BU MECH E

2018

Senior Capstone

Photonics Center Rm 210 & 211 | May 3-4, 2018

Adobe Connect links for live viewing of the presentations:

Room 210: http://bu.adobeconnect.com/me_capstone_2018_rm210/

Room 211: http://bu.adobeconnect.com/me_capstone_2018_rm211/

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DAY 1 SCHEDULE | MAY 3RD

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Letter from the Chair, BUMechE

Welcome to the Mechanical Engineering 2018 Senior Conference where our graduating class will share work they have done to address a wide range of societal challenges. Project ideas have originated from across the university—from the College of Engineering, to the Medical College, the Fitness and Recreation Center, and the College of Arts and Sciences—as well as from the vibrant ecosystem that surrounds us. Project sponsors include corporations that are household names, as well as a local veterinary hospital, two entrepreneurs who fashion hand-crafted jewelry, and a manufacturer of custom bicycles. Projects were identified by capstone staff reaching out in search of opportunities, by alumni reaching back to perpetuate their own good experience, and by student clubs and individual students proposing devices and systems that support their own activities, their curiosity, or their entrepreneurial bent.

To solve these real life problems, several of the project teams include not only students majoring in Mechanical Engineering, but also students in Biomedical Engineering and Computer Engineering.

Going forward, in Fall 2018, Mechanical Engineering will extend the capstone design course to a full academic year. This extension will facilitate even stronger collaboration across departments and enable the longer engagement which external sponsors have told us they desire. If you have a project idea, please share it with a member of the capstone faculty whose names appear on the following pages in this booklet.

Those of you who have attended previous capstone presentations will note the absence of Professor Theo de Winter. Professor de Winter has been a faculty member in the College of Engineering from close to the time of its founding. For many of these years, he has mentored students working on capstone projects, first in the Department of Manufacturing Engineering, and more recently in the Department of Mechanical Engineering. Illness has forced him to miss this year's event, which includes three projects that were launched under his tutelage. We will miss his challenging questions and iconic presence and hope that he is soon back on his feet.

Alice E White
Professor and Chair
Department of Mechanical Engineering

Project Abstracts

Anheuser-Busch

Operational Analysis of Can Filling Line

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Anheuser-Busch
221 Daniel Webster Hwy,
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Background

Anheuser-Busch is a subsidiary of the global conglomerate AB InBev, with 12 breweries across the US. The plant operates at a daily production rate of approximately 51,480 barrels. At maximum efficiency the Line 10 filler has the capacity to fill 1725 cans per minute. However, due to various reasons throughout the line, the filler line operations stop and the beer inside the filler warms up, eventually resulting in a "warm bowl dump". AB loses about $65,000 per year due to wasting warm beer during these line stoppages.

Project Goals

Our objective is to come up with solutions to reduce the losses due to these warm bowl dumps by 10% with a targeted breakeven 3 years. We evaluated a number of technical solutions as well as process solutions. By Glycol cooling the CO2 in the filler, the beer could be kept at the required filling temperature during downtime. While the Glycol cooling solution would have saved $19,500 annually, the cost and disruption to install was not balanced by the savings. Second, we evaluated where changes to MTTF and MTTR, buffers and cycle times could reduce the frequency and the impact on machine down time. Using FlexSim, a discrete event simulator, we were able to model the factory dynamics and evaluate various possible improvement opportunities.

Figure 1: Line 10 Filler

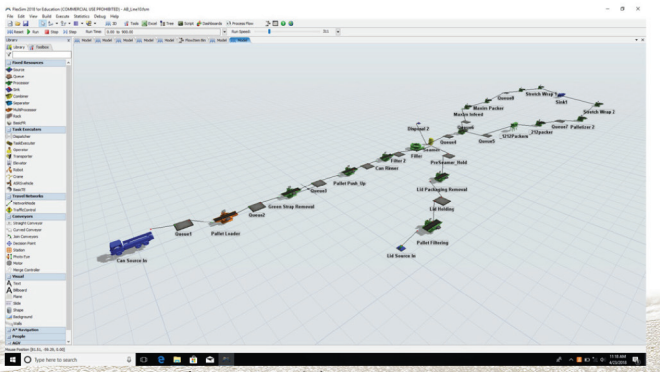

Figure 2: Line 10 FlexSim Model

MERMAID SURVEILLANCE

Underwater Video Surveillance System

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Simran Bhatia
Connor McDonnell
Ricardo Cumberbatch
Spencer Graves

Client
Prof. Robinson W. Fulweiler
Fulweiler Labs
Boston University

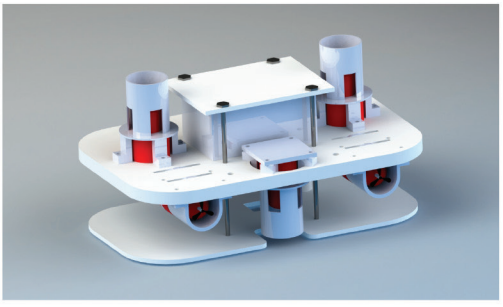
Faculty Advisor
Prof. Enrique Gutierrez-Wing

Background

Prof. Robinson W. Fulweiler conducts research about humans' impact on underwater environments. To do this she and her team obtain samples from the seabed via coring operations. These coring operations are conducted from the water's surface and are later analyzed in a lab. In this process, direct observation of the seafloor is difficult and therefore the samples are taken blindly and the samples are very often not useable. The ability to visually survey the seafloor before taking samples would increase the number of useful samples and decrease the time consumption for this process.

Solution

Our product is an underwater drone that supports a live-streaming video surveillance system. It has the ability to transmit videos and images so that researchers can remotely explore underwater environments up to 50 feet below the water's surface. The system itself is a tethered vehicle to be used with a GoPro camera. It includes an LED light that enables videography of dark spaces and it is designed to be unobtrusive to underwater environments. This device gives researchers the ability to effortlessly explore the mysterious underwater world from the safety of the ocean's surface.



BUILDING A NEST

Perch

Background

Perch is a startup company with a goal to "move heavy things fast" by developing a 3D camera software to track bar path. This weightlifting product aims to enter professional and Division 1 collegiate gyms in June 2018.

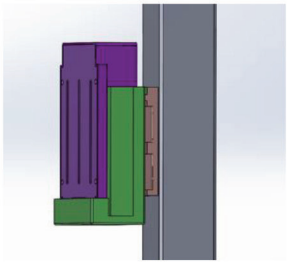
Perch was faced with a number of issues related to bringing the alpha prototype to market. These included manufacturing processes for the housings that could be done in volume and enabling the device to be run off a battery pack rather than being plugged in. This battery pack is call the Nest.

Solution Concepts

A number of outer casing designs were evaluated as well as a variety of manufacturing processes such as: Urethane Casting, Sheet Metal, Injection Molding, and Thermoforming. As part of the analysis, we evaluated both the cost, repeatability and the post-processing work required to produce in volumes of 10-100.

The battery capability was a two-part problem. The first was identifying an appropriate off-the shelf certified battery that would provide the right voltage, power and current while being convenient for the weight room staff. The second was designing a low cost but effective way of physically integrating the battery into the product as well as concepts for how to manage the re-charging process. The design process had to take into consideration the range of weight rack geometries as well as the suboptimal environment the product needed to live in.

Results



Manufacturing Outer Casing- We explored Thermoforming to increase outer casing quality and decrease cost. Developed a solution with Kydex material which is a cold workable plastic.

BatteryModule- Experimented using drill and professional camera batteries. Designed the Nest for a 12V 6Ah camera battery to be mounted to the weight rack with a cam belt and bracket.

Client
Perch Fitness
-Jacob Rothman
-Nate Rodman
-Jordan Lucier

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Automated Integratable Deployment System

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Customer:
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Faculty Advisor:
Professor Enrique Gutierrez-Wing

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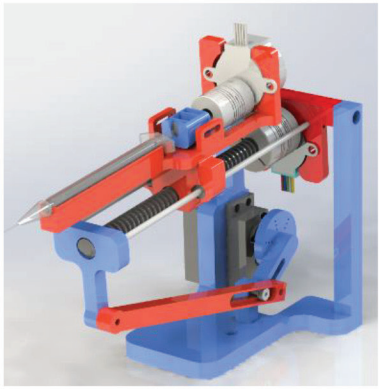
Background:

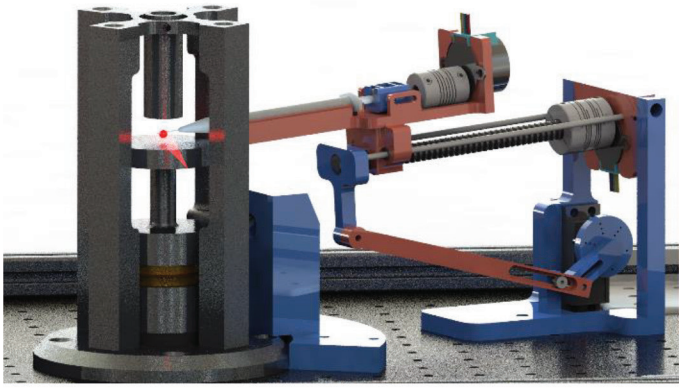
Medical professionals use thromboelastography on the blood samples of admitted patients to check for a coagulopathy. Coagulopathy is a condition that affects the way blood clots which could result from diseases like sickle cell disease, diabetes, hemophilia or trauma. Current disadvantages of commercially available rheometric devices include contact containment, which potentially yields erroneous results, and large sample sizes, which can be problematic for patients who do not have a surplus of blood.

To avoid the disadvantages of traditional contact rheometers, an acoustic levitation technique can be employed to position and manipulate a droplet of blood using only the acoustic radiation pressure without the need for contact with an exterior component. Current operation of the acoustic levitation device requires a time-consuming, manual deployment of a blood sample by a well-trained technician

Objective:

In a previous year, a senior design group made a deployment system that would automate the blood deployment process. However, their prototype was not fully integratable with the tensiometer housing due to its large size and incompatible mounting components. The goal of this project is to redesign the previous deployment system while also ensuring full automation of the blood deployment process. In theory, a researcher or technician will able to use the Automated Integratable Deployment System by simply loading the desired sample into apparatus. The system will the then deliver the desired volume to be tested.





mspca angell
Kindness and Care for Animals®

INNOVATING THE SURGICAL TOOL TRAY

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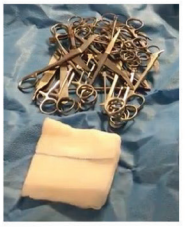
Graciela Martinez
Cody Yardley

COMPANY ADVISORS:
Spencer Yeh
Meghan Sullivan

ADVISOR:
Prof. Anna Thornton

Problem Statement

Angel Memorial Animal Hospital performs 8 - 12 surgeries per day. For each of those surgeries, the surgeons use a "basic pack." Currently, the surgeons spend a significant amount of time untangling and organizing the tools prior to surgery while the animal is under anesthesia. This often results in perforated gloves and missing tools, extending the time that the animals are under anesthesia unnecessarily.




