, even in the 21st century. I completed this research through various means, both corresponding to contacts in and from Ukraine, as well as utilizing various sources, both scholarly and non-scholarly due to the constantly developing situation of the war. I believe that through my research Bucha and Irpin were specifically targeted due to their youthful, innovative nature, and that although what happened there may not completely fulfill the measures of genocide, as time continues and Russia's atrocities in Ukraine grow, the case for genocide will be solidified.

Department of History

"*Petite Guerre* Influences and Implementation during the New York and New Jersey Campaign, August 1776 to March 1777"
C1C Abigail Asplund
Faculty Mentor: Lt Col John and Dr. Jennifer Weber

Abstract:
The century of frontier conflicts leading up the start of the American Revolution played a major role in influencing the Fabian tactics and *petite guerre* implemented by General George Washington's Continental Army. Some of these conflicts include engagements such as King Philip's War, King George's War, and the French and Indian War, each of which provide examples that prove the benefit of these unconventional styles of warfare during the American Revolutionary War. This is apparent when viewed through the lens of the August 1776 to March 1777 New York and New Jersey Campaign, as the Continental Army took on King George III's British Army. While the starting months of the campaign saw multiple Continental Army retreats, later conflicts such as the Battle of Trenton and the Forage Wars provide excellent examples of the usefulness of Fabian tactics and *petite* guerre respectively. Though smaller in size and less professionally trained, the Continental Army and local militias' use of small war tactics made it possible to take on both the British Army and their hired Hessian mercenaries in asymmetric conflict.

"Horses to Helicopters: US Army Airmobile Cavalry 1960- 1965:
C2C Dean Fecteau
Faculty Mentor: Maj Christopher Reith

Abstract:
Combat mobility and malleability, with the horse as the central figure, has been the face of US army cavalry doctrine for over 150 years. However, in 1960, the Howze Board tested the first airmobile cavalry units -- a brand new way of warfare tasked to conquer the harsh topography and an unforgiving enemy in Vietnam. After the board, President Johnson sent these new "airmobile divisions" to Vietnam. The multirole, brand-new Bell UH-1 Iroquois helicopter was at the helm. LTC Hal Moore was the tactical pioneer for airmobile cavalry doctrine, when the North Vietnamese tested his battalion at the Battle of Ia Drang in 1965. The fundamental basis of cavalry tactics, operations, and strategy in prior conflicts to Vietnam dictated the decision to enable cavalry units to become airmobile. Not only did these new airmobile cavalry units embody the legacy of the horse, but it also took that legacy and diversified it as never before seen within cavalry units. The effectiveness of Airmobile Cavalry operations in the Vietnam War was a testament to the ingenuity of the US Army to effectively adapt to the situation in Southeast Asia.

"Germany's *Mahnmale* and the Implications on Collective Memory of the Holocaust"
C1C Haley Hoffmeister
Faculty Mentor: Maj Christopher Reith

Abstract:
Monuments, museums, memorials, and national remembrance days exist to recognize and preserve memories of the Holocaust. Yet, there is also a culture of guilt and shame surrounding the Holocaust. How can perpetrating countries honor victims while also addressing their culpability for the largest genocide in history? This paper will examine such questions, particularly focusing on Germany. The Holocaust is engraved in Germany's past and present, which creates an overwhelming difficulty for the nation as it confronts its Nazi history and memorializes the Holocaust. As a result, there is widespread disagreement over crucial questions regarding memorialization, including attitudes towards perpetrators and victims, guilt, responsibility, and the roles of ordinary citizens. Although most Germans agree on key aspects of memorialization, national memory and memorialization require continued engagement to combat persistent negative attitudes. Navigating the culture of guilt and shame surrounding the Holocaust is no easy feat, as this study illustrates. This paper will examine Germany's modern-day acknowledgment and embrace of *Mahnmale* – a monument of caution and warning to the public – will illuminate how Germany and the international community continue to confront this tragedy even as new generations reinterpret the history.

"Burn This Letter Presently: Sir Francis Walsingham and the St. Bartholomew's Day Massacre"
C1C Alexander Stamp
Faculty Mentor: Dr. Robert Wettemann

Abstract:
In August 1572 the murder of a Protestant admiral cast Paris into an orgy of violence that lasted for three days and killed thousands of Protestant Parisians. Witness to this massacre was the Protestant English ambassador Sir Francis Walsingham, who would soon become England's secretary of state under

Elizabeth I. In contrast to Elizabeth's *realpolitik* approach to foreign policy, Walsingham saw England as a bastion of Protestantism beset on all sides by enemies of the faith. As such, his foreign policy was driven almost exclusively along religious lines through English intervention in the Dutch Revolt, the execution of Mary Queen of Scots, and the 1585 Anglo-Spanish War. This paper will examine how Walsingham's experience of the St. Bartholomew's Day Massacre affected his outlook on foreign policy, and how ideology can successfully drive international relations. It argues that the massacre made Walsingham view international relations along religious lines, and that his foreign policy was always concerned with advancing the Protestant cause. The sources for the paper consist of Walsingham's official correspondence, legal documents from the Trial of Mary Stuart, published works from Walsingham and his associates, and modern secondary sources to construct a thorough understanding of Walsingham's actions.

Department of Law

Dobbs' Potential Impact on In Vitro Fertilization
C2C Faith Collins
Faculty Mentor: Dr. Dominic Angiollo

Abstract:
In *Dobbs v. Jackson Women's Health Organization* the Supreme court held that abortion was not a protected right under the Constitution, overturning *Roe v. Wade* and its progeny. As a result, the Supreme Court returned the decision regarding abortion to the democratic process. This paper explores the Dobbs impact on in vitro fertilization laws. Specifically, whether states can prohibit IVF practices where the state determines that life begins at fertilization. The paper begins by introducing the historical issue of abortion leading up to *Dobbs*. Then, the paper will introduce and explain the practice of in vitro fertilization. It focusses on the possibility that states may impose restrictive laws over numerous pregnancy-related procedures, including in vitro fertilization. I then analyze three distinct aspects of such restrictive laws on IFV: the potentiality and viability argument, the constitutionality of such laws, and their probable impact on the nation. I posit that considering these three facets, along with the state's burden to meet strict scrutiny, that if states ban IVF practices in their attempt to regulate abortion, it will be deemed unconstitutional because it is in violation of the fundamental right to procreate.

The Modern Character of War: A Reexamination of the Law of Armed Conflict
C3C D. Micah Stark
Faculty Mentors: Dr. Shawn McKelvy and Dr. Logan Sisson

Abstract:
Italian Air Marshall Giulio Douhet once prophesied that "Victory smiles on those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur."

Although the quote, forever burned in my mind from freshman year at the Academy, rings true for strategists, the laws which govern warfare respond painfully slowly to evolutions in its character. Therefore, as new domains of conflict, such as space and cyberspace, are opened and warfare shifts increasingly towards these non-kinetic methods of inflicting power between rival actors, the Law of Armed Conflict (LOAC) ought to be revised to encompass these threats. This paper will advocate for a reexamination of the terminology used in the legal basis as well as compare how these new adaptations will fit within just war theory. Furthermore, we see an increase in cybercrime as acted by states yet do little about it statutorily. Ultimately, I conclude that as state-sponsored kinetic warfare becomes less and less common, LOAC ought to include focus on non-state and non-kinetic policies, such as cyber warfare or civilian outsourcing, enabling state sponsored kinetic or non-kinetic retaliation and deterrence, while maintaining proportionality.

