NORTHROP GRUMMAN

ENGINEERING & SCIENCE
STUDENT DESIGN SHOWCASE

Florida Tech

Friday, April 12th, 2019

Book of Engineering and Science Projects

10th ANNIVERSARY

Welcome Message

Welcome to the 10th Annual Northrop Grumman Engineering and Science Student Design Showcase!

The mission of the College of Engineering and Science at the Florida Institute of Technology is to educate and challenge students in the basics of rigorous engineering and scientific theory, ethics, and practice, as well as to expand collective knowledge through novel research, discovery, and entrepreneurship integrated with that education.

The Showcase brings this mission to life and provides a great platform to our engineering and science projects that creatively demonstrate Florida Tech's renowned hands-on approach to education. Project-based learning through student design gives students experience that not only helps them gain a better understanding of their field, but also helps them acquire highly sought-after workplace skills, such as leadership, collaboration, communication, and problem-solving.

The College of Engineering and Science is enthusiastic and proud of the students' abilities to demonstrate their academic achievements and technical prowess.

We invite you to enjoy the Showcase and to engage with the students and faculty to learn more about their outstanding work and accomplishments.

Marco Carvalho, Ph.D.
Dean, College of Engineering and Science

Message from the Organizers

On behalf of the Office of Student Projects, we would like to welcome you to the 10th Annual Northrop Grumman Science and Engineering Student Design Showcase.

This event provides an opportunity for our students to present their hard work and allows us to highlight and evaluate the essential benefits of our hands-on educational approach. This year, we celebrate our 10th consecutive annual Student Design Showcase thanks to the generous support from Northrop Grumman and the participation of many of our industry partners.

We would also like to thank our distinguished judges for their hard work and time. Your feedback is an invaluable resource for our students.

We hope that you enjoy this event and get an opportunity to appreciate the projects, which are a reflection of the commitment and hard work of our students and the application of the knowledge they have received throughout their time at Florida Tech.

Juan Avendano
Director of Student Projects
College of Engineering and Science

Showcase Awards

The projects presenting in the Student Design Showcase are recognized for their outstanding performance with several different awards.

During the event, a panel of industry judges will interview representatives from each project in order to determine the project that best represents each discipline. This team of judges selects and awards the ***Best of Category*** award for each of the disciplines displayed at the event.

A special delegation from Northrup Grumman Corporation will interview all the participating projects in order to grant the ***Northrop Grumman Best of Show in Science*** and ***Northrop Grumman Best of show in Engineering Awards.***

Dr Dwayne McCay, President of Florida Institute of Technology, tours the showcase, visits projects from every discipline in order to evaluate them for the prestigious ***Presidents Cup for Engineering*** *and* ***Presidents Cup for Science.***

<u>New awards for the 2019 Northrop Grumman Student Design Showcase at Florida Tech</u>

To encourage and recognize the importance of positive changes in our society, the College of Engineering and Science has created the college level awards for this year's Northrop Grumman Student Design Showcase.

With these recognitions, we hope to highlight innovative and entrepreneurial mindsets of our students, and encourage a progressive social impact that benefits our communities.

Innovation Award

The Innovation Award recognizes the project that brings new ideas to life. An innovative project is the one that solves the assigned problem in a novel and creative way, anticipates challenges of the future, and has the ability to adapt under those circumstances. A significant innovation can take place through the application of more-effective products, processes, services, technologies, or business models.

Whether that idea is big or small, the ideas behind the innovation award recipient should strive to change the way we experience the world.

Entrepreneurship Award

The Entrepreneurial award recognizes a project that has demonstrated an entrepreneurial achievement with the application of the 3C's of an entrepreneurial mindset: Curiosity, Connections, Creating Value.

The team must demonstrate curiosity in their research: pursuit of knowledge and integrate it with their discoveries and designs to create a solution. The project must generate new connections between ideas, individuals, project, and communities. Finally, the recipient of this award must create and demonstrate extraordinary value.

Social Impact Award

The Social Impact Award recognizes a project whose work is makes a positive impact on society. The winning project must demonstrate both commitment and dedication to address issues within our society and the foster social change to bring positive influence within the same.

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Aerospace Engineering

Project Name	**Recoverable High Altitude Balloon (ReHAB)**
Team Lead:	Emils Senkans
Team Member(s):	Dunyawat Kriedtharumal, Kulwarang Preeprem, Chimmy Joeaneke, Michael Koramoa, Kenneth Hausrath
Faculty Advisor(s):	Dr. Tiauw Go, Dr. Kimberly Demoret

Introduction

The affordable cost and high feasibility of High Altitude Balloon (HAB) missions appeal to university requirements to conduct research in the near space environment. HAB missions are used mainly in weather forecasting and observation of various atmospheric phenomena. However, HAB payloads are often lost or not retrieved due to a lack of recoverability of the payload. The goal of the ReHAB project is to use a foldable wing glider to return a payload designed to collect data for weather predictions from its ascent to the upper atmosphere. The project is limited by FAA regulations for free unmanned balloons and unmanned aerial vehicles (UAV). For the 2018-2019 ReHAB team, the UAV will be a controlled glider as it can provide significant range from the high burst altitude with minimal weight required.

Methods

Based on limitations set by FAA regulations the whole mission sequence cannot be tested without obtaining a waiver. Therefore the design is based on testing requirements and the ideal mission sequence is split in two parts - balloon test flight and glider test flight.

The balloon flight test vehicle is a fixed foam structure that is shaped to be identical as the glider in folded wing position. This folded wing position is designed to reduce the moments caused by the wind during ascent. This specific vehicle is attached to a weather balloon filled with helium, and this setup carries all the avionics which will be tested in the flight upon ascent. During ascent the payload must record the pressure and temperature every second and store data onboard while also transmitting data to a ground station. This is done using an Arduino and a radio transmitter. The avionics also includes GPS tracking that transmits on the APRS network and a cut-down system designed to release the balloon at a predetermined altitude using a premade zip tie cutter to limit the distance balloon drifts away from launch site.

The glider flight test vehicle is a glider that is capable of folding its wings. The glider design is optimized for range performance, so it can cover maximum distance from the cut-down altitude. Wing design is optimized for elliptical lift distribution and reinforced using carbon fiber rods. The folded position of the wing is achieved in a single rotation about a complex angle relative to the fuselage reference line. The wing deployment mechanism uses a servo to rotate the wing to its unfolded position. The wing is locked into position by a ratchet gear mechanism that allows rotation only in one direction, this means once the wing is unfolded it cannot rotate back without being reset by an operator.

Conclusion

Project ReHAB is a HAB platform to carry a scientific payload up to an altitude of 10 km, and then recover the payload in an accessible location. This year's project is designed as a proof of concept to test all individual requirements in compliance with FAA and FCC. Results of ReHAB project may be used at Florida Institute of Technology to further develop HAB platform to improve recoverability options for a wider range of scientific payloads from Physics department.

Acknowledgements

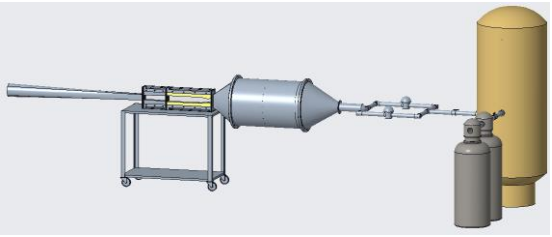
The authors would like to acknowledge and thank our primary sponsor, Northrop Grumman Corporation, for their funding and support. The authors would also like to thank Aldrin Space Institute for their funding and support. Additionally, the authors would like to thank industry mentors Mr. Travis Rennemann and Mr. Ronald Fussell along with the FIT Machine Shop for their continued support and guidance through the course of this project.

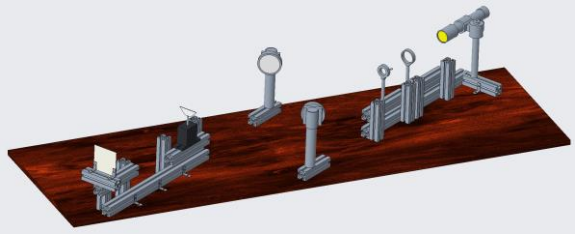
Project Name **Supersonic Wind Tunnel**

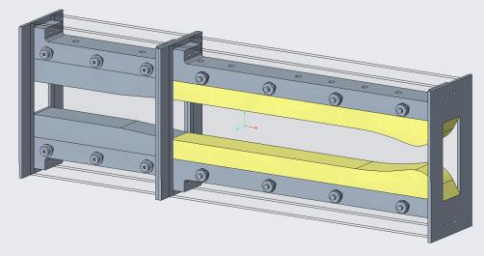
Team Member(s): Andres Alarcon, Francisco Bayon, Paige Christensen, Dominic Ditmyer, Alonso Juan, Nick Pattison, Ishan Sen, Kevin Urban

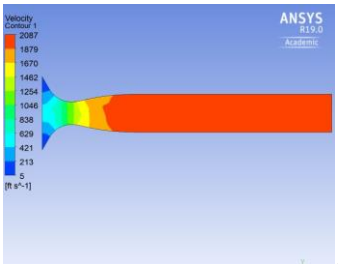
Faculty Advisor(s): Dr. Chelakara S. Subramanian and Dr. Kimberly B. Demoret, Dept. Of Aerospace, Physics And Space Sciences, Florida Institute of Technology

The Supersonic Wind Tunnel project set forth to design and fabricate a modular intermittent blowdown supersonic wind tunnel. The manufactured portion of the tunnel contains two nozzle blocks and two diffuser blocks optimized for Mach 2.0 conditions. These interchangeable components will provide future teams the opportunity to design geometries capable of operating at various supersonic regimes. The design included a surge tank of compressed air, a high-pressure settling chamber, a convergent-divergent nozzle, a 2.5 by 3.2-inch test section, an oblique shock diffuser, a diverging diffuser duct, a control system, and a Schlieren optical system. Due to time and budgetary limitations, the full scope of the project could not be fulfilled. Therefore, the team chose to fabricate the test section, diffuser throat, Schlieren optics, and controls system with hopes of the project being completed by another team in the future. The supersonic capabilities were confirmed using computational fluid dynamics simulations, and the structural capacity of the test section was examined using ANSYS Workbench. The controls system was analyzed using a 3D-printed, subscale model of the design, which would also represent the original intention of the project. If the supersonic wind tunnel were to be fully completed, the educational benefits would be substantial to both undergraduate and graduate aerospace students' courses such as experimental aerodynamics, compressible flow, or experimental fluid dynamics.





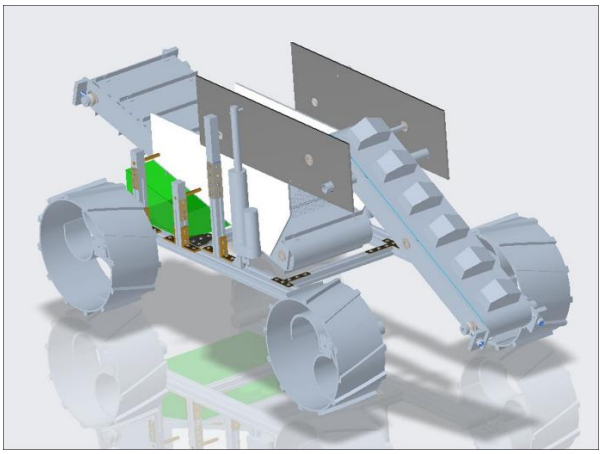




Sponsor: Office of Naval Research

Project Name	**NASA Robotic Mining Competition**
Team Lead:	Matthew Bernier
Team Member(s):	Donovan Southwell, Kittiwin Kumlungmak, Daniel Penaranda, Taewook Lee, Bindi Nagda, Marlisa Lim, Tim Porath, Andy Griscom, Daryl George, Kleanthis Tegos, Evangeline Minet
Faculty Advisor(s):	Dr. Demoret, Dr. Reichard

NASA's Robotic Mining Competition (RMC) invites universities to build a mining robot that can perform Martian-simulated missions. The robots are built to excavate as well as deposit icy regolith simulant into a collection bin while exposed to Martian environmental conditions. Significant resources were dedicated to the design of an innovative excavation system to reach the necessary depths in the arena to mine the icy regolith simulant. Stress analysis of the wheels and scoops, motor torque calculations, tractability, and bending calculations were used to verify the design considerations and justify the specifications of the robot. Data analysis projects the robot will be competitive at its upcoming competition in May 2019. Future work for the robot will include mass optimization, improvement in the excavation methodology, streamlining the autonomous programming, and a more efficient use of power during its operations. These improvements will see greater appeal to the NASA officials that judge this competition, as they use the innovations from universities to design their future rovers.



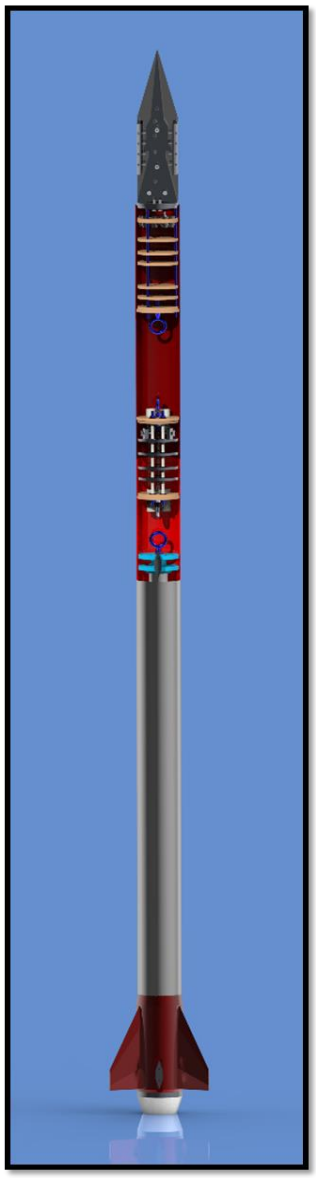
Project Name	**Exoplanet Observation Satellite**
Team Lead:	Justin Dyer
Team Member(s):	Reed Kennaday, Christopher Rios, Danilo Esquivel Leiva, Brad Barrett, Alroy Fernandes, Xzavier Flowers, Connor Nelson, Darrel Ramasray, Andrew Salmon, Joe Sitton
Faculty Advisor(s):	Dr. Markus Wilde, Dr. Kimberly Demoret

The EOS team created a conceptual design of a mission capable, space-grade satellite, with the ability to observe exoplanets. The mission considered includes satellite sizing, communication windows, and pointing requirements. These were used to design a preliminary satellite capable of performing the mission using space grade components. The mission-capable satellite was used to develop a prototype satellite which demonstrated the capabilities of a comparable attitude control system manufacturable within the scope of a Capstone Project. A laser communications system was implemented for image transmission, and provided valuable insight into the capabilities of a laser communication strategy for the mission.

Figure 1- System Integrated Prototype.

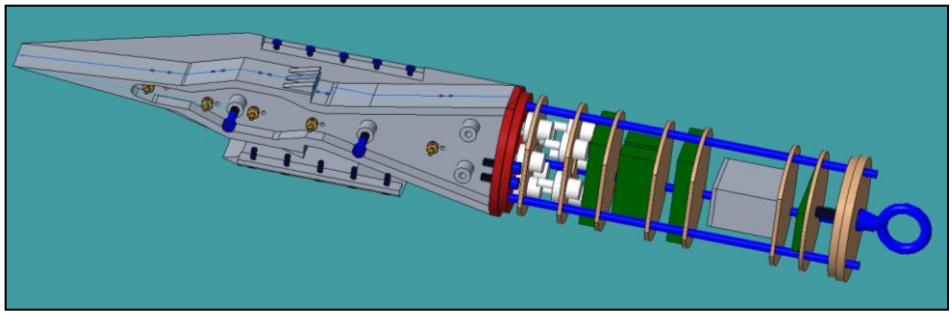
Tests were conducted at the Florida Tech Orion lab to make use of its Optitrack optical system, which provided real-time data on the prototype's position. The prototype was tested on a hemispherical air bearing, which allowed for frictionless rotation. A test stand and mass balancing system were developed to interface with the laboratory and air bearing. This project has created the necessary test infrastructure to allow for the testing of future prototype satellites to optimize attitude determination and control systems. Future teams can work to further reduce disturbance torques in the system through use of a Helmholtz coil or a linearly actuated mass balancing system.

Project Name	**High Altitude/Mach Rocket**
Team Lead:	Jesse Nyffenegger
Team Members:	Fernando Aguirre, Reed Antonich, Jarrett Elrod, Ethan Hunt, David Lomomte, William McCormick, Amanda Noori, Silviu Solomon
Faculty Advisor:	Dr. Kimberly B. Demoret, Dept. Of Aerospace Physics and Space Science, Florida Institute of Technology



Project description:

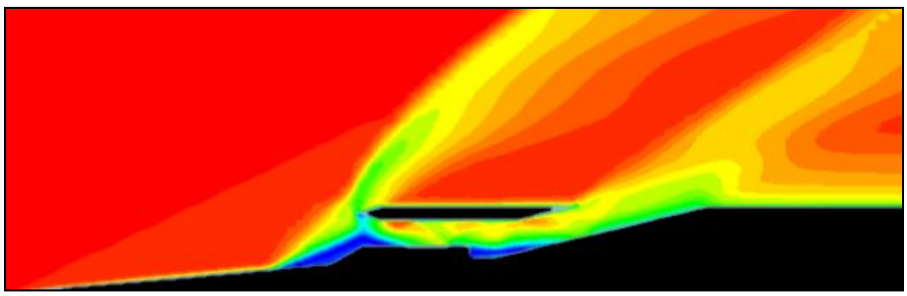
Hypersonic and supersonic flight are increasingly important fields of flight with billions of dollars being invested in research for both military and commercial applications. Flight testing of supersonic and hypersonic air breathing engines is expensive and risky. CFD and wind tunnel models can be accurate, but do not include aspects of a real-world flight regime such as vibrations and the randomness of the real atmosphere. To bridge the gap between these two methods we propose the following: a payload that will model a ramjet engine, and a booster to propel it to near 3 times the speed of sound.



Design Solution:

The design consists of two subsystems: a payload consisting of a nosecone with modeled ramjet geometry and a launch vehicle to propel the nosecone to Mach 2.8. The Nosecone will be instrumented with temperature and pressure sensors to collect information about the compression performance of the design. The launch vehicle is powered by a Class 2 solid rocket motor and is designed to carry and safely recover the payload to Mach 2.8 and 50,000ft. The rocket will be recovered using a dual deployment parachute system and tracked with GPS and radio beacons. Because of the high altitude the full power flight will occur at the 2019 Spaceport America Cup in New Mexico, and a local sub-powered flight will occur in Palm Bay.

CFD analysis is performed using ANSYS Fluent. 2D Static, 2D transient, and 3D Static analyses were performed on the nosecone, as well as the fins and launch guides.



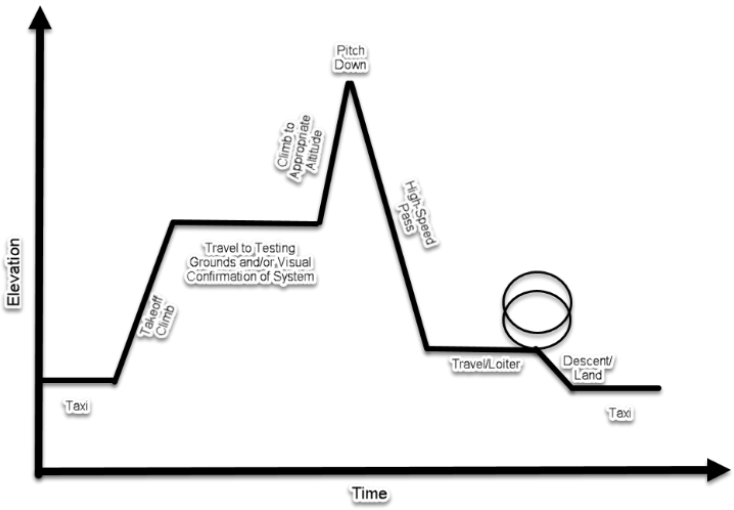
Project Name **Peregrine Jet UAV**

Team Lead: Brandon Maier

Team Member(s): Brian Nyffenegger, Zach Comeau, Jeremy Jones, Nabil Osorio, Cloency Chua, Jimmy Krenger, Alex Whidden, Cody Nettleton Anthony Messina, Christian Cambron

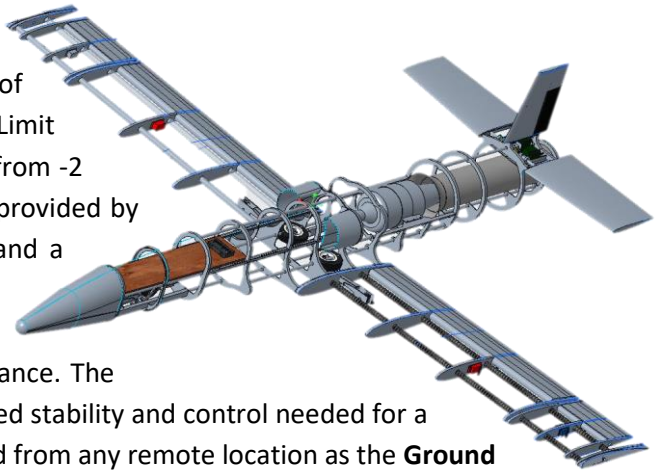
Faculty Advisor(s): Dr. Brian Kaplinger, Dr. Siddhartha Bhattacharyya

The Peregrine II Senior Design Project has designed and begun manufacturing a jet-powered, high-speed unmanned aerial vehicle capable of performing flight test experiments with a science payload. The Peregrine team aircraft will work as a test aircraft which will be able to perform a variety of meaningful tests and experiments, and help the University build its body of knowledge on jet UAV operations.



This conceptual **Mission Profile** would span a total duration of around seven minutes at max throttle. The following table reflect the estimated fuel usage and fuel fractions of such a flight profile. General Parameters of interest:

- Total weight: 55 lbs.
- Maximum Speed: M = 0.39 = 300 mph
- Maximum Thrust: 67 lbs.
- Maximum Service Ceiling: 32,000 ft



The **Structural Design** of the UAV is robust and is capable of withstanding much larger flight loads than previous projects. Limit load factors outlined by the aircrafts flight envelope ranges from -2 G's to +5G's. **The Propulsive** capabilities of the aircraft are provided by the JetCat P300 PRO which delivers 67 pounds of thrust and a service ceiling of 32,000 feet. While at max thrust, the aircraft is expected to deliver a thrust-to-weight ratio greater than one which allows for incredible flight performance. The **Aerodynamic Design** is also defined to provide fully developed stability and control needed for a flight test platform. The aircraft is capable of being controlled from any remote location as the **Ground Control Station** provides flight control, data processing, video feed and GPS monitoring while maintaining constant communication with the aircraft through telemetry radios attached to a Pixhawk 4 Flight Management Unit that relays signal to communicate with the **Onboard Avionics** and control the mechanical systems.

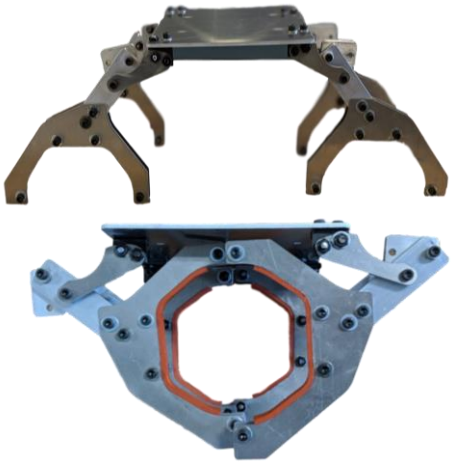
In the realm of flight test engineering, Universities are confronted with a gap between wind tunnel and full-scale flight tests. Performing flight test experiments with full scale aircraft is costly and restricted. Peregrine II offers an affordable intermediate platform that allows for real world experimentation and help expand the University's skills in operating jet UAV flight programs.

Project Name	**Perching Unmanned Monitoring Aircraft (PUMA)**
Team Lead:	Chirag Dodani
Team Members:	Tengjie Gao, Tjimon Louisy, Dev Patel, Srishti Patil, Howard Rogers, Channing Ryan
Faculty Advisors:	Dr. Kimberly B. Demoret, Dr. Tiauw H. Go, Dept. of Aerospace, Physics and Space Sciences, Florida Institute of Technology

The maneuverability and efficiency of vertical takeoff and landing (VTOL) vehicles are in high demand in today's aerospace industry. One of the major divisions within the industry taking advantage of perching operations is surveillance. Moreover, there are no fixed wing UAVs in the market that combines ability of VTOL and perching. Such an aircraft has immense potential and current traffic surveillance cameras are stationary, creating a gap in the market for mobile surveillance platforms. PUMA is capable of fulfilling this market gap by providing a mobile surveillance platform that is able to perch and perhaps most importantly, be mobile. This gives PUMA ability to virtually land and take off at any location, and in our case on traffic light poles.

The aim of PUMA is to act as a mobile surveillance platform in urban cities as well as remote areas by perching on traffic light poles to observe traffic or any road incidents and help assess the situation before the necessary services arrive. The aircraft takes off vertically and transitions to horizontal flight and transition back to vertical flight when ready to perch or land. PUMA takes advantages of tricopter agility in tight spaces without the associated limitations on endurance and speed. Additionally, the perching mechanism will allow us to limit power usage by perching on an object instead of depleting power during hovering. Due to the complexity of the project, PUMA will inherently have some challenges. To, being with the FAA limits the weight of such aircraft needs to be less than 55 lbs. Furthermore, in order to be able to perch the aircraft has to be modest in size with a durable construction. In addition, the aircraft needs to be buoyant so it can be perched and also be able to perform maneuvers as a conventional drone. This problem is fixed in part, by choosing a thin airfoil with great lift characteristics and relatively low drag characteristics for the wing in addition to having an aerodynamic lifting body contributing to overall flight characteristics.

Having this functionality in a small package will greatly benefit local law enforcement keep a constant lookout and expand the range of observation while also being cost effective. This helps the overall welfare and safety of the community by having faster and more efficient emergency response times in case of accidents as the current situation can be observed and analyzed within minutes of deploying PUMA.



Project Name	**Spin-Induced Gravity Module**
Team Lead:	Roger 'Benny' Lucier
Team Member(s):	Roger 'Benny' Lucier, Elijah Dury, Altayeb Hashim, Alahna Reto, Shaula Rey, Rumesh Senthilnathan
Faculty Advisor(s):	Dr. Kimberly Demoret, Dr. Kunal Mitra

Project Description

Flights to planets or moons beyond Earth's sphere of influence are at least six months flight time, one way. Given the outbound voyage, the time exploring a lower gravity body, and the return trip, the shortest a mission can be is about two years. While astronauts have spent as long as one year in microgravity, there is still a significant rehabilitation period that follows. Without intervention during the outbound and return flights, many issues that arise when spending extended amounts of time in microgravity include osteoporosis, muscular atrophy, hyper/hypovolemia, and cataracts. However, it would not be practical to bring all recovery equipment on a mission.

The Spin-Induced Gravity (SIG) team is dedicated to designing a single-launch multi-role artificial gravity module that could be used to complete missions in deep space without compromising astronaut health, as well as extending the duration of an orbital missions using knowledge from both an engineering and biomedical perspective.

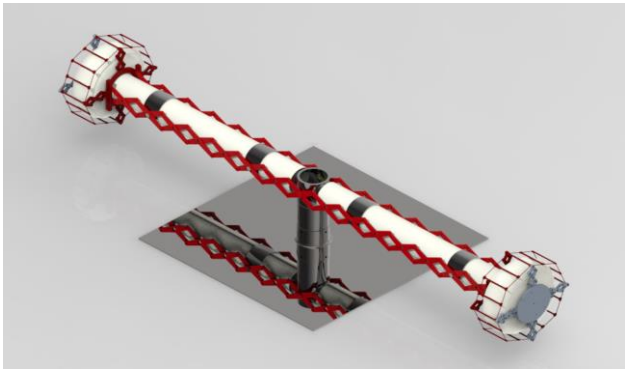


Figure 1: Sub-scale SIG

A collapsible set of trusses similar to a scissor lift works as stiffeners outside inflatable hallways and the habitat section connected to a metal hub section, with a low-friction docking collar permitting entry into the target spacecraft.

Analysis shows the SIG module is capable to withstand normal running conditions. The devices nominal running speed creates a low torque that can be countered by the docked craft's reaction wheels.

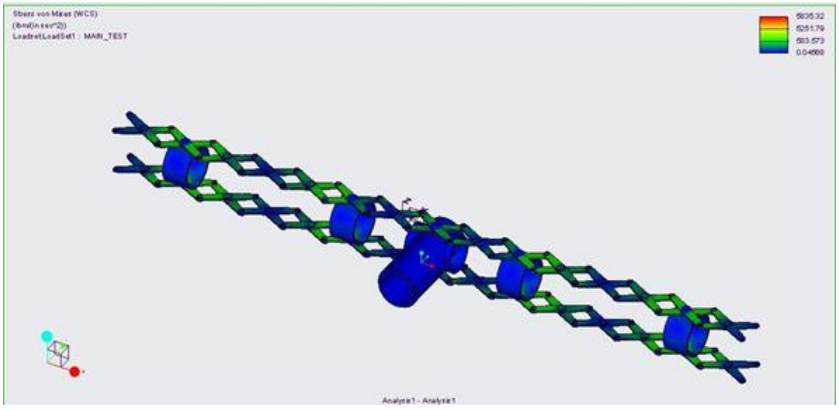


Figure 2: Stress Analysis of SIG-PRO

If implemented in an interplanetary exploration mission, SIG-FUL would be a useful piece of equipment. The spacecraft could fly longer with more fuel-efficient routes while keeping astronauts healthy. It could be used in orbital stations to allow longer stays by astronauts, while zero-gravity experiments are performed in docked modules. A prototype could be docked to the next-generation space station to test what level of partial gravity is necessary for normal life and could provide invaluable information for human colonization efforts. Further research could include better manufacturing procedures, exercise procedures, and effects of partial gravity levels on humans.

Project Name **ULA Cryogenics**

Team Lead: Ryan Piersa

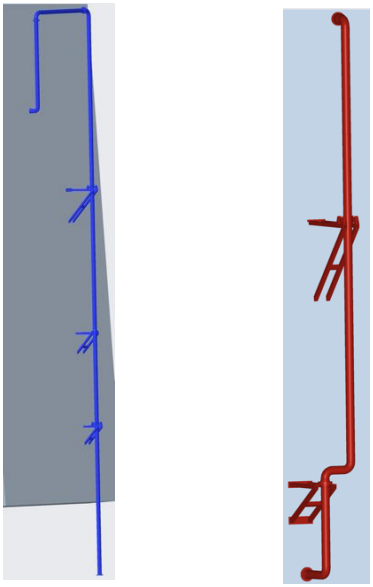
Team Member(s): Israel Gavilanes, Michael Hornbuckle, Damian Smith

Faculty Advisor(s): Dr. Kimberly B. Demoret

Cryogenic propellants or liquefied gases are among the most popular choices for launch vehicles due to their high energy density; however, cryogenic fueling is complex, and implementing the fueling system can be challenging. As the complexity of a system increases, the need for testing also increases. Proper operation and successful checkout of the cryogenic ground support system must be verified before the vehicle arrives at the launch site. For United Launch Alliance (ULA) to test the cryogenic ground support system without the launch vehicle, a Cryogenic Test Tool is needed to connect the Mobile Launch Platform (MLP) fill and vent systems.

This team will provide a design of these cryogenic test tools and their support structure to ULA, who will be responsible for fabrication. For the Engineering Showcase, the team will manufacture a replica of the MLP and test tools. Images of the test tools are shown here:

LOX System **LNG System**



To achieve successful checkout, there will be two Cryogenic Test Tools: one supporting Liquid Oxygen (LOX) and one supporting Liquefied Natural Gas (LNG). The tools will interface with existing structures and connect the launch facility's fill system to the facility's vent system. The adapters for the fill and vent connectors will be provided by ULA. The tools will support their own weight as they are lifted and placed into the structural supports of the Mobile Launch Platform (MLP). The structural supports attached to the MLP will support the test tools under the loading cases that were considered.

In order to address this design challenge, two separate subsystems were defined: Structural Design and Flow Field Analysis. The Structural Design subsystem will consider the weight and strength of the piping system to ensure limit loads are met. The Flow Field Analysis subsystem will consider the thermal analysis of the piping system as well as the consequences of the fluid flow field within the piping for both commodities: LOX and LNG.

The design and implementation of these cryogenic test tools is of critical importance to ULA and their Vulcan rocket project. The successful checkout of ground support equipment on the MLP and Vulcan launch pad is one of the first prerequisites for launch.

The team would like to thank the engineers of United Launch Alliance (ULA) for their support

Physics and Space Sciences

Project Name **Versatile and Cost-Effective Cosmic Ray Detector**

Team Lead: Zachary Shelton
Faculty Advisor(s): Dr. Francisco X. Yumiceva, Dept. of Aerospace, Physics and Space Sciences, Florida Institute of Technology

Cosmic Rays originate from outside of our solar system, they interact with our atmosphere and create pions that decay into muons. The muon has a long enough lifespan that they travel through the earth surface in a relatively regular manner, in general 1 muon passes through 1 square centimeter per minute at sea level. The muon represents the background in most high energy physics experiments, its frequency and long lifespan make it a great experiment for students to introduce them to the exciting sub-atomic world!

MIT designed the CosmicWatch cosmic ray detector, this study sought to determine if the detector will be effective at Florida Tech in general experimentation and for introductory labs. The detector would be built and used to count cosmic rays passing through the scintillator, it would also be programmed to test if the detector can effectively determine the energy of the particle. The detector counts the number of cosmic rays passing through the scintillator in a 30 second period, these rates are taken into a weighted average and compared to the expected rate given the surface area of the scintillator. To test if the detector could effectively determine the energy of the particle, this was achieved by using the fitting characteristics of the circuit to determine the initial peak voltage, the Silicon Photomultiplier (SiPM) taking in the light discharges just like an RC circuit. This allows us to integrate over 5 time constants and estimate the total charge from the SiPM and by extension the energy of the photon produced by the ionizing particle. These counts would be taken in ambience on the 3rd floor of Olin Physical Sciences and with 2 sources above the scintillator. The counting of muons and from the source was partially successful, the ambient count was within one sigma of the expected and the source counts saturated the detector causing them to have similar rates despite having two different decay rates and schemes, this was due to the scintillator saturating the SiPM, both gave off beta particles faster than the detector could measure. The detector was not equipped in its current form to measure the energy because of the scintillator, the energy measured from the SiPM is consistent around 12KeV representing the minimum ionization energy of the scintillator.

The detector in its current form would be effective for introductory labs, as it can make accurate counts of cosmic rays. For general experimentation and use in particle identification, a scintillator that annihilates the particle and a redesign of the current circuit would be necessary. Despite this, the ~$100 price and the ease of set up and programming with Arduino and/or python. With these improvements, the detector could be optimized for general experimentation and would make high energy physics more accessible at Florida Tech.

	Cs-137	Co-60	Ambient
Weighted Avg Rate(s^{-1})	13.66±.42	13.42±.15	1.19±.21

Figure 1: Resulting average rates.

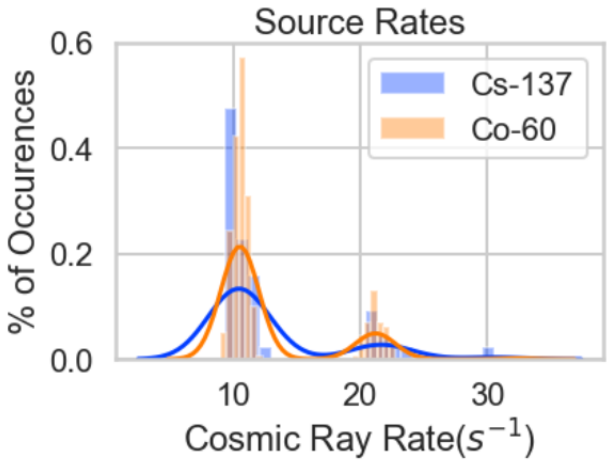


Figure 2: Source rate distribution.

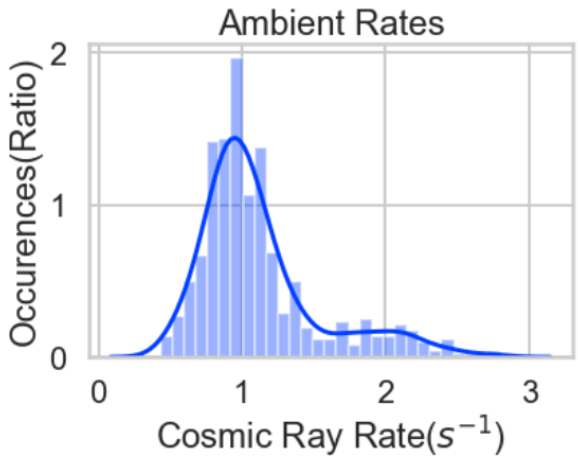


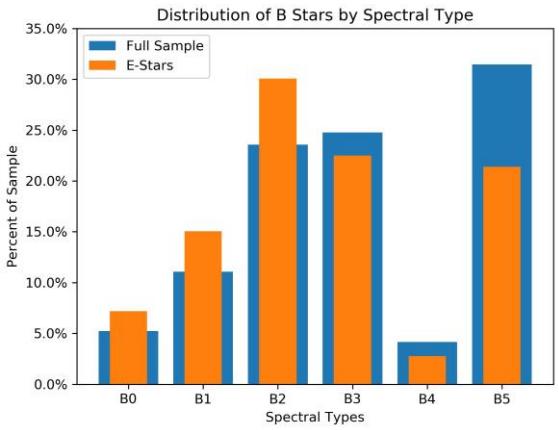
Figure 3: Ambient rate distribution.

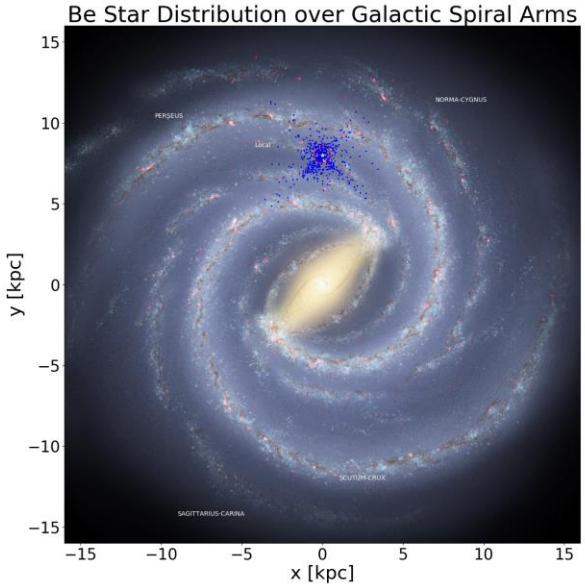
Project Name **Be Star Multiplicity Survey**

Team Member: Keefe J. Kamp

Faculty Advisor: Dr. Saida M. Caballero Nieves, Dept. of Aerospace, Physics and Space Sciences, Florida Institute of Technology

B Type stars are the progenitors of such phenomena as Supernovae, Cepheid Variable, and Be Type stars. With the recent discovery of gravitational waves in 2015, Binary B type stars are a viable path to create such neutron star-neutron star and black hole-black hole mergers required to create these waves. The purpose of this project is to search the B type stars in the Michigan Spectral catalog, and by extension the Henry Draper catalog, in order to carry out a census of B-type binary systems. The survey uses the Southeastern Association for Research in Astronomy (SARA) telescopes at Cerro Tololo Interamerican Observatory in Chile, Roque de los Muchachos Observatory in the Canary Islands, and Kitt Peak National Observatory in Arizona. We combine new photometric and spectroscopic observations using these 1-m class telescopes along with the recent GAIA DR2 to look for companions of B -type stars showing emission lines in their spectra. The Be stars phenomena are likely to have companions that are causing the B-type star to rotate rapidly and form a decretion disk that shows emission lines. The emission B-type stars account for 726 of the total 5,553 stars in our complete sample. We plan to expand the survey for all 5,553 stars in the sample to have a complete multiplicity census of a possible channel that leads to supernovae, gravitational waves or Cepheid variables.





Thank you to The Massive Stars Research Group for help with this project.

Project Name **Protein Fibril Self-Assembly & Alzheimer's Disease**

Team Member(s): Samantha Jackson
Faculty Advisor(s): Dr. Shaohua Xu, Dept. Of Biomedical & Chemical Engineering and Sciences

Project Description: Insoluble protein fibril deposits in human tissues are linked to neurodegenerative diseases such as Alzheimer's Disease (AD) and Dementia. Different proteins are linked to different diseases. In this case, lysozyme was used to model protein aggregation as seen in AD. Microgravity is a realistic environment to study cellular conditions as surface tension and diffusion are the dominant interactions. The study of molecular self-assembly could give insight into the origin of life. It is also important to study protein fibre organization in microgravity as the future of spaceflight continues to grow.

AD is currently the 6th leading cause of death in the United States, with almost 6 million sufferers in the US. It is an irreversible brain disorder that destroys memory and cognition. As human spaceflight continues to progress, it is important to study the effect of space travel on the human body.

Fibres were grown on the ground and also on the International Space Station (ISS) to simulate protein growth in microgravity over 15 days. Once back on the ground, the fibres were analysed using an atomic force microscope (AFM) to measure the thickness and length of the fibres.

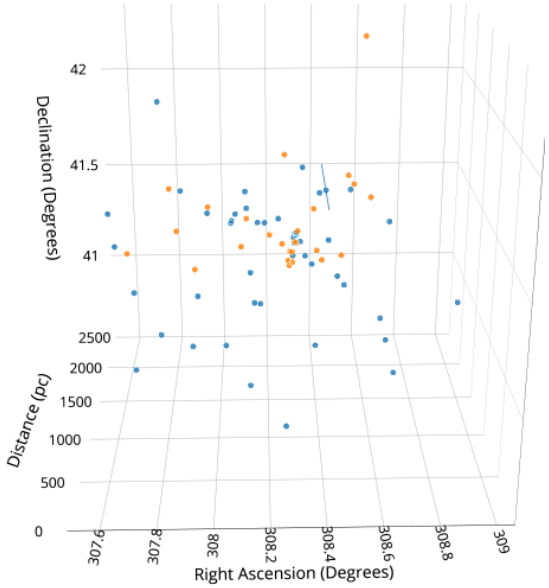
For the space based system, only 3 of the 9 mechanisms operated correctly so not as much data was collected as expected. However, there is a clear difference in fibres formed on the ground compared to those formed in microgravity. The space based fibres are shorter, straighter, and thicker.

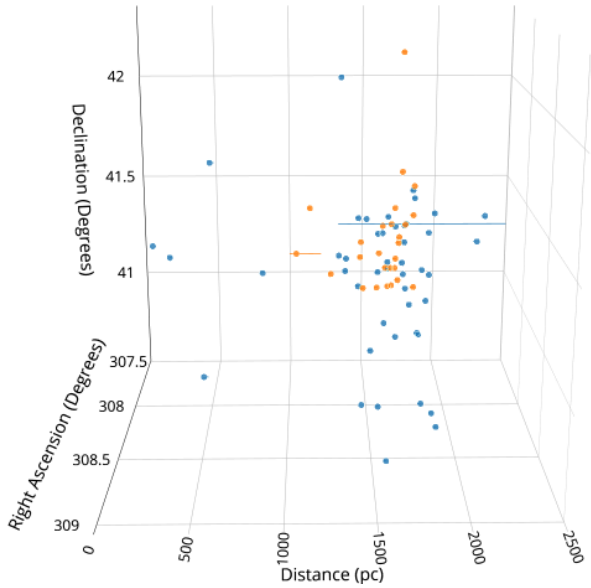
AD still needs to be studied further, both in space and on Earth. Projects testing different seeding causes such as melanin are being researched as well as the impact of fibre bundles. A new diagnostic system and cure for AD are also being researched. Another spaceflight would be ideal to gather more data.

