BUMECHE

Senior Capstone 2023

BOSTON UNIVERSITY

Department of Mechanical Engineering

MAY 5, 2023

BUMECHE

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Welcome to the Mechanical Engineering Senior Capstone Day for the class of 2023!

It is so exciting to celebrate the hard work and achievements of our senior class in their capstone projects! These projects are the culmination not only of their work over the last year in Senior Capstone, but also the result of their entire undergraduate education. Capstone presents an amazing opportunity to leverage the knowledge and skills gained in MechE at BU to address challenging, real-world problems.

This year we have 30 projects hosted within the department, covering a wide range of topics within Mechanical Engineering. We have projects in vehicle control, in automation, in robotics, rocketry, manufacturing, energy, and more. I am particularly thrilled to see that the trend of projects that require true interdisciplinary expertise is continuing. The success of these projects showcases the abilities of our students to complement their core mechanical engineering knowledge in topics such as fluids, mechanics, materials, computer-automated design, manufacturing, and rapid prototyping, with non-traditional MechE skills such as programming and electrical circuit design. Real problems are solved by using the right tools at the right time, not by just blindly swinging the hammer in your hand (though sometimes a solid hit with that hammer is just what's needed!). These capstone projects show that our students are up to the challenge!

The projects themselves come from many different sources. We are always excited by the participation of Boston-area companies who sponsor capstone projects, as well as by our faculty members seeking devices that support and augment their research, by our student clubs, and by individual student initiatives. We are grateful to all our sponsors, both new contributors and those who have participated for many years. We are always looking for new project opportunities and invite anyone with a project idea to contact Professor Tony Linn.

I hope you will enjoy this year's presentations and exhibits. I am extremely proud of what our students have accomplished and look forward to joining you in celebrating their achievements.

Sean B. Andersson
Professor and Chair
Department of Mechanical Engineering

Nichole Lawton

Financial Administrator

Frank Dibella

Senior Lecturer

James Geiger

Lecturer

Steve Chomyszak

Professor of the Practice

Anthony Linn

Professor of the Practice

Tasker Smith

EPIC Laboratory Supervisor

Robert Sjostrom

EPIC Laboratory Supervisor

Kara Mogensen

EPIC Laboratory Supervisor

Caroline Carbo

EPIC Laboratory Supervisor

Ryan Bakinowsk

EPIC Laboratory Supervisor

Nicole Bacca

GST

Terrier Motorsport Manufacturing

OVERVIEW

We are testing and creating procedures for Terrier Motosport to manufacture composite materials for the aerodynamic components of their vehicle.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Ian Conners
Leo De La Torre
Jared Pratt
Andrew Schmid

THE PROBLEM

Terrier motorsports, Boston University's electric formula team, designs a new electric race vehicle regularly. Nearly all students in the club have no experience working with composite materials; each car is made by a different set of students starting with zero knowledge of the process. Terrier Motorsport needs a cost effective, manageable method for reliably manufacturing aerodynamic packages that can be easily followed by club members with no prior experience.

THE REQUIREMENTS

Given to us by William Krska, Terrier Motorsport Chief Engineer

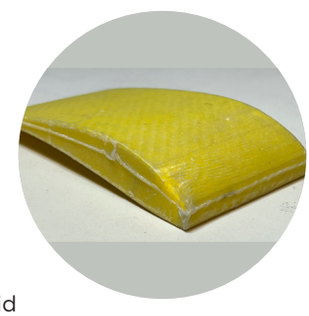
- Design for Manufacturing (DFM) analysis on aerodynamic package components with suggested changes to CAD designs to ensure ease of manufacturing.
- Reliable and cost effective method to manufacture aerodynamic components.
- Standard Operating Procedures (SOPs) for chosen manufacturing methods for each major component of the aerodynamic package along with supporting documentation on material selection, Design for Assembly (DFA) analysis guidelines, etc.

THE SOLUTION

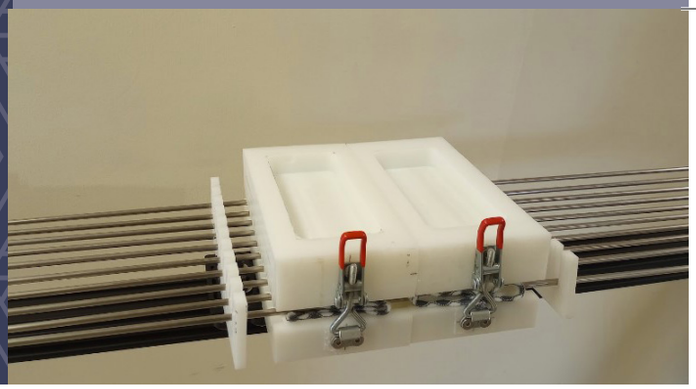
Our chosen manufacturing method for the aerodynamics package is vacuum bagging. Vacuum bagging is the best choice to create the lightweight and strong parts needed for racing without requiring excessive capital costs. Creating master reference documentation alongside step-by-step SOPs ensures that the manufacturing process is able to be replicated for aerodynamics packages in the future.

THE RESULTS

Terrier Motorsport now has the tools needed for vacuum bagging with instructions on how to use the materials to make aerodynamic components. They will soon possess a lengthy reference document with material, where to buy them, strength analyzes, DFM considerations, vacuum bag specific instructions, assembly recommendations, and anything else the club will need. The components manufactured are able to be used in the formula hybrid university competition.



Centerless Grinding Fluid Removal System



OVERVIEW

Our project aims to design a system to automatically clean coolant from the surface of long tubes (5’ and 10’) of various diameters (1/4’’ to 1/32’’ OD).

PROJECT ADVISOR

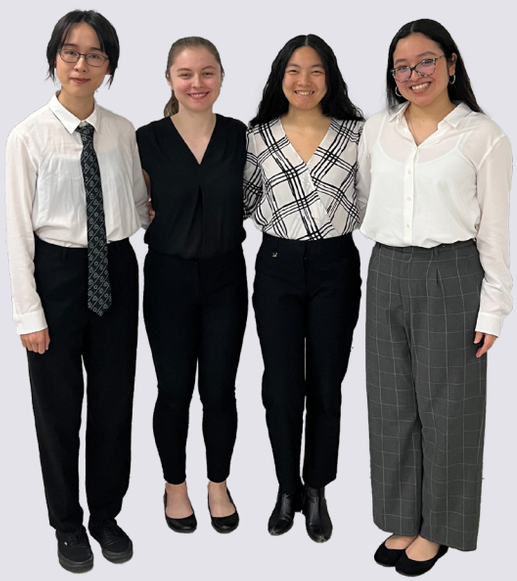
Prof. Steve Chomyszak

TEAM MEMBERS

Nicole Hernandez
Junhan Liao
Sarah Stantial
Olivia Young

CLIENT

Vita Needle Company



THE PROBLEM

Vita Needle uses centerless grinding to create long lengths of tubing with varying small diameters and needs to clean this coolant from the tubes with isopropyl alcohol (IPA). Currently, they do so manually with a spray bottle and paper towels which is cumbersome and inefficient so they would like a system that automates the process.

THE REQUIREMENTS

Our requirements were given to us by our customer Vita Needle.

- The system should clean coolant off tubes with an outer diameter between 1/4’’ to 1/32’’ and lengths of 5’ and 10’ while protecting the tubes from deformations.
- The system needs to be semi- or fully automated.
- The system needs to be safe to interact with and have design considerations of the explosiveness of IPA.

THE SOLUTION

The system consists of two clamps that will be filled with bamboo cloth and move via a continuous linear drive. The clamps will start at the center of the tubes and move outward until they surpass the ends of the tubes. A center gripper will also close around the tubes to secure them as the cleaning clamps move outwards.

THE RESULTS

The cleaning clamps and linear drive have been tested and proven to successfully clean coolant from tubing. We anticipate to have a fully functioning system that is able to be controlled with buttons and an Arduino.

NASA Blue Skies

Iron Powder as a Clean Aviation Fuel Source

OVERVIEW

We participated in the NASA Blue Skies competition by researching iron powder combustion as a potential alternative fuel source for commercial aircraft, and we developed a preliminary proof of concept.

PROJECT ADVISOR

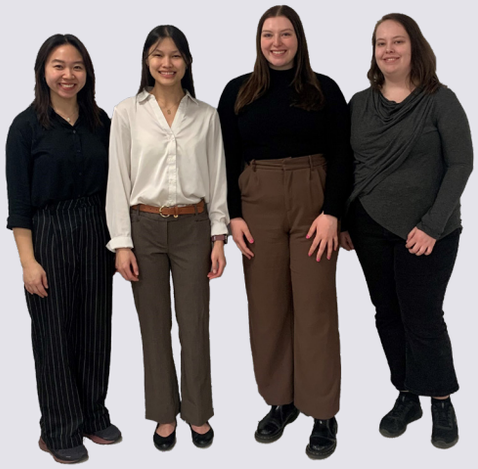
Prof. Anthony Linn

TEAM MEMBERS

Kaylea Gaughan
Emily Osurman
Michelle Ramoska
Hadassah Flagg

CLIENT

NASA's 2023 Gateways to Blue Skies: Clean Aviation Energy Competition



THE PROBLEM

Air travel is a vital part of the economy, servicing billions of passengers and supporting over a trillion revenue tonne-kilometers across the globe. The NASA Blue Skies competition called for student teams to conceptualize the source-to-flight lifecycle of one potential clean aviation energy source of the 2050s, as the application of sustainable energy to aircraft can decrease CO2 emissions by millions of tons per year.