Justiciability of Partisan Gerrymandering
C2C Rebecca Wusinich
Faculty Mentor: Dr. Doug McKechnie

Abstract:
The ability to vote, and to have one's vote actually count, is the foundation of democracy in the United States. However, unchecked partisan gerrymandering threatens that right. Gerrymandering has long plagued the United States, however until the Supreme Court's 2019 decision in *Rucho v. Common Clause*, federal courts had the power to remedy gerrymandered districts. This paper examines the United States Supreme Court's debate over whether partisan gerrymandering is a political question, and thus justiciable or not. Prior to the Supreme Court's 5-4 decision in *Rucho*, federal courts heard arguments under the Equal Protection Clause about partisan gerrymandering due to notable causes such as *Baker v. Carr* and *Davis v. Bandemer*. After the Court's 2019 decision, issues with partisan gerrymandering are no longer within the Court's control since the majority opinion expressed that the power to address such issues belongs to Congress. This paper argues that the Supreme Court should return to the standard before *Rucho*, since citizen's constitutional Fourteenth Amendment rights are being violated through these unfair elections. Although the Court has been clear that racial gerrymandering violates the Fourteenth Amendment, since race and political party are often correlated, the allowance of partisan gerrymandering provides the opportunity for minority races to be excluded. This paper relies on Justice Kagan's dissent, as well as Supreme Court precedent to establish that partisan gerrymandering violates the Fourteenth Amendment, and that it is not a political question. Failing to return to the pre-*Rucho* standard allows for legislators to strip U.S. citizens of their crucial right to decide their representatives.

The need for a United "Space" Nations
C3C Daniel Avila, C3C Ruben Banks, C3C John Boranian, C3C Michael Fey, C3C Savannah Ledbetter, C3C Samantha Miles, and C3C Rachel Parillo
Faculty Mentor: Lt Col Timothy Goines

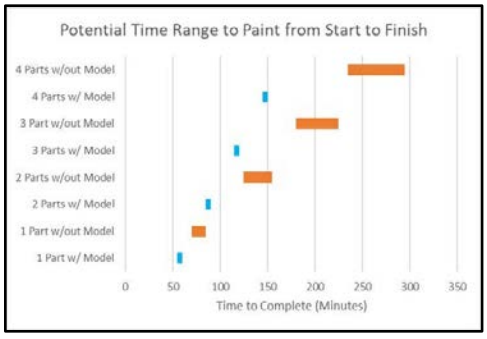
Abstract:
With space at the forefront of technological advancements, it is time to implement a plan to protect this new land of opportunity. After much exploration, the Space Policy Research team has produced a fictional organization to produce policies, strengthen relations, and protect the international community's rights to space. The United Space Nations (USN) has been designed to supplement and

redevelop the current space policies from the sitting United Nations, however, strictly concerning space. To help understand the USN is broken into five areas: Militarization, Space Policies, Commercial entities, Bodies within Space, and Space Vehicles. Overall, the Space Policy team's mission is to create end goals of responsibilities through the use of specific policies, while creating a means of policy enforcement.

Department of Management

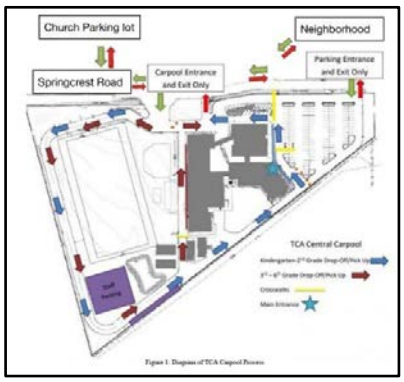
Improving Robotic Painting Utilization at an Air Logistics Complex Depot
C1C Brandon Koch, C1C Jose Rubio, and C1C Luke Rohlwing
Faculty Mentors: Lt Col John Miller and Lt Col James Maher

Abstract:
One mainstay within all United States Air Force operations has and will continue to be the necessity of maintaining aircraft. To support more efficient maintenance processes, the 402nd Commodities Maintenance Group at the Warner Robins Air Logistics Complex (WR-ALC) located in Warner Robins, Georgia seeks to implement robotics into their painting processes. Unfortunately, restrictions within the software and physical restrictions of the robotic painting arms have resulted in difficulties obtaining widespread acceptance and use of robotics in the unit. To alleviate this issue, we created a Uniform-Cost Search algorithm in conjunction with a user interface to output viable aircraft part placement to ensure the robotic arm can paint multiple parts at once. The search algorithm produces valid part combinations 95% of the time and saves 45 minutes per painting cycle on average. Implementation of the software at the WR-ALC is expected to increase output by 12 parts painted per day, allowing maintenance to be completed faster and removing one of the bottlenecks of the depot maintenance operations.



Improving the Student Pickup Process at a School without Busing
C1C Nicholas Bourgeois, C1C Mackenzie Kummer, C1C Adriana Francis, and C1C Natalie Root
Faculty Mentor: Lt Col John Miller and Lt Col Heidi Tucholski

Abstract:
The Classical Academy, TCA, is the largest K-12th grade public charter school in Colorado Springs that requires students without a driver's license to be picked up from school at the end of the day as they do not maintain a bussing system. Our project focuses on the Central Campus with hopes of expanding in the future based on this foundation. Central campus consists of Kindergarden-6th grade students being picked up by their parents from either the church parking lot across the street, the neighborhood parking lot behind the school, the school parking lot, or the pickup lines. We created a discrete events simulation and interviewed parents and school faculty to assess the current pickup process. We then tested various methods of improvement through this simulation process. Based on our analysis, we were able to improve the Central Campus pickup process by about 15%. In addition, our group recommends various qualitative methods to further improve the process.

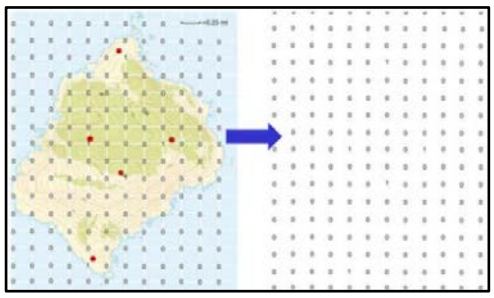


Simulation	Num of Cars	Crossing Guard	Emergency Fire Exit	Time in Q - StreetChoke Ave	Num in Q - StreetChoke Ave
1	300 (+)	No crossing guard (-)	Fire exit closed (-)	1.18 Minutes	5.6089 Cars
2	210 (-)	No crossing guard (-)	Fire exit closed (-)	0.86 Minutes	2.869 Cars
3	210 (-)	Crossing guard (+)	Fire exit closed (-)	2.56 Minutes	8.4621 Cars
4	300 (+)	Crossing guard (+)	Fire exit closed (-)	5.44 Minutes	25.749 Cars
5	210 (-)	Crossing guard (+)	Fire exit open (+)	1.04 Minutes	2.4051 Cars
6	300 (+)	Crossing guard (+)	Fire exit open (+)	0.97 Minutes	3.0693 Cars
7	300 (+)	No crossing guard (-)	Fire exit open (+)	0.12 Minutes	0.3532 Cars
8	**210 (-)**	**No crossing guard (-)**	**Fire exit open (+)**	**0.13 Minutes**	**0.2522 Cars**

Determining Optimal Autonomous Small Unmanned Aircraft Vehicles Swarm Composition and Search Patterns

C1C Josiah DeValois, C1C Jeremy Kappel, C1C Luke Poudel, C1C Kyle Villacorta
Faculty Mentors: Lt Col John Miller and Dr. Gerry Gonzalez

Abstract:
The United States military is developing large swarms of Unmanned Aerial Vehicles (UAVs) which will reduce risk to pilots and increase flexibility when dealing with peer adversaries. This research provides a recommendation for Air Force Special Operations Command (AFSOC) to find the best search pattern and expected success rate for a team of Unmanned Aerial Vehicles to maximize mission success rate subject to budget, distance, and specific scenario assumptions. Mission success is defined as the proportion of targets found and tracked by the vehicle swarm of the assigned targets in a simulated five-by-five nautical mile search area. Using a Python simulation, we found that the Sparrow Hawk and the Altius yield the best mission success rate based on budget and target detection. Our findings support the future application of UAVs and provide a deeper understanding of what attributes are most important to mission success for AFSOC.

