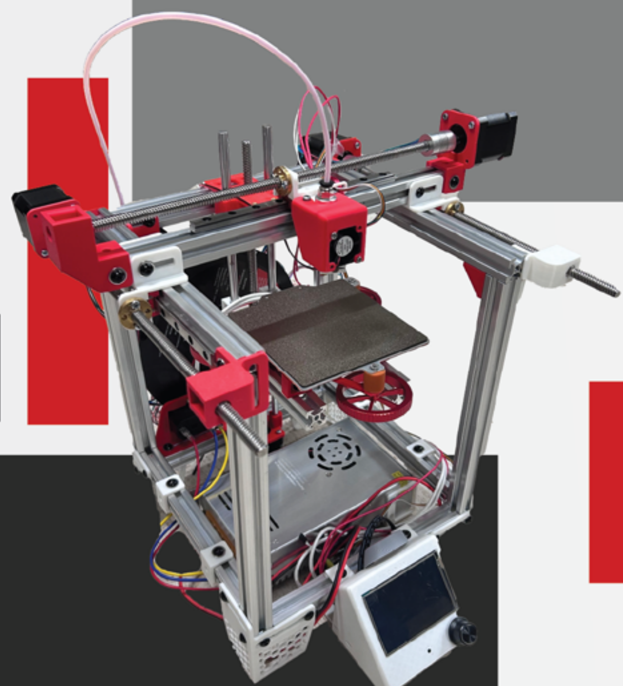
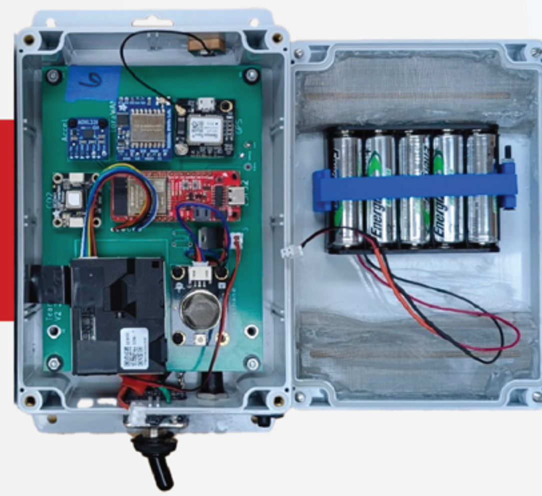
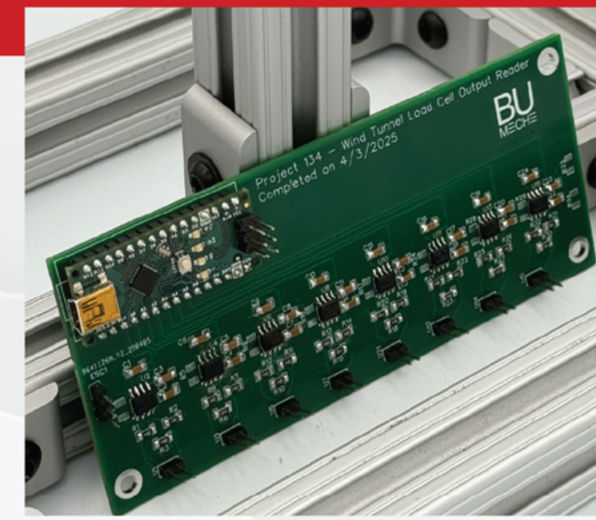
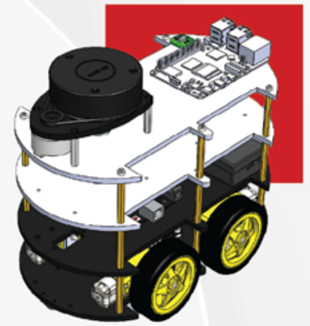


BU

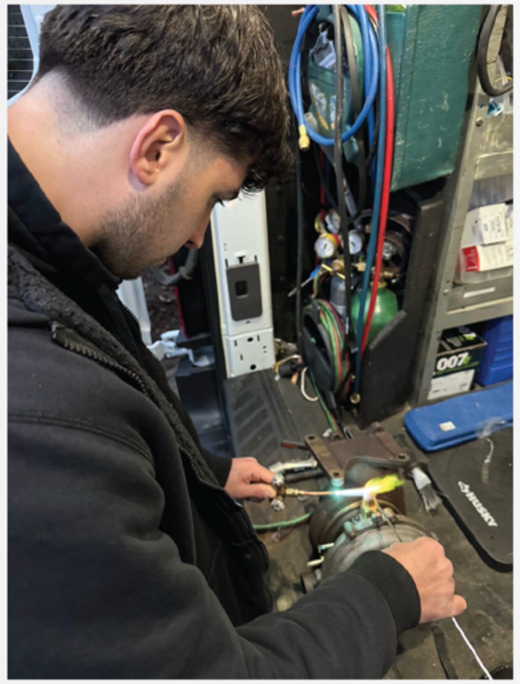
Boston University
College of Engineering
Department of
Mechanical Engineering

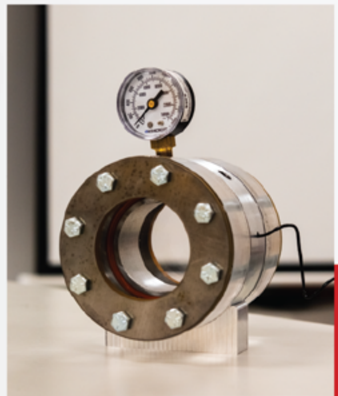


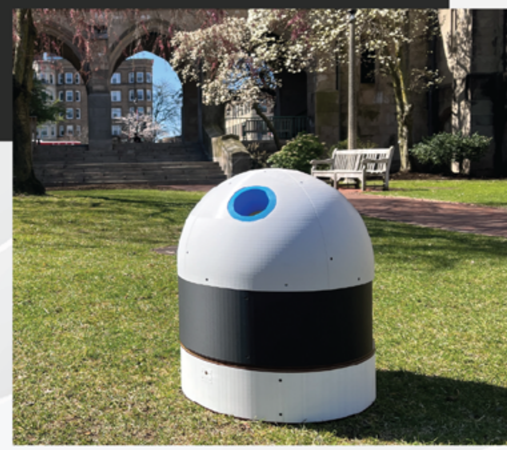


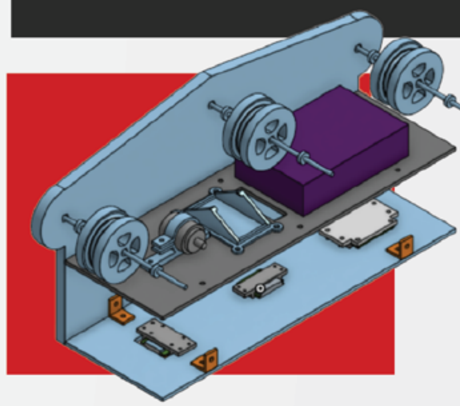
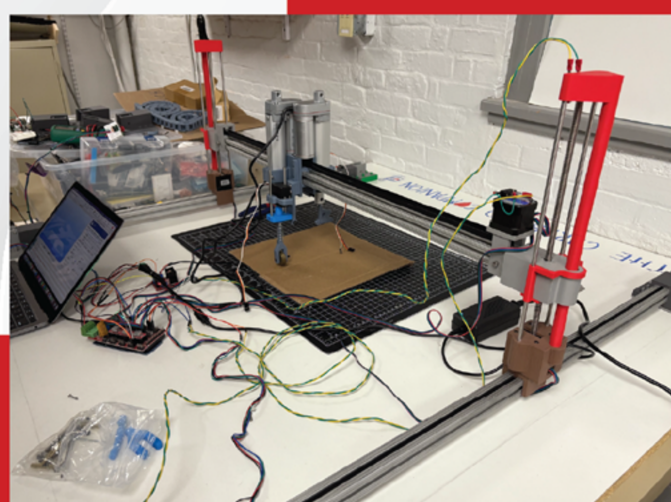
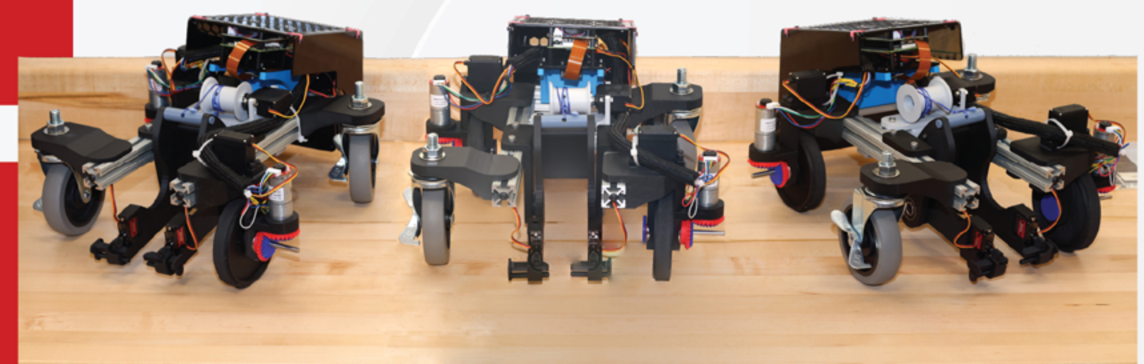

SENIOR CAPSTONE

May 2, 2025

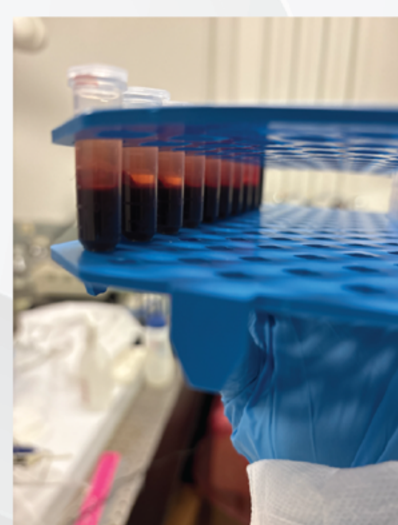



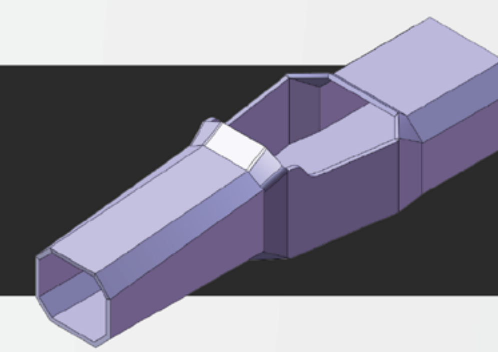









PEM
Hydrogen Generator
PLAANT
Precision Land Assessment and Aerial Nitrogen Treatment

Welcome to the Mechanical Engineering Senior Capstone Day for the Class of 2025!

Today, we celebrate an incredible milestone — the culmination of a year filled with innovation, dedication, and creativity by our outstanding Mechanical Engineering students. In fact, it's not just the culmination of the past year, but of the entire undergraduate program for these students! The Senior Capstone projects you will see throughout the day represent not just the application of skills from statics, fluid dynamics, electromechanical design, and beyond, but a full embodiment of the passion and perseverance that define our amazing senior class.

This year, we are thrilled to showcase 42 projects, covering a broad spectrum of Mechanical Engineering and its intersections with the world around us. Are you fascinated by cutting-edge robotics, space exploration, environmental sustainability, or medical technology? Then you're in the right place! Whether it's ocean conservation, future space missions, or next-generation healthcare devices, there's something here to inspire every imagination.

We are beyond excited to have an incredible lineup of project sponsors this year, including Vibram, NASA's AREN project team, the GLOBE (Global Learning and Observations to Benefit the Environment) organization, the New England Aquarium, and physicians from Massachusetts General Hospital, and Dovera Design! Their support — along with the initiatives of our faculty, our dynamic student clubs such as Terrier Motorsports, and our entrepreneurial students — has been critical in making these projects not just possible, but exceptional.

If you're inspired by what you see today and want to be part of this amazing journey, we are always looking for new project opportunities and partnerships. Please reach out to Prof. Tony Linn to get involved!

Thank you for being here to celebrate the achievements of the Class of 2025. I am incredibly proud of what our students have created and can't wait to see the impact they will have on the world. Let's dive in and enjoy the energy, innovation, and excitement that make this day so special!

Sean B. Andersson
Professor and Chair
Department of Mechanical Engineering

Anthony Linn
Professor of the Practice

Francis DiBella
Adjunct Professor

Jim Geiger
Adjunct Professor

Scott Bunch
Associate Professor

Enrique Gutierrez-Wing
Master Lecturer

Annmarie Roth-Haley
Financial Administrator

Steve Chomyszak
Professor of the Practice
and EPIC Director

Tasker Smith
EPIC Senior Shop
Manager

Ryan Bakinowsk
EPIC Laboratory
Supervisor

Kara Mogensen
EPIC Laboratory
Supervisor

Caroline Carbo
EPIC Laboratory
Supervisor

Adam Zelny
EPIC Laboratory
Supervisor

Eric Hazen
Senior Research Engineer

Projects (Click to jump to each project.)

Interdisciplinary Projects

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AIAA HYBRID-ELECTRIC REGIONAL TURBOPROP

TEAM 9

TEAM MEMBERS

Ronith Bellary
Luis Padilla Hernandez
Luke Borders
Kaan Altmisdort

PROJECT ADVISOR

Jim Geiger

OVERVIEW

In response to the growing need for sustainable aviation solutions, this legacy AIAA project aims to design a hybrid-electric regional turboprop aircraft that effectively reduces block fuel consumption compared to current market competitors.

THE PROBLEM

Since the 1980s, turboprop aircraft have largely been replaced by faster, but less fuel-efficient, regional turbofan aircraft for short-haul operations. However, these aircraft consume significantly more block fuel compared to turboprops. Our project seeks to study the feasibility of hybrid-electric powertrains as a means to improve upon existing economic performance, reduce environmental impact, and gain a first-mover advantage in the regional airline market.

THE REQUIREMENTS

Our design targets a passenger capacity of 46–50, range of 800 nmi, cruise speed of 250–350 KTAS, and cruise altitude of 28,000 ft, using battery and hybrid-electric propulsion technologies feasible for our entry-into-service of 2037. An effective power management strategy is essential for optimizing performance and minimizing carbon emissions. Therefore, a key challenge is determining when to activate the batteries throughout the mission.

THE SOLUTION

Through a series of analyses, we selected a realistic battery specific energy and determined the optimal power management strategy for our design. To minimize fuel consumption, the aircraft will fly at 250 KTAS, use no battery power during cruise, and operate at 40% electric during takeoff and 90% electric during climb, descent, and landing.

THE RESULTS

Our final software-defined prototype weighs nearly the same as our main competitor, the ATR 42, while burning 24% less fuel than it for a 400 nautical-mile mission. Additionally, we were able to reduce our ticket prices by up to 10% compared to the national average of ticket prices for similar short-haul flights, all while maintaining a strong financial operating margin.

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HYBRID-ELECTRIC STOL AIR TAXI

TEAM 12

TEAM MEMBERS

Aidan McCready
Kaitlin Villalba
Jo-Wei Fang
Maria Lerena Sanchez

PROJECT ADVISOR

Jim Geiger

OVERVIEW

This hybrid-electric short takeoff and landing (STOL) air taxi design delivers point to point regional transportation while reducing carbon emissions and boosting profit margins.

THE PROBLEM

The growing demand for sustainable regional transportation highlights the need for innovation in aviation. Traditional fossil-fuel aircrafts produce high carbon emissions and lack efficiency for short routes. By balancing sustainability, battery energy storage limitations, and economic viability, the hybrid-electric short takeoff and landing (STOL) air taxi, powered by a series distributed electric propulsion system, offers a solution.

THE REQUIREMENTS

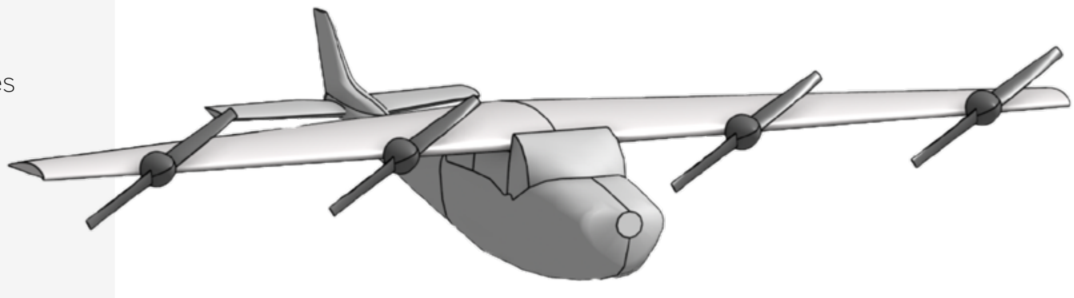
This previous 2021 graduate level AIAA project outlines many of the constraints for this aircraft. It is required that this aircraft has a hybrid-electric propulsion system, can take off and land on a 300-foot runway, travel for 300 nautical miles, generate 15% profit, and seat 3 passengers plus one crew member. The design prioritizes the optimization of economic profit and powertrain configurations.

THE SOLUTION

We optimized our hybrid-electric aircraft prototype using Response Surface Methodology with an Excel workbook that allowed us to build metamodels to approximate simulation behavior of the aircraft. An optimization screening helped us identify the most influential key factors affecting fuel burn and profit. Regression analysis generated contour plots to visualize trends and determine optimal design conditions.

THE RESULTS

The final prototype features a hybrid powertrain that utilizes a lithium-ion battery. The prototype also features an aerodynamic blown wing configuration with 4 propellers distributed across for short landing and take off capabilities. The profit requirement of 15% was exceeded with a profit margin of 22.2%. Finally and most importantly, this aircraft achieves a 23.0% fuel savings compared to the Cirrus SR22, a conventional engine 4-seater aircraft.



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NASA SELF-PILOTED AIRCRAFT FOR CRITICAL RURAL/ SUBURBAN NEEDS

TEAM 13

TEAM MEMBERS

Oscar Xu
Casey Whitworth
Yoomin Choi
Avery Bantrup
Parker Frost

PROJECT ADVISOR

Jim Geiger

SPONSOR

NASA Legacy Project

OVERVIEW

Design a small commuter aircraft to provide affordable air transport to passengers and cargo in rural and suburban communities, optimizing cost-efficiency through remote piloting capabilities during cargo operations.