THE REQUIREMENTS

NASA Blue Skies required

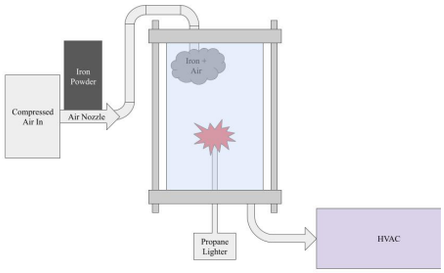
- The single chosen fuel source (excluding Jet A or Sustainable Aviation Fuel) must power flights lasting at least 2 hours with near-zero emissions.
- A source-to-flight lifecycle overview, including creation/generation, storage, and transportation of the energy source.
- Supply chain analysis related to climate impacts, safety, current technology readiness levels, and manufacturing readiness levels, in addition to a timeline of necessary technological advances for 2050s implementation.

THE SOLUTION

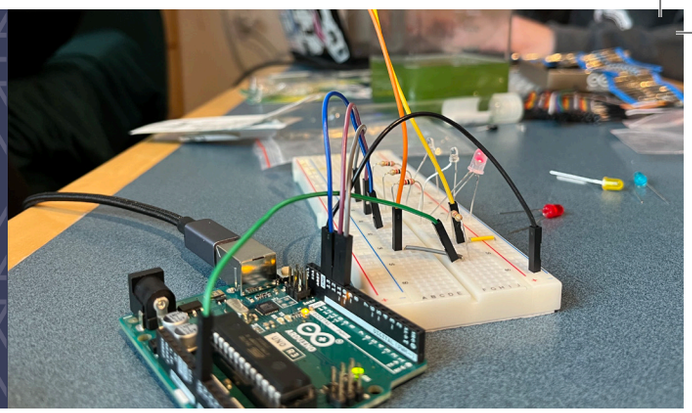
We proposed electricity generated via iron powder combustion as a potential fuel source. The combustion of the powder would be used to drive the hot reservoir of a heat cycle which would produce electricity to charge lithium-sulfur batteries. Reduction of the iron oxide back to iron would be performed via electrolysis, where the energy required would be derived from renewable energy sources. This reduction results in a cyclical process.

THE RESULTS

Through our research, we have concluded that the combustion of iron powder to charge batteries is theoretically possible and could be used to charge electric planes in the 2050s. We also demonstrated that electrolysis can successfully reduce iron oxide back into iron, thereby verifying the cyclical potential of the technology. Finally, we produced a small-scale model demonstrating the combustion and heat output of iron powder.



AWCUA



OVERVIEW

For this project, three sensors were invented to continuously detect cyanobacteria, E. Coli, and turbidity levels in bodies of water such as the Charles River in order to regularly gauge the health of the river.

PROJECT ADVISOR

Prof. Francis DiBella

TEAM MEMBERS

Cathy Cheng
Fallon McBrien
Charles McGinn
Ava Remler

THE PROBLEM

Based on current data, there is a significant threat from harmful algal blooms (HABs) and bacteria in the Charles River in Boston, Massachusetts. There is a deficiency in cost-effective, continuous monitoring techniques of indicators of HABs and bacteria in order to contribute to selective remediations for these organisms. The intention of this project is to monitor the presence of HABs and bacteria in the Charles River via a cost effective device.

THE REQUIREMENTS

- In terms of requirements and constraints from our stakeholder, each device must cost under $1,000, and the system and data must be retrievable.
- It must be durable and scalable, and rely on renewable energy. The energy requirements should be below 10 Wh, to be charged within 1 hour.
- The data accuracy and precision should be within 5% error rate and variation rate respectively, and the device should store data.

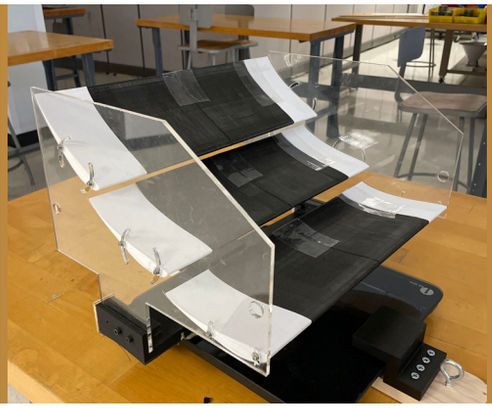
THE SOLUTION

Following a literature review, the experimental design was devised, alongside a preliminary device design following determined specifications. Then, electrical and chemical experiments were conducted to validate the operability of the sensing and optical detection method. As the ideal wavelengths for detection were determined using control samples of cyanobacteria and E. coli, the housing and docking station designs were initiated and evaluated. Finally, prototypes were tested and refined for final fabrication.

THE RESULTS

Spectrometry testing indicated that the species of cyanobacteria of interest had nearly identical absorbance range peaks, simplifying the project's scope while maintaining the scale of impact. Additionally, UV vis results showed that E. coli exists within the detectable range of visible light. This joins the finalization of the sensor housing and docking design, as well as the capability of the device to detect major biological and non-biological compounds in water.

Terrier Motorsport Front Wing



OVERVIEW

Our project is to design and manufacture both a scale model and full scale model of a front wing for the Terrier Motorsport Car.

PROJECT ADVISOR

Prof. James Geiger

TEAM MEMBERS

Aayush Amrit
Matthew Spak
Shannon Kelly

CLIENT

Terrier Motorsport

THE PROBLEM

In order to improve the aerodynamic performance of the Terrier Motorsport car, we are making a front wing. A front wing creates downforce which reduces understeer and helps to decrease the lap time in the race. Our group also had to devise a method to collect real world data showing quantities of downforce.

THE REQUIREMENTS

Our requirements were given by the Terrier Motorsport E board.

- Generate 30 to 40 lbs of downforce at 40 mph
- Weigh between 12 to 18 lbs
- Cost less than $1000
- Comply with Formula Hybrid competition rules

THE SOLUTION

Our group examined multiple research papers, journals and products on the market to help with brainstorming multiple options for configurations of the wing. Once we decided upon the airfoil, materials, angles of attack and mounting method we began building our scale model. The scale model was then tested in the BU wind tunnel to determine the amount of downforce generated. Finally, we proceeded to manufacture the full scale model.

THE RESULTS

We anticipate our full scale model will generate 36 lbs of downforce at 40 mph based on the data we collected during wind tunnel testing. Our final prototype also complies with the rules of the Formula Hybrid competition and meets the budget requirements. We also anticipate that our final prototype will weigh between 12 and 18 lbs.

Design, Build, Fly: 3D Printed Glider

OVERVIEW

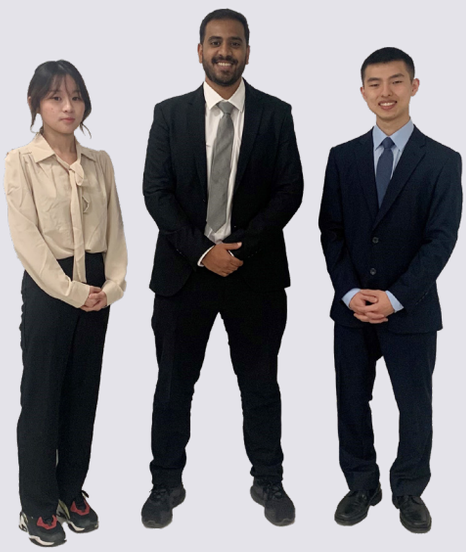
Modular 3D printed aircraft that is optimized for endurance and range inspired by the UTA Annual 3D Printer Aircraft Competition.

PROJECT ADVISOR

Prof. James Geiger

TEAM MEMBERS

Anas Alamoudi
David Zhu
Yong Ng



THE PROBLEM

The use of 3D printing technology in the field of aircraft design is gaining interest due to its potential benefits over traditional manufacturing methods. Inspired by the University of Texas at Arlington (UTA) Annual 3D Printed Aircraft Competition, our project aims to apply the principles of aircraft design and 3D printing to design and build a modular, long-range glider to understand the advantages and limitations of 3D printing in aircraft design.

THE REQUIREMENTS

The goal of this project is to develop a modular 3D printed aircraft that is optimized for endurance and range, in line with the requirements of the UTA Annual 3D Printer Aircraft Competition. A key constraint of the project is that all structural components must be created using BU 3D printers exclusively. Aircraft may be unpowered or they may be powered using a safe propulsion method for a maximum continuous duration of 5 seconds. Aircraft must be launched by hand or takeoff under their own power. Catapults or other launching devices may not be used.

THE SOLUTION

Due to the flexible nature of design in 3D printing, many different concepts were considered. Ultimately, we decided to create an unpowered, high aspect ratio glider as our design of choice. Modularity was a key aspect of our design philosophy, allowing for flexibility in the assembly process. The glider was produced using Fused Deposition Modeling (FDM) printers, and the quality of the components was optimized by strategic orientation to improve the overall surface finish. Dissolvable supports were employed to minimize post-processing requirements, making for a more streamlined production process.

THE RESULTS

We have manufactured and assembled the glider in accordance with our conceptual design. The initial flight tests have shown that the glider exhibits a stable flight performance. However, in order to meet our goal of achieving a range of 100 ft, we are currently focusing on optimizing the design by reducing its weight and enhancing its aerodynamic performance to improve its overall performance.

3D Filament recycler

OVERVIEW

A recycler that extrudes
3D filament PLA

PROJECT ADVISOR

Prof. Steve Chomyszak

TEAM MEMBERS

Aayan Grove
Erick Romero
Jonathan Acevedo
Binghao Zhao (Joseph)

THE PROBLEM

The problem being addressed is the excessive use of plastics in the 3D printing industry, which has led to significant environmental and health issues due to plastic waste generated by failed prints. The solution proposed is a 3D printed waste recycler that can extrude filament of uniform thickness with a diameter of 1.75 +- 0.05 mm and can be used to recycle failed prints in EPIC. The goal is to reduce the amount of plastic waste that ends up in landfills or polluting the environment, and the budget for the project is $400.