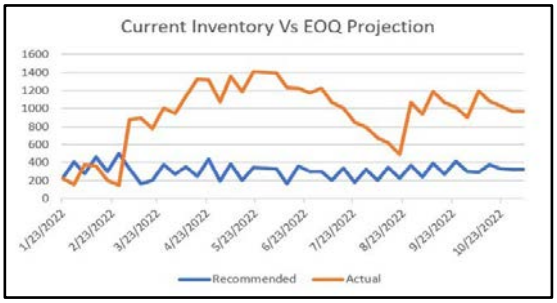


Improving Inventory Management for a Large Foodservice Supplier
C1C Harmoni Blackstock, C1C Christian Ingersoll, C1C John Krolick, and C1C Joseph Fuentes
Faculty Mentors: Lt Col John Miller and Capt Alex Contarino

Abstract:
Golden State Foods (GSF) is an international foodservice supplier. Their Georgia manufacturing plant currently produces thousands of condiments for restaurants across the United States. This project reduces the days of inventory of seasonal ingredients, which decreases GSF's working capital and inventory holding cost. Every year, GSF pays a rate of interest based on their stock on hand, which can be reduced by maintaining a lower inventory while maintaining daily and weekly demands from their customers. By inputting product recipes, ingredient usage, and weekly inventory data into a dynamic and nonstationary lot-sizing model, we predict optimal order quantities and reorder points for GSF's seasonal and expensive ingredients. This will decrease the facility's $1.2 million holding cost and increase their long-term profits.

gsf
golden state foods

$$\sqrt{(2 * D * F)/P * H)}$$



Applying Sabermetrics to Improve a Baseball Team's Batting Lineups and Pitcher Substitutions
C1C Hayden Archer, C1C Jeremiah Hoppe, C1C Shannon Osoba, and C1C Mitchell Woelfle
Faculty Mentors: Lt Col John Miller, Lt Col Brian Lemay, and Lt Col John Dulin
Abstract:
The U.S. Air Force Academy baseball team is an NCAA Division I program that has struggled to find consistent success in the Mountain West Conference. Since funds are prioritized in other areas, the team has never allocated resources to use data as a way to put players in the best positions to excel. This paper examines how data collected from the 2022 season can be leveraged to maximize the number of runs scored and minimize the number of runs allowed. A matrix of pitcher similarity ratings was developed using the Euclidean distance method, allowing for more informed pitching substitutions. A second model was created to improve the batting lineup, finding the right combination and order of players to maximize the number of runs scored per game. When implemented in the fall season, the team's earned run average was 4.0, down 59% from the previous season. Further, the team batting average increased to .351, up from .315 last spring. These results represent successful application of the aforementioned models, and have launched USAFA's baseball team into the top 20% of all NCAA Division I programs in both batting average and ERA during the 2022 fall season.

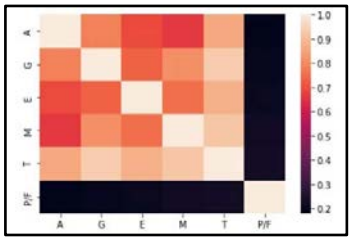
	Player A	Player B	Player C	Player D	Player E	Player F	Player G	Player H	Player I	Player J
Player A	0.0000	17.1516	14.1958	16.3731	19.4539	21.1151	22.0071	23.4492	26.1872	13.756
Player B	17.1516	0.0000	7.8643	11.6998	16.0554	9.5606	20.3434	10.0418	14.2438	14.087
Player C	14.1958	7.8643	0.0000	13.4189	14.4285	13.0524	13.4718	13.9313	19.5513	7.226
Player D	16.3731	11.6998	13.4189	0.0000	8.9099	19.0960	15.3485	18.3228	26.1596	9.896
Player E	19.4539	16.0554	14.4285	8.9099	0.0000	17.1170	17.0910	19.5560	17.3356	17.779
Player F	21.1151	9.5606	13.0524	19.0960	17.1170	0.0000	16.2358	15.3457	16.1484	15.249
Player G	22.0071	20.3434	13.4718	15.3485	17.0910	16.2358	0.0000	22.5059	10.5358	19.343
Player H	23.4492	10.0418	13.9313	18.3228	19.5560	15.3457	22.5059	0.0000	18.1700	16.140
Player I	26.1872	14.2438	19.5513	26.1596	17.3356	16.1484	10.5358	18.1700	0.0000	17.251
Player J	13.7561	14.0878	7.2266	9.8965	17.7797	15.2494	19.3431	16.1407	17.2515	0.000

558th Flying Training Squadron Sensor Operator Production Analysis
C1C Colton Bassford, C1C Andrzej Buniowski, C1C Daniel Nesburg, and C1C Nicholas Swanson
Faculty Mentors: Lt Col Brian Lemay and Lt Col Jeffrey Newcamp

Abstract:
Sensor operators for Remotely Piloted Aircraft are essential for collecting intelligence to inform strategic decisions for military forces. To qualify for this role, individuals must complete the Basic Sensor Operator Course (BSOC) offered by the 558th Flying Training Squadron (FTS). The 558th FTS has the goal to achieve a BSOC passing rate of at least 90%; however, the current passing rate is 83%. To improve this statistic, we have developed a mathematical model that uses the Armed Services Vocational Aptitude Battery (ASVAB) test scores, which is an exam meant to determine eligibility for a military career, to identify students who are more likely to be successful in the BSOC course. This enables us to target specific students during the admissions process and proactively provide additional support to students who are less likely to pass the course. Our model suggests that if the 558th accepts students with a combined 300 ASVAB score, the passing rate will reach 90%.

	Predicted	
Actual	0	1
0	2	54
1	17	437

Average Scores	Pass	Fail
Administrative	70.92	63.08
General	68.31	58.39
Electrical	73.11	64.5
Mechanical	62.95	49.42
Total ASVAB Score	275.29	235.40



Optimizing Undergraduate Pilot Training version 2.5 at Vance Air Force Base
C1C Allie Dyer, C1C Laurel Klawes, C1C Skyler Royse, and C1C Keane Singleton
Faculty Mentors: Lt Col John Miller and Maj Colby Shufeldt

Abstract:
With a continued increase in demand for qualified pilots, in an environment of continual budget constraints, Air Education Training Command (AETC) has been searching for ways to improve operations and produce more pilots. AETC has developed Undergraduate Pilot Training (UPT) 2.5 as the newest beginner pilot training syllabus aimed at training pilots more efficiently. However, at Vance Air Force Base (AFB) in Oklahoma, one of three UPT bases implementing this syllabus, there have been numerous issues with efficiently cycling students through this program. Historically, an average of 16.5% of students have failed UPT 2.5 and 43.5% have had to wash back to other classes because they could not complete the syllabus requirements on time. To address this, we developed a discrete event simulation model of pilot training using a program called SIMIO to identify where and why students are most likely to be delayed. We used this information to calculate the necessary number of resources to graduate certain class sizes. The delays in one class exacerbate those of the following classes, so being able to determine the optimal resources for one class will allow leadership within AETC to better allocate resources to the pilot training bases. This will ultimately increase efficiency within UPT and reduce the pilot shortage.