Solution Concept

The project's goal was to design potential solutions to this problem. To develop an effective and inexpensive solution, 15+ hours of observations of surgery setups were done. In addition, the cleaning, autoclaving and kit assembly processes were analyzed to ensure all stakeholders needs were included in the solutions.

Results

A number of possible solutions were identified and mocked up. These mockups were reviewed with our clients where we found that the features that were most important to them were intuitive design and a small total footprint on the surgical table. We combined features from our previous concepts, such as the grip of the silicone and the compactness of the sheet metal boxes, to select one final concept that eliminates several pain points and streamlines the surgical setup process.

Shock Dynamometer

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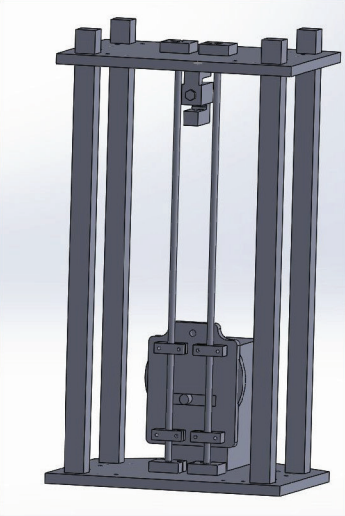
Xinyu Sun

Faculty Advisor
Enrique Gutierrez-Wing

Customer
Calvin Lin



Background
Shock absorbers stabilize a car's body movement when the car travels on irregular terrain, but they lose performance over extended period usage. BU Racing team can service them to regain performance but need a device to measure the absorber 's performance to compare it with factory specification.

Objective
Build a prototype which can move a damper along its shaft at various velocity and measure the corresponding force exerted by the damper.

Solution
Our prototype has an electric motor with a gear reducer driving a crankshaft, which in turn moves a Scotch Yoke mechanism vertically in an oscillatory manner. The damper is attached between the Scotch Yoke and a S-type load cell, and an IR distance sensor is also installed. Data from the sensors are collected via Arduino to a computer and a Force-Velocity graph is created.

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TOOL MANAGEMENT SYSTEM

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Dr. Meghan Sullivan

FACULTY ADVISOR:

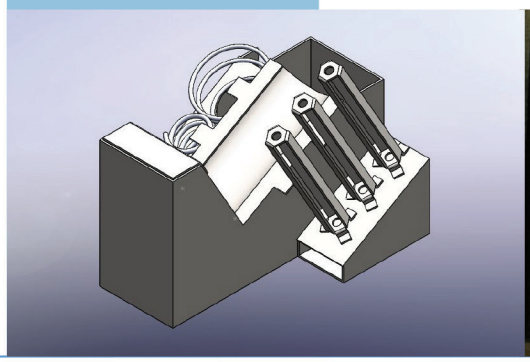
Prof. Anna Thornton

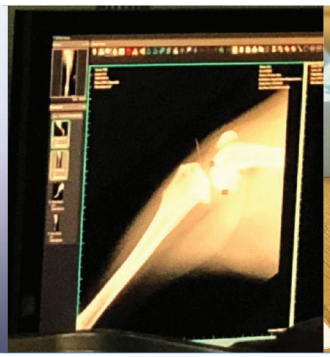
MSPCA-Angell is a veterinary medical center and teaching hospital providing intensive care to patients for the past 70 years.

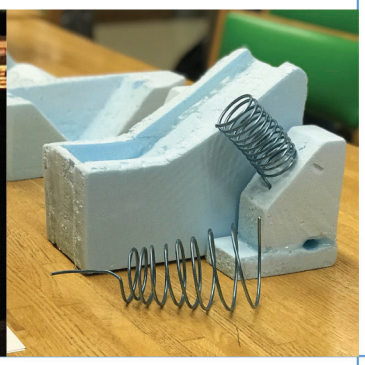
A commonly faced injury is the cranial cruciate ligament (CrCL) rupture in dogs. The TPLO (tibial plateau leveling osteotomy) has become the most used approach for repairing CrCL injuries.

Our project aims to deliver a device which improves tool organization in the operating room while addressing ergonomic factors related to the procedure itself.

Using modular side containers for both caulets and drill bits along with soldering-inspired spring storage, the device can be setup with a single hand. Critical outcomes of the project include reducing the total time required for each surgery, thus improving patient outcomes and providing savings to the hospital.

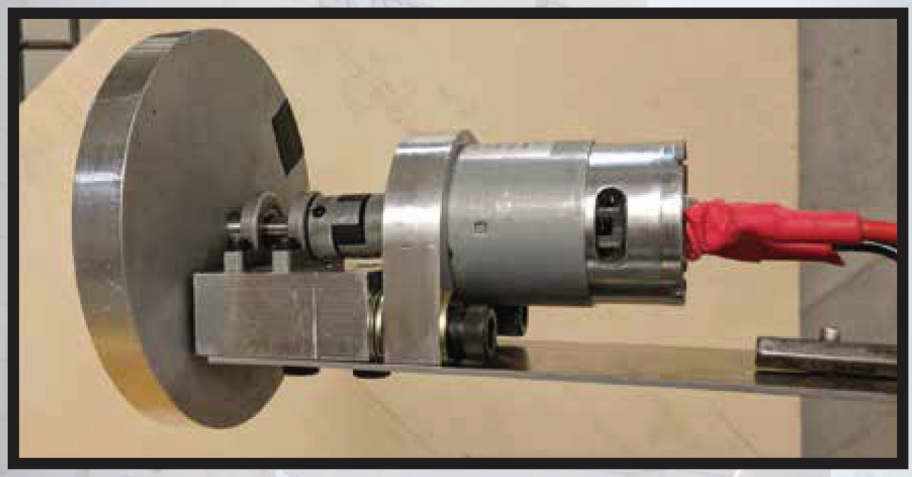






GYROSCOPIC BLADE STIFFENERS

Kyle Hallock, Will Pearson, Mischa Rothko
Faculty Advisor: Enrique Gituerrez-Wing



Challenge

Power generation capacity from wind energy has skyrocketed over the past 20 years to nearly 500,000 MW globally. This is due in large part to the increase in size of wind turbine blades. Longer blades yield more power, but they also experience much larger stresses from the wind. An increase in global demand for sustainable power generation has created an imminent need for longer turbine blades. However, the challenges of increasing blade length have hindered industry growth. As the strength limits of composite blade materials are reached new solutions are required to supply the wind energy the market demands.

Solution

A well-studied, but counterintuitive result of rotational dynamics is gyroscopic precession - where a rotating body precesses due to an applied torque . Instead of following the standard approach of using composite materials to support growing blade lengths, we opted to implement gyroscopes on the blades of a prototype wind turbine. The gyroscopes mitigate blade stresses by applying torques that counter the wind loads. We believe our novel approach, with further study, is a viable alternative to composites for obtaining long yet rigid blades for increased power production.

Design for Additive Manufacturing on a Concept Laser Metal 3D Printer

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Client

Boston University
Engineering Product
Innovation Center (EPIC)

Faculty Advisor

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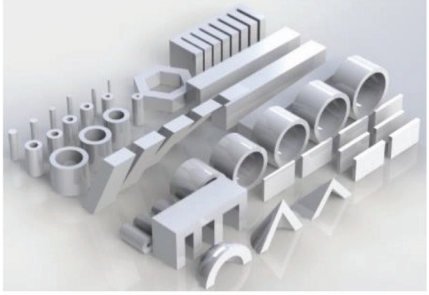
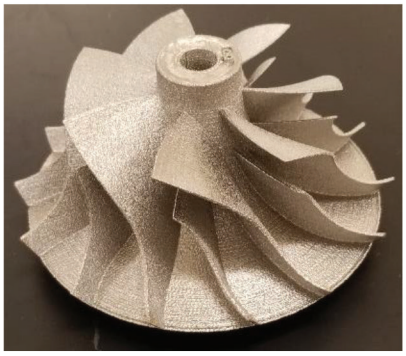
Acknowledgements

Kara Mogensen
David Campbell
GE Additive



Recently EPIC was gifted a metal 3D printer by General Electric and Concept Laser. This direct metal laser sintering style printer brings about many new potential users, although almost all are novice to additive manufacturing technologies. Moreover, they lack the knowledge to successfully use such a machine. It is therefore necessary to outline when and how to use the metal 3D printer by establishing a set of design for [additive] manufacturing (DFAM) rules to serve as a guide on how parts should be optimized to be printed.

To accomplish the aforementioned goals, a finalized set of DFAM rules were compiled. Accompanying the DFAM rules is a manual outlining what features and designs are acceptable for use on the metal 3D printer. Additionally, topological optimization of a few unique parts was documented. This approach to design reduces non-loaded, non-functioning surfaces. A test part and multiple optimized parts were printed which demonstrate the different features the metal 3D printer can handle. Future work will exhibit the capabilities of the printer as well as realizing additive manufacturing's possibilities.



Device for Heavy Metal Detection in Water

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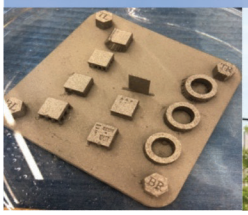
Faculty Advisor:
William Hauser

Lebanon, a rapidly growing country on the eastern shore of the Mediterranean, experiences water quantity and quality issues due to the country's relative lack of water treatment and management infrastructure. The toxicity level of water in Lebanon is so great a concern that residents drink only bottled water. The situation is even worse in the large camps that house Syrian and Palestinian refugees.