THE REQUIREMENTS

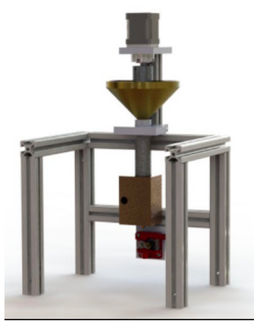
Plastic waste generated by 3D printing has harmful effects on the environment and human health. To address this issue, a 3D printed waste recycler has been designed to reduce plastic waste generated during the 3D printing process. The recycler should be able to extrude filament of uniform thickness with a diameter of 1.75 +- 0.05 mm, be intuitive to use, and complete the project within a budget of $400. Additionally, the recycler should be able to handle PLA which is commonly used in 3D printing. Overall, the 3D printed waste recycler is a small but significant step in addressing the plastic waste issue in the industry.

THE SOLUTION

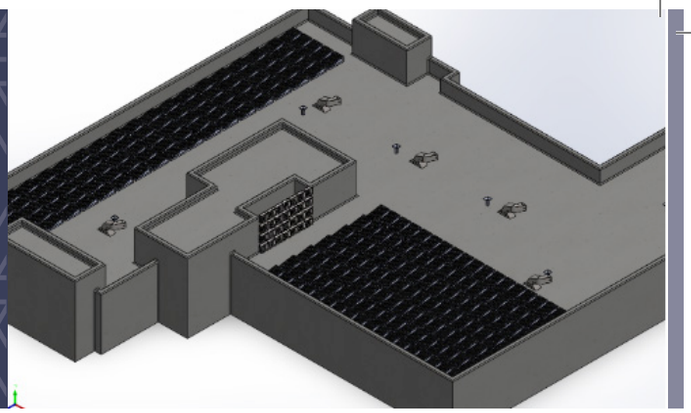
The proposed solution to recycle PLA into a spool involves the use of an auger bit and heater cartridges. The auger bit will further shred the plastic and push it towards the nozzle , and the heater cartridges will heat up the shredded plastic and push it through a nozzle, creating a uniform filament. This method is an effective and safe way of reducing plastic waste generated during the 3D printing process by recycling failed prints into usable filament.

THE RESULTS

The anticipated outcome of the waste recycler is to recycle a minimum of 200 grams of plastic safely and efficiently, producing uniform filament with a diameter of 1.75 mm (+-0.05 mm variation). This result will contribute to reducing plastic waste generated during the 3D printing process by converting failed prints into usable filament. The safe and efficient operation of the waste recycler can easily recycle > 250 grams of plastic at the same time have a consistent diameter and a length > 70 feet.



Water Purification with Renewable Energy



OVERVIEW

Our project focuses on designing a system that produces 50,000 gals of potable water for an average size hotel in Hawaii through a desalination device which is powered by renewable energy.

PROJECT ADVISOR

Prof. Francis DiBella

TEAM MEMBERS

Arno Ero
Derya Binal
Frans Luttmer
Yury Luzhkov

THE PROBLEM

Coastal hotels in remote locations use water purification devices like reverse osmosis and vapor recompression to generate clean potable water to fulfill their water needs. These devices offer a resolute solution to the water needs, however they have high energy requirements. Considering that these hotels are in locations where grid power is harder to access, the water purification devices are often powered with generators that use fossil fuels.

THE REQUIREMENTS

Uses Ocean water to make potable drinking water. Can be used by coastal hotels in Hawaii. Meets all potable water demands for a single hotel. Only uses proven and commercially available technologies. Is competitive with current cost water use. Uses 100% renewable energy sources. Can be easily installed on hotel property. Can be assembled off-site and shipped to location. Has both usable potable water and energy storage.

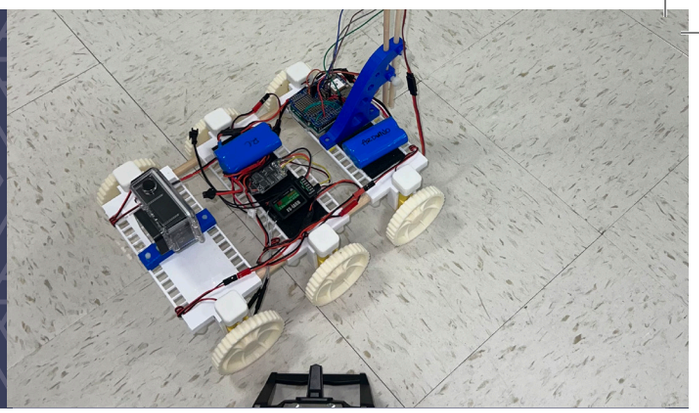
THE SOLUTION

A weighing system was used to decide on what type of energy generation, storage and water purification method were going to be used. Engineering specifications were determined. A system that would output 50,000 Gallons/day with an energy input of 500kWh/day, installation area of 7000 square feet, 25 tons max weight. Appropriate vendors were contacted to get quotes and engineering specifications for devices. A system was designed by using vendor models and specifications.

THE RESULTS

A system with 75,000 gal/day desalination capacity working on 84 kW solar system composed of 216 solar panels was designed. The roof of Hilton Hawaiian Village Waikiki Beach Resort's Ali'i Tower was modeled on Solidworks. Appropriate areas for installation were identified and models of panels, inverters, reverse osmosis device and lithium ion batteries were placed on the model of the roof. Capital and operational expenses of the project were estimated. Finally, the serviceable market size for the project was forecasted.

TerraROVER



OVERVIEW

The purpose of this project is to improve the design and assembly process of the TerraROVER for students to maximize learning of engineering and climate concepts.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Kiran Gomatam
Erin Dougherty
Justin Le
Darin Sumetanon

CLIENT

NASA, RESA, and GLOBE

THE PROBLEM

The TerraROVER is a remote-control operated vehicle holding sensor packages for the use of data collection surrounding climate phenomena. Alongside data acquisition, the TerraROVER developers intended for it to be an educational tool used in classroom lessons. Initial versions of the TerraROVER proved confusing to build and required resources that may not be available to secondary schools in the United States, limiting the extent of the educational aspect.

THE REQUIREMENTS

- Creating an assembly kit and an instruction manual for building and operating the TerraROVER that can be followed by middle school and high school students.
- Increasing safety and keeping the production cost within $200 of the TerraROVER's original cost.

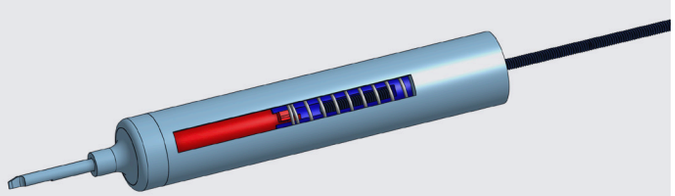
THE SOLUTION

Initial trial builds led the team to update the current TerraROVER design to enhance safety and ease of assembly. Through communication with expert professors in STEM education and product testing at local high schools, the team then worked to create a "Lego"-style assembly manual with corresponding tutorial videos that would educate students in key engineering and climate concepts.

THE RESULTS

The TerraROVER design has been updated for safety and simplicity. With the assistance of the manual, the assembly time is estimated to be less than 1.5 hours. Information included within the manual aids students in understanding engineering concepts and exposes them to hands-on STEM experiences. Finally, it is anticipated that feedback received from high school students will provide insight on areas of improvement for future iterations of the TerraROVER.

Gillete Razor Damage Maker



OVERVIEW

The Pen Indenter is a handheld tool designed to create calibrated damage on Gillette razor blades.

PROJECT ADVISOR

Prof. Steve Chomyszak

TEAM MEMBERS

Emerson Detering
Eva Langenbrunner
Sophie Caplan

CLIENT

Proctor and Gamble Gillete Division

THE PROBLEM

Create a mechanical system that can repeatedly and accurately damage blades in order to calibrate Gillette's edge-damage inspection software.

THE REQUIREMENTS

- Damage size: 50 to 500 µm
- Accuracy: +- 5 µm
- Repeatability: +-3 µm
- Blades kept in assembled cartridge during damage process

THE SOLUTION

The Pen Indenter is a novel solution that utilizes Hooke's law in order to provide consistent and repeatable damage to the edge of a Gillette razor blade. The simple nature of this tool allows Gillette engineers to quickly and easily create calibrated damage to blades, allowing them to validate their quality control software.

THE RESULTS

The Pen Indenter was successful in achieving repeatable and accurate damage that allowed for the calibration of P&G edge-damage inspection software. In addition to this, the components used to create the tool were simple and easily reproducible, allowing for this tool to be distributed across many Gillete production sites. The Pen Indenter was brought to the Gillette facility in Boston, where it was showcased to the manufacturing engineers.

Beaded Jewelry Manufacturing

OVERVIEW

This device aims to facilitate the bead stringing process by automating the stringing process through a three-step operation that dispenses, threads, and transfers the beads onto a clamped wire in hopes of decreasing both production time and cost while increasing profit.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Alan Cuevas
Sabrina Dilig
Bryson Garriques
YingNan (Sarah) Sun
Kreiver Zhou

CLIENT

Dovera Designs

THE PROBLEM

It takes 25 minutes for our customer to manually string a bracelet. There are 13 beads of various sizes in a sequence and there are ~38 sequences in a bracelet which results in over 500 beads in total. This process is strenuous and there are currently no machines in the market to combat this issue.