Resources						Time in System					Throughput		
Sim Lines	IPs	Aircraft	ITDs	IFTs	OFTs	Average	Minimum	Maximum	Half width	O&M Days	Graduates	Washouts	Throughput
18	84	45	20	7	5	3,285.97	3,171.02	3,380.61	263.99	97.80	393.33	83.67	477.00
18	84	45	20	9	5	3,254.97	3,192.80	3,334.88	180.56	96.87	390.00	78.00	468.00
18	86	45	20	9	5	3,320.22	3,275.96	3,352.80	98.71	98.82	398.00	72.00	470.00
18	86	45	22	9	5	3,231.61	3,181.29	3,329.55	210.74	96.18	394.67	77.33	472.00
18	86	48	22	9	5	3,161.36	3,053.56	3,236.15	237.67	94.09	390.00	82.00	472.00
21	86	48	22	9	5	3,141.95	3,080.55	3,202.98	152.08	93.51	397.33	71.67	469.00
21	86	51	22	9	5	3,082.66	3,059.47	3,107.90	60.32	91.75	398.00	78.00	476.00
24	86	51	22	9	5	3,001.59	2,936.98	3,058.81	152.17	89.33	387.67	86.33	474.00

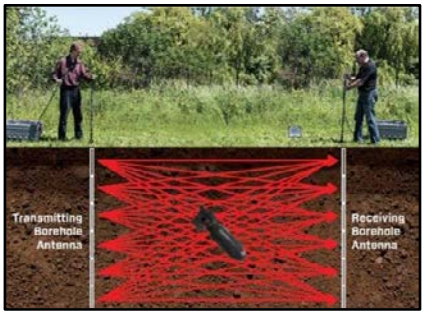
Department of Mechanical Engineering

Indoor Exploration with Autonomous Systems
C1C Madison Yates, C1C Devon Grundvig, C1C Andrew Smith, C2C John Olson, C2C Teresa Bush, and C3C Joseph Olson
Faculty Mentor: Dr. Michael Anderson

Abstract:
Autonomous systems are being proposed for exploration work, such as entering unknown indoor environments, collecting data and transmitting it back to the entrance. In ongoing work, unmanned air and ground vehicles are being developed for this mission with the ability to navigate without Global Positioning System (GPS) information. Additional features and behaviors have been developed, such as the ability to deploy unattended sensors and communication relays, overcome barriers and launch projectiles. The current effort is exploring the use of multiple unique unmanned systems that complement each other. In one potential solution architecture, a ground robot with autonomous navigation capability teams with a quadrotor unmanned aerial system (UAS) to explore further afield, in more remote locations that would be inaccessible to the ground robot. A major goal of this work is to develop novel robot architectures and capabilities that can supplement existing commercial off the shelf systems by working with and deploying from larger, host systems, such as the Ghost Vision 60 quadruped robot, which is in high demand for civil and military operations. For example, such enhancements may include smaller ground and air vehicles that can access tighter spaces and steeper terrain, and are more covert. Such a system could significantly enhance the capabilities and safety of human teams operating in hostile or hazardous environments. The Final poster presentation will provide details of recent accomplishments and plans for future work in the coming academic year.

Detection and Location of Subsurface UXO on a Runway
C1C William Mockel, C1C Adrian Falcon, C1C Aiden Francomb, C1C Zachary Olson, C1C Joshua Sheldon
Faculty Mentor: Dr. Michael Anderson

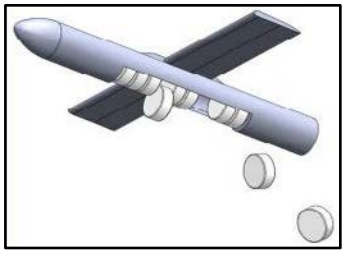
Abstract:
The United States Air Force conducts flight operations around the world, and many of its airfields are vulnerable to aerial attack. Recovering from such attacks is a critical concern for the Air Force Civil Engineering Center. After an airstrike, the runway may be contaminated with unexploded ordinance (UXO) that may be buried beneath the surface. This poses a very dangerous and difficult problem for Air Force Explosive Ordinance Disposal (EOD) experts. In this work, a system is being developed that will be capable of detecting and locating subsurface UXO in the Rapid Explosive Hazard Mitigation (REHM), stage of the Rapid Airfield Damage Recovery (RADR) process. The current mitigation procedure is for EOD personnel to inspect the runway on foot, visually identify ordnance penetration entry points, manually localize the UXO using a magnetometer or similar subsurface detection technology, and then dig under the surface to extract or neutralize the UXO. The current procedure can take up to two weeks and requires extensive manpower and substantial risk to airmen. This work seeks to create an autonomous solution that will detect and locate subsurface UXO in 30 minutes to allow for more accurate and expeditious mitigation. After evaluating stakeholder needs and currently available technology, a system will be pursued that incorporates multiple sensors (e.g., magnetometers, ground penetrating radar, thermal) and locating capabilities from current EOD technology such as Rapid Airfield Damage Assessment System (RADAS) and Android Tactical Awareness Kit (ATAK) to complete the task. The final system will be able to navigate a damaged airfield to UXO entry holes and then complete a search of the area using its sensors to precisely locate the subsurface UXO. If successful, this capability would greatly enhance the RADR mission.



An Autonomous System for Payload Navigation and Arrested Descent
C1C Enrique Arjona, C1C Harold Fotso, C1C Griffin Hemingway, Cayden Boll, Christian Lund
Faculty Mentor: Lt Col Jason Christopher and Dr. Rusty Powell

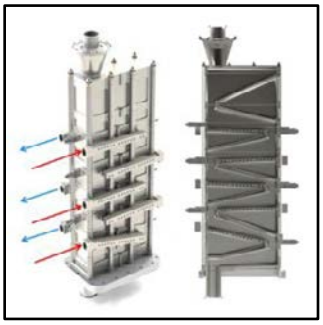
Abstract:
The team's mission is to develop a system to drop a payload of approximately 5-10 lbs from an altitude of 500 - 1,000 ft and accurately guide the payload onto a target the size of a vehicle up to a compound. The cargo storage was designed to accommodate various payload forms, which could include sensors or ordnance. Due to the wide range of potential payloads, the team focused on reducing impact forces on landing. Additionally, the team considered options for the system to be covert while descending and after landing. To achieve the precision aspect of the project, efforts were also dedicated in designing a

guidance system to continuously update and orient the system. Altogether, efforts for shock reduction, covertness and and system guidance were successful in terms of individual effectiveness. System integration proved to be a more challenging aspect of the project and would require more testing in the future. With proper adjustment of the parachute guidelines, an increase in wing size for higher payload capacity, and the addition of a propeller for thrust, this system could see more robust adaptation. Current iterations of the system otherwise satisfy criteria for a proof of concept.