Project Name **Multiplicity Properties of the Massive Stars of Cygnus OB2**

Team Member(s): Taylor Sey
Faculty Advisor(s): Dr. Saida Caballero-Nieves, Dept. Of Aerospace, Physics and Space Sciences, Florida Institute of Technology

Massive stars are an important subject in the discussion of star formation and galactic evolution. Evolved massive stars are the source of the heavier elements in the Universe, which contribute to planet formation and thus the possibility of the evolution of life elsewhere in the Universe. While being such a crucial subject, we also know the least about massive stars, due to their shorter lifespans, there being significantly fewer than smaller stars, and are typically a greater distance from us. Cygnus OB2 is a nearby active star association (~1700 pc away) that happens to have a population of over 160 massive stars. By modelling 75 stars from its massive star population and observing their distribution we can better grasp their formation, evolution, and the role their environment plays. By utilizing parallaxes provided by data from the European Space Agency's Gaia mission, the distances to the stars can be calculated. One major challenge arises in that the parallaxes provided are measured parallaxes rather than observed parallaxes, however this can be solved by utilizing Bayesian statistics to calculate an accurate distance measurement based on parallax error. From the results, it appears that a few stars are located much further away and much closer than Cygnus OB2's distance, so these stars can be excluded from discussion.





Project Name **Investigating Solar Wind Turbulence Correlations**

Team Member(s): Izabella Maxfield
Faculty Advisor(s): Dr. Jean C. Perez

Until recently, the solar wind has only been studied at distances relatively far from the Sun (between 0.29 AU and AU) using the Taylor hypothesis of turbulent flow, which assumes that the turbulent structures within the plasma are “frozen in flow” because the bulk flow velocity is much greater than the small-scale turbulent velocity. With the launch of the Parker Solar Probe (PSP), we will be able to study the solar wind much closer to its source. PSP will be analyzing the solar wind at a distance from the sun where the turbulent flow velocity is comparable to the bulk flow, which means the Taylor hypothesis will be invalid and the data from the PSP will be more difficult to understand. The goal of this project is to enhance our understanding of the solar wind by analyzing correlations within the turbulence to identify conditions where the Taylor hypothesis is valid and use the data where it is invalid to develop new models. The Taylor hypothesis is dependent on the correlation of fluctuations at different points in space and time to provide an understanding of turbulent structures. To test the hypothesis, data from the Magnetospheric Multiscale Spacecraft (MMS) is being collected to measure the decorrelation rate of data under different solar wind variables. The first step in the data analysis includes graphing the power spectrum of the fluctuations in the magnetic field to help identify intervals of pure solar wind turbulence. The correlations between the data in those intervals are then calculated for different points in time and space to populate a graph. The correlation graphs will help characterize how the turbulent structures within are changing over time. To date, a python code has been developed in order to download and process large amounts of MMS data for analysis. Three intervals of plasma turbulence have been identified as fit for further analysis. The data within those intervals have been plotted into correlation graphs. Our research group is making great strides in developing models to understand PSP data. Going forward, the goal is to collect large amounts of solar wind data from the MMS under different conditions. Once a sufficient amount of data is gathered, we will use it to test various models, including the ones we are developing.

Project Name **Florida Tech Rocketry**

Team Lead: Karly Lorenzini

Team Member(s): Florida Tech Rocketry et al.

Faculty Advisor(s): Dr. Andy Aldrin, Dr. Daniel Batcheldor, Dr. David Harris, Dr. Brian Kaplinger, Dr. Daniel Kirk, Dept.of Aerospace, Physics and Space Science, & Dr. Stephen Rivet, Dept. of Business, Florida Institute of Technology

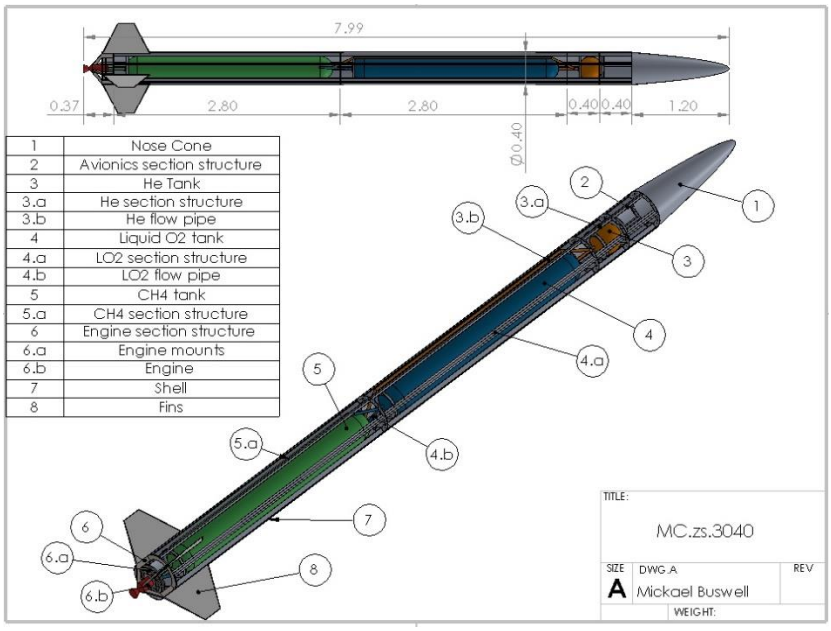
Florida Tech Rocketry is a group of students from across 3 academic colleges, 15 different majors, 10 nations, and 15 states. Florida Tech is a space-grant university with a passion for space that can be seen throughout the student body regardless of their major. FTR is working towards accomplishing a 3-year mission set out by Base 11. Base 11 is a non-profit STEM accelerator program helping students to get hands on experience in the industry while still in college. We are competing to send the first liquid bipropellant rocket made by university students to the Kármán Line 100 km above sea level.

FTR knows that this mission will not be easy. We are university students currently attending the classes needed to learn the tools required for this mission. The drive to learn these essential skills and apply them has ignited a fire within the team. John Glenn, a hero to many people who love space, said at the Ohio State University commencement speech in 2009 “We are more fulfilled when we are involved in something bigger than ourselves.” This statement rings true for the members of FTR working to send a rocket to space. The focus and perseverance of the members to achieve this goal has elevated us as students. There is no place for procrastination when building a rocket and attending 8 am Partial Differential Equations at the same time.

This mission is a perfect chance for Florida Tech to show that there is a student run project that allows the chance for hands on experience building a rocket here on campus. This is a dream opportunity for many of the members and will help build skills not just for their first job but lifetime of career success.

We are currently competing with a multitude of universities across the nation such as Purdue, Georgia Tech, Berkeley, University of Wisconsin, as well as international teams from Canada. This contest will be fierce, but Florida Tech was born from the space race and if there was ever a competition made for our school, the Base 11 challenge is it.

My role on Florida Tech Rocketry is the Chief Business Officer. The Business Team’s has many components that work in sync with the other subteams in order to help FTR run smoothly. Business has been broken down into main tasks that were divided among the Business Team members. Under the Chief Business Officer (CBO) is PR & Marketing, HR & Member Maintenance, Legal, Team Branding and the Chief Financial Officer (CFO). Under the CFO is Treasure, Financial Controller, Fundraising & Outreach, and Parts Acquisition. These parts together make up the Business Team.



Project Name **Faint Galaxies of the Perseus Cluster**

Team Member(s): Samantha Martin
Faculty Advisor(s): Dr. Eric Perlman, Dept. of Aerospace, Physics and Space Sciences, Florida Institute of Technology

The Perseus cluster is a massive galaxy cluster located in the Perseus constellation. NGC 1275 is its brightest member, located 237 million lightyears away at the cluster's center. It is a highly luminous active galaxy with a super-massive black hole at the center. The primary goal of this project was to use data from archival Hubble Space Telescope (HST) images to study properties of galaxies within the Perseus Cluster by producing color magnitude diagrams across three filters.

Images of NGC 1275 were obtained in three different filters: F435W in the blue, F625W in the red, and F550M in between. Images for each of the three filters were mosaicked together using the DrizzlePac software package, and the images were analyzed for data, such as flux and magnitude, using the sExtractor software package. Using the acquired data, color magnitude diagrams showing the correlation between the color and the magnitude of the galaxies in the cluster were created.

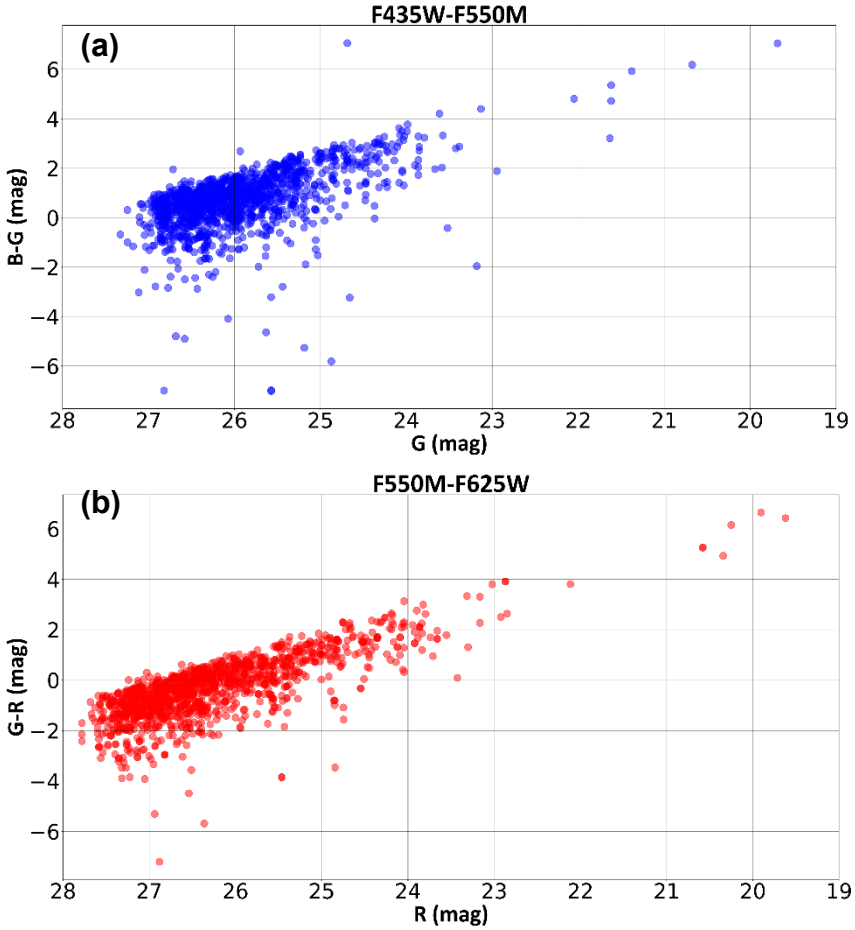


Figure 1: The galaxy color magnitude diagrams showing the brightness of the galaxies across the (a) F435W and F550M filters and (b) F550M and F625W filters.

There are three regions of interest in a galaxy color magnitude diagram. The red sequence which includes red galaxies, the blue cloud which includes blue galaxies, and the green valley which is a less populated region in between. Seen in Figure 1, the majority of the galaxies appear in the red sequence, with fewer galaxies appearing in the blue cloud and green valley regions below it. Older stellar populations, consisting of F-type stars and older, are present in the red sequence. Younger A-type stars are still present in the green valley. Stars are still forming in the blue cloud. Blue galaxies begin to transition from the blue cloud towards the red sequence as star formation begins to cease.

Project Name	**Mars Simulation Chamber**
Team Lead:	Joshua Newman
Team Member(s):	Mark Moffett
Faculty Advisor(s):	Dr. Daniel Batcheldor

The goal of this research is to outfit a chamber with which we can simulate the Martian environment. The chamber is being fitted with systems to replicate the pressure, heat profile, and UV exposure that the surface of Mars experiences. Challenges include depressurizing the chamber, powering the depressurized chamber, measuring and controlling instrumentation, and extract meaningful data.

Solutions to the challenges include a multi-stage pump to depressurize, a proportional controller to extract a signal, and a LabVIEW program to process the signal and control the pump. Additionally, to fit the chamber with instrumentation, we installed a range of power options that are available while the chamber is depressurized. Future work includes developing a data acquisition system that will control the instrumentation and allow measurements to be adjusted in real time. From these measurements we will be able to conduct experiments research and extract meaningful data.

Ultimately, this environment will provide the ideal Martian analog that will be capable of supporting instrumentation of all types and house a variety of extraplanetary related research.

Figure 1: Mars environment chamber wrapped in protective insulation awaiting transport to FIT

Project Name **Simulating a Detector at an Electron Ion Collider**

Team Member(s): Akshath E. Wikramanayake
Faculty Advisor(s): Dr. Marcus Hohlmann

The Electron Ion Collider (EIC) is a proposed particle collider to be built in the United States. One proposed detector to be used at the EIC is the Brookhaven eA Solenoidal Tracker (BeAST), which is being designed by the Brookhaven National Laboratory (BNL). As this detector is still in its design phase, it is necessary to simulate the detector to understand how proposed changes to the detector will impact its performance. For this purpose, BNL has released the EicRoot framework, which is a Monte Carlo physics simulation framework for studying detectors. This project used EicRoot to simulate the forward region of the BeAST detector to study the impact of some proposed additions to the detector.

It is hypothesized that by improving various detector components, the BeAST detector can be operated with a 1.5 Tesla magnetic field instead of the current proposed 3.0 Tesla magnetic field. The weaker magnetic field would lead to significant cost reductions as a solenoid from an existing detector could be reused. However, the weaker magnetic field will result in a penalty to the momentum resolution of the detector. One proposed addition that could partially mitigate this resolution penalty is the addition of an additional set of Gas Electron Multiplier (GEM) trackers to the far forward region of the detector. In order to study how these outer GEMs would affect momentum resolution, the performance of the forward region of the BeAST detector was simulated with and without the outer GEMs. Trials were conducted with particles with pseudorapidities ranging from $\eta = 0.356$ to $\eta = 3.131$, and momentums ranging from 2 GeV/c to 60 GeV/c.

The tests suggest that the addition of outer GEMs has a significant impact on the momentum resolution of the detector for particles with pseudorapidities in the range $1.15 < \eta < 3.13$. These results show that the outer GEMs can help bring the momentum resolution of the detector close to the desired range, even with the weaker 1.5 Tesla magnetic field.

Project Name **In-Flight Radiation Detector**

Team Lead: Zachary Paul
Team Member(s): Devon Madden
Faculty Advisor(s): Dr. Marcus Hohlmann, Dept. Of Aerospace, Physics, and Space Sciences, Florida Institute of Technology

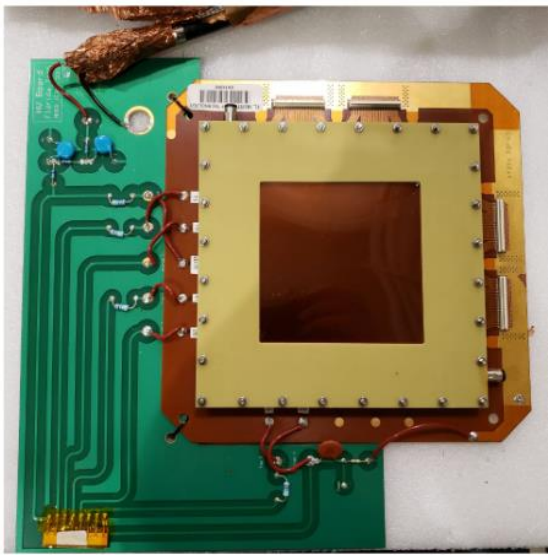


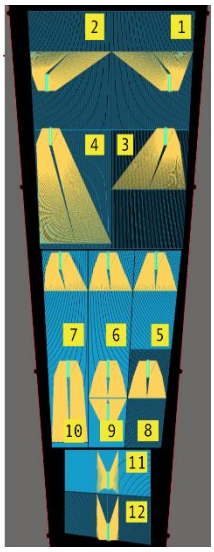
Fig 1: In-flight radiation detector prototype

Passengers and pilots of high altitude aircrafts and spacecrafts need improved method of ionizing radiation detection because of the harmful effects of exposure from cosmic radiation on humans. The solution is a 10cm × 10cm Gas Electron Multiplier (GEM) detector (**Fig 1**) is to be flown in either a high altitude aircraft (F104b - altitude 15 km) or in a suborbital vehicle (such as Blue Origin New Shepard - altitude 80 km) to determine the changes in direction and magnitude of incoming radiation throughout the flight profile to improve the protection of humans in high altitude flights against the harmful effects of ionizing radiation. To evaluate the detector's ability to detect ionizing radiation, a series of Quality Control (QC) tests are conducted. The results of each test are compared to the criteria set by CERN documentation for the GE1/1 detector to determine if the detector passes or not. During QC testing, the following challenges were encountered: sealing the gas chamber of the detector, reaching max voltage for the high voltage (HV) board without tripping, reducing the spurious signals from the detector, and identifying the origin of the non-damaging discharges when HV is applied. To achieve the max voltage for the HV board, the researchers attached a GNC connection between the HV board and the HV source; flattened, rounded, and cleaned soldering connections on HV board; and ensure shielding didn't contact surface of HV board. To reduce the rate of spurious signals, additional high pass filters were added; additional grounding cables attached; and a copper sheet faraday cage was enclosed around the detector. Current methods to determine the source of the non-damaging discharge and resolve are: remove any frayed strands from wiring, cover the electronics with conformal coating, and inspect HV board for sparking under low lighting to visually detect the location of discharging. Future works include resolving the non-damaging discharges from the detector to continue QC 5 testing. After the device passes QC testing for radiation detection, the Inflight radiation detector will be developed to determine the direction of incoming ionizing radiation. The implication of this detector is to better detect the direction and magnitude of incoming ionizing radiation, cosmic radiation, to better protect humans during future space tourism and transportation missions by commercial space companies.

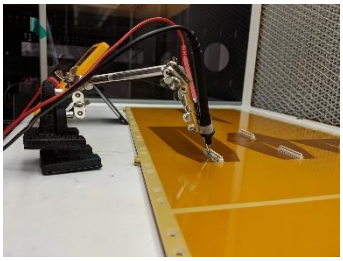
Project Name **Calculation and Measurement of Interstrip Capacitance on the GE2/1 Prototype Detector**

Team Lead: Alejandro Busto
Team Member(s): Alejandro Busto, Dev Roy, Liam Shaw, Joey Weatherwax
Faculty Advisor(s): Dr. Marcus Hohlmann , Dept. Of Physics and Space Sciences, Florida Institute of Technology

The Phase II upgrade of the CMS (Compact Muon Solenoid) will prepare the experiment for the high luminosity LHC. Without upgrading the muon system, the increased muon rate will saturate the L1 triggers. Florida Tech received a prototype of the new GE2/1 generation of detectors. This prototype has 12 sectors of readout strips, each with a different geometry and arrangement, with the goal of identifying which strip geometry has the lowest interstrip capacitance, and thus the lowest noise.



For the first set of interstrip capacitance measurements, 8 to 19 strip pairs were selected, and the interstrip capacitance of each pair was measured using an Excelvan M6013 capacitance meter sensitive to the picofarad range. For each strip pair, one person held the capacitance probes 1 cm away from the strips, and another person zeroed the meter. The interstrip capacitance was measured 4 times for each strip pair. The same measurements were also taken with a copper plate below the board to simulate the bottom of the third GEM foil.



One major challenge was taking the measurements with the copper plate under the board, because the readout strips could no longer be accessed. This meant that the measurements had to be taken from the signal trances on the top of the board, which are only 1mm across. One solution to this problem was to create a stand to hold the probes, making it easier to hold the probes of the traces without sliding off.

For the Module 4 (M4) sectors, sector three had the lowest average capacitance of 15.32+-0.03pF. For the Module 1 (M1) sectors, those that would be located closest to the detector, sector 9 had the lowest average capacitance of 9.32+-0.05pF. The interstrip capacitances of sectors with double width and half height, sectors 3 and 8, were increased the most by the addition of the grounding plate. On sectors with long traces, the innermost strip pairs appear to have systematically lower interstrip capacitances than the outermost strip pairs.

The new generation of detector should employ the double width and half height length for Module 4, and the half length design for Module 1. The measured capacitances also found these designs to have the lowest interstrip capacitance, but there is a discrepancy of about 30%. This difference is most likely due to the simplicity of the model, only depending on one pair of strips rather than all 128. Future work may include developing a simulation to calculate theoretical values for the interstrip capacitance with grounding plate.

Table 1: GE2/1 Interstrip Capacitance

Sector	Module	Parameters	Calc. Cap. (pF)	Avg. Meas. Cap w/o plate (pF)	Meas. Cap. Calc. Cap.	Avg. Meas. Cap w/ plate (pF)	Meas. Cap. w/ plate Meas. Cap. w/o plate
1	M4	Default	16.7	21.69 ± 0.05	1.30±0.003	25.85±0.27	1.192±0.003
2	M4	Gap: 0.3 mm	15.3	19.98 ± 0.12	1.31±0.01	20.99±0.03	1.050±0.006
3	M4	2×Width, 0.5×Length	10.5	15.32 ± 0.03	1.46±0.003	21.72±0.05	1.316±0.002
4	M4	Long traces	21.1	27.87 ± 0.09	1.32±0.001	28.43±0.06	1.020±0.002
5	M1	Default	12.7	16.27 ± 0.04	1.28±0.003	19.04±0.21	1.170±0.003
6	M1	Gap: 0.3 mm	11.2	14.65 ± 0.07	1.31±0.01	18.26±0.06	1.247±0.006
7	M1	Gap: 0.4 mm	10.6	13.17 ± 0.04	1.24±0.004	14.85±0.08	1.128±0.003
8	M1	2×Width, 0.5×Length	8.5	11.82 ± 0.06	1.39±0.007	15.8±0.32	1.340±0.008
9	M1	0.5×Length	5.9	9.32 ± 0.05	1.58±0.01	8.19±0.04	0.984±0.005
10	M1	Long traces	15.3	20.07 ± 0.07	1.31±0.01	20.67±0.07	1.302±0.004
11	M1	Minimal traces	11.8	14.02 ± 0.02	1.19±0.002	14.82±0.03	1.057±0.002
12	M1	Minimal traces, 0.5×Length, 2×Width	7.6	10.39 ± 0.07	1.37±0.009	10.33±0.11	0.995±0.007

Project Name **Long Duration Gamma Ray Bursts**

Team Member: Alec Daly
Faculty Advisors: Dr. Ming Zhang, Dr. Lulu Zhao, Dept. Of Aerospace, Physics and Space Sciences

Project Description: Solar energetic particles (SEPs) are produced in the solar corona. They propagate through coronal magnetic fields (CMEs) subject to scattering and diffusion across field lines by turbulence. Once solar energetic particles are released from the Sun into space, they become a hazardous space weather component that could affect human lives and infrastructures in space as well as on the ground. Long duration gamma ray emissions are typically found in the deaths of massive stars but can also be measured from bright solar flares. We examine the behaviors of particle transport using a stochastic 3D transport simulation in a potential field source surface model of coronal magnetic fields. The models in each figure references an event on February 7 of 2010. Three scenarios of particle injection are studied: one at a solar flare site, one at a coronal mass ejection shock, and the last at an extreme ultraviolet wave. Particles injected on open field lines can escape the corona. If perpendicular diffusion occurs, particles injected at compact solar flare sites can spread to a wide range of longitude and latitude, with stronger pitch-angle scattering resulting in a more lateral spread. Some injected particles eventually end up precipitating onto the solar surface, which would be the loop-like pattern seen in CMEs.

Our goal is to understand particle acceleration and particle transport in the solar corona, as well as SEP propagation and SEP interaction on the sun's surface. Extending the model of particle Crossfield diffusion is also one of our primary goals, as we seek to visualize gamma ray injection over a large area of the solar surface.

Currently, a method of numerical analysis is used to solve the particle transport equation. This equation is a 3-dimensional focus transport equation, which is numerically solved through programming. The data, gathered from the Gong database website, is plugged into Fortran files created by Dr. Ming Zhang and run using the Blueshark supercomputer located in the Olin Engineering Complex. These files output data for the 3-dimensional magnetic field in the corona. This data is then placed into python scripts created by Lulu Zhao, which can plot the magnetic field distribution of the escaping particles.

We found that, for disturbed magnetic fields, particles tend to stay in the corona by enhanced pitch-angle scattering. The models also predict that SEPs spread more easily in longitude and latitude after multiple solar events. With a small amount of perpendicular diffusion, particles can get to closed or unconnected open field lines. Eventual particle precipitation on these field lines can produce an image pattern of gamma-ray emissions. It is possible for gamma rays to come out from regions where no solar flares or CMEs are seen, providing the opportunity to explore the mechanisms of particle acceleration and transport, as well as magnetic field structure in the corona. As of now, the model can be improved with a more realistic solar wind model that allows non radial expansion of the solar wind and embedded magnetic field in the outer corona.

Project Name **Machine Learning in Particle Physics**

Team Member(s): Noufel Maalal
Faculty Advisor(s): Dr. Marc Baarmand, Dept. Of Aerospace, Physics and Space Sciences, Florida Institute of Technology

This project is part of a larger one which consists of making a more precise measurement of the top quark mass. We intend to make this measurement by implementing a likelihood fit to compare a data distribution with simulated distributions for different possible masses. In order for this method to produce an accurate result, we need simulated distributions for intermediate hypothetical masses. By the Universal Approximation theorem, shallow neural networks with a finite number of perceptrons can approximate any continuous real function. Since the surface plot of our dataset looks smooth, we have decided to try using a neural network to produce the necessary distributions. Our network contains a single layer of 300 perceptrons, using the “softmax” activation function, the “Adamax” optimizer, and the “logcosh” loss function, which is less sensitive to outliers. The errors in the morphed histograms were calculated from the weights in the known distribution which has the highest statistics. The initial results we have obtained are encouraging, especially given how small our dataset is. However, since the errors in the tails of the distribution are small, our percent errors on the right of the distribution are large. None of the methods we have attempted so far to improve our results have been successful. Since we are working with histograms, which are essentially images, we intend to use a GAN (Generative Adversarial Network) next.

Project Name	**Construction and Test of a Modular GEM for EIC**
Team Lead:	Matthew Bomberger
Team Member:	Jacob Chesslo
Faculty Advisor:	Dr. Marcus Hohlmann, Dept. of Aerospace, Physics and Space Sciences, Florida Institute of Technology

Project Description: The construction and test of a prototype gas-electron multiplier (GEM) is presented, with reduced mass to decrease multiple Coulomb scattering. This design is proposed to be implemented at a future electron-ion collider (EIC, simulated detector assembly in Fig. 1). An innovative element of this design is the introduction of drift and read-out foils to significantly reduce the radiation length in the active region (Fig. 2). The stretching issue arising from the introduction of more foils is studied when the inner mechanical support structure is made completely of 3D printed acrylonitrile-butadiene-styrene (ABS), when the inner frames (Fig. 3) are ABS and the pull-out parts are polyether-ether-ketone (PEEK), and when two inner frame layers and the pull-out parts are both PEEK. Capacitance of and between the GEM foils is compared for these configurations as a direct test of foil spacing. This study suggests that the introduction of PEEK parts in the stack support structure improves the stack geometry. Future work will involve testing the electrical performance of the detector and to determine the spatial resolution of the chamber.

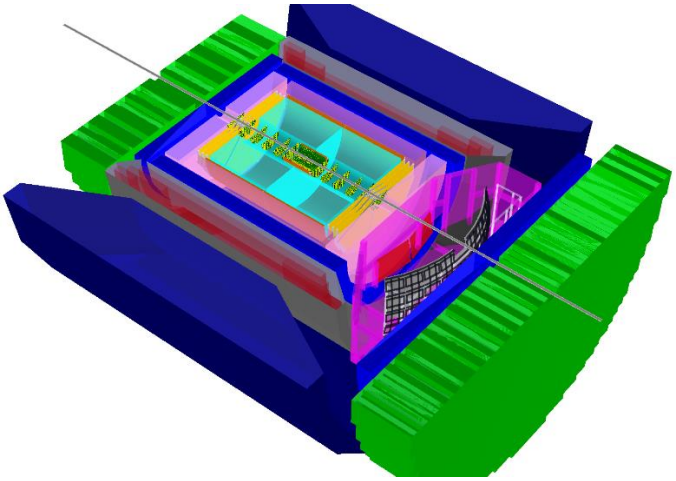


Figure 1: Simulated view of BeAST detector for EIC (Alexander Kiselev, BNL)

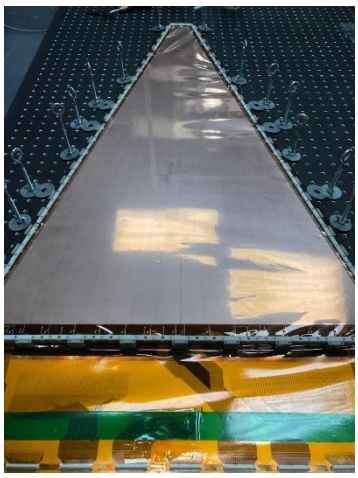


Figure 2: Open GEM chamber showing stack of 5 foils

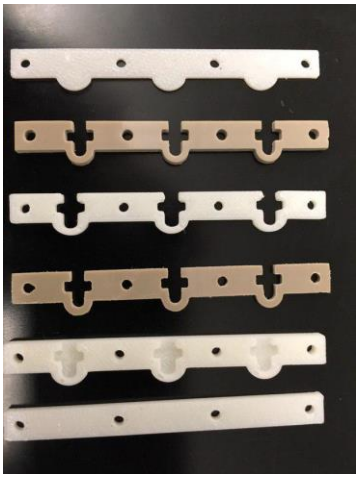
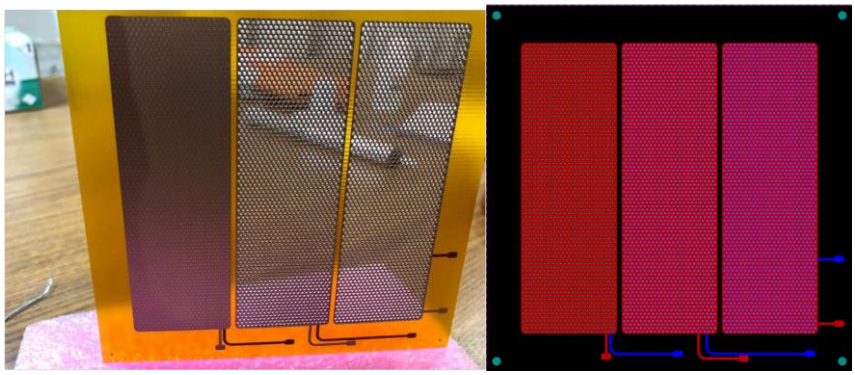


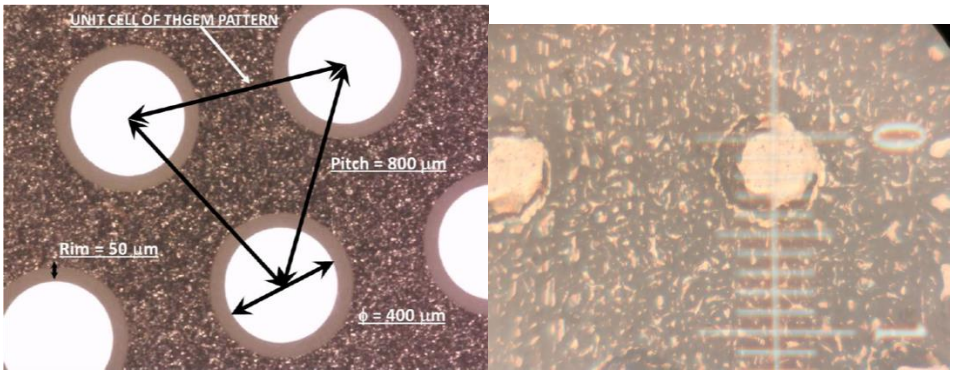
Figure 3: Inner frames, ABS (white) and PEEK (brown)

Project Name **THGEM**

Team Lead: Jerry Collins II
Team Member(s): Omar Nour
Faculty Advisor(s): Dr. Marcus Hohlmann

The thick GEM (THGEM) is a technology very similar to the standard GEM and works in a similar way but about 5-20 times the dimensions. THGEMs are strong, low cost, easy to produce, and provide a high gain of electrons. Our goal is to produce a working Thick GEM at lower cost, less sparking, and more efficient electron collection than the standard GEM. We produced a 3D model of a THGEM with 0.7mm holes and with three electrically isolated sectors with rim sizes 0, 0.1, and 0.18mm and had it printed. Unfortunately, the board we received had a masking over the surface, different size holes, and unclearly defined to no rims. The holes were measured under a microscope and the sizes were observed to range from 0.5 – 1mm. We have yet to test this board due to an issue with a component in the detector. We're currently attempting new techniques of high energy particle detection.

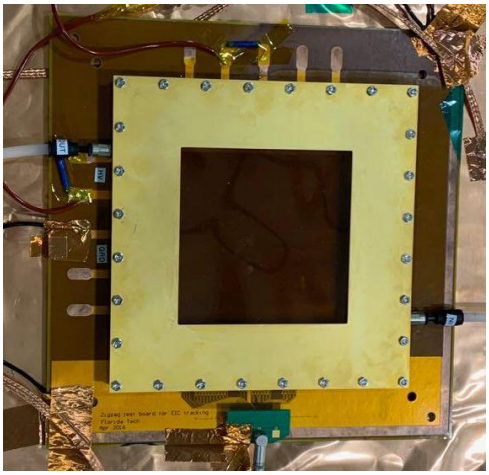


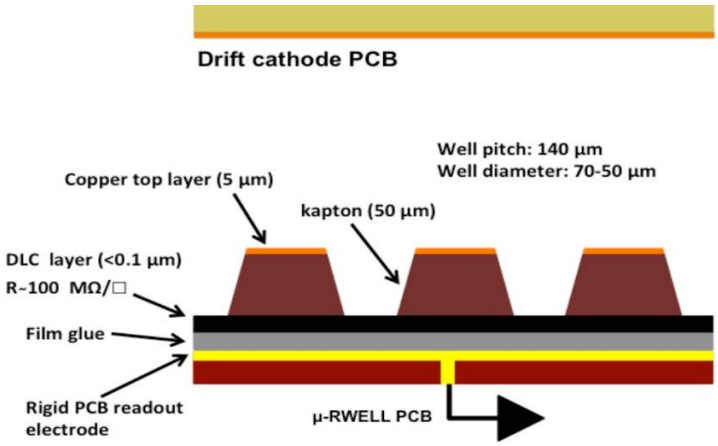


Project Name **URWELL**

Team Lead: Jacquelyne Miksanek
Team Member(s): Sarah Arends
Faculty Advisor(s): Dr. Marcus Hohlmann, Department of Aerospace Physics and Space Sciences, Florida Institute of Technology

The Micro-Resistive-WELL (uRWELL) detector is a relatively new technology in the field of micro-pattern gas detectors (MPGDs). The design, currently being tested by researchers at Florida Tech, consists of a single amplification stage in the form of a polyimide foil. The signal charge is induced and spread on a resistive layer of Diamond-Like Carbon (DLC) in front of the readout electrode, which allows for high gain with low discharge probability. The performance of this technology was investigated through the construction and testing of a 10cm by 10cm uRWELL detector. Due to the sensitive nature of the detector components, the meticulous construction process was conducted in an ISO class 1,000 clean room in the Florida Tech experimental physics hall. Several quality control tests were conducted on the detector in order to quantify characteristics such as gas tightness, high voltage circuit performance, and detector gain. The simplified production associated with a single stage detector and the uncompromised efficiency in high rate environments make the uRWELL a viable candidate for implementation in the future Electron Ion Collider (EIC).





Project Name **Underground Nuclear Explosion Recognition Simulation**

Team Member(s): Matthew Ward
Faculty Advisor(s): Dr. George Rybicki

This research project focuses on the modeling and simulation of nuclear weapons tested underground. The reason for this research is to better understand the short and long-term effects from an underground weapons test and the isotopic indicators left behind. This can assist in identifying possible weapons testing sites where access to rapid analysis is limited. In both fission and fusion reactions, there are radioisotopes left at the test site which can identify the type and size of weapon as well as when it was detonated. The specific isotopes focused on for this research were Argon-37 and Argon-39 for their strong indication of a nuclear test and direct decay from Calcium-40 and Potassium-39, both of which are relatively abundant in soil. Simulations were created using Monte Carlo N-Particle (MCNP) Transport Code. Fission and fusion reactions were simulated for 10, 100, and 1,000 kT yields to cover a wide range of possible weapons tested. During this research we had to overcome the challenges that came with limited access to mature soil and gas samples. Future work on this subject could involve better geophysical models of local geology as well as the fate and transport of gasses through the air and soil around a nuclear explosion. Nuclear radiation research will continue to be valuable as future weapons and energy creation methods are created and tested.

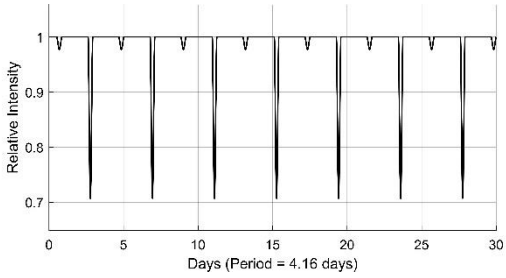
Project Name **Optimizing Observations of Eclipsing Binary Stars**

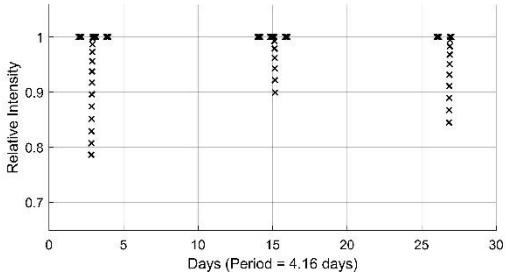
Team Member(s): Peter Freund
Faculty Advisor(s): Dr. Saida Caballero-Nieves**,** Dept. of Aeronautics, Physics and Space Sciences, Florida Institute of Technology

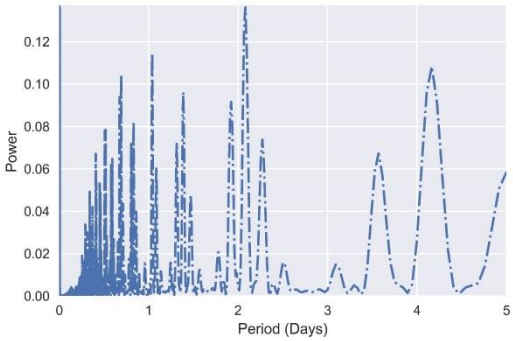
Project Description: Eclipsing binary stars serve an important role in astrophysics for their ability to directly measure stellar masses, deduce radii and temperature ratios, and refine distance measurements. Their orbital planes lay nearly edge-on to our line of sight, so their brightnesses change as the stars eclipse and transit each other. Astronomers studying these systems are interested in knowing their periods, but initial determinations are typically guesswork since they can be anywhere from a few hours to several years. The scope of this project is to search for periodicity within existing observational data and use it to set the cadence for future observations. Observatory scheduling typically grants an individual 5-20 nights between several months to conduct their research, meaning it is crucial that this time is used effectively and efficiently.

Due to aliasing that exists in the Lomb-Scargle method, there is some discrepancy between true and derived periods. However, it remains a powerful tool to indicate periodicity in observational data and can be used to optimize future observations for star systems under investigation. Since eclipsing binary stars divulge a wealth of information in their stellar components, they garner particular interest and afford bountiful research potential. Timing an observing campaign is then essential for acquiring a well-rounded data set, and to avoid consuming valuable observatory time when the system in question will display no measurable changes. Future work will incorporate observatory locations and celestial coordinates of binary stars to further optimize how these systems are observed.

Graphics: include images that holistically present the project within the space available.







Biological Sciences

Project Name **Effects of UVb and UVc Radiation in *Helianthus annus.***

Team Lead: Nashaita Patrawalla
Faculty Advisor(s): Dr. Andrew Palmer

The main goal of this experiment was to test the resistance of *Helianthus annus.* against UVb and UVc radiation. Unlike the Earth, Mars does not have an ozone layer to shield itself against UV radiation. The daily fluence in kJ/m^2 of UVb and UVc radiation (200-315nm) on Mars is about 9.25 times that of the Earth. Hence it is essential to test for the effect of UV radiation on plants. Being able to successfully grow and maintain plants for basic human needs would be beneficial for establishing a successful Martian habitat. It would greatly reduce costs of transporting payload across planets if humans could utilize available resources on Mars to sustain themselves.

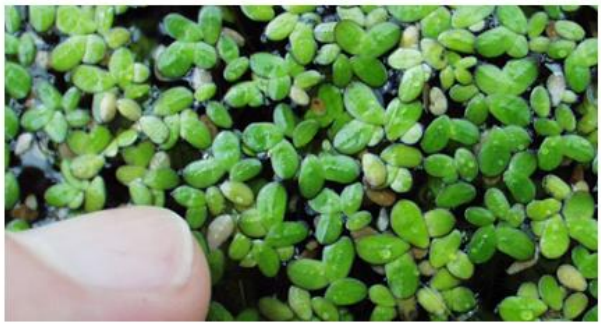
Project Name	**Evaluating the Accuracy and Agricultural Viability of Martian Regolith Simulants**
Team Lead:	Nathan Hadland
Team Member(s):	Janely Rodriguez
Faculty Advisor(s):	Dr. Andrew Palmer, Dept. Of Biomedical and Chemical Engineering and Sciences, Dept. Of Ocean Engineering and Marine Sciences

Project Description:

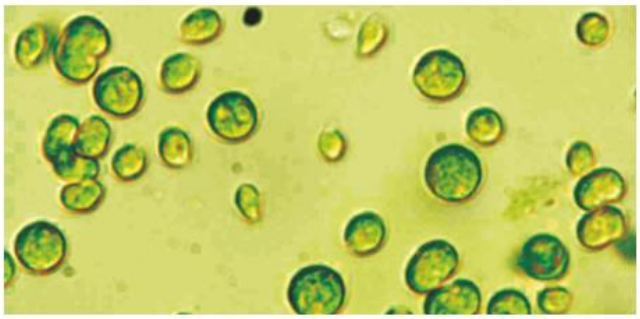
As space agencies look to establish off-world colonies, mission planners are discussing how to establish long-term colonies in these hazardous environments. A major component of this effort will be a robust and sustainable food production system, including traditional substrate (soil)-based agriculture. The use of regolith on Mars for plant growth will reduce the cost of space exploration and will allow for a more sustainable long-term presence on the Red Planet. When astronauts arrive on Mars, they will have to extensively analyze the regolith before using it for plant growth. This research investigates how Martian regolith can be evaluated for its mineralogical composition and mechanical properties to determine whether it is a viable substrate for agriculture. In order to further constrain our methods, we conducted analogous experiments at the Mars Desert Research Station (MDRS) during Crew 205's two-week simulation in February of 2019. At Florida Tech, we have evaluated three different Martian Regolith Simulants (MRS): JSC-MARS-1A whose composition is based off of spectral analysis of Mars, Mars Mojave Simulant 1 (MMS1) which reflects the regolith composition at the poles, and Mars Global Simulant (MGS) which represents the regolith composition at the equator. We have focused on the ability of these MRS to support the growth of the model angiosperm *Arabidopsis thaliana* using Hoagland's #2 nutrient supplement. Our initial baseline *A. thaliana* growth study resulted in the MGS trials dying rapidly while JSC-MARS-1A and MMS1 supported growth. Our initial hypothesis was that the fine particle size of the regolith simulants resulted in a "cement" effect when wet, consequently suffocating seeds. Upon analysis with Scanning Electron Microscopy (SEM) and Electron Dispersive Spectroscopy (EDS), the MGS had a much smaller average particle size than the JSC-MARS-1A and MMS1 simulants which may contribute to the compaction upon contact with water. In order to test the particle size hypothesis, we sieved the MRS into larger and smaller particle sizes and conducted the same growth experiments. The MGS trials again died rapidly prompting us to investigate other properties of the regolith, such as pH and redox potential. The pH was substantially higher, and the redox potential was much lower in the MGS than in the MMS1 and JSC-MARS-1A. Because the particle size growth study resulted in seedling death again, higher pH and lower redox potential likely contribute to MGS' inability to support plant growth more than particle size. The MRS differ in their ability to support plant growth, suggesting a substantial difference between the viability of regolith-based food production systems between sites. In order to further constrain the feasibility of these growth studies on Mars, we conducted the same experiments at a Mars analog station, MDRS. Again, regolith that had basic or acidic properties and turned to a "cement" performed the worst in terms of plant growth. These experiments highlight the importance of site selection in Mars mission planning and demonstrates the need for regolith characterization prior to plant growth studies and full-scale agriculture in regolith. These baseline experiments investigating mechanical and mineralogical properties of regolith are essential for astronauts on future Mars missions to conduct.