Heavy metals are a major pollutant in the Lebanese water. These toxins are the result of industrial waste and pollution and from the Lebanese civil war (ending in 1990). Our aim is to construct a device to test for one of these dangerous metals: cadmium. The device will operate by mixing chemical reactants with a water sample, changing the color of the solution. After the appropriate amount of time has passed, the device will use a controlled light source and a camera to measure and report the concentration of cadmium in the sample. Upon its completion, the device will be sent to our client in Beirut. There, it will be used to test a variety of water sources and determine the extent of pollution and the location of the greatest problem areas.

ConceptLaser Setup



TEAM MEMBERS

Caitlin Costello
Rafal Chudzik
Alex McQuire
Sally Wu

ADVISOR

Prof. Anna Thornton

CLIENT

BU Engineering Product Innovation Center (EPIC)

COLLABORATORS

CONCEPTLASER

Background

General Electric, the parent company of ConceptLaser, recently donated an Mlab Cusing R to BU EPIC. This additive metal printer uses direct metal laser sintering (DMLS) technology. DMLS is a powder bed fusion method in which a laser scans and fuses metal alloy powder particles layer by layer to create the final part.

EPIC

EPIC is a facility available to all of the Boston University community. It is used for projects and undergraduate, graduate, and faculty research. The metal additive capability needs to be accessible to the wide community. However, the complexity and cost of the equipment and the steep learning curve are a barrier to making the technology easily available. There is a concern that without proper guidance, infeasible and expensive (time and material) parts will be printed, wasting the limited capacity of the equipment.

Project Objective

The project objective is to understand and document how to translate a design into a final product using the 3D metal printer. In addition, our goal is to educate new users on the proper design, orientation, support structures, and post-processing to both increase the chance of successful parts and reduce the load on the EPIC staff.

We are creating a standard operating procedure (SOP) and process plan checklist to document the process and ensure users follow the necessary steps. Several test parts designed by our team will verify the thoroughness of the SOP and checklist.

SUPERABRASIVE BLADE MANUFACTURING IMPROVEMENT

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Peter Erf
Sonny Ray Dominguez
Faraz Iqbal

FACULTY ADVISORS
Professor
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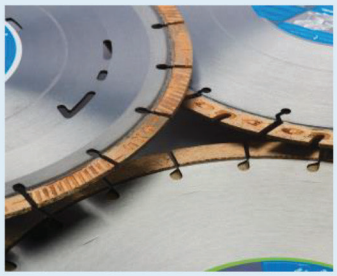
Theo A. de Winter

COMPANY CONTACT
Michael Pettit



BACKGROUND

Norton Abrasives (purchased by Saint Gobain in 1995) is the largest abrasives manufacturer in the world. Originally founded in 1885 to make grinding wheels, they now supply the aerospace, automotive, construction, and other industries with grinding, cutting, blending, finishing and polishing products. One product line that Saint Gobain Abrasives (SGA) supplies is a family of blades that they manufacture in their metal single layer factory in Worcester, MA. SGA receives unprocessed blades (stamped steel disks), which need to be coated with an adhesive braze paste and a single layer of superabrasive diamond around the outer diameter before being fired in a vacuum furnace. The vacuum firing creates a permanent bond, while the diamond layer increases the life of the blade and allows it to cut various materials, from concrete slabs to railroad tracks.

OBJECTIVES

The scope of this capstone project ends at the vacuum furnace, and focuses on the process of the braze paste and diamond application. This process is currently the bottleneck of production process. This team was tasked with reducing the total cycle time by 30% while also addressing possible quality and operator safety improvements.

Ride-Feel Data Acquisition System

TEAM:
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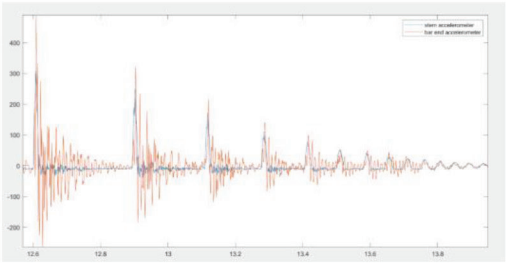
Caoyue Wang

COMPANY ADVISORS:
Justin Tucker
Andrew LaNoue

ADVISOR:
Prof. Anna Thornton

Background:

Specialized is committed to providing the best cycling experience to its customers. Providing a comfortable yet efficient bike is a crucial part to this goal. Because riders are willing to give up large sums of money to companies promising more comfortable rides, it is critical that Specialized be able to have experimental evidence to show that their products are the most comfortable.



Objective:

Specialized desires a low-cost data acquisition device to quantify riding vibrations. This device along with qualitative analysis from the rider will allow Specialized to perform more wide scale testing of various components and how they effect the vibrations and user experience.

Findings:

After developing and proving the credibility of the accelerometer based data acquisition system, it was found that the resulting ride data was being effected by too many uncontrolled variables. Developing experimental setups to test the impacts of each component separately was necessary.

New Balance Manufacturing

Problem:

Established in 1906, New Balance is one of the leading shoe manufacturers in the United States. Currently, as part of their midsole process they treat the midsoles with processes including spray painting, CNC machining, laser cutting, and laser printing. To complete these operations, the midsoles are manually placed in the machine and clamped down. With the current clamp, all operations cannot be done in one loading, and the operator must remove the midsole and change its orientation for each process resulting in two or more loadings per process. New Balance wants to have an operator place the midsole only once for all operations and orientations.

Solution:

To solve this problem, we designed a vacuum fixture with an internal manifold. A hole on the top side connects to vacuum. The other side splits via the manifold to separate gripper holes. In order to ensure repeatability, we manufactured a base plate with an extension on which the vacuum fixture can sit. On the extension are three sole-locating brackets to create three points in contact for positioning repeatability.

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Sahil Sharma

Faculty Adviser:
Professor William Hauser

Primary Contact:
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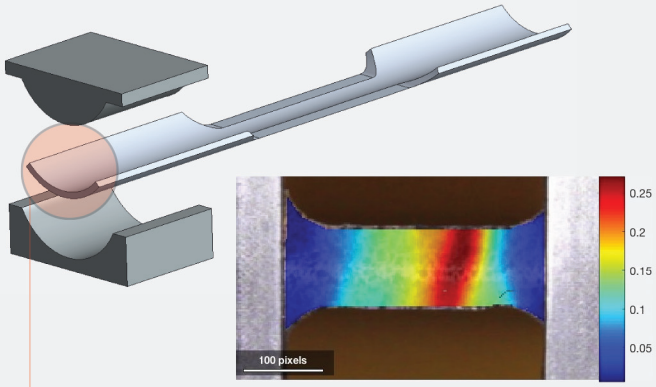
Special Thanks to:
Professor Gutierrez
Kara Mogensen

Problem Statement

Specialized is an industry leader in high-performance bicycles and bicycle components. With many of their raw materials sourced from overseas manufacturers, accurate material characterization presents a significant challenge in their design process. Currently, this lack of accurate material properties forces them to use conservative estimates of material strength and behavior, resulting in heavier products. The aim of this project is to develop measurement procedures for incoming tubes that Specialized can use to obtain accurate material data. The presented results were developed by examining the aluminum tubes used for seatposts, but the core principles and methodologies apply to multiple components and materials.



Approach

The proposed procedure is to machine "dogbone" specimens out of tube samples and manufacture custom fixtures to secure them in a tensile testing apparatus without altering the original curvature. Strain measurements are obtained using digital image correlation, and the cross-sectional areas of the samples are measured using 3D metrology tools and geometric calculations. FEM modeling is presented to demonstrate the application of experimentally determined material properties. This project's deliverable is a summary of the samples' material properties, a detailed error analysis, an outline of the current measurement procedures, and recommendations for improvements that can be made with Specialized's resources.

Conclusion

These results and proposed methods comprise a set of strategies that Specialized can use to improve their ability to develop optimal designs for their high-performance products.

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Hannah Levin
Benjamin Newbery
Grace Ware

Faculty Advisor
Anna Thornton

Client Company
Specialized Bicycle Components, Inc.

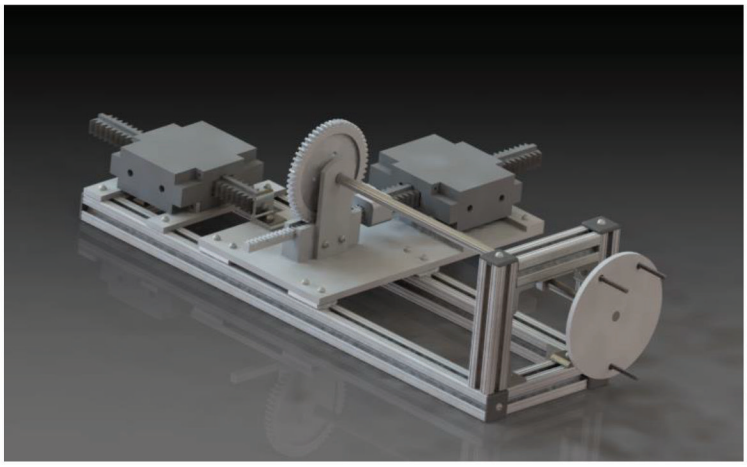
Company Contact
Justin Tucker

Special Thanks
Kara Mogensen
and the staff of EPIC

BU NEIDL
MRI Positioning Device

Project Description

The Boston University National Emerging Infectious Diseases Laboratory seeks a means to remotely adjust the position of an anesthetized animal within the torus of a Magnetic Resonance Imaging (MRI) machine. The high magnetic field of the machine rules out the use of ferromagnetic materials, thus the positioner cannot employ conventional electric motors. Pneumatic actuators, normally air-cylinder based, have the disadvantage of poor controllability because of the compressibility of air. This team has examined the feasibility of using two pneumatic stepper motors, made entirely of non-magnetic materials, to achieve the axial and rotational positioning accuracy and the repositioning speed required by the application.



Solution

Pneumatic stepper motors have demonstrated by other investigators. This team has explored the feasibility of making such a motor with tools readily available in the university's EPIC facility. This year's work was intended only to demonstrate feasibility and has succeeded in identifying design choices and fabrication techniques required for reliable performance. Additional work by future teams will be required to perfect the motor, to fabricate it with materials suitable for the harsh bio-safety working environment, and to design and integrate the display, command, and control systems required for convenient remote operation by a biomedical investigator.