Energetics Mixing for Use in Additive Manufacturing
C1C Collin Jensen, C1C Bennett Whitney, and C1C Jackson Mitchell
Faculty Mentor: Dr. Neil Thompson, Maj Jared Erickson, Dr. Ioan Feier

Abstract:
The goal of this project is to create a mixing system capable of continuously blending two energetic feedstock pastes. After mixing, the energetic material will be extruded from a 3-D printing head for additive manufacture of explosive devices. 3-D printing energetic material will increase the effectiveness of current munitions as well as enable convenient and flexible production of future explosives. The energetic material in question is roughly the consistency of Play-DohTM with sugar like granules mixed evenly throughout. Additionally, the material is non-Newtonian and sensitive to high temperatures. Within the mixing system there may not be any tight tolerances between unyielding surfaces that could crush the granules. The mixing device should be no larger than a cubic meter and should weigh less than 40 pounds. Five mixing techniques are currently being researched as possible solutions.

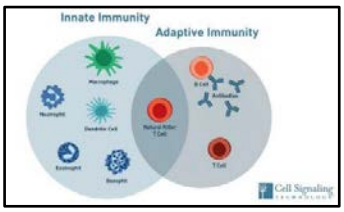


Equilibrium Analysis in Action: Tumor - Immune Interactions with Radiotherapy
C1C Sean Richard
Faculty Mentor: Dr. Maila Hallare

Abstract:
Cancer is a relentless and destructive disease that has touched the lives of many people. Radiotherapy is a type of treatment used to treat this disease by killing malignant cells, which are cells that rapidly grow and divide. In this report, we present a mathematical model that captures the interaction between cancer cells, healthy cells, natural immune response, and adaptive immune response under the effects of radiation-induced harvesting on the cancer cells and healthy cells. This is represented by a system of ordinary differential equations. To analyze the effect of radiotherapy treatment on the cells, we utilize equilibrium and stability analysis. Qualitative analysis reveals eight equilibrium solutions and these have been classified into desirable and undesirable equilibria. By requiring the desirable equilibrium solutions to be stable and the undesirable equilibrium solutions to be unstable, interval estimates on the strength of the radiotherapy have been computed. We performed numerical simulations on the model in order to confirm our theoretical results.

Variables	Population Density of...	Initial Values (Experimental)
$C(t)$	cancer cells	0.8
$N(t)$	normal cells	0.2
$T(t)$	natural immune cells	0.1
$L(t)$	adaptive immune cells	0.1

Parameters	Definition	Experimental Values
$\alpha_1, \alpha_2, \alpha_3$	growth parameters of C, N, and T, respectively	0.7, 0.1, 0.7
α_4	interaction parameter between C and T	0.5
K_1, K_2, K_3	carrying capacity for C, N, and T, respectfully	1, 1, 1
b_1, b_2	interaction parameters between C and N	0.01, 0.05
c_1, c_2	interaction parameters between C and T	0.5, 0.2
d_1, d_2	interaction parameters between C and L	0.01, 0.005
μ_1, μ_2	natural death parameters of T and L, respectively	0.5, 0.01
γ	parameter of radiotherapy strength	0, 0.03, 0.8
ϵ	parameter that scales down effect of radiotherapy on N	0.01



Maximizing Harvest Yields in a Three-Species System
C1C Jacob Kahn
Faculty Mentor: Dr. Maila Hallare

Abstract:
Management decisions on sustainable harvesting of any species in our marine ecosystems benefit from mathematical modeling and simulations due to the underlying complex ecological interactions between species. Using basic mathematical analysis and numerical simulation tools, we consider the problem of investigating the maximum sustainable yield (MSY) and the maximum economic yield (MEY) when harvesting in a fishery system consisting of one predator and two competing prey species. Results show that the harvesting effort required to achieve MEY is less than what is needed to achieve MSY. This implies that increasing harvesting effort beyond what is needed to reach MEY will not necessarily deliver more profits but may run the risk of driving some of the species of the system into extinction. Furthermore, results show that under the MEY management policy, a predator oriented harvesting approach is recommended when harvesting single-species only. For double-species harvesting in a system with weak interspecific competition and weak predation, a prey-oriented harvesting approach is recommended, but when there is strong interspecific competition and strong predation, a predator-oriented harvesting approach is recommended.

Department of Physics and Meteorology

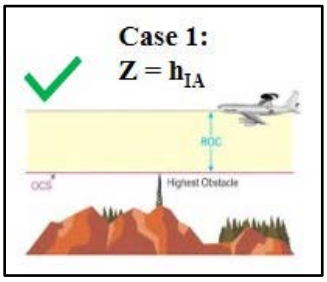
Event Based Sensor Lightning Detection
C1C Cassidy Basset
Faculty Mentors: Dr. Matthew McHarg and MSgt Nate George

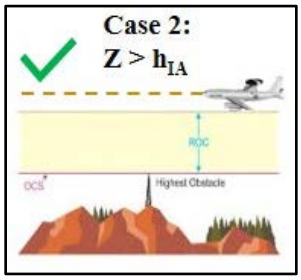
Abstract:
While traditional high-speed cameras such as the Phantom are very effective in capturing photos of precisely timed events such as lightning strikes, the new Prophesee Event Based Sensor camera is able to capture events in a new fashion, gathering different and more detailed data. To test the effectiveness of the Prophesee, we have been analyzing lightning strikes in the Colorado Springs area near USAFA using both cameras simultaneously. We are comparing lightning characteristics using a Global Lightning Mapper (GLM) and ground based measurements of lightning from the Lightning Detection Network (LNDN). So far, we have been focusing on gathering as much data as possible while the rainy season resides over Colorado. We will be continuing to analyze data and see how well the temporal response of the Prophesee camera compares with that of the Phantom high-speed camera. This data will be crucial to evaluating the effectiveness of the Prophesee camera for use as a lightning sensor in the Falcon ODIN payload, which is scheduled to fly to the International Space Station in 2025.

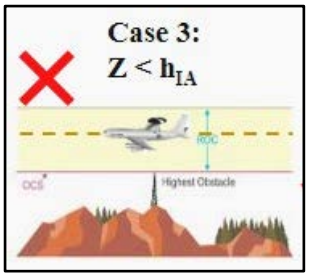
Cold Weather Effects on Altimeter Error
C1C Andrew Hartnett, C1C Nathaniel Spidel, and C2C Raquelle Roesch
Faculty Mentors: Maj Louis Cascino and MSgt Nathaniel George

Abstract:
One of the in-flight safety measures pilots adhere to is the correction of the barometric altimeter reading using the International Civil Aviation Organization (ICAO) Temperature Correction Table[1], which indicates the height above ground according to the International Standard Atmosphere (ISA) temperature and pressure profile[2]. While the ISA is a convenient and internationally recognized tool, it is rarely representative of the actual atmosphere's temperature and lapse rate, and, thus, an aircraft's true altitude above ground. An in-depth look at the current use of the ICAO Temperature Correction Table is warranted especially for atmospheric conditions where surface temperatures are subfreezing. In these circumstances, pilots may think they are flying at a higher altitude than they actually are.
In this study, we work toward ascertaining the deviation between 1) the true altitude derived from upper air soundings, and 2) ICAO Temperature Correction Table-adjusted altitude (a combination of barometric altimeter reading and the ICAO Temperature Correction Table). A deviation (1 minus 2) of zero maintains that the aircraft is flying at the true altitude, a negative deviation gives a pilot of false sense of height, and the safety of aircraft is enhanced when the quantity of this deviation is adequately large and positive. Radiosonde data over Aberdeen, South Dakota (ABR) and International Falls, Minnesota (INL), covering a 20-year period between 1 January 2002 to 1 January 2022, were collected. In total, this data represents a wide-range of atmospheric conditions over non-mountainous topography. Height deviations at 3 different altitudes were investigated: 200 ft above ground level (AGL), 2000 ft AGL, and 3000 ft AGL to capture the 3 common instrument approach altitudes in the United States.
Our results confirm the deviation is an adequately large and positive in both the ABR and INL soundings for the 2000 ft AGL and 3000 ft AGL instrument approach altitudes as well as the ABR soundings for the

200 ft AGL instrument approach altitude. We find, however, the deviation for the 200 ft AGL instrument approach altitude over INL was not adequately large and positive for temperatures from -2°C to -12°C in 161 of the 1372 soundings.