Project Name	**Bioremediation of perchlorate contaminants from Martian water**
Team Lead:	David Handy
Team Member(s):	Alejandro Perez, Cynthia Montanez
Faculty Advisor(s):	Dr. Andrew G. Palmer, Dept. of BCES and OEMS, Florida Institute of Technology

Perchlorates are extremely rare on earth, only forming naturally in extreme desert climates, and produced manually for munitions and explosives. Martian regolith, dust, and ice contains calcium and magnesium perchlorates at concentrations from 0.5-1% by mass. At these levels, the compound presents an extreme risk to astronauts and potential colonists. The EPA considers safe chronic perchlorate exposure to be a maximum of 0.00007 mg/kg/day. Martian colonists have the potential to be exposed to concentrations at least 6 orders of magnitude greater than what is considered safe. The presence of this compound poses a medical risk if ingested either through water or dust inhalation and could pose a physical risk if regolith is used as a construction material. Yet it is imperative that Martian water sources are made viable, as it will be prohibitively expensive to transport the amount of water necessary to support a crew and their scientific efforts. It is therefore mission critical to develop safe and effective methods for detecting and removing perchlorates from both regolith and aqueous systems. Remediation using biological means provides methods that greatly reduce chances for combustion, can produce usable compounds through degradation, or inspire the development of new filtration systems. The experiments performed here explore the use of phytoremediation (using plants) and bioremediation (using microbes) as possible methods for remediation from an aqueous system. We discuss our findings within the context of their broader impact on the crew support systems for a future Mars mission.



L. minor

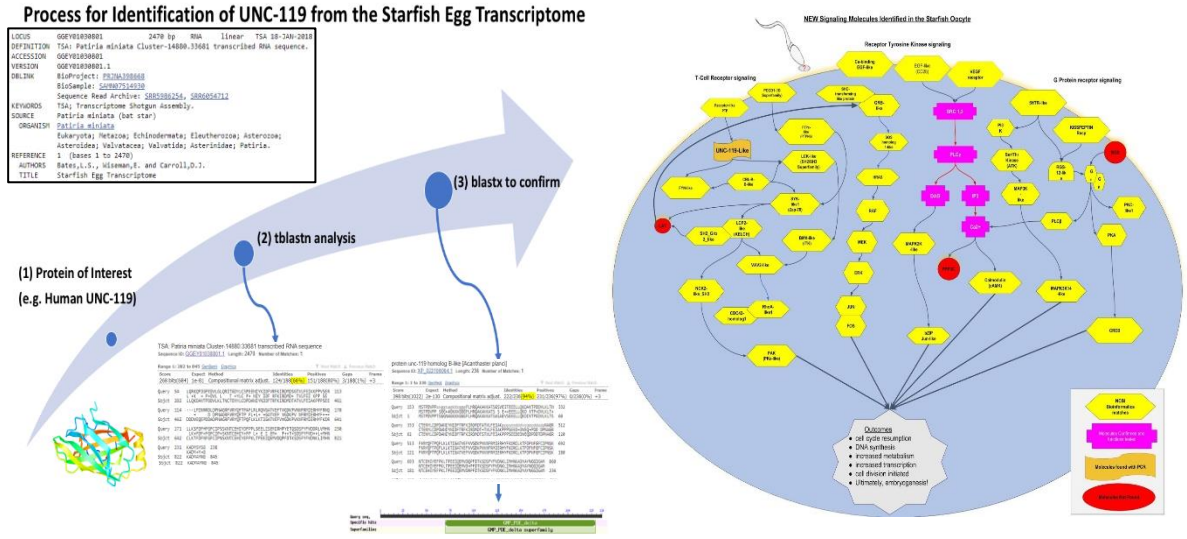


C. reinhardtii

Project Name **Investigation of the role of an UNC119-like protein in controlling calcium release at fertilization in *Patiria miniata***

Team Member(s): Jamie Kitson
Faculty Advisor(s): David Carroll, Dept. Of Biomedical and Chemical Engineering and Sciences, Florida Institute of Technology

Sperm-egg interactions during fertilization lead to a permanent block to polyspermy and re-initiation of the cell cycle. Release of Ca^{2+} from the endoplasmic reticulum is the integral molecular mechanism responsible for this activation. The molecular players involved in the initiation Ca^{2+} release are not well-established in any organism. Research in the fertilization field has been hampered due to difficulty in studying the sperm-egg cell system. Using the starfish model system, we aim to identify more of these critical molecules to provide better targets for infertility treatment and contraception development. We produced the first *P. miniata* egg transcriptome by *de novo* RNA sequencing, which will allow us to predict which proteins could be present and function in controlling the fertilization signaling pathway. Through bioinformatic annotation of the *P. miniata* mature egg transcriptome, an mRNA was discovered that shared 66% identity with human Unc119 homolog A isoform, a Src Family Kinase (SFK) activator. SFKs are one of two known types of proteins controlling calcium release in starfish fertilization. The starfish Unc119-like mRNA was purified from starfish eggs through RT-PCR and successfully cloned to construct a GST-tagged Unc119-like fusion protein. This fusion protein will be used to investigate the role of the Unc119-like protein in starfish fertilization through affinity interaction experiments and live cell experiments to evaluate its effect on calcium release.



Project Name **Geranylgeranylacetone Increases Lifespan and Suppresses Alzheimer's Disease-Related Phenotypes in *C. elegans***

Team Lead: Isiah Mossiah
Team Member: Sabrina M. Perez
Faculty Advisors: Dr. Eric A. Guisbert and Dr. Karen S. Kim Guisbert, Dept. Of Biomedical and Chemical Engineering, and Sciences, Florida Institute of Technology

Age is a key risk factor in numerous human diseases, including neurodegenerative diseases and cancer. The heat shock response (HSR), mediated by the transcription factor HSF1, is one of several cellular pathways that has been shown to regulate aging. Geranylgeranylacetone (GGA) is a common antiulcer drug used in several Asian countries that has recently been shown to activate the HSR in cultured human cells. Here, we tested whether the activation of HSF1 by GGA could extend lifespan and improve Alzheimer's-related phenotypes in *Caenorhabditis elegans*, a notably effective model organism for aging studies due to its short lifespan. First, we showed that GGA can activate the HSR in *C. elegans* using a worm strain containing a fluorescent HSR reporter. Next, we found that incubation of worms with GGA caused a significant increase in their lifespan compared to untreated controls. This lifespan extension was dependent on the HSR as the lifespan of worms with mutant HSF1 were unaffected by GGA. Finally, we found that GGA was able to reduce the toxicity associated with expression of the human A□ peptide in two established *C. elegans* models of Alzheimer's disease. GGA was able to reduce the paralysis induced by A□ expression in muscle cells and reverse inhibition of associative learning induced by A□ expression in neurons. Together, these findings suggest that the health benefits of GGA in humans may extend far beyond its current use as an antiulcer agent.

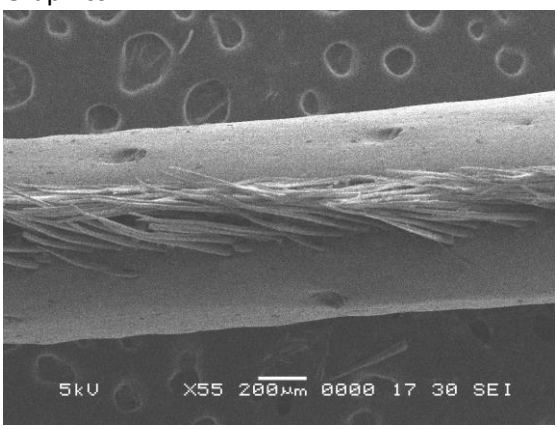
Project Name **A morphological analysis of the microstructures used for out-of-water climbing in the Mangrove Tree Crab (A. Pisonii)**

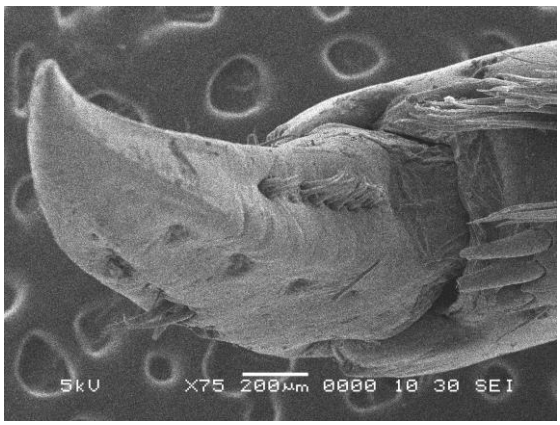
Team Lead: Samara Zinman
Team Member: Andrew Rivera
Faculty Advisor: Ralph Turingan. Dept. of OEMS, Florida Institute of Technology

Project Description

In this study, we investigate the biomechanics of mangrove tree crabs in order to determine their potential as a model for biomimetic robots. Our investigation primarily utilizes a Scanning Electron Microscope (SEM) in order to investigate the microstructures present on the dactyls of the tree crabs. Previous studies have shown that mangrove tree crabs are adept climbers and are capable of traversing both vertical and horizontal surfaces. These studies have also shown that tree crabs can walk on multiple types of surfaces with little limitation, ranging from coarse sandpaper to smooth PVC piping, regardless of whether or not the crab moved vertically, horizontally, or was submerged or on dry land. The goal of this experiment is to determine the presence of microstructures that allow mangrove tree crabs to traverse such terrain, using both the SEM and photographic analysis, and to determine if the presence of such structures is dependent on the size of the individual crab. Using photographic analysis of the acquired SEM photos, pockets of setae were identified on the tips of the crab dactyls, along with a thick covering of setae between the first and second joints. With this, tests were run to determine if the number of pockets, the number of setae within each pocket, and the thickness of the setae between joints one and two were dependent on the carapace length of the crab. Our analysis found that while the number of pockets does not differ between crabs of different sizes, the number of setae in each pocket did differ between crabs of different sizes. Not only did larger crabs have on average more setae per pocket, but also had thicker setae coverings between joints one and two. We believe that these emergent trends will develop as more legs are studied and tested. However, the presence of setae pockets on the tips of the crab dactyls could provide insight on their ability to climb a variety of surfaces under different conditions, and as such could prove an ideal method for a biomimetic climbing device if the mechanics could be scaled up from their current microscopic state.

Graphics:





Project Name **Chemotaxis in Leptocephalus Larvae**

Team Lead: Mason Thurman
Team Member(s): Katie Wilson, Noah Haag
Faculty Advisor(s): Dr. Jonathan M. Shenker, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Chemosensory systems are the organs and organ systems that allow an organism to react to chemical signals. These signals can help the organism to find food, avoid predation, or choose a habitat. Leptocephalus are the larval form of four species: tarpon (*Megalops atlanticus*), bonefish (*Albula vulpes*), ladyfish (*Elops saurus*), and speckled worm eels (*Myrophis punctatus*). The olfactory organ in these larvae have been observed through scanning electron microscopy and three of the four species have unusually large olfactory pits. Only the speckled worm eel has enclosed olfactory apparatus'. By studying the systems that detect the signals this study hopes to better understand how they work.

Larval leptocephalus were collected near Goat Creek in the Indian River Lagoon between the months of February and March using light traps. Two scents were created to be tested, a positive and a negative olfactory cue. The positive olfactory cue, crushed coral, is a homing scent. This scent was created by putting an excess amount of crushed coral into a 5 gallon bucket with saltwater and aerated heavily for 45 minutes. The particles were allowed to settle and the water was skimmed from the top and the salinity was made to match that of water the test subjects came in. The second scent, barracuda, is a predatory scent. A deceased barracuda was cut up and mashed. The barracuda was then microwaved and the bodily juices were separated and added to water with the same salinity as the water the test subjects came in. A Y-maze was filled with filtered saltwater before a specimen was added. Larva were added at the end of the Y-maze with a holding wall placed 15 cm from the end of the maze. Down one arm of the maze a scent was added at a certain flow rate. Down the other arm of the maze clean saltwater was added at the same flow rate. Both arms were started at the same time. The holding wall was then removed and the response was recorded. To avoid cross contamination, the maze was drained and cleaned with RO water after each trial.

We found that leptocephalus larvae show a strong positive response to both the crushed coral homing scent and barracuda predator scent. We hypothesised that leptocephalus use olfaction for determining settlement. For the predator scent, we hypothesized a strong negative response. After testing, our group concluded that the mashed up barracuda, especially after some decomposition, provoked a food response. The decomposed fish may resemble marine snow which Wightman hypothesized was consumed by leptocephalus larvae. Further studies may look at the effect of suspended particles on chemosensory response or the effects of contaminants and water quality during development on development of olfactory response. This study allowed for a better understanding of olfaction and its role in finding food, avoiding predators, and settlement.

We would like to thank the Florida Institute of Technology Ocean Engineering and Marine Sciences Department, Louis Penrod, and Mathias Cramer. We are especially grateful for the work done by Molly Wightman.

Project Name **The Effects of Temperature and Genetics on Lifespan and Reproduction in C. elegans**

Team Member(s): Toni-Ann Martorano, Rosemary Plagens
Faculty Advisor(s): Dr. Karen Kim Guisbert, Dr. Eric Alan Guisbert

Reproduction in *C. elegans* is exquisitely sensitive to chronic temperature stress, but the mechanisms behind this sensitivity are unknown. We investigated genetic variations in 2 key stress response players, *hsf-1* and *daf-2*, to determine whether their known thermotolerance and lifespan-extending roles could also help protect reproduction during chronic, sublethal heat shock (HS) at 28℃. Overexpression of *hsf-1* has been shown to extend lifespan under normal conditions, but our *hsf-1* overexpression mutant did not show the expected lifespan extension under control conditions, suggesting this strain may have lost the overexpression. However, a single-point mutation in the *daf-2* gene, which has been previously shown to negatively regulate lifespan, nearly doubled lifespan under both control and chronic stress conditions but did not protect reproductive output. Together, this indicates that lifespan and reproductive pathways are mechanistically distinct and are independently regulated.

Biomedical Engineering

Project Name	**Astronaut patch**
Team Lead:	Meetu Kawatra
Team Members:	Brandon Henry, Alston Feggins, Theresa Lynne, Maya Prempin
Faculty Advisors:	Dr. Kunal Mitra, Dept. Of Biomedical Engineering, Florida Institute of Technology Dr. Marius Silaghi, Dept. of Computer Science and Engineering, Florida Institute of Technology Dr. Kenneth Gibbs, Dept. of Computer Science and Engineering, Florida Institute of Technology

Project Description: Astronaut Patch, is a wearable electronic device intended for astronauts during takeoff, cruising, and any other time the astronauts are wearing their Intra Vehicular Activity suit. The project hopes to use a small armband around an astronaut's bicep that measures various vital signs of the astronaut such as heart rate, oxygen levels, and body temperature. Then it compares them to the baseline values of the astronaut under normal conditions to monitor for abnormalities during the aforementioned actions. The Patch would then relay this information to central computer or data base.

Significance of the Problem: NASA currently has no means of monitoring astronaut's vitals when they are wearing their Intravehicular Activity (IVA) Suit. These instances include necessary steps for space missions in which the body is subjected to extreme conditions. It was evident a method is needed to monitor astronauts.

Major Challenges: The initial design of the device was a miniature patch for the wrist. However, this design was not feasible due to the resources available. Another challenge was to provide sufficient power to all components. Lastly, a method of information transmission was needed to be developed to get the information from the sensors to the computer and to people.

Solution Methods: The patch was re-designed for the bicep as an armband which can accommodate all of the sensors, microcontroller, and power cables. The band is made of silicone, and Velcro is used. Combatting the lack of expertise and miniaturization resources, the components are all regular sized and rudimentary but effective methods of assembly. Bluetooth is used for information transmission. The information will be processed on the microcontroller and sent via Bluetooth to a mobile app.

Anticipated Future work: The major goal is to miniaturize the device by using higher quality parts and more resources available. All sensors will have improved accuracy and precision. Addition of other non-invasive sensors such as blood pressure monitoring will also be considered.

Result:

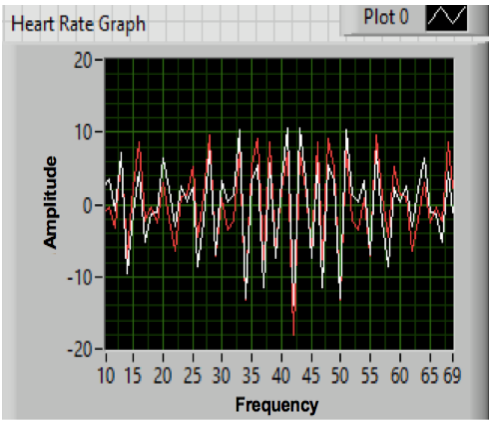


Figure 1: Frequencies received from the heart rate sensor.

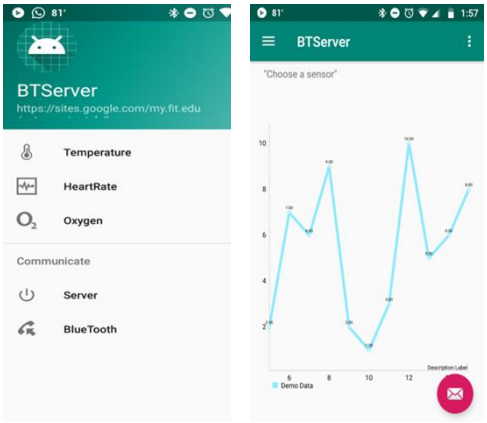
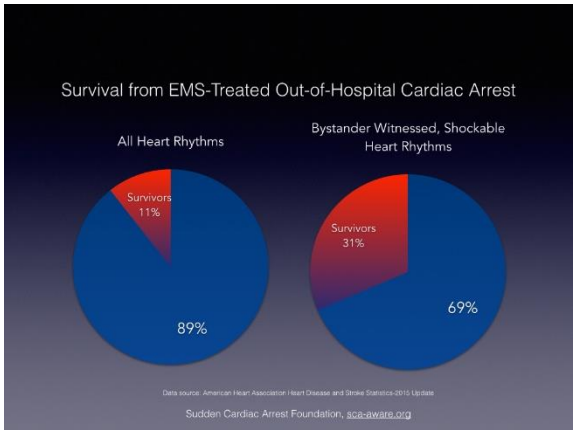


Figure 2: Application and Temperature sensor.

Project Name **Low-Cost Automated CPR**

Team Leader: Mackenzie Houdek
Team Member(s): Mohammed Ahmed, Ryan Antony, Christopher Intriago
Faculty Advisor(s): Dr. Kunal Mitra, Dept. Of Biomedical Engineering, Florida Institute of Technology



Cardiac health is a major issue in the United States that can lead to Cardiac arrest. Cardiac arrest is a sudden diminution of heart activity which impairs the pumping of blood to the brain, lungs and other vital organs. In one year alone, 475,000 Americans die from a cardiac arrest. Globally, cardiac arrest claims more lives than cancer, HIV, respiratory illness, and fires incidents, combined. According to the *American Heart Association* only 20% of Americans are certified to perform CPR; a majority of these are healthcare professionals. The effectiveness of the CPR depends on many factors, where the promptness and the quality of the resuscitation procedure are the most important. Since CPR is performed manually, there is a large scale of discrepancies. Recently, several companies have developed automated CPR machines. These machines, although very efficient, are **costly with a price range of $6,000 - $15,000.** Due to the financial constraint, automated CPR machines are **not available in third world countries** and are still not highly available in first-class hospitals either. Currently, low-cost automated CPR machine are being developed, the most affordable prototype has a manufacturing cost of $545. **Lazarus aims to provide the most affordable alternative to the pricy automated CPR systems currently on the market making the life-saving technology available to all.**

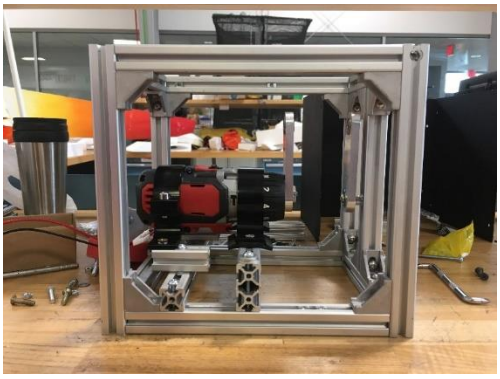


Figure 4 – Design Mechanism and Structure

This new design encompasses the use of an affordable motor and sleek design that can provide compressions at 100-120 per min and at a depth of 2 inches. The designs validity was tested using the AHA guidelines and with the use of a CPR dummy. The CPR dummy allowed data collection in the form of highlighting whether the compressions were at a correct rate and depth. Furthermore, the design includes a backboard to provide stability and optimal transportation.

Overall, our team was able to design and develop a new low-cost prototype that can perform CPR automatically. In comparison with current prototypes in the market, Lazarus was able to reduce the cost and keep the effectiveness of the compressions. **The manufacturing cost to produce this design is $226.45,** which is the most affordable automated CPR machine.

Since the design did manage to accomplish in decreasing the cost factor that was intended, further implementation such as an EKG and adjustable compressions rate are ideas for future designs. These implementations would increase the price but would benefit the outcome of survival since more accurate compression could be performed depending on the arrythmia.

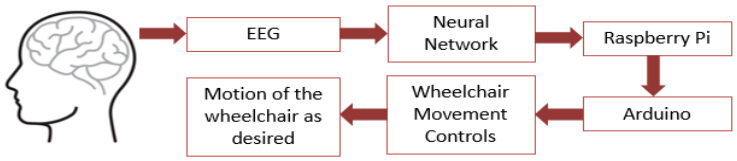
Project Name **ee.motion - A Brain-Controlled Wheelchair**

Team Lead: David Cisek
Member(s): David Cisek, Oceane Fruchet, Raoul Kurian, Tucker LeBreton, Karla Marquez
Faculty Advisor(s): Dr. Kunal Mitra, Dept. of BCES, and Dr. Debasis Mitra, Dept. of CES

Project Topic: Interpretation of EEG Waves to Control a Wheelchair

Problem Statement: Millions of people in the U.S. live with severe disabilities and rely on the use of a wheelchair to move around. The wheelchairs available on the market all require some form of movement. In some pathologies, these movements are not possible and these people become dependent on others to move.

Project Description: ee.motion is an electric wheelchair system that is controlled through mental commands. The brain waves are detected by a headset placed on the user's head, and the commands are decoded using signal processing and a neural network. The interpreted commands are then transmitted to the joystick circuit of the wheelchair to make it move in the desired direction.



Challenges	Design Solution
Accurately Interpreting EEG Waves: Non-invasive electroencephalography (EEG) is recorded from the scalp, which yields a low amplitude signal. In addition, EEG signals have high noise, and movement artifacts can sometimes be mistaken for brain activity. Mental commands are difficult to interpret, because the different EEG signals are often very similar to one another. Controlling the Wheelchair: The wheelchair uses a joystick that outputs pulse width modulation to control the direction of the chair. The voltage outputs of the joystick must be mimicked to be able to move the wheelchair without using the joystick.	Input Data: Data was recorded from 8 electrodes near the motor cortex. Imagined movements were chosen as commands as significant changes in brain waves occur during motor imagery. Data processing techniques included filtering, wavelet transformation, and scalogram images formation. Blink Detection: Long eye blinks were chosen as a command to turn the Movement Mode On/Off. This mode allows the user to send mental commands to be interpreted by the neural network. An algorithm was developed to ensure that normal eye blinks would not be mistaken for commands. Neural Network: The ee.motion system uses a convolutional neural network to decode and classify the mental commands given by the user. If the class probability is above 75%, the command is sent to the wheelchair circuit. Wheelchair: The Raspberry Pi inputs a signal which is interpreted and classified. The detected command is then sent to the Arduino which mimics the necessary joystick voltages and moves the chair in the corresponding direction.

Results: An executed command is considered "accurate" if it is the same as the mental command given by the user. With the convolutional neural network, a maximum accuracy of 82% was achieved when comparing two different classes. The system accuracy was improved by only transmitting the command to the wheelchair if the probability of detection was above 75%.

Future Work: This project offers a promising solution for wheelchair control through EEG command detection. Future work needs to be done to increase the accuracy and the number of distinct features that can be used.

Project Name	**Gaitway: Prosthetic Limb**
Team Lead:	Kimberley Toperzer
Team Members:	Ahmad Alhandhali, Austin Evarts, Ziwen He, Stephanie Redmond, Ling Wan, Bo Wang, Lei Zhao
Faculty Advisors:	Dr. Kunal Mitra, BCES, Dr. Ken Gibbs, CES, Florida Institute of Technology

This design is focused on a prosthetic leg that offers adjustability above and below the knee.

The problem of current prosthetic limbs is relatively well known. Efficient ones that utilize computers and microchips can be very pricey for the patient, and adjustability is not a common design factor. Current adolescent patients must get refitted for a new prosthetic every six months to a year, depending on how fast they grow. One of the most common issues we saw while researching our design is adjustable prosthetics were only adjustable below the knee (Transtibial). Another issue with above the knee (Transfemoral) prosthetics is how the artificial knee moves. Current prosthetics use hydraulic or pneumatic actuators coupled with a microprocessor to allow the person to walk. These designs are more passive and require the residual limb to initiate the first movement.

Deciding on how to drive leg movement was one of the greatest challenges for the group, as we wanted the design to be innovative but functional. Options such as linear actuators and servo motors were considered, but it was finally decided that the group would build a worm gear, a novelty approach to movement in prosthetics. Another obstacle that presented itself was the integration of the EMG signals and the mechanical leg. This proved to be difficult as none of group members had participated in this level of work.

The prosthetic uses a worm gear to simulate knee movement while walking. A force feedback control loop is applied by installing a load cell in the back of the motor. The feedback control loop allows the prosthetic to work smoothly and can even provide a sensory feedback to the user, so the user feels as if the prosthetic is an actual leg, and this results in smoother movement and maximum comfort. The custom 3D printed socket is paired with a sock liner to create a snug fit for the user, resulting in higher functionality and a better experience. The EMG sensor was used in a simple design, so that whenever the sensor detected a value above a threshold, an output would be executed.

The brush motor transmits the motion to the optical encoder, which will send the position and direction to Arduino. The torque of the motor is transmitted through a 3.7:1 planetary gearbox and then drive a 60:1 worm gear on the knee joint. The motion control accuracy of the knee joint is 0.25 degree. A load cell can sense the torque on the knee joint, along with the limit switch can protect the collide of the structure.

PID control takes over the encoder and load cell signal to create a position feedback control loop and a force feedback control loop; which has a continuous torque output on the knee joint greater than 20 N*m with an accuracy of 4 mN*m (40 grams*cm).

We designed and developed a prosthetic leg for children. This is an above knee prosthetic leg which is adjustable and uses EMG signals to drive knee motion. The leg was successfully built to withstand a child's weight as well as an active lifestyle.

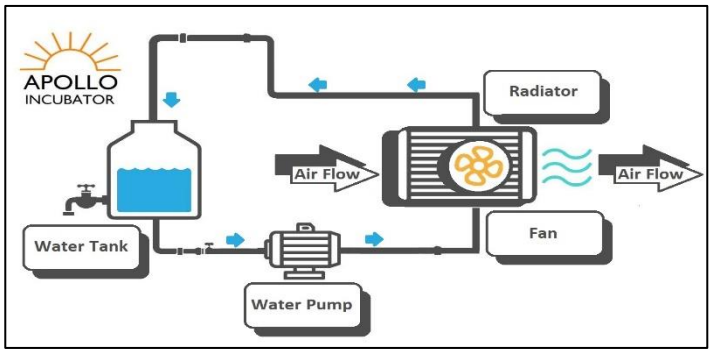
We can improve the algorithm for decomposing the EMG signal and change to a more compact brushless motor, which is more lightweight, powerful and waterproof. Also creating an adult version of this adjustable leg to accommodate a broader population which allows more people to benefit from this product.

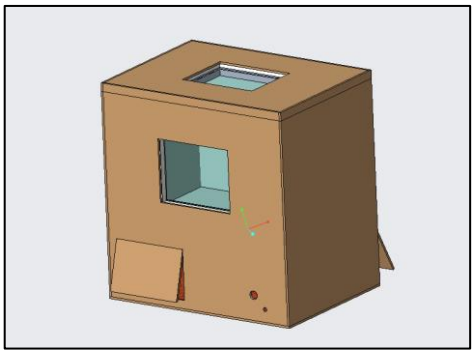
Project Name	**Apollo Low Cost Neonatal Incubator**
Team Lead:	Brianna Matthew
Team Member(s):	Amanda Davidek, Kesha Hyacinth, Amani Watson, Meshri Alatiki, Zawad Islam
Faculty Advisor(s):	Dr. Kunal Mitra, Dept. of Biomedical and Chemical Engineering and Sciences, Florida Institute of Technology

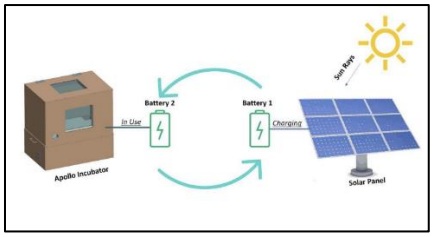
Prematurely-born infants, despite their compensatory mechanisms, have a limited capacity to thermoregulate and are prone to decreased core temperature. Currently, countries with the highest premature infant mortality rates worldwide are developing nations, which are strongly correlated with restricted access to electricity. The Apollo Low-Cost Neonatal Incubator (ANI) strives to reduce neonatal infant mortality by providing a relatively low cost off-grid solar powered system that attains physiological temperature, thereby diminishing the likelihood of hypothermia in premature infants.

The primary challenge of the ANI's design was the incorporation of locally available, cost-effective, insulative materials that maintain the physiological temperature range of 36.5 – 37.5^{o}C. Moreover, another challenge of the design was selecting a power system that optimized efficiency and effectiveness but had a relatively low manufacturing cost. Although placed under several constraints, the team was able to fabricate a heat exchanging system that integrates boiling water as a thermal mass. The ANI utilizes a high-efficiency particulate air (HEPA) filtration system that removes 99.97% of bacteria, which reduces the probability of infection in premature infants. Furthermore, the neonatal cabin can be sterilized using various disinfectants; the walls are made of polycarbonate sheets, a thermoplastic that absorbs minimal moisture, making it resistant to impact and water damage.

According to the data collected, it was determined that the ANI is capable of heating to 37°C upon the addition of boiling water to the system. Unfortunately, the cabin can hold this temperature for approximately 15 minutes, which is below the target time of 1-2 hours. Further studies include developing insulative methods to prolong the cabin temperature of 37°C.







Project Name **Nixus**

Team Members: Thomas Ward, Ariana Eichler, Samantha Schultz, Daniel Mastellar
Faculty Advisors: Dr. Kunal Mitra, Dept. Of Biomedical Engineering, Dr. Kenneth Gibbs, Dept. Of Electrical and Computer Engineering, Florida Institute of Technology

Lymphedema is a long-term chronic condition due to damage of the lymphatic system that generates swelling of an appendage, causing pain and partial or total inhibition of the appendage. 180 million people worldwide, and the 6-10 million American who suffer from lymphedema would benefit from compression devices. However, 60% are noncompliant with wearing compression stockings due to discomfort and difficulty putting the sock on. Presently available pumps systems, which are used for only short periods each day, are not sufficient at controlling lymphedema.

We designed a slimmer fitting pneumatic compression device which can be worn continuously and is easy for patients to apply. This device incorporates Nickel Titanium Shape-Memory Alloy Actuators. Four ballistic nylon bands are attached to the actuators, medially and laterally, to prevent torque on the underlying tissue (figure 2). These bands compress sequentially from the ankle to knee to facilitate lymphatic drainage. Pressure sensors are placed between the device and the patient's leg to ensure therapeutic and safe pressures. A simple diagram of the device's control system can be seen in figure 1.

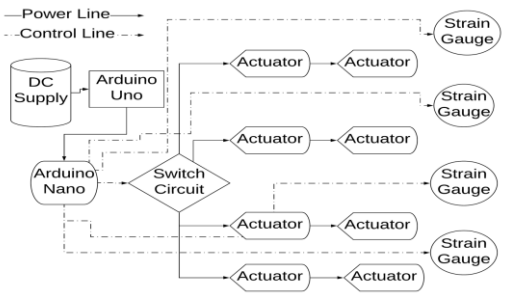


Figure 1- Circuit/Control Diagram

Figure 2- Device

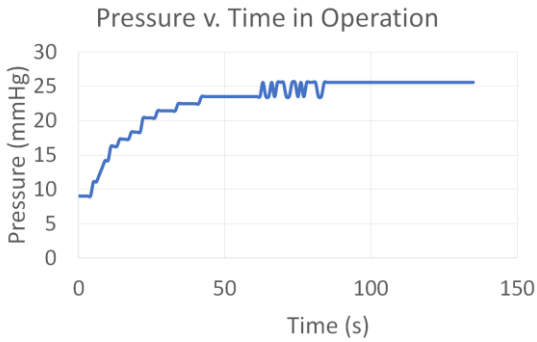


Figure 3- Pressure Reading of a Band

In testing we applied the device around a PVC pipe and recorded pressure readings in each band (figure 3). The maximum pressure of each band reached 25 mmHg. The usage and pressures of the device can be tracked by a phone application which can send therapy reminders to help patients achieve successful treatment.

In the future, we would like to make the device battery compatible as well as introduce a quantitative method for evaluating swelling reduction in the patient's leg. Additional improvements will include more comfortable materials and ergonomic design.

Project Name	**Osiris: Bioreactor**
Team Lead:	Stephanie Dominguez
Team Member(s):	Malia Ashmead, Andrea Bianca Bodden, Jamison Burch, Ilan Davidescu, Emanuele Rossi, and Sarah Strauss
Faculty Advisor(s):	Dr. Kunal Mitra, Dept. of Biomedical and Chemical Engineering and Sciences, Florida Institute of Technology

This project posted challenges that Biomedical Engineers have to consider when desiring to grow a vascularized tissue. In previous studies, bioreactors were only considered for the growth of cell culture and its control; it also worked for the study of different cell types and their reaction to different drugs such as sarcoma cells, also known as cancer cells. Nowadays, bioreactors are expanding into more complex elements, such as the conservation and growth of scaffolds that can be used not only for research studies but also for their implantation in different living beings (Wang et al., 2005). Perfusion bioreactors, in particular, allow constant nutrient feeding of the cell culture or the cell-embedded scaffold from an external source, a cell media bottle, which contains all the nutrients and soluble gases necessary for cell growth and differentiation. The media flows thanks to an external force, a peristaltic pump in this case, through tubes and other apparatus (explained in detail in the next sections) in order to maintain ideal oxygen levels, carbon dioxide levels, pH levels, temperature, and other factors. It also allows the application of mechanical stress to the cell culture due to the shear flow created by the cell media and to mimic the biological environment the scaffold will be subjected once introduced to the body (Bancroft et al., 2003). Osiris Bioreactor is a simplified and user-friendly benchtop-size perfusion bioreactor system that costs less than the commercially available systems. The team designed this bioreactor to hold two scaffolds where a flow system will continuously feed the cells in the scaffold and stimulate their growth and cell proliferation.

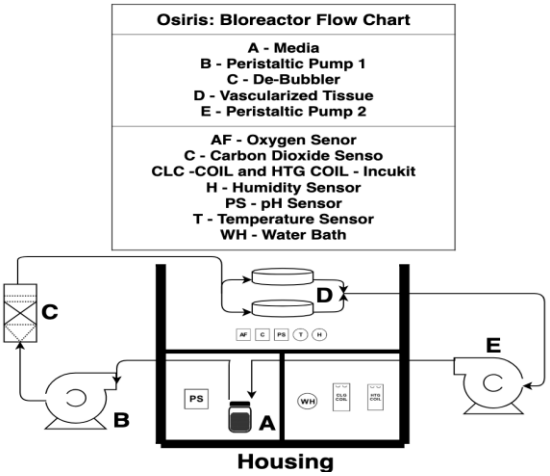


Figure 1: Osiris Bioreactor Flow System Chart

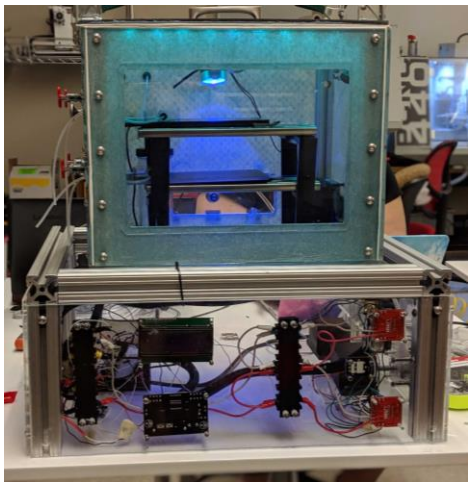


Figure 2: Housing Unit Assembly

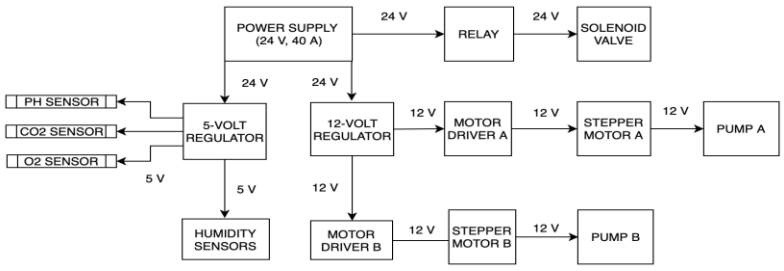


Figure 3: Osiris Electric Circuit Diagram

Project Name	**Guardian Wearables**
Team Lead:	Matthew Lanoue
Team Member(s):	Jennifer Berg, Songda Lei, Keira McCarthy, Alexander Romeo, Rebeca Quintero, Daniel Welch, Alexzandriea Van Hoekelen
Faculty Advisor(s):	Dr. Kunal Mitra and Dr. Ken Gibbs

The nature of contact sports does not provide ample time for athletes to self-access their injuries and determine if they need to be removed from play. From this, athletic trainers experience an even more problematic time assessing injuries from the sideline due to the amount of players, distance from the players and other distractions that an athletic trainer must handle. Guardian Wearables is a comfortable, lightweight compression-like shirt that can be worn to detect high impact body contacts on the collarbone and rib area. The device accurately measures impact forces up to 4,000 Newton, while also providing reliable location feedback of the area impacted. The data transfer process is in real-time, communicating with the specially designed app that can be easily accessed by athletic trainers at a sideline station. Design challenges include- determining the type of sensors, the type of sport, and the particular area of the body to focus on. Through research, piezoresistive sensors were chosen for their ability to detect high impacts, while also being flexible and small. Football was chosen as the sport of focus due to its excessive rate of high impact forces to the upper body. With the knowledge gained from Guardian Wearables, future work can extend into several ideas including testing further parts of the body in other contact sports, potentially leading to a fully accessed heat map where athletes can determine where the most contact was received during a practice or game.

Figure 1: Outside Guardian Wearables Design Layout

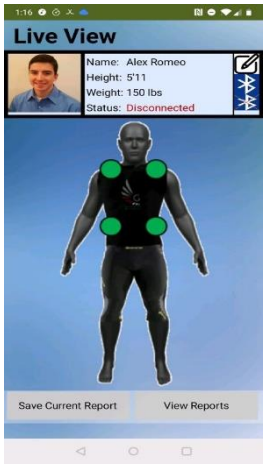


Figure 2: App Design for Android

Chemical Engineering

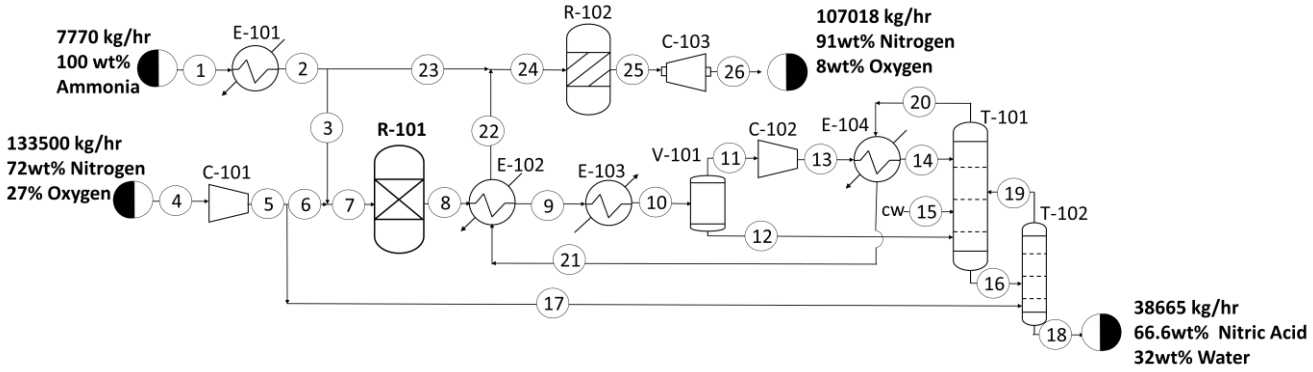
Project Name	**Catalytic conversion of biomass to the acrylonitrile**
Team Lead:	Ziyana Al Hashimi
Team Members:	Ghaida Al Fannah ,Nurs Al Jabri, Ziyana Al Hashimi
Faculty Advisor:	Dr. Jonathan E. Whitlow, Dept. Of BCES, Florida Institute of Technology

The aim of this project is to design a chemical plant that produces Acrylonitrile (ACN) with a commercially viable, and cost-effective thermochemical process while enabling the utilization of an alternative feedstock - non-food sugars. The plant will be in Kennesaw, Georgia, close to the supplier of the cellulosic sugar feedstock. The multi-functional catalytic system operates at mild conditions and should eventually allow a production cost of $1.00/lb or less. Alternative feedstock is more reliable due to the stable prices of derived sugar unlike conventional feedstock (e.g. Propane, Ammonia). Low cost pathway to produce high value chemicals and use their co-products. The production rate of the process is $1578 tons/year with a capital cost of $28.3 million and a total manufacturing cost $76.5 million. This process reduces greenhouse gases and uses high performance catalysts that meet the target for sugar to glycerol, glycerol to Acrolein, and Acrolein to acrylonitrile conversions.

Project Name **Catalytic Intensification of Nitric Acid Production**

Team Lead: Sunil Rajana
Team Member(s): Ibrahim Al-Wahabi, Hamad Jassim
Faculty Advisor(s): Jonathan Whitlow

This project focused on the process design, simulation and profitability for producing Nitric Acid (HNO_3) with purity 66.6 wt% by using a feed of water, 8000 kg/hr Ammonia and 134000 Kg/hr Air . The proposed of this project is to evaluate the kinetics of the catalytic oxidation of NO to NO2 using a Pt/alumina catalyst, under conditions relevant to industrial nitric acid production. This may lead to reduced capital expenditure (CAPEX) and footprint of new build plants. The Process Plant Capacity is 200000 metric tons per year (38676 kg/hr). The process is a modified Ostwald method simulated using Aspen plus 10 computer software. The prospective site of the process plant was chosen to be Rio de Janeiro, Brazil due to the increasing population and the growing Agricultural industry.



Project Name **Enhancing Sulfuric Acid Alkylation via Rotating Packed Bed Reactor**

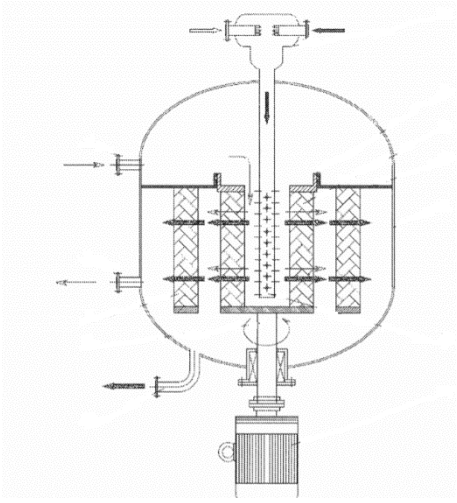
Team Member(s): Logan Sweeney, Antoine Mora, Tyler Brentzel
Faculty Advisor(s): Dr. Jonathan E. Whitlow, Dept. of Chemical Engineering, Florida Institute of Technology

Alkylation is a downstream process in petroleum refineries that combines isobutane with light olefins in the presence of a strong acid catalyst. The reaction yields a highly branched, paraffinic product known as alkylates. Alkylate oil is considered one of the ideal additives for gasoline blend stocks because of its unique properties: high octane number, low vapor pressure, and lack of impurities such as olefins, sulfur and nitrogen compounds, and aromatics.