/NEIDL

Team Members:

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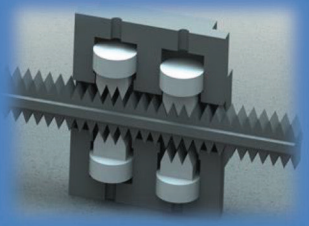
Jiayue (Johnny) Jiang
Jianing (Kyle) Li
Yuyuan (David) Tang
Jiaying (Serena) Yu

Faculty Advisor:

William Hauser

Customers:

John McCall
Dr. Bang-Bon Koo



Robotic Pick and Place Through Vision Integration

Group Members:
Nathaniel Feldman
David Widel
Vincenzo DiMonaco
Ryan Servais

Client:
Professor Peter Zink
Boston University Engineering Product Innovation Center (EPIC)

Faculty Advisor:
Professor Sheila Russo

Background

The EPIC Automated Design & Manufacturing Lab (ADML) serves to provide relevant hands on experience with modern manufacturing processes to undergraduate engineering students. The facility teaches students about collaborative industrial robotics, real-time process control, computer vision, statistical process control, and programmable logic control, among others. The ADML consists of two Haas Mini Mills, one Haas Office Lathe, three Universal Robot UR5's, three Teledyne Dalsa cameras, a Robotec elliptical conveyor, and a computer integrated manufacturing (CIM) system that allows the individual systems to be run together as an automated flexible manufacturing cell.

Currently, the ADML UR5 robotic arms can only interact with stationary objects with known locations. This limits the potential applications of the ADML system. The ability for the UR5 robotic arms to pick up a dynamically located and moving object would greatly increase the functional capacity of the ADML.

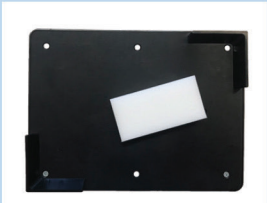
Solution Concept

In order to provide the ADML with the ability of picking up dynamically located stock moving along the conveyor belt, a proximity sensor, camera, and vision software have been incorporated. The proximity sensor triggers the camera to take a picture of the orientation of the stock on the conveyor. The camera communicates stock position to the robot, and with a combination of linear slide and robot motion, the robot is able to pick the moving object up off the conveyor. A laboratory project and associated manual will teach the robot's new functionality to future ME 345 Automated Manufacturing class.

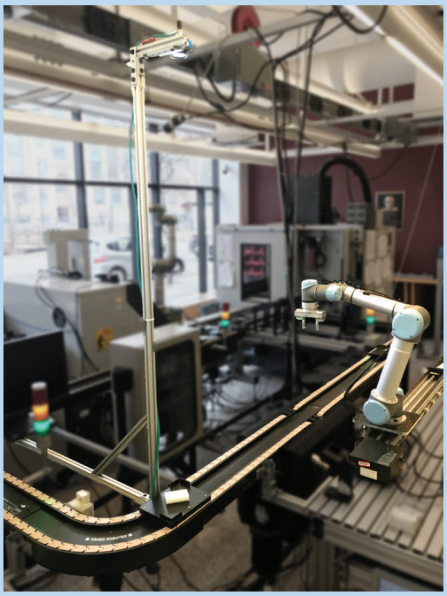
Results

After implementation, the UR5s are capable of picking up dynamically located stock material from moving automated guided vehicles on the conveyor and placing the stock in any accessible and known location. Further improvements can be made to this new ability to integrate it with the CIM system.

Stock with Fixed Location



Stock with Dynamic Location



ADML

DEPLOYABLE SOLAR PANEL

TEAM

Marc Arnau
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CLIENT

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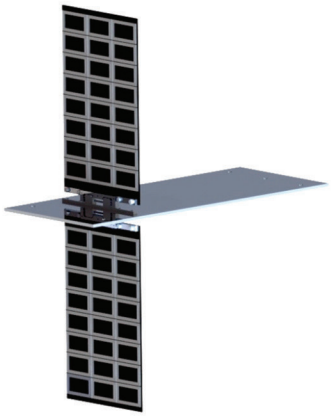
Center for Space Physics

FACULTY ADVISOR

Prof. William Hauser
BU Mechanical Eng.

THANKS TO

Ken Holland
Schneider Electric



CubeSats are a class of nanosatellites that through standardization provide low-cost access to space. For CubeSats, photovoltaic solar panels are usually the only source of power generation; available power is a critical limitation on data transmission, payload capabilities, and overall mission complexity. Deployable solar panels, which provide more surface area for solar power collection than only body-mounted panels, provide an increased amount of generated power.

The objective of this project is to provide our customer, Professor Brian Walsh and the Center for Space Physics, with a Deployable Solar Panel (DSP) system design and a mechanically functional prototype. The DSP is of a size that would be suitable for a 6U (~10x20x30cm) CubeSat satellite and is a starting point for future satellite mission proposals.

In the design of the DSP, reliability and solar cell area were optimized within temperature, size, and weight constraints. Furthermore, several actuation methods were analyzed and tested including springs, shape memory alloys, and electromagnets. Additionally, a test stand, which can be used in future design iterations, was built to demonstrate the DSP's design viability in a low gravity environment.

Online Raman Spectroscopic Analysis of the Growth of Engineered Cartilage Tissues

Tim (Wei) Wong

Faculty Advisor:
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Boston University Department of Mechanical Engineering

Customer:
Dr. Michael Albro
Boston University Growth Factor Mechanobiology Lab

Collaborator:
Dr. Mads Bergholt
Imperial College, London

Acknowledgment:
Kimberly Kroupa
Sylvia Baeyens

Osteoarthritis is a debilitating condition of the synovial joints that leads to pain and severe limitations in mobility. Tissue engineering (TE) has the potential to provide a solution to this condition by fabricating and successfully implanting compatible tissue into a patient's joints. In order to fabricate tissue that has mechanical properties and extracellular matrix (ECM) content, namely Collagen and Glycosaminoglycan (GAG), similar to that of native cartilage tissue, a quick and non-invasive method for evaluation would prove to be invaluable. Raman Spectroscopy, an inelastic light scattering technique, is capable of quantifying protein and sugar content in engineered tissue constructs *in vitro*. This characterization is essential due to the correlation between tissue protein and sugar content and its mechanical properties. The focus of this project is to implement a modular and low cost improvement to the existing Raman Spectroscopy system, by introducing a custom tissue culturing chamber that allows for real time monitoring of engineered cartilage growth. Magnesium Fluoride lenses, PTFE annuli, and aluminum bases are incorporated in a strategic orientation to minimize the chamber's Raman background and anabolic growth factor binding tendencies. The chamber has been preliminarily able to show steady increase in GAG content over a 2-month tissue culture period.

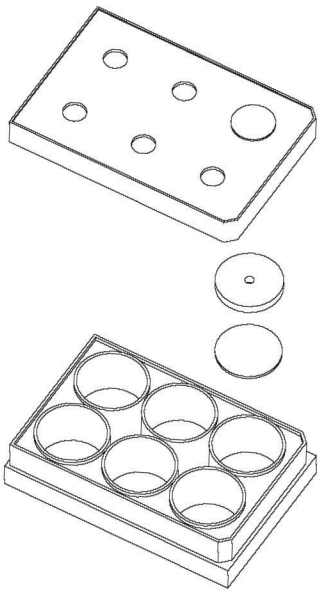

Figure 1: Tissue Culturing Chamber

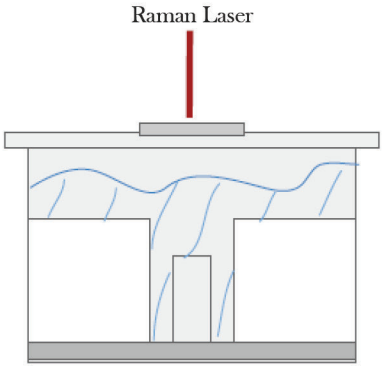

Figure 2: Cross Sectional View of Chamber

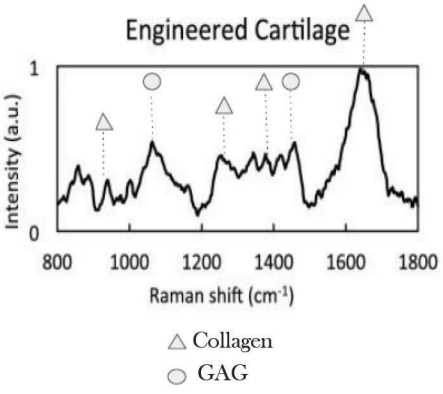

Figure 3: Engineered Cartilage Raman Spectra

PLANETERRELLA

Client
Boston University Center for Space Physics,
Prof. Brian Walsh

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Juan Tomas Leal
Jonathan Margolis

Advisor
Prof. William Hauser

Acknowledgements
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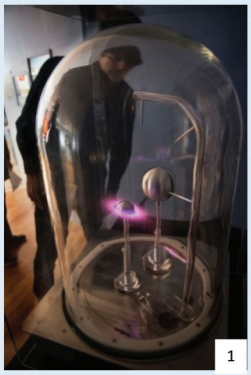

Contact
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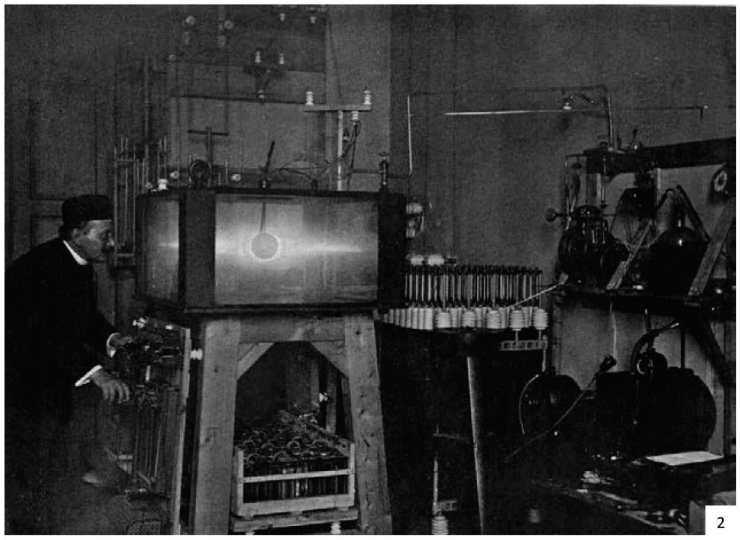
Background

High above the Earth's surface, where the atmosphere meets space, solar winds are caught by the magnetosphere and directed towards Earth's poles. As these enter the Earth's atmosphere, they interact with the ionosphere and cause a magnificent display of vibrant colors and mesmerizing shapes. This phenomenon is called the *Aurora Borealis* in the north and the *Aurora Australis* in the south.