THE PROBLEM

Small commuter aircrafts face economic challenges due to low passenger demand, high operational cost per seat, frequent short-range trips, and limited utilization. Eliminating pilots during cargo missions and eventually passenger flights can significantly reduce costs. Developing optionally-piloted aircraft capable of autonomous operations offers an economically viable solution to maintain critical air services to rural and suburban communities, ensuring continued accessibility without sacrificing safety or affordability.

THE REQUIREMENTS

Our aircraft must seat at least 9 passengers, achieve flight durations no more than 99 minutes, cover ranges of 200-500 nautical miles, and carry cargo payloads between 2,000 and 7,500 lbs. It requires remote piloting capabilities and a life-cycle operational cost below $2 per seat mile. Principal constraints include compliance with short-field takeoff and landing capabilities, noise restrictions, regulatory standards, and ensuring efficient multimodal passenger-cargo operations.

THE SOLUTION

Our strategy was to start with a design that was able to meet all of the minimum requirements, and then work from there through numerous iterations. This method allowed us to tackle each technical challenge one at a time, continuously improving our design to eventually reach the objectives. For the remote-pilot part of our project, we implemented a multi-step failsafe system to ensure connectivity through the entirety of the flight.

THE RESULTS

The final design was successful in that it met all of the project requirements as well as surpassing competitor planes. Our communications system has proven to be reliable as we are using the industry standard as well as newer technologies and optimized to be cost effective. By sticking with a value design strategy, we were able to get our seat cost per nautical mile to be $0.76.

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BEADED JEWELRY MANUFACTURING

TEAM 19

TEAM MEMBERS
Caroline Canty
Rejwan Himel
Nicole Nemerson
Ella Brown
Omar Hassan

PROJECT ADVISOR
Enrique Guiterrez-Wing

SPONSOR
Dovera Designs

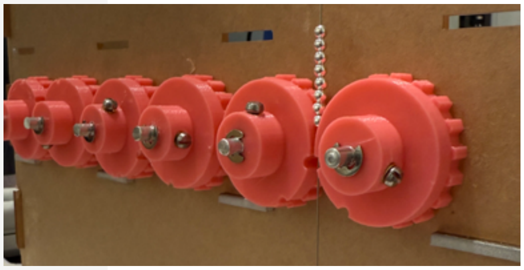
OVERVIEW
This project delivers an automated beading machine that increases production efficiency and precision for customizable jewelry manufacturing.

THE PROBLEM
Dovera Designs currently relies on manual bead stringing, which limits production speed and scalability. Prior automation attempts faced challenges with bead alignment, sequencing accuracy, and reliability. This project solves those issues by designing a robust, user-friendly system that automates the collection, orientation, and sequencing of beads for handcrafted jewelry, reducing labor time while preserving the company's high standards of quality and customization.

THE REQUIREMENTS
The system must align and thread beads accurately at a faster rate than manual methods, support multiple bead sizes and materials, and allow for user-defined patterns through an intuitive interface. Key constraints include maintaining consistent alignment, minimizing jamming, and integrating all mechanical, electrical, and software components into a cohesive and scalable design. The machine must be modular, cost-effective, and durable for extended use in a small-scale production environment.

THE SOLUTION
To automate the tedious and repetitive task of bead stringing, our team designed a semi-automatic system consisting of two main subsystems. The first uses motorized spinner bowls to help users collect beads onto wire leads, with three bowls accommodating different bead types. The second automates sequencing using gear pairs that hold pre-loaded wire leads. These gears, driven by motors and featuring bead-gripping cusps, advance one bead at a time based on a user-defined pattern entered via keypad and displayed on an LCD. A collecting needle on a linear stage moves to receive beads in the correct sequence.

THE RESULTS
We fabricated a functional prototype using 3D printing, laser cutting, water jet cutting, CNC milling, and lathe work. Spinner bowls collect about 10 beads in 30 seconds, and gear-based sequencing reliably dispenses one bead at a time with minimal jamming. Final integration of the collection stage is in progress. Once complete, the system is expected to match or exceed manual stringing in speed and reliability, while maintaining the quality of handcrafted jewelry from Dovera Designs.



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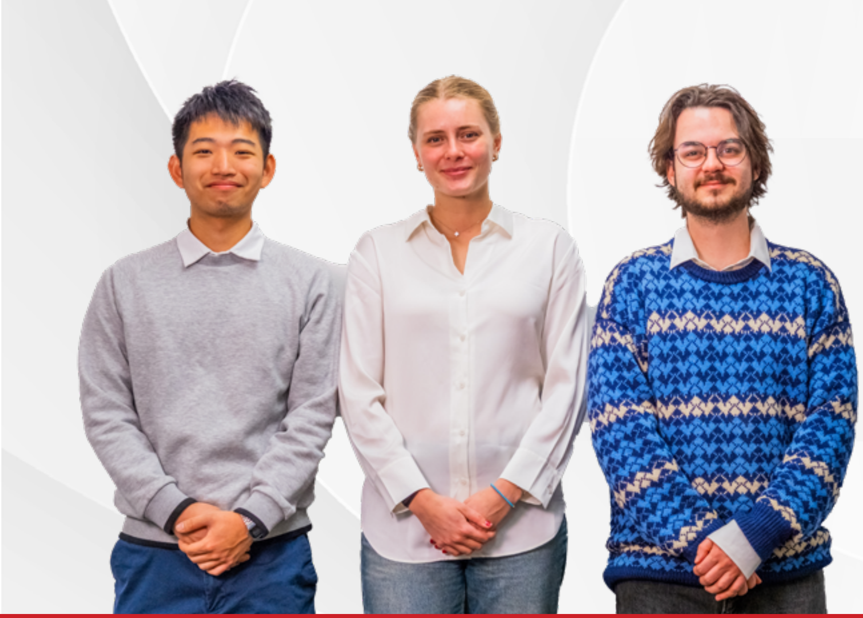


MOBILE AIR QUALITY SENSORS

TEAM 112

TEAM MEMBERS

Andrew Zhang
Tessa Graebner
James Roberts

PROJECT ADVISOR

Francis DiBella

OVERVIEW

Develop and test low cost mobile air quality sensors.

THE PROBLEM

This project seeks to help Professor Ryan of the Computational Energy Lab investigate how low cost mobile sensor packages compare to high precision stationary sensors for understanding local air quality across Boston.

THE REQUIREMENTS

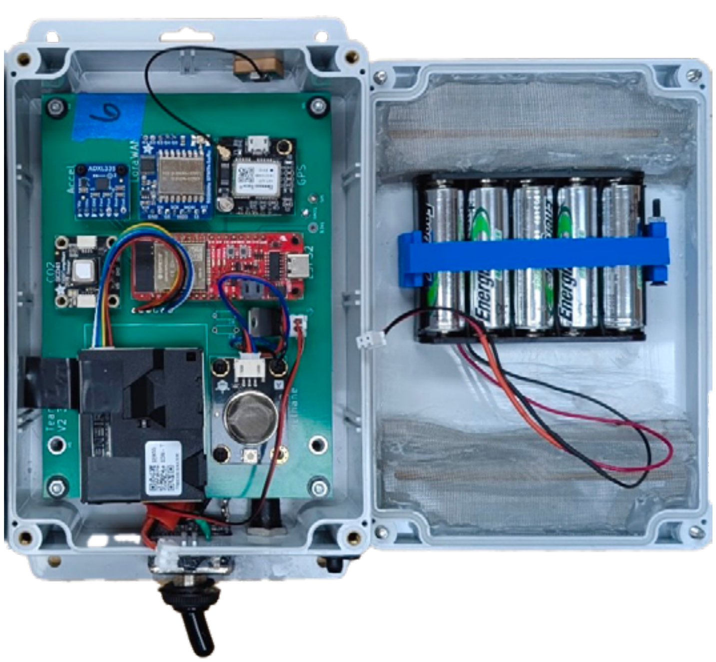
For this sensor to be viable for its intended use it has to be low cost, compact and robust in addition to being accurate.

THE SOLUTION

This project addresses the gap of limited access to pollution data by the development of the low-cost mobile air pollution sensor, developed by a previous senior design team. Confirm solution design by deploying sensor package and evaluate the capabilities of the sensor package to accurately measure local air quality.

THE RESULTS

The mobile air quality sensor has shown to be low cost, mobile and robust. The conducted testing indicated reliable results, aligning with the trends of high-quality MassDEP sensors and expected values. The NOx sensor was identified as needing improvement because is not sensitive enough to detect NOx concentrations observed by the MassDEP accurately. Overall, the testing suggested promising results, in spite of the need to investigate NOx sensing technologies.



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BU 3D PRINTER

TEAM 114

TEAM MEMBERS

Sed Lomani
Bailey Bishoff
Cynthia Fu
Nicolas Canete
Sun Nuntiruj

PROJECT ADVISOR

Enrique Guiterrez-Wing

OVERVIEW

Scalable 3D printer with modularity and customization features designed to enhance manufacturability.

THE PROBLEM

There is a lack of accessible, customizable 3D printers for engineering courses, limiting students' ability to prototype and manufacture parts in-house. Existing options require outsourcing or lack modularity, increasing costs and reducing efficiency. This project aims to provide a scalable, easy-to-assemble, and maintainable 3D printer that supports hands-on learning, rapid iteration, and customization for engineering students.

THE REQUIREMENTS

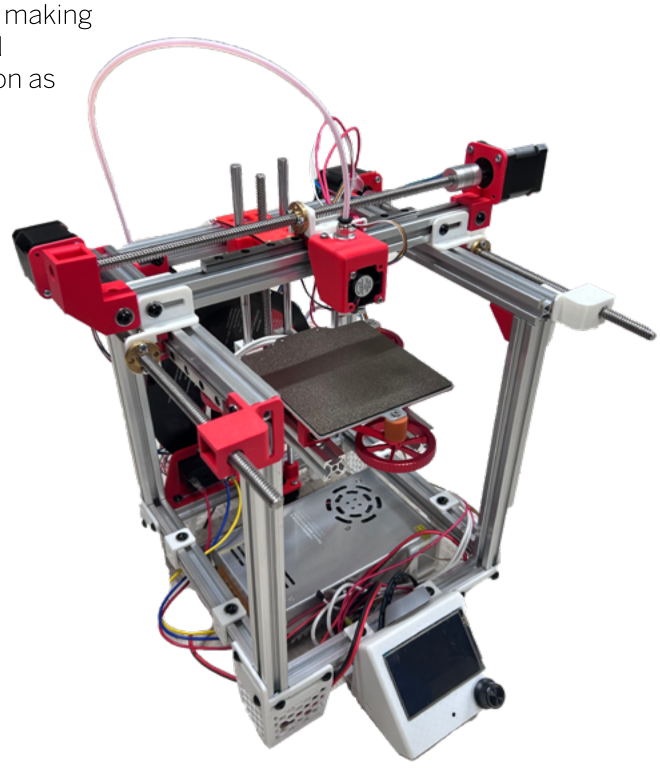
The 3D printer must be easy to assemble and manufacture, robust, scalable, and customizable. Designed for engineering students, it should minimize outsourcing by enabling in-house part customization. Based on previous projects, it will feature a 120mm x 120mm x 120mm build volume, with quick assembly and maintenance for efficient use in coursework.

THE SOLUTION

A quick and reliable 3D printer that can be easily assembled. The printer should also feature easily maintainable parts and be able to be modified for custom projects.

THE RESULTS

A compact 3D printer featuring lead screws on all axis for extreme precision. The printer is also easily modifiable, making maintenance simple and allowing for customization as needed.



PEM HYDROGEN GENERATOR

TEAM 115

TEAM MEMBERS

Tristan Dolenc
Mario Yakicier
Shrijit Banerjee
Kaitlyn Callen
Eric Davis
Renato Korzinek

PROJECT ADVISOR

Anthony Linn

OVERVIEW

Design and fabricate a cost-effective and durable PEM cell capable of producing green hydrogen.

THE PROBLEM

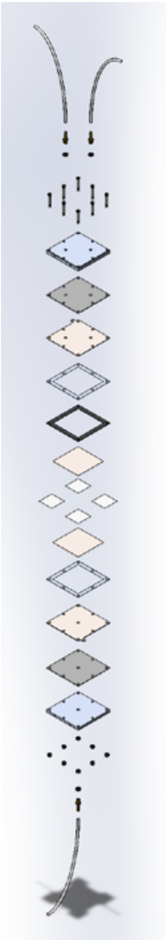
Most hydrogen is currently produced through steam reforming, a process that emits large amounts of CO_2. Amid the growing concerns around climate change, there is a need for low carbon fuel alternatives. PEM water electrolysis offers a cleaner method of hydrogen production, but its adoption is limited by its high costs and low durability. These challenges make the system expensive and difficult to scale.

THE REQUIREMENTS

Building on previous research, the primary requirement is to design and fabricate an operational PEM cell electrolyzer capable of efficient hydrogen production. The system must utilize low-cost, commercially available materials to minimize overall manufacturing expenses. Design simplicity is critical to enable the ease of replication and scalability.

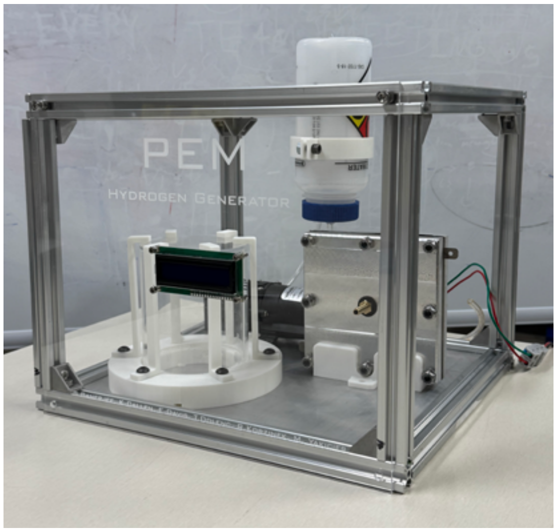
THE SOLUTION

To effectively produce hydrogen, research was conducted on the optimal materials to facilitate the electrochemical reaction. Based on our findings, our team was able to source the necessary PEM layers to improve proton conductivity and gas diffusion. Using a prototype PEM cell purchased online as our reference, we redesigned key components to further enhance hydrogen output, including increasing membrane surface area and using alternative tubing connections.



THE RESULTS

We expect the increased size and optimal material selection to yield greater hydrogen output than a standard PEM cell that can be purchased online. To prove this, we will compare hydrogen output results between our manufactured cell and our purchased prototype cell by analyzing the ppm of hydrogen in a defined volume over time.



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HYDROGEN FROM SOLAR

TEAM 115A

TEAM MEMBERS

Drew Fenton
Tia Rao
Lauren Zukiwski
Emiliano Valencia-Donohue

PROJECT ADVISOR

Anthony Linn

OVERVIEW

A solar powered system that produces electricity and powers a PEM electrolyzer to create green hydrogen, a key energy storage medium for a renewable energy future.

THE PROBLEM

The current preferred technology used for energy storage is the lithium ion battery. However, one major downside is the self-discharge that occurs within the batteries chemical reaction, causing them to lose storage capacity over time. Hydrogen is a good alternative for long term storage because it does not degrade over time. Unfortunately, current hydrogen production methods rely on methane gas, a known greenhouse gas.

THE REQUIREMENTS

One principal constraint is the generation of hydrogen must be with a renewable energy source, which in this case is solar power. The system must be closed-loop to account for variability in the sun's ability to provide energy. Another key factor is building a system that can withstand the high currents powering the electrolysis process. Finally, the system must be robust enough to produce large quantities of hydrogen that can be used for electricity generation as needed.

THE SOLUTION

Our solution strategy revolved around the hydrogen electrolyzer and the power requirements. We compared the compatibility of different renewable energy sources and settled on solar. Then, we examined the power needs of the electrolyzer and designed the system to meet these needs, such as the battery capacity required to run the system for a desired amount of time.

THE RESULTS

The performance tests reveal that our electrolyzer runs at 2.9 volts and 20A. Further optimization tests with temperature indicate that while increasing the temperature from 20 to 80 degrees Celsius had a slight impact on efficiency, it wasn't significant enough to warrant implementing in our final system. Theoretically, our system has enough capacity to operate throughout the day, including in unpredictable weather conditions

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SUPERCRITICAL CO2 TURBINE GENERATOR

TEAM 116

TEAM MEMBERS

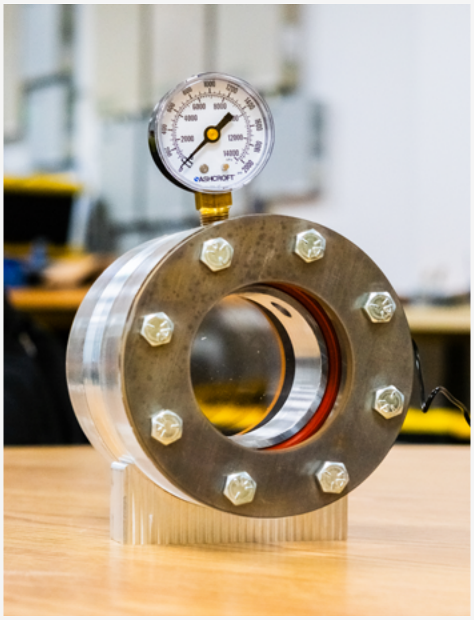
Tyler Hart
Danial Arab
Brett Goldstein
Joseph Hu
Vincent Coolberth
Zubin Gu

PROJECT ADVISOR

Anthony Linn

OVERVIEW

The project's goal was to design a supercritical CO_2 turbine generator system for future students in the College of Engineering to run experiments.



THE PROBLEM

Supercritical CO_2 power cycles have the potential to drastically reduce the size, complexity, and most importantly, the cost of power generation. Designing a lab-scale system would allow students to get hands-on experience with thermodynamic and turbomachinery analysis using this state-of-the-art technology.