A major source of air pollution in the world comes from automobiles and boiler emissions, which are mainly composed of nitride oxides and sulfur oxides. Automobiles have reached a high volume and will continue to grow with the growing population. In turn, environmental protection standards are becoming increasingly stringent to decrease the pollution caused by the combustion of olefins, aromatics and impurities derived from motor gasoline. Alkylates can be used to improve the quality of gasoline and make it more environmentally friendly by reducing pollutant emissions from the combustion process leading to a strong demand for alkylates in the future.

Currently, many types of catalysts have been applied to the alkylation reaction including sulfuric acid, hydrofluoric acid, ionic liquid and solid acids. Although the reaction can take place at high temperatures without a catalyst, the only process of commercial importance today uses sulfuric or hydrofluoric acid catalysts at low to moderate temperatures. Between the two, hydrofluoric acid is considerably more dangerous and is starting to be phased out of industrial plants.

The high demand for alkylate oil has pushed for research dealing with the intensification of alkylation, specifically sulfuric acid alkylation. A novel packed bed reactor has proven to enhance the reaction due to its high efficiencies of mass transfer and micromixing. The rotating packed bed reactor (RPB) generates high shear force, pushing the liquid out through the packing creating liquid droplets and threads around 10^{-5} to 10^{-4} meters. This results in a significant enhancement on micromixing and mass transfer between liquid elements. Moreover, the inner mole ratio of isobutane to olefins is dramatically decreased in the RPB, meaning more of the isobutane reacts in the process. In turn, the cost of recycling materials is greatly reduced for the process. To the right is a schematic for the rotating packed bed reactor.



The novel packed bed reactor was implemented into the project design simulation using the literature provided. Overall, the sulfuric acid alkylation process was simulated and costed, yielding high quality alkylates via the rotating packed bed reactor.

Project Name	**Production of Light Olefins from Fatty Acid Methyl Esters rived from Waste Cooking Oil.**
Team Lead:	Thais Sousa
Team Members:	Jawaher Al Falahi, Lilah Henderson, Mengqi Yuan, Thais Sousa
Faculty Advisor:	Dr. Jonathan E. Whitlow, Dept. of Chemical Engineering, Florida Institute of Technology

Project Description:

The project process is the Production of Light Olefins from Fatty Acid Methyl Esters (FAMEs) derived from Waste Cooking Oil (WCO). The process uses filtered WCO and converts it to FAMEs via supercritical transesterification using methanol. FAMEs then go through two hydroprocessing steps which include saturation and hydrodeoxygenation (HDO). The saturated FAMEs are then steam cracked and finally separated to produce Light Olefins and other products such as light alkanes, pyrolysis gasoline and fuel oils. The main Light Olefin products are Ethylene and Propylene gases, widely used as raw materials for various petrochemical industries. This novel process integrates the pre-saturation and hydrodeoxygenation steps prior to conventional steam cracking units to provide higher n-alkane content that results in higher yields of Light Olefins compared to conventional fossil fuel feedstocks such as Naphtha. The process was designed and optimized using Aspen Plus V10.

The major challenge of the project was to design industrial scale saturation and hydrodeoxygenation reactors since no industrial-scale reactor has ever been legitimately created. This was overcome by a large-scale literature review and a high level of optimization in Aspen Plus. Another challenge of this project was to create a simulation of steam cracking. Steam cracking is a very high temperature process that contains many simultaneous reactions, each with different selectivity and yields. Because of this, we were unable to simulate this reaction in Aspen Plus. Instead, we created a black box calculation in which we used our data from Aspen Plus and literature review to estimate the products of the steam cracking reaction.

We were able to analyze the data from our simulation processes and come up with estimations for the cost of equipment and the cost of manufacturing. We used Turton Capital costing analysis along with the CEPCI index for these estimations.

The motivation of the project was to promote a more sustainable production of highly demanded and valuable products. In the minimum, renewable resources should have a larger contribution to conventional production processes and create a more sustainable petrochemical industry.

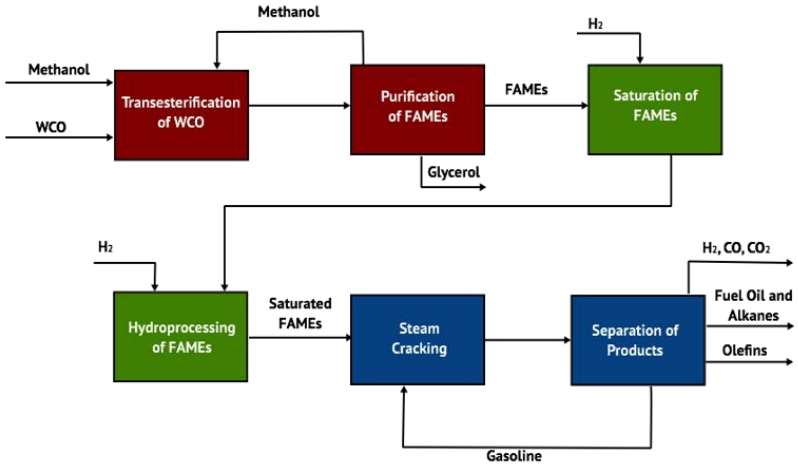


Figure 1. Comprehensive Block Flow Diagram of Process.

Project Name **Novel Process to Synthesize Lactide from Lactic Acid**

Team Lead: Kaylee Cornish
Team Member(s): Kaylee Cornish, Antonio Gentilini, David Rinderknecht
Faculty Advisor: Dr. Jonathan E. Whitlow, Dept. of Chemical Engineering, Florida Institute of Technology

A current hot-button issue today is the large amount of plastic waste. There have been many strides to reduce the waste by recycling, but the issue will not be solved until plastic packaging is no longer the norm. In the modern market, bioplastics are positioned to have tremendous and prolonged growth as replacements for current petrol derived plastics. Poly Lactic acid has been considered one of the only biodegradable plastics that is economically viable on a large production scale. The main markets for PLA usage include packaging, construction, agriculture, transportation, furniture, electronics, and biomedical. The goal of this project was to design an efficient large-scale chemical plant to produce lactide from lactic acid. The lactide produced can then be polymerized to form PLA to be used as a biodegradable plastic.

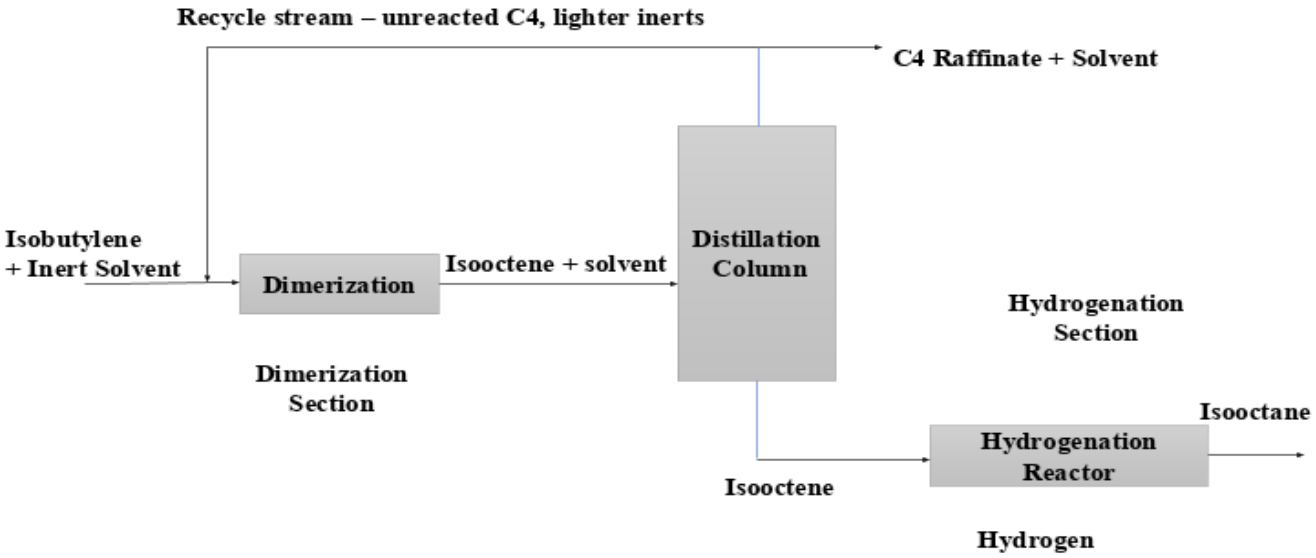
Due to the formation of undesired by products, the current commercial process requires a series of reactive distillation columns operating under vacuum, which is energy intensive. High energy costs have kept the market price of PLA higher than those of the petrol-based competitors. In order improve the process, a reaction scheme that eliminates by products is required.

A preliminary literature review was performed to obtain information on this chemical process. A novel tin oxide-silica oxide nanocomposite catalyst (SSO-80) was found to accomplish this goal however the data available was for a lab scale reactor. The project was to take this data and scale it to industrial scale operation. The expected result from using this new catalyst was a more energy efficient process and higher reaction yield, resulting in better market positioning of PLA. The Chemical engineering software, Aspen, was employed to design and simulate a scaled-up version of the process. Major challenges that arose include reactor scale up and designing the crystallizer used as the solids separation technique. Reactor scale up was difficult because lab-scale kinetics refer to reactor operations with little to no mass transfer limitations. This was addressed by upscaling the reactor in a way that ensured internal mass transfer effectiveness approached 100% and by increasing flow velocity while respecting residence times to negate external mass transfer limitations. With these parameters, the use of lab scale kinetics were judged a good estimation of reactor performance. The crystallizer was a challenge because crystallizers are not discussed much in undergraduate courses and are not well modeled with theoretical equations. In order to design the crystallizer, Aspen simulations were performed until matching experimental literature results pertaining to Lactide crystallization. Ultimately, the expected results were obtained through the scaled-up design.

Project Name	**Process For Isooctane Production By using Catalytic Distillation**
Team Lead:	Nayaf Alsharif
Team Member(s):	Baddah Aldossary, Hamed Alhajri
Faculty Advisor(s):	Dr. Jonathan E. Whitlow

Project Description: Isooctane is a chemical compound of heightened industrial interest. The NExOCTANE process licensed by KBR is the state-of-the-art technology for converting isobutylene to mainly di-isobutylene (isooctene) that is optionally hydrogenated to paraffinic isooctane. In this project, we propose to review the NExOCTANE process. It is a highly energy intensive process and can be improved significantly by introduction of a green, hybrid approach of Catalytic Distillation (CD).

Graphics:



Project Name **Pyrolysis of Waste Plastics for production of Hydrocarbons**

Team Lead: Ziyad Al Hinai
Team Members: Hirad Ahmad, Al Moatasem Al Hajri
Faculty Advisors: Dr. Jonathan E. Whitlow, Dr. James R. Brenner, Dept. of BCES, Florida Institute of Technology

Production of Hydrocarbons through burning waste plastics in a pyrolysis furnace is a unique approach not embraced by many companies and facilities due to its complexity. This project aims to get rid of all those plastics that aren't recycled and left as waste lying around.

Our focus was to make sure that though the process seems very realistic, it is also as practical at the same point, and that the desired products achieved are not only made so with efficient practices, but also with eco-friendly applications. The process itself is clean and optimistic with gasoline and diesel being our main product components along with Char (carbon black).

Optimization of the Fractionating Tower was a major challenge due to composition characterization, meaning that the exiting streams had to be adjusted according to the number of stages of the tower so as to obtain the desired fuels in the desired product streams. This issue was resolved using a sensitivity analysis built in the simulation software along with estimations and assumptions. The final results were then reconfigured using existing sources and databases.

This methodology of making fuels from plastics was first started off in the United Kingdom and a few northern European countries mainly Netherlands. The technique isn't very old and still new to the market, as stated before because of its complexity and control processes, many facilities and companies don't aim for such a risk as an investment measure. Though, Pyrolysis plants do exist in some states like Virginia, still, majority of the people and public are unaware of the process mainly due to lack of awareness. Not only is the process environmentally – friendly, it can also serve as a thought for inspiration for its unique applicability and futuristic approach towards reserving natural resources to an extent.

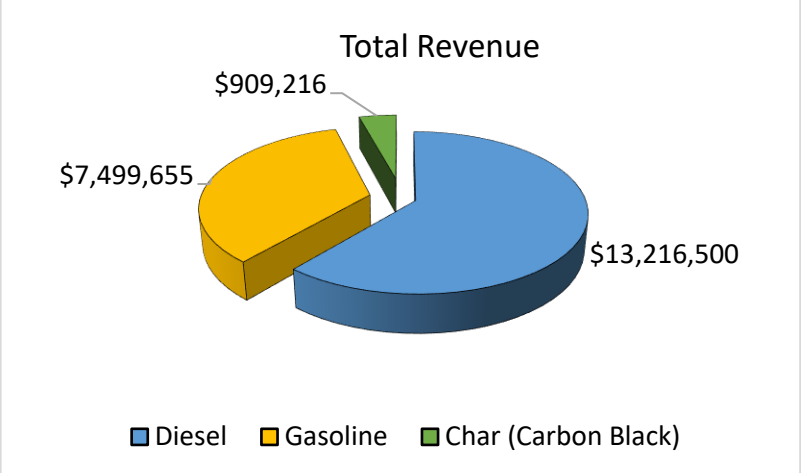
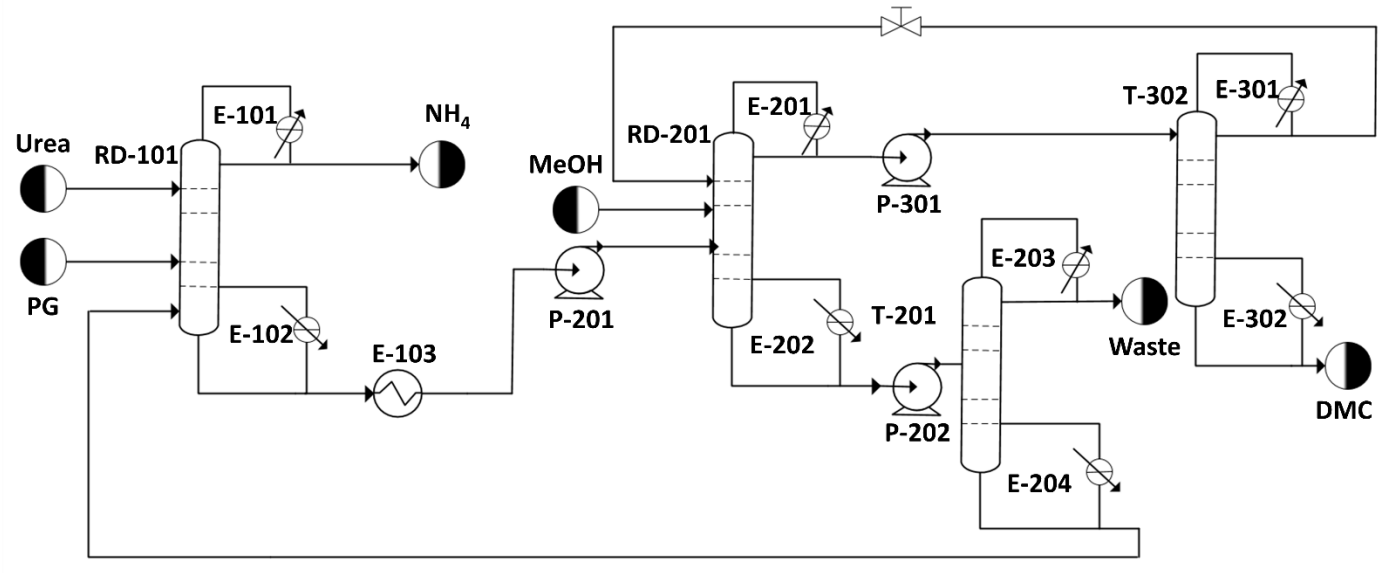


Figure (1): Total Production Revenue.

Project Name **Synthesis of Propylene Carbonate Through the Indirect Alcoholysis of Urea for Dimethyl Carbonate Production**

Team Lead: Juliana Burgos
Team Member: Jessica Alvarado
Faculty Advisor: Dr. Jonathan E. Whitlow, Dept. Of Biomedical and Chemical Engineering and Sciences, Florida Institute of Technology



PG = Propylene glycol NH_4 = Ammonia MeOH = Methanol DMC = Dimethyl carbonate

Dimethyl carbonate has traditionally been produced through oxidative carbonylation of methanol. This process operates under dangerous conditions, such as it must use very high pressures usually between 20-40 atm. This process also has byproducts, which decrease the purity of the product. One of the byproducts is carbon dioxide, which is toxic for the environment and people. In this project, the process has been intensified and the danger minimized using reactive distillation columns. Traditionally, the process would have a reactor and a distillation column. With a reactive distillation column, the process only needs one piece of equipment where the components react and then are separated. The reactive distillation column in the project operates at 1 atm, has no side products, and better purity of dimethyl carbonate. This project also utilizes the novel process of the indirect alcoholysis of urea to produce propylene carbonate. The use of both reactive distillation and the indirect alcoholysis of urea help to make this process safer than the traditional process.

Project Name — Production of Acetaldehyde from Ethanol Using Copper and Calcium Silicate

Team Lead: Seth Ricketts
Team Member(s): Jillian Collins, Harry Sale
Faculty Advisor(s): Dr. Jonathan E. Whitlow, Dept. of Biomedical and Chemical Engineering and Sciences, Florida Institute of Technology

This project is a preliminary design of an acetaldehyde production plant using a novel copper-calcium silicate catalyst in place of a conventional copper-chromium catalyst. The novel copper-calcium silicate catalyst is an improvement from the conventional catalyst due to the increase selectivity at lower temperatures as well as decreased product and by-product toxicity due to a lack of chromium. A feed stock of biologically produced ethanol was used to further reduce the environmental impact of the plant.

The chemical plant was simulated in Aspen Plus V10 with an acetaldehyde production rate of 2,080 metric tonnes per year and molar purity of 99.5%. Challenges in making this simulation included designing the reactor with limited catalyst characteristic information and designing a highly efficient recycle stream to reduce plant waste. The reactor was designed by estimating catalyst characteristics based on composition and pressure drop in the reactor using the Kozeny-Carman equation. The recycle stream was made possible through a multi-step distillation process, including a multitude of initial sensitivity analyses performed within the Aspen Plus V10 program to determine optimal temperature and pressure conditions for operation. Then, using heuristics provided in conjunction with sensitivity analyses to minimize the heating and cooling duties required for the distillation columns, the distillation columns were designed in order to recover 99% of the non-reacted ethanol and water, containing 99.999% molar ethanol and water in the recycle stream.

All capital and operating costs were estimated based on a method outlined in Richard Turton et al.- *Analysis Synthesis and Design of Chemical Processes* and analyzed using Microsoft Excel. The plant construction was assumed to take two years and the plant operating life was assumed to be ten years. Product and raw material prices were found online.

Further Design iterations would include purification of a hydrogen product stream by means of adsorption, further by-product analysis, and more detailed design of each unit operation in the plant. The hydrogen stream could be purified from 97 % to ultra-high purity (99.999 %) by using a multi-step pressure swing adsorption process, but it is unknown how economical that process would be. Another consideration is the value of byproducts and determining whether is it economical to purify them for sale. The piece of equipment that will require the most work in the redesign will be the reactor because the catalyst characteristics such as bulk density and porosity were not given along with reaction kinetics. Therefore, a conversion consistent with lab scale tests was assumed in this design iteration.

Summary:
This project outlines the preliminary design of a production plant producing of 2,080 metric tonnes per year of 99.5% molar acetaldehyde through the dehydrogenation of ethanol using a novel copper-calcium silicate catalyst.

Project Name	**Industrial Production of Acrylonitrile with a Micro-Channel Reactor**
Team Lead:	Timofey Broslav
Team Member(s):	Mohammed Al Hadhrami, Hitoshi Shinagawa,
Faculty Advisor(s):	Dr. Jonathan Whitlow, Dept. of Chemical Engineering, Florida Institute of Technology

Current production methods for Acrylonitrile utilize tubular reactors which are plagued by high temperature gradients within. Micro-Channel reactors offer a solution for such an issue. The purpose of this project was to simulate and perform an economic study for industrial scale production of Acrylonitrile utilizing a Micro-Channel reactor and validate such study.

Albeit Aspen Plus is an exemplary software for Chemical Engineering processes, it cannot model Micro scale processes correctly. For instance, the flow through the micro-channel reactor was assumed to be turbulent enough for a "plug-flow" model to be considered. Otherwise, such a simulation is impossible using solely Aspen Plus. To verify this assumption, Comsol was used to simulate the reaction scheme within a block of several channels and then compare it to the Aspen simulation. The reason for using Comsol, was due to its prevalent use of modeling fluid dynamics. This comparison includes the concentrations of the products in the reactor effluent, the pressure-drop within the reactor, and the temperature distribution throughout the channels. This portion is presented on a computer due to limited space on the board. Additionally, modeling the Quench Block in Aspen led to difficulties in the simulation upstream, hence it had to be modeled in a separate file, and have its stream data transferred to a new Aspen file. It was assumed that all the Ammonium reacted in the vessel. Furthermore, the Acrylonitrile reaction scheme was difficult to simulate due to the amount of side-reactions which occur, and the limited scope of research done on kinetics of such reactions. Hence, reactions with low yields of less than 1% were discounted to allow for a simpler scheme to be implemented.

Alongside the process simulation, difficulties arose during the costing process. Especially when costing the catalyst price. These costs were estimated by extrapolating past cost data into the future. Unlike the others, the cost of the catalyst was determined by looking at the individual chemicals needed to create the catalyst, and the processes used in the catalyst manufacture.

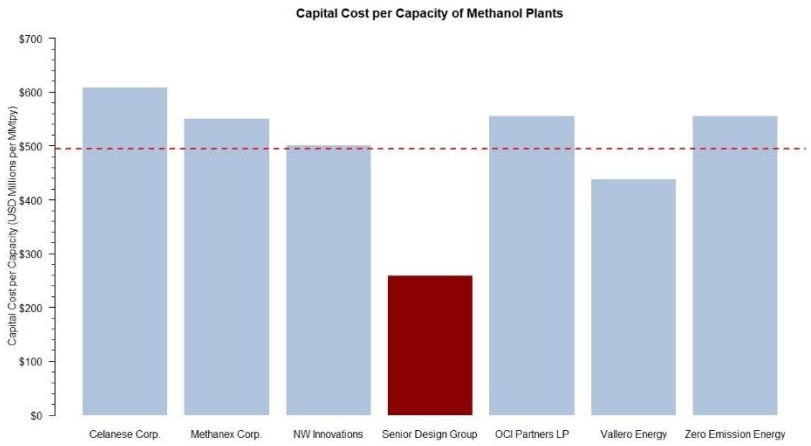
The Capital and Manufacturing costs were determined using the Turton Costing method alongside company quotes for several products. Moreover, an annual inflation rate of 7% was estimated for costing purposes. The validity of the simulation will be met if the Micro-channel results are within 90% of the more accurate Comsol values.

The objectives of this project were two-fold: profitability estimation using the Turton method for a 20% return, and model validity of the Aspen simulation with Comsol Multiphysics. Further research on utilizing several of Micro-channel reactors in parallel for greater output, and profitability, should be performed in the future for unveiling greater possibilities of such a process.

Project Name	**Methanol Production Plant from Greenhouse Gases**
Team Lead:	Ayo Adebisi
Team Member(s):	Andrew Earls, Richard Trumblak
Faculty Advisor(s):	Dr. Jonathan Whitlow, Dept. Chemical Engineering, Florida Institute of Technology

Methanol is an important chemical used to produce a vast number of chemical compounds with a diverse range of applications, moreover, methanol is also a high-octane, clean burning fuel. However, the traditional method of production involves the copious emission of greenhouse gases, such as CO_2. The motivation of this project was to augment the mature technology, steam reformation (SRM), by combining it with dry methane reformation (DRM) all in a single reactor. SRM produces greenhouse gases that can be consumed by the DRM reaction – reducing the overall emission of greenhouse gases. DRM is more environmentally friendly method to produce syngas. However, catalyst deactivation from coking has inhibited its development as a mature technology, hence, the augmentation between SRM and DRM.

A large capacity methanol production plant, producing 2.7 MMtpy, was designed in Aspen Plus 10, with the bi-reformation of SRM and DRM producing syngas. A combination of bi-reformation and recycling reduced 97% of the carbon dioxide emissions. A 30% improvement when compared to the reference process that reduces 67%. Despite breaking even in year 4 after construction, the long-term profits driven by the growing global demand of methanol should alleviate any concerns of potential stakeholders; at our current production rate an annual revenue upwards of $1.1 billion can be earned. In addition, after normalization the capital cost of the plant is below average when compared to other large capacity methanol plants at $260/MMtpy.



.The team is an enterprising and environmentally concerned unit. Thus, whilst a methanol production plant could have been designed to maximize profits, the team opted to minimize greenhouse emissions, as this is a future and present concern

Project Name	**Production of Glycerol Esters from Free Fatty Acids**
Team Lead:	Khalid Alagga.
Team Member(s):	Ghazi Alshammary, Ahmed Almarzooqi.
Faculty Advisor(s):	Dr. Jonathan E. Whitlow, Dept. of CHE, Florida Institute of Technology.

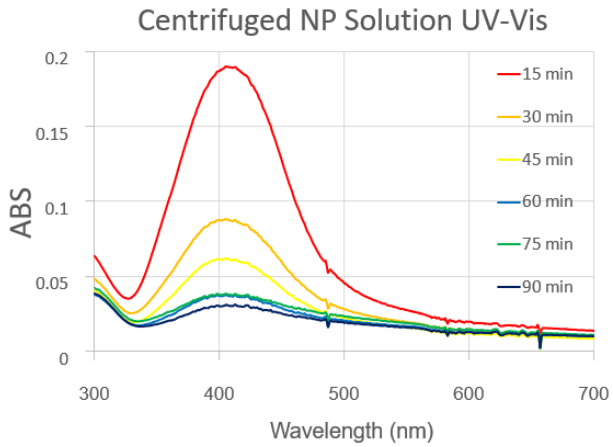
- **Production of Glycerol Esters from Free Fatty Acids**

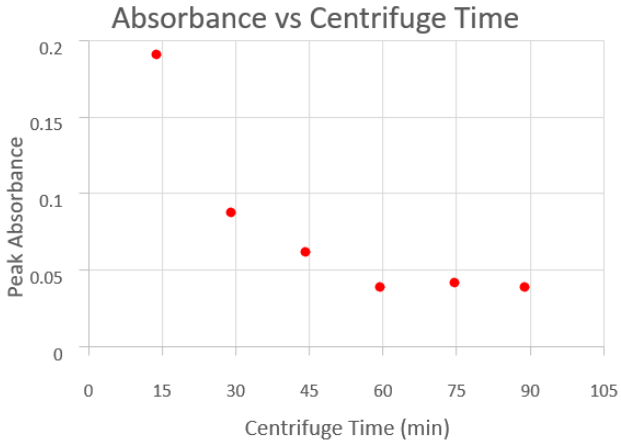
It's a novel process includes glycolysis reaction for free fatty acid by new catalyst and equipment causes higher economic profit. Production of biodiesel is recommended environmentally to reduce petroleum consumption and greenhouse gas emissions. Production of biodiesel includes trans-esterification of glycerides with alcohol (usually methyl alcohol) in alkaline catalyst environment. The efficiency of production depends mainly on the purity of feedstock. The feedstocks include impurities need additional treatment unit to produce biodiesel. The problem is increasing the prices of pure feedstocks, so the objective and novelty of this process is to produce a pure feedstock from fatty acids to biodiesel production by profitable process. The design procedures started with Drawing detailed flow sheets (In/Out diagram, P&ID). Then Process design of ASPEN Plus, After that, Detailed equipment design by excel sheet, other software if any, and hand calculations. Next, Energy Analysis of the process by ASPEN Energy Analyzer. Finally, Economic Analysis of the process by ASPEN Process Economic Analyzer. Future tells us that oil and petro-diesel will be drained. Replacing petro-diesel by bio-diesel is the driving force for using more amounts of triglycerides. (Zion research, 2016) discusses the global market of triglycerides and shows the expected global revenue of 2020 will reach 1,250 million $. The research shows the expansion of the market and demand which encourages designing a production process.

Chemistry

Project Name	**Quantification of Silver Nanoparticle Yield for Common Synthesis Methods**
Team Member(s):	Brendan Swiger
Faculty Advisor(s):	Dr. Kurt Winkelmann, BCES (Chemistry), Florida Institute of Technology

Project Description: The goal of this project is to quantify the percent conversion of silver cations to silver nanoparticles (AgNPs) for well-known wet synthesis methods using multiple analytical techniques. One method is a colorimetric analysis that detects unreacted silver cations that form a vivid blue-colored charge transfer complex ion. For the second method, AgNPs solutions are centrifuged then the concentration of unreacted $Ag^{+}(aq)$ remaining in solution is measured using flame atomic absorption (AA). Neither method thus far has been successful in producing consistent data, but the method of centrifuging to remove AgNPs from solution has proved reliable. Future work on this project will focus on producing consistent results for each method, as well as investigating agreement between the two methods with each other once consistency has been established.





Computer Science and Software Engineering

Project Name	**Revamp of High Energy Physics Laboratory's Computer Systems**
Team Lead:	Ryan Wojtyla
Team Member(s):	Josef Bostik, Eric Periera
Faculty Advisor(s):	Dr. Marcus Hohlmann

Dr. Hohlmann's High Energy Physics (HEP) research group at Florida Tech contributes to micropattern gas detector research for both the Compact Muon Solenoid (CMS) experiment at CERN and the future Electron-Ion Collider (EIC). In order to conduct this research, the group makes extensive use of several computer systems. These systems can be split into three main sections: the high throughput computing cluster, the muon tomography station (MTS), and general use machines.

The high throughput computing cluster is primarily used by the group's researchers to store data and run calculations. It is also affiliated with the Open Science Grid (OSG), where researchers from across the globe can submit jobs to be run. The MTS is an experimental device that makes use of micropattern gas detectors to track the paths of muons in order to image an object placed within it. Our project focuses on the computer system used to interface with the device. The research group uses general purpose Linux machines to interface with miscellaneous detectors and electronics, process and store data, and run simulations. The researchers using these machines often run into technical trouble and benefit from technical assistance provided both within and without the group.

The computing cluster had been under severe maintenance for a good deal of time, and its software would soon be outdated. After communicating with them for some time, the OSG support staff recommended a full rebuild of the entire system. The computer system for the MTS was running outdated software, had grown unreliable, and had an inefficient and convoluted data-taking workflow. The lab's general purpose machines, while largely usable, had much room for optimization in terms of resource allocation and workflow automation.

Linux Computing Cluster		**General Purpose Machines**		**Muon Tomography Station**	
Install ROCKS 7 onto the head node.		Reallocate hardware.		Install software onto new machine.	
Install ROCKS 7 onto the other cluster components.		Optimize workflows.		Configure the software to work together.	
Configure HTCondor.		Develop solutions for long-term maintenance.		Create a user interface for operating the software.	
Integrate cluster with OSG.		Provide miscellaneous technical support.		Integrate the new machine with the MTS.	
Create a cluster rebuild manual.				Create a manual describing the construction and operation of a new MTS machine.	

We had substantial difficulty installing the latest version of the cluster-building Rocks Linux distribution on first the head node, then the subsequent cluster components. While building and configuring the software for the MTS's new computer system, we found that the installation procedure requires very specific versions and configurations of all the pieces of software. Although the servicing of the general computer systems was not without hiccup, it was far less catastrophically burdensome than the other two sections of computing.

Daniel Campos helped us overcome obstacles encountered with the computing cluster. **James Cicak** from Florida Tech's IT department helped start us off with the computing cluster. MTS researchers, **Miguel Gutierrez** and **Tommy Walker**, provided us with guidance in designing the new MTS machine. **Samantha Wohlstadter** assisted us a great deal with the computing cluster, saving us much valuable time.

Project Name **A Java API for unifying ad-hoc Wifi networking**

Team Lead: Peter Banis
Team Member(s): Peter Banis, Klaus Çipi, Michael Kolar, Robert Olsen
Faculty Advisor(s): Dr. Marius C. Silaghi, Dept. Of CES, Florida Institute of Technology

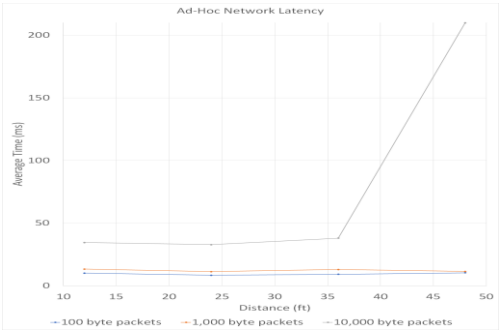
Our goal was to create a single API utilizing existing Ad-Hoc wifi capabilities across Windows, Linux and Mac operating systems(OS). Also, we aimed to incorporate the Wifi Direct standard across Linux and Android systems. We pursued this project because there is not currently a standardized tool to create Ad-Hoc networks using multiple OS.

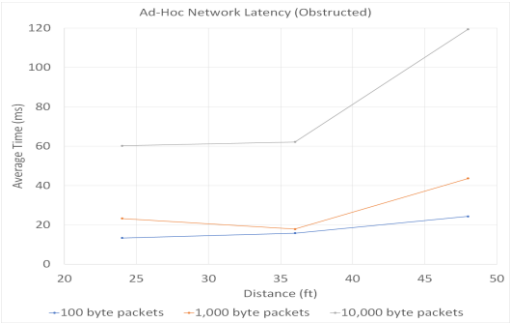
One of the major challenges was that each OS has a different API for networking. There was a difficulty in finding a useful and generic interface for our API users that could properly convey information to each OS's API. Finally, we had trouble identifying devices on our networks.

In order to address the aforementioned problems we came up with some intricate solutions. For each of the OS's we identified a core set of information needed to create and join Ad-Hoc networks that was common to all OS's. This meant we could not take full advantage of each OS's capabilities, but the resulting interface is clear and straightforward to anyone utilizing our API. Each OS utilized a series of scripts for creating and joining networks. In order to identify connected devices we limited the subnet to 255 IP's.

We identified two factors relating to the network as critical: Number of connections supported, and Number of packets dropped in communication. The unifying nature of the Java API will allow for easy cross-platform communication and enable easier transfer of files or other information between devices, which will be convenient for their users via Ad-Hoc networks.

The API supports three operating system groups (Windows, Mac, Linux), and each network can handle up to 255 devices connected at the same time. A reliable network connection can be maintained for up to maximum range of 230 feet. Bandwidth between two devices on an Ad-Hoc network will fall within a range from 1.04 to 1.33 megabits per second (Hardware-dependent).





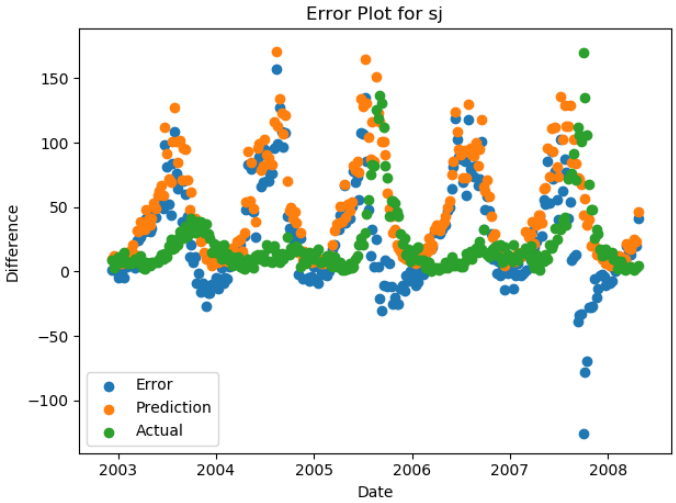
Project Name **DengAI: Predicting Disease Spread**

Team Member(s): Hy Diep, Micah Oltmann
Faculty Advisor(s): Dr. Phillip K. Chan Dept. of Computer Engineering and Sciences, Florida Institute of Technology

DengAI is a program whose goals are to predict the outbreak of dengue fever based on climate data. In this program we use modeling techniques including single and multi-variable regression as well as ARIMA and negative binomial methods to create predictions of future dengue outbreaks. The major challenges in this project was understanding the limitations and capabilities and implementing the various modeling techniques we chose.

Looking at the various modeling techniques we use, the single and multi-variable regression models are simple linear models that create a “line of best fit” or plane in the multi-variable instance, that tries to minimize the error between the line and each predictor. This is one of the simplest model techniques that exist. Moving forward, ARIMA is a method that accounts for auto-regression, that is it accounts for cases where things that happen now possibly affecting what happens later i.e. lagged predictors. Finally, in the negative binomial methods, this model assumes that the data being modeled as a count data (positive integers) instead of real numbers.

To analyze the results of our models, we used both the competition's submission system which gives us a mean average error (MAE). A higher MAE indicates a higher error, and vice versa. Furthermore, we evaluated our system by holding back 70% of the data and used the other 30% to calculate our own MAE based off of the predictions we generate. With our current modeling techniques, we have put ourselves on the top 600 out of 5844 with a MAE of 24.9663.



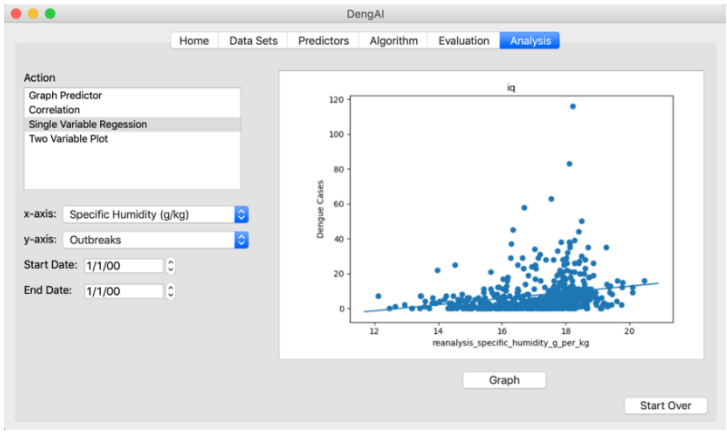


Figure 1 (Above Left): Error plot of our best model techniques (Negative Binomial + Fourier) generated using held back training data.

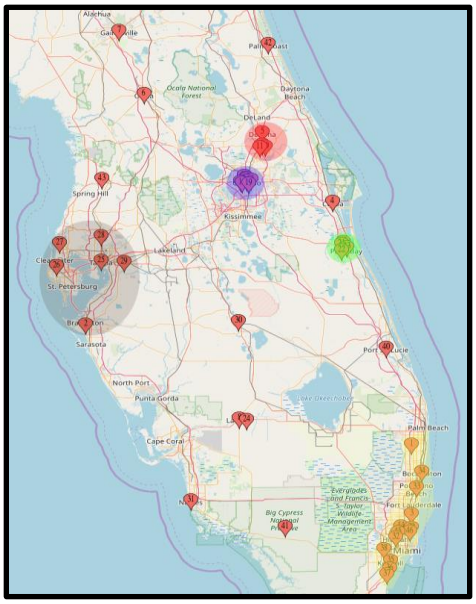
Figure 2 (Above Right): Here is a screenshot of the GUI developed for the project. This step, named Analysis, was included to help look at data in relation to other factors and to investigate specifics of the data. Specifically, the plot shown above is a Correlation plot. Given more time we would have our GUI dynamically import data.

Project Name **ICED**

Team Lead: Daniel Campos
Team Members: Kevin Crowley, George Nelson, Thomas van Haastrecht
Faculty Advisor: Dr. Heather Crawford, Dept. Of Computer Science, Florida Tech

The Interface for Coordinating Emergencies and Disasters (ICED) relief platform is a site that crowd sources disaster-related information on property damage and the like to build up disaster maps and analytics before official records are written. With ICED, users in disaster stricken areas can catalog and record accidents or damages like flooding, wind damage, or fires. Once enough reports are pulled into the system, ICED can plot and organize these reports into unofficial disaster areas based on the damages incurred, historical trends, and time. The platform also allows users to upvote and downvote each other's submissions, to allow the public to counter false reports or boost severe reports without overloading the system. Organizations like FEMA can then come in and view the information in an easy-to-search interface for prioritizing relief areas and planning recovery routes, with the hope of improving the disaster-to-relief recovery time. For future preppers, we hope to build a database of historical data to not only analyze and identify weak points where significant damage was incurred, but to help predict and formulate disaster plans for future disasters.

For users who wish to be more informed, ICED also provides an interface for organizations to submit alerts for disaster stricken-areas. In these areas, a constant internet connection can be difficult to obtain, and the large flow of traffic to specific disaster sites can make it very slow, sometimes even unusable. Technologies like Parity, an ethereum-based private blockchain software and IPFS, the InterPlanetary File System, are used to distribute these alerts in a peer-to-peer way. By doing so, users with intermittent connections can propagate and relay updated information to other users so long as a device-to-device connection can be made, like in the case of a shelter network. Furthermore, each shelter or disaster area can deploy a ready-to-use server image that automatically synchronizes and distributes information pertaining to the disaster area. This ensures that uplink/limited internet resources are not wasted as a result of redundant information downloads, and the information will persist and be available even when the uplink drops. Furthermore, users who may have more recent information can update the in-house server and as a result, update information for all to download.

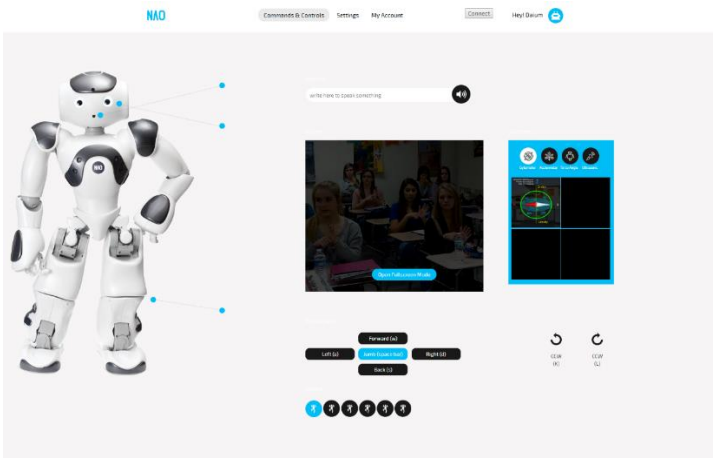


-Disaster zones of reports within Florida

Project Name **NAO Web Control**

Team Member(s): Daium Ahsan Butt
Faculty Advisor(s): Dr. Marius Silaghi, Dept. Of Computer Science, Florida Institute of Technology

NAO is an autonomous, programmable humanoid robot developed by Aldebaran Robotics. The NAO Robot is used for research and educational purposes in over 200 institutions in over 70 countries. The purpose of the NAO web control is to allow developers to control and program the robot through an easy to use web-based interface which is accessible from virtually anywhere in the world. The NAO Web Control removes the requirement for the developer to be connected to the robots local WIFI Hotspot and allows over the air uploading of program files. The NAO Web Control offers an easy to use interface that allows the developer to perform all the basic tasks of the robot by simply clicking on buttons. The NAO Web Control offers version control, all uploaded files are uploaded on the web server rather than the robot and offers for easily switching between code files in real time. The NAO Web Control also keeps track of output history of the programs for the developer. There were many challenges faces while the implementation of the system as the robot does not support such a mechanism and is programmable in Python. The integration between Python and PHP, the language in which the web control platform is built in, proved to be complicated. Another major challenge was using the web control functions and the socket in parallel. The socket is run in the background using ajax, as the user interacts with the web control platform, a database is updated. The socket program is responsible for communicating with the database and based on commands received it is responsible for sending the received data to the robot. The robot will then translate the command and perform appropriate actions. When a user uploads a program file, the file is stored on the server. When the program is executed, the NAO Robot imports the file inside the parent python program and executes the main method. The response is that reported back to the database to be stored.