Purpose

Our client, Professor Walsh, has requested our team to build a device that allows students to visualize these phenomena. The device is to be used as a study aid for plasma physics by bringing auroras to the classroom environment. To host an aurora, the device contains a vacuum to recreate the conditions of the upper atmosphere and terrellas, which are charged magnetized spheres, to represent the Sun and the Earth. The solar winds (plasma) will be recreated with an electron gun connected to the Sun terrella. The overall goal of the device is to create a self-contained, safe, and easy-to-transport aurora simulator.



[1]Modern Planeterrella Assembly, 2017, University of Iowa
[2]K.R. Birkeland's Terrella, 1908, The Norwegian Aurora Polaris Expedition

EPIC IMS

inventory management system

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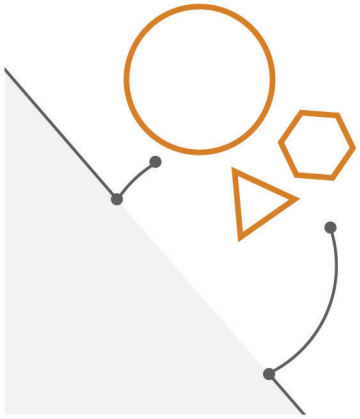

PROBLEM STATEMENT:

Boston University's College of Engineering offers several design courses that require purchased parts. Since these design courses are offered every semester, standard engineering components[1] are either re-ordered or reused. Our client, Professor Blonder wants to allow students to efficiently use parts from older projects for future projects. Currently, the parts are stored in the Maker Breaker Taker space of EPIC with minimal organization, security and tracking methodology.

SOLUTION CONCEPT:

The solution is to create an EPIC inventory management system (EPIC IMS) to track and manage the parts. The EPIC IMS will have a python-based software with a user interface for operators to check-in parts and for students to check-out parts. This software will be linked to a modular automatic locker system, which will hold and check the integrity of the parts stored, i.e. the system will signal the operator if an unintended part is stored in the locker.

[1]Standard engineering components refer to the most common and essential components used in engineering projects. Example: fans, microprocessors, power-supply, hand-held instruments, etc.

3D Printing for Sand & Investment Casting

Background

Many students that use sand casting at the Engineering Product Innovation Center (EPIC) are faced with the problem of the geometric constraints that are involved in the sand casting process. This project focuses on introducing instructions and methods for investment casting with the resources available at EPIC. This process will primarily use 3D printed molds which will then be investment casted to overcome the physical limitations of traditional sand casting methods used at EPIC.

Goals

We will provide a variety of geometries and patterns to help identify the strengths and weaknesses of investment casting. This process will then be turned into a manual which will be used by future students to use in EPIC.

Faculty Advisor

William Hauser, Ph.D

Client

Greg Blonder, Ph.D

Special Thanks

Kara Mogensen

Team

A Nawaz

R Poirier

Team Members: Michael Matos and Christopher Collins
Client: Boston University Dance Studio
Primary Contact: Lynda Reiman, Assistant Dance Coordinator
Faculty Advisor: Professor Frank DiBella

The Boston University Dance Studio hosts various shows, classes, and events throughout the course of a given semester. The performers dance on special mats that are rolled up and laid out for different performances. After these performances when the mats are rolled up to be put away for storage, they are placed onto a mobile cart that holds the mats and is kept inside a storage closet within the dance studio. The problem is that the mats when rolled up are quite heavy, weighing close to 90 lbs. It takes three to four people to lift each mat to its specific shelf on the mobile cart. This poses a safety hazard and can harm those who are trying to the lift the mat. Our job was to design and construct a new apparatus that would be able to lift the mats to their specified spot on the mobile cart and would reduce the amount of effort to lift them. Our solution was to modify the mobile cart that is currently being used by adding a pulley and crank system to lift the mats to their specified shelves. This solution reduces the number of individuals needed down from three or four to only two and eliminates the hazard of a mat falling and injuring any parties in the vicinity of the cart.

We would like to thank the Boston University Dance Studio staff and Lynda Reiman, the Assistant Dance Coordinator, for working with us this semester on this senior design project. We would also like to thank Professor Frank DiBella and Professor William Hauser for their guidance and support over the duration of the semester.

BOSTON UNIVERSITY

TEAM MEMBERS
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Sabrina Kaye
Aimee Manderlink

FACULTY ADVISOR
Frank Di Bella

ENVIRO DUCT

CLIENTS
Sarabeth Buckley
Rebecca Sparks
Prof. Nathan Phillips, Ph.D.
BU Department of Earth & Environment

BACKGROUND

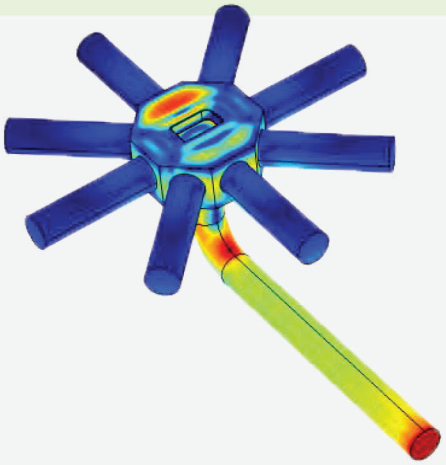
Free-Air Concentration Enrichment (FACE) is a method to raise the concentration of CO_2 in a specified area to increase plant growth. Inspired by the positive results of these open environment experiments, Boston University students are conducting an experiment to divert CO_2-rich exhaust from a vent on the roof of the College of Arts & Sciences building to eight crates of spinach plants. The ultimate goal is to promote plant growth while sequestering CO_2.

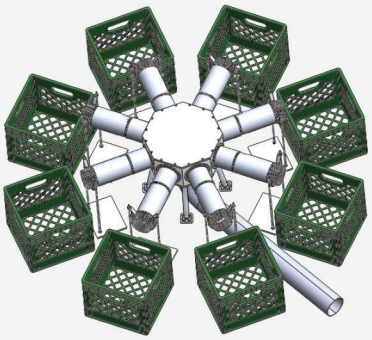
OBJECTIVE

In order to carry out this experiment, our clients needed a physical system to channel the vent exhaust to the plants. The system had to direct the emissions over 15 meters from the vent to the plants and uniformly distribute the air to each crate at an optimal velocity of 1 m/s.

SOLUTION

Our system captures emissions through an open-bottom torus of flexible aluminum duct, and directs it along a main pipe to an octagonal distribution manifold surrounded by a circle of eight crates of plants. We obtained the optimal output velocity by incorporating a 78 W in-line fan. To verify the results of the experiment, we constructed an identical control system with atmospheric air as the input source instead.





EW200 HYBRID ELECTRIC GENERAL AVIATION AIRCRAFT FAMILY

NEW WAVE AIRCRAFT

Katherine Bax, Thompson Cragwell, Benjamin Del Cid, Thao Nguyen, Ravi Parent

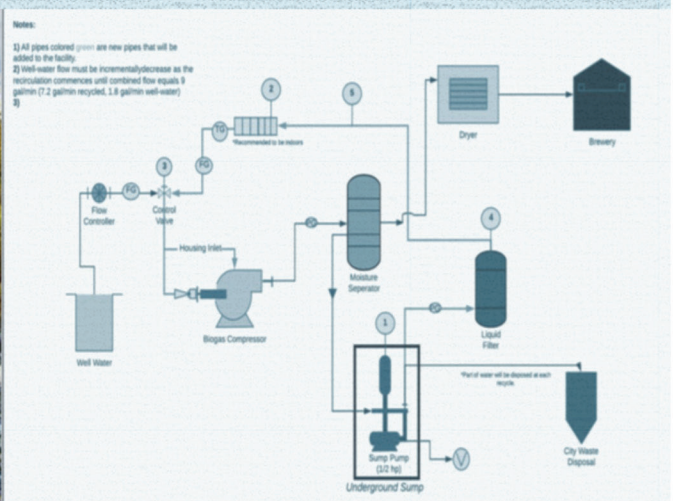
For submission to the American Institute of Aeronautics & Astronautics

Acknowledgements to advisor James Geiger, BU College of Engineering and General Electric, and technical contact Matthew Orr, Ph.D., The Boeing Company

The conceptual design for a hybrid electric aircraft family for submission to an AIAA Request for Proposals. With an entry into service of 2028, this family will carry four to six passengers up to 1000 nautical miles using a combination of stored electric and chemical energy sources. Reduced fuel burn and two energy sources make the EW200 a safe and fuel-efficient design for general aviation aircraft owners.

Water Efficiency Recirculator

Anheuser-Busch | Merrimack, NH | Spring 2018



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Alejandra Flores

Jacob Nikolajczyk

Eric Ulin

Customer

Anheuser-Busch

Engineer

Bill Dineen

Faculty Advisor

Frank DiBella

Project Summary & Goal

Anheuser-Busch has been working to reduce well water consumption. They have a goal oriented program called "Seed to Sip" which stands for their company-wide focus to be responsible and sustainable water stewardship. Their current water usage at their Merrimack, New Hampshire location is 3.46 hl/hl (hectoliter of water used per hectoliter of beer produced) and their ultimate goal is to reach 2.70 hl/hl. Our project aims to decrease their current usage by 0.02 hl/hl (70,000 gallons) per year.

Conceptual Design

By reusing waste water from the biogas compressor, we will improve the efficiency of the water used. This entails feeding the reused water through a chemical filter, cooling it to an optimal operating temperature, and feeding it back into the compressor to be reused rather than discarded. This will improve the existing biogas compressor, to reduce the amount of freshwater used to synthesize biogas from the brewery's waste water.

F1D Indoor Model Aircraft

Problem Summary
The Fédération Aéronautique Internationale (FAI) hosts annual competitions for aero-modeling. The F1D class of model is a rubber band-powered aircraft measuring 2.5ft long, weighs slightly more than two $1 bills, yet can stay in the air for around half an hour.

Project Objective
Team Swoosh is to create an aircraft capable of competing in the Class I (8m) ceiling height category, following the regulations set by the FAI, while aiming to beat the previous BU record of 8m17s with a flight goal of 10m.