THE REQUIREMENTS

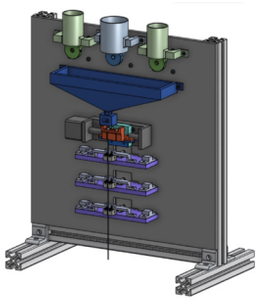
- The focal constraint is cost; with each member allotted $100, the total cost had to be under $500
- The device needs to be portable and small enough to fit on desks
- The cycle time must be comparable to that of manual stringing (~25 minutes)
- Time constraint of 2 semesters (7 months) to provide proof of concept

THE SOLUTION

The device has a three-step process that uses a vibratoray motor to dispense beads, 3 machined gripper systems to hold a hypodermic needle, and hypodermic needle to house the string for easy loading/unloading. The hypodermic needle was incorporated because it's stiffer therefore less susceptible to deformation from repeated clamping of steel grippers. This version of the device uses machined parts and solenoids to decrease cycle time and increase precision.

THE RESULTS

The gripper system operates as anticipated. It successfully opens and closes to clamp the needle in place without deforming the needle. The hoppers are also successfully dispensing beads into the funnel. All parts of the system were completed and printed. The next steps include incorporating a flushed out user interface with an intuitive control system.



Produce Bag Opener

OVERVIEW

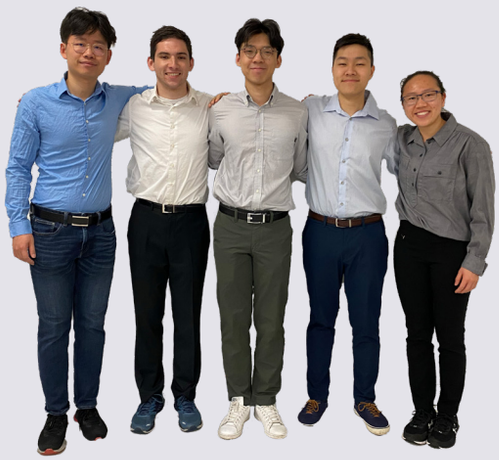
Our team developed a compact, user-friendly, and fully mechanical device that opens produce bags while dispensing them at the supermarket.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Zi Heng Lim
Jeffrey Morrissey
Daralyn Wen
Ding Wen
Dan Zheng



THE PROBLEM

At grocery stores or supermarkets, produce bags are often difficult to open, especially for individuals with lower motor skills. As a result, individuals may resort to solutions such as licking their fingers to make opening the produce bags easier. This can lead to sanitary concerns such as the increased risk of disease transmission.

THE REQUIREMENTS

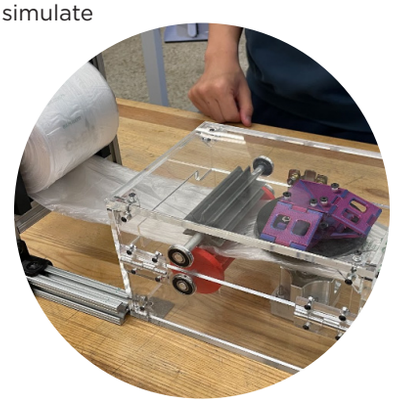
- The produce bag opener needs to be lightweight and cost-competitive with current dispensers.
- The product needs to create an average finger-size (¾ inch diameter) opening.
- The opening mechanism should be fully mechanical, without the use of electric power.

THE SOLUTION

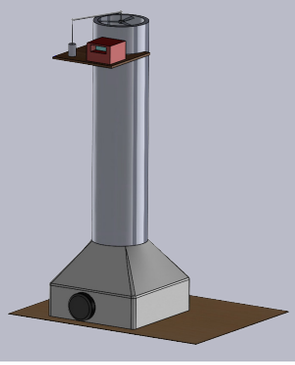
Our product translates the linear motion from the customer pulling the produce bag into a rotational motion using a gear incorporated belt and pulley system. The rotational motion is then used to shear open the bag using friction. This will open the bag for the user, thus improving customer satisfaction and reducing disease transmission.

THE RESULTS

A working prototype of the device was built using a combination of acrylic sheets, custom 3D printed parts, and various metal components. The device was tested at a local supermarket to simulate its effectiveness in a real life environment. The results showed that the produce bag opener was successful in accomplishing its stated requirements of opening and dispensing.



Updraft Tower Power Recovery In Existing Industrial Structures



OVERVIEW

This project proposes an evidenced plan for the creation of an Updraft Tower power recovery system using the structures and byproducts of industrial processes.

PROJECT ADVISOR

Prof. Francis DiBella

TEAM MEMBERS

Jacqueline Bachrach
Allison Boaz
Antonio Shanley
Eric Stack

THE PROBLEM

Updraft Towers are capable of utilizing thermodynamics to amplify existing energy sources. This increases power generation efficiency, reduces costs, and helps to mitigate causes of climate change. However, the construction and operation of these structures is expensive and environmentally harmful. Additionally, many industrial plants produce heated exhaust through melting or drying which is emitted, acting as expensive and environmentally harmful waste.

THE REQUIREMENTS

Requirements were determined in conjunction with our customer, Professor DiBella

- All components of the system must be able to be fitted to an existing chimney structure
- The target power generation is 5% of daily power consumption for an industrial setting
- The fabrication of any scale models is limited to a budget of $2000 in KHC funds

THE SOLUTION

In order to address challenges of Updraft Tower construction and to address waste in industrial systems, our team created a full proposal suggesting that industry leaders install a turbine system which uses industry smokestacks as updraft towers. This system allows for power recapture in a manufacturing plant, reducing overall energy expenses and the emissions associated with power generation.

THE RESULTS

The viability of this solution is proven by our team's MATLAB model that can calculate the energy savings of any generation source and any sized tower system. Additionally, our scale model fabrication is capable of generating power efficiently and proves a lack of interference with ordinary function at a site. Finally, an analysis of industry factors and emissions information proves the financial and environmental benefits of this concept.

2023: Gateways to Blue Skies Competition

Aluminum Powder Combustion

OVERVIEW

Our project is a proposal to use aluminum micropowder/ nanopowder as an alternative fuel source for the aviation industry in order to achieve a completely carbon-free supply chain and energy conversion process.

PROJECT ADVISOR

Prof. James Geiger

TEAM MEMBERS

Patrick Olah
Odin Francis
Max Pounanov
Michael Osuji

CLIENT

NASA's 2023 Gateways to Blue Skies: Clean Aviation Energy Competition

THE PROBLEM

High CO_2 emissions in the aviation industry come from the production and combustion of Jet A fuel. There are alternative aviation fuels being researched currently, but they do not have net-zero emissions and would not allow for a net-zero aviation industry by 2050.

THE REQUIREMENTS

Our requirements were outlined in the competition guidelines as such:

- Propose and justify one potential clean aviation energy source of the 2050s, excluding Jet A and Sustainable Aviation Fuel (SAF).
- Provide an overview of the source-to-flight lifecycle for the selected energy source, detailing the steps taken to get from raw material to ready to use fuel.
- Analyze the energy source's supply chain and necessary technological and infrastructural upgrades required.

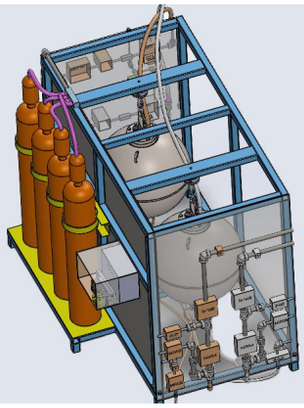
THE SOLUTION

Our team sourced 8 potential solutions that each had their benefits and downsides for future use in the aviation industry. After comparing each solution to current aviation fuel and looking at factors such as energy density, burn emissions, and safety, our team was able to narrow the choice down to aluminum powder due to its high energy density, recyclability, and zero-emission combustion.

THE RESULTS

After choosing aluminum powder as the best candidate as an alternate energy source, we planned a comprehensive supply chain that revolves around new refining technologies and the recyclability of aluminum oxide. The team was selected as a finalist in the Blue Skies competition, and is currently working to identify potential solutions to high-risk areas of the proposal, such as combustor design, exhaust capture, and NOx abatement.

Bipropellant Liquid Rocket Engine Test Stand



OVERVIEW

Our project is a test stand which contains all components used to fuel, control, and test a bipropellant liquid rocket engine.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Emmanuelle Bilodeau
Maxine Bresnaider
William Carson
Tyler Mowry
Madeline Stull

CLIENT

Triton Space Technologies

THE PROBLEM

Our client, Triton Space Technologies, needs a test stand that contains the fuel tanks, propellant tanks, data acquisition system, and feed system necessary to remotely test a bipropellant liquid rocket engine. The engine has many specific requirements and the company has special requests as well. Therefore, there are no compatible test stands available on the market making it necessary to design and build a custom stand.

THE REQUIREMENTS

- For safety reasons, the stand must be able to be operated remotely through ethernet.
- The stand must include two fuel tanks, four propellant tanks, a data acquisition system for controlling the systems and recording measurements, and a feed system to run the fuel to the engine.
- The stand must be transportable via forklift.
- The client specified system operating parameters and materials.

THE SOLUTION

Our team designed two custom spherical propellant tanks that are pressurized by high pressure nitrogen tanks. These components are connected by a feed system composed of valves and gauges that allow the flow to be controlled and monitored. The data acquisition system provides the electrical power and inputs to control the valves remotely, as well as record various measurements throughout the system. All components are mounted to a steel frame.