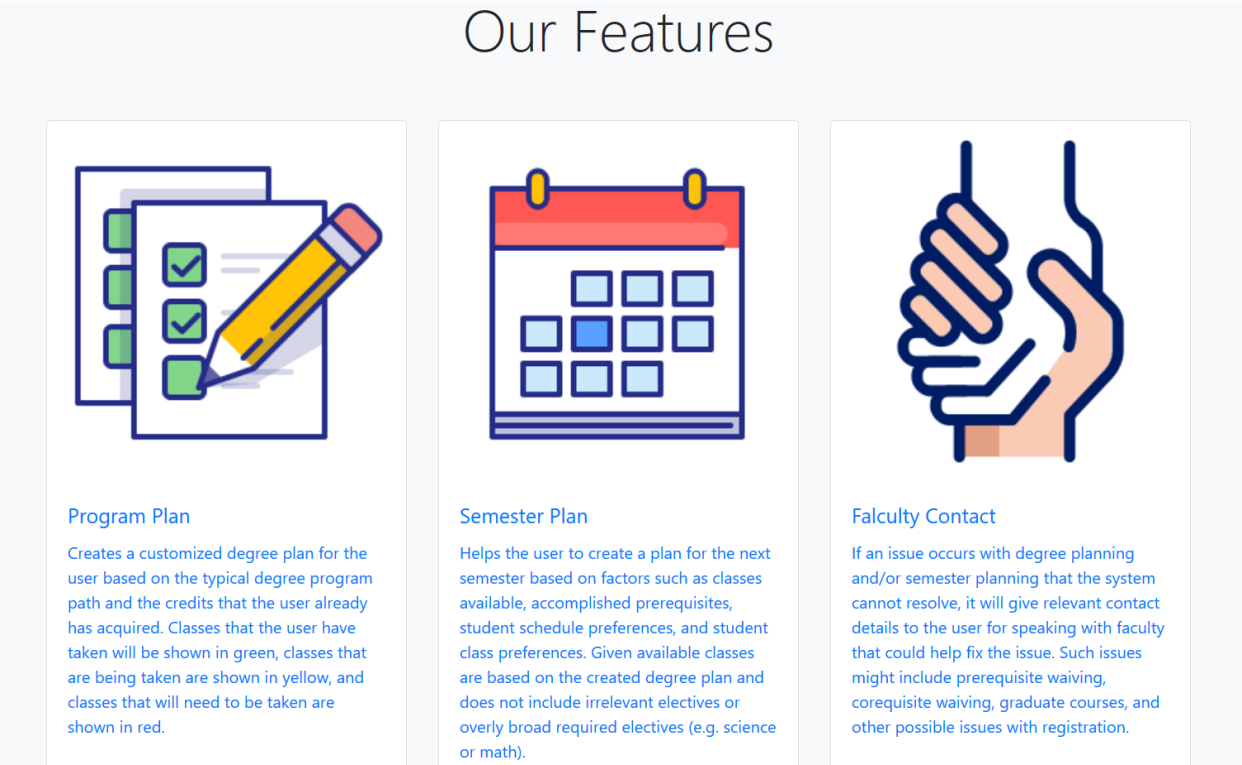
Project Name **Course Planning Assistant**

Team Members: Ariana Bishop, Jarrod Broom, Tariq AlMaashani, Zilong Zhao
Team Leader: Jarrod Broom
Faculty Advisor: Ryan Stansifer

Project Abstract:

Delayed graduation results from ineffective course planning. The problem may be more prominent for transfer students with previously acquired credit, as they might not be able to follow predefined degree plans like first-time students. Therefore, the ultimate goal is to develop an assistive tool that will aid in efficiently choosing relevant courses to ensure that students graduate in a timely fashion. One of our major challenges in this project was working with web development tools that we never used before. Another challenge was designing a database system with little prior knowledge of Database Management Systems and concepts. Designing a system with hopes that it may be more helpful than the one already in place (PAWS) proved to be our most difficult obstacle. For our system we used: Django for web framework, DigitalOcean as a server/domain provider, and PostgreSQL as our DBMS. We decided on two major parts of the website: the Degree Plan and the Semester Plan features. The first feature creates a customized degree plan for the user based on the typical degree path provided for their major and the credits that they already acquired. The latter feature helps the user to create a plan for the next semester based on factors such as classes available, accomplished prerequisites, and student schedule/class preferences. Data analysis of computer science/software engineering program plans and the data used in the course listing for the school registration system was conducted for our project. Overall, this project has been a challenge but not impossible.

Graphics:

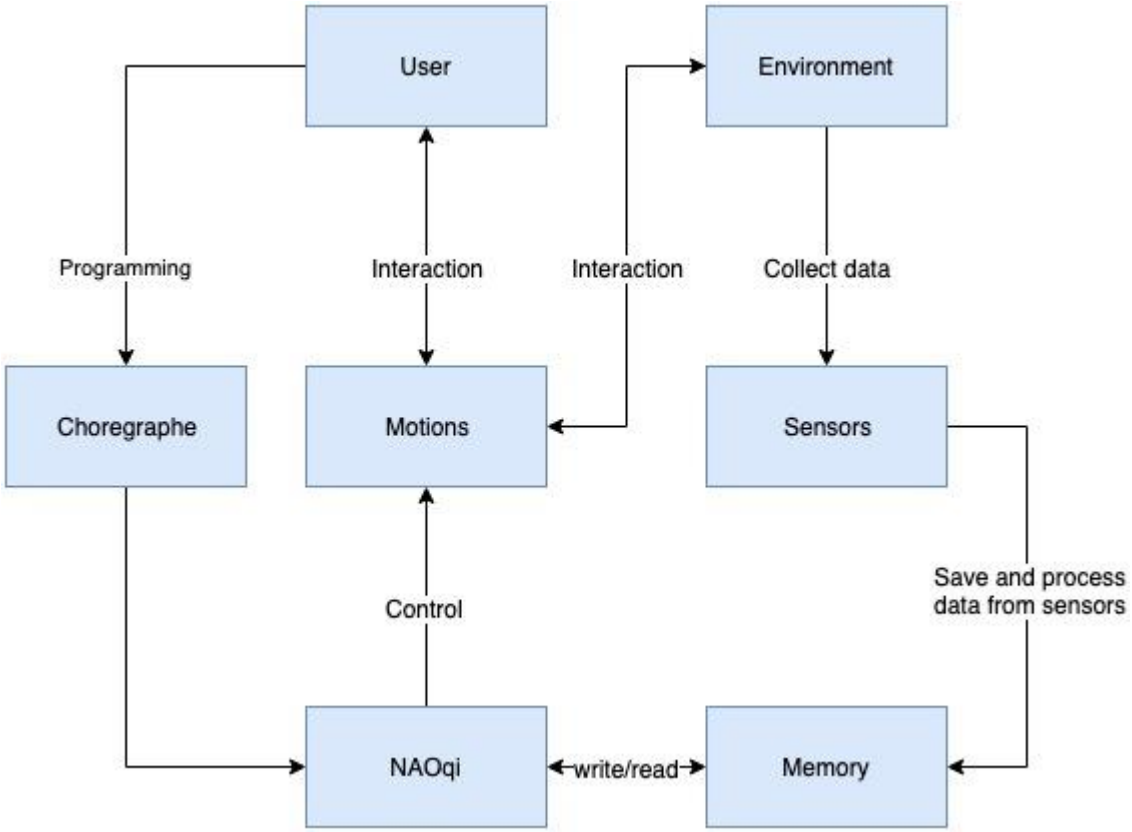


Project Name **NAO Bumblebee**

Team Lead: Chenlei Zhu
Team Member(s): Chenlei Zhu, Ljina AL Muharrami
Faculty Advisor(s): Dr. Marius. Silaghi, Dept. Of Computer Engineering and Sciences, Florida Institute of Technology

Project Description: The NAO Bumblebee project is based on the robot NAO, which is an autonomous, programmable and humanoid robot developed by Aldebaran Robotics. The robot could be programmed to execute orders from human, for example, moving from point A to point B. Although the robot is humanoid, the performance is limited due to its hardware constraints. For example, the robot cannot go through a locked door if the door appears in its routine. To finish its mission, the robot needs help from human. The goal of this project is to enable the robot NAO to find human proactively and ask for help when meet obstacles along its designated routine. The team implemented it by using face detection and sound localization. Once the robot needs help, it should start detecting nearby human faces and human voices and then try to localize them. Once the robot localize a nearby human, it should go approach this person and ask for help.

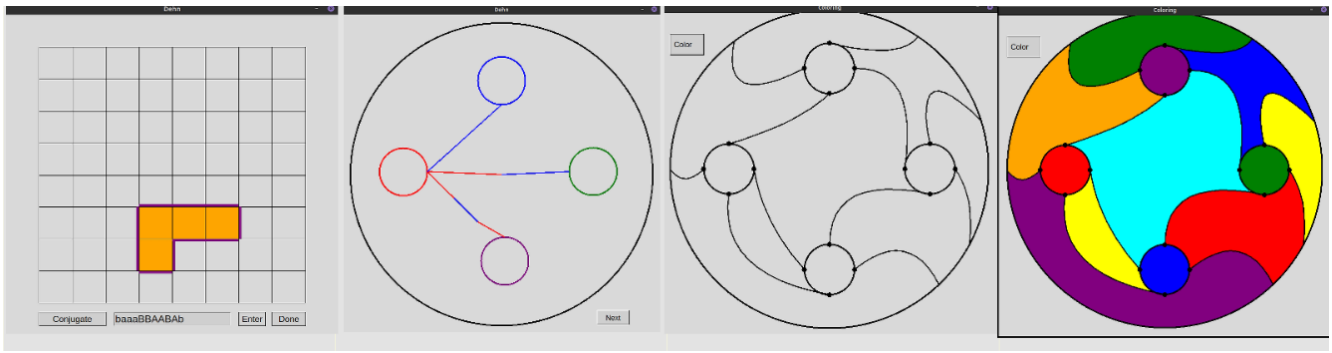
System Architecture:



Project Name	**Word Processing of Groups**
Team Lead:	Steven Cheswick
Team Member(s):	Natasha Bowman, Steven Cheswick, Matt Mayer, Ian Sprole
Faculty Advisor(s):	Dr. Keith B. Gallagher Dept. Of Computer Engineering and Sciences, Florida Institute of Technology

The goal of this project was to take the mathematical description on Word Processing of Groups, laid out in the text "Word Processing of Groups", and create a computer program capable of stepping a user through the process with the goal of ultimately creating stained glass designs as the final output. The program is designed to have four stages. Firstly, Dehn Diagram and conjugate creation, where the user manipulates a grid to create the "word" associated graph, along with conjugate definitions. The second stage is the automatic creation of the bouquet of conjugates graph, where the user can manipulate the edges and vertices of the graph for aesthetic purposes. Next, the minimization step is an interactive process where the user will reduce redundant information within the graph and apply transformations defined within the text. Finally, the recoloring stage, during which the user can add color to the product, thus mimicking the look of stained glass.

Design challenges revolved around two main points, lack of technical ability and resources for programming graphical elements in the Python language, and a lack of explanations, within the text or otherwise, for certain steps in the underlying mathematics. The main portion of the program was built upon the graphics.py library. Unfortunately, this library is very limited and did not provide some core functionality required to complete the project. To provide support for these missing functionalities, the team extended and modified parts of the TKinter library into graphics.py. This was a natural solution to the important missing functionalities, as graphics.py itself was built upon TKinter. Other challenge, such as recoloring, required finding new libraries that would be usable within the constraints of graphics.py. The success of implementation will be gauged by assessing new users ability to use the program with little to no knowledge of the underlying mathematics.

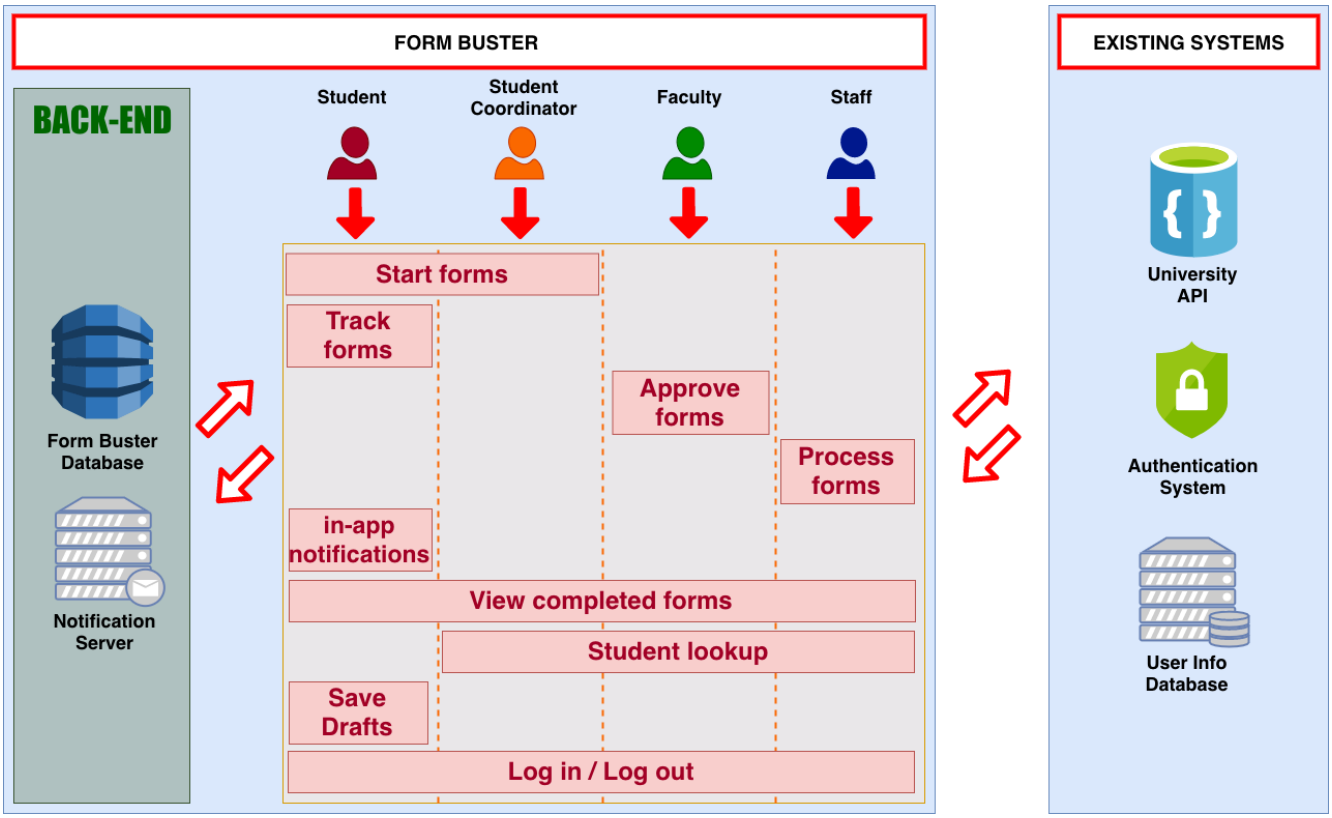


Project Name	**Form Buster**
Team Lead:	McNels Sylvestre
Team Members:	Grace Dolphy, Raphael Setin, McNels Sylvestre
Faculty Advisor:	Dr. Eraldo Ribeiro, Dept. Of Computer Engineering and Sciences, Florida Institute of Technology

Form Buster's main goal is to improve the current form process which requires physical forms to be transferred in between departments manually. The issues that arise from the manual process are that students do not know the status of the form, which staff members need to sign the document, and when to find a good time to visit the staff member.

Form Buster offers novel features such as forms tracking and automatic routing of forms based on approvers. Users can access a friendly interface where they perform actions such as submit and track forms, approve or decline forms, receive forms-related notifications, and student form records look-up among others. The system is designed to be easily interoperable with existing authentication systems and databases.

A feedback survey revealed that 88.4% of the potential users thought Form Buster was better compared to FIT's current system, and 94.1% of them said they would recommend Form Buster over the current system. With the addition of more features such as live updates and mobile responsiveness, Form Buster could make the form processing system easier and more transparent at FIT and at other universities.



Electrical and Computer Engineering

Project Name	**Formula SAE Electric Charge Cart**
Team Lead:	Jacob Hamilton
Team Members:	Jacob Hamilton, Vincenzo Catanza, Adnan Al Sabagh, Anas Alddarwish, Trevaris Warren, Filip Dujmic, Zeyad Alwarthan, Sam Crocker, Dan Cantres, Sebastian D'Uva, Abdulaziz AlYahmadi
Faculty Advisor:	Dr. Kenneth P. Gibbs, Dept. of Computer Engineering and Sciences, Florida Institute of Technology

The Formula Electric Charge Cart project is the first step in establishing an all-electric Formula SAE team at Florida Tech. The project designed, tested, and manufactured both a waterproof and crash-hardened container called the Accumulator for the vehicle's batteries, as well as a charging infrastructure for the Accumulator. Formula SAE requires that the batteries are not charged on the vehicle, but instead on a charge cart. Because the accumulator moves between the vehicle and the cart, they all have common electrical and mechanical interfaces. Mechanically the accumulator is challenging because of:

- Structural integrity requirements
- Number, size, and placement of electrical components to meet high-voltage isolation rules
- Thermal design

The electrical work included design and integration of several boards for the accumulator which must be compatible with the charge cart safety circuit, the anticipated vehicle safety circuit, and the motor controller. The accumulator must also have separation of high voltage (HV) and low voltage (LV) systems as stated specifically by Formula SAE requirements. The accumulator also includes a complex Battery-Management System (BMS) that measures every cell voltage and which functions as a safety system during charging and discharging of the batteries.

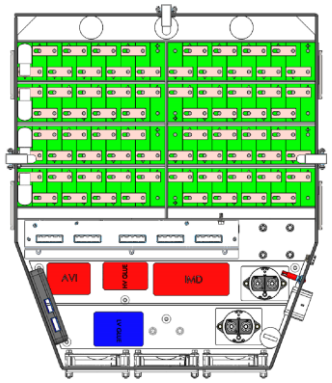


Figure 7: Top view of the accumulator

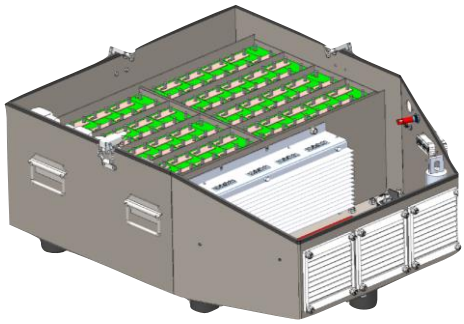


Figure 7: Oblique view of the accumulator

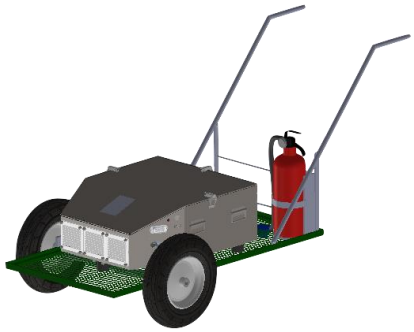


Figure 7: The accumulator on the charge cart

Project Name **Formula SAE OBD2 (On-Board Diagnostics 2)**

Team Lead: Ahmed Okasha
Team Members: Abdulrahman Alkaabi, Ahmed Okasha, Ebrahim Alnuaimi, Pan Cao
Faculty Advisors: Dr. Kenneth P. Gibbs, Dept. of Computer Engineering and Sciences, Florida Institute of Technology

This project is an essential tool for the SAE Formula Electric team, as it displays CAN-bus status messages from components on the vehicle and the charge cart. The system is divided into two subsystems, the physical display unit and the LabVIEW software that creates the user interface. The display unit is similar to a commercial OBD2 device; it attaches to the OBD2 port on either the cart or the vehicle. It has an internal PC-on-a-stick Azulle Access3, a 10.1" inch touchscreen, a USBCAN-Pro, and a battery pack. The Access3 runs LabVIEW to create the user interface, and to send and receive the logical CAN-bus messages. The USBCAN-Pro provides the actual CAN-bus physical interface for the display unit. The device acts as a diagnostic tool, receiving messages from an Electronics Control Unit (ECU) such as the BMS (Battery Management System) and showing them on the display screen. Each ECU encodes its messages into numbers and letters using a CAN-bus database. That database information is added to LabVIEW to make these messages understandable and useful. The ability to handle custom messages and ECUs makes this an essential tool for the Formula Electric team.

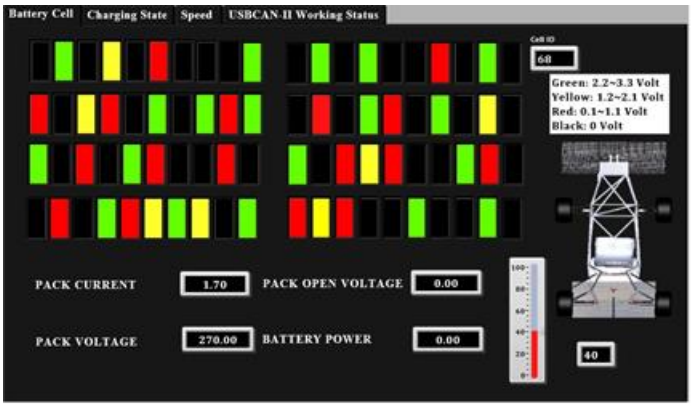


Figure 1: The User Interface using LabVIEW, displaying the states of each of the battery cells in the pack

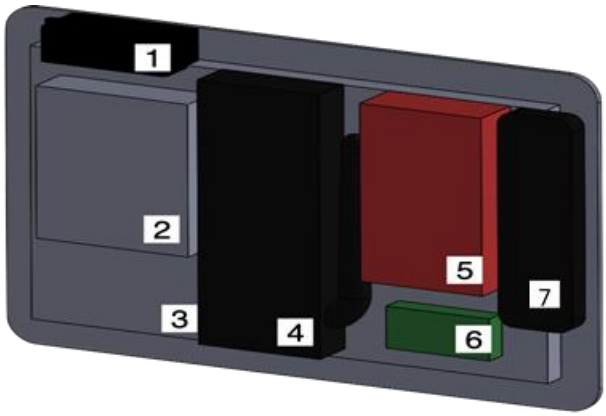
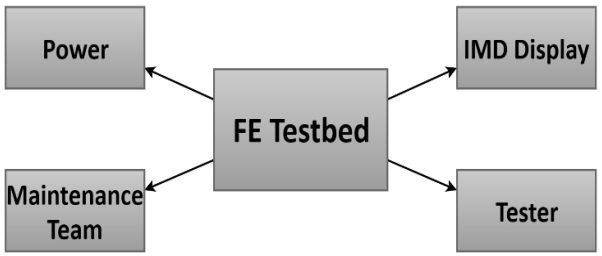
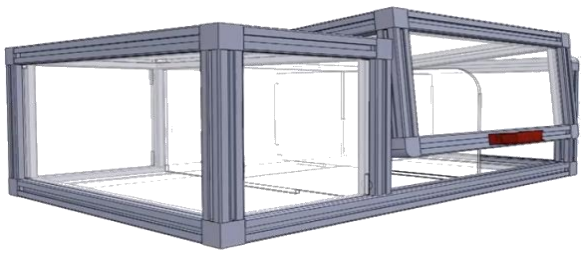


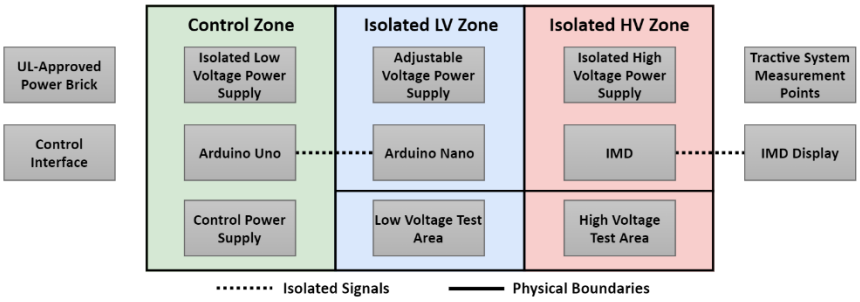
Figure 2: Components Used for the Display 1) Battery Reader and Power Switch; 2) Display Control Board; 3) Sunfounder 10.1" Display; 4) Azulle Access 3; 5) USBCAN Pro; 6) 5V, 12V Regulators 7) USB Hub

Project Name	**Formula SAE Electric Testbed**
Team Lead:	Justin Tomlin
Team Members:	Justin Tomlin, Shane McConkey, Elfaitouri Alhashmi, Hazem Almadani, Muath Hathah, Jaifar Al Anbari
Faculty Advisor:	Dr. Kenneth P. Gibbs, Dept. Of Computer Engineering and Sciences, Florida Institute of Technology

The Formula Electric (FE) Testbed project, along with the FE Charge Cart and FE CAN Bus projects, are the start of the Florida Tech Formula SAE Electric team. The FE Testbed suite consists of two pieces of testing equipment, the Testbed itself and the IMD Display. FE Testbed is an isolated container for the integration and testing of low-power, high-voltage components of the FE Charge Cart and eventually the FE vehicle. The FE Testbed is powered externally by a UL-approved power brick, similar to a laptop changer, and it produces an output of up to 300 volts for testing. Since the Testbed will produce a high voltage output similar to the FE Vehicle, both chassis contain a Bender Insulation Monitoring Device (IMD) that monitors the insulation resistance between the high-voltage and low-voltage systems. This device will shutdown the high voltage system when a loss of isolation occurs and will produce measurements encoded in a PWM waveform. The IMD Display is a handheld device that connects to the IMD in each chassis and decodes these PWM signals, verifying that the IMD has properly detected any faults in isolation. Both the vehicle and the testbed contain shrouded Tractive System Measurement Points (TSMPs) where a loss of isolation can be simulated to verify IMD operation. In this way the Testbed suite also supports training of FE team members in high-voltage safety procedures. Figure 1: High Level Block Diagram







Project Name	**IEEE SECON Robot**
Team Lead:	Nathan Kilgus
Team Members:	Gabrielle Pelletier, Frank Savino, Nam Anh Nguyen Tang, Tseganesh Menore, Mmusi K. Motsumi, William Harrington
Faculty Advisors:	Dr. Kenneth P. Gibbs, Dept. of Computer Engineering and Sciences, Florida Institute of Technology

The IEEE SECON Robot is a fully autonomous robot built for the 2019 Student Hardware Competition in Huntsville, Alabama on April 12th. The objective is to score points by performing autonomous tasks within an 8' x 8' field during the three minutes allotted. The robot will execute two consecutive phases during the competition sequence: the orbital phase and the collection phase.

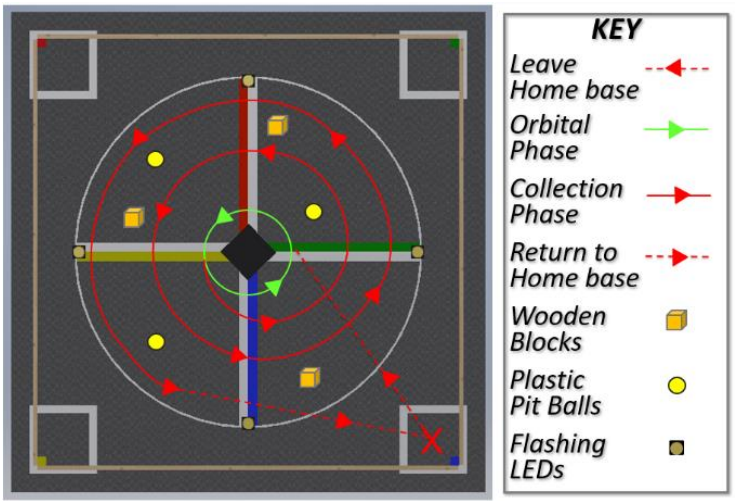


Figure 8: The Robot's Path on the 8' x 8' Field

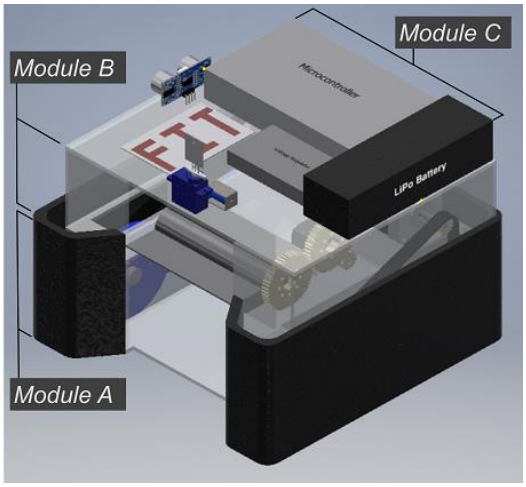


Figure 9: The IEEE SECON Robot

The robot's design consists of three seperable modules: Modules A, B, and C. Module A is comprised of the collection bay for debris storage, a neoprene bumper, and four disk wheels with mounted pulley mechanisms. Module B consists of two NEMA 17 motors which provide the robot with tank drive propulsion via timing belts connected to the pulleys. Module C contains the Gen MKS microcontroller board which controls all of the robot's functions. Module C also contains the 14 V LiPo battery which powers the robot, the LIDAR sensor and its servo, the ultrasonic sensor, the solenoid for raising the Florida Tech flag at the end of each round, and a voltage regulator. The robot's software is written entirely in C++, and is programmed to execute the phases in Figure 1 while counting orbits and maintinaing optimal proixmity from the center post.

Project Name	**Intelligent Ground Vehicle Competition (IGVC)**
Team Lead:	Nick Sutphin
Team Members:	Nick Sutphin, Zezhou Zhang, Zhizhao Miao, Jiayin Lu, Hung Tran, Renjie Liang, Alex Hsieh, Zhaolun Yu, Xinyuan
Faculty Advisors:	Dr. Kenneth P. Gibbs, Dr. Marius Silaghi, Dept. of Computer Engineering and Sciences Dr. Matthew J. Jensen, Dept. of Mechanical and Civil Engineering, Florida Institute of Technology

The Intelligent Ground Vehicle Competition, or IGVC, is an annual competition held in Michigan. The IGVC robot is an autonomous robot that can travel between lane markers and avoid obstacles, while navigating between GPS waypoints. Vehicles that complete the course are judged by their completion time; vehicles that do not complete the course are judged based on their maximum distance traveled. Robots receive "tickets" that result in time or distance penalties for failures such as crashing into or displacing an obstacle, blocking traffic, or crossing a lane marker. Some tickets end the robot's run through the course.

This year's team re-worked the chassis to make multiple improvements. The mechanical upgrades included a camera mounting system that can be removed for robot transport. It is a dual-post system based on a vibration analysis. The robot was also made more water-resistant with improved access doors, and an improved e-stop mounting. The electrical upgrades improve the reliability of the robot by moving to printed circuit boards and generally improving the wiring harness and the fusing. The software upgrades include an improved messaging framework between the software subsystems shown in Figure 1.

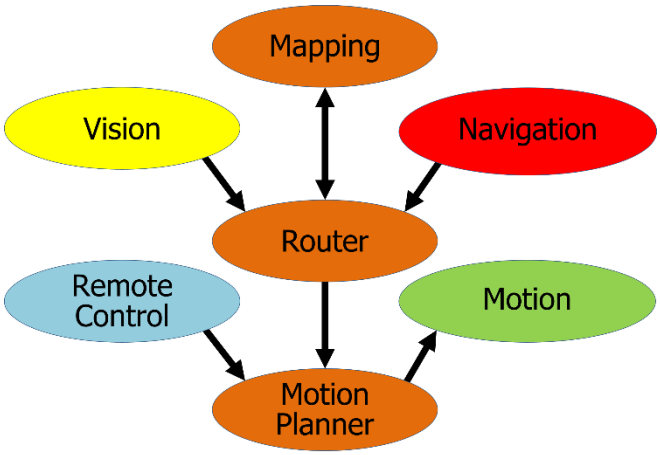


Figure 1: Subsystems diagram

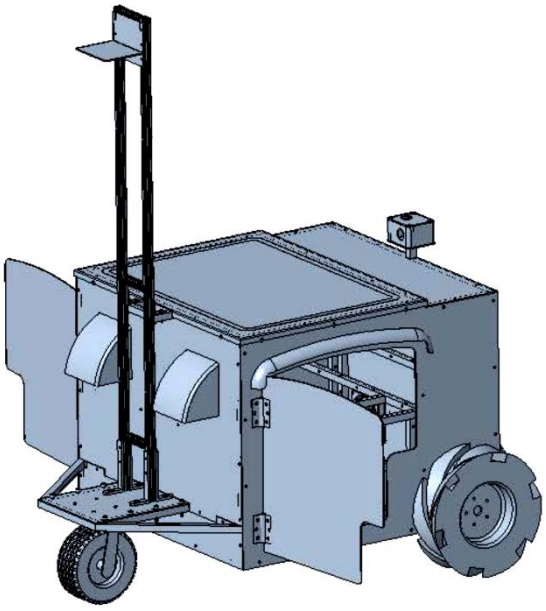


Figure 2: CAD model of the robot

Project Name	**Lionfish Remediating Invasion Device**
Team Lead:	Micah Billouin
Team Members:	Micah Billouin, Guilherme Bueno Dorea, Jason Pack, Godwyll Aikins, Chenyu Wang
Faculty Advisors:	Dr. Ken Gibbs, Dr. Anthony Smith, Dept. Of Computer Engineering and Sciences, Dr. Matthew Jensen, Dept. of Mechanical and Civil Engineering, Florida Institute of Technology

Since their introduction in 1985, the invasive lionfish has caused significant damage to the marine environment in the Atlantic, Caribbean, and parts of the Gulf of Mexico. To reduce the lionfish population, numerous removal methods have been attempted, but none have been truly effective in curbing the population boom. We developed an automated Remediating Invasion Device (RID) to operate during peak lionfish activity hours. The RID runs for a period of up to one week, or until 30 adult lionfish have been captured, after which it is brought up to the surface for maintenance. The RID is placed at a depth of 100 ft., a common depth for lionfish activity. The entire system is controlled by an Arduino Microcontroller (called the Master Controller), which determines which state the system is in, and the next transition the system should make. The Master Controller transfers control of the RID between three different subsystems: the Visual Recognition subsystem, the Fish Detection subsystem, and the Mechanical subsystem. The Mechanical subsystem is made up of two gates, one at the entrance of the RID and one at the center. The gate at the entrance of the RID ensures that we only have to perform visual recognition on one fish at a time. The gate at the center of the RID directs the fish throughout the RID. Infrared Break Beam Sensors, part of the Fish Detection subsystem, track the movement of fish throughout the RID. When a fish enters the RID, a Raspberry Pi, part of the Visual Recognition subsystem, takes an image of the fish and then executes a machine learning algorithm to determine whether the fish in the RID is a lionfish. The label computed by the Raspberry Pi determines if the fish is then captured (if it is a lionfish) or released back to the ocean. Images captured by the visual recognition system are stored on a USB flash drive for later studies. Our solution provides a more efficient method of reducing the lionfish population.

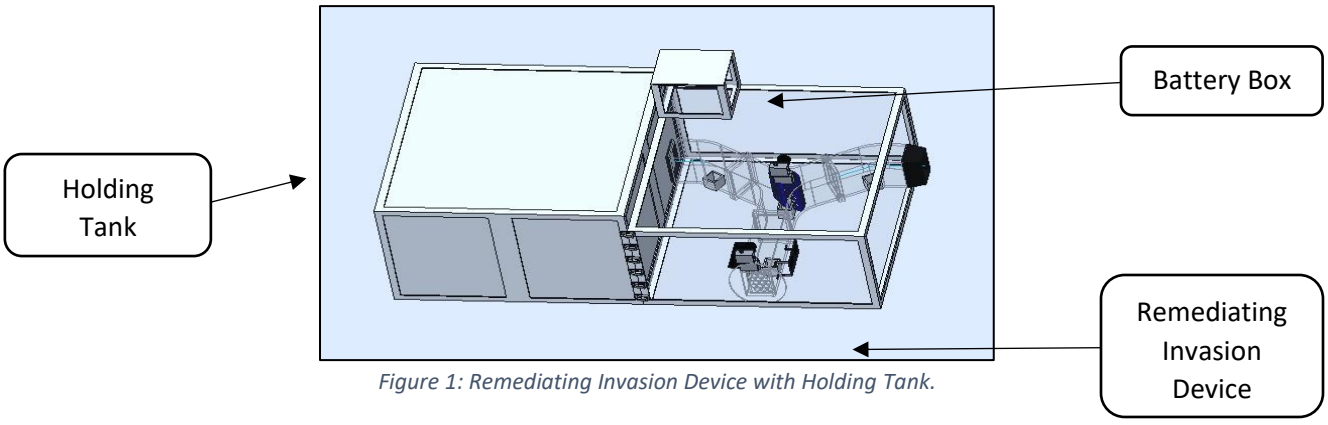


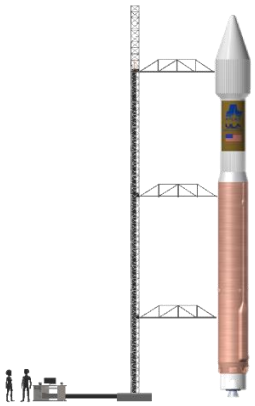
Figure 1: Remediating Invasion Device with Holding Tank.

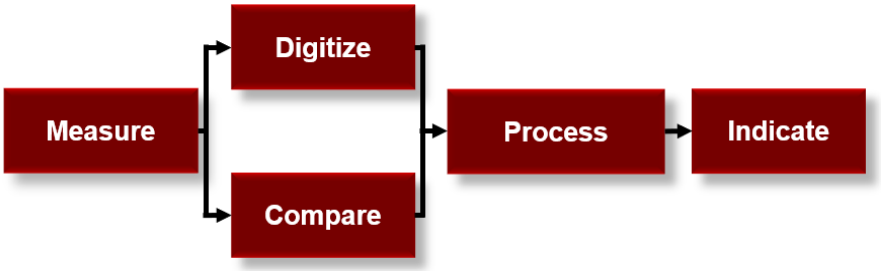
Project Name	**Networked Electrical Test System (NETS)**
Team Lead:	Ryan Riley
Team Members:	Samantha Highfield, Michael Piazza, Ryan Riley
Faculty Advisors:	Dr. Kenneth P. Gibbs, Dept. Of Computer Engineering and Sciences, Florida Institute of Technology

The Networked Electrical Test System (NETS) is a distributed voltage and current measurement system which validates the functionality of pulse-trigger generating circuits and makes the results available over a local area network. This system replaces an existing measurement system used by United Launch Alliance (ULA). It improves their current system by increasing measurement capabilities and by providing the requisite data in an easily distributable and scalable way. The system measures firing pulses up to 18 Amps lasting for up to 200 milliseconds. All hardware interfaces withstand at least 32V between any two points without incurring damage.

NETS consists of multiple "nodes". Each node contains a microcontroller, a configurable resistive load, and voltage and current sensors. A node is connected to a Power over Ethernet (PoE) switch by means of a single ruggedized network cable. This cable provides both power and communications to the node. Data and telemetry are collected, aggregated, and then leave the node as a stream of User Datagram Protocol (UDP) packets. These packets are received by client machines connected to the same network. Nodes are commanded by sending specific Transmission Control Protocol (TCP) packets from a client terminal.

This system is scalable to a large number of nodes. It is platform agnostic and devoid of specialized hardware; it can therefore be easily modified to suit a variety of different voltage or current sensing applications.





Project Name **RESPEM: Respiratory Monitor**

Team Lead: Ryan Clark
Team Members: Yousef Alyami, Fahad Alkhathami, Samudith Kumarasinghe
Faculty Advisor: Dr. Kenneth P. Gibbs, Dept. of Computer Engineering and Sciences, Florida Institute of Technology

Wearable monitoring systems for respiratory rate which rely on measurements through the skin vary in accuracy and comfort. RESPEM is a low-cost, non-intrusive method that measures respiratory rate using a fundamental property of fabrics coated with conductive polymers. Specifically, the resistivity of the fabric changes as it stretches. The monitor uses two strips of resistive fabric attached to a vest on either side of the chest. The two fabric strips form two legs of a Wheatstone bridge. The bridge output is monitored by a differential analog-to-digital converter which communicates with the onboard microcontroller using I^2C. The microcontroller runs an autocorrelation function to resolve the subtle periodicity of the user's chest movements and return a lag value that is converted into breaths per minute. The autocorrelation function was selected as the low-level signal processing method because it does not require a lot of computational power or time to process the data. The project in its current iteration focused on the viability of the measurement technique with limited development on the multitude of methods for display, control, and notification regarding the measured signal. This sub-system can easily be integrated into larger systems for athletic, biomedical, or even animal husbandry fields of research.

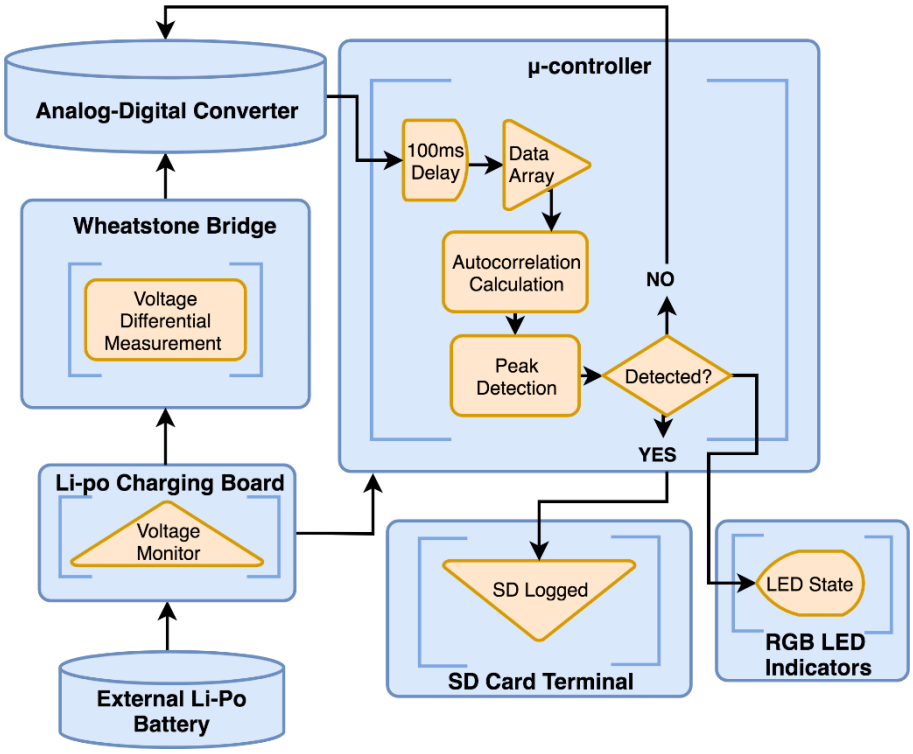


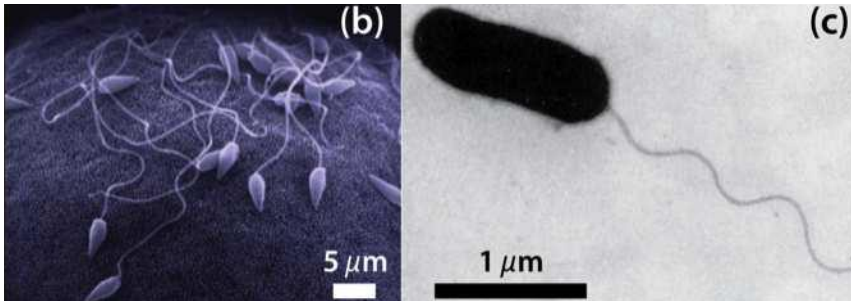
Figure 1: RESPEM System and Subsystem Flowchart

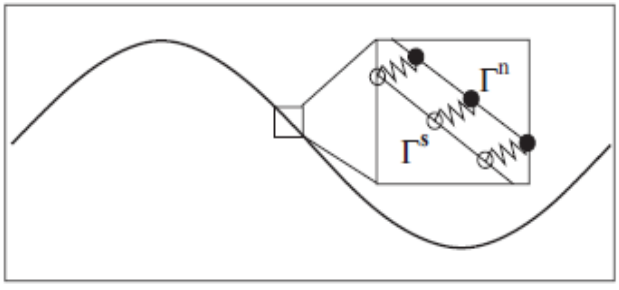
Mathematical Sciences

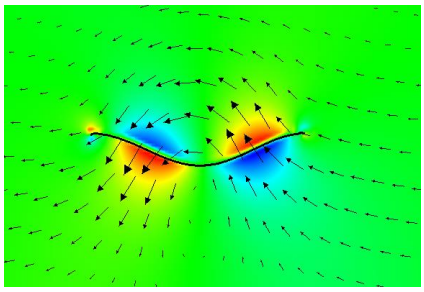
Project Name **Locomotory Response of Undulatory Swimmers in Two-Phase Biogels**

Team Member: Bindi Mahesh Nagda
Faculty Advisor(s): Dr. Jian Du

Project Description: Many important biological functions depend on microorganisms' ability to move in viscoelastic fluids such as mucus and wet soil. An investigation of the effects of swimming gait and fluid elasticity on the locomotion of a swimmer in a viscous, low Reynold's number two-phase fluid is performed. In order to capture the coupled fluid-structure interactions, an extension of the classical immersed boundary method was developed by Du *et al*. The IB method employs both Eulerian coordinates and Lagrangian coordinates. Upon discretization, these two kinds of variables are defined on a fixed Cartesian grid and moving curvilinear grid, respectively. These grids are linked together using a 4-point smoothed approximation to the Dirac Delta function. The numerical simulation developed here uses a 192 × 128 computational grid in the domain [-1.5, 1.5] × [-1, 1]. The boundary condition in the x-direction is periodic and that at $y = \pm L$ is no-slip. The swimming speed is calculated by averaging the x velocity over all the immersed boundary points over one wave period. Results obtained indicate that swimming speed is dependent on type of swimming stroke, with the kicker swimming speed being substantially higher. It is also observed that elasticity of polymer slows swimmer down.