Team Swoosh
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Edward Chen
Alex Rodriguez

Faculty Advisor
James Geiger

Consultant
Ray Harlan

HYDROPAC WASTE DISPOSAL SYSTEM

TEAM MEMBERS
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FACULTY ADVISOR
FRANK A. DI BELLA

CLIENT
PATRICK GAGNON

Background

The Boston University Animal Science Center manages various lab animals such as mice and primates that are used for medical research and testing purposes. The workspace consists of over 6000 cages of mice. In order to supply the lab animals with water, the facility uses a single-use water pouch called Hydropac that feeds water through a plastic valve. The used HydroPacs, which contain usually less than half full of water, are collected and thrown out.

Problem

The hydraulic machine that drains the remaining water was broken a few years ago. The lab technicians have been draining out the water manually, which is very inefficient.

Objective

To design and manufacture an automated or semi-automated apparatus that provides a better solution to dispose of HydroPac waste. The apparatus should drain the water from used HydroPacs and collect the plastic waste from the bags and the valves.

BU Rocket Propulsion Group

Rocket Engine Nozzle Extension

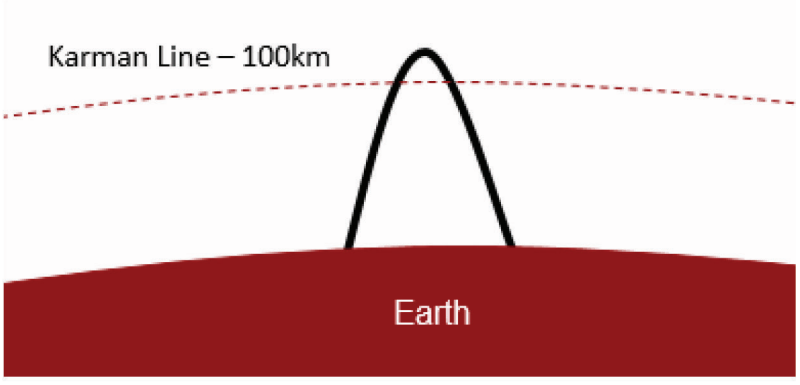
BURPG
Boston University Rocket Propulsion Group

Background

The Boston University Rocket Propulsion Group aims to become the first collegiate rocket team to successfully send their rocket, Starscraper, to the Karman Line ,which is considered to be the edge of space. To accomplish this goal, the group is developing their own liquid bipropellant rocket engine named Lotus Dev-2 (LD-2). Because of manufacturing constraints, LD-2 exit area is not optimized for the current mission. A nozzle extension would allow for the engine geometry to be optimized and improve the engine's performance. A nozzle extension would also provide a smoother path to converting LD-2 into a second stage engine if the team aims to go beyond a suborbital flight.

Objective

The aim of this project is to perform a preliminary design, trade study, and evaluation for a rocket nozzle extension to be used on LD-2. The nozzle extension should improve the performance of the rocket and be easily integrated into the current architecture. This was done by assessing various sizes, shapes, materials, cooling methods, and types of nozzles. The results will be presented to the Group, where they will determine the future of the nozzle extension.



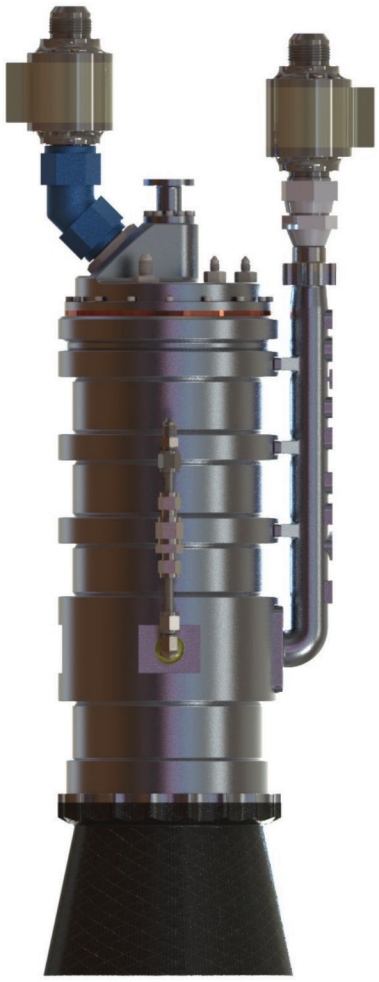
Team

Austin Magsig

Edward Zuniga

Faculty Advisor

James Geiger



Steam Powered Canoe

Team Members: Patrick Casey, Joe Karam, Ryan Kelly, Nicholas Morales, Fred Williams

Client: Richard Williams

Faculty Advisor: William Hauser

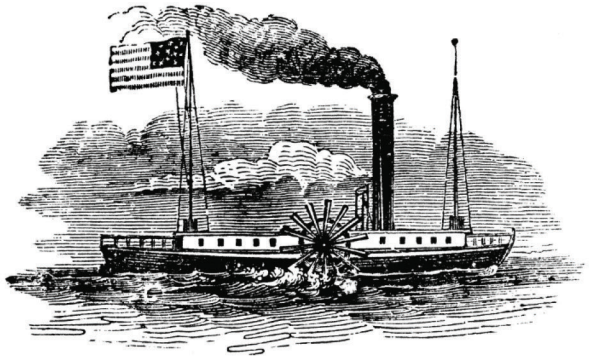
Special Acknowledgment: The Staff and Faculty of EPIC

Steam-Powered Canoe: Industrial Sailing on a Personal Scale

For centuries, steam power was the heartbeat of civilization; propelling humanity forward into an industrial world. Today, it still inspires enthusiasts around the globe to reimagine the products and technology that surround their everyday lives to incorporate steam power. One subset of these hobbyists use steam to drive various watercrafts, self-dubbed “steam boaters”. The most common vehicle steam boaters modify is the humble canoe.

The goal of this project is to design a standalone steam powered propulsion system that can be retrofitted onto an existing canoe. The design must be simple enough that in can be mass produced and sold as a kit as an introduction for new steam boaters with limited knowledge.

The proposed solution involves simple modifications to an existing internal combustion engine to power a set of paddle wheels. The system is mounted on press-together framework that is attached to the canoe proper. Currently, the engine is powered by compressed air, but future designs will incorporate a boiler to deliver steam proper to the engine.



THE AMAZING VOYAGER

Team Members
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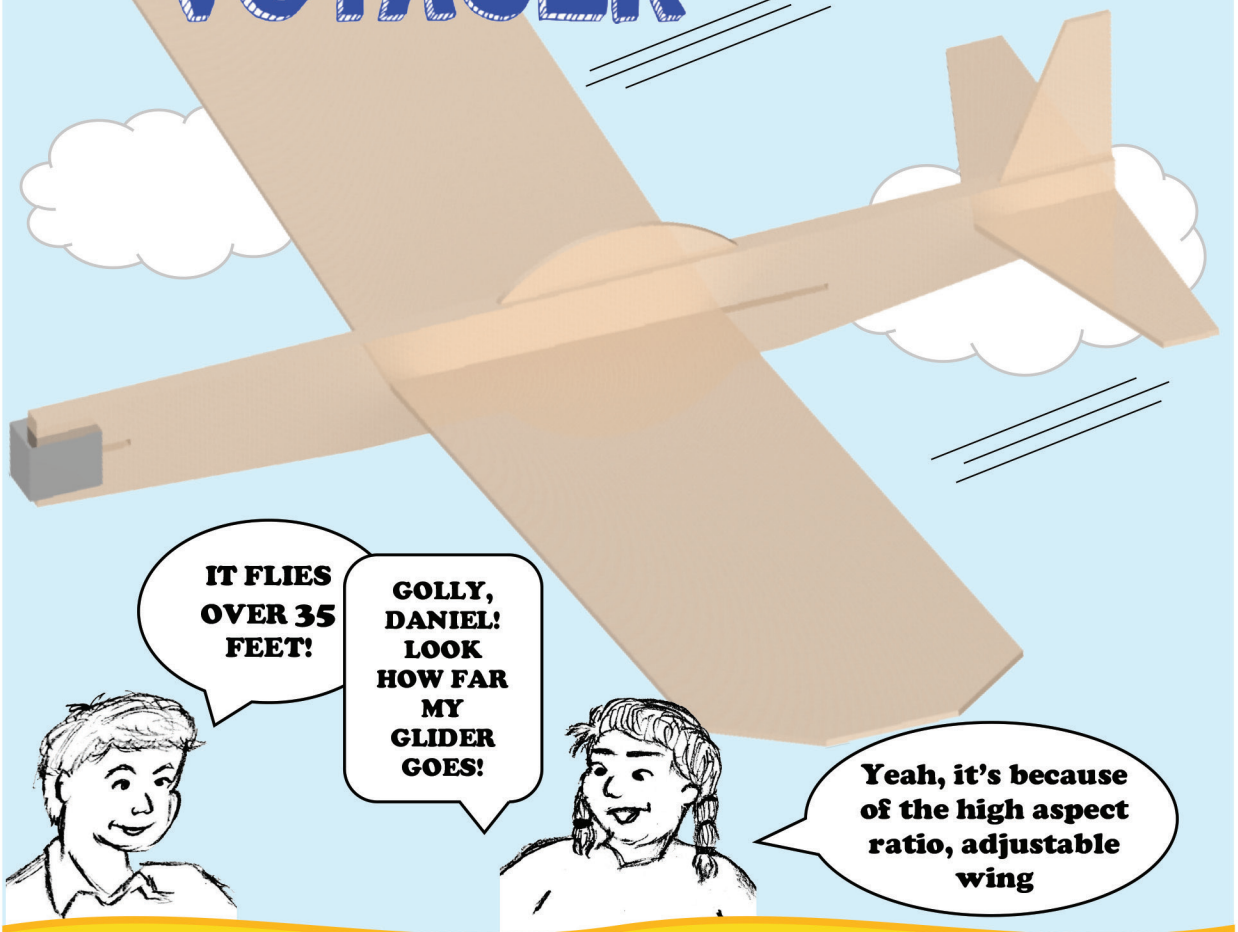
Yeu Su
Katie Williams
Faculty Advisor
James Geiger



Challenge
Our challenge is to create a balsa wood aircraft that will be a competitive entry into the toy glider market. The glider will be able to fly farther than existing models while offering greater control and endurance.

Solution
The Amazing Voyager wins the day! The Voyager glider is bigger and better than its competitor, the Jetfire. With an aspect ratio of 7, Voyager is dominating the sky. The larger wing is expected to result in a whopping 35 ft flight. The attached vertical tail adds safety for the youngsters, and the larger horizontal tail add stability and grace to this titan in the sky.