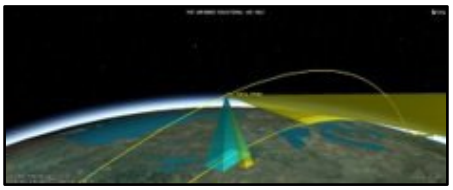






Spectrographic Analysis of Neuromorphic Camera Data
C2C Blake Eastman
Faculty Mentors: Maj Daniel O'Keefe and Dr. Matthew McHarg

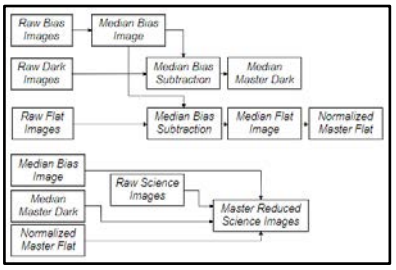
Abstract:
Unlike conventional cameras, Neuromorphic cameras do not take images of all pixels simultaneously. Rather, these cameras record individual events detected by their pixels, p $3s^2 3p^2\ ^3P_1 \rightarrow 3s^2 3p 4s\ ^3P_0$ out where and when specific light struck the camera. One advantage of this method if data acquisition is that it has much finer time resolution than conventional cameras. Using this enhanced sampling rate, it is possible to conduct spectrographic analysis of imaging. Current spectrographic analysis using USAFA's neuromorphic cameras reveals strange patterns in the frequency domain. Specifically, some frequency bands appear to cross over each other at certain sampling rates, while also varying without known cause in time. Current methods involve converting the neuromorphic data into a timeseries by creating bins of various length. This approach to spectrography may be the cause for the strange behavior in the data. This work intends to remedy this by utilizing bayesian methods to execute spectrographic analysis, rather than the current method of binning. Ideally, this will better represent the data and allow for better exploitation of a neuromorphic camera's abilities.



Falcon Telescope Network (FTN) Limiting Magnitude Research
C2C Luke King
Faculty Mentor: Lt Col Benjamin Roth, Dr. Timothy Giblin, Dr. David Strong, and Dr. Francis Chun

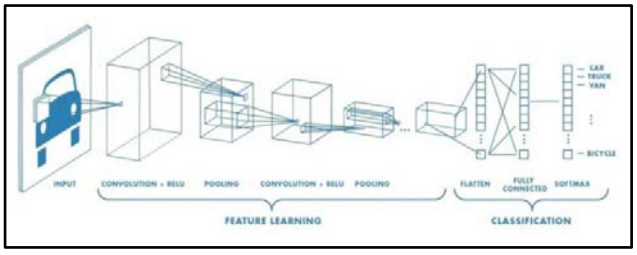
Abstract:
The United States Air Force Academy (USAFA) Falcon Telescope Network (FTN) consists of 12 telescopes around the globe. The purpose of the FTN is to support cadet space education at USAFA through studies of artificial satellites and the nearby universe. The FTN consists of half-meter telescopes around the world with CCD cameras and photometric filter sensors. FTN sites and additional hardware specifications are described in detail in Chun et al (2018). Determining the limiting magnitude, the lowest brightness a

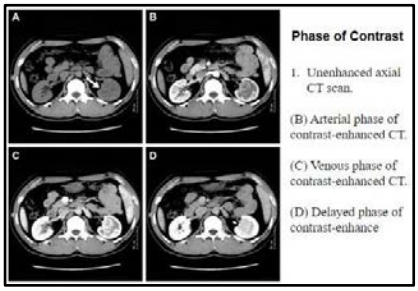
telescope can observe, is necessary for understanding system capability for desired civil and government research. This study creates and demonstrates a method to determine the limiting magnitude of any telescope within the network. We utilize observations of Landolt Standard Fields captured using B, V, and R Johnson-Cousins filters. The limiting magnitude data drives and maximizes various efforts with the FTN, including Space Domain Awareness (SDA) and astronomical research.



Intravenous CT Contrast Time Evolution: Early Detection of Pancreatic Cancer
C1C Madison Marsh
Faculty Mentors: Dr. Monte Anderson and Dr. Michael Rosenthal

Abstract:
CT-based research has now been accomplished through the use of Artificial Intelligence (AI) to determine biometric data like muscle attenuation, which lessens the labor-intensive task for physicians. However, CT imaging presents another barrier in determining true muscle attenuation because it can fluctuate depending on the use of IV contrast. IV contrast can falsely increase muscle attenuation and no current model exists to eliminate its effects. This could misrepresent a patient's risk to cancer, so we seek to eliminate this error. Our study aims to train and validate a convolutional neural network model to estimate the IV phase-of-contrast on abdominal CT scans for a pure objective measure of muscle. The adjusted model for muscle attenuation will then be used for pre-diagnosis of CT scans on an established cohort of patients with pancreatic cancer. The adjusted muscle attenuation will be used in regression analysis with pancreatic cancer risk in pre-diagnostic pancreatic cancer cohort.

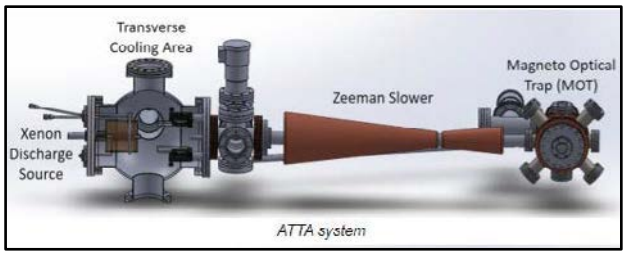




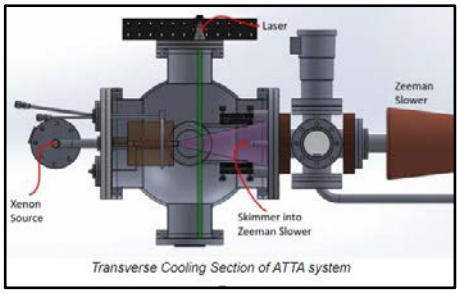
Transverse Cooling of Atom Trap Trace Analysis Xenon System
C1C Tommie Lamarche Granger and C1C Baileigh McFall
Faculty Mentors: Dr. Michael Shaffer & Dr. Monte Anderson

Abstract:
Using an Atom Trap Trace Analysis (ATTA) system with a magneto optical trap (MOT), xenon isotopes can be trapped and their concentrations can be identified. The isotopes fluoresce at different frequencies which gives the ability to target specific isotopes and allows for identification of the source

of the Xe. This system is important for its application of detecting possible nuclear tests which are prohibited by Nuclear Test Ban Treaty. Xe is a byproduct of fission reactions of uranium and is a noble gas that able to move into the atmosphere without reacting with other atoms. This system would improve detection of nuclear fission reactions and allow for better enforcement of the Nuclear Test Ban Treaty. A transverse cooling section before the MOT is being added to increase the loading factor of Xe. Transverse cooling will be achieved using Doppler cooling and radiation pressure from a laser and mirror system. It is expected that the loading factor into the MOT will increase by a factor of 30-50.