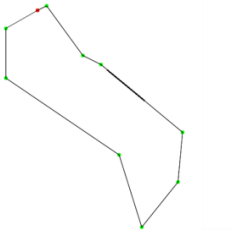




Project Name **An Efficient Genetic Algorithm and User-Friendly Software to Solve the Traveling Salesman Problem**

Team Member(s): Paul Arbic
Faculty Advisor(s): Dr. Munevver Mine Subasi,
Department of Mathematical Sciences, Florida Institute of Technology

Project Description: The Traveling Salesman Problem (TSP), introduced in the 18th century by Hamilton, is one of the most intensively studied NP-complete problems. TSP's can be applied to various real-world problems, such as routing, drilling of printed circuit boards, gas turbine engines, transportation, and telecommunication networks. Since the problem is of practical importance and computationally challenging, several research efforts are channeled to developing efficient and effective techniques for its solution. These methods vary from more efficient but less effective greedy-type heuristics to more sophisticated algorithmic approaches, including genetic algorithms inspired by Darwin's theory of natural evolution. In this project we develop a genetic algorithm for solving the TSP. Our algorithm is hard-coded in PHP, JavaScript, and HTML. As such, the program runs primarily in a standard internet browser. The proposed algorithm uses sixteen weighted variables, including present position, average distance of other points, number of selected and unselected points, and a bias. We test our algorithm on several datasets. We analyze the benefits and shortfalls of genetic algorithms and demonstrate how an effective solution can be found to most, if not all, optimization problems using limited data and information. We then perform a detailed analysis of the computational results.



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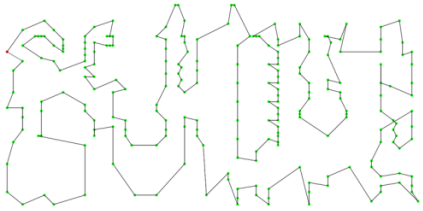

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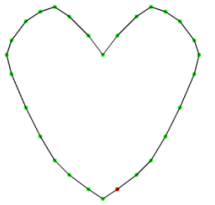


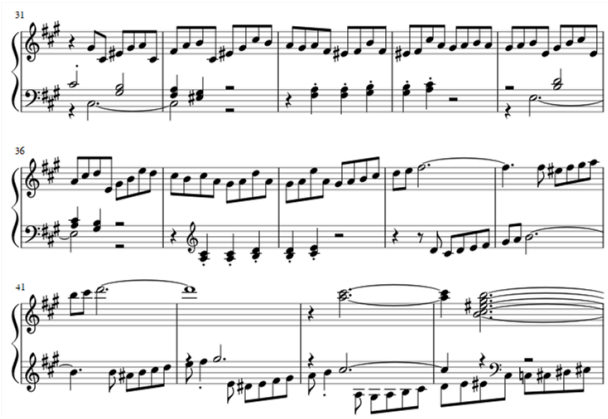
Heart

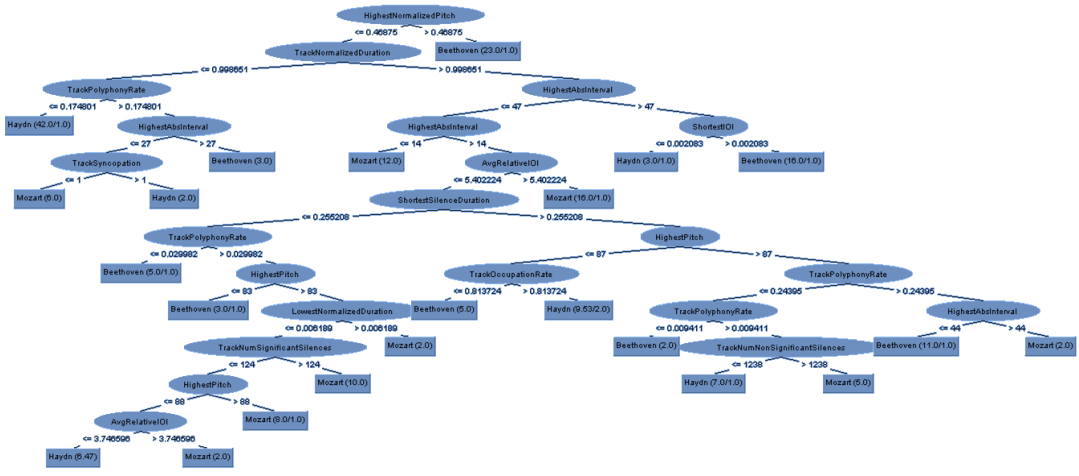
Set 3

Project Name **Identification of Style-Markers and Composer Attribution in Classical Music**

Team Member(s): Shelley Mitchell
Faculty Advisor(s): Dr. Munevver Mine Subasi,
Department of Mathematical Sciences, Florida Institute of Technology

Project Description: Stylometry is the quantitative study of literary style. It is based on the observation that authors tend to write in relatively consistent, recognizable, and unique ways. In this project, we investigate the current approaches in stylometric analysis and apply machine learning methodology to identify style-markers and composer attribution in classical music. Over 200 works from three classical composers of the late 18th and early 19th centuries (Beethoven, Haydn, and Mozart) were gathered from an online archive and downloaded as MIDI (Musical Instrument Digital Interface) files. These were then converted to ARFF (Attribute Relation File Format) files using software called ARFF Extractor. This program extracted data from the compositions concerning notes, pitches, rhythms, silences, intervals, and so on. The data was then organized into four data sets: one for each pairing of composers, and one containing data for all three composers. These data sets were then analyzed using the Waikato Environment for Knowledge Analysis (WEKA). A Support Vector Machines classifier was used for feature selection to identify the best style-markers of the musical compositions; these style-markers helped differentiate the composers' works. We ran 10x10-folding cross-validation experiments for six well-known supervised learning algorithms to test the prediction of the three composers' attribution based on the top style-markers.





Project Name **Mapping Genetic Sequences – Theory & Application**

Team Member(s): Gyorgy Halo
Faculty Advisor(s): Dr. Munevver Mine Subasi,
Department of Mathematical Sciences, Florida Institute of Technology

Project Description: A reliable and traceable method based on linear algebra to compare and contrast genomic sequences was developed by Randić et al. 1 (2000). His mapping technique stores exons of the genomic map in a matrix to represent the nucleic acid bases by their totality. In this research we adopt Randić's approach and apply it to full mitochondrial genome of the Human Neuroblastoma Cell Line 751-NA to compare a cancerous genotype sequence with a noncancerous genotype sequence. The mapping technique proposed by Randić et al. (2000) proved to be a valuable tool to compare large sets of DNA sequences together. Genetic analysis techniques could be made easily with a superimposed DNA graph so any mismatches between any two DNA sequences could immediately be recognized. Either comparing different species genomic sequences with same function, or comparing a disease causing gene sequence to a healthy genotype could be inspected without any degree of degeneracy on the graph. Applying such a computational tool in clinical research is a valuable technique that could save time and if time matters then it could eventually save life as well.

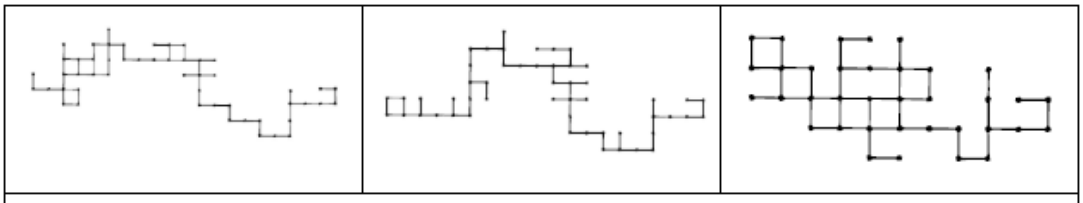


Figure 2. The figure shows the visual representation of the human, goat, and opossum (from left to right on the image) β-Globin exons.

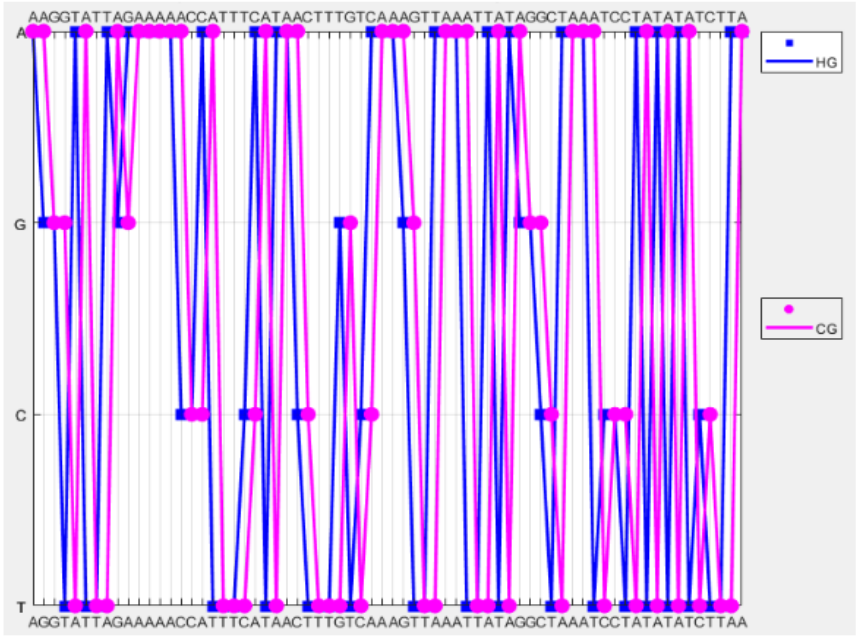
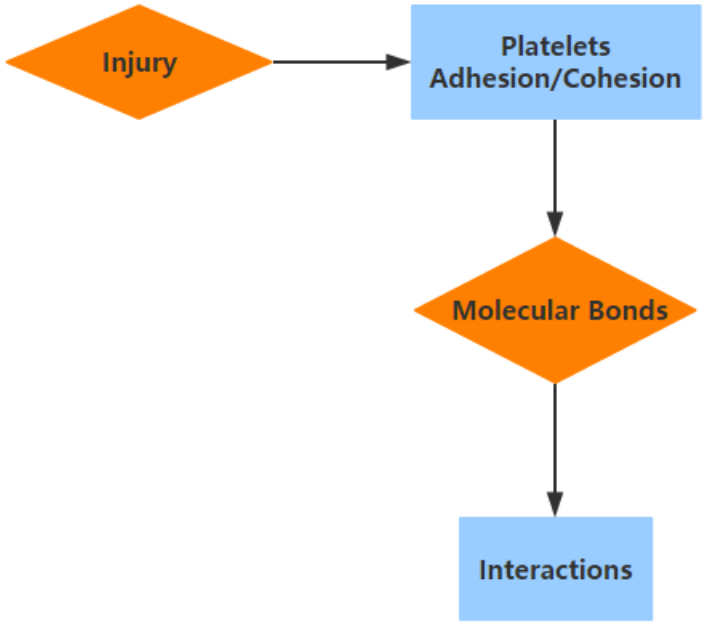


Figure 7. The image shows the cancerous and healthy mitochondrial DNA genes from nucleic acid base pairs of 7519 to 7586. On the image, the upper part of the gene sequence is the cancerous genetic sequence that runs on the graph in pink, while the lower part of genetic sequence represents the healthy genetic sequence that runs on the image in blue.

Project Name **Computational Modeling of Blood Clot**

Team Member(s): Rui Huang
Faculty Advisor(s): Dr. Jian Du

We present a two-phase model of platelet aggregation in coronary-artery-sized blood vessels. The model tracks the number densities of three platelet populations as well as the concentration of a platelet activating chemical. Through the formation of elastic bonds, activated platelets can cohere with one another to form a platelet thrombus. Stresses produced by the elastic bonds act keep the bound platelets at the injury site. Movement of the bound platelet material and that of the background fluid are coupled through an interphase drag. Computational results from the computational model indicate that through complicated fluid-structure interactions, the platelet thrombus can develop significant spatial inhomogeneities and that the amount of intraclot flow may greatly affect the growth, density, and stability of a thrombus.



Project Name **Optimal Control of Genetic Network with Bistable Switch**

Team Lead: Sally Anderson
Team Member(s): Sally Anderson
Faculty Advisor(s): Dr. Jonathan Goldfarb, Dept. of Mathematics, Florida Institute of Technology

In systems biology, parameters must be identified within the mathematical framework. In the genetic network with bistable switch model, Protein A (P_a) and Protein B (P_b) act in competition to repress one another. This action is similar to an electrical circuit, where there is a high or low state between the two components. The inducer, I(t), is the intermediate which acts to suppress Protein A in relation to Protein B, and vice versa. The corresponding mathematical model is a system of ordinary differential equations (ODEs) with unknown parameters, which forms the inverse problem. By linearizing the system, a Fréchet gradient can be found, giving an appropriate search direction for the optimal control u(t). The application of this model would be particularly useful in understanding the behavior of cancer in the proliferation of malignant tumor cells.

Inverse Problem: Given the mathematical system that represents the bistable switch:

$$\dot{P}_a = f^a(P_a, P_B, u), \quad P_a(t_0) = P_(a_0), (t_0 \le t \le T)$$
$$\dot{P}_b = f^b(P_a, P_b, u), \quad P_b(t_0) = P_(b_0), (t_0 \le t \le T)$$

$$f^a(P,u) := \frac{\alpha}{1+(uP_b)^n} - P_a$$
$$f^b(P,u) := \frac{\alpha}{1+(P_a)^n} - P_b \qquad u = u(t) = \frac{\beta}{1+(I(t)/k)^m}, (t_0 \le t \le T)$$

where f^a is (1) and f^b is (2)

Formulation of Variational Problem: Find the control parameter u(t) that brings the genetic network to the desired state $P* = \vec{P}* = (P_a*, P_b*)$. Consider the minimization of the functional $J_N(u_N) = ||P_N(T;u_N) - P^*||^2$. Minimizing the functional is equivalent to driving the system to the desired state. The functional is defined on the control set $D = \{u \in L_\infty(t_0,T),\ 0 \le I(t) \le M,\}$ and the state vector $P(\bullet, I) = (P_a(\bullet, I), P_b(\bullet, I)) : [0,T] \to \mathbb{R}^2$ solves the system (1) and (2). The linearization of the system of equations is necessary to address the ill-posedness of the inverse problem (i.e. the problem may not have a solution, or the solution may not be unique, or the solution is unstable.) The Jacobian matrix and sensitivity matrix are derived in this process:

$$J(P,u) := \begin{bmatrix} f^a_{P_a} & f^a_{P_b} \\ f^b_{P_a} & f^b_{P_b} \end{bmatrix} = \begin{bmatrix} -1 & \frac{-\alpha n u^n (P_b)^{n-1}}{(1+(uP_b)^n)^2} \\ \frac{-\alpha n (P_a)^{n-1}}{(1+(P_a)^n)^2} & -1 \end{bmatrix} \qquad U(P,u) := \begin{bmatrix} f^a_u \\ f^b_u \end{bmatrix} = \begin{bmatrix} \frac{-\alpha n u^{n-1}(P_b)^n}{1+(uP_b)^n} \\ 0 \end{bmatrix}$$

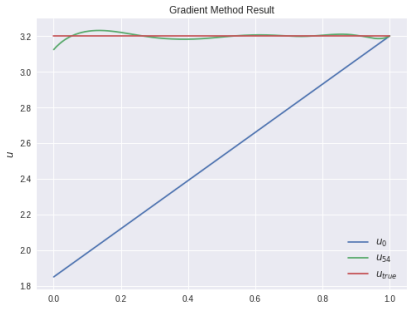
Quasilinearization: Fix $P_0 = (P_0^a, P_0^b)$ and u_0; for N=1, 2, … the linearized state P_N is given by

$$\dot{P}_N := f(P_{N-1}, u_{N-1}) + J(P_{N-1}, u_{N-1})\Delta P_N + U(P_{N-1}, u_{N-1})\Delta u_N$$

The gradient update is calculated according to

$$u_N(t) = u_{N-1}(t) - \alpha J'_N(u_{N-1})(t) \text{ where } \dot{\psi}(t;u) := -J^T(P,u)\psi(t;u) + 2\begin{bmatrix} P_a(t,u) - P_a^* \\ P_b(t,u) - P_b^* \end{bmatrix}, \quad \psi(T) = 0, (t_0 \le t \le T),$$

$$J'_N(u_N)(t) = \frac{-\alpha n u_N^{n-1}(P_N^b)^n}{1+(uP_N^b)^n}\psi^a(t)$$



Conclusion

By finding the optimal control parameter u, the genetic regulatory network with bistable switch can be implemented in causing Protein A and Protein B to be switched from their high to low states, respective of each other. A quasilinearization and variational formulation due to Dr. U. Abdulla is used to address the ill-posedness of the nonlinear inverse problem and facilitates the calculation of the Fréchet Gradient. In this formulation, the system is solved iteratively to move the control u(t) in a search direction that minimizes the functional. The numerical results show that this method gives a reasonable result given a distant initial approach. In future work, this method can be developed to encompass larger systems of ODEs and the convergence improved through higher-order methods. In particular, the modeling of cancer propagation would greatly benefit by the knowledge gained from this mathematical model.

Project Name	**Bayesian statistics using a deep learning approach**
Team Lead:	Mahmoud Saad Abouamer
Team Member(s):	Jiri Kapralek
Faculty Advisor(s):	Dr. Nezamoddin N Kachouie

Project Description: The goal of this research to develop a Bayesian approach using deep neural networks, specifically convolutional neural networks and recurrent neural networks. We train a Markov chain Monte Carlo (MCMC) parametrized by deep neural networks that converges and mixes quickly to target distribution. This is a generalization of Hamiltonian Monte Carlo, which is successful at sampling more challenging distributions such as strongly correlated Gaussian and mixture of Gaussian distributions. Based on data augmentation, a population estimation model is developed where MCMC is used to obtain the posterior distribution of population size.

Graphics:

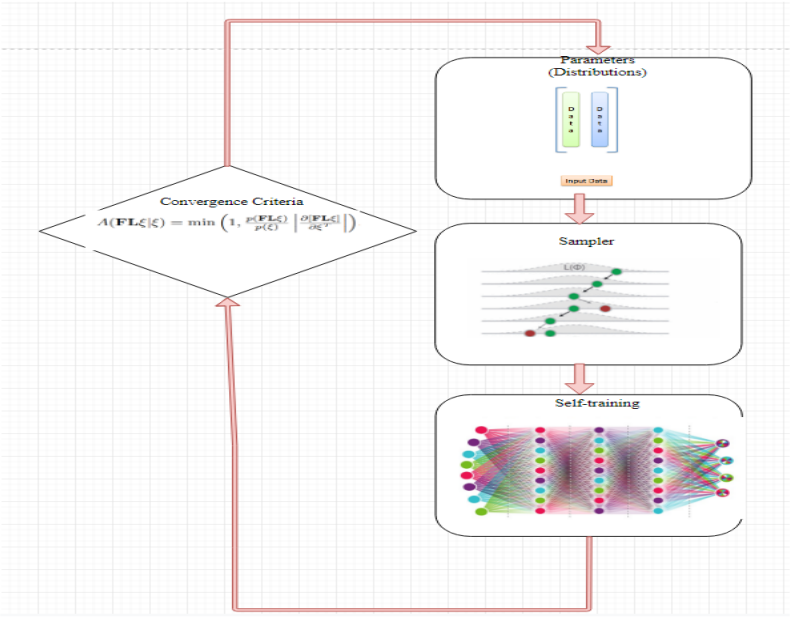


Figure 1: Schematic for the algorithm

Figures 2 and 3 show Samples obtained from two challenging distributions:

Strongly correlated Gaussian (SCG): We rotate a diagonal Gaussian with variances [100, 0.01]] by π/4.

Mixture of Gaussians (MoG): Mixture of two isotropic Gaussians with variance = 0.1, and centroids separated by distance 4.

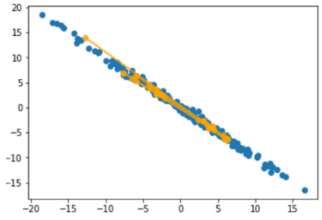


Figure 2 : SCG samples (yellow)

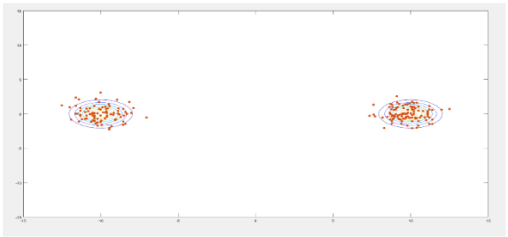
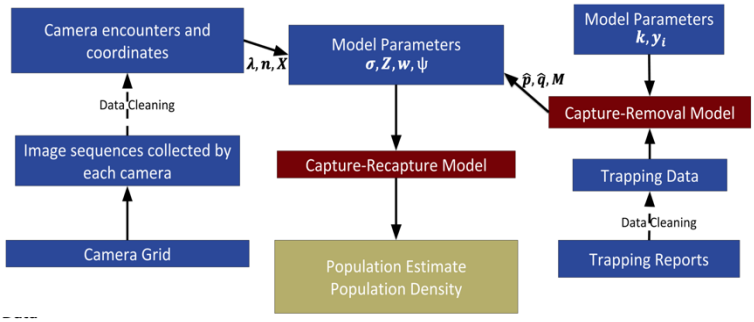


Figure 3 : Samples obtained from MOG

Project Name **A Hybrid Bayesian Spatiotemporal Model for Population Analysis**

Team Member: Elizabeth Kurkowski
Faculty Advisor: Dr. Nezamoddin N. Kachouie, Dept. of Mathematical Sciences, Florida Institute of Technology
Dr. Brean Duncan, KSC Ecological Program of NASA

Figure 1: Diagram of analysis flow



The goal of this research is to develop a Bayesian framework to design a generic spatiotemporal model for estimation of probability distribution of population size. Hogs are an invasive species and an increasing problem in Florida. We use the proposed spatiotemporal Bayesian model to estimate the number of hogs in the Merritt Island and Kennedy Space Center Refuge to best gauge population control effectiveness. The data for the capture removal analysis was obtained from NASA. This data was reported by hunters in the area and included hog count, gender, and weight as well as the date captured ranging from 2004 to 2017. The data for the capture-recapture analysis was collected using CCD cameras over the course of several weeks, covering roughly 10% of the entire unit. The camera encounters were then obtained using captured image sequences.

Capture-Removal: Haynes Method

To estimate population, we plot y_i, the number caught in i^{th} trapping, versus the previous total catch up until the i^{th} trapping. Then we use linear regression to estimate total population $\widehat{N}$ as the x intercept and the probability of capture, p, as the slope of the line.

Capture-Removal: Multinomial Method

Multinomial regression was used to estimate a population size over two month periods. Then, a distribution was estimated from the results. This distribution was used to estimate an initial value for the number of added zeros, M. The following equations were used in order to estimate the population using k trappings and y_i animals caught in i^{th} trapping –

$$\widehat{N}=\frac{T}{(1-\hat{q}^k)},\quad R=\frac{\hat{q}}{\hat{p}}-\frac{k\hat{q}^k}{(1-\hat{q}^k)}=\frac{\sum_{i=1}^{k}(i-1)y_i}{T}$$

Capture-Recapture: Spatial Temporal Model

This method is a Bayesian posterior density estimation that estimates the posterior probability distribution of population size given multiple unknown parameters. We use Monte Carlo Markov Chains (MCMC) and Gibbs sampling in order to estimate the posterior distribution:

$$[\boldsymbol{z},\ \boldsymbol{w},\ \boldsymbol{s},\ \psi,\ \lambda_0,\ \sigma|\boldsymbol{n},\ \boldsymbol{X}] \propto \left\{\prod_{\boldsymbol{i}=\boldsymbol{1}}^{\boldsymbol{M}}\left\{\prod_{\boldsymbol{j}=\boldsymbol{1}}^{\boldsymbol{J}}\prod_{\boldsymbol{k}=\boldsymbol{1}}^{\boldsymbol{K}}[n_{\boldsymbol{jk}}|z_{\boldsymbol{ijk}}][z_{\boldsymbol{ijk}}|\boldsymbol{s_i},\ \sigma,\ \lambda_0]\right\}[w_{\boldsymbol{i}}|\psi][\boldsymbol{s_i}]\right\}[\psi][\lambda_0][\sigma]$$

Project Name	**Spatiotemporal Bayesian Framework for Estimating Population Size**
Team Lead:	Robert Breininger
Team Member(s):	Dylan Keuthan, Mohamed Jaber
Faculty Advisor(s):	Dr. Nezamoddin N Kachouie, Dept. Of Mathematical Sciences, and Dr. Rob van Woesik, Dept. of Biological Sciences Florida Institute of Technology

Project Description: Camera traps are an effective way in counting individual animals of a population of interest. Therefore, finding an optimal design for a camera grid is essential to estimate the size and density of a population. The goal of this study was to design a camera grid for observing and monitoring a growing population. To assess and control a growing population, collected camera encounters will be used to estimate the population size and density. The feral hog (Sus scrofa) was used as the case study in this research. It was found that a detection probability of at least 0.4 was needed to accurately estimate the population size of feral hogs. This is an important outcome of our research and can be potentially used to ensure the minimum coverage for estimating population size when designing a monitoring system and collecting camera encounters. Our future work is focused on how to maintain the minimum probability of detection in designing a camera sampling grid.

Challenges: There was a limited amount of resources that could be used for the project. There was only 24 cameras available to be used for two study sites. Hence, a set of 12 cameras was used for each study site. The camera grid design was changed to fit a 12-camera grid. There was also a limited number of camera batteries, with rechargeable and lithium types. The rechargeable batteries needed to be replaced once a week. Cameras were rotated at a biweekly schedule to capture images from as many locations as possible.

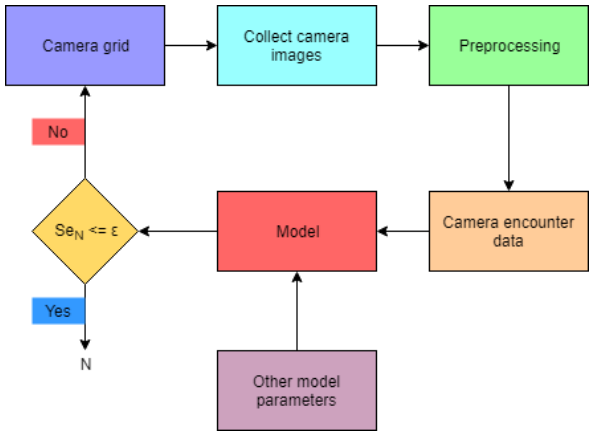


Figure 1: Schematic design for the project

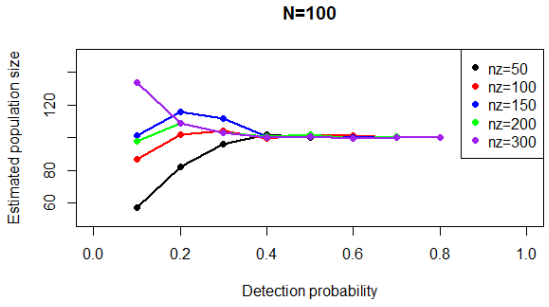


Figure 2: Graphical results of sensitivity analysis

In Collaboration with:

KSC Ecological Program of NASA directed by Dr. Brean Duncan

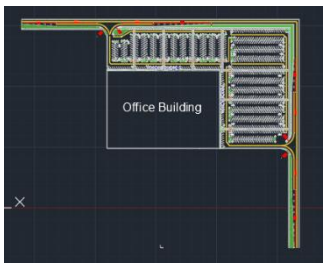
KSC Ecological Program Team in NASA: Dr. Breininger, Dr. Stolen, Mr. Hunt, Mrs. Legare, Mr. Breininger

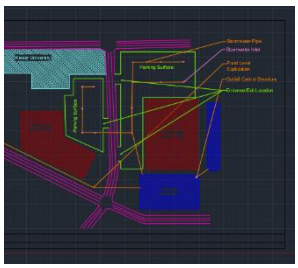
Civil Engineering and Construction Management

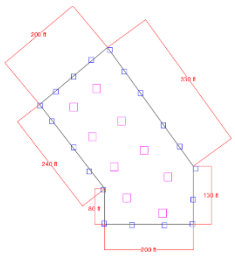
Project Name	**Design of Office and Manufacturing Facility**
Team Lead:	Nicholas Menyhart
Team Member(s):	Zoe Southwick, Katie Reed, Wistenly Alphonse, Nikola Selakovic
Faculty Advisor(s):	Dr. Howell H. Heck Department of Mechanical and Civil Engineering

Project Description

We are MAG Engineering, a group of students tasked with designing a facility in the local Melbourne area capable of providing office space for over 1,000 employees as well as a 200,000 ft^2 office facility. Our work consisted of dividing the project into multiple disciplines: Transportation, Structural, Geotechnical, Water/Wastewater, and Stormwater. This combined led to the design and plans to construct this facility. Being such a large facility, this project took two semesters to design and complete the design of and took a great amount of coordination between disciplines. A greater amount of the work was completed on AutoCAD and computer design software to analyze and present data for this project. Through this we seek to better our understanding of the work done in the civil engineering field every day and familiarize ourselves with the design processes. One of the larger challenges with our project was we did not have a structural component due to our group being smaller in size. This ultimately did not alter the specifications of the project and we were able to create the sit plans as if the structures were included. This meant the plans would all function accordingly as if the structural plans did exist. The design process began with researching the codes and ordinances required for each discipline and coming up with a design that would fit the needs of all disciplines and the client. This took coordination to ensure there would be no conflicts in the design across disciplines. The next step was determining the layout and features of the site and the necessary steps it would take to complete such a task. Finally came the actual design and selection of materials that would be needed to complete the project. In addition to the design of the building we were also tasked with coming up with the construction schedules as well as cost estimates for the construction of the structure. This was done using programs such as Microsoft Project to help provide detailed schedules and a breakdown of the projected costs. This project was a great introduction to the engineering profession and gave each one of us a bit of insight into what our future careers might hold.







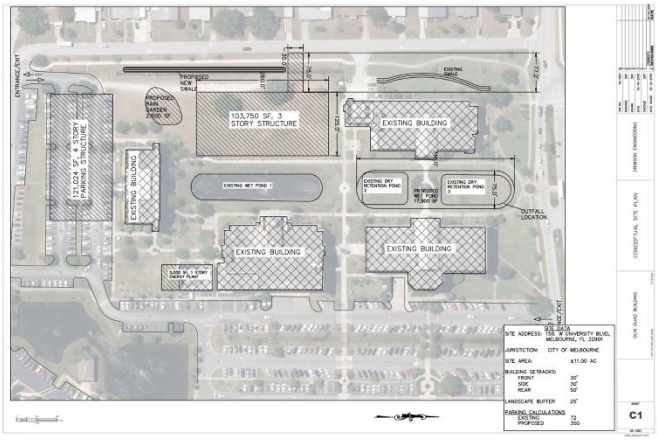
MAG ENGINEERING

Project Name	**Florida Tech Center for Engineering Research and Innovation (CRI)**
Team Lead:	Victoria Pavsic (CVE), Dan Flock (CON)
Team Member(s):	Shubham Desai, Quinn Duffy, Agathe Malmberg, Christopher Peterson
Faculty Advisor(s):	Dr. Howell H. Heck, Dr. Troy Nguyen, Dept. of Mechanical and Civil Engineering, Florida Institute of Technology

This project encompasses the engineering design process as it relates to the field of Civil Engineering and the construction of a conceptual structure named the Florida Tech Center for Engineering Research and Innovation. This concept was developed for the University's outlined need for a multidisciplinary engineering research and education facility that also met the needs for the growing Biomedical Engineering department, our world renowned research projects, and the future needs of students and facilities on campus. A major controlling factor of the project was the goal of a LEED certified structure which combined with other challenges associated with this project were the requirements of the existing site, institutional zoning abutted by residential, high traffic site, need for additional parking, and a schedule of usage on a college campus.

Overall, Crimson Engineering Consultants utilized the professional skills endowed by an education at Florida Tech to ensure that the structure was designed to meet the needs of the client, align with the project budget and schedule, and provide a solid proof of concept for a structure of this caliber. The team provided solutions for the geotechnical aspects of the structure, designs for the overall structural components and envelope, recommendations and design options for transportation requirements, improvements to the existing stormwater infrastructure, and modifications to the site and main campus water and wastewater system.

The future implications of the project may include an investment by the client to propose such a structure, allow future engineering design teams to further the project by using similar construction techniques, as well as transforming the way civil engineering senior design projects are completed as part of a larger group.



Project Name **Logistical Systems**

Team Lead: John Kleess

Team Member(s): Jake Bredeck, Ken Holder, Nathaniel Ashton, Wei Li

Faculty Advisor(s): Dr. Troy Nguyen; Dept. of Mechanical and Civil Engineering

The central mission of our team is to design effective safety and logistics plans, as well as implementing a virtual reality experience to compliment the design of the Florida Tech Center for Engineering Research and Design. The project team produced documents for safety, logistics, project commissioning, and produced an interactive VR model for the project. The safety plan complies with OSHA standards, and the logistics and facilities management plans will maximize efficiency in both construction and upkeep of the project. The commissioning plan is designed to ensure customer satisfaction.

Knowledge of construction management practices obtained both through classes at Florida Tech, and through work experience, was crucial to develop the documents and virtual reality experience. The safety plan was developed after completing OSHA 30 hour certification, and studying a variety of safety practices enforced by established construction companies. Through BIM modeling class, and extended practice with Revit and Revit Live, the VR experience for the building was developed overtime. Additional Revit techniques and knowledge were required to implement the building into virtual reality, as the ability to enter and navigate the building raised the required accuracy of the model.

Safety and Logistics planning are very important aspects for any jobsite, as keeping the site safe and organized protects workers, pedestrians, and saves money. The commissioning plan ensures customer satisfaction by confirming the building was constructed as designed. The virtual reality implementation allows the prospective customer or client to explore the building, take measurements, and make decisions about changes or issues found when exploring the building in virtual reality.

Project Name	**Construction of the Florida Tech Center for Engineering Research and Innovation (CRI)**
Team Lead:	Noah Clanahan (CON), Dan Flock (CON)
Team Member(s):	Addison Abramson, Jacob Berger, Chase Causey, Julia Mokuy-Eyene
Faculty Advisor(s):	Dr. Troy Nguyen and Dr. Howell Heck; Dept. of Mechanical and Civil Engineering.

This project encompasses the work and planning of a general contractor for the conceptual construction of the Florida Tech Center for Research and Innovation. The building was developed after the need for a new research and education facility was determined by the university. This project began by working with a Civil Engineering team in a design-build construction approach. A major challenge of this project was the desire to seek a LEED certification for the building. This required clear communication with all teams involved and a solid energy efficient design for the structure and systems of the building. Panther Construction's main goal for the project was to create a schedule, cost estimate, material specification manual, and obtain a LEED certification.

The project schedule was created to provide a framework for a team in the field to use for the building's construction. The schedule was designed to minimize the construction duration while still working a normal 5-day work week. The proposed budget for the building was 35 million dollars, this was the cost estimates main restriction. If the estimate went over budget we would need to use "value engineering" to reduce costs. The budget was created by using Revit 2019 to perform virtual quantity takeoffs and then using RS Means to obtain pricing information. This electronic takeoff method allowed for changes in the design during the estimating process to easily be re-evaluated. With the absence of an architectural team, a material specifications manual was created to supplement the design performed by Crimson Engineering. Our main goal for this manual was to use common vernacular so that any person working on the site or project could understand it with no questions asked. The building obtained a LEED Silver certification. This was calculated using the US Green Building Council's Credit library for LEED V4. All required credits for the building including water usage reduction, energy analysis, material procurement requirements, and waste and recycling plans were achieved. In total the building earned over 50 points from its LEED credits giving it the Silver rating.

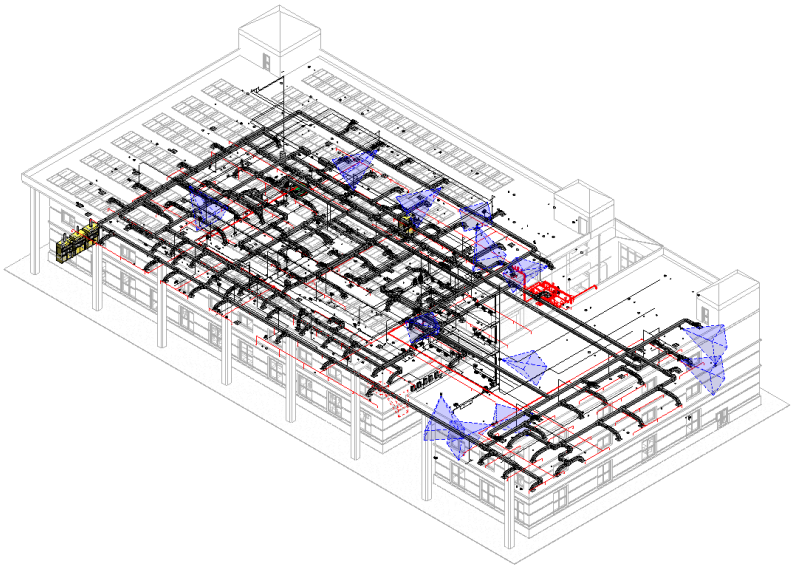
Future implications of this project were to set the foundation for this building to be funded and constructed on Florida Tech's campus in the future. The joint method of work between the Construction Management and Civil Engineering teams was also tested for its viability for future projects. The goal of our team was to create a comprehensive set of project documents pertaining to the project just like general contractors would in a real project.

Project Name	**Building Systems**
Team Lead:	David DiGioia
Team Member(s):	Colin Cristello, Yuchen Liu, Sultan Qasmi, Matt Young
Faculty Advisor(s):	Dr. Troy Nguyen, Dr. Howell Heck Dept. of Mechanical and Civil Engineering, Florida Institute of Technology

This team was tasked to work on the Building Systems for the Florida Tech Center for Engineering Research & Innovation (CRI). Our worked to accomplish a Leadership in Energy and Environmental Design Silver certified building. To help achieve this goal we will be followed LEED Silver certification standards, United States Green Building Council standards, Florida Building Codes, and the Florida Institute of Technology Building standards. The goal for this team is to develop energy efficient building systems and have protect the building using high tech security cameras and alarm systems. All the systems have been selected to meet the building's demands.

The key components of our systems shall demonstrate an increased energy efficiency compared to the other comparable sizes buildings and most importantly all systems shall utilize the Building Automation System (BAS). The BAS is the brain of the building, it will utilize occupancy sensors and monitor the building to maximize the efficiency of our systems. Selecting systems that match LEED standards is a challenge, there are numerous prerequisites that need to be accomplished before we can earn the amount of points needed for LEED Silver. Our team did extensive research and reached out to multiple companies to ensure that the systems we have selected are energy efficient and appropriate for the size of our building. After we selected the systems, we worked hard in Revit even after a loss of data the week before spring break. We collaborated on a single Revit file, adding all of the details and systems that we have previously researched and selected.

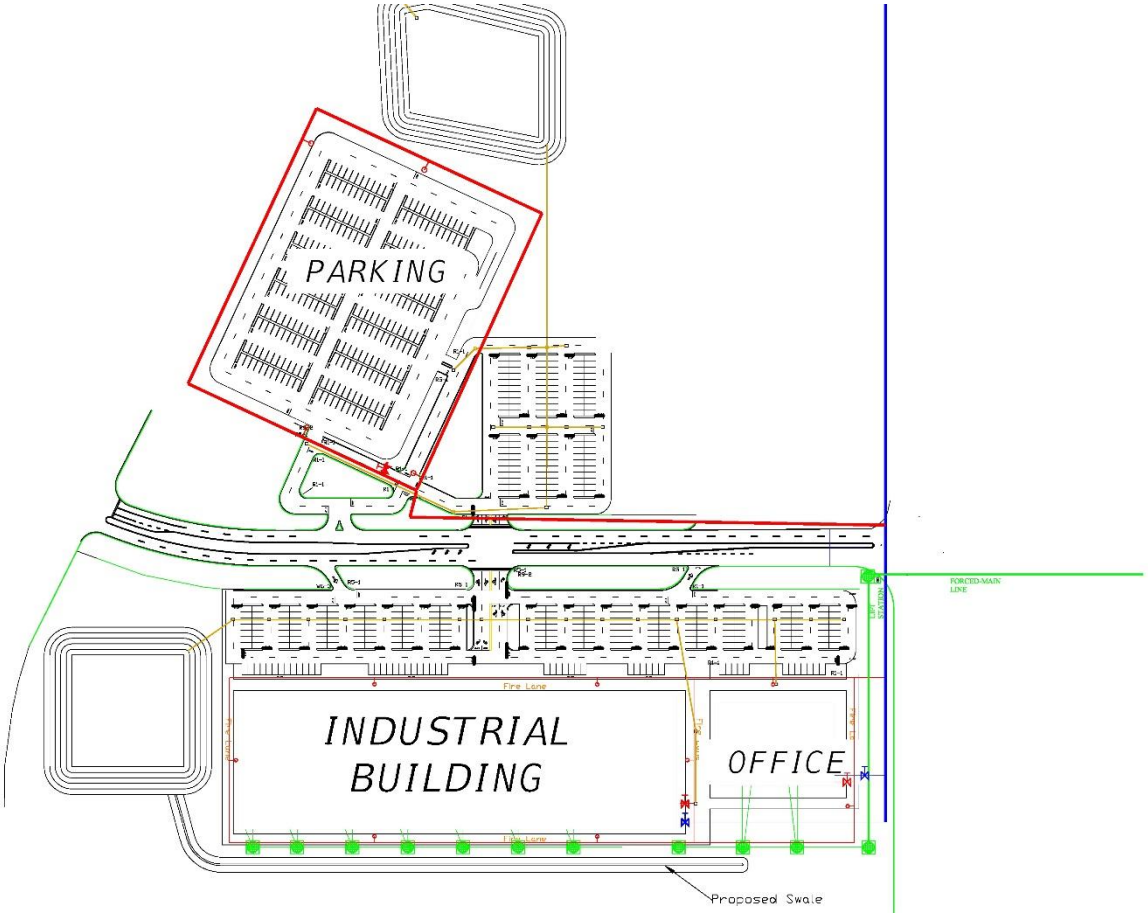
The overall goal for this team was to develop an energy efficient MEP, Security and Alarm Systems, which are all tied together by the Building Automation System (BAS). The team researched and assessed list of possible building systems in order to choose the most cost-effective options.



Project Name	**Design of an Industrial Building, Office Building, and Parking Structure**
Team Lead:	Ricardo Figueroa
Team Members:	Alexander Thierer, David Shin, Abdulrahman Almansouri, Salim Al-Kharusi
Faculty Advisors:	Dr. Howell H. Heck, Dr. Ashok Pandit, Dr. Paul J. Cosentino, Dr. Albert M. Bleakley, Dr. Rodrigo Mesa-Arango

This project is the design of the required infrastructure for the development of an office and a manufacturing facility, and new parking lot. This includes the design of a storm water treatment system with wet retention ponds. The necessary connections of water and wastewater utilities to the existing infrastructure. The design of all traffic signals, turning lanes, internal roads, parking lots and associated transportation studies will be provided. The main transportation design components will be intersection(s) on Babcock Street and Airport road, internal roads, parking facilities, signage, MOT during construction and traffic studies of current and future conditions. A complete redesign and re-pavement of Babcock Street will be required from where the recent improvements stopped to Apollo Blvd. The office building and manufacturing facilities foundations will be designed. The facilities structural plans will not be part of the scope.