THE REQUIREMENTS

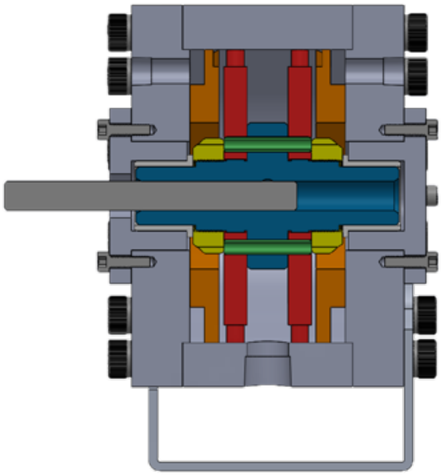
Our project had several key requirements: small size, simplicity, and safety. To be used in a lab, the full system would need to fit on a desk. Due to budget and manufacturing constraints, a Rankine cycle was selected to reduce component complexity. Lastly, to be operated in an indoor environment with a large group of people, safe operation was paramount, especially given the high pressures and temperatures needed for sCO_2.

THE SOLUTION

The thermocycle design of a transcritical Rankine cycle was established based on literature research and power input limitations. A system layout, including a P&ID and process flow diagrams, was developed to support the selected cycle. The component design followed, taking into consideration material corrosion, high pressures, and cost-effectiveness. Heat transfer analysis enhanced the evaporator's multi-flow path design. All components were designed to be manufacturable in EPIC.

THE RESULTS

A 7-15 MPa cycle with a turbine inlet temperature of 225°C was selected. To counteract high axial bearing loads from the large pressure gradient, a dual blade turbine (right) was designed, with an aluminum prototype fabricated as a proof of concept. A sCO_2 transition viewer (left) was fabricated as an educational demonstration model. Future projects could continue to develop the system and component designs to bring a full sCO_2 power cycle into a BU laboratory.



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TRACKING SOLAR THERMAL COLLECTOR

TEAM 117

TEAM MEMBERS
Roberto Di Tucci
Maggie Driggs
Gavin Kensinger
Peachy Malik
Alexander Rocca

PROJECT ADVISOR
Enrique Gutierrez-Wing

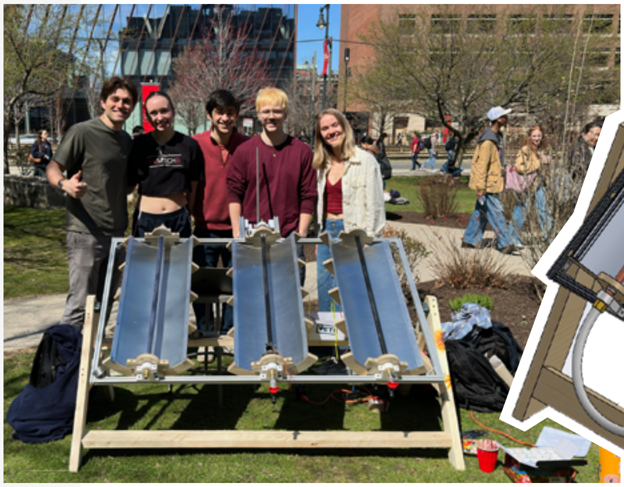
OVERVIEW
This product is a semi-automatic, two-axis tracking solar thermal collector that uses parallel heating reflectors to optimize the capture of solar thermal energy.

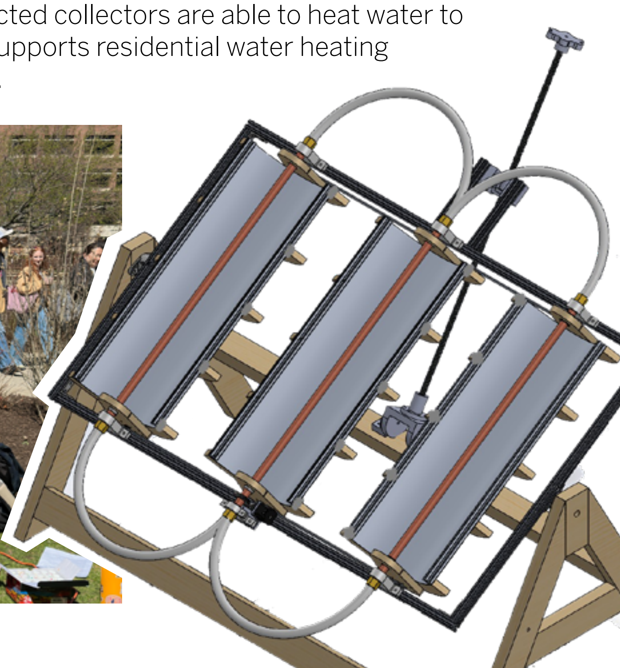
THE PROBLEM
Power generation traditionally relies on high-temperature sources of thermal energy from fossil fuel combustion, releasing carbon dioxide and contributing to climate change. This heat generation process is common in power plants, combustion engines, and HVAC systems. Solar thermal energy offers a sustainable and renewable alternative for producing heat. This project aims to develop a device that efficiently tracks and captures solar energy for residential heating applications.

THE REQUIREMENTS
The product must convert solar irradiation into high-utility thermal energy. It must feature an accurate tracking system that follows the sun's trajectory for optimal energy capture. Designed for sustainability, the system must integrate into existing infrastructure, such as unused rooftops or wall spaces, to reduce carbon emissions. Additionally, the product must remain affordable, use no rare-earth metals, and keep costs under the $500 budget.

THE SOLUTION
Our product uses an automated system to track the sun's East-West path, combined with a manual adjustment for seasonal elevation changes. Active tracking allows for installation without relying on preloaded sun position data. A modular array of reflectors concentrates sunlight onto a focal line, enhancing thermal energy capture. Using water as the working fluid, the system is easy to install and ideal for residential applications.

THE RESULTS
The device tracks the sun's position throughout the day using a photoresistor sensor module and a worm-gear drive system for precise reflector alignment. Seasonal tilt adjustments are made manually and locked in place. The automated tracking system has a resolution of 1.8 degrees per motor actuation. Three parallel-connected collectors are able to heat water to 70°C. This temperature range supports residential water heating needs, between 40°C and 70°C.





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PERSONAL VTOL COMMUTER AIRCRAFT

TEAM 129

TEAM MEMBERS

Dominic Johnson
Michael Warfield
Hannah Rubine
Anisa Chowdhury
Valentino Tartamella

PROJECT ADVISOR

Anthony Linn

OVERVIEW

Our project is to design a commuter VTOL vehicle that integrates with existing urban infrastructure, utilizing vertical takeoff and landing alongside ground-driving capabilities to transport commuters to and from work more efficiently than ever.

THE PROBLEM

With increasing congestion in urban areas and limited road infrastructure, personal transportation has become inefficient and time-consuming. A VTOL hybrid aircraft offers an alternative to conventional methods by combining the vertical takeoff convenience of a helicopter with the speed of a plane, all within the footprint of an SUV. This solution addresses the growing need for a compact, fast, and efficient mode of transportation that can bypass ground traffic.

THE REQUIREMENTS

Design a lightweight, low-cost, low-maintenance commuter flight vehicle with minimal complexity that supports VTOL or equivalent landing method after power failure. It must carry 1–2 passengers and 50 lbs of cargo and transform between a small SUV-sized ground mode and a sub-50 ft flight footprint. The mission profile should exceed 100 nm and reach speeds over 150 kn; ground range should be under 3 mi at less than 30 mph.

THE SOLUTION

Our solution uses a lightweight airframe and aerodynamic fuselage constructed from proven, readily available materials to reduce manufacturing costs. A hybrid powertrain allows for quiet urban takeoff without requiring large batteries for cruise. Folding wings and rotors enable the VTOL to transition into a compact ground vehicle after landing, allowing it to operate comfortably within existing car-based infrastructure.

THE RESULTS

Our final design meets all mission requirements with a hybrid-electric VTOL capable of transporting two passengers and 50 lbs of cargo. It achieves a flight range of over 100 nautical miles with a cruise speed of 150 knots and includes ground mobility for short-distance travel on either end of the journey. Its compact, SUV-sized footprint allows seamless integration into urban infrastructure, while the design prioritizes efficiency, safety, and operational simplicity.

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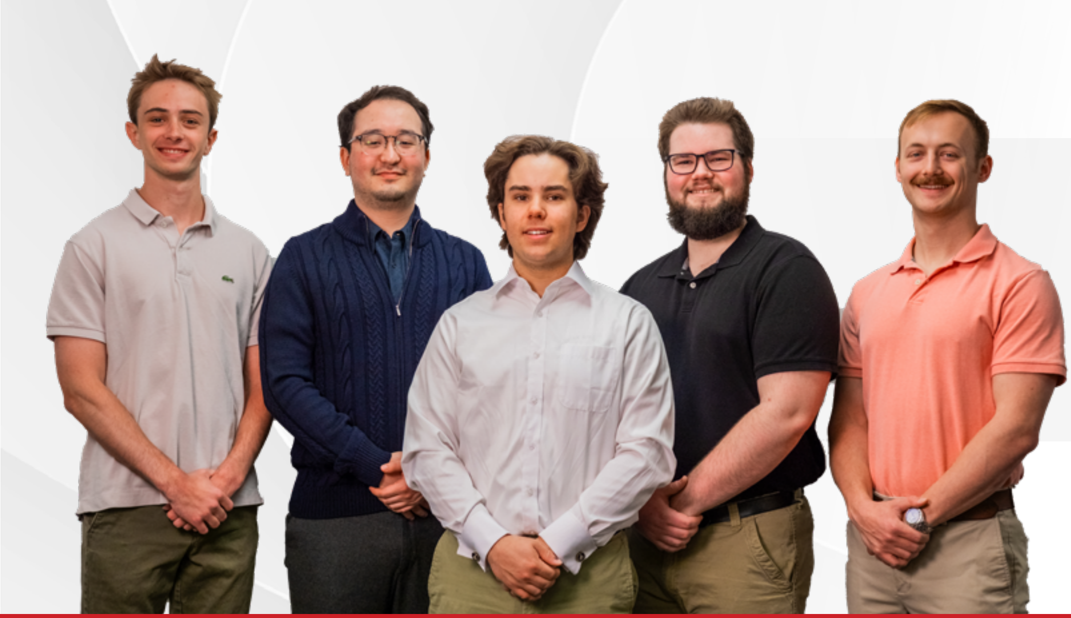

MORPHING SAIL

TEAM 132

TEAM MEMBERS
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PROJECT ADVISOR
Jim Geiger

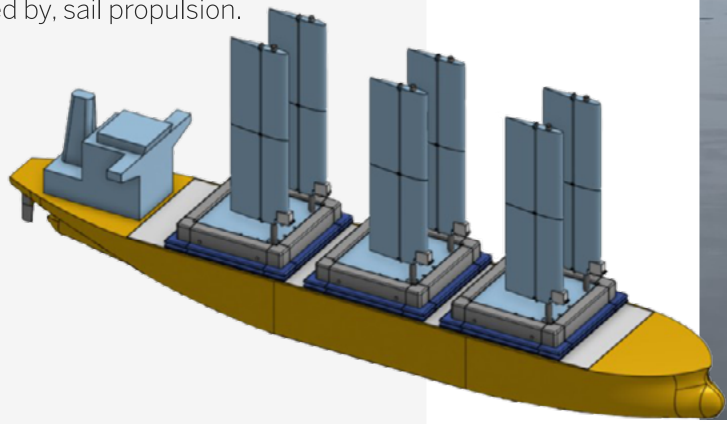
OVERVIEW
Create a system of morphing sails to provide propulsion to cargo ships.

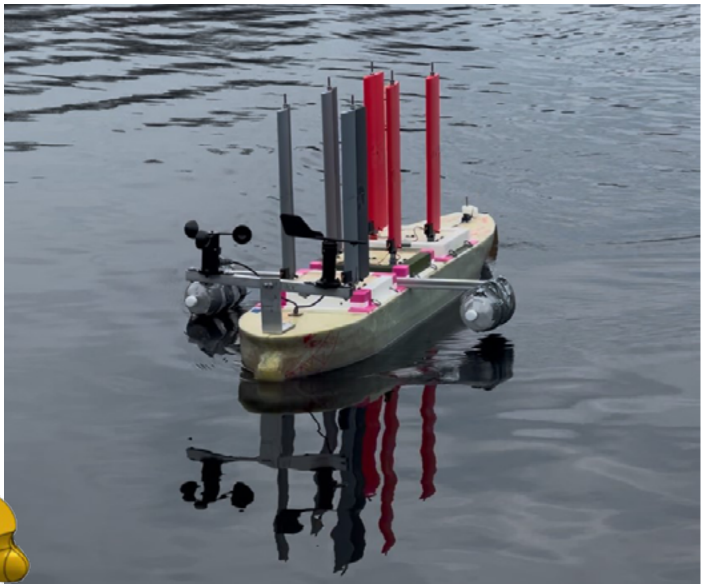
THE PROBLEM
Container ships and bulk carriers have been forced to reduce speed both for fuel conservation and reduction of CO2 emissions. Cargo ship speeds today are actually slower than the sailing ships of the 19th century. It has been proposed that cargo ships could return to, or assisted by, sail propulsion.

THE REQUIREMENTS
A modern sail propulsion system will require a solid airfoil design. The sail will be able to “morph” its shape and orientation by, at minimum, changing its camber line and angle of attack. The system will ideally be automated and use weather and GPS data to calculate optimal sailing routes and sail orientations.

THE SOLUTION
Our solution was a sail system consisting of 6-8 sails that could change their shape and angle to best utilize the wind. Each sail would possess a symmetrical airfoil cross section with a pivot point around the halfway point that would allow the sail to morph into a more efficient shape . A central mast located in the leading edge section would be motor operated to change the angle of attack.

THE RESULTS
Calculations for the full size prototype yielded a fuel and emission savings of ~30%. A scale model ship of 6ft was built with a 6 sail configuration to fully explore our design. Testing showed that the scale model was able to move and navigate using only the wind and, while this would be unlikely at full scale, it proves that some savings would be experienced by a real ship.





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MORPHING SAIL

TEAM 132A

TEAM MEMBERS

Ann Flynn
Olivia Brookhart
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Kent Liao
Matthew Siegel

PROJECT ADVISOR

Anthony Linn

OVERVIEW

Our project is focused on exploring the viability of an automated sailing system that utilizes modern airfoil technology to reduce CO_2 emissions in the shipping industry.

THE PROBLEM

As new regulations are put in place to counteract the devastating effects of climate change, cargo ships have been forced to significantly limit their transportation speeds in order to curb CO_2 emissions. This decline has been so drastic that cargo ships now travel at slower speeds than they would be capable of achieving with sails.

THE REQUIREMENTS

To demonstrate the viability of an automated sailing system, it was necessary to develop a sailing algorithm capable of dynamically adjusting an airfoil in response to varying wind directions, as well as a physical prototype that simulates the core functionality of a cargo ship and sail. Project development was constrained by scaling challenges, unpredictable weather patterns in real-world application, and the complexities of environmental adaptation.

THE SOLUTION

Our proposed solution is a prototype vessel designed to optimize wind energy utilization by automatically adjusting its sail and rudder in response to changing wind conditions. This innovative system maximizes the vessel's propulsion through clean, renewable wind power. The prototype features a single airfoil sail mounted on a kayak, engineered for efficient energy capture and course correction.

THE RESULTS

The construction of the sail involved creating a robust skeletal structure using precision-laser-cut ribs and battens, which were then wrapped in monokote—a material commonly employed in model aircraft construction. This sail was mounted on a mast equipped with a gear mechanism, connected via a belt to a motor. The motor's movements are controlled by a program that translates real-time wind direction data into precise rotational commands. The successful integration of airfoil technology for lift generation in a maritime environment underscores the potential and effectiveness of automated sailing systems, validating the feasibility of this approach for sustainable navigation.

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WIND TUNNEL FORCE BALANCE

TEAM 134

TEAM MEMBERS

Nora Zonay
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Gokay Goktug
Minyoung Kim
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PROJECT ADVISOR

Anthony Linn

SPONSOR

Boston University

OVERVIEW

The objective is to design and develop an advanced, compact, and highly accurate force balance sensor capable of precisely measuring aerodynamic forces and moments, intended as a replacement for the current sensor used in Boston University's low-speed wind tunnel.

THE PROBLEM

Wind tunnel testing requires accurate measurement of aerodynamic forces (lift, drag, side) and moments (pitch, roll, yaw). The existing sensor only measures drag, lift, and pitching moment, facing accuracy challenges with lift and pitching moment data. Our compact force balance sensor integrates strategically placed strain gauges and Wheatstone bridges, prioritizing ease of calibration, minimal interference, and precise, reliable measurements across all six axes.

THE REQUIREMENTS

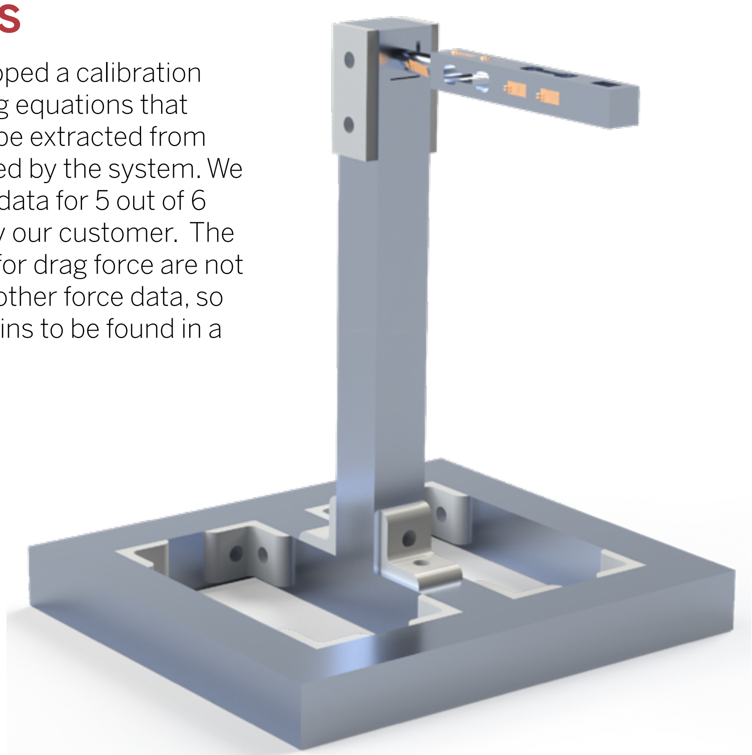
The primary requirements include a compact cross-section, accurate measurement of three forces and three moments, and minimal electrical noise. Constraints involve fitting within limited wind tunnel space, simple manufacturability, cost-effectiveness, and ease of repair and calibration. Strain gauges must be carefully oriented to measure bending and torsional strains effectively, and the electronic setup should minimize interference, ensuring reliable voltage-to-force data conversion.