BURPG

Rocket Engine Piston Pump Prototype

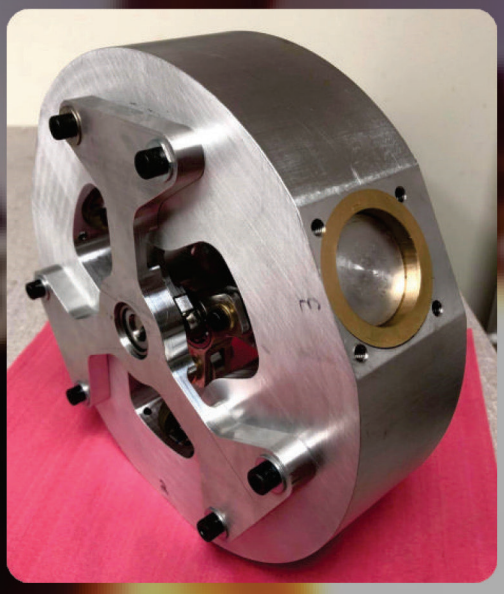
A new generation of orbital rockets are being developed to service the small and micro-satellite market – a rapidly growing sector with more than one billion dollars invested in the first quarter of 2018. Tight competition and ambitious performance goals demand the most of the new rocket launch systems.

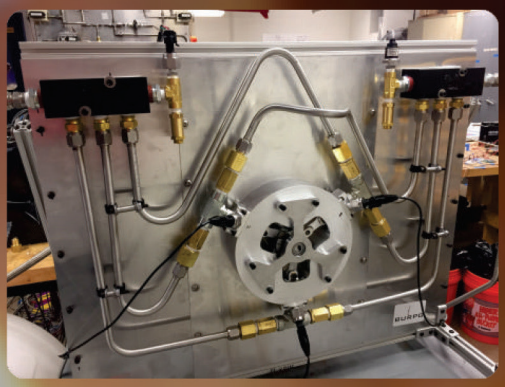
•

With the support of the BU Rocket Propulsion group, our project aims to research and develop a novel type of piston pump and demonstrate how it could increase launch vehicle efficiency and reduce the cost of getting to space.

•

Our research delivers a fully functional prototype radial piston pump, numerical simulation toolbox and the technology's use in the launch market.





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Daniel Poe

PRAXOPHONE

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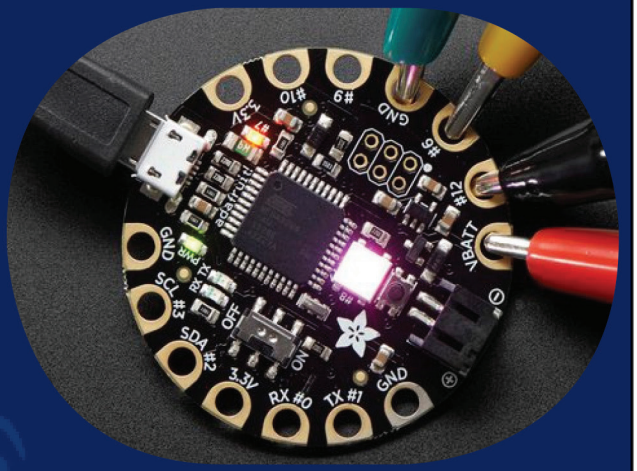
Cayla Freeman
Elisabeth Han
Alexandria Persaud
Kristyn Wooldridge
Client:
Dr. Jennifer Bill
Faculty Advisor:
Dr. Enrique Gutierrez-Wing



Problem & Objective:
Musicians who play wind instruments face the problem of practicing their instrument without producing loud noise. Our goal is to design a device that lessens or muffles the intensity of the sound waves produced by an alto saxophone while maintaining the "feel" of playing (e.g., air support), allowing students to practice in any location. The instrument is connected to headphones, so that only the user can hear the produced synthesized sound.

Solution:
Our solution involves modified gloves and an alto saxophone neck replacement. Gloves with soft buttons connected to Flora micro-controllers are used to detect which keys the musician presses while outputting USB MIDI signals. These signals are then converted into synthesized tones. The neck replacement serves two functions: 1) to acoustically mute the sound from the mouthpiece reed vibrations and 2) to sense when the user is blowing into the instrument. A microphone secured over the neck replacement's hole senses airflow, detecting when the user is blowing into the instrument.

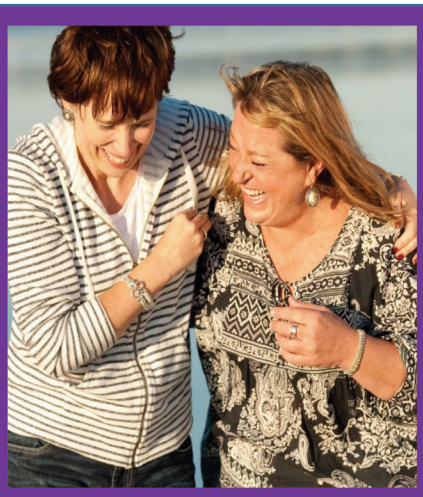
Dovera Designs

Problem

Dovera Designs is a fine jewelry company based in Boston, founded by a woman named Susanne Greelish. Their bracelets are made from Swarovski crystals using unique handcrafting techniques. While these bracelets are stunning in design and appearance, the current hand/manual driven methodology behind stringing the beads is posing inventory problems. The beads are of millimeter in scale and are very easy to lose for the employees. Thus, affecting the number of potential bracelets that could made.

Solution

We have attempted to solve this problem through building a bead stringing machine. machines exist already, but the bracelets are made in a specific sequence of beads. Thus, in our design and execution, our focus has been to orient, sequence and ultimately string the beads. We have conducted numerous experiments and will demonstrate some working mechanisms for these three main functions using our 3D printed parts.



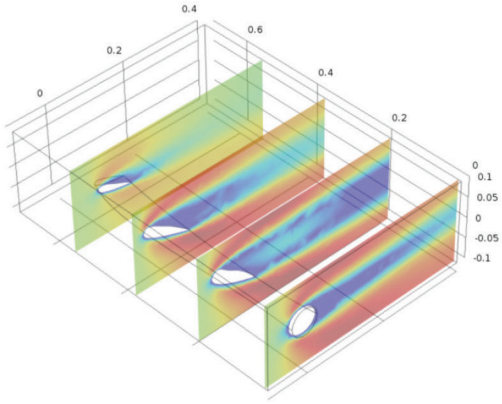
Members: Hamid al Hussona, Meirlan Kanatzhanov, Shaahid Mahmed, Mohammed Mohtasim, Arjun Ramanathan

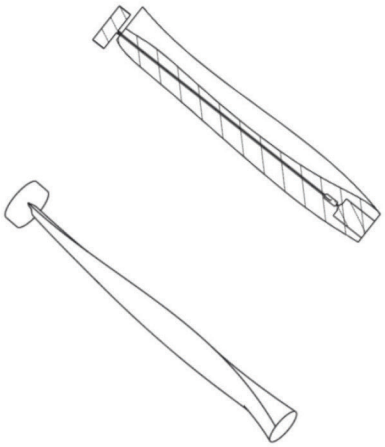
Client: Susanne Greelish

Advisor: Professor William Hauser

Gyroscopically Stiffened Wind Turbine Blades

BOSTON UNIVERSITY





Team Members

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Antonio Pinto de Arruda Assy

Robert Rosado

Client and Faculty Advisor

Professor Enrique Gutierrez-Wing

Challenge

Wind turbines are constrained by stresses induced by wind drag, limiting operational speeds and power generation.

These stresses wear on the system over time, decreasing the economic lifespan of the projects.

Current design trends aim to combat stresses by increasing the strength of components through material or structural improvements.

An alternative strategy could be to counteract the bending forces through the gyroscopes mounted within the blades. Our goal was to create a viable prototype to demonstrate this while solving the practical issues of the added mechanics of the gyroscope.

Solution

A gyroscope allowed to rotate around a secondary axis will resist changes to that axis, and this resistance will be used to counteract the forces of wind drag by matching the gyroscope's secondary axis to that of the turbine blades. In the construction of a small-scale prototype, a gyroscopic mass was mounted at the tip of the blade and spun to high speeds. We found that gyroscopic stiffening yielded positive results in a controlled setting.

Steam Jet Ejector

Team Members

Alma Alhussaini
Leena Alawami
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Abdulraouf Agha

Faculty Advisor

Prof. William Hauser

Customer

Richard Williams

Background

Steam engines date back to the late 17th century. They have revolutionized the way we generate energy and paved the way for greater inventions we use today. Although they are not widely used nowadays, steam engines continue to fascinate and inspire engine enthusiasts. Our customer, a steam engine enthusiast himself, was interested in building a steam engine alongside a propulsion system to move his canoe.

Objective

Inspired by our customer's request, our team decided to focus on the propulsion system aspect while still incorporating elements of a steam engine. For that reason, we have designed a steam jet ejector; a device that utilizes steam to propel a vessel such as a canoe across a body of water. The application of a steam jet ejector on a canoe is a fun and novel idea that demonstrates essential fluid dynamics and thermodynamics knowledge.

Design

The foundation of the jet ejector is nozzle design that incorporates no moving parts. In order to reach our required speed and thrust goal, various 3D printed nozzle designs were investigated by manipulating the areas, lengths, and inlet and outlet dimensions. The designs were tested using compressed air through a series of trial and error and corresponding theoretical and experimental calculations were performed. Due to safety concerns and time constraints, the design was not tested using a boiler but was theoretically explored in our calculations.

TORSIONAL STIFFNESS TESTER

Project team: Karim El Rawas, Shivin Poonglia, Joel Lavoie, Abdalaziz Babgi

Project Advisor: Professor Hauser

Client: Boston University Formula SAE

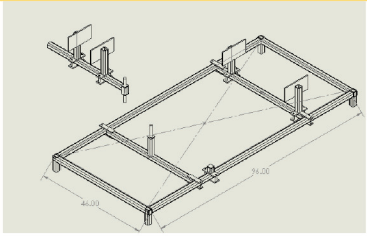
Project Background: BU's Formula SAE club has built a car frame for entry into the Formula SAE competitions. This is one of several cars that the team plan to build as they enter competitions annually. In developing the car, the team needs to measure several performance related factors in the cars chassis to optimize performance. One important measurement is the torsional stiffness of the chassis which we have been asked to measure for them by building a test frame.