Project Site Plan:

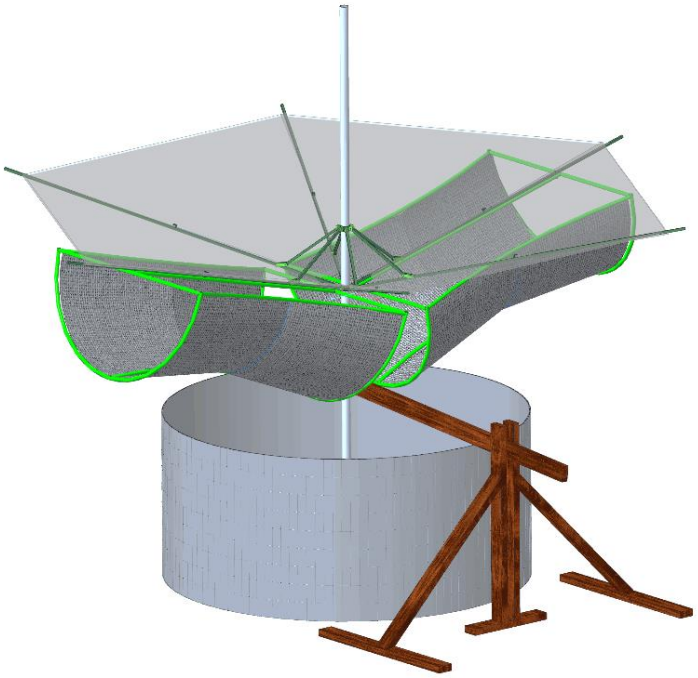


Mechanical Engineering

Project Name	**CacTech: Water Acquisition & Storage System for Agriculture**
Team Members:	Anisha Tiwari, Fatema Al Maamri, Leigh-Riane Amsterdam, Mallory Rhamy, Manal El Yaalaoui, Mawaba P. Dao
Faculty Advisor:	Dr. Beshoy Morkos, Dept. of Mechanical & Civil Engineering, Florida Institute of Technology

The Humanitarian Team (CacTech) was assigned to find an issue in a developing country and design an engineering solution to solve or improve upon the issue. Our target country - Kenya in East Africa, experiences inconsistent periods of rain which cannot fully provide the amount of water necessary to irrigate crops. This results in early stage crop death and eventual food scarcity. Kenyan farmers also experience lack of reliable and inexpensive water collection and storage systems. Team CacTech has designed and manufactured a system that collects and stores water during rainy and dry seasons so that farmers can have a cost effective, environment friendly and electricity independent source of water. Over the course of this project, some of the major challenges that the team faced include, designing while keeping in mind the accessibility of materials in these areas, as well as creating an inexpensive system. There were also experimental aspects such as the artificial roots and moisture collecting mesh, which required extensive research and testing. The proposed solution involves three main sources of water collection: traditional rainwater harvest, rainwater harvest through artificial roots, and collection of moisture in the air. Areas where future work can be done include further research on materials that reduce cost without compromising the functionality of the system and exploration of various effective methods to activate the foldable roof based on rainfall.

The capabilities of this system as described will ensure that farmers in developing countries have reliable access to water regardless of the season. This project will provide farmers with food security while promoting sustainable agricultural methods and financial security.



Subsystem	Collected Data
Storage tank	Stores 2500L of water
Mesh	Collects 0.34L/m^2 of water every 24 hours
Foldable Roof	Collects rainwater over an area of 50m^2
Artificial Roots	Absorbs 0.5L of water per 60 g of crystals
Solar Still	Recovers 80% of water in 1 week
Lever	Requires 0.75L of rainwater to fully open foldable roof

Project Name	**Heavy Equipment Maintenance and Handling System**
Team Lead:	Ireland Connors
Team Member(s):	Ireland Connors, Khalid Alkahtani, Evan Kananis, Luis Martinez, Trevor Petri, Robert Rew, and Kristine Wall
Faculty Advisor(s):	Dr. Beshoy W. Morkos, Dept. of Mechanical & Civil Engineering, Florida Institute of Technology

Lockheed Martin tasked the team with designing a system that can lift and rotate half million dollars truncated cones. They needed to be able to safely transport, rotate, and perform maintenance on this equipment.

Cone A:

- Weight – 1000 lbs
- Height – 48 inches
- Top diameter – 19 inches
- Bottom diameter – 36 inches

Cone B:

- Weight – 400 lbs
- Height – 42 inches
- Top diameter – 13.12 inches
- Bottom diameter – 34 inches

The system can only interface with the truncated cones through a 0.5 inch thick flange that serves as the point of rotation. The flange is not located at the center of gravity. The proposed system consists of two sub-assemblies: a sling and a stand. The sling permits the truncated cones to be rotated and the stand allows a worker to inspect and perform maintenance on the cones. The team was given following requirements:

- Picks up and rotates truncated cones to horizontal or vertical position
- Mobile and collapsible by at least 50% of its footprint for storage
- Yield strength factor of safety of 3.0 and ultimate strength factor of safety of 4.0
- Sling and stand interface and lock into place with locking pins

In addition to meeting all the requirements proposed by Locked Martin the system has the following additional features:

- Sling permits truncated cones to be rotated 360° and locked in place every 90°
- System can be assembled in under 15 minutes
- System is able to support and rotate any sensitive or heavy equipment with minimal modification to the collar
- Minimal maintenance will keep the system running for a minimum of 20 years

This innovative design has met all Lockheed Martin's requirements and will support operations for years to come.

Figure 1: Deployed System and Truncated Cones

LOCKHEED MARTIN

Project Name: **Hybrid Cool**

Team Lead: Daniel Hocheimy
Team Members: Bhaskar Aggarwal, Ilona Kalashnikov, Tejas Thakur, Mario Acosta, Omar Farrag
Faculty Advisors: Dr. Beshoy Morkos & Dr. Hamidreza Najafi, Dept. of Mechanical Engineering, Dr. Ken Gibbs Dept. of Electrical Engineering, Florida Institute of Technology

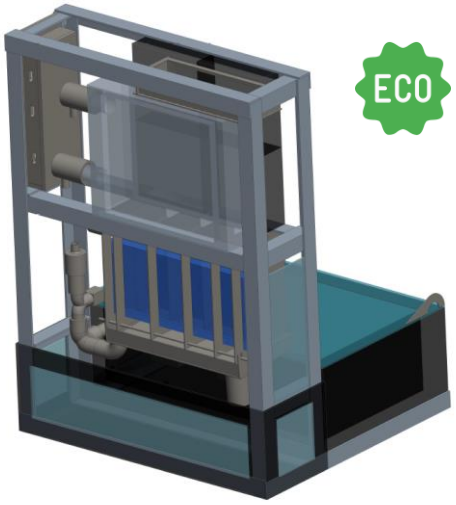
Project Description:

Due to the rapid economic growth in the developing world, it is projected that there will be an exponential demand for air cooling systems in such markets. For instance; India has a total of 36 million units today and by 2050 they will accrue 1.14 billion. As a result, energy demand will inevitably increase.

Statistics show that the share of the world's total energy consumption for cooling will increase from 8% today to 37% by 2050 for space cooling alone. The rise in energy consumption will make it increasingly difficult to supply power with clean energy sources, resulting in even more greenhouse gas emissions; a great obstacle in the fight against climate change.

Project Goal:

- Design a low-cost alternate cooling system using an environmentally friendly refrigerant.
- Cool a room of 121 Sq. ft average area.
- Meet ASHRAE's 'Indoor Environmental Quality' standards: Indoor temperature must be below 76°F and the relative humidity must be below 65%.



Product:

Our product incorporates evaporative cooling and a water-to-air heat exchanger with ice as the source of cooling. Temperature and humidity sensors are used to make the product reactive to ambient conditions and therefore make the system more efficient.

The heat exchanger subsystem is used when ambient relative humidity is high so that the system cools as well as dehumidifies. Whereas, when ambient humidity is low the system operates on evaporative cooling to cool and humidify. This way the system maintains comfortable conditions at all times. Therefore, hybrid cooling.

Comparison:

Parameter	Hybrid Cool	Existing Products
Power Consumption	240 W	900 - 1200 W
Initial Cost	$420	$500
Running Cost	$45	$180 - $240
Cooling Capacity	8,000 BTU	12,000 BTU
Cooling Fluid	Water	Refrigerants

Benefits:

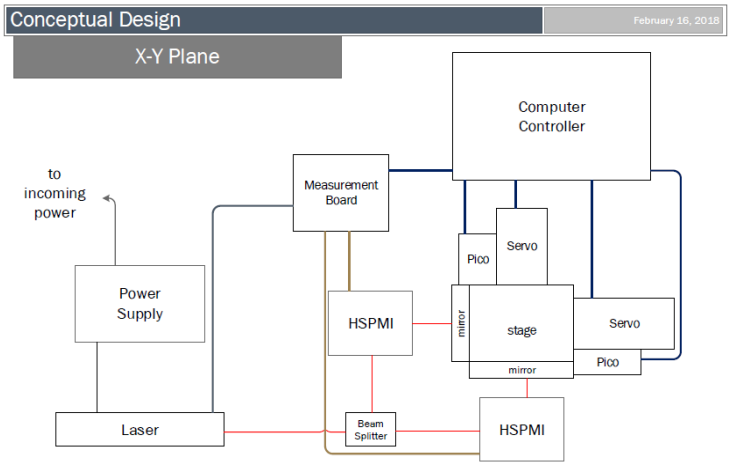
- Reduced cooling bill and maintenance costs.
- Option for cooling in very dry weather.
- No ozone-depleting refrigerants.
- Portable and lightweight.

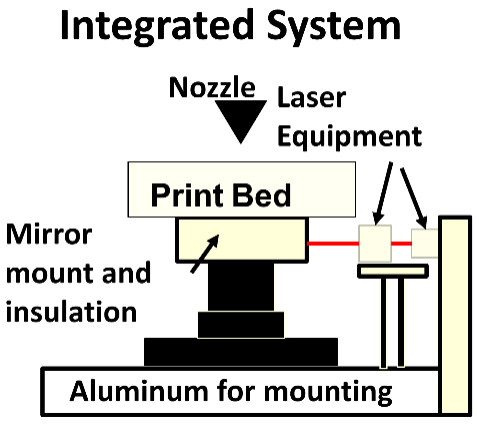
Future Development:

- Optimization of cooling capacity and cooling rate.
- Improvement in design for ease of mass production.
- Integration of a mobile app to control temperature and humidity levels remotely and gain feedback on ice and water contents.

Project Name	**Nano-stepper**
Team Lead:	Tanner Johnson
Team Member(s):	Logan Johnson, Robert Koss, Kenneth Verderber, Daniel Hochiemy
Faculty Advisor(s):	Dr. Jim Brenner, Chemical Engineering, Florida Institute of Technology Dr. Hector Gutierrez, Mechanical Engineering, Florida Institute of Technology

The NANOPOS project's goal was to create a 2-axis positioner with submicron precision without sacrificing distance and staying under $3,000, with the eventual goal of integrating this into a 3D printer. The problem for this project stems from sacrificing distance to achieve accuracy with motors. Almost all motors are limited to 16-bit precision, but we are using a relatively inexpensive 24-bit servo motor, giving us the potential for an 256-fold improvement in precision. After examining several options, it was decided that the best solution would be a telescoping motor system with a servo as the macro motion motor and a piezoelectric motor as the micro-motion controller, with feedback from an interferometry system. The servo motors and drivers were chosen to be the Parker Daedal MX80L motor stage with a ViX-250IH controller, with a 0.8-micron error for point by point motion. The piezoelectric motors were chosen to be the Newport New Focus Picomotors, which have an absolute error of 16 nm. The laser system was chosen as the Zygo 501 interferometry system that can give a position of up to 10 m distance with an accuracy 1.64 nm. The main challenge for this project was getting the pre-owned MX80L motors working. After connecting the servo motors, the laser system software interface was written, the setup for the two-axis motor system was finished, and brackets for the laser equipment were designed and fabricated. After the servo motors make a macroscopic motion to home at a new z-height, the servo's overshoot error is read by the interferometry system, and the piezoelectric motors correct for that error via a LabVIEW code. The main remaining issue is getting a plane mirror that is long enough and flat enough to not cause error into the system. An addition to the VI would be the offset of the mirror itself so that the error can be more properly attuned. Another addition to the VI would be a G-code converter to change the macro positions for the x and y to be in the language of the servo motors. The rest of the 3D printer's G-code would be untouched. These would all be sent out through proper ports and data reading could be taken from the normal 3D printer board via a USB connection. The final addition for next year's project would be designing the enclosure and the z-axis. The z-axis would need a stepper motor for motion in z only, a nozzle system, and a feed system. The enclosure would need to be tinted for laser safety reasons. A future goal of this system is to add it as the positioning system for a bioprinter for collagen or Bioglass. This would allow for precise positioning of growth and differentiation factors using a printer that costs less than $20,000.

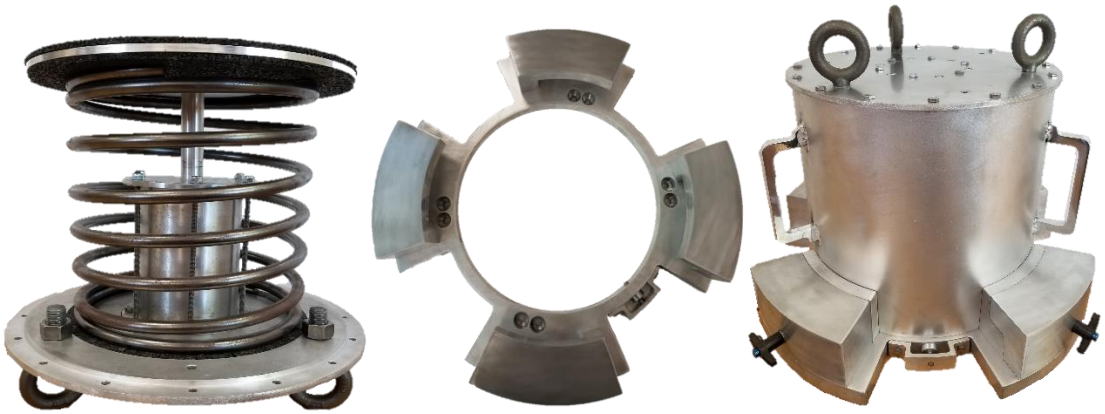




Thank you to Mr. David Beavers for donation of 2 UpBox printers.

Project Name	**Piston Damping System**
Team Lead:	David Zanni
Team Member(s):	Tyler Crawford, Trevor Gebelein, Garrett Jacobellis, Barbara Shreve, Randi Stewart, and Alana Thornton
Faculty Advisor(s):	Dr. Beshoy Morkos, Department of Mechanical and Civil Engineering, Florida Institute of Technology

In a joint effort with Lockheed Martin and the United States Navy's Fleet Ballistic Missile Ground Equipment Team, we have designed an improved safety system that interfaces with and protects multi-million dollar equipment while safeguarding civilians from an unexpected piston deployment. This system is designed to bolt-on to a piece of multi-million dollar hardware while it is on the ground and stop a piston ejection with a force of 32,000 pounds. To stop this force, a custom spring-dashpot system was designed that adequately absorbs and dissipates the energy. In order to stop the force without causing damage to the system or allowing the piston to recoil, the spring and dashpot work in tandem, with a calculated spring rate of 28.55 lbs./in and damping coefficient of 18.46 lbs·s/in respectively. Aside from stopping the piston force, a primary design challenge was effective interfacing with the bolt pattern of piston receptacle while adhering to the geometric constraints of 18" maximum height and 25" maximum diameter. Currently, the system being used fastens using 18" long bolts at the interface, causing binding and creating difficulty with installing or removing the safety device. To solve this, we have developed an adapter plate which serves as an interface to the United States Navy's equipment and a locking mechanism for the damping container used to house the spring-dashpot system. Our adapter plate design reduces the bolt length at the interface by 94.5% and yields a complete system installation time of 4 minutes and 33 seconds. To test the functionality of our safety device, we replicated the energy of the piston caused by the 32,000 lb force by dropping a mass directly on our system while it was bolted to a mock interface. The energy of the weight was adequately absorbed by the system without causing any structural damage, while creating an impact sound of 116 decibels, falling well under the OSHA standard of 140 decibels for an impact. Through transient analysis using ANSYS Workbench 19.0, the adapter plate and damping housing unit produced an ultimate strength factor of safety of 10.2, indicating that material cost and system weight can be reduced in the future. Ultimately, this safety device saves millions of dollars through increased efficiency and equipment protection while protecting personnel from serious injury.



LOCKHEED MARTIN

Project Name	**Ridgid Hyperdrive**
Team Lead:	Justin Daimler
Team Member(s):	Helal Almazrouei, David Alvarez, Stefan Bogason, Caleb Burks, Matthew Dupras, Caleb Wochnick
Faculty Advisor(s):	Dr. Beshoy Morkos, Dept. Of MEE, Florida Institute of Technology

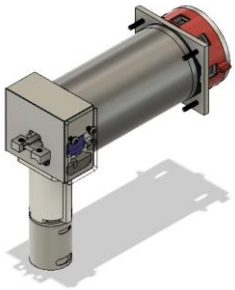
The problem statement for this project is as follows:

> The RIDGID brand electric finish nailer is to be redesigned with a primary focus on reducing the latency between the user triggering and the driving of the nail by 100 milliseconds. The nailer shall retain adjustment capabilities and driving power.

While electrically powered nailers have many advantages over pneumatically powered nailers in the way of convenience and energy efficiency, most pneumatic nailers have a negligible latency between trigger pull and nail drive. Team TTI's goal was to make this level of performance possible in an electric nailer for the purpose of creating a more satisfying and efficient user experience. This called for conceptualizing and fabricating a new vision for the Hyperdrive—that is, the current nail-driving system developed by Techtronic Industries (TTI) and available in RIDGID nailers. Our solution to this problem was developed with the commitment that key features and attributes of the current product, as defined by our stakeholder, would not be sacrificed.

The Hyperdrive generates its nail-driving force by creating a vacuum between two pistons in a cylinder and allowing it to collapse. Our solution revolves around minimizing the most substantial portion of the driving cycle—namely, the creation of the vacuum—by a process which we refer to as "priming." According to the current nailer design, the creation of the vacuum, followed by the release of the driving piston, are both triggered, in sequence, by one trigger. Through priming, these two processes are triggered separately so the priming trigger may be activated before the user chooses to drive a nail, thus saving driving time.

One of the project's greatest challenges was that of vacuum leakage during the primed state, as the Hyperdrive was not designed to hold a vacuum for a substantial amount of time. When air leaks into the cylinder, driving power is diminished. This issue was addressed by improving the nailer's vacuum sealing capabilities and placing limits on the amount of time for which the primed state may occur.



The product of our work and centerpiece of our showcase is a functional prototype nailer featuring reenvisioned Hyperdrive technology. The nailer has the capacity to be primed and fired by separate triggers and its driving latency has been reduced by approximately 330 milliseconds from the current nailer while retaining adjustment capabilities and a small decrease in driving power. This product, along with our research, is being sent to TTI with the hope that it can be further refined, tested, and packaged for future production.

RIDGID TTI

Project Name	**Drag car**
Team Lead:	Saif Al-Yami
Team Member(s):	Faisal Al-Rawas, Hongrui Liu, Khalid Aldoukhi, Khalifa Aldossary, Renjie Dai, Ali Al Naimi, Xiaoou Yang, Yiyang Qian, Zixia Xue
Faculty Advisor(s):	Dr. Gerald J. Micklow & Dr. Beshoy Morkos, Dept. of Mechanical and Aerospace Engineering, Florida Institute of Technology.

The aim of the drag car project is to set a quicker time on the track every time it is upgraded. The team was given a classic 1976 Buick Skylark with a small block 350 coming from a 1974 chevy corvette. The car's drivability needed to be improved to make the driver drive it better in a competition. The car needs to produce more power and the team needs to come up with ideas that would make the engine produce more power. A new paint is needed for the car as well. The major challenges that the team faced was how to make the analysis for the seat mount and steering column and make the car compatible with 95% of the average tall of the drivers. Also, finding data acquisition for the car using the engine codes and installing thermistors to measure the temperature in a few places around the car. Wiring and connecting this was challenging. The team decided to lower the seat mount and shorten the steering column. Also, powertrain team made some analysis using a code. This code contributed in finding the right solutions for powertrain performance. Finally, the team was able to achieve the main goals, which is shortening the steering column and lowering the seat mount. The team was expecting changing the camshaft with more powerful camshaft, but after running the code we figured out it will not add the expected horsepower.

Figure 10 car interior

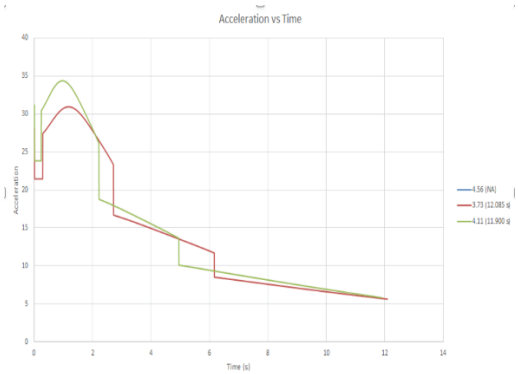


Figure 11 engine analysis

Project Name	**Formula IC SAE at Florida Tech**
Team Lead:	Emily York
Team Member(s):	Khaled AlSamri, Mohammed Alyami, Rashid Alzaabi, Ahmad Alzlfawi, Cameron Gagnon, Jessica Goblick, Elijah Goodman, Richard Hord, Nathaniel Jennings, Tahir Kanchwala, Filippo Mazzanti, Dallas McCloud, Johan Mihindukulasuriya, Elifsu Orhon, Matthew Petersen, Gabriel Pinto, Matthew Standifer, Austin Taft, Warren Thies,
Faculty Advisor(s):	Dr. Beshoy W. Morkos & Dr. Gerald J. Micklow Dept. of Mechanical and Civil Engineering, Florida Institute of Technology

This year the team has been tasked to design, build, and a test a formula style vehicle for the average non-professional weekend autocross racer. The subsequent solution to this problem became Formula Panther 2019. The car features a CBR600RR engine, an unequal length double wishbone suspension system, a 4130 Chromoly Steel chassis, and an aerodynamics package manufactured in-house. Some of the main challenges faced this year include the mold manufacturing for aerodynamics, the suspension fitment for suspension, the engine rebuilds for powertrain, the tabs manufacturing for chassis, and the electronics for the dashboard and onboard computer system. While these problems caused delays within the manufacturing process, solutions were found and implemented. Solidworks and Ansys were used to model and create the CAD for the prototype. Once manufacturing was completed, testing commenced, which allowed the team to gather data on the suspension, as well as tuning the engine. This also allowed the team to test the manufacturing of the car and ensure that it is prepped and ready for competition in May. Competition consists of 4 dynamic events to test the car's design, and 3 static events to test the business logic behind the car. The team is looking forward to competition and hopes to place within the top 50 teams with the new design of the car.

Special thank you to our sponsors: Hi-Tide Manufacturing, Solidworks, RapidHarness and Hoosier Tires.

Project Name	**XSTAR- Extraterrestrial Sample Transport and Retrieval**
Team Lead:	Sephie Cooper, Austin Lakata
Team Member(s):	Yuhua Zhu, Aziz Almansour, Jing Lu, Tarique Alam, Ziyu Liu, Ashen Perera, Zixuan Song, Waleed Asiri, Xucheng Zhu, Aziz Alshubany, Ahmed Aladhadh, Shadi Moustafa, Lihui Zhang, Joseph Nke
Faculty Advisor(s):	Dr. Beshoy Morkos, Dept. of Mechanical Engineering, Florida Institute of Technology

We've sent plenty of people into space, but now it's time to start bringing space to us. The goal of this project is to bring ice samples from Europa back to Earth for analysis. Scientists will test these samples for signs of current or previous life and study the composition of Europa. To accomplish this, the NASA JPL senior design team conceptualized a space-ready system that will intercept a sample container sent from Europa and deliver it to the International Space Station where it will make its final decent to Earth with the astronauts. The team then created a proof of concept design that highlights one specific aspect of this entire system. The proof of concept product focuses on intercepting the sample container by first detecting the exact location of the sample container and then capturing and docking it to the body of the interception system. Our problem statement is as follows: "A sample container carrying ice from Europa will intersect a specific Earth orbital point. The container needs to be intercepted at this point and transferred to the ISS while maintaining the integrity of the ice sample."

The proof of concept system (XSTAR) manufactured by the team demonstrates the detection and docking portion of this process by using a robotic arm with an electromagnet fixed to the end. Interface points on the sample container are marked by bright colors to interface with a Pixy2 sensor attached to the arm. The sensor on the arm autonomously detects the colors present and is able to determine the position of the sample container while it moves magnetically attach to one of these interface points. Once the docking maneuver is complete, pins will lock the sample container in place. The body of the XSTAR is constructed of Aluminum 3003 frame and plates, along with the female end of the machined nylon docking system. The sample container is composed of acrylic plates, attributing to weight constraints from the robotic arm, and includes the male end of the nylon docking system. The sample container is equipped with sensors that wirelessly transmit and monitor: the temperature and pressure of the samples inside, the orientation of the sample container, which interface point the electromagnet is attached to, and confirmation when docking is complete.

The biggest challenges the team faced included: designing and manufacturing the docking mechanism to mimic the power data grapple fixture used by the CanadaArm2 on the ISS. Additionally, we found difficulty in increasing the efficiency of the sensor on the arm when detecting the location of the sample container and translating that data in order to autonomously dock the sample container.

The team was able to determine the number of pixels that the Pixy2 sensor on the arm can detect from the interface point at relative angles from 0-90 degrees. This experiment was conducted at three distances of 1, 2 and 3 feet from the sensor. During this experiment, light bouncing off of the reflective exterior of the sample container was causing a degradation of the detection capabilities of the Pixy2's sensor; this happened when the pixel count of the target was below 200. For the prototype to be successful in capturing the sample container, it is necessary that the pixel count stay above 200 pixels. This is achievable as long as the sample container target is no further than 2 feet from the sensor and angled at no more than 50 degrees relative to the sensor.

The future of space exploration lies with sample return missions, because of this, the system's design is intended for reuse with sample containers from future missions. The team found it would be beneficial to improve capture efficiency of the sample container along with reducing the capture process duration. Power and data sharing, long range communication, and thrusters need to be implemented to make this design complete. The team hopes that future NASA JPL senior design teams will work on this project and help in the discovery of new life in this universe and will be the next giant leap into the future of exploration.

Project Name	**Sun Nuclear Water Pumping Reservoir**
Team Lead:	Spencer Caldwell
Team Member(s):	Clinton Kannenberg, Jeff Stanifer, John Linn, Ljubomir Garvic, Chen Han, Qurat-ul-Ain Panjwani, Jicmat Ali & Michael Anderson
Faculty Advisor(s):	Dr. Beshoy Morkos & Dr. Hamidreza Najafi, Department of Mechanical and Civil Engineering, Florida Institute of Technology

The task at hand was to redesign the Water Pumping Reservoir used with the Sun Nuclear Corporation's (SNC) Radiation Scanning System. Replacing the pump allowed the fill and drain time to be reduced from 5 and 7 minutes to 3:36 minutes and 3:35 minutes respectively. Other modifications include reorganizing components on the cart to optimize tank capacity. To prevent corrosion in the stored water, a UV light and carbon filter were also added to the system to reduce bacterial growth and Chlorine levels respectively. A major requirement of this project was the maximum weight restriction for the cart of 62.5kg. This requirement was met by selection of components and redesigning the chassis. The final product was required to be compatible with current SNC dosimetry while providing a user-friendly interface. A touchscreen connected to the system through a Raspberry Pi was incorporated in the user interface to allow ease of use. The final product must be compatible with IEC and RoHS regulations. Multiple tests were conducted on individual components of the system and additional tests were also done on the final product to ensure all the requirements were met. The proposed system meets all requirements given by SNC and is a step forward for quality assurance in the field of radiation treatment.

SUN NUCLEAR corporation

Ocean Engineering

Project Name	**Reef Life**
Team Lead:	Brittany LaPadula
Team Member(s):	Stephen Hammond, Jenna Katrina, Jack Mueller, Emily Perron, George Robinson, Brett Robinson
Faculty Advisor(s):	Dr. Stephen Wood, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

The objective of the Reef Life coastal project was to design and test a scale model of an artificial surf reef. The purpose of the designed reef was to create the ideal surfing wave while also reducing shoreline erosion. The team worked to optimize wave steepness and surfability of the wave, promote coral growth, and minimize coastal beach erosion. Multiple designs were assembled and tested in the Florida Tech wave tank in order to find the ideal reef shape and size. Data was collected using wave sensors and video analysis that allowed the team to analyze how each reef design affected wave height, shoreline erosion, and coastal sand transportation. Along with optimization of the reef design, experiments were conducted to determine the best material for full scale reef construction. The selected material will enhance coral growth and strength. The final scale model reef design met all the desired specifications; it reduced erosion along a coastal beach and generated the ideal surfing wave.

Shortened Triangular Reef

Project Name **AUV Docking Station**

Team Lead: Brandyn Watterson
Team Member(s): Abagail Hardman, Ryan Kendall, Thomas Lipscomb
Faculty Advisor(s): Dr. Stephen Wood, Dept. of DOEMS

Project Topic

Autonomous Underwater Vehicles (AUVs) are underwater robots which travel and collect data without operator input. The current state of AUV's require a vessel to deploy and retrieve the AUVs each time a test is run to recharge the batteries and transmit the data collected. This limits the use of AUVs since rough surface water or weather can prevent a vessel from being able to deploy an AUV. An AUV docking station would ease these shortcomings by providing an offshore base which can autonomously carry out these functions.

Design Problem Statement

Four design objectives were set at the beginning of the project. The first was to create a catching system which will guide an AUV into the docking station from different approaching angles. The second goal was to create a base which self-aligns itself with the current when deployed. The third was to create an inductive charging system which can recharge the batteries, transfer data, and hold the AUV in place. The final goal of the project was to create a compatible AUV nose cone for the Remis 100 which works with inductive charging system.

Major Challenges

Subsea transfer of power poses several challenges as the ocean is susceptible to extreme conditions and corrosion along with a dynamic atmosphere. Within the pressure housing of an AVU can be several hundred thousand dollars of water sensitive electrical equipment so power must be transferred without jeopardizing this seal. The nature of AUV operation also means that a human operator cannot directly intervene in case of malfunction, so the system must be robustly autonomous.

Solution Methods

The fiberglass catch net was constructed according to standard composite design formulas. Dimensions for critical points such as the junctions and bond areas were calculated from the material properties and mechanics equations. Mathematical approximations for coil inductance were used to create the charging module taking into consideration the average radius of windings, the length of coil, and the difference between the outer and inner radii of the coil.

Data Analysis

Output of the inductive charging module was examined using an oscilloscope. The first iteration of the base design was simulated in finite element analysis revealing many problems that were resolved in future iterations.

Summary Sentence

The docking station was deployed over the previous summer and successfully landed on the bottom, aligned itself to current, and accepted the AUV demonstrating the viability of the system.

Future Work

The work done on this project is intended to form the base of future development on the docking station. Future improvements to the project would include programming the AUV so it functions properly, adding acoustic and power systems to the dock, and adding a buoy to support communications.

Project Name	**Foundation Vessels SWATH**
Team Lead:	Cooper Mitchell
Team Member(s):	Kyle Gullikson, Cooper Mitchell, Matthew Rabins, Patrick Clary, Jacob Clary
Faculty Advisor(s):	Dr. Stephen Wood

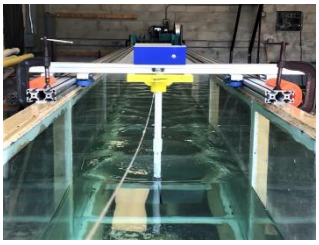
Project Description:

A SWATH is a Small Waterplane Area Twin Hull vessel. It glides with two pontoons below the water to minimize effects from waves on the vessel. The SWATH was designed to be a small unmanned research vessel with the capacity of remote/ autonomous operation such as navigation, propulsion, drone land system, towing and scientific research. Major challenges included fabrication of fiberglass and adjustment of vessel sea keeping capabilities. We overcame the obstacles by consulting professionals, trial and error and in-depth research. The SWATH project features an excellent overview into naval architectural design with successful movement, drone landing and launching, instrument deployment and plenty of modular space for a variety of technical packages on a working research vessel. In addition, the modular design allows following teams to continue to build on this successful project.

Project Name **Ocean Current-Driven Turbines**

Team Lead: Max Williams
Team Member(s): Jorden Grant, Max Williams, Aaron Vegh, Jake Pierson
Faculty Advisor(s): Dr. Stephen Wood

The project centered around the design and implementation of an experiment (and the necessary apparatus to carry out the experimentation) that aims to quantify the effectiveness of current-driven turbines and then subsequently and continually use the findings to design increasingly efficient turbines.



The project focused on a design that pulls the turbines through the water at various, adjustable velocities. After piloting multiple designs to achieve this, the towing design that yielded the least variance in linear velocity and in angle of attack on the turbine was a wheel and track system mounted atop the Florida Tech wave-generation tank—towed along by a variable speed motor.

The RPMs of a given turbine are measured by applying two magnets diametrically opposed about a flywheel at the base of the axle, and affixing Hall-effect sensors that record the passing of the magnets as the axle turns. A DC electric motor is attached to the base of the axle and is manipulated to act as a generator that converts the kinetic energy of the rotating flywheel into electrical energy. The RPM data from the Hall-effect sensors as well as the generated voltage data from the motor are processed via an Arduino Mega and are wirelessly transmitted via an XBEE RF module. These components are housed in custom 3D-printed enclosures.

The experimentation began with a relatively random collection of several varying designs donated to the group by a previous project on experimental propeller designs. These prototypes were qualitatively tested and ranked by type and individual design and the best-performing designs were selected to serve as a starting point for further design and refinement. Additionally, novel designs were modeled and 3D-printed for testing.

Though the primary goal of this project was to design an experiment and develop a methodology for the testing of current-driven turbines, the process required the testing of turbine prototypes. The secondary goal was to design, develop, and test additional turbines in the hopes of creating a novel design that proved to be effective and could feasibly be scaled up for further testing and eventual implementation. The existing prototypes were tested, as well as numerous novel designs, and the turbines that generated the most power at a given flow velocity were ranked.

Speed 8					
Ranking	Type	RPM	Voltage	P (watts)	T (Nm)
1	Screw 10	427.952	0.695	0.0484	0.000113
2	Screw 4	383.807	0.614	0.0377	9.82E-05
3	Screw 3	440.333	0.588	0.0347	7.86E-05
4	Screw 21	373.121	0.538	0.0292	7.82E-05
5	Screw 20	444.587	0.508	0.0258	5.81E-05
6	Screw 14	355.359	0.470	0.0221	6.21E-05
7	Screw 18	367.078	0.450	0.0202	5.51E-05
8	Fan 4	247.856	0.411	0.0169	6.84E-05
9	Basic 20	241.600	0.296	0.0087	3.62E-05
10	Basic 7	206.368	0.288	0.0083	4.02E-05
11	S2	241.551	0.270	0.0073	3.01E-05
12	S3	235.618	0.255	0.0065	2.75E-05
13	Prop 10-1	150.132	0.242	0.0059	4.64E-05
14	flip fan	189.0260	0.2173	0.0047	2.34E-05
15	Wood 1	145.7302	0.2085	0.0044	3.63E-05
16	Fan 5	124.352	0.150815	0.002277	1.83E-05

Project Name **R.O.U.C. – Remotely Operated Underwater Crawler**

Team Lead: Shane Sampson
Team Member(s): Connor Bol, Michael Giannotti, Dante Volpe
Faculty Advisor(s): Dr. Stephen Wood

The main goal of the project is to create a vehicle capable of modular expansion to fill any variety of roles that the Ocean Engineering department can imagine. The largest challenge that the team faced was having to complete an ROV from a simple base framework, two motors, non-functioning computer parts, and a non-functioning pre-built buoyancy system from a previous project. The team devised a way to design and build the unit so that it would be simple yet effective in its given task. The entire motor system was reassembled, and the computer system was replaced with a more intuitive design. The main role of the unit is recovery of artifacts and equipment lost off the coast. Future work for the R.O.U.C. includes more modules for the unit to increase its applications and effectiveness in the field, including but not limited to a soil sampler, robotic arm, trenching unit, and a claw. The R.O.U.C. system as a finished unit of this type could solve many problems for the Ocean Engineering department and provide possibilities for hands on experience that students can gain from the platform's expansion projects.

Oceanography, Environmental Sciences and Marine Biology

Project Name: Genetic relatedness and connectivity in great white sharks (*Carcharadon carcharias*) from the Pacific Coast of Baja, Mexico

Team Member(s): Ken Ogborn and Nicolette Murphey
Faculty Advisor(s): Dr. Toby Daly-Engel

Introduction: Great white sharks (*Carcharadon carcharias*) are apex marine predators, vital for maintaining ecosystem health. Like most sharks, they grow and reproduce slowly, which makes them vulnerable to depletion. White sharks migrate between prey sources and nursery grounds and have been known to use philopatry (natal homing) (1), but little is known about how specific nurseries link to offshore feeding areas. We generated DNA fingerprints for nine highly variable microsatellite loci (2) in 56 white sharks from two sites in the Pacific, a foraging area (Guadalupe Island, N = 35) and a coastal nursery (El Vizcaíno Biosphere Reserve, N = 21). We identified familial relationships via degree of shared DNA (50% for parent-offspring/full siblings, 25% for half-siblings) coupled with demographic data. Using genetics to identify critical reproductive habitats for Pacific great white sharks will help to conserve these areas for the animals that depend on them.

Materials and Methods:

- 1cm ^{3}skin samples were collected using modified longlines and a biopsy-tipped spear and stored in 1.5 mL 20% DMSO buffer.
- DNA was extracted using a DNeasy Blood & Tissue Kit from Qiagen (Germantown, MD) and amplified with nine pairs of species-specific microsatellite primers (3)(4).
- 10 µl PCR reactions with MyTaq Red Mix were performed (Bioline, Memphis TN) and the products were visualized on a 1% agarose gel before sequencing on an ABI 3730XL DNA Analyzer at the University of Arizona Genetics Core.
- Pairwise and overall maximum likelihood methods were employed in the programs Cervus and Colony (5) to determine relatedness between individuals (6)(7), and we tested for population subdivision with Arlequin v3.1 (8)

Results: We detected evidence (>95% confidence) of relatedness between specific individuals at both Pacific locations. In Guadalupe, we found two individuals with a parent-offspring relationship (P24 and F44) as well as two full siblings (P45 and P56). In Vizcaíno, we identified four members of one family (three full siblings and one half-sibling), indicating multiple mating by at least one parent. No direct relationships were detected linking the two locations, though population differentiation was not significant ($F_{st} = 0.012$, $P > 0.05$)

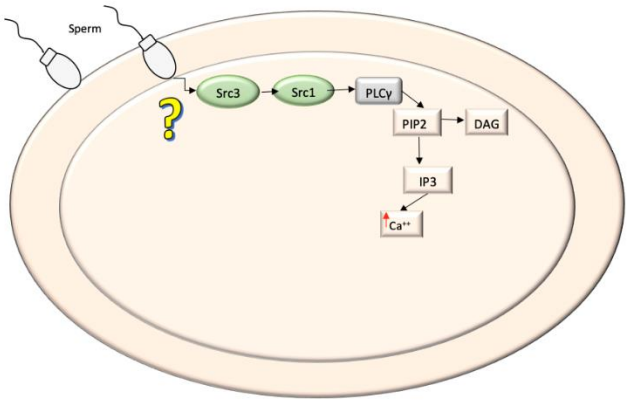
Conclusion: Using DNA fingerprinting techniques, we were able to identify genetic families of white sharks at both Pacific sites. At Guadalupe, an offshore island with a high prey population, a mature female and one of her pups, plus a pair of immature full siblings, were all sampled in Fall 2017. In Vizcaíno, almost 20% of all sharks caught belonged to the same three-parent family. Though no direct connection was found between sites, population-level differentiation tests were not significant, suggesting ongoing migration between sites. These data indicate that both locations are critical habitats for white sharks in the Pacific, which likely exhibit philopatry throughout their lives. Given that even the largest sharks rely on shallow coastal habitat for reproduction, it is essential to identify and conserve such areas to help shark species (and the rest of the ocean) flourish.

Acknowledgements: Peter Kragh, Ernie Kovacs, Ernesto Ruiz, Corey Clancy, and all the members of the Daly-Engel Lab. Funding was provided by the Department of Biology at FIT and Discovery Channel.

Project Name **Identification of Src family tyrosine kinases in the egg and ovary transcriptomes of the sea star *Patiria miniata***

Team Member(s): Mehrasa Baghban
Faculty Advisor(s): Dr. David Carroll, Dept. of BCES, Florida Tech

Project Description: The signature event of fertilization in all organisms is a large increase in the concentration of cytoplasmic calcium. This calcium is released from the endoplasmic reticulum through IP3-sensitive calcium channels. The signaling pathway that produces the IP3 that causes this increase at fertilization involves phospholipase Cg activated by one (or two) Src family tyrosine kinases. Because of the pivotal role of these kinases we decided to take advantage of newly published egg and ovary transcriptomes of the sea star *Patiria miniata* to identify all members of this Src kinase family. The egg (PRJNA398668) and ovary (PRJNA236087) transcriptomes are available in the National Center for Biotechnology information (NCBI) GenBank database. To identify transcripts that may express Src kinase family members, we utilized protein sequences from four previously identified sea star Src kinases (AAS01045, AAS01044, AAS01047, and AAS01046) to search the sea star transcriptomes using tblastn. The closest transcribed RNA sequence matches were found and recorded. Clustal Omega was used to align sequences and the tyrosine kinases of each accession were identified using ORF finder and blastp. This identified multiple possible Src family tyrosine kinases that appear to be expressed in the sea star ovary and egg. The result of this study can be used as an initial step towards identifying role of src tyrosine kinases in activation of egg during fertilization of *Patiria miniata*.



Funded by NIH R15 Award to David Carroll

Project Name **Identifying A New Genetic Signature Underlying Invasive Potential In Bluegill Sunfish**

Team Member(s): Sabrina M. Perez
Faculty Advisor(s): Dr. Karen Kim Guisbert and Dr. Eric A. Guisbert

Invasive species can have devastating effects on their non-native environments, yet it is difficult to predict which organisms have the greatest potential to become invasive. The bluegill sunfish is a freshwater fish native to the eastern United States that is considered an invasive species in many parts of the world including Europe and Japan. However, the closely related redear sunfish, whose native range overlaps with the bluegill, is not considered an invasive species even though it has also been introduced to new areas. To investigate whether there could be a genetic basis for the invasive potential of the bluegill sunfish, we sequenced the muscle transcriptomes for both of these sunfish. Our analysis of these transcriptomes revealed that there was a bluegill-specific expansion for some families of heat shock genes. These heat shock genes encode for molecular chaperones which facilitate protein folding and are an important component in the cellular defense against increased temperatures and other stresses. Our results suggest that this heat shock gene expansion could play a role in the adaptation of bluegill sunfish to new environments and therefore constitute a new genetic signature for invasive potential.

Project Name	**Functional basis of the diverse diet of the invasive lionfish, Pterois spp., in the Western Atlantic**
Team Lead:	Stephanie Porche
Team Member(s):	Alexander Barry, Paige Koehler
Faculty Advisor(s):	Dr. Ralph Turingan, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Lionfish, Pterois volitans/miles, have been considered generalist predators based on the number of prey items the species consumes. However, recent research has indicated that, although the species is generalist, the diet of individual populations is highly specific. We investigated the extent of variation in the lionfish diet across their invasive range via literature review, attempting to identify environmental or physiological cues that would induce a varied diet. The data suggests that diet composition is not generalist and not spatially related.

Project Name **Effects of Regional Upwelling on Corals in Pacific Panamá**

Team Member: Samantha Schiano
Faculty Advisor: Dr. Richard Aronson, Department of Ocean Engineering and Marine Sciences

This project focuses on the morphological differences of the dominant coral species in Pacific Panamá, *Pocillopora damicornis*, and how upwelling may be a major cause of these differences. It was hypothesized that the morphology of the branching structure and density of the branches would be different between the Gulf of Chiriquí and the Gulf of Panamá because of differences in the intensity of upwelling at these sites and mass transfer effects reducing branch density. The Gulf of Panamá experiences strong upwelling, which causes cold, nutrient-enriched water to come to the surface in the winter of each year. On the other hand, the Gulf of Chiriquí experiences some upwelling, but not to the same degree as the Gulf of Panamá. The purpose of this investigation was to understand how the morphology of *P. damicornis* may change in upwelling and non-upwelling conditions.