THE SOLUTION

Fabricated a 1"×6" aluminum flexure instrumented with six strain gauges, mounted in a custom calibration rig, and designed a PCB to condition and digitize bridge outputs. Using MATLAB, we collected voltage data for known load and moment cases, assembled a 6×6 sensitivity matrix, and computed its inverse. Multiplying measured voltages by this inverse matrix yielded accurate estimates of the three forces and three moments.

THE RESULTS

Successfully developed a calibration matrix and resulting equations that allow force data to be extracted from the voltage produced by the system. We collected accurate data for 5 out of 6 forces requested by our customer. The readings collected for drag force are not as sensitive as the other force data, so improvement remains to be found in a future iteration.



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TURBOCHARGER TO GAS TURBINE

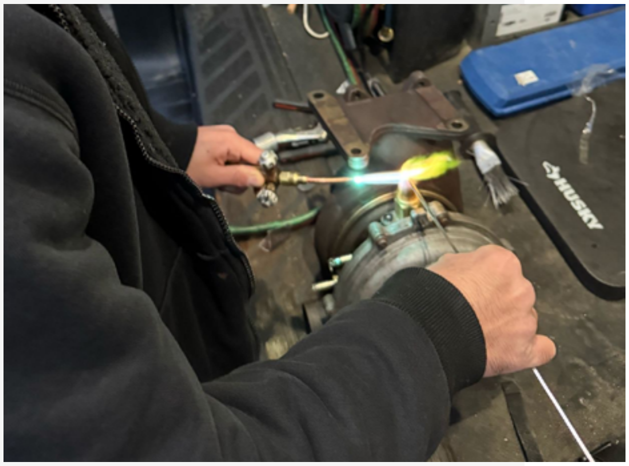
TEAM 136

TEAM MEMBERS
David Gardner
Ximing Lei
Fayek Howeedy
Mateo Quka

PROJECT ADVISOR
Anthony Linn

OVERVIEW
Conversion of an automotive turbocharger into a gas turbine for laboratory use.

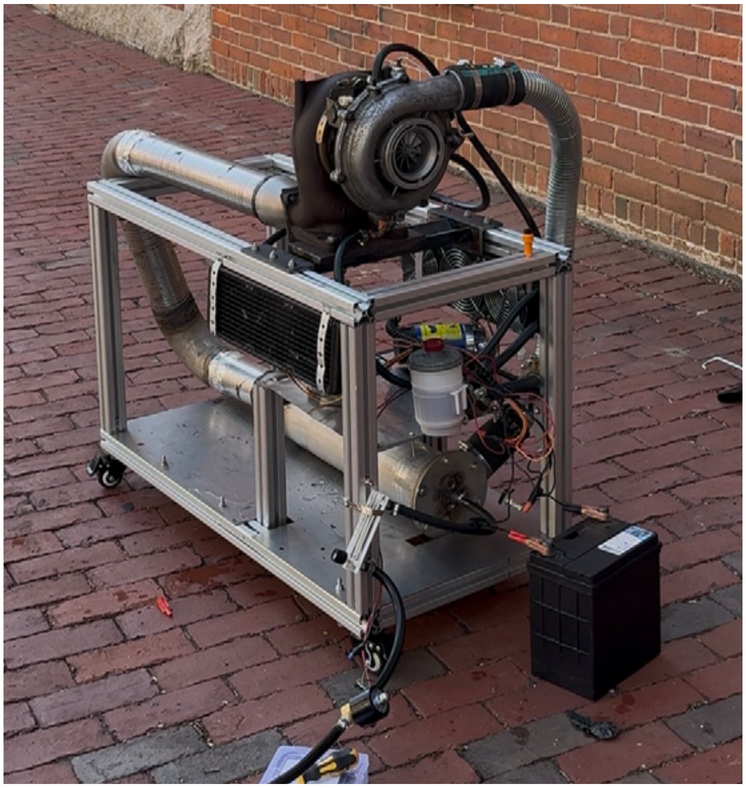
THE PROBLEM
Lack of a lab apparatus for Prof. Linn's compressible flow class. This lab setup will allow for hands on experience with the thermodynamic principles and mathematics used when considering propulsion and compressible flow.



THE REQUIREMENTS
Functioning Turbine system, emergency shutoff, cooling solution to stop from overheating, must run on propane but be able to convert to kerosene fuel, must fit through a standard door.

THE SOLUTION
Converted a turbocharger into a gas turbine by designing and fabricating a custom combustion chamber and integrating a fuel and ignition system. Focused on reliable high-RPM operation through system integration and heat management. Conducted testing to refine startup, combustion stability, and overall performance.

THE RESULTS
Functioning gas turbine that is ready to be instrumented, After which, it will be used as a lab apparatus.



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AEROBATIC BLACK BOX

TEAM 137

TEAM MEMBERS

Alexander Rosenthal
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Nathaniel Marino
Jason Bard
David Moody

PROJECT ADVISOR

Anthony Linn

OVERVIEW

The Aerobatic Black Box captures the movement and the control inputs of the plane to enable data driven training.

THE PROBLEM

The Aerobatic Black Box project seeks to fill a critical gap in aerobatic training and performance analysis by developing a compact, mountable device for capturing in-flight data and generating post-flight simulations. The simulation will allow pilots to visualize what they did while in the air, assisting their ability to learn from the experience.

THE REQUIREMENTS

The device must be easily removable to avoid aircraft recertification. Consequently, the information present on the dashboard and control inputs (control stick, pedals, and throttle) must be captured without substantially modifying the plane. The gathered data should be sufficient to accurately reproduce the pilots actions and resulting aircraft movement for review.

THE SOLUTION

Our solution integrates digital sensors, cameras, and machine vision to record and digitize flight data and cockpit interactions, eventually incorporating this data into a 3D simulation. A Raspberry Pi 5 handles capturing the video and communicating with a Cube Black drone controller and a Ublox GPS. These devices are consolidated and securely mounted in the plane.

THE RESULTS

We performed instrument detection and reading off of a dashboard video. Digital sensors recorded altitude, inertial, and GPS data through a Cube Black drone controller and Ublox GPS. The data was then replayed in the X-Plane 11 flight simulator to recreate the flight. This simulation allows pilots to analyze their performance from both internal and external perspectives.

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AUTOMATIC DOG BALL THROWER

TEAM 138

TEAM MEMBERS
Sean Park
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PROJECT ADVISOR
Francis DiBella

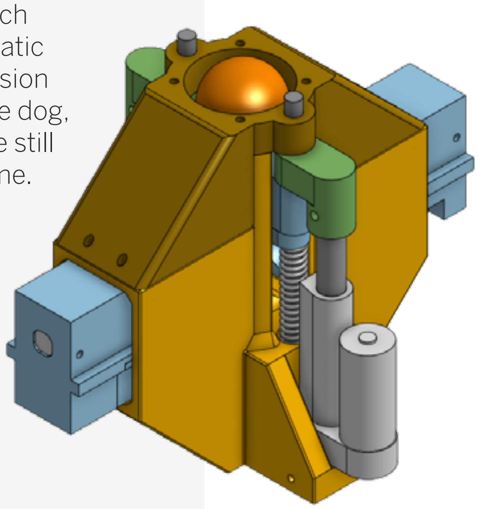
OVERVIEW
Our project is an Automatic Dog Ball Thrower that uses a vision system and launching mechanism to launch a ball, helping owners prolong their playtime with their dogs!

THE PROBLEM
Our customer's dog, Aka, is incredibly energetic and loves to play fetch. However, at times, his owner is unable to match his energy level. An Automatic Dog Ball Thrower uses a vision system to visually track the dog, ensuring Aka's safety while still allowing even more playtime.

THE REQUIREMENTS
The Automatic Dog Ball Thrower must not hurt Aka, must use machine learning to detect the dog's relative position, and must not use flywheels, which produce a noise that Aka dislikes.

THE SOLUTION
The launching system uses a spring-loaded platform compressed by high-force linear actuators. Two other linear actuators extend to lock the platform in place and retract to release it. The launching mechanism is supported on a rotary turntable controlled by a stepper motor, allowing the mechanism to change its launch direction. A computer vision system visually tracks Aka's position to determine a launch direction that will not hit him.

THE RESULTS
The mechanism achieves accurate horizontal rotation in 1.8-degree increments across a 70-degree angular range. It consistently launches a ball an average horizontal distance of 16 feet. The computer vision model reliably detects the dog within the live camera frame with more than 95% precision, allowing for precise real-time adjustments.



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PLAANT (PRECISION LAND ANALYSIS AND AERIAL NITROGEN TREATMENT)

TEAM 160

TEAM MEMBERS
Jillian Martin
Charles Litynski
John Fitzgerald
Addison Chu
Ethan Jackson

PROJECT ADVISOR
Jim Geiger

SPONSOR
NASA's 2025 Gateways to Blue Skies Competition: AgAir (Aviation Solutions for Agriculture)

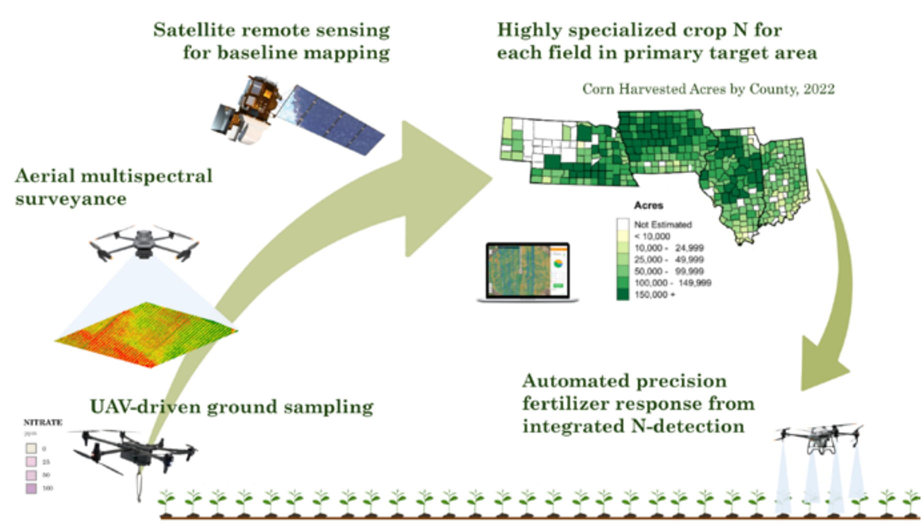
OVERVIEW
PLAANT is a comprehensive, UAV-driven aerial nitrogen management system designed to advance targeted fertilizer application through improved nutrient analysis.

THE PROBLEM
Nitrogen is the most essential nutrient for plant growth, but the dynamic nature of the nitrogen cycle makes tracking difficult. The current leading practice of broadcast fertilization ignores system variation and leads to losses of up to 50%, resulting in water pollution, GHG emissions, and billions of dollars wasted. Targeted fertilizer application combats the problem, but is underutilized at scale due to lack of precise nitrogen information and system approachability.

THE REQUIREMENTS
The requirements of this competition were to propose a novel aviation solution to solve an environmental problem in the agriculture space. This involved proper defense of the technical problem area chosen, contextualization of current solutions in that space, use case development, conceptualization of the technology and implementation, and design of a path to reasonable deployment by 2035. This was constrained to creative applications of new, under-developed, or underutilized technologies.

THE SOLUTION
After considering many different solutions, the team honed in on a phased UAS approach for comprehensive nitrogen management, deploying three different drones to leverage the partnership of remote sensing crop surveyance and physical soil sampling for improved nitrogen sensing and precision fertilization. Throughout development, the team's solution strategy relied heavily on research, calculations, and feedback from a range of experts at the cross-sections of agriculture, academia, and the government.

THE RESULTS
PLAANT improves nitrogen use efficiency (NUE) by providing real time soil nitrogen information and response at scale. This empowers farmers to improve growth efficiency and yield, reduce agricultural pollution and emissions, and strengthen environmental resiliency. The team was selected as one of eight finalist teams to present a detailed and improved proposal to NASA judges at the Blue Skies Forum at the end of May. Wish us luck!



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MENTHA

TEAM 160A

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Jake Dietiker
Matthew Luponio
Josh Hancock

PROJECT ADVISOR
Anthony Linn

SPONSOR
NASA's 2025 Gateways to Blue Skies Competition: AgAir (Aviation Solutions for Agriculture)

OVERVIEW
Agricultural UAV system which monitors mint crop field health and harvest readiness.

THE PROBLEM
Mint farmers subjectively decide when to harvest their fields, leading to millions of dollars lost in mis harvesting and non optimized use of resources.

THE REQUIREMENTS
Come up with an aviation system that solves a problem in the modern agricultural industry.

THE SOLUTION
Defined all the necessary technical systems and concept of operations for an agricultural UAV fleet to be deployed by 2035 which would objectify the cultivation and harvest of peppermint fields.

THE RESULTS
A research proposal document was submitted detailing the problem, the hardware and software required to operate our system, and the overall concepts of operation.

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ROADMAP TO CARBON NEUTRAL

TEAM 161

TEAM MEMBERS
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Ata Basol
Mark El-Daher
Ali Doganci

PROJECT ADVISOR
Anthony Linn

OVERVIEW
The world faces an urgent challenge: fossil fuel reserves are running out, with only 50 to 60 years left for oil and natural gas and about 100 years for coal, while 80 percent of our energy still comes from these sources. To address this, our project evaluated the efficiency and scalability of major renewable energy pathways, analyzed solutions for shifting U.S. energy demand away from fossil fuels, and identified practical strategies for accelerating the transition to a carbon-neutral economy.

THE REQUIREMENTS
The question is how we can transition to a renewable energy economy before these resources are depleted. Our project sets out to answer this challenge.

THE PROBLEM
We focused on three critical questions. How efficient are the natural and engineered energy pathways available to us? Which renewable energy source—solar PV, hydropower, or wind—is best positioned for large-scale adoption, based on rigorous criteria? And finally, how much of current U.S. energy demand can realistically be shifted away from fossil fuels through proposed solutions?

THE SOLUTION
To answer these questions, we conducted an in-depth analysis using a weighted Pugh chart to compare solar, hydropower, and wind energy across thirteen key criteria. We also researched demand-shifting strategies, such as retrofitting suitable coal plants with nuclear reactors and expanding energy storage, to determine their real-world impact. Our work highlights that energy storage remains the biggest bottleneck for scaling renewables, but technological upgrades and new storage solutions offer promising paths forward.

THE RESULTS
Our analysis found that solar PV is the most effective and scalable renewable energy pathway, though hydropower and wind still play important roles in certain regions. By combining these renewables with practical solutions like storage expansion and nuclear retrofits, the U.S. could shift up to 15 percent of its current energy demand away from fossil fuels. Our research provides a practical roadmap for accelerating the transition to a carbon-neutral future.

Weighted Pugh Chart Comparison of Solar PV, Hydropower, and Wind Energy				
Criteria	Weight	Solar PV	Hydropower	Wind
Economic Feasibility and Return on Investment				
Initial Hardware Cost	8	+	-	0
Operating & Maintenance Cost (incl. degradation)	5	+	0	-
Storage and Grid Integration Cost	5	0	+	-
Lifespan and Payback Period	7	-	+	0
Capital Costs and Financing Challenges	8	+	-	0
Geographic Compatibility and Site Selection				
Regional Suitability (Resource Quality)	10	+	-	0
Land Required per Megawatt	9	-	+	0
Ecosystem and Community Impact	6	+	-	0
Dual Land Use Potential	4	+	-	0
Lifecycle Emissions and Material Recyclability	8	+	-	0
Energy Capture and Reliability				
Energy Production per Unit of Installed Capacity	7	+	-	0
Capacity Factor and Dispatchability	9	-	+	0
Storage Needs and Grid Integration Effectiveness	5	0	+	-
Unweighted total		3	-2	-1
Weighed total		17	-7	-10

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AIAA: DESIGN/ BUILD/FLY

TEAM 165

TEAM MEMBERS
Joseph Cinquemani
Allison Glick
Jesse Cooper
Trevor Stahrr

PROJECT ADVISOR
Jim Geiger

SPONSOR
American Institute of Aeronautics and Astronautics competition sponsored by Textron Aviation and Raytheon.

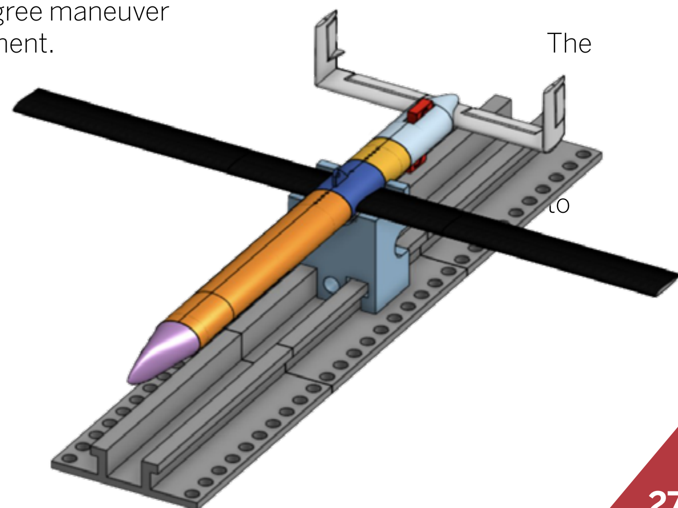
OVERVIEW
Designing, building, and testing a lightweight, autonomous glider intended for the 2025 AIAA DBF competition.

THE PROBLEM
As part of the 2025 AIAA Design/Build/Fly competition, our team is designing the X-1 test vehicle: a small glider released mid-flight from a parent aircraft that must autonomously perform maneuvers and land on target. The project focuses on achieving aerodynamic efficiency through careful tradeoffs in stability, control, and glide performance, while also integrating a reliable release mechanism for consistent deployment.