THE RESULTS

We delivered a complete design report including a CAD assembly and drawings of components of the stand. We also completed a process and instrumentation diagram of the feed system, a bill of materials, a wiring diagram for the data acquisition system, and assembly instructions.

DBF Raw Egg Transport Glider

OVERVIEW

A glider must be able to transport a raw egg 100-150 ft without acquiring any damage to the egg during launch, flight, and landing.

PROJECT ADVISOR

Prof. James Geiger

TEAM MEMBERS

Delaney Bernier
Felicia Devorris
John Morgan

THE PROBLEM

A glider with a fragile payload is an additional aerodynamic concern on top of the baseline challenges of stability, modularity, and manufacturability. Therefore, the final prototype should be simple in design so that all components can easily be replaced if damage occurs, but also robust enough to support the weight of the egg. Additionally, the glider must produce repeatable results and not destruct upon impact to be considered successful.

THE REQUIREMENTS

- The glider must travel 100-150 ft in an indoor environment (objective).
- The materials used should remain within the requirements of balsa wood, foam, cardboard, and adhesive (unless a separate material request is filed).
- The glider should support an egg weight range of 1.25-2.5 oz (threshold-objective).
- Only a catapult or a slingshot are acceptable forms of propulsion
- For each repeatable flight, the accuracy must be within ±10% of range

THE SOLUTION

After thorough research and benchmarking on gliders, an analytical approach was then implemented to determine optimal stability. The designs, locations, and modularity of components were based on flight speed, payload weight, airfoil selection, and an initial prototype solidworks model. The glider was manufactured within the material restrictions and tested many times to identify possible improvements with a particular focus on egg protection.

THE RESULTS

The final glider is able to achieve stable, repeatable, and protective flights within the material restrictions with an overall modular design. Notably, the horizontal stabilizer features a clamp that allows the angle of attack to be easily adjusted in place.

Hybrid STOL Air Taxi

OVERVIEW

Design a hybrid-electric air taxi that transports passengers between metropolitan areas using a combination of fossil fuel and electricity capable of taking off and landing within 300 feet and has a 300 nautical mile range.

PROJECT ADVISOR

Prof. James Geiger

TEAM MEMBERS

Rushan Manek
Rahat Mahbub
Carolina Leonard
Martin Dimo
Noura AlMusharraf

THE PROBLEM

As the world transitions towards utilizing “green” energy in order to combat the increased risk of global warming, aircrafts must also make the shift from fossil fuel technologies to “greener” alternatives. Furthermore, increased congestion within metropolitan areas has led to an increase in greenhouse gas emissions produced from vehicles stationary in traffic. As the allure of hybrid automobiles increases, it is being debated whether or not these technologies can be brought into the aeronautical industry.

THE REQUIREMENTS

- The requirements and constraints were provided by AIAA as well as Professor Gieger. They consisted of a variety of parameters, but most notable are listed below.
- Capable of taking-off and landing within a field length of 300, a cruise speed of 150 knots, and a range of 300 nautical miles.
- Capable of seating 1 pilot, 3 passengers (along with cargo).
- Utilize electric propulsion during takeoff and landing with a standard internal combustion engine (ICE) utilized during cruise.

THE SOLUTION

A parallel systems aircraft was chosen as the solution. The design features an all-electric, distributed electric propulsion system (DEP) to aid in the short distances required for takeoff and landing. It also features an internal combustion engine attached to a propeller at the nose of the aircraft to provide the majority of power during cruise. The DEP system will be variably adjusted to harvest wind energy during cruise and recharge the batteries.

THE RESULTS

While the final rendering of the parallel system aircraft hasn’t been created yet, our team is confident that we will be able to meet all requirements by simulating our solution using knowledge from various aerospace courses. Our final deliverable will be in the form of a design report, documenting the entire design process and all the choices made to achieve design specifications.

MegaShark: SharkNinja Heavy Duty Trailer

OVERVIEW

Team 18 partnered with SharkNinja, a company that manufactures and distributes lifestyle devices and appliances, to create a prototype of MegaShark—a behavior module of the manufacturer's SharkClean vacuum robot—that enhances the robot's load carrying capacity and other utility functions than it was prior designed.

PROJECT ADVISOR

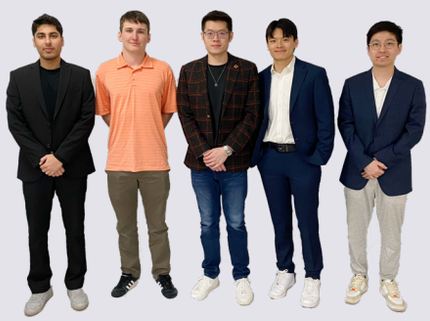
Prof. Francis DiBella

TEAM MEMBER

Kshitij Goel
Owen Haskins
Yuchen Cui
Chengzhi Cai
Gary Chen

CLIENT

SharkNinja



THE PROBLEM

Team 18 worked with SharkNinja, a company that manufactures and distributes lifestyle devices and appliances, to improve and extend the functionality of their self-driving SharkClean robot. To emphasise SharkNinja's mission to positively impact people's lifestyle and upon thoroughly analysing the SharkClean robot, our team decided to increase its load carrying capacity and utility function.

THE REQUIREMENTS

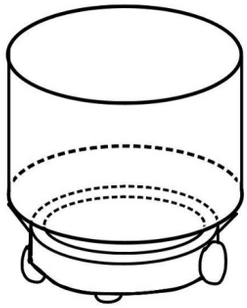
- The size of the prototype was constrained as it had to fit in a similar size packaging to what SharkNinja used at the time.
- The minimum weight capacity had to be double the original robot's weight.
- No required maintenance and extra tools for buyer after purchase, giving the new robot a minimum lifetime of 3 years.
- Controls and code to the drive unit were not provided to the team.

THE SOLUTION

The team manufactured MegaShark, a new module that negates the use of the original robot's drive unit. Using a PUGH analysis, we designed an integrated system that had an external compressible basket retrofitted to the top of the SharkClean robot. It has its own wheels that elevates the original robot above the ground. The bin in the SharkClean robot now includes a new motor and battery that is remote controlled.

THE RESULTS

MegaShark is now a fully developed prototype, that is operated with a PlayStation controller. The new module required a larger battery and motor to give the robot the extra power needed to carry heavy loads. It slightly exceeds the cost budget but meets all other requirements by SharkNinja. The team was able to make a heavy duty trailer, however our goal is to have MegaShark acquired by SharkNinja.



AquaROVER 2.0

OVERVIEW

AquaROVER 2.0 is an autonomous wind powered rover used for water data collection mainly targeted towards educating underprivileged K–12 districts.

PROJECT ADVISOR

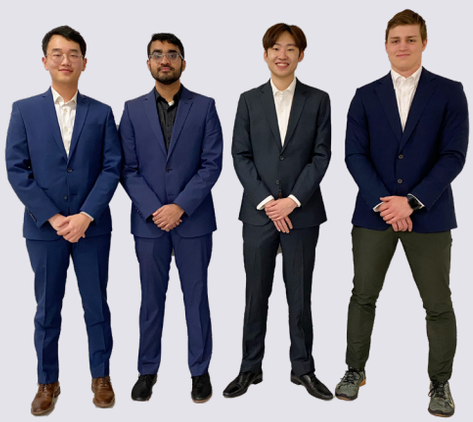
Prof. Anthony Linn

TEAM MEMBERS

Wonjin Lee
Michael Lu
Arius Eich
Mayukhmali Bandyopadhyay

CLIENT

NASA, RESA, and GLOBE



THE PROBLEM

Improve upon current Aquarover design by adding a sail for locomotion and create an instruction manual for assembly of the rover. Evaluate the concept of autonomous control based on GPS inputs.

THE REQUIREMENTS

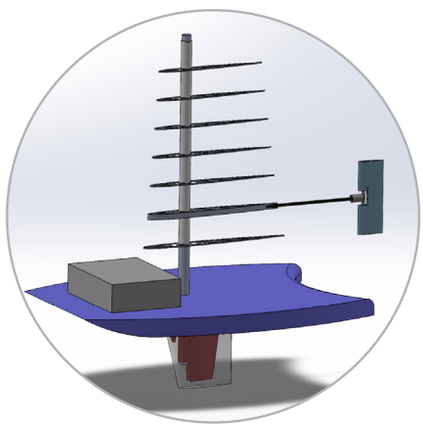
- Total assembly process must be simple, yet applicable and feasible in middle and highschool classroom settings.
- Must not exceed a $400 budget.
- Must add a sail to original AquaROVER design and accordingly be able to sail given wind.

THE SOLUTION

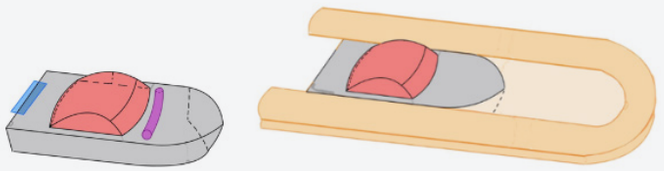
The main objective of this project is for the AquaROVER2.0TM to locomote under wind power. In order to achieve this goal, the team designed a 3D printed solid sail which is controllable through an aileron. A keel was also printed and installed for increased stability along with redesigning the rudder for increased control. An Arduino integrates different sensors for planning and control of the systems.

THE RESULTS

We expect to have a functional wind powered prototype which can collect water data through autonomous or manual control. Additionally, NASA, RESA, and GLOBE have tasked us to further their initiative of providing underprivileged students with additional educational opportunities.Thus, part of our project is to create a detailed assembly manual which will guide the students through the assembly, calibration, and testing process of the AquaROVER 2.0.