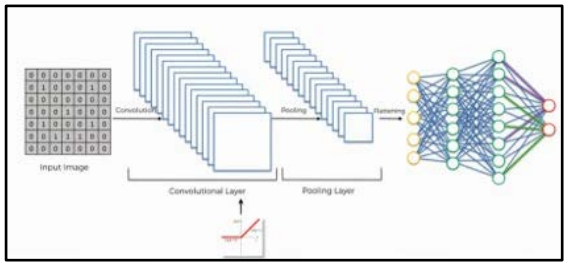
ATTA system

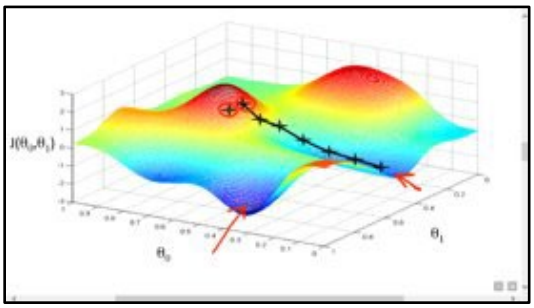


Transverse Cooling Section of ATTA system

Neural Networks for the Analysis of 2D Radio-Xenon Beta Gamma Spectra
C1C Connor Barberi
Faculty Mentors: Dr. Thienbao Carpency, Lt Col James Scoville, and 2d Lt Robbie Hall

Abstract:
Traces of radioactive xenon in the atmosphere are a telling indicator for underground nuclear fission reactions. The primary isomers used to detect fission reactions are Xe-131m, Xe-133, Xe-133m, and Xe-135. International treaty agencies detect these isomers and calculate their concentrations through sensors placed throughout the world. The ratios of these concentrations can help monitoring agencies to distinguish between peaceful nuclear usage and non-peaceful nuclear testing. The concentrations of the isomers are currently calculated using Region of Interest (ROI) algorithms, which have several drawbacks. To improve the analysis of radioxenon isomer concentration, we have developed a technique that utilizes a supervised neural network implemented with TensorFlow and Keras to predict the concentrations of radioxenon isomers based off the beta-gamma spectra produced by radioxenon decay events.

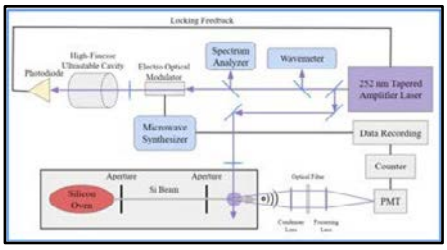


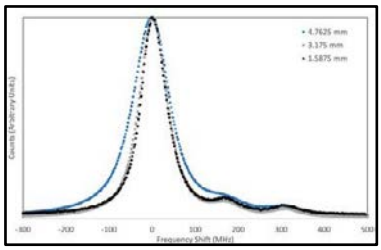


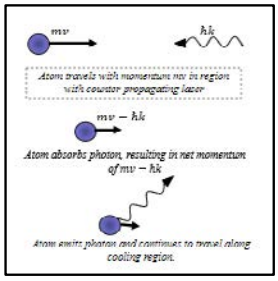
Laser Cooling and Spectroscopy of Silicon
C1C Samuel Angus
Faculty Mentors: Dr. Alina Gearba-Sell and Dr. Jerry Sell

Abstract:
One potential method for constructing a scalable silicon-based quantum computer involves placing 31P to act as atomic qubits on a 28Si substrate. The precise placement necessary to make a system of atomic

qubits can be accomplished by laser cooling and trapping atoms; however, 31P cannot be laser cooled and trapped directly. This paper presents a method for laser cooling and trapping 31Si atoms, which decay into 31P with a half-life of 2.5 hours. We perform laser spectroscopy to determine the isotope shifts for 28Si, 29Si, and 30Si with a 252.4 nm laser on the 3s 23p 2 3P1 → 3s 23p4s 3P0 transition of Si. In our apparatus, we heat silicon powder to 1500 ◦C and then allow the resulting beam of Si vapor to enter a chamber through a small aperture. For laser cooling, we add a counter-propagating laser in the chamber and explore the use of magnetic and electric fields to track the Doppler shift of the atoms' resonant frequency as they are cooled by the laser.

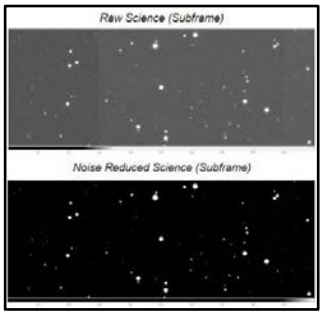


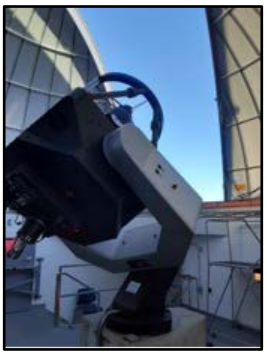




USAFA one-meter Telescope Limiting Magnitude Research
C1C Chia-Hsiang Shen
Faculty Mentors: Lt Col Benjamin Roth, Dr. Timothy Giblin, Dr. David Strong, and Dr. Francis Chun

Abstract:
The United States Air Force Academy (USAFA) Observatory's one-meter telescope system installation was completed and became fully operational with the addition of a large format CCD camera in early 2022. Determining the limiting magnitude of the telescope system is required to know its capability to support specific research objectives and observation requests from the government and civilian agencies. In this study, we observe multiple Landolt Standard Star Fields with BVR Johnson-Cousin filters to calculate the limiting magnitude for a series of Signal-to-Noise Ratio (SNR) values. A rigorous characterization of the limiting magnitude for the telescope system allows the USAFA team to further advance research goals in astronomy and space situational awareness.





Radiation Trapping in Potassium Vapor
C1C Peter Spengler
Faculty Mentors: Capt Anita Dunsmore and Dr. Brian Patterson

Abstract:
Understanding the effects of radiation trapping is important in applications such as the creation of gas lasers or the validation of atomic models. We used a Monte Carlo computer algorithm to simulate the

effects of radiation trapping on the excited state lifetime in a potassium vapor cell. Simulations were made for helium buffer gas pressures from 100 to 600 torr and temperatures from 343.15K to 453.15K. Using experimental data from a 100-femtosecond laser pulse used to excite potassium atoms along the D2 absorption level, we validated our simulation using an exponential fit to determine the excited state lifetime.