THE REQUIREMENTS
Per competition rules, the glider must weigh less than 0.55 lbs, release from a parent aircraft at altitude, transition into stable flight, execute a 180-degree turn, and safely land. It must fit within the parent aircraft's release system and deploy cleanly in flight. Constraints include the flight profile, size limit, and speed of release.

THE SOLUTION
Our team designed a compact, lightweight glider using 3D printed modular components for rapid iteration and ease of repair. The glider features a twin-tail configuration for passive stability and was optimized through aerodynamic analysis and field testing. A custom-built slingshot launcher simulated the air-release deployment at high speeds. Design tradeoffs focused on balancing, maneuverability, glide efficiency, and structural integrity within strict weight and size constraints.

THE RESULTS
Our glider met key competition requirements, weighing under 0.55 lbs with the ability to be released from a parent aircraft attachment system. The glider demonstrated consistent autonomous flight and durability across flight tests. Success was achieved in executing turns via passive controls, with full 180-degree maneuver completion under refinement. The project delivered a test-proven airframe, functional deployment system, and a platform for future teams to build upon.



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M.O.T.H. (MINI OFFSET TORQUE HELICOPTER)

TEAM 168

TEAM MEMBERS

Harman Singh
Nicholas Ng
Esther Hunt
Ziyuan Zhou

PROJECT ADVISOR

Jim Geiger

OVERVIEW

This project involves designing and building an autonomous, ultra-light mini VTOL aircraft that weighs less than 10 grams and is capable of controlled hover and transition flight.

THE PROBLEM

While VTOL vehicles perform reliably at larger scales, the demand for smaller versions has increased. Miniaturization is extremely challenging due to scaling effects that impact aerodynamics along with current limitations on energy and control systems. This project focuses on addressing these issues by selecting lightweight materials and optimizing both structure and performance while adhering to rigorous size and weight requirements.

THE REQUIREMENTS

The vehicle must weigh under 10 grams, fit within a 5×5×5-inch box, and demonstrate stable indoor hovering without external power. It must also exhibit controlled transitions, such as moving 10 feet in a straight line or tracing a 10-foot circle, before hovering. Advanced objectives include autonomous operation, transitioning between indoor and outdoor through a standard doorway, and sustaining stable flight within a 2-meter diameter sphere

THE SOLUTION

The primary focus was on weight reduction in the fuselage design and precise positioning of the vehicle's center of gravity. We utilized ultra-thin carbon fiber rods to construct a frame for our components and conducted flight tests using OptiTrack motion capture software. Comprehensive data analysis revealed issues related to the vehicle's center of gravity, which guided the redesign for our final prototype.

THE RESULTS

Our team successfully built and optimized a remote-controlled mini VTOL helicopter weighing 9.25 grams. The vehicle features a coaxial rotor configuration powered by an onboard LiPo battery and transmitter, allowing a total flight time of 6 minutes and 10 seconds with minimal drift. Our design is 20.3% lighter than the smallest commercially available RC helicopter while still maintaining structural robustness and maneuverability.

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MINI VERTICAL TAKEOFF AND LANDING (VTOL) FLIGHT VEHICLE

TEAM 168A

TEAM MEMBERS

Harrison Del Vecchio
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Daniel Kania
Dionysios Valentis
Thomas Barrette

PROJECT ADVISOR

Jim Geiger

OVERVIEW

Our senior capstone engineering project is focused on designing, prototyping, and testing a lightweight, autonomous mini Vertical Take-Off and Landing (VTOL) aircraft that fits within a 5x5x5-inch space and weighs under 10 grams, utilizing a coaxial helicopter configuration to push the boundaries of current aerospace technology.

THE PROBLEM

Most mini VTOLs are limited by heavy components and outdated materials, making them too heavy or non-autonomous. Past attempts, like the Robobee and Syma S100, fall short and are often abandoned research projects. Cost and time further delay innovation. This project aims to push technological limits by using advanced lightweight materials and modern manufacturing to create the lightest, fully autonomous mini VTOL to date.

THE REQUIREMENTS

The mini VTOL must be under 10 grams, fit within a 5x5x5-inch space, operate autonomously, and demonstrate controlled indoor flight. It should hover stably, travel at least 10 feet, pass through a doorways, and complete takeoff, hovering, and landing cycles. The aircraft must sustain a 5-minute hover, be completed within 8 months, and stay within a $500 budget. Autonomous steering and power are desirable for enhanced functionality.

THE SOLUTION

Our solution strategy was to build a mini VTOL prototype using a mix of 3D printed resin parts and lightweight components scavenged from other mini VTOLs. We prioritized minimizing weight by selecting the lightest available materials and printing with resin, the lightest option accessible to us.

THE RESULTS

The result was a lightweight mini VTOL prototype, lighter than any currently on the market. It can hover for extended periods, operates autonomously, and features a rechargeable battery with strong controllability.

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TERRIER MOTORSPORTS COMPOSITE MONOCOQUE CHASSIS

TEAM 170

TEAM MEMBERS

Arjun Bharadwaj
Eddie Hulit
Feng Xiong
Tong Wu
Zakir Kadwa

PROJECT ADVISOR

Scott Bunch

SPONSOR

Terrier Motorsports

OVERVIEW

A lightweight and high-strength carbon fiber monocoque chassis designed for Terrier Motorsport with optimal performance and safety in the Formula Hybrid & Electric competition.

THE PROBLEM

We are creating a validation design for a lightweight yet structurally robust carbon fiber chassis that meets the rigorous safety and performance standards of the Formula Hybrid & Electric competition, while improving manufacturability and overall vehicle dynamics compared to a traditional steel tube frame. We iterated our model in SolidWorks and conducted multiple FEA analysis to ensure chassis performance. Various material sample were made to perform various material strength tests.

THE REQUIREMENTS

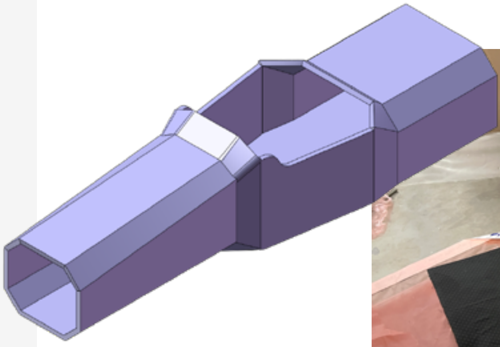
We are designing a carbon fiber monocoque chassis to participate in the Formula Hybrid+Electric (FHE) competition. This chassis will be lighter and stronger than a traditional steel tube frame, which will improve overall vehicle dynamics. We created designs in SolidWorks and conducted finite element analysis (FEA) simulations in Ansys to predict chassis performance. We also manufactured carbon fiber test samples on which we performed various physical strength tests.

THE SOLUTION

We first analyzed the FHE rules and looked at other schools' designs for inspiration and information about the carbon fiber layup process. With this knowledge we made initial designs and manufactured our test samples by vacuum bagging them. We then performed physical tests on these samples to obtain their material properties. For FEA, we prepared simulations in advance that we would run with the material properties from our testing.

THE RESULTS

Through our Ansys simulations, our monocoque chassis design was confirmed to withstand loads mandated by the FHE rules. From our physical testing, we successfully found accurate material properties for our samples that we used in our simulations. We also learned that for the real chassis, we should use three layers of carbon fiber on either side of the aluminum core rather than two for added strength and minimal weight gain.



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TERRIER MOTORSPORT ACCUMULATOR HOUSING

TEAM 171

TEAM MEMBERS
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Matthew Kim
Alex Saykali

PROJECT ADVISOR
Scott Bunch

SPONSOR
Terrier Motorsports

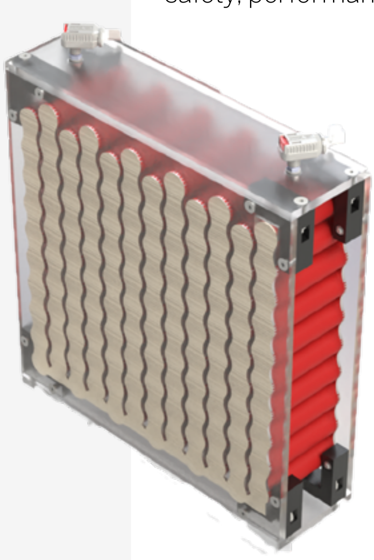
OVERVIEW
Designing a battery (as known as an accumulator) housing structure for a Formula Hybrid + Electric race car for Terrier Motorsport.

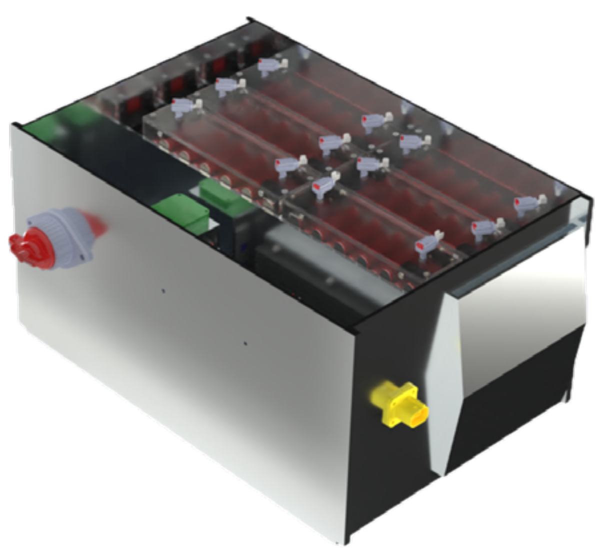
THE PROBLEM
Terrier Motorsport is on the path to a rules-compliant car. Our team is aiding in this process by designing a thoroughly validated, robust, and fully rules-compliant battery housing structure for a monocoque chassis.

THE REQUIREMENTS
As mentioned, the accumulator housing must be fully rules-compliant, which comes with many constraints. Some of these constraints include: he housing must satisfy IPX4 or greater to protect the high voltage components, the accumulator segments must be protected by fireproofing material rated UL94-V0, and accumulator mounts must satisfy regulated loading requirements, which can be confirmed by FEA simulations.

THE SOLUTION
Our solution is validated through thermal simulations, structural FEA, and compliance with Formula Hybrid + Electric rules. The accumulator housing is designed for modularity; thermal management, and crash resilience, with materials and geometry optimized for safety and manufacturability in EPIC. We analyzed cell heat generation, g-load survival, and electrical analysis to ensure reliability under race conditions.

THE RESULTS
Our simulations confirmed the accumulator withstands 40g horizontal and 20g vertical loads. Thermal analysis showed temperatures remain below 30°C under race-condition current draw. The straightforward design and accessible materials ensure manufacturability in EPIC. The final design meets all relevant Formula Hybrid + Electric rules and regulations, balancing safety, performance, and ease of fabrication.





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VIBRAM TRACTION TESTING BENCHTOP

TEAM 172

TEAM MEMBERS

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Genkai Watanabe
Wyatt Weber

PROJECT ADVISOR

Frank DiBella

SPONSOR

Vibram

OVERVIEW

An integrated gantry and modular surface testing system that improves the repeatability and efficiency of outsole testing by providing means of easy surface and weight modification.

THE PROBLEM

Testing with Vibram's custom made traction testing benchtop is repetitive, with one shoe sample being tested several times with a variety of weights and surfaces. This requires more than one person to help carry heavy plate weights from their storage area to the device. It sits on a makeshift shipping frame, with no convenient way to change testing surfaces from underneath the device without removing all testing weights.

THE REQUIREMENTS

Key requirements include improving ease of use of the system by one person and the capacity to run at least 3 concurrent tests. The designed weight lifting system must be mobile and able to lift 500 pounds. The surface testing system must be able to accommodate a range of surface types, including those with depth of up to 2.5 inches.

THE SOLUTION

Our solution features a benchtop designed for efficient and repeatable traction testing. It includes a slide-in tray system that allows for quick surface changes without disassembly. A winch system is used to load and unload weights, ensuring faster setup times between trials. Designed with adaptability and user-friendliness in mind, the system reflects the feedback from Vibram through frequent meetings, emphasizing minimized setup time and scalability for future surface testing requirements.

THE RESULTS

Our evaluation strategy consists of four tests: gantry lifting, tray swap time, structural load-bearing, and full cycle timing. Relevant data includes lift height, applied load, timing, and structural response. Team roles cover operation, observation, and safety. Success criteria include lifting over 500 lb, reducing testing time by more than 50%, and supporting a 500 lb load on the benchtop, and scalability for future surface testing requirements.

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INCLINABLE WALKWAY WITH TRANSPARENT SURFACE

TEAM 173

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Charlotte Derose
Alexander O'Flaherty
Aditya Meruva

PROJECT ADVISOR
Francis DiBella

SPONSOR
Vibram

OVERVIEW
Create a walkway that can be inclined to various angles and have a transparent surface.

THE PROBLEM
Be able to view the interaction of a shoe sole with a surface while a person is walking at various inclines.

THE REQUIREMENTS
The walkway must be 5.5 feet in length, incline from 0-45 degrees, and be transparent. The walkway also needs to be elevated such that a camera can be placed underneath to record the shoe sole interaction. Lastly, the walkway must be safe enough for a person of 220 pounds to walk comfortably on it.

THE SOLUTION
Research was conducted on inclining mechanisms, suitable materials, and ideal structural composition. Additionally, CAD models were created and iterated in SolidWorks, and Finite Element Analysis simulations validated our approaches. Finally, the physical assembly was machined in the Engineering Product Innovation Center.

THE RESULTS
Our team successfully designed an inclining transparent walkway fitted with a camera system for our sponsor, Vibram. It is capable of sustaining 500 lbs and inclining from 0-40° in 10° increments. Additionally, it is driven by an exclusively mechanical system, and it enables outsole-surface interaction analysis along 3-4 steps.

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THE CARDBOARD COMPANION

TEAM 174

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PROJECT ADVISOR
Scott Bunch

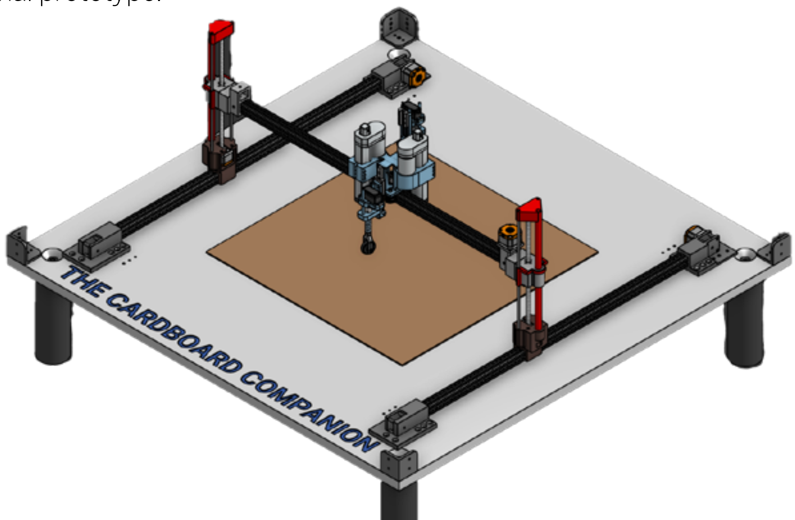
OVERVIEW
The Cardboard Companion is an automated system designed to scan, measure, and create custom-sized cardboard boxes to reduce waste and enhance sustainability.

THE PROBLEM
The surge in online ordering has led to excessive cardboard waste due to oversized packaging, inefficient material use, and increased shipping costs. While recycling helps, a significant portion of cardboard remains in landfills. Our project addresses this by developing an automated system that produces custom-sized boxes, promoting a more sustainable and cost-effective solution.

THE REQUIREMENTS
The system must accurately scan objects, determine optimal box dimensions, and cut and score cardboard efficiently. The Cardboard Companion must operate within our $500 budget, with other key constraints such as sensor accuracy, material limitations, and integration of mechanical and software components. Overall, the final product must be cost-effective, user-friendly, and scalable.

THE SOLUTION
The Cardboard Companion is a semi-automated system that scans objects using a ToF sensor, processes data with a custom box-optimization algorithm, and generates a G-code for cutting and scoring custom-sized boxes. Our modular design divided the system into scanning and cutting/scoring subsystems, allowing parallel development. Emphasizing adaptability and accuracy, we conducted iterative testing, sensor calibration, and dimension filtering to meet performance goals within the budget and material constraints.

THE RESULTS
The Cardboard Companion successfully scans objects, collects dimensions, and processes data to generate G-code for cutting and scoring cardboard. These processes meet precision and functionality expectations, with iterative design improvements enhancing overall system performance. Notably, the XYZ motion system operates smoothly after adjustments, demonstrating stability and reliability. We achieved significant advancements which reflect promising progress toward achieving a fully functional prototype.



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MECHANICAL CATHETER

TEAM 175

TEAM MEMBERS

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PROJECT ADVISOR

Enrique Gutierrez-Wing

SPONSOR

Massachusetts general hospital physicians Graham Lieberman MD and Brian Eisner MD

OVERVIEW

We were tasked to design a mechanical irrigator that controls fluid flow and handling, with an ergonomic design for the removal of blood clots in the bladder.

THE PROBLEM

Patients with hematuria suffer from blood presence in their urine. Current procedures to dislodge and completely remove the blood clots are either manual irrigation, which could take up to hours, or surgical intervention in extreme cases. Our device aims to automate the clot removal and irrigation process, thereby reducing patient discomfort and reducing the dependence on physician manual labor.

THE REQUIREMENTS

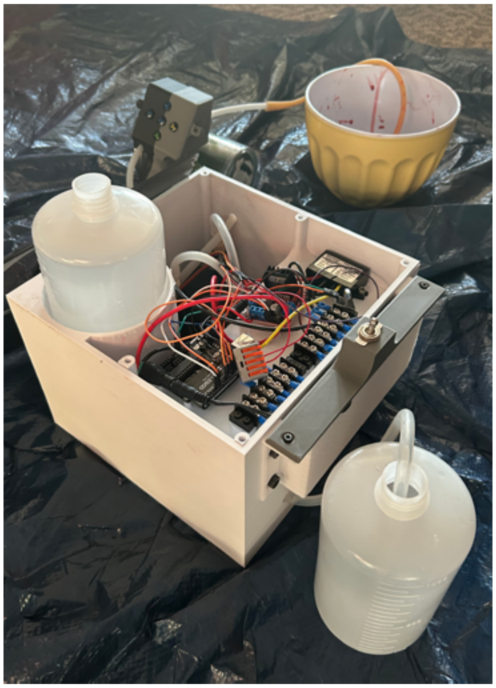
The device will be designed for single use. It must be sterile and keep the surrounding area clean and sanitary. Its operation shall not require more than 5L of fluid. It also must be small enough to comfortably fit on a patient bed and be easy to move. The cost must not exceed $200.

THE SOLUTION

Our solution utilizes a pump and a series of custom-built pinch valves. The user controls the direction and destination of fluid via an IR remote, replacing the labor-intensive process of manually flushing the bladder with saline to fragment and aspirate blood clots. Our novel method significantly reduces both the time and saline required compared to the manual procedure, improving safety and overall efficiency.

THE RESULTS

The customer's requirements for our device were a reduction in procedure time, saline solution required, and physical strain to the operator. We achieved this by confirming our device broke apart and aspirated 250 mL of blood clot-like material in under five minutes using 100 mL of saline solution. Furthermore, the device removes the physical stress, as it is controlled by an ergonomic IR remote.



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ELECTROCHEMICAL DEPOSITION PEN

TEAM 176

TEAM MEMBERS

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PROJECT ADVISOR

Scott Bunch

OVERVIEW

The purpose of this project is to develop a fun, interactive tool for introducing young students to electrochemistry.

THE PROBLEM

Despite the critical role it plays in modern-day life, electrochemistry is a topic rarely broached outside of higher education. In an effort to increase accessibility, a group in France developed an "EChemPen"—a pen that writes in metal using electrodeposition. Their designs are functional, but require laboratory equipment and safety measures, and lack a form attractive to young students. Refining their designs will yield a safer, more effective educational tool.

THE REQUIREMENTS

- Pen must be fully leak-proof; cartridge must act as primary containment and pen body as secondary containment for the "electrochemical ink"
- Assembly/disassembly must be easy and mess-free, so that the workings of the pen are readily accessible when teaching
- Must be battery-powered so as to remain portable and "wireless", but retain the form factor of a pen
- Project must be completed within a budget of $500

THE SOLUTION

Our design consists of five machined polypropylene components: a body, a pen tip, a battery compartment, a battery compartment cap, and a pen cap. These are designed to be friction-fit tightly together, ensuring the design is leak-proof, (dis)assembleable, and safe. Internally, there is a porous polymer nib and cartridge, a copper anode that partially encases the reservoir, components electrical connections, a 12 volt A23 battery, and a potentiometer.

THE RESULTS

The Electrochemical Deposition Pen is able to write, draw, and erase thin films of copper onto any conductive surface. This prototype can be used to demonstrate electrochemistry in a fun and interactive way to students of all ages, and potentially even be developed into a classroom experiment or home science-kit in the future.

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3D PRINTED HAND PROSTHETIC FOR UNDERSERVED COMMUNITIES

TEAM 177

TEAM MEMBERS

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PROJECT ADVISOR

Enrique Gutierrez-Wing

OVERVIEW

Creating a fully mechanical, 3D -printed hand prosthetic to provide affordable and functional solutions for individuals in underprivileged communities, including those with limited access to medical care and assistive technology.

THE PROBLEM

Our project addresses the need for affordable hand prosthetics in underserved communities by designing a 3D-printed, wrist-driven prosthetic for individuals with transmetacarpal amputations.This solution enhances accessibility and empowers individuals in low-resource settings, highlighting how engineering innovation can bridge the gap between healthcare needs and technological access.

THE REQUIREMENTS

The project requirements include the ability for the hand to open and close, grasp and lift objects, and be easy to maintain and assemble for simple part replacements. Additionally, the design must prioritize low-cost materials and manufacturing to ensure overall affordability.

THE SOLUTION

To complete our project, we designed and 3D-printed a fully mechanical hand prosthetic. Over the course of the semester, we iterated through multiple prototypes, improving the design based on function and range of motion. Each finger consists of three jointed segments held together with screws, with a cable extending from the fingertip to the wrist. When the wrist is flexed, the cable tightens to close the hand, while elastic cords restore the fingers to an open position.

THE RESULTS

The final prosthetic design is expected to successfully restore basic grasping functionality through a wrist-driven mechanism. Testing has proved smooth finger flexion and extension, with improved movement and durability in the latest iteration. The mechanical structure allowed consistent and reliable closing of the hand when the wrist was flexed, while the elastic cords effectively reopened the fingers. The design met our goals for functionality, ease of assembly, and low-cost fabrication.

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TERRAROVER MANUFACTURING SCALE-UP

TEAM 178

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PROJECT ADVISOR
Enrique Gutierrez-Wing

SPONSOR
AREN project team at NASA

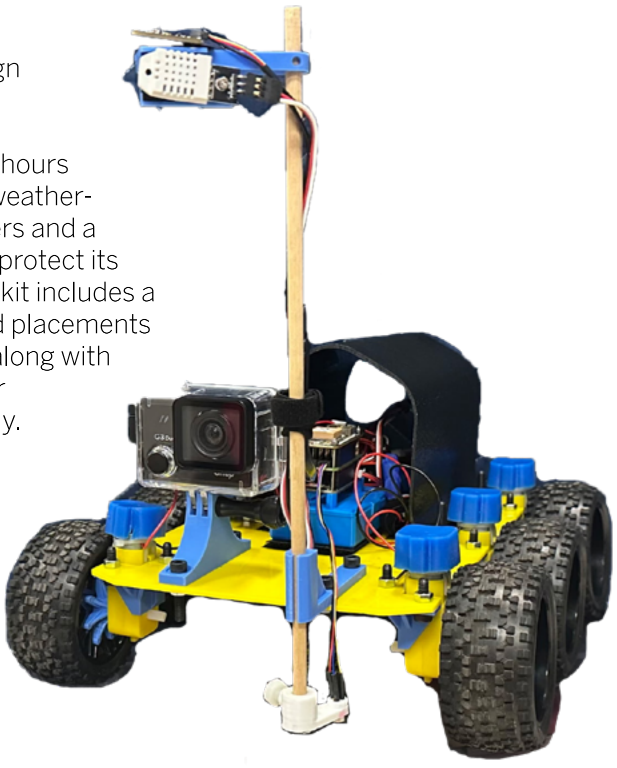
OVERVIEW
Redesign the TerraROVER, a remote-controlled vehicle used to collect environmental data for urban heat island monitoring in schools, for ease of manufacturability and assembly.

THE PROBLEM
The AREN team at NASA has been limited to making 30 TerraROVERs a year due to its time-intensive manufacturing and assembly and hopes to increase production to reach more nationwide schools and extend STEM education. This project focuses on redesigning the current TerraROVER for higher-volume manufacturing, reducing production costs and assembly time while maintaining functionality.

THE REQUIREMENTS
The TerraROVER must maintain the functionality of the current AREN design: ease of control, multiple sensor integration, and weatherproof. It should be easy to assemble and operate, being suitable for middle and high school students. To increase accessibility, TerraROVER's manufacturing and assembly are time-efficient and affordable. Most importantly, the TerraROVER is designed to be interactive and engaging to encourage and excite students about STEM technologies and the world around them.

THE SOLUTION
Our strategy was to reevaluate and modify the original TerraROVER design to reduce manufacturing and assembly time as well as production costs. We achieved this by minimizing previous 3D printing complexity, utilizing more cost-efficient material, and exploring alternative manufacturing processes such as laser cutting, thermoforming, and silicone molding. Additionally, we redesigned the TerraROVER as a kit to allow students to build it themselves.

THE RESULTS
The TerraROVER's new design is much faster to assemble and manufacture, reducing manufacturing time from 13 hours to 4. The updated design is weather-proof, featuring silicone covers and a thermoformed enclosure to protect its motors and electronics. The kit includes a laser-cut deck with engraved placements for electronic components, along with instructional videos and user manuals for ease of assembly.



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TERRAROVER INDOOR NAVIGATION

TEAM 179

TEAM MEMBERS
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Thanadol Sangprasert
Andrew Cao
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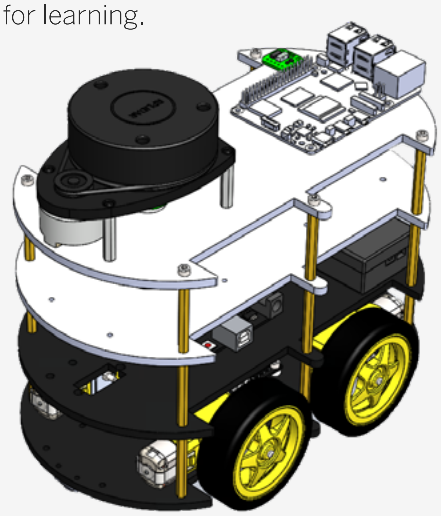
PROJECT ADVISOR
Enrique Gutierrez-Wing

SPONSOR
NASA and GLOBE (Global Learning and Observations to Benefit the Environment) Organization

OVERVIEW
The TerraROVER is an autonomous navigation rover designed for indoor navigation and environmental data collection, serving as an educational tool for learning.



THE PROBLEM
The TerraROVER, equipped with sensors for data collection in local outdoor environments, faces challenges in navigating enclosed spaces. This project expands the capabilities of the rover by addressing the need for a reliable indoor navigation system, while retaining its core functionality of collecting data. Equipped with new sensors and an improved navigation system, the TerraROVER enhances its role as a user-friendly educational tool for fostering STEM learning in classrooms.

THE REQUIREMENTS
The TerraROVER must navigate enclosed spaces without GPS, while enabling precise coordinate plotting and tracking through indoor mapping of a room. It is designed to gather and provide analysis on environmental data, such as light intensity. As an educational resource for classrooms, the design functions as a cost effective and easy to implement tool for learning. Balancing affordability with its necessary functionality is essential to address the principal constraints.

THE SOLUTION
To address the lack of indoor navigation in previous TerraROVER iterations, we evaluated multiple navigation methods, focusing on coordinate tracking accuracy, mapping reliability, and ease of use. Autonomous navigation was selected as the best approach, with a 2D LiDAR sensor chosen due to its consistent performance. For data collection, we focused on capturing information that could be easily visualized by students, opting for sensors that would show clear environmental variations.

THE RESULTS
To enable indoor navigation with coordinate tracking, we integrated a 2D LiDAR sensor onto a new rover platform, forming an autonomous system using SLAM mapping. The LiDAR provides real-time mapping and obstacle detection, allowing the rover to localize in enclosed environments. A Raspberry Pi manages data processing and navigation, while an Arduino controls motor functions - eliminating reliance on GPS. Environmental data is collected using a thermal camera and light sensor.

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SMART CLOTHING FOR KINEMATIC AND DYNAMIC MOVEMENTS

TEAM 180

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PROJECT ADVISOR
Scott Bunch

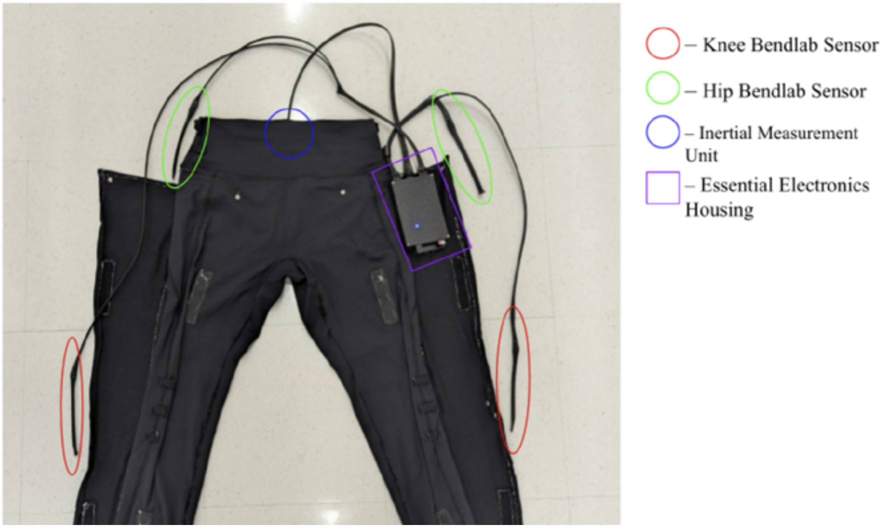
OVERVIEW
To design, fabricate, and evaluate the accuracy of an non-invasive, at home, lower body mobility monitoring system to be used by elderly individuals.

THE PROBLEM
With an ever increasing elderly population, preventive care is on the rise. In order to monitor mobility decline in an individual, recording human motion over an extended period of time is critical. Current devices in use depend on computer vision, IMUs, and EM systems which are intrusive and require complex setup to achieve accurate results. Therefore, independent everyday use within unstructured environments is impractical without a medical professional.

THE REQUIREMENTS
The device must collect and store a variety of measurements including joint angles, gait parameters, and postural states. It should continuously monitor data for up to 8 hours during daily use, and store data for 3 weeks. The system should be easy for the individual to put on, comfortable, and unobstructive during their daily activities. Additionally, the device should provide real time, intuitive user feedback.

THE SOLUTION
Our final design features form-fitting leggings with 2 BendLab sensors in each leg (knee and hip), covered by a flap secured via Velcro and buttons, and 1 IMU located in the center of the lower back. An ESP32 controls the system and data is stored via SD card. A built-in lighting system alerts the user during initialization and provides updates on system functionality.

THE RESULTS
An operational prototype, allowing versatility of movement and user type, was fabricated and tested through individual component testing and kinematic analysis of transitional body positions. Accuracy of the system was recorded within 5 degrees of freedom via ground truth testing with IMU gyroscope data recording within 1.04 in/s of movement. For easy use and knowledge transfer, a build and user guide was developed.



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ACTIVE ROCKET STABILIZATION

TEAM 182

TEAM MEMBERS
Kacper Bazan
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Lily Cannell
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PROJECT ADVISOR
Jim Geiger

OVERVIEW
Dual electric linear actuator thrust vector control.

THE PROBLEM
During the atmospheric flight regime, a rocket will be subject to various static and dynamic loads that will alter its trajectory. To better control the trajectory of the rocket, means of stabilization have been introduced throughout history. These include passive and active stabilization means, including spin stabilization, actuated fins, reaction control systems, and engine gimbals. We aim to tackle this issue by developing, manufacturing, and testing a novel active control system and by doing so we hope to gain insight into how the system operates.

THE REQUIREMENTS
The design must be mass optimized such that it can be integrated into a flight vehicle. It must withstand all static and dynamic structural loads from engine transients and inertial forces. It must withstand thermal loads from the engine. The actuation of the mechanism must be positionally accurate and repeatable. The systems must have a way of being reliably calibrated such that thrust is aligned with the flight vehicle center of mass.

THE SOLUTION
A dual electric linear actuator gimbal system. Active control is achieved by actuating two linear actuators clocked 90 degrees from each other which gimbal the engine about a universal joint. The system is capable of active pitch and yaw control. The system can be controlled by potentiometers or on board software. A load cell is integrated into the system such that thrust can be measured. The test setup allows for both cold-gas tests with low pressure air supply or hot-fire tests using a small solid rocket motor.

THE RESULTS
A fully designed, built, integrated, and tested system. Testing began with actuation of both actuators to verify the full range of motion. This was followed by several cold-gas tests, culminating in two hot-fire tests lasting 7 seconds each. Calibrating the neutral angle position can be done using cold-gas testing. The system has a gimbal range of +/- 10° at a speed of 10°/s. Positional resolution is 0.2°.This system is a scale demonstrator and as such it can be sized up for higher thrust rocket engines.

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RUBIK'S CLOCK RANDOMIZER

TEAM 182A

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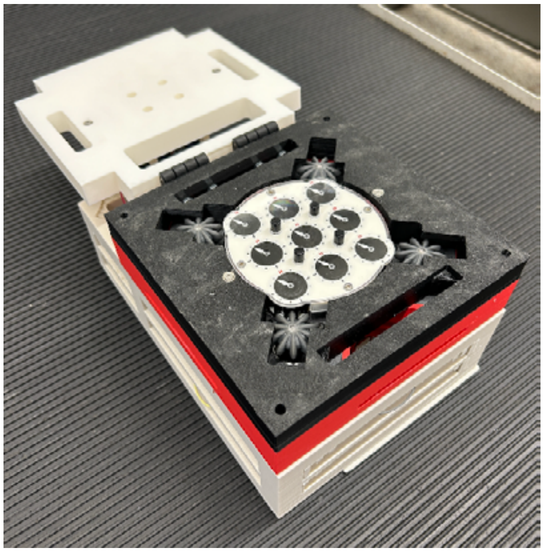
OVERVIEW
Develop a Rubik's Clock scrambler that ensures accurate and uniform scrambling for World Cubing Association competitions while also solving the puzzle and offering multiple difficulty levels to enhance fairness and engagement in competitive cubing.

THE PROBLEM
Rubik's Clock competitions face challenges in ensuring fair and accurate scrambles, as manual randomization introduces a 5% error rate, leading to miscrambles that undermine competition integrity. The increasing popularity of these events highlights the need for a reliable, automated solution to eliminate human error and controversy, ensuring all puzzles are scrambled uniformly and fairly before being solved by competitors.

THE REQUIREMENTS
The deliverable is a conceptual design of a portable, reliable randomizer specifically for the Rubik's clock. It must accurately scramble puzzles within 5 seconds, support multiple WCA difficulty levels, and reduce manual scrambling errors. The device must weigh less than 5 pounds, fit within an 18-inch cubic space, and be durable, easy to assemble, and operable using standard 120V power or optional battery power for competitive use.

THE SOLUTION
Our goal is to automatically scramble a Rubik's Clock for World Cube Association (WCA) competitions. The Clock is scrambled by rotating the four corner gears and pushing the pins either up or down, following a specific pattern. To automate this process, we 3D-printed custom gears that are turned by stepper motors, and we use solenoids to move the pins. A Raspberry Pi runs an algorithm that controls the motors and solenoids to perform the scramble accurately.