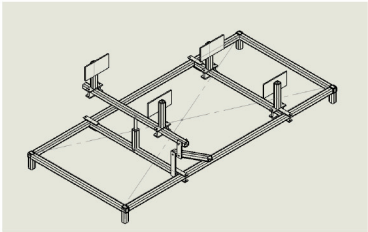
Problem Definition: Provide our customer, BU Formula SAE, with a test frame capable of accurately measuring the torsional stiffness of their car and any future cars built by the team. The Frame should not damage the car and should be adjustable to different sized car frames

Proposed Solution: The team has developed a torsional stiffness tester frame that allows the team to mount their car frame on it to measure torsional stiffness. The frame is easily adjustable to allow for different sized cars to be mounted as well as being easy to disassemble for ease of transport and storage.

OBJECTIVE

To build and test a torsional stiffness tester that can accurately measure the stiffness of a car chassis for the BU Formula SAE team





BOSTON UNIVERSITY racing

Rolls-Royce®

Process Improvement for Hub Assembly

Client:
Rolls-Royce Marine

Primary Contacts:
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Faculty Advisor:
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Team:
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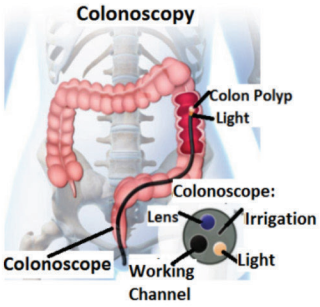
Rolls-Royce Marine, located in Walpole, MA, manufactures, assembles, and repairs large scale propellers for commercial and military applications. The propeller blades, and assembly hubs to which they are attached, are returned to the plant for periodic maintenance and undergo a "teardown" and "build up" process to carry out inspections and replace worn parts. In addition, RR Marine produces new hubs. Our objective was to identify workflow improvements and potential method improvements for Rolls-Royce's hub assembly process. Our customer was the assembly workers on the floor who tear down and build the hubs, as well as the managers who are responsible for the results.

Our team aimed to increase efficiency by utilizing LEAN techniques and making the assembly workers' lives easier. We developed a solution to eliminate waste, reduce motion, and decrease inventory while also increasing productivity. Our designs will quickly reduce operating costs, improve employee satisfaction, and provide a greater sense of order to the hub assembly floor. One recommendation incorporates tooling and drying racks that match Health & Safety standards and work in conjunction with existing crane and forklift operations. A second recommendation implements a Kanban batching system to set the beat of the drum for the hub assembly process. A formal proposal has been submitted to the General Manager, along with a full financial justification.

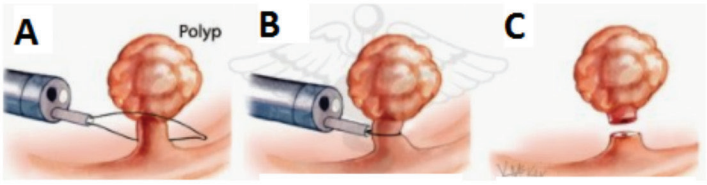
Endoscopic Snare Optimized for Cold-Cutting Polypectomy

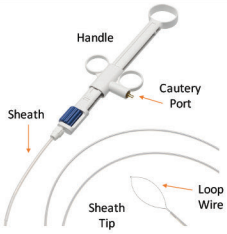
Team Members: Jacob Nazarian, Alexandra Osman, Brian Luis, Drew Wolos
Corporate Partner: Boston Scientific
Primary Industry Contact: James Baker, Endoscopy, R&D Engineer
Boston University Faculty Advisor: Professor Sheila Russo, Ph.D.



BACKGROUND: In the United States, colorectal cancer is the second and third leading cause of cancer-related deaths in men and women, respectively. During a colonoscopy, when an abnormal tissue growth, or polyp, is identified, it is removed from the inner lining of the colon. This procedure is called a polypectomy, and is performed to extract the potentially malignant growth for biopsy to test for cancer.

MOTIVATION: During this removal procedure, the polyps are removed using a wire loop, either with or without electrocautery (hot snaring vs cold snaring). Hot snare polypectomy, which uses electricity to heat the cutting wire, is recommended to cut polyps greater than 10mm in diameter. For polyps less than 10mm in diameter, cold snaring is recommended as there are fewer post-surgery complications, but it requires a stronger snare without the help of a heated wire. Currently, no single snare is able to optimally perform both hot and cold polyp resections.





GOAL: The purpose of this project is to develop a single snare designed to excel at both hot and cold snaring applications, enabling it to completely remove polyps of all sizes during the same polypectomy. The project investigates different combinations of sheath materials and wire loop configurations to optimize the snare's cold cutting ability, without affecting its electrocautery functionality. A suite of new test methods has been developed to measure the friction actuation force, tactile control, and polyp cutting ability against the control group, Boston Scientific's current Captivator II snare. This optimized snare has potential to reduce post-surgery complications, surgery time, and total polypectomy snare costs.

Boston University College of Engineering, Mechanical Engineering Department

Low-Cost Damper

Objective

The idea is to design an inexpensive damper that mitigates vibrations in the 5-10Hz range. Drawing from what caused the collapse of the millennium bridge, the goal of this project is to understand the natural frequency of structures and design a damper that through resonance, alleviates motion. Pre-existing tuned mass dampers transfer energy - initially absorbed from the motion of the system - back into the system once it reaches equilibrium. This is an undesired effect of dampers and the challenge is therefore, to find a way to dissipate the energy into forms such that the system remains at equilibrium.

Designed by: Raizel Girum

Faculty Advisor: Professor Gutierrez

Solution

Steel and Aluminum beams are cantilevered and tuned to vibrate with desired frequency ranges. After attaching the designed damper onto the free end of the beam, the vibrations show observable changes and allow the beam to quickly reach equilibrium. The damper comprises of a U shaped channel and was designed to accommodate liquids that flow through controlled areas within the container. Once the beam starts vibrating, the kinetic energy transfers to the liquid in the damper causing it to slosh back in forth from within. The movement of the liquid creates friction within the damper allowing the energy to cause heat. The heat can then escape to the environment through an opening at the top of the damper.

DRAPER

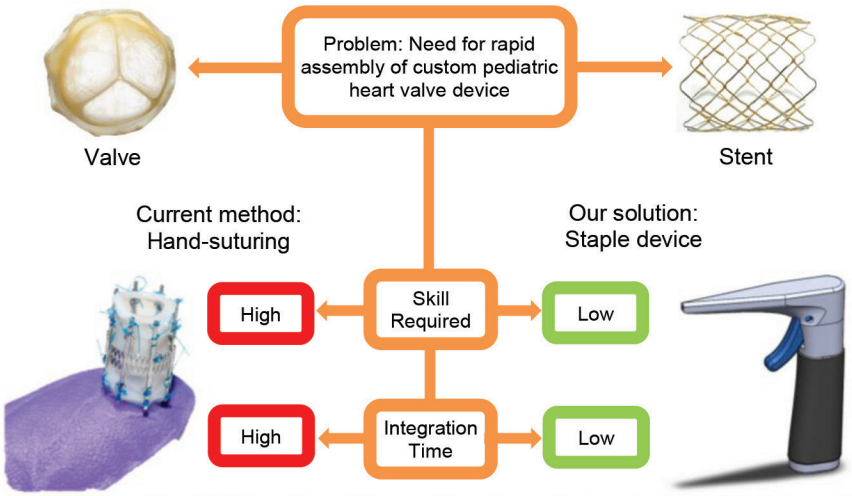
Development of an Efficient Method for Integrating Bioprosthetic Valves and Stents

BACKGROUND

Every year in the US, approximately **40,000 babies are born with congenital heart defects**, of which at least a quarter have a defective heart valve. Currently, there are **no prosthetic valves designed specifically for pediatric applications**. In fact, many surgeons have to manipulate and restructure existing valves in order to make them fit young children, which is not ideal and in most cases is performed on the back table in the operating room (OR). The current process of hand-suturing a valve to a stent is extremely specialized, time-consuming, and expensive.

OBJECTIVE

Design and develop a rapid and low skill method to facilitate custom valve assembly in the OR.



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BU Advisors:
Sheila Russo
William Hauser
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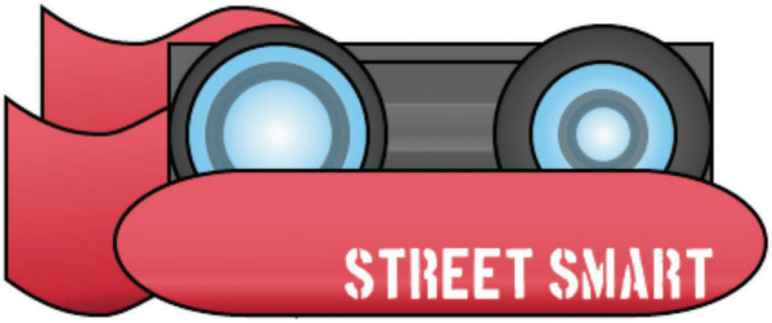
SOLUTION

Our design consists of a **stapling device and custom staple** that would allow for rapid integration of the valve and stent. We developed a proof of concept design and simulated staple movement and staple release. Our design presents a **faster and simpler method that could be used by surgeons or low-skill technicians**. In the long-term, our solution will help **increase access to valve replacement for pediatric patients** by reducing skill and cost for custom valve assembly in the OR.



BACKGROUND

The City of Boston annually spends approximately $20 million dollars on snow removal. Most of this money is allocated to plowing contracts and salt distribution. Access to real-time data describing road conditions, such as depth of snow or the presence of ice, can boost efficiency and cut costs. With this information, they will be able to better dispatch plows or salting trucks according to their exact needs.

OBJECTIVE

We solved the problem by providing a monitoring system that will collect live snow and ice levels from the streets of Boston. Our devices will be attached, universally, to any light post around the city while being able to withstand all weather conditions. Each sensor will collect multiple points of data by rotating a LiDAR v3 sensor. These instances will be networked together and the data will be aggregated, analyzed, and displayed on our intuitive software suite. Key design parameters include

- Weatherproof housing
- Allow for Sensor Rotation
- Total cost under $300

A Collaboration between Mechanical Engineering and ECE Department

CLIENT