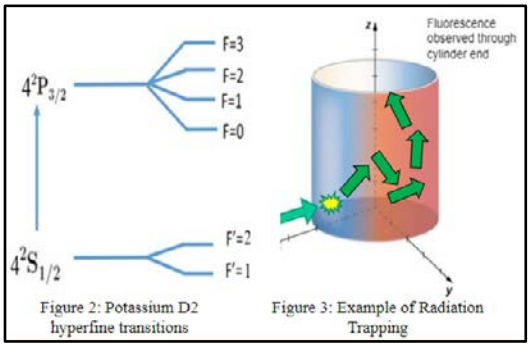
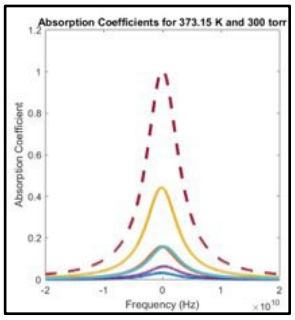
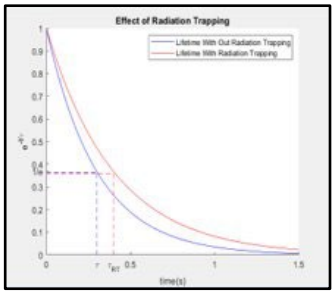


Figure 2: Potassium D2 hyperfine transitions

Figure 3: Example of Radiation Trapping





Project Auto-Sextant

C2C Mihiri Fernando, C2C Victoria Salvador, Nicholas Hamby, C2C Luke Matlock, and C2C William Voelker

Faculty Mentors: Maj Daniel O'Keefe and Lt Col James Bowers

Abstract:

Project Auto-Sextant is revolutionizing sextant technology to create a new device that can calculate latitude and longitude coordinates of a moving aircraft using an image of a celestial object. In the event that both military and civilian GPS satellites are taken out Project Auto-Sextant will take over as an emergency backup system to provide navigational data to a flight crew. This system uses a camera to take an image of celestial objects, and then using the azimuth, elevation, and time of day, the system runs an algorithm to output the plane's geographic location. This system is currently being designed for the KC-135 Stratotanker, and will utilize the existing sextant port in the aircraft to ensure a smooth implementation of the device.

On Orbit SDA - The Case for Neuromorphic Imaging

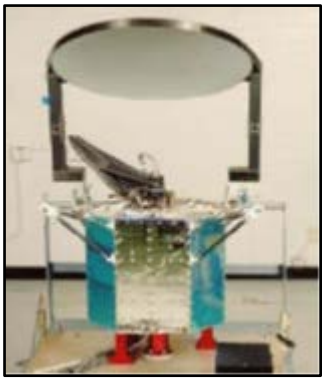
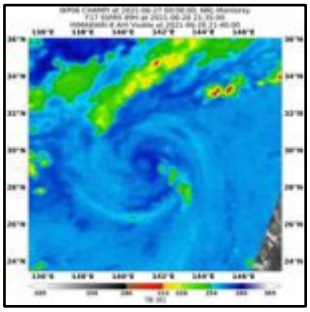
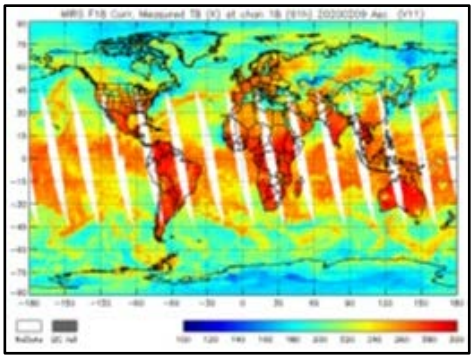
C1C Marc Previlor

Faculty Mentors: Maj Daniel O'Keefe and Dr. Matthew McHarg

Abstract:
Neuromorphic imaging is a new method of capturing dynamic scenes using silicone retinas to sense changes in light intensity that is more similar to how early visual-processing characteristics of the eyes of a living organism works. The space environment is getting more congested, contested, and competitive. In this austere environment, as more valuable payloads and military systems are being deployed, new methods must be investigated to better monitor possible threats to secure satellites in space. As part of my research I will be engaging directly with the specs and data collected from a Neuromorphic Camera (Event Base Sensor) and compare it head to head with USAFA's very own high-speed camera to draw a conclusion on whether it would be beneficial to employ this technology and improve Space Domain Awareness (SDA).

The Importance of Department of Defense Space Based Environmental Monitoring for Tropical Cyclone Forecasting
C2C Kendall Barrows
Faculty Mentors: Lt Col Robert Wacker

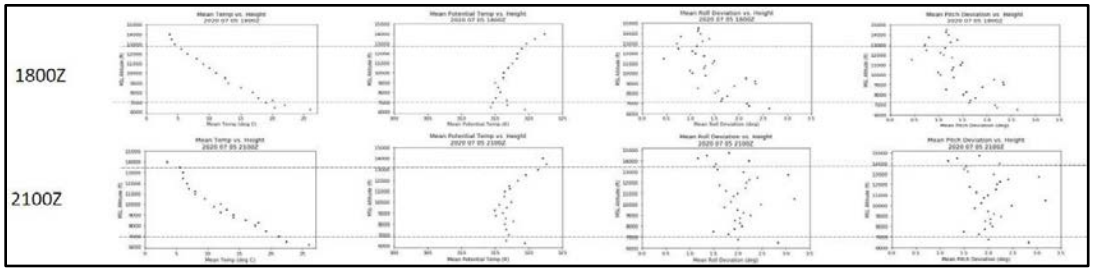
Abstract:
The Joint Typhoon Warning Center (JTWC) covers 70 percent of the annual tropical cyclones through their AOR and provides tropical cyclone tracking and intensity predictions through space based environmental monitoring (SBEM). In order to provide such resources, JTWC needs a given requirement of microwave imaging data which is not being met due to satellites aging out. This research seeks to quantify the operational impact and provide justification for future DoD SBEM. Current orbital data from satellites combined with JTWC best track data will quantify the significance of having gaps in data and the impact on the tropical cyclone forecasting mission.

Characterizing the Atmospheric Boundary Layer Using an Inexpensive General Aviation Flight Data Sensor
C1C Alexander J. Molino
Faculty Mentors: Lt Col Robert S. Wacker

Abstract:
Observing the atmospheric boundary layer has traditionally required expensive ground- and aircraft-based instrumentation to capture the small-scale temporal and spatial variability in atmospheric variables. Recently, inexpensive devices have become available for light general aviation aircraft that measure altitude, airspeed, heading, and aircraft attitude. We used such a device to record data during

ascents and descents within the boundary layer at three-hour intervals over the course of a day. This research explores methods for processing the sensor data to produce potential temperature, wind, and turbulence profiles. Initially, these profiles will be used as instructional aids in the Boundary Layer Structure and Processes course taught at the United States Air Force Academy. A longer-term goal is to employ similar data exploitation techniques to make use of data gathered inexpensively by light aircraft for boundary layer research.



Department of Political Science

A Policy Proposal for the United States to Counter China's Reach for Global Hegemony
C2C Jacqueline Kelly
Faculty Mentor: Dr. Lynne Chandler-Garcia

Abstract:
America's relationship with China is one where partnership is fundamentally impossible. China and America's strategic and ideological differences set their ability to be truly partners irrevocably at odds. China as an authoritarian state and America as a democracy differ in terms of beliefs ranging from human rights, sovereignty of states, and even communism vs democracy. Despite these odds, China and America both wish to see a peaceful world.[1] The key difference is that both countries wish to lead that peaceful world order and as such the resulting world order would be marked by the winning country's ideology. A world order led by China is repugnant to American policy makers because such a world order would be one marred by human rights violations, authoritarianism, and destroyed dreams. However, the United States and China do not want to go to war since that would bring about destruction on a scale undreamed of. Thus, the United States foreign policy makers must evaluate their foreign policy towards China while also examining China's foreign policy towards achieving global hegemony. Looking into the past, present, and future, American policy makers must understand the failings and successes of both American foreign policy and Chinese foreign policy to begin to develop a foreign policy approach towards Chinese foreign policy that effectively counters it.

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