THE RESULTS
The Rubik's Clock Randomizer has three difficulty levels: Easy (scrambles part of the front), Medium (scrambles the entire front and part of the back), and Competition (scrambles all clocks on both sides following WCA rules). It also includes a Custom Scramble mode where users can create their own scrambles using a GUI, and a Solve mode that figures out and performs a solution based on the user's unsolved clock. All scrambling and randomizing features work with reasonable accuracy.



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D.U.N.G.
(DEVICE UPLIFTING AND NAVIGATION GROUP)

TEAM 183

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Zaid Bhatti
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Zachary Wu

PROJECT ADVISOR
Scott Bunch

SPONSOR
RASTIC at BU

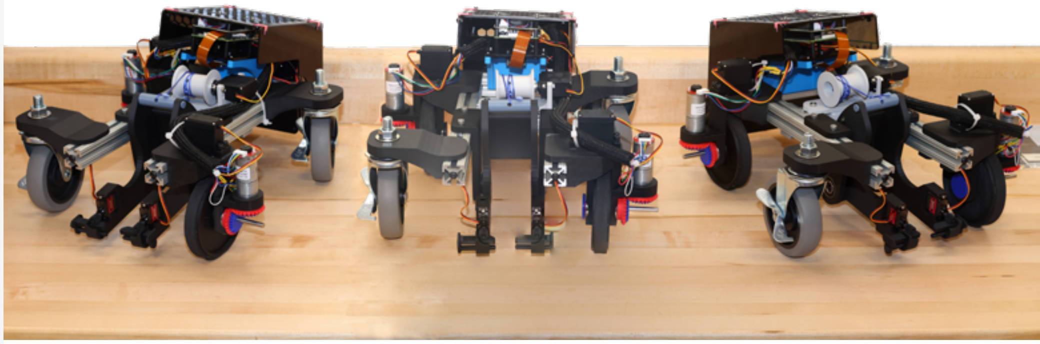
OVERVIEW
A swarm robotic system designed to maneuver planes around an airport.

THE PROBLEM
Moving planes around hangars is a delicate and time-consuming task, especially when the desired aircraft is stored at the back. Such aircraft are expensive, and a collision could cost both owners several thousands of dollars. In addition, many members of the aviation community are unable to maneuver these vehicles without assistance, which presents a new barrier to entry for a pastime that is already wrought with impediments for newcomers.

THE REQUIREMENTS
This project aims to develop a collaborative swarm robotic system. This involves the construction of 3 robots that can move a model plane around a 2D airport. It also involves implementing software that calculates the pathing of each robot and navigates them to their destination, align themselves, and lift the desired object. Finally, this project requires a user interface allowing clients to interact intuitively with the system.

THE SOLUTION
Project DUNG employed a bottom-up approach, with subsystems developed independently and integrated later. Half the team focused on fabricating the robots' physical structures using CNC Milling, Laser Cutting, and 3D Printing, while the other half dedicated their efforts to software and control development. This collaborative process exemplified innovation and precision, culminating in a highly efficient product development system.

THE RESULTS
The team developed a trio of robots that operate together successfully, achieving the project's objectives with precision. Tackling such a complex system honed the team's skills and fostered invaluable expertise. The mechanisms functioned as intended, highlighting collaboration and ingenuity. This milestone serves not only as a testament to the team's dedication but also as a solid foundation for future ambitious projects.



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SOFT ROBOTIC HAND EXOSKELETON FOR POST-STROKE REHABILITATION

TEAM 191

TEAM MEMBERS

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Zihao Hong
Yu Lin Tung

PROJECT ADVISOR

Francis DiBella

OVERVIEW

Our project is a soft robotic exoskeleton glove designed to aid stroke rehabilitation by providing motor-actuated finger assistance, enhancing hand functionality and recovery.

THE PROBLEM

Stroke survivors often experience impaired hand function, limiting their ability to perform daily tasks. Traditional rehabilitation methods can be time-intensive and lack personalized assistance. Our project addresses this by developing a soft robotic exoskeleton glove that provides motor-driven finger actuation to facilitate movement and improve hand function. This device enhances rehabilitation by offering consistent, adjustable support tailored to the user's needs, promoting more effective recovery.

THE REQUIREMENTS

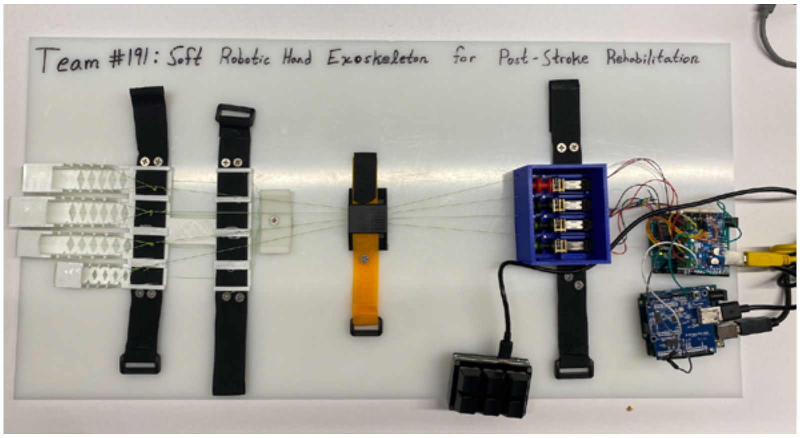
Our design must actuate four fingers while ensuring a comfortable, adjustable fit for various hand sizes. It must generate sufficient grip force for rehabilitation without compromising safety. Key constraints include durability through material selection, grasping load validation, and rigorous testing while maintaining portability. The control system must be intuitive for users, with safety features like an emergency stop to prevent unintended motion and ensure reliability.

THE SOLUTION

Our solution integrates soft robotic actuators into a wearable exoskeleton glove that provides controlled flexion of four fingers, each driven by a motor-tendon system. The design emphasizes modularity, portability, and adjustability for various hand sizes. We validated grip strength and performance through iterative prototyping, FBD analysis, and force testing using spring deflection and dynamometer methods. An intuitive control interface prioritizes safety and supports effective rehabilitation outcomes.

THE RESULTS

Our testing demonstrated over 20N of force exerted per finger, confirmed through both dynamometer and spring deflection methods. All four motor-driven tendons showed consistent performance. Object interaction tests—grasping items like cups, markers, and tape measures—validated dexterity and functional range. The glove maintained structural integrity under load, supported varied hand sizes, and proved reliable and ample for rehabilitation, aligning well with our intended performance outcomes.



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OIL SKIMMING SOLUTIONS

TEAM 192

TEAM MEMBERS

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Brian Sull
Yashiv Singh

PROJECT ADVISOR

Francis DiBella

OVERVIEW

We're creating a prototype for an aquatic, semi-autonomously-moving drone that will separate oil and water via a skimming technique and safely transport the oil to a collection point.

THE PROBLEM

Deepwater Horizon occurred 15 years ago, and yet despite increased global security measures, oil spills are still frequent today. The only existing methods of cleanup are not only expensive but also inefficient, and by combining oleophilic technology with a drone-like design, we hope to create a cost-effective and functional solution.

THE REQUIREMENTS

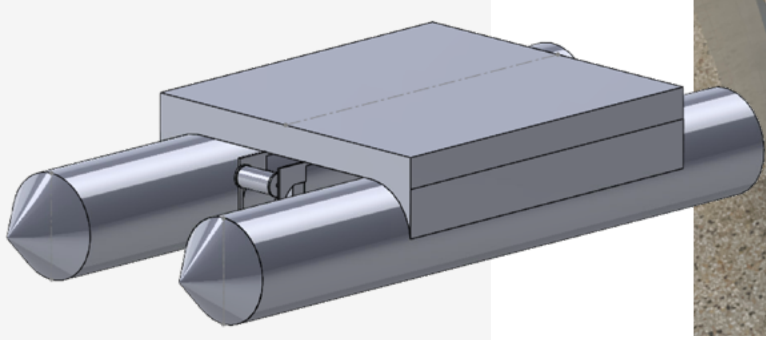
We are required to design the vessel and its components, create a functional circuit able to power all electronics, build a pulley-system operable with an oleophilic belt, implement pumping methods into the tanks and propulsion methods, and solve for the buoyancy of the vessel. Many constraints were, but not limited to, cost, power, weight, and time of operation.

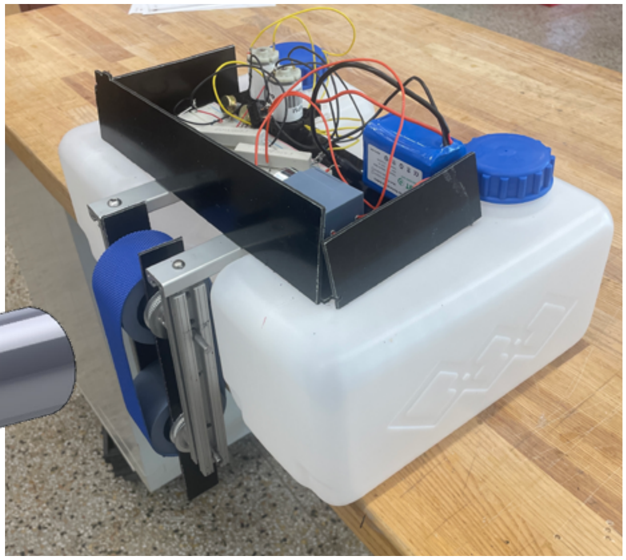
THE SOLUTION

To overcome various obstacles, we used a simple catamaran design to allow for buoyancy and easy movement. The oleophilic belt will be driven by a pulley system, and wiper blades will physically scrape off oil into a funnel, which is pumped into the tanks. The vessel will return using underwater propulsion to a mothership once it has filled its tanks, and will be able to display energy/capacity levels remotely.

THE RESULTS

Our model is a 3.2m x 1.8m vessel with an 8-inch wide oleophilic belt purchased from Abanaki, and it can hold around 900L of oil per cycle. Each vessel will take 4 hours to fill and houses a motor with maximum of ~6000RPMs and a rechargeable 24V battery. Our prototype is physically scaled down with a 2-inch width belt and can hold up to 5L of oil.





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CFD OF LOOPING BLOOD FLOW

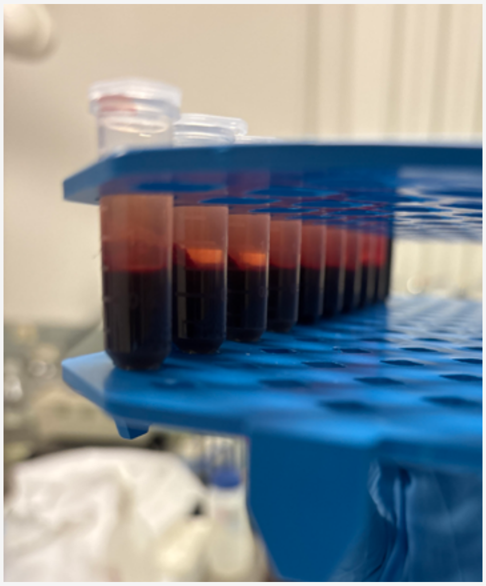
TEAM 194

TEAM MEMBERS
Neil Barbour

PROJECT ADVISOR
Scott Bunch

OVERVIEW
A research project focused on understanding what causes hemolysis (blood damage) from a fluid mechanics perspective.

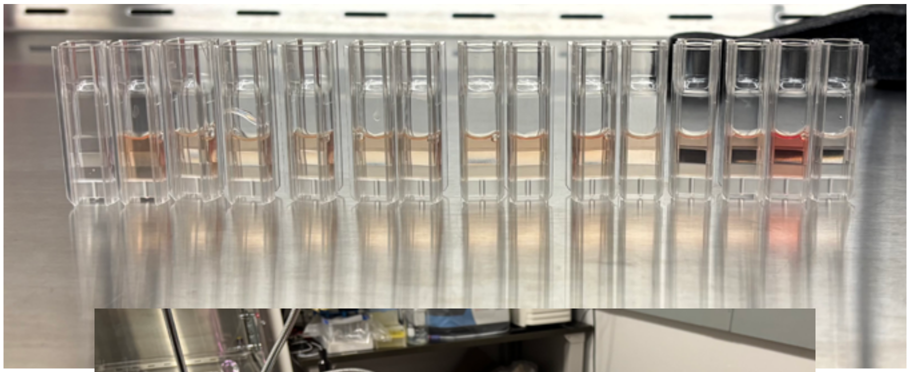
THE PROBLEM
What kinds of forces go into hemolysis, and how can we best model blood in Computational Fluid Dynamics?

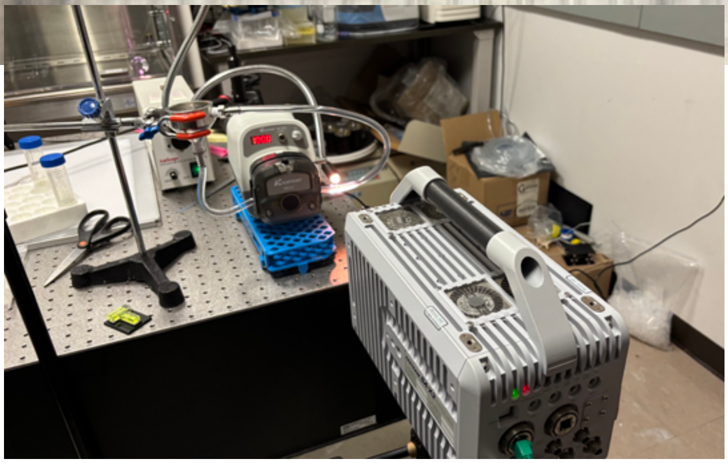


THE REQUIREMENTS
The main constraint here is time as well as computational power for the CFD model.

THE SOLUTION
Experimental hemolysis results are taken using spectrophotometry and analyzed using machine learning, while a Computational Fluid Dynamics model is also developed using Particle Tracking Velocimetry to find boundary conditions.

THE RESULTS
The hemolysis data is following a linear increase with time, and is hemolyzing more as the blood gets older, following anticipated trends. The CFD model can then be coupled to the hemolysis data, allowing a clearer expectation of how and when hemolysis happens





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SEA TURTLE MONITORING SYSTEM

TEAM 197

TEAM MEMBERS

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Yuyang Qiu
Lillian Snow

PROJECT ADVISOR

Francis DiBella

SPONSOR

New England Aquarium

OVERVIEW

A motorized and cable-based camera testing system simulating drone flight dynamics to assess resolution under real-world conditions (motion, glare, altitude), optimizing hardware selection for aerial monitoring of cold-stunned sea turtles in Cape Cod Bay.

THE PROBLEM

Climate-driven northward migration traps endangered sea turtles in Cape Cod Bay, increasing cold-stunned cases during seasonal temperature drops. Current manual detection by biologists is slow and range-limited. Given licensing restrictions that prevent direct drone development, we instead focus on evaluating camera resolution, a critical parameter for drone-based monitoring, under simulated conditions (motion blur, glare, altitude) to identify optimal hardware for more efficient turtle monitoring and rescue.

THE REQUIREMENTS

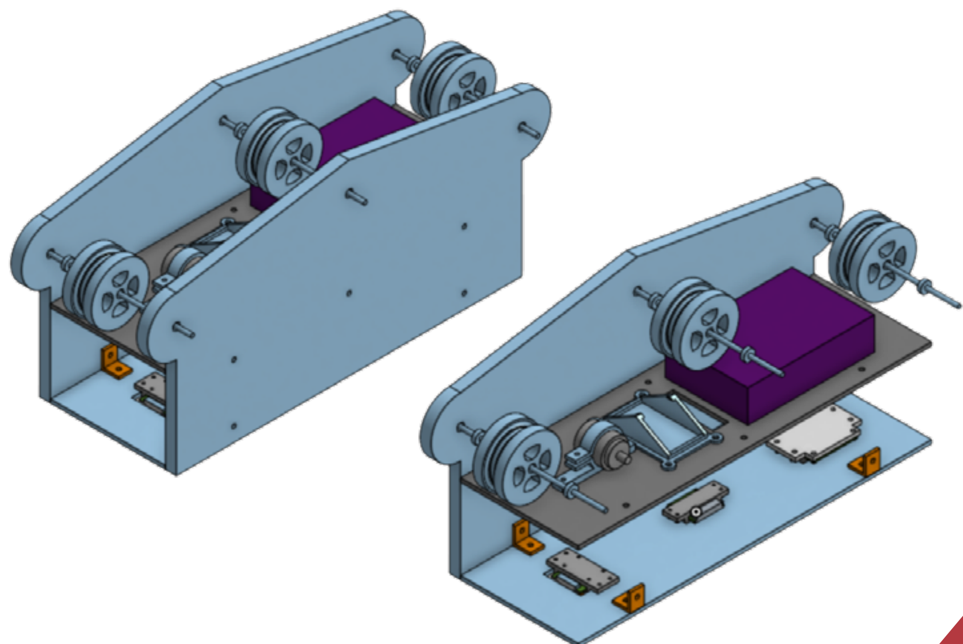
- Camera cart: Portable; modular design for rapid camera swaps; precise speed control scaled proportionally to drone specs.
- Frame: Stable with adjustable height; maintain FAA/NOAA-mandated drone-to-wildlife distance ratio.
- Testing: Simulate motion blur, glare, and turbulence while preserving scaled proportions (turtle size, drone velocity, height) to ensure real-world accuracy.

THE SOLUTION

To evaluate the performance of different camera models when equipped on research drones, the team aims to design and create a system with precise bidirectional motion that evaluates the camera module's resolution when subjected to environmental factors like motion blur and surface glare.

THE RESULTS

The system tests the performance of three different cameras in three criterias(vertical height, speed, lighting), aiming to determine how the resolution is impacted by motion blur, distance, and surface glare. By analyzing the output resolutions, we expect the system to reveal differences in camera performance, allowing us to determine an optimal camera model.



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AI COFFEE MACHINE

INTERDISCIPLINARY TEAM

TEAM MEMBERS

Sebastian Seun
Naomi Gonzalez
Krish Shah
Bryan Zhang

SPONSOR

Kenn Sebesta

ABSTRACT

The AI Coffee Machine project addresses the long-standing challenge of brewing consistent, high-quality coffee, a process made difficult by the complex chemistry of coffee, which contains over 1,000 compounds. Our solution is a centrifugal coffee machine that automates critical brewing parameters such as pressure, temperature, and grind size, providing an innovative, user-friendly approach to delivering consistent flavor profiles. The machine incorporates a state-of-the-art machine learning model that analyzes user feedback and dynamically adjusts brewing settings to achieve optimal results.

The final deliverable is a fully functional prototype that combines cutting-edge mechanical design with advanced software capabilities to bridge the gap between user preferences and precise brewing. Key innovative features include the use of FDAcompliant materials, an inverse problem-solving algorithm for flavor optimization, and integration of user feedback to enhance performance over time. This project represents a significant step toward revolutionizing coffee brewing, providing both convenience and quality for coffee enthusiasts and professionals alike.

NEUROTOYS

INTERDISCIPLINARY TEAM

TEAM MEMBERS

Andres Marquez Santacruz
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Adam Shaikh
Robert Bona
Mete Gumusayak

ABSTRACT

This project aims to revolutionize human-machine interaction by enabling control of a robotic device using brain signals. It addresses the challenge of enabling individuals, particularly those with mobility impairments, to control devices effortlessly and intuitively using their brain activity. Traditional device control methods such as joysticks and remotes are restrictive and often inaccessible. Using Electroencephalography (EEG) signals, NeuroToys aims to create a non-invasive brain-computer interface (BCI) that translates brainwave patterns into real-time motor commands for a car toy.

The final deliverables will include a fully functional robotic device controlled by EEGsignals, a software interface for real-time feedback, and a user-friendly graphical interface for calibration and monitoring. The system will incorporate robust signal processing, achieving 95% noise reduction and a command recognition accuracy exceeding 85% after calibration. The portability and wireless nature of the system ensure ease of use with a communication range of at least 10 meters.

The proposed technical approach integrates machine learning for signal interpretation classification, dynamic threshold calculation for real-time command interpretation, and innovative hardware design. NeuroToys features a low-cost, portable, and user-friendly EEG system optimized for comfort and usability. This solution not only fosters greater independence for individuals with disabilities but also opens pathways for applications in healthcare, rehabilitation, and entertainment, contributing to the advancement of accessible human-machine interaction technologies.

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PIANO PEDALS

INTERDISCIPLINARY TEAM

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Rohan Alexander Krishnan
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Professor Alan Pisano

ABSTRACT

Our project is a device that allows a piano player to use the pedals of the piano without using their feet or legs. Our goal is to give the full capabilities of a piano to musicians who cannot use their legs or feet. The device depresses the pedals using linear actuators which extend downward on top of the pedals. The device is portable, and the linear actuators are adjustable so it can work on any standard piano with three pedals. The device makes use of three different sensors for each pedal, two finger-pressure sensors for sustain and sostenuto and one shoulder-motion sensor for the soft pedal. These sensors plug into our control unit, which has controls for each pedal to adjust maximum and minimum depression of the piano pedal, as well as sensitivity of the input sensors. The control unit then outputs a signal to our linear actuators which depresses the pedals with the force the user instructs it to. Our device allows the user to seamlessly and dynamically actuate the pedals of the piano while they play the keys.

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SMOOTH OPERATOR

INTERDISCIPLINARY TEAM

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Christian So
Jacob Chin

ABSTRACT

Post-COVID staffing shortages in the hospitality industry have increased mobility challenges for travelers with physical impairments, particularly regarding luggage transportation. With over 61 million Americans (26% of adults) living with disabilities, there is a significant need for assistive solutions. The hospitality sector has experienced a 38% reduction in workforce since 2019, with airport ground staff decreasing by 25%, further limiting available assistance.

SmoothOperator addresses this need through an interactive robotic assistant designed to autonomously and safely transport luggage in consumer environments. We developed a complete full-scale, end-to-end robotic solution that seamlessly integrates multiple subsystems. This involved manufacturing custom components and assembling a sophisticated network of sensors, actuators, algorithms, and communication protocols. These systems allow SmoothOperator to navigate using either terminal destinations or direct user input via an onboard touchscreen interface. To ensure safe and reliable operation, we implemented multiple redundancy strategies and layered safety mechanisms, including dynamic obstacle avoidance that prioritizes human interaction. SmoothOperator is designed to enhance accessibility and convenience in the hospitality sector, improving the quality of life and providing greater confidence for individuals with mobility impairments when traveling.

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WIND POWERED RESEARCH

INTERDISCIPLINARY TEAM

TEAM MEMBERS

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Philip Nied
Mateo Marsella Balzola
Joshua Bardwick

SPONSOR

Professor Ryan Lagoy and the Woods Hole Oceanographic Institute

ABSTRACT

Our project this year was to build an autonomous boat for researchers at Woods Hole Oceanographic Institute (WHOI). They need an autonomous vehicle to navigate around the coast of Southern Massachusetts and Rhode Island to take time and location-stamped readings from their environmental sensors. Our vessel must be able to make a two-hour journey, up to a kilometer from shore, without human intervention. Our boat is able to switch between emergency manual control, autonomous navigation under motor power, and autonomous navigation with sail power. The base structure of the boat, including the keel and wing, is 3D printed polylactic acid, with waterproof sealing on the surface and acrylic paste in contact points for waterproofing. Our project also has a custom web user interface that is accessible offline for use in remote areas near the coast.

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DEVICE DEVELOPMENT FOR INDUCING COMMINUTED FRACTURES IN MICE TIBIAE

INTERDISCIPLINARY TEAM

TEAM MEMBERS
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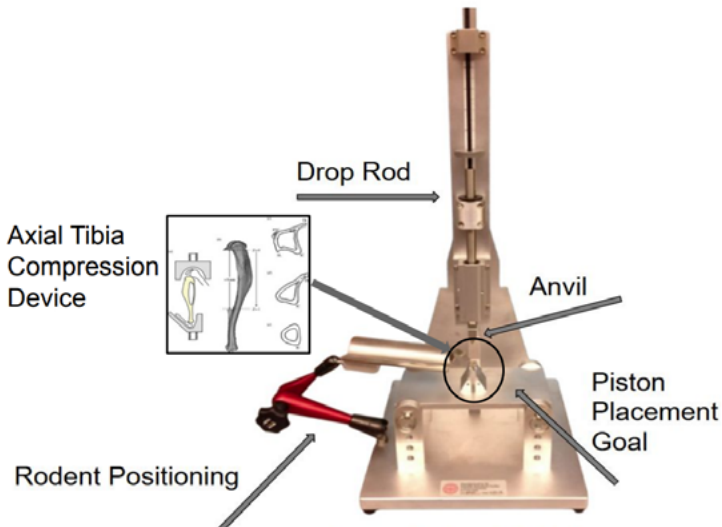
PROJECT ADVISOR
Elise Morgan

ABSTRACT

This project aims to develop a device that reproducibly induces comminuted fractures in mice tibiae, addressing the gap between clean fractures produced by existing devices and the complex breaks observed in real-world trauma cases. By combining axial compression with transverse loading in a single prototype, we seek to generate consistent fractures, with three separate force settings depending on the scale of the fracture desired. Our experimental plan included replicating the vertical compression device for testing, creating an axial compression device, and then fitting it to the existing transverse load device. We tested the setup using 3D-printed resin tibiae before transitioning to biological extracted tibiae. Based on our trials of the device at the minimum, medium, and maximum force we have found that an average force of approximately 4.44 lbs is sufficient to create a comminuted fracture of the tibiae under controlled conditions, confirming the feasibility of our approach. These findings suggest that the combined forces produce comminuted fractures, providing a more accurate model for studying bone healing. Future work will refine the device's repeatability, expand testing on mice legs, and evaluate the precision of fracture patterns. This device may improve orthopedic research by enabling controlled studies of comminuted fractures and improving bone healing studies.



Current device at BU Med Campus

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BUZZ BRACELET: ALERTING USERS WITH HEARING LOSS TO AUDITORY DANGERS

INTERDISCIPLINARY TEAM

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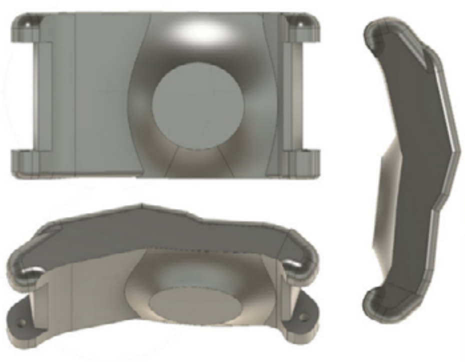
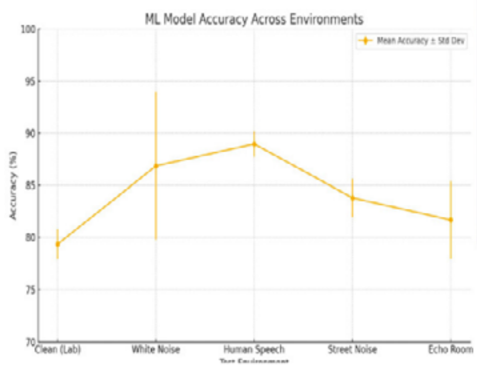
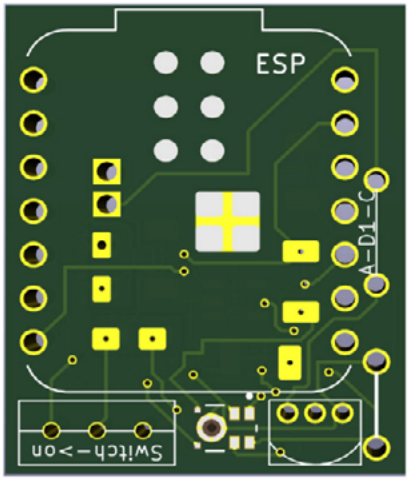
PROJECT ADVISOR
Kamal Sen

ABSTRACT

We continued the development of a wearable safety device for people with hearing loss. With our goal being to provide users with real time haptic alerts of dangers such as sirens, fire alarms, and car horns. Our current device predecessor, the BUzz Bracelet V1, proved that cheap, readily available electronics could be used to accomplish this goal. However, the V1 was far from a finished product. With version 2, we were able to enhance the BUzz Bracelet's battery life, aesthetics, and durability. While also optimizing sound detection in order to achieve minimal latency as well as higher accuracy. In terms of physical parts, we upgraded the battery, microphone, and processor for better classification capabilities. As well as created a 60% smaller device housing with an adaptable strap. We performed market research to figure out which strap materials/styles will provide users with the most comfort and durability, while still balancing large-scale manufacturing feasibility and cost. On the software side, we conducted rigorous testing of our ML model, in order to ensure its efficiency and accuracy. Throughout the entire process we were able to keep costs extremely low. We strive to offer a cheaper, more accessible alternative to expensive hearing aid.







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FLEXIBLE, FLUIDIC-ACTUATED SOFT ROBOTIC ASPIRATOR FOR BLOOD CLOT REMOVAL

INTERDISCIPLINARY TEAM

TEAM MEMBERS
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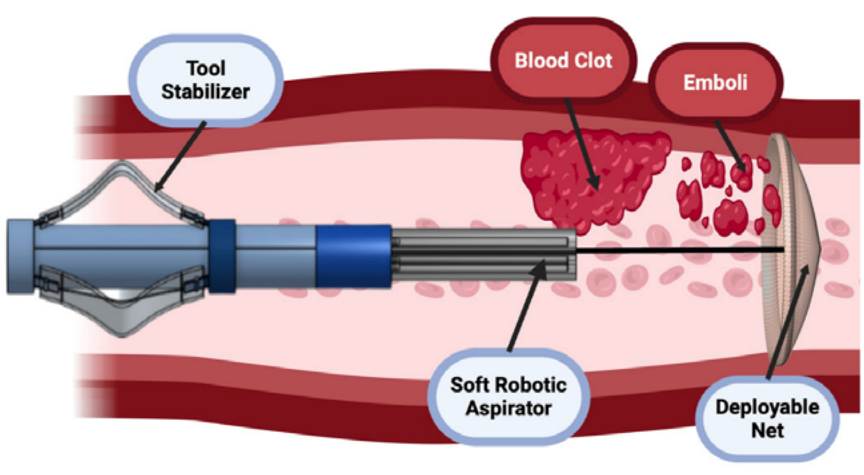
PROJECT ADVISOR
Kenn Sebesta

ABSTRACT

Blood clots remain a major health challenge in the U.S., contributing to an estimated 100,000 deaths annually. Traditional thrombectomy devices, while essential, often lack flexibility and precision — increasing the risks of embolism and vascular damage. To address these challenges, this research focuses on developing a biocompatible, fluid-actuated soft robotic aspirator designed to improve clot removal while minimizing vascular trauma and maintaining oxygenated blood flow.

The system features a sensor-integrated catheter that is able to respond to clot conditions and adjust in real time for precise, minimally-invasive thrombectomy. To further enhance patient safety, a cable-actuated capture mechanism prevents clot fragmentation from causing additional blockages. The mechanical system includes a soft robotic tip for multi-directional movement, a rigid catheter body for support and tubing, a pop-up stabilizer for controlled positioning, and a pneumatic adapter for secure tube connections. A porous net expands to capture emboli and maintain oxygenated blood flow. The main control circuit facilitates real-time pressure sensing, precise pneumatic actuation, and continuous visualization of the surgical field. By integrating these multidisciplinary elements, our project seeks to transform thrombectomy practices, presenting a safer, more effective alternative to conventional blood clot removal methods.



FLUORESCENCE IMAGING OF NANOPARTICLE-TREATED TUMOR CELLS IN MICROFLUIDICS

INTERDISCIPLINARY TEAM

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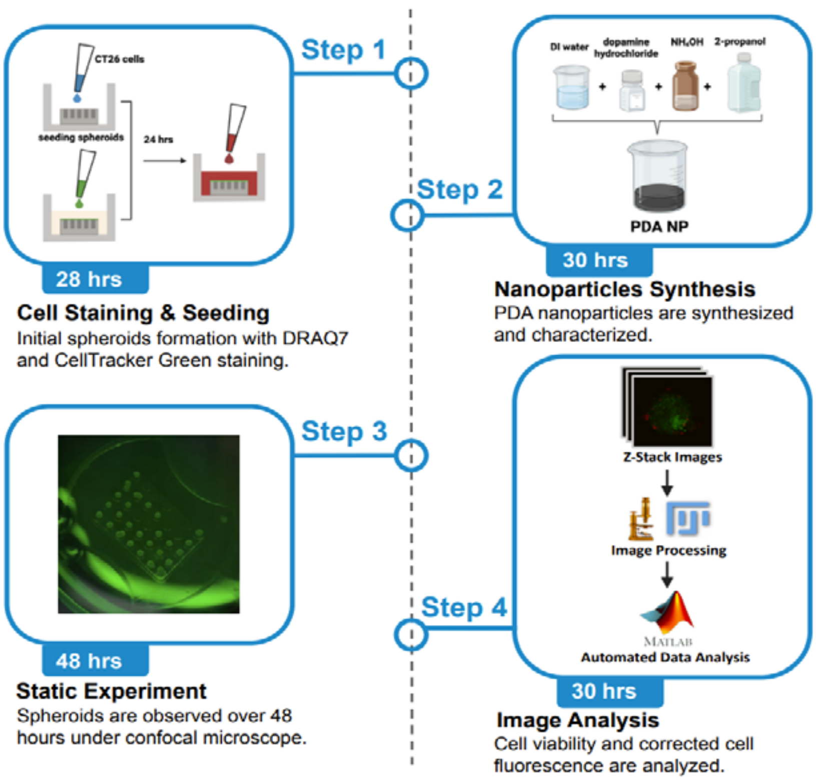
Jian Knight (ME)
Namanjyot Singh
Yuei Taou Lee

PROJECT ADVISORS
Alex Markoski
Jeffrey Borenstein (Draper)

ABSTRACT

Current challenges in personalized cancer therapy include the need for in vitro models that accurately predict treatment efficacy while streamlining data acquisition. We present an integrated platform combining polydopamine nanoparticles (PDA-NPs) with automated viability analysis in tumor spheroids. CT26.WT mouse colon carcinoma cells are cultured into uniform spheroids and stained with CellTracker Green CMFDA and DRAQ7 to distinguish live and dead cells. In parallel, PDA nanoparticles are synthesized from dopamine hydrochloride, with efforts to optimize morphology, stability, and drug-loading performance. Rigorous image acquisition and automated analysis, enabled through a MATLAB-to-ImageJ (MIJ) pipeline, supports efficient quantification of spheroid viability. Initial results reveal measurable viability differences between untreated controls and PDA-NP treated spheroids under static conditions. Further refinement of nanoparticle formulations and expansion to dynamic flow systems are ongoing. Our research aims to advance in vitro models for high-throughput screening of nanoparticle-based therapies, with the hypothesis that PDA-NPs will enhance detection of therapeutic responses in tumor spheroids.



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SOFT LAYER-JAMMING MEDICAL DEVICE FOR COMPRESSION THERAPY

INTERDISCIPLINARY TEAM

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PROJECT ADVISOR
Andrew Sabelhaus

ABSTRACT

Compression therapy (CT) has proven to be a successful clinical treatment for venous and lymphatic disease, yet standard elastic-based garments are compromised by poor patient compliance by way of discomfort and stiffness. To eliminate such drawbacks, we present an autonomous, pneumatic soft robotic compression sleeve that can adjust dynamically to the wearer's limb using real-time sensing and actuation control. We use balloon actuators (BAs) for active compression and layer jamming (LJ) mechanisms for adjustable stiffness in our system. The sleeve is designed to accommodate varying calf anatomies and offers adjustable radial compression within the therapeutic range of 14-35 mmHg. Air pressure sensors provide real-time feedback to enable closed-loop control by a wireless Arduino Nano ESP32 microcontroller. Sensor feedback is utilized in a control algorithm that controls pneumatic elements to maintain uniform compression, with user input provided through an iOS interface. Initial validation indicated successful BA deformation and stiffness modulation via LJ. This is the first to integrate LJ and BA in an independently wearable device for the delivery of CT. Our device represents a significant innovation in healthcare soft robotics, offering greater improvement for critical factors determining long-term therapeutic efficacy and clinical acceptance.