Remotely Operated Water Vessel for Emergency Relief (ROWVER)



OVERVIEW

The goal of this project is to devise a remotely operated aquatic rescue vehicle to aid flood victims following a natural disaster without endangering rescuers.

PROJECT ADVISOR

Prof. Francis DiBella

TEAM MEMBERS

Felix Flores
Eric Jackson
Natchaya Makjumroen

THE PROBLEM

Floods have been one of the most common and dangerous types of natural disasters occurring around the world, exposing the susceptibility of urban regions that lack the appropriate flood risk reduction policies and equipment. At times, make-shift or inflatable rafts are the only means of saving flood victims. In these cases, rescuers are commonly seen out in the open, potentially endangering them during extreme weather. As a result, there is a pressing need to find a more dependable and secure way of survival following a flood without endangering a rescuer.

THE REQUIREMENTS

- Create a full-scale ROWVER design on Solidworks and a small-scale prototype model
- Conduct feasibility analysis, and fluid analysis and administer control design for the full-scale model
- Limited by the time available to us in two semesters and a constraint budget

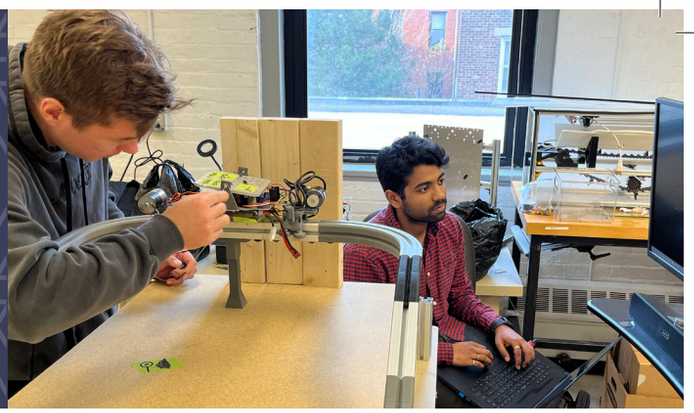
THE SOLUTION

An aquatic vehicle, ROWVER, can be remotely maneuvered by rescuers on land to reach the victim. Once this vehicle arrives at the location of the victim, a surrounding inflation system is activated, creating a larger space that can allow a victim to board. Capable of seating up to four people, ROWVER also contains a safety kit that provides essential resources for someone in distress. This device is then controlled back to land, enabling the entire rescue to be conducted remotely, replacing current solutions with a more effective and efficient system that has the potential to save more lives.

THE RESULTS

A fully functional ROWVER has been designed and assembled in SolidWorks, allowing for proper simulation and testing. With these tests, mechanical specifications can be identified, and proven through kinematic and fluid analysis. This device has been divided into three main subsystems: 1. A module that will hold major components, 2. A motor and control system to direct the boat, 3. A mounted pneumatic system that can be deflated and reinflated as needed. To accurately model this design, a small-scale prototype will be built, focusing on the inflation and deflation stages to reflect a real scenario.

Project VLAD



OVERVIEW

The Vehicular Laboratory Automated Device (VLAD) is a modular system for automating laboratory workflow.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Adam Boldi
Miguel Ianus-Valdivia
Abin George
Vlad Pyltsov
Kyle Fieleke

THE PROBLEM

Many labs have menial tasks that involve transporting a sample from one testing instrument to another. The purpose of our project is to create a system that can automate these tasks such that the lab can operate continuously without human intervention.

THE REQUIREMENTS

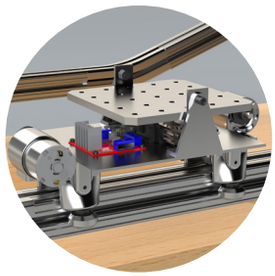
- Modular and open-source such that it can be implemented in any lab
- Relatively inexpensive and easy to assemble
- Keeps the sample vertical as it transits
- Can sustain a 1 kg sample
- Able to go around corners and up and down an incline of 20 degrees
- Safety stop mechanism
- Real-time, remote monitoring of kinematic and logistical data
- Positional accuracy of 1cm

THE SOLUTION

A battery-powered tilting platform that traverses an 8020-based track using DC-motor-driven wheels. Dynamics are monitored using a 9-axis Inertial Measurement Unit (IMU), linear encoders, and infrared sensors. Two onboard microcontrollers regulate the motion of the device and tilting platform.

THE RESULTS

The VLAD is capable of moving back and forth between experimental stations while the platform maintains the sample upright. Station locations are marked using colored tape and a Graphical User Interface (GUI) is used to set the order of stations and prescribe tasks to be completed.



Toy Glider

OVERVIEW

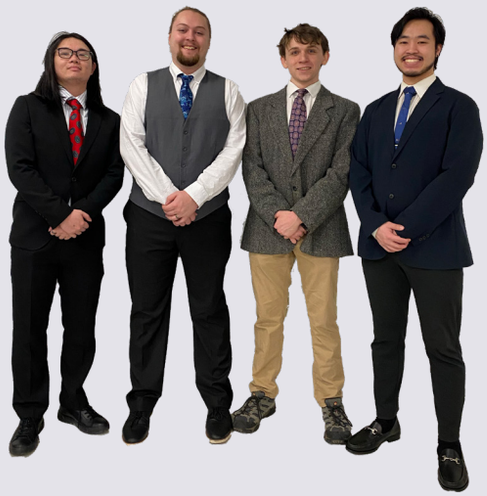
Our goal is to design a balsa wood glider that can compete/outperform others in the toy glider market.

PROJECT ADVISOR

Prof. James Geiger

TEAM MEMBERS

Lucas Chao
Jacobus Kwaak
Anh Nguyen
Owen St. Germain



THE PROBLEM

Guillow's has held a major share of the balsa toy glider market for over half a century, with their popular "Jetfire" model first being introduced in the 1950s. This project is an attempt to break into the toy balsa wood glider market by utilizing improved aerodynamic design concepts and the usage of advanced manufacturing methods such as laser cutting and 3D printing.

THE REQUIREMENTS

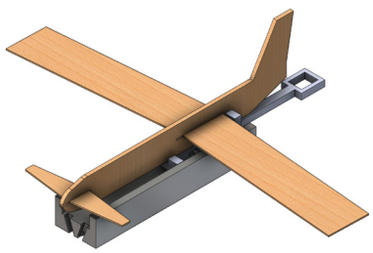
- Be able to compete with existing designs by flying a range of at least 25 feet.
- Build Time of at most two minutes.
- No more than 10 Components.
- Accuracy of +/- 10% from straight-line distance
- Maximum weight of half a pound.
- Maximum volume similar to existing gliders; launchers should be able to be packaged with it.
- Able to be assembled by children, the primary user of toy gliders.

THE SOLUTION

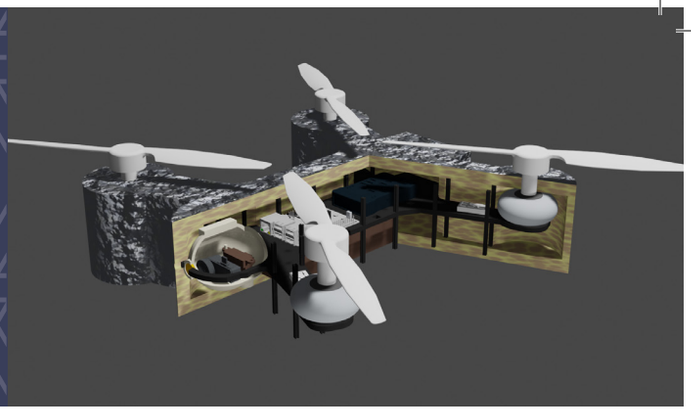
3D models were created and used to calculate the aerodynamics of the glider. Then the glider was tested in controlled conditions to be able to understand the flaws of our design. With each build, we iterated as necessary to get to our current design. We wanted to make our design unique compared to other gliders, so we decided to add a launcher to be part of the product.

THE RESULTS

Our glider will be able to be manufactured and assembled in less than a minute and achieve the desired performance, having long range and accuracy. Using the launcher to shoot the glider is fun, and does not pose any major hazards to younger audiences. Additionally, the glider is durable enough to land multiple times without breaking.



BUD-E Fire Rescue System



OVERVIEW

Our team's goal is to design and build a cost effective, fire resistant quadcopter drone that is capable of navigating a residential fire while simultaneously mapping the structure and relaying data to firefighters.

PROJECT ADVISOR

Prof. Francis DiBella

TEAM MEMBERS

Ryan Connor
Liam Corliss
Jack Crowley
Matthew Farrell
Emily Sawosik

THE PROBLEM

According to the National Fire Incident Reporting System (NFIRS), 92% of all civilian fire fatalities occur due to home fires and roughly 40% are due to egress and escape problems, like obstacles in path to exits. Firefighters must explore by crawling, which is a slow method of moving when 5 minutes could mean life or death. There is a need to decrease the time between finding and rescuing a victim.

THE REQUIREMENTS

Our requirements were determined after extensive research and consultation with the Brookline Fire Department:

- The drone must be able to traverse throughout a building, so its size should be smaller than residential doorways.
- Device should function for 10 minutes in 200° thermal layer to match size-up time.
- Provide intuitive floor plan data by constructing a 3D map of the interior.

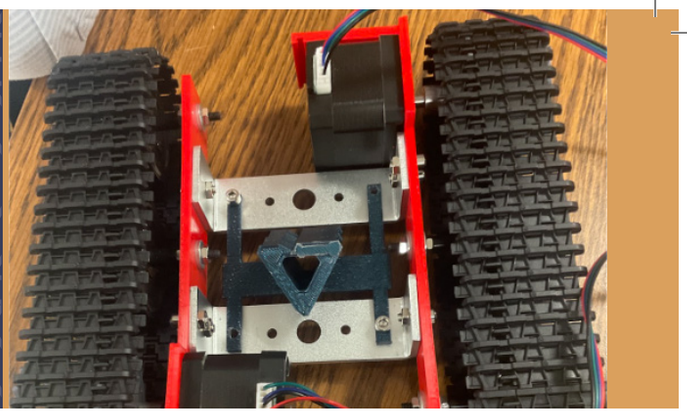
THE SOLUTION

A quadcopter was chosen for its speed and maneuverability. To ensure the drones survival in an active fire, electronics are protected from convective heat transfer by a layer of mineral wool and a vacuum sealed chamber. A reflective foil layer can reject 95% of incident radiation. An onboard thermal camera feeding an edge detection algorithm takes images through smoke, allowing 3D maps of the interior space to be created.

THE RESULTS

Through simulations and experimental tests, the prototype is anticipated to be able to function semi-autonomously for about 10 minutes while maintaining a 1 foot height using an IR sensor's feedback loop. Our drone is able to stitch a series of images together to create a 3D map of a room's interior, which will speed up the firefighters' process of clearing rooms.

Robot Street Artist/ SharkNinja



OVERVIEW

We have developed a portable robotic system to draw images on sidewalks using standard chalk for advertising purposes.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Hai Tran
Zhiwei Zhang
Xiangzhi Zhao
Patrick Peat
Matthew Chen

CLIENT

SharkNinja

THE PROBLEM

Restaurants and coffee shops often advertise their special menu items on small blackboards to attract customers when they walk by. Our project will be used to substitute or complement other advertising by drawing images on the sidewalk outside the establishment.

THE REQUIREMENTS

The device should be capable of transforming arbitrary images, possibly mixed with writing, into drawing paths with a choice of colors in an aesthetically pleasant way.

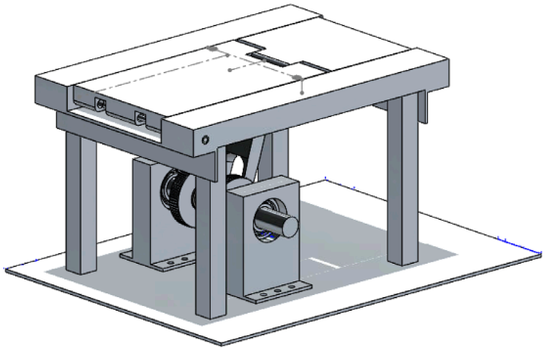
THE SOLUTION

The rover holds a piece of chalk which is lightly pressed to the ground as the rover moves to draw a line. The drawing app works as the interface by which art is sent to the rover. As the user draws, each line is converted into a mathematically calculated path. The finished drawing is then translated into instructions that tell the rover how to move the chalk to recreate the image.

THE RESULTS

We have fully assembled a functional prototype and developed software that can accept a user drawing and replicate in chalk on the ground within the one meter square with one centimeter deviation.

Vehicle Energy Harvester



OVERVIEW

The product harvests energy from the vehicles on the road and convert that into electricity for use.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Jainil Surelia
Hoshing Lau
Ryan indarto
Easus Jimenez West

THE PROBLEM

The issue of climate change is ubiquitous and urgent and one step towards solving it can be to get rid of fossil fuel powered generation systems and shift to cleaner renewable sources of energy. Also, utility companies are faced with the challenge to shift to off-grid energy sources so connections to the substations are not necessary.

THE REQUIREMENTS

Requirement of the product is to keep the cost of the product lesser than 1000$ when we mass produce. The prototype cost us 800$ and it should be lightweight, easy to install, and easy to connect to street lights around.

THE SOLUTION

A push button type structure is installed on the road, so every time a car passes over the button it pushes it down and activates the mechanism to harvest electricity. The electricity can power street lights around the product making it an off-grid renewable source of energy.

THE RESULTS

The product is anticipated to produce around 0.1W of power every time a car passes over. A 10W LED light can work for an hour. So about a hundred cars per hour can make the street light self sustaining.

Diaphragmatic 9000

OVERVIEW

An electro-mechanical system that automates the processes of sorting, orienting, inspecting, and stacking for stamped metal diaphragms used to feed downstream automation applications at Senior Metal Bellows.

PROJECT ADVISOR

Prof. Steve Chomyszak

TEAM MEMBERS

Sanjana Ahmed
Boyu Cao
Jaime Diez
Haobin Li
Aredo Plloci

CLIENT

Senior Metal Bellows

THE PROBLEM

No process currently exists to autonomously inspect, orient, sort and stack a large quantity of metal diaphragms produced in a stamping press. The press stamps diaphragms at a rate of 1 per second; parts are then air-blasted into a bin in random orientations. Currently, an operator sorts, orients, inspects and stacks these parts onto a magazine for downstream use. This process is susceptible to downtime, quality issues and human error.

THE REQUIREMENTS

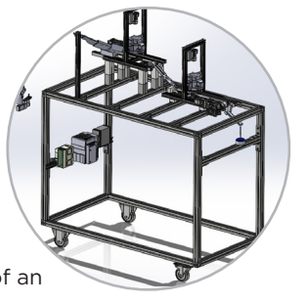
This interdisciplinary project called for a prototype to autonomously sort, orient, inspect, and stack the stamped diaphragms ejected from the press, complete with a feasibility demonstration, technical report, and economic justification. Requirements included vision inspection to check for defects, a way to distinguish parts by concavity, & the designing, building, testing, and debugging of electromechanical systems. Constraints included time, resource availability, and occasional travel to the plant in Sharon, MA.

THE SOLUTION

We constructed an assembly with the following components.

- Inlet: a sorter designed to separate diaphragms by concavity, orient all parts to face one way, and converge both part streams back to one channel.
- Middle: 2 motorized conveyor belts, with a flipping device in between, to move diaphragms under 2 cameras and inspect for flaws on either face.
- Outlet: a stacker to receive all remaining good parts onto a fixed rod.

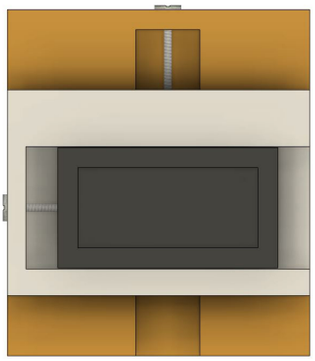
THE RESULTS



The team designed a system to continuously inspect a feed of pre-separated diaphragms coming off the press; we are currently evaluating for repeatability, technical efficiency, and economic justification to replace the previous process.

We created a schematic, programmed the requisite motor, vision, and pneumatic controls, and built a working physical 4-stage autonomous system to complete the current tasks of an operator: sorting/orienting, inspecting, flipping, re-inspecting, and stacking the diaphragms.

Bone Strength and Toughness Measurement



OVERVIEW

A system to aid in the testing of strength and toughness of an injured mouse's tibia.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Benjamin Dowon Kerrins
Scott Smith
Karolyn Bravo

THE PROBLEM

The effects of mechanical loading on healing fractures is not well enough understood; such loading is fundamental to essential functions for daily life. To understand this further, an in situ indentation test must be performed at a mouse tibia's injury site. The goal of our project is to facilitate testing of the strength and toughness of the healed bone by creating a fixed testing bed for the tibia.

THE REQUIREMENTS

- Flat face of the testing material embedded at the injury site must be parallel to the testing device's indentation head at all times.
- The deflection of the fixture used to hold the tibia in place must not be detectable by the testing device / is consistent enough to factor into analysis to determine the scaffolding's stiffness.
- System conditions must keep a mouse alive throughout the testing process.

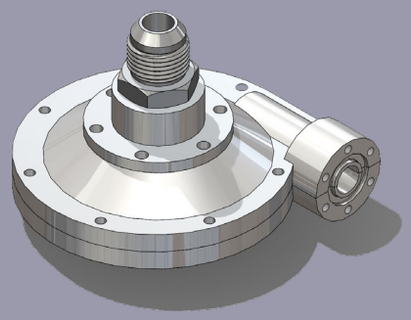
THE SOLUTION

The system was designed around the usage of a thin layer of epoxy to account for the geometry of a mouse tibia, which inherently varies from specimen to specimen. Additionally, the site of injury will maintain alignment with the testing device's indenter head through the usage of a decoy probe, which is to hold its position during epoxy curing and henceforth during testing.

THE RESULTS

A process was created such that any given mouse's tibia could be prepared in a way that would procure consistent and accurate results from the testing device. This process specifically describes to the lab technician the manner in which the process must be performed in order to yield high fidelity results. Current analysis shows that the test can be performed without any detectable deformation in the testing system.

Rocket Engine Pump



OVERVIEW

The goal of this project is to design an electric pump capable of pressuring fuel prior to injection into a rocket engine combustion chamber.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Casey Goodwin
Nicholas Mangold
Miles Stern
Maxwell Malamut
John Sullivan

THE PROBLEM

This project analyzes the feasibility of producing a small scale electric driven fuel pump for use in orbital rockets. The use of pre-made aerospace grade pumps is locked behind high paywalls, and such systems are typically custom built to flight vehicle specifics. The analysis presented in this project seeks to design a liquid isopropyl/ethanol fuel-side pump around flight conditions set forth by the Boston University Rocket Propulsion Group.

THE REQUIREMENTS

- Geometries which can be manufactured via both 3D printing and machining
- A mixture of COTS and custom electronics, to test a variety of concepts with a low cost of entry
- 50 psi inlet pressure, 600 psi exit pressure, 2 minute run time, and a 1.1 kg/s mass flow rate with isopropanol

THE SOLUTION

We are choosing to work with liquid fuel as it's simpler and safer than oxidizers. Our concept consists of a pump with housing, connected to an electric motor capable of 80,000 RPM. Included are speed controllers and power electronics. Our fluid system piping and instrumentation diagram (P&ID) contains valves, sensors, and pressure regulators. The interface of our three systems, pump, electrical, and fluids, will allow us to test.

THE RESULTS

Using design manuals, fluid mechanics principles, and CAD software, a turbopump model has been developed. This consists of an impeller, top and bottom enclosures, and a diffusing inlet. Attached are the shaft, bearings, and motor driving the impeller. We have 3D printed several models to facilitate design iterations and have begun manufacturing. We have also assembled and hydrostatically tested a run tank for use with both water and isopropyl alcohol.

HARVEE: Automatic vertical farming system

OVERVIEW

Automatic vertical farming system

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Aman Patel
Peter Quiros
Devin Goodwin
Daniel Vinals-Garcia
Scott Wade

THE PROBLEM

The aim of this project is to not only develop an optimal warehouse shelving plan that will allow for the greatest possible usage of energy and space while reducing costs, but to also develop a fully automated robot that can harvest the plants without the need of transporting cells or having workers manually care take.

THE REQUIREMENTS

Our system is only constrained to harvesting strawberries. No additional systems, such as water and light systems, will be added to our project.

THE SOLUTION

The harvesting robot will be able to recognize strawberries using computer vision technology and harvest them via a robotic arm with 6 degrees of freedom. Our solution also includes a scalable shelving architecture with troughs for the strawberries and a railing system for the harvesting robot to maneuver across.

THE RESULTS

The robot will be able to detect a ripe strawberry along the trough via a depth camera and computer vision. This will signal the linear drives to move the robot to the region of the strawberry and then have the arm move to the location of the strawberry. The claw (end effector) will cut the stem of the strawberry, which is being pulled towards the claw via a vacuum pipe connected to it, and will fall into the vacuum pipe leading it to a storage basket that is below the robot.

Goose Chaser

OVERVIEW

We built a quadcopter drone programmed to detect and follow geese, with the ultimate goal of deterring them away from parks and sports fields.

PROJECT ADVISOR

Prof. Anthony Linn

TEAM MEMBERS

Josh Barton
Mike Terekhov
Halim Ghafary
Roger Finnerty

THE PROBLEM

It's a problem we have all experienced: Large flocks of geese that hang out at outdoor places we would like to use, from sports fields to parks and cemeteries. Their presence disrupts our ability to enjoy these places, as they take up space, chew up the grass, and leave behind a mess of goose droppings. Furthermore, geese in urban environments are even more difficult to scare away.

THE REQUIREMENTS

Existing goose deterrent methods use outdated technology or require man hours to operate, which is costly.

- We set out to design a self-contained system that could autonomously and effectively scare away geese without the need for human operation
- We were constrained to a budget of roughly $400 and a time constraint of two semesters.

THE SOLUTION

We considered both a land based and an air based robot, but decided to go air-based to avoid the issues of dealing with natural terrain. We built a drone using the Pixhawk 3DR Mini as our onboard flight controller and an Odroid XU4 as the onboard computer. We implemented a TensorFlow based object detection algorithm and PID controller to enable tracking and following of geese.

THE RESULTS

We built a drone and programmed it to follow geese. At the current moment we haven't added any active goose deterrent, such as a blinking light or predator noises; this would be the next phase in the project. Eventually we envision creating a charging station such that the drone would complete a scan of a field/park for geese and then return to recharge; thus achieving fully automated goose control.

INTERDISCIPLINARY TEAM

SharkCam: Autonomous Photography Accessory for Shark Vacuum Robots

CLIENT

Shark Ninja

TEAM MEMBERS

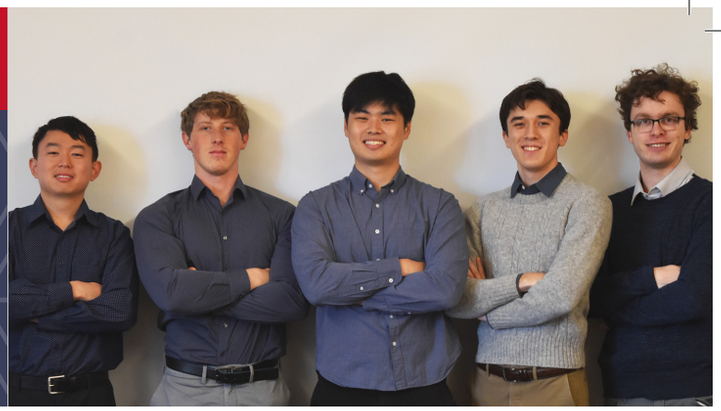
Sophia Delia (CE)
Liron Dubin (ME)
Alex Hureaux-Perron (EE/CE)
Brett Senders (ME)
Kevin Vasquez (ME)

ABSTRACT

The SharkCam is a hardware accessory and app for the Shark® AI Ultra 2-in-1 vacuum robot that autonomously photographs events and parties using a smartphone camera. SharkNinja tasked Team 28 with designing an accessory for their robot that augments the device's functionality and takes advantage of its existing sensors and autonomous capabilities. The rise of apps designed around capturing spontaneous photos, and the resurgence of retro camera technologies such as instant and disposable cameras have demonstrated the growing demand for novel ways to create and share pictures, especially at social gatherings. The SharkCam system will autonomously traverse an indoor event space, capturing candid photos which are uploaded to a database for easy viewing and sharing through a mobile application. The app allows users to set parameters such as capture time and capture interval, takes photos by accessing the phone's camera, and sends commands to the robot through a network-connected Raspberry Pi. A rotating motorized phone holder facilitates photo-taking in all directions, ensuring the action is captured no matter the robot's orientation. The phone holder is connected to a detachable telescoping column mounted to a semi-permanent base. An auxiliary obstacle avoidance system utilizes a laser sensor to prevent collisions with the column. The SharkCam accessory is user-installable, removable, and non-destructive to the stock robot.

INTERDISCIPLINARY TEAM

Torque Vectoring



CLIENT

Terrier Motorsports

TEAM MEMBERS

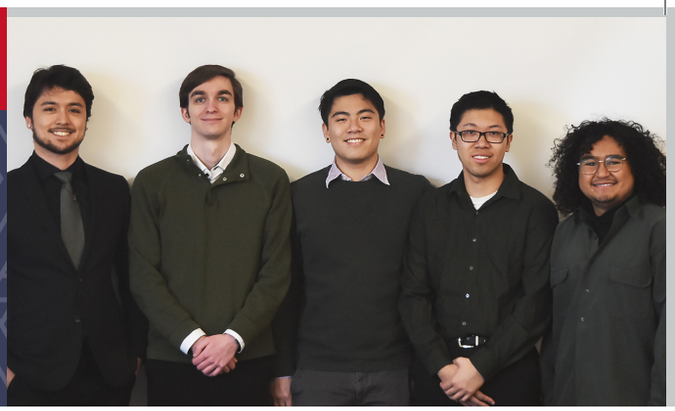
Will Krska
Jonathan Ye
Alex Zhou
Nick Marchuk
Giacomo Coraluppi

ABSTRACT

As motorsports categories are turning towards electric vehicles, teams are developing new strategies to reduce lap times. One such strategy is to develop a torque vectoring system to independently control two rear wheels of the vehicle to improve cornering performance and driver control. The final deliverable will be a fully functional torque vectoring system that can be integrated with the tractive system of the car as well as user-friendly documentation to assist clients with implementing the torque vectoring system onto the car. The proposed technical approach is to design a PID controller to track the yaw rate of the rear wheel-driven vehicle. To do so, a 2-degree of freedom (DOF) linear model and a 7-DOF nonlinear model will be designed. The developed controller will be embedded to an onboard microcontroller on the vehicle to control the independent motor inverters. To maintain robustness of the hardware, a Controller Area Network (CAN) interface will be developed so that the motors can maintain a given torque difference from the controller. The main innovative feature of the project is to independently control how much power goes to each of the rear wheels rather than giving the same power to both to improve speed and control. Additionally, a large focus has been placed on user-serviceability so it can easily be adapted to any future vehicle. Finally, the developed system will be easily implemented to existing vehicles as our software will be properly parameterized and a utilization/ implementation guide will be communicated through documentation.

INTERDISCIPLINARY TEAM

SOL-R



TEAM MEMBERS

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Tony Chau

Dylan Quattro

Nicholas Simbaqueva

Benjamin Ang

ABSTRACT

Conventional solar panel installations generally use mono-facial panels which have silicon-based photovoltaic cells on one side and are opaque on the other. With the creation of bifacial photovoltaic modules (BPV), cells on both sides are capturing solar energy and producing more electricity per panel. The purpose of our project is to orient the reflectors in a way that conserves the least amount of space while generating the most amount of energy possible. Our intent is to create a linear stage in which the reflectors are motor-driven while the solar panels remain vertical and stagnant. The angle of the reflectors will be adjusted via code and data of solar azimuth based on longitude/latitude values. Not only would this generate energy more efficiently, but it also saves extra space in an agricultural setting. This is because the system is mounted up above the plants vertically instead of at an angle. The extra land can be used for additional food production or for satisfying any other needs. Our system will be able to capture more light and take up less space with the diffuse reflectors, a rather novel idea in the industry.

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