Coral branches of the same size were cemented to permanent stations at 3 islands in the Gulf of Panamá and 3 islands in the Gulf of Chiriquí. The coral branches were grown in situ for 6 months before being collected. The samples were taken back to the lab at the Florida Institute of Technology and photographed. The photos were uploaded into Agisoft™ Photoscan, where digital models of the corals were made, and volume and surface area were calculated. Sea-surface temperature (SST) data were gathered from permanent stations at each island in the Gulf of Panamá and Gulf of Chiriquí. Chlorophyll α data were downloaded from the MODIS database, converted from raster files, and averaged for the 6 months prior to the collection of the corals.

R studio was used for the statistical analysis. A t-test was run to examine the relationship between the means of the surface area to volume (SA:V) ratios in each gulf. The SA:V ratios were significantly higher in the Gulf of Chiriquí than in the Gulf of Panamá [t= -2.7185, df=8, p=0.02631]. This can be seen by the grouping of gulfs in Figures 1 and 2. However, there was no significant effect of SST or chlorophyll α on the SA:V of the corals [SST: p=0.05241, R^2=0.3171; Chl. a: p=0.1151, R^2= 0.191]. Although individually there was no significant difference in ratio with SST or chlorophyll α, a combination of the two factors could be responsible for the variation in morphology found in the corals between the two gulfs. There seems to be less variability in the SA:V ratio at lower temperatures than at higher temperatures, as indicated by denser branches and body forms at the lower temperatures in the Gulf of Panamá. The larger ratios in the Gulf of Chiriquí compared with the Gulf of Panamá indicate a thinner branch structure in the former, which could be due to high mass transfer rates and/or preferential survivability of thinly branched corals exposed to higher SSTs (Loya et al, 2001).

The major challenges to this experiment came in the design and methods. These samples were collected in the Spring of 2017 and 2018 and used for other investigations. The Gulf of Chiriquí had only two represented islands, while the Gulf of Panamá had three. The other main challenge of this project was creating the models and aligning the photos correctly in the photogrammetry software. The models took a considerable amount of time to make in order to allow accurate measurements, and the software did not always align all photos properly causing distortion or holes. Many of these problems were fixed when the software on the computer was updated to run faster, and the efficiency when making the models increased over time. The holes and distortion were fixed by realigning the photos and/or adding photos to the project. In summary, this study involved non-invasive measurements of corals which could improve and digitize coral samples for future studies. This work could also show signs of how corals may be adapting to climate change and provide evidence supporting upwelling as a refuge for corals in the future.

Project Name **Enhancing aquaculture production through functional genomics and hormesis.**

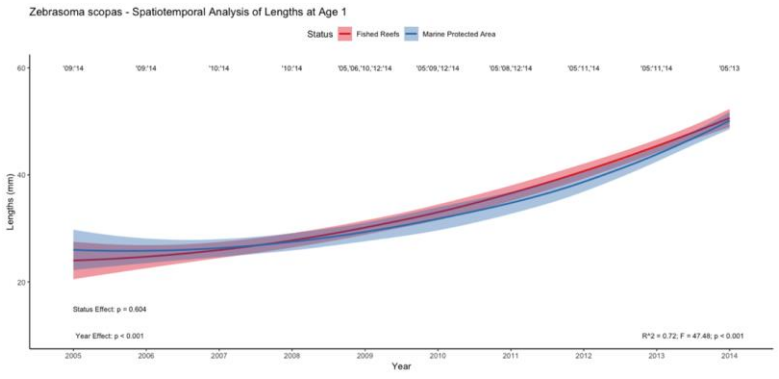
Team Member: Gautam Ghosh
Faculty Advisor: Dr. Ralph Turingan, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

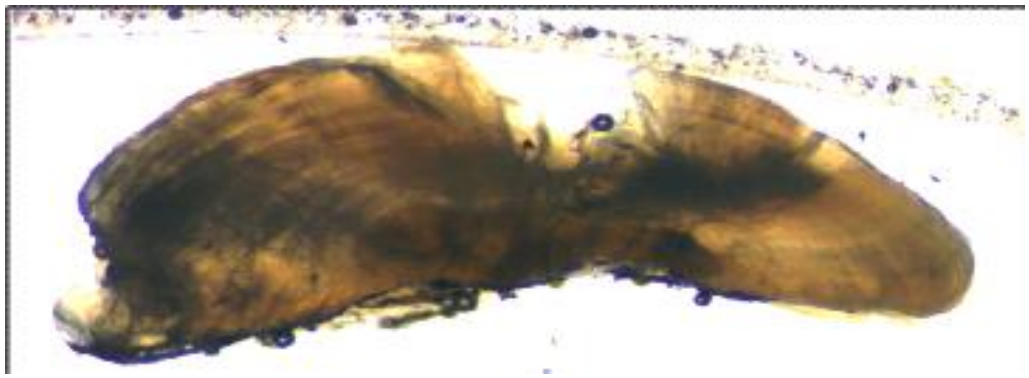
The basis of this project is to show how functional genomics and hormesis can be used to enhance aquaculture production and in this specific project, we are focusing on the aquaculture of the Florida Pompano (*Trachinotus carolinus*), a highly sought-after bony fish commonly found in the warm waters on the US East Coast and Gulf of Mexico. Little is known about its life history and ecology, creating issues in initial attempts at commercial aquaculture. However, the Florida Pompano is a good candidate for aquaculture because of its ability to tolerate a wide range of salinities, tolerance of high densities, and capacity for reproduction in captivity. Also, studies have been conducted on the commercial viability of Pompano and its aquaculture has advanced to the point that it is ready for commercialization. In this study, we describe an initial sequencing and assembly of the genome of Florida Pompano in combination with a draft transcriptome, which greatly enhances gene prediction and aids the identification of non-coding sequences. Having access to the full genome provides a platform for future identification of variant sites that will help in selective breeding practices in the aquaculture of Florida Pompano. We aim to use this sequencing technology to inform sustainable aquaculture of Florida Pompano in the United States by increasing quality and market value. This project will improve production efficiency through the identification of markers for growth, efficiency, and disease resistance. To sequence and assemble the genome of the Florida Pompano, the RNA was extracted from skeletal muscle tissue of another individual and sequenced with Illumina HiSeq sequencing. Having access to the full genome after the sequencing will allow us to compare the genomic structure of the Florida Pompano with five other teleost fish species: *Takifugu rubripes* (Japanese puffer), *Cynoglossus semilaevis* (tongue sole), *Danio rerio* (zebrafish), and *Scophthalmus maximus* (turbot). The analysis of the genomic data showed that 50% of the Pompano genome is assembled from contigs that are at least 1.5 Mbp in length and the 500 longest contigs cover almost 80% of the Pompano genome. This shows that we have a good representation of the genome. We predicted 33,574 transcript-based and 31,046 de novo-based protein coding genes in total. We also compared the orthologs of our predicted proteins to the five different teleost fish species' proteomes. The majority of our predicted protein genes were shown to have an ortholog in at least one of the five species, and there were 10,179 orthologs found between all 6 proteomes. Of all the protein coding genes, only 591 from the other fish were missing from either of our pompano predicted protein sets. This shows that we successfully constructed a good representative of gene predictions. Through analyzing this data, we were able to form a picture of the life history of the Florida Pompano and compare this species to other teleost species as well. Our study provides a platform for sequencing of additional Florida pompano individuals to identify sites of variation, which would allow us to uncover genetic markers linked with favorable traits. This could be helpful in future selective breeding processes for aquaculture. In the future, we are planning to look for repeats and non-coding RNA sequences to form a more complete picture of the genome.

Project Name **Back Calculations: A Solution to the Repeated Sampling Problem in Marine Protected Areas**

Team Lead: Erin Casalles
Team Member(s): Ethan Brown
Faculty Advisor(s): Dr. Ralph G. Turingan, Department of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Marine Protected Areas (MPAs) have widely been popularized for a solution to combat the adverse effects of overfishing and exploitation of marine habitats. Theoretically, the establishment MPAs would not only increase body mass and size of fish due to increased food availability within protected area, but also the surrounding regions for the benefit of fisheries and conservation alike. However, the efficacy of MPAs has yet to be fully realized as very little supporting evidence exists. Acquiring long term temporal data is virtual impossible because of the principles of no take MPAs preventing researchers from capturing large quantities of fish over time. In order to circumvent this issue, a combination of body length and otolith visual analysis and the novel application of back calculations were applied to generate temporal spatial data of the MPA and surrounding area. Otoliths are calcium carbonate deposits within the fish formed in seasonal banding patterns that are proportional to the size of the fish at capture while back calculations, specifically the Modified Fry Back Calculation in this study, extrapolate the life history data to further data yield. Zebrasoma Scopas and their otoliths were studied during this investigation because this species expresses indeterminate growth and are commonplace within Asian markets. The results supported MPAs efficacy with the trend of increasing growth over time within age cohorts from age 1 to 8. In conclusion, the study indicated that MPAs are functioning as intended and that the Modified Fry Back Calculation model is applicable in MPA assessment for future studies.





Project Name **Phenotypic Responses of Coral Reef Fish to Marine Protected Areas Relative to Fished Areas**

Team Member(s): Harley Graham
Faculty Advisor(s): Dr. Ralph G. Turingan, Dept. Of OEMS, Florida Institute of Technology

Overfishing and unsustainable fishing practices have drastically reduced the amount of harvestable biomass in fisheries worldwide (FAO 2016, Worm et al. 2009). Marine protected areas (MPAs), areas in which fishing and other exploitative human activities are prohibited, have become one of the most commonly utilized management tools for both biodiversity conservation and fisheries management (Kelleher and Kenchington 1992; Edgar et al. 2007). As fish stocks continue to decline, and reliance on MPAs as a primary management tool increases, it is critical that we gain a more thorough understanding of the spatiotemporal impacts of protection on harvested fish populations. This study utilizes a rare opportunity to sample within MPA boundaries to introduce the use of back-calculation models as a technique capable of ameliorating the logistic and legal difficulties of repeated temporal sampling (Casselman 1990; Francis 1990; Secor et al. 1995). We demonstrate that back-calculated size-at-age information derived from otoliths can be used to illustrate temporal patterns of phenotypic divergence and convergence between protected and harvested fish populations, which will ultimately enhance our understanding of the capacity of MPAs to achieve their stated goals.

Figure 1. *Zebrasoma scopas* Annotated otolith (age 5).

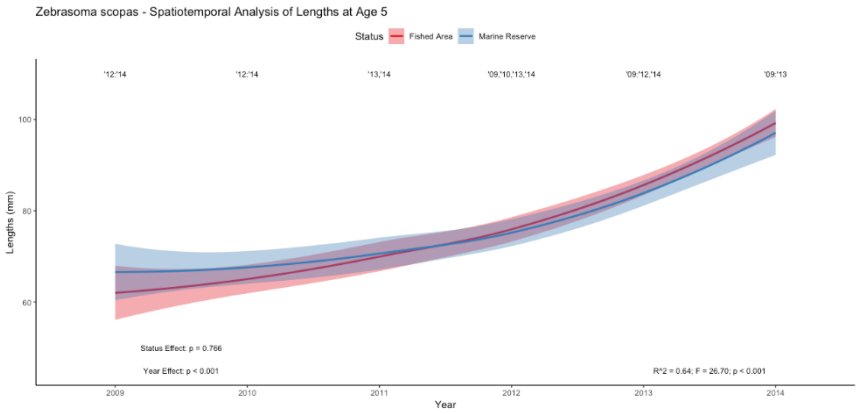


Figure 2. Locally Estimated Scatterplot Smoothing (LOESS) regressions for age 5 cohort.

Project Name	**Cryptic speciation and genetic diversity in dogfish sharks (Genus *Squalus*)**
Team Lead:	Heather Bowersox
Team Member(s):	Carly McCall
Faculty Advisor(s):	Dr. Toby Daly-Engel, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Project Description:

The dogfish sharks (Genus *Squalus*), ubiquitous in the deep sea, were long assumed to belong to just a few species because of their physical similarity and "boundless" deep sea habitat. We examined relatedness among 14 specimens comprising 6 putative Squalus species to elucidate patterns of evolution using >1 kb of mitochondrial DNA. We found that several co-occurring species are genetically unrelated, despite being nearly identical with regards to morphology. Our study highlights the need for taxonomic studies to include genetic data to pinpoint cryptic diversity in the deep ocean.

Graphics:

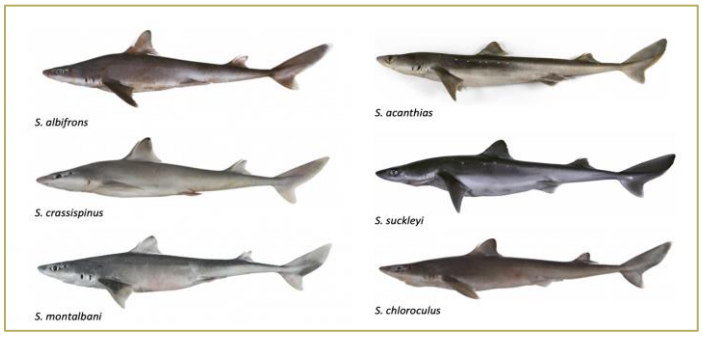


Figure 1. Species sampled in the genus *Squalus*

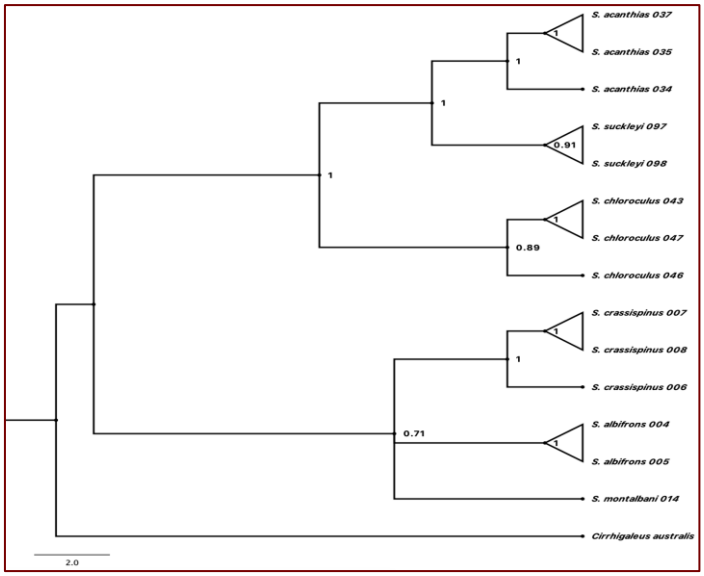


Figure 2. Phylogenetic tree created using concatenated ND2 and D-loop sequences

Project Name	**Variation in Thermal Response Between Disparate Populations of Bluegill Sunfish (*Lepomis macrochirus*)**
Team Lead:	Jusvin Gofandi
Team Member(s):	Hannah Ryback
Faculty Advisor(s):	Dr. Ralph Turingan, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Different populations (i.e., demes) of a widely distributed species evolve through the process of local adaptation. This study asks the question, "How do different locally adapted populations respond to variable thermal regimes?" Addressing this question is timely because of our concerns about the effects of climate change in the sustainability of populations. In this study, we determined if the velocity of swimming and prey-capture varied between Florida and Massachusetts population of the bluegill sunfish, *Lepomis macrochirus*, when fed at four experimental temperatures: 20°C, 24°C, 28°C, and 32°C. Fish from each population were first conditioned to the experimental room in the Aqualab at Florida Tech in 20°C waters for 2 months. After 2 months, the feeding behavior of the fish were filmed using a high-speed camera that could capture behaviors at a filming rate of 300 fps. The filming began in 20°C water. After every other day, the temperature of the water was increased to the desired temperatures, all the way up to 32°C. Once filmed, the fish videos were edited using a free software called Kinovea to measure the approach and strike velocities of their feeding behavior. Average velocities were compared between the two populations among temperatures. The results suggest that there is no significant difference in the feeding behavior of the bluegill sunfish when exposed to various temperatures, even if they were from different locations with disparate thermal regimes. A plausible mechanism that underlies the resilience of bluegill to thermal changes is the development of coping or compensatory mechanisms, including the differential expression of heat shock proteins (HSP), the variable abundance of mitochondria, and the range of phenotypic plasticity in fish.

With the large range in distribution, different populations would be affected differently by temperature.

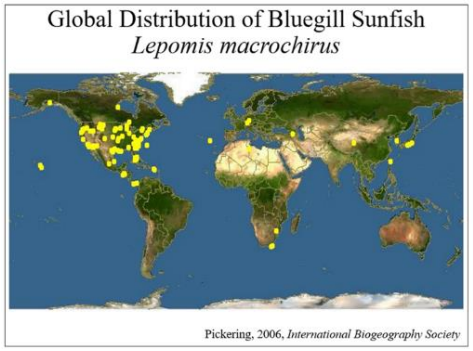


Figure 1: Global Distribution of Bluegill Sunfish.

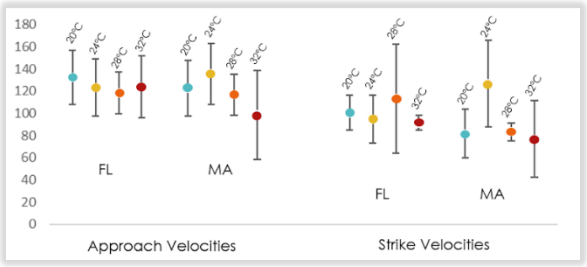


Figure 2: Maximum velocity of fish.

. The graph represents the maximum velocity, for the approach and strike velocities, divided into each state and individual temperatures.

A Q10 graph of the results, showing a value of 1 and slightly less, signifying no change in the thermodynamics of enzyme activities.

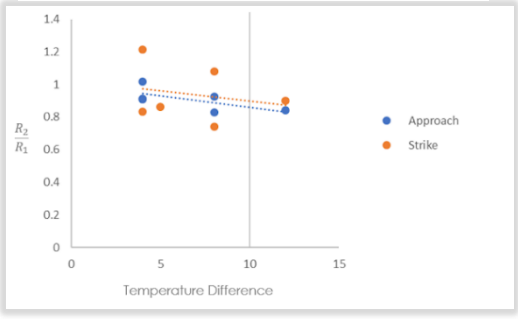


Figure 3: Change in maximum velocity with temperature.

Project Name	**Effect of Temperature on Lionfish Predatory Approach Angle**
Team Lead:	Kara Watts
Team Member(s):	Mason Thurman, Miles Swanson
Faculty Advisor(s):	Dr. Darby P. Proctor, Dept. of Psychology, Florida Institute of Technology Dr. Ralph G. Turingan, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Lionfish (*Pterois volitans*) are an invasive species native to the Indo-Pacific region in the South Pacific and Indian Oceans. The species current invasive range encompasses the east coast of the United States from the coast of Florida to New York. Eating up to 30 times their stomach volume, lionfish are ferocious predators threatening the survival of many native species. As a tropical fish, it is surprising that lionfish have been found thriving in cold regions. Many prey fish avoid predators by escaping upwards toward shallow water. In response, predators have exhibited risk sensitive foraging in relation to reduced foraging success. Colder water temperatures affect the physiological system of fish (sensory and mechanistic) which alters how prey respond to threats and may alter how predators attack. The purpose of this study is to examine the effects of temperature on lionfish hunting behaviors. Colder water temperatures reduce the metabolic rate of fish, reducing the amount lionfish would need to consume at colder temperatures. Therefore, we expect lionfish will use more risk prone hunting patterns in colder temperatures.

To test this, we analyzed attack angles from four wild-caught *P. volitans* from Port St. Lucie, Florida. Each lionfish was acclimated to 20C, 25C, and 30C in series. Attack orientation was measured from videos recorded for the Turingan and Sloan (2016) study. A RedLake High-Speed Motionscope 2000S camera with a shutter speed of 1/1000 s at 250 frames per second was used to record the predatory response of the lionfish when introduced to a live mosquitofish at each temperature. The angle of attack was measured in degrees, clockwise from the eye of the prey to the eye of the lionfish using Kinovea. This provides an attack angle based on prey orientation.

Rao spacing tests on the lionfish's attack angle indicated non-uniform attacks at 25°C and 30°C, with 20°C having uniformity (Fig. 4). A circular ANOVA indicated that lionfish significantly alter their angle of attack at different temperatures, ($F(2, 108) = 11.59$, $p < 0.01$, $\eta 2 = 0.14$). Posthoc tests indicated that a significant difference exists between each temperature condition.

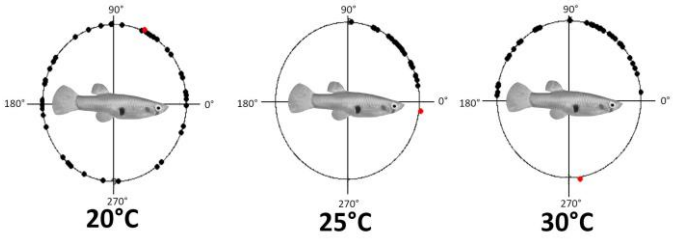


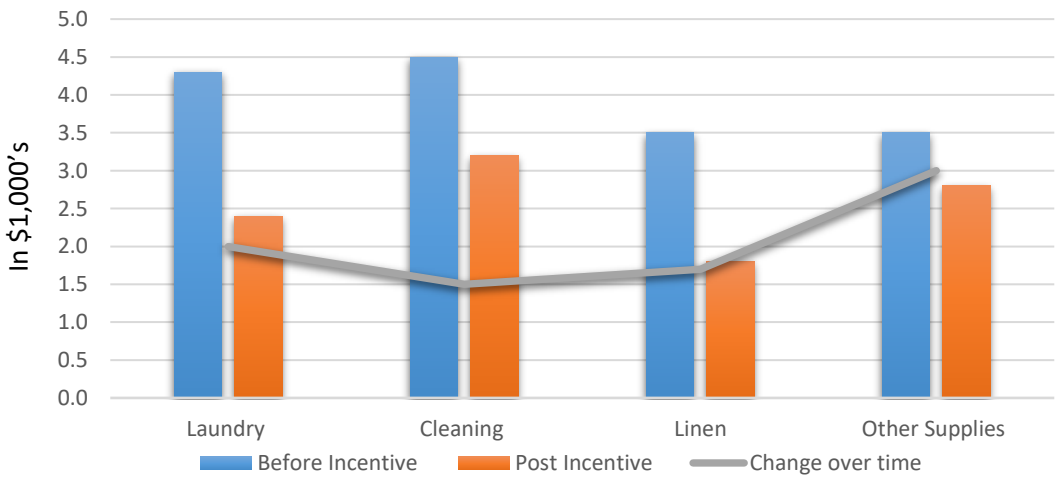
Fig. 4 Lionfish approach angles at various 20°C (*M* = 152.8, *SD* = 96.7), 25°C (*M* = 42.3 *SD* = 17.7), and 30°C (*M* = 95.2, *SD* = 52.8)

We found that lionfish vary their attack angles depending on temperature. Lionfish only attack from underneath the prey at the coldest temperatures. This is the least efficient angle as mosquito fish flee in an up and forward direction. This may indicate a more risk prone hunting strategy as they may not have the metabolic energy to position themselves more efficiently. There was also a difference between the warmer temperatures. While in both of those temperatures the fish attack from above, only at the warmest do they attack from above and behind. Additionally, mosquitofish are prone to reduced responsiveness at lower temperatures. Lionfish may have experience with the limited escape response and learned that tactical approaches are unnecessary for success. More research is needed to explore this pattern of behavior. However, further research is required to examine this relationship. Further understanding of lionfish adaptability will enhance our ability to predict future distribution patterns and negative effects of lionfish populations.

Sustainability

Project Name	**Incentivizing Hotel Guests to Adopt Sustainable Practices, Hilton & DoubleTree Beachside Hotels**
Team Lead:	Adi Davidov
Team Member:	Max Erdman
Faculty Advisor:	Dr. Ken Lindeman

To reduce both expenses and environmental impacts, the Hilton and Doubletree Hotels, beachside in Melbourne, Florida, are working with Florida Tech to incentivize customers to practice more sustainable behaviors. The main objective was to incentivize hotel guests to reduce demands on the Housekeeping Services department (HS). We designed an initiative where Hilton Honors guests can earn bonus travel points for each second night, they choose to skip HS. We observed hotel operations and planned with managers and staff on a weekly basis to develop an incentive program utilizing the Hilton Honors Points system, valued by repeat customers at all Hilton properties including Doubletree, Hampton Inn and others. We estimate that a 40-50% decrease in HS operations from this program is possible at the Beachside Doubletree with reductions in use of laundry and cleaning supplies, which saves water and energy (an estimated $5,800 in savings per month). Hotel financial performance will also be improved as knowledge of the opportunity begins to snowball: based on a 35% guest participation rate, an estimated total reduction of $16,000/month in overall expenses including labor could be realized. The accumulated savings will be invested to improve hotel operations and to develop green incentivizes for employees. These hotels are now beginning operational adjustments to align the new program among the HS, front desk, sales, and IT departments. The hotel IT department will assist information gathering regarding which room should be serviced to establish more efficient program implementation. This business-university partnership has produced early actions and future interns will examine next generation client behavior-change opportunities.



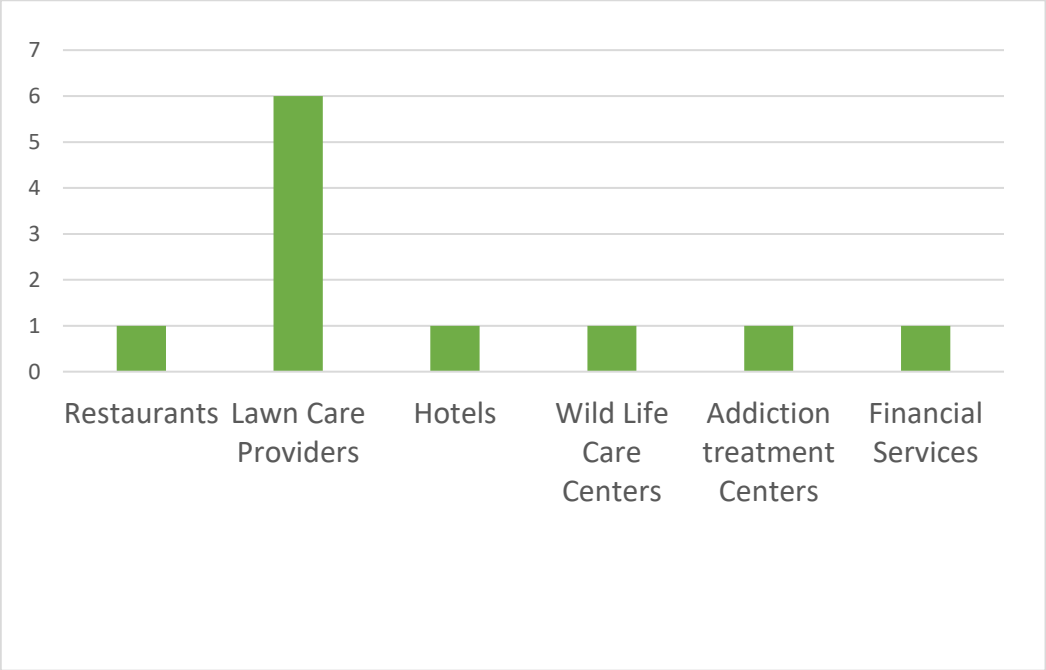
DOUBLETREE BY HILTON™

Hilton HONORS

Project Name **Implementing a Green Business Certification Program in Brevard County, Florida**

Team Member: Marcus Carreiro Farley
Faculty Advisor: Dr. Ken Lindeman

The Indian River Lagoon (IRL) extends along 40 percent of Florida's eastern coast (IRLNEP 2007). Decades of nutrient pollution has caused widespread decline in water quality that threatens the environment and economic opportunities. The Marine Resource Council (MRC) was established in 1983 to use science and policy tools sustain the health of the IRL. The Green Business Program (GBP) is an eco-certification initiative of the MRC to recruit local businesses to adopt sustainable practices to improve IRL water quality. The GBP has been developing since 2017 with the goal of more green businesses throughout Brevard County. From summer 2018 to the spring of 2019, GBP program resources have been greatly developed and implementation is now underway. Sixteen new businesses have been contacted since fall 2018. There were 9 businesses participating in the GBP at the end of 2018 since then the membership has increased by 22 percent. GBP has new program structure to insure more steady program attention into 2020. In addition, program administrative descriptions of grant opportunities and best management practices (BMP) have been re-written and are available to businesses. Additional literature has been developed to assist green business interns with future recruitment and management to catalyze a snowball effect in new members by mid-2020.



Project Name **Optimizing Fresh Water Production Onboard Carnival Cruise Line Ships**

Team Member: Natalie P Gadelrab
Faculty Advisor: Dr. Ken Lindeman

Carnival Cruise Line (CCL) is a major cruise line based in Doral, Florida, the company owns and operates 25 cruise ships globally which have a large environmental impact. CCL is consistently researching conservation methods whether it be decreasing energy usage in cabins, ship greenhouse gas emissions, or fresh water (FW) consumption. It is vital for cruise ships to have clean FW on board, it is used for cooking and for all passenger's activities such as bathing and drinking. Cruise ships have two main methods of obtaining FW: onboard production or bunkering. FW produced onboard is done with reverse osmosis (RO) systems or evaporators, while bunkering is receiving FW from a port while the ship is docked. The cost and quality of FW varies. An analysis of the methods of FW production for 8 ships was completed to compare actual production and manufactures design production as well as determine which process has a lower cost per unit of FW produced. A RO can produce 1 m^3 of FW for $0.65, while an evaporator can produce the same amount at $0.30. RO and evaporator systems have variable efficiency. There is evidence of large differences in FW consumed that is produced onboard for ships with the same inventory of FW production systems. Further research should examine and test for significant differences among several factors including: differing ship sizes, operating locations and water temperatures, manufacturer efficiency, and ship-specific operation protocols.

Ship Names	# RO	# Evap	FW Consum. (m^3/hr)	Evap Product. (m^3/hr)	RO Product. (m^3/hr)	Bunkered (m^3/hr)
Fascination	3	1	27.71	6.64	12.87	8.23
Glory	0	3	50.44	32.33	0	18.39
Imagination	1	2	32.23	0.64	7.77	23.96
Inspiration	1	2	30.29	4.89	7.14	18.26
Legend	1	2	30.74	19.59	5.30	5.66
Miracle	1	2	33.12	15.22	12.26	5.44
Pride	1	2	35.69	22.27	10.19	2.89
Spirit	1	2	30.87	16.10	11.36	3.39

Table 1. FW production & consumption among 8 ships,

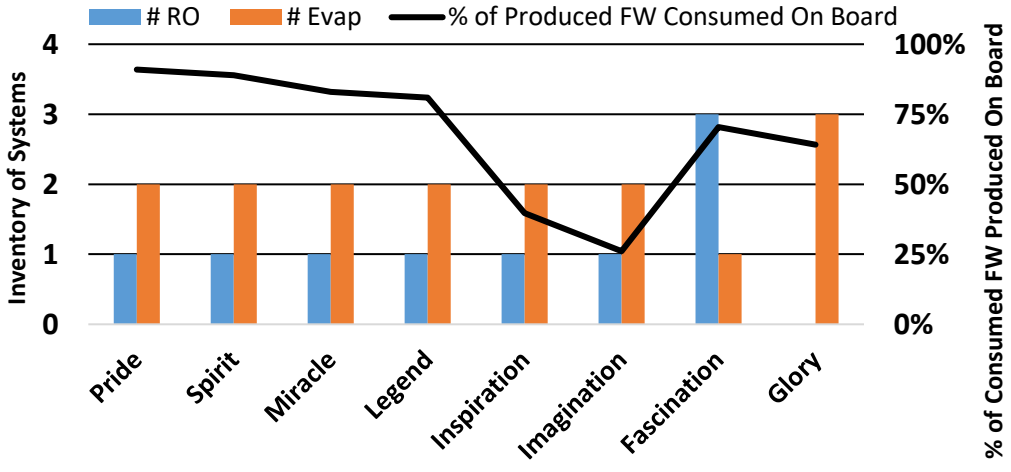
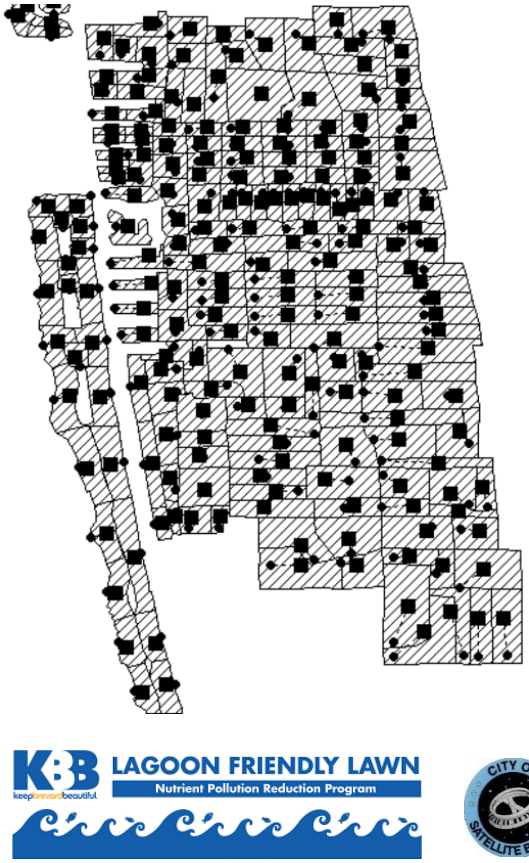


Figure 1. FW consumed that is produced on board.

Project Name **Modeling Potential Reductions of Nutrient Outflows in Stormwater Using Eco-certified Lawns**

Team Leader: Abigail Hardman
Team Member: Thomas Stevens
Faculty Advisor: Dr. Ken Lindeman

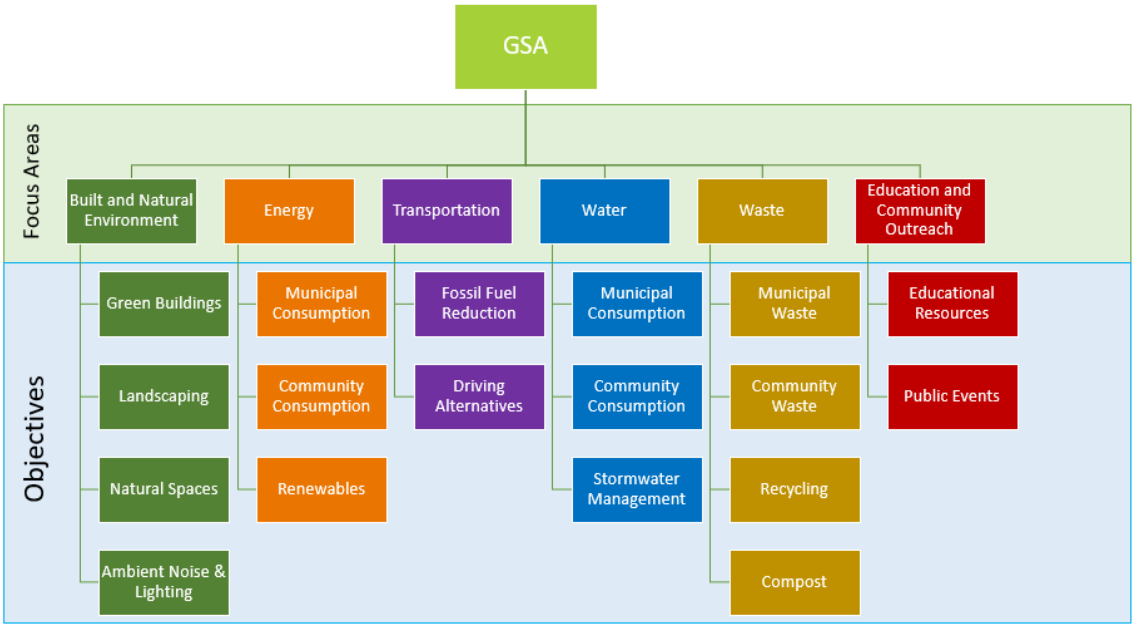
The Indian River Lagoon (IRL) is threatened by nutrient pollution and lawn runoff which have major impacts on water quality. Keep Brevard Beautiful (KBB), a Brevard County non-profit, has developed an eco-certification program called Lagoon Friendly Lawns (LFL) which certifies lawns as member, silver, or gold levels based on green landscaping attributes. The Satellite Beach area was examined because of the high concentration of LFL certified lawns (57/317 in 2019). This project uses geographic information systems and LIDAR data to outline catchments, areas of land that drain to a common point due to topography. Using the EPA Storm Water Management Model (SWMM), nitrogen and phosphorus runoff levels were simulated. The permeability of a lawn was calculated using Google Earth by averaging permeable and non-permeable areas for lawns in five randomly chosen catchments. To model member and non-member lawns, the permeability was varied. A non-member lawn was modeled as 100% impermeable and LFL lawns were modeled with increasing permeability, corresponding with decreasing turf areas. A 10-year, 60-minute storm event was run with a rainfall amount of 3.04 inches. Three different SWMM models were run: all LFL members, no LFL members, and the current number of LFL members. By modeling the nitrogen and phosphorus in the runoff, an area with the most nutrient dense runoff was identified. One area of catchments was identified as the highest priority focus area for KBB at the city scale, this area includes Desoto Pkwy north to Cassia Blvd and extends west of South Patrick Drive.



Project Name **Creating Municipal Sustainability Guidelines for the Town of Melbourne Beach, Florida**

Team Member: Kaitlin Reed
Faculty Advisor: Dr. Ken Lindeman

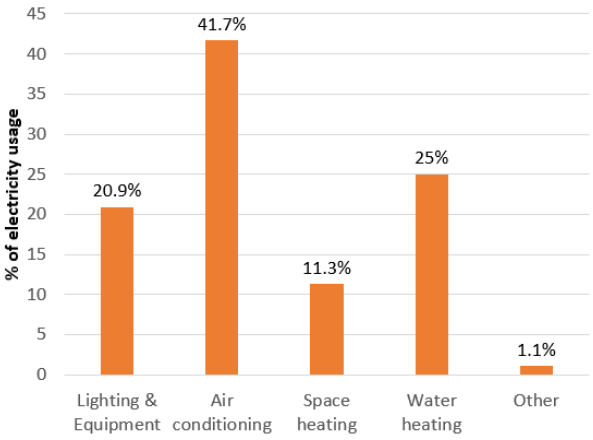
There is an increasing need for sustainability and resilience planning at a local level. To ensure successful economic, social, and environmental capital now and for future generations, strategies and actions are being developed in many coastal cities and counties to address current and predicted issues that may negatively impact local communities. This paper summarizes the process taken to create a Guidelines for Sustainability Actions (GSA) document for the Town of Melbourne Beach, Florida. The GSA will be a living, adaptable document that serves as the first formal, town-approved guidelines for prioritized sustainable management actions. Working with the Town Environmental Advisory Board and senior town staff, an analysis of current conditions was completed. Other town sustainability documents were reviewed and adapted to create a framework specific to Melbourne Beach. Several baseline measurements were recorded for different performance indicators. The sustainability guidelines are divided into six goal areas. There are between two and four objectives for each goal area, followed by specific actions to be taken to achieve each objective. Following the initial assessments, the actions were prioritized according to expected cost, benefit, and timeline, which produced a list of ten action items that should be addressed first. The guidelines suggest specific, attainable goals for the Town, steps to reach the goals, ways to measure progress, and how to fund these measures. Further work involves presenting the document to the Town Commission in May for official adoption and continuing an intern program to assist project implementation.



Project Name **Energy Audit and Solar PV Array Proposal for a Beachside Hilton Hotel, Melbourne, Florida**

Team Lead: Anisha Tiwari
Team Member: Addison Abramson
Faculty Advisors: Dr. Ken Lindeman, Dr. Troy Nguyen

The Hilton Energy Team worked with the Hilton Melbourne Beach Oceanfront Hotel's management to expand their green energy initiatives. Our mission was to obtain empirical information to inventory energy usage to strategically save energy and reduce expenses for the hotel. While working with management, we performed an electrical energy audit to identify individual energy loads that each system in the South Tower of the hotel uses. We found that the largest electrical outputs were from these systems: Air Conditioning, Water Heating, and Lighting and Equipment. The energy audit identified areas in the hotel that have room for efficient improvements. We generated an Energy Audit report that consists of multiple Energy Conservation Measures (ECMs) as well as Operation and Management Procedures to potentially be implemented. The main ECM we proposed was a solar photovoltaic array to be installed to generate electricity for the South Tower. Research on different types of solar arrays was conducted to determine the most cost effective and energy efficient system. We determined the 305-Watt Mission Solar Energy solar array was the best choice due to its low cost/watt (0.64) and 19.4% efficiency and a payback period of approximately 7.8 years. Other measures recommended are in the form of equipment and appliances that can be purchased and installed with respectable payback periods. Procedures that will not require new capital, but commitments from the employees to perform simple services that promote sustainable work strategies were also recommended.



Item	Projected Cost ($)
Panels (257)	$58,421
Equipment + Structures	$62,256
Installation costs	$54,231
Gross cost	$156,770
Federal Tax credit	(-) $47,031
Total cost	$109,739
Savings over 25 years	$336,830
ROI (per year)	8.3%
Payback period (years)	7.8

Project Name	**Development and Implementation of Florida Tech's First Greenhouse Gas Emissions Inventory**
Team Lead:	Hannah Vest
Team Member(s):	Iven Webb, Joseph Luya
Faculty Advisor:	Dr. Ken Lindeman

Many universities across the U.S. are developing greenhouse gas (GHG) emissions inventories to save money, track their carbon footprints, and reduce CO_2 releases. To create an inventory for Florida Tech, we worked on three objectives: 1) identify GHG inventory protocols and apply them to Florida Tech, 2) identify emission sources associated with campus and estimate annual GHGs, and 3) deliver a GHG inventory with best management practice suggestions. Due to our College of Aeronautics, this will be the first university GHG inventory in the state of Florida that includes a flight program. In order to complete the inventory, Facilities Operations purchased a carbon calculator where all data was entered and saved for final emission calculations. We estimated that Florida Tech emitted approximately 10,604.8 eMT CO_2 in Fiscal Year 2018. Emissions were split into three different scopes: scope 1 includes sources such as stationary fuels, scope 2 includes utilities, and scope 3 includes sources such as landfill waste, paper, and waste water. Scope 2 emissions (which includes utility consumption as the main contributing source) was the largest contributor to eCO_2 emissions, making up 62% of the 10,604.8 eMT CO_2 estimated for FY18. Improved record keeping on all sources may improve accuracy of results acquired for future inventories. Obtaining GHG emissions inventory information is fundamental for a potential campus climate action plan for reducing carbon emissions to be developed.

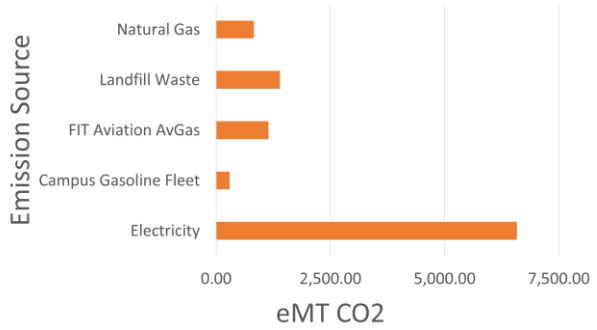


Fig. 1: FY18 Emissions by Source

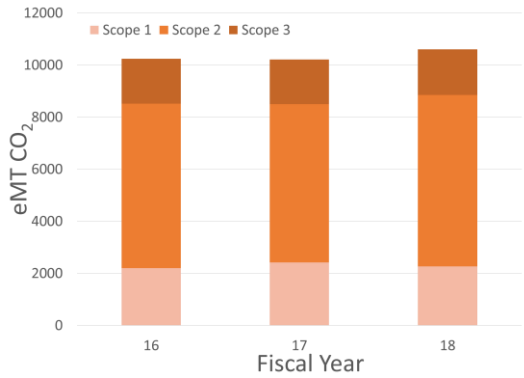


Fig. 2: GHG Emissions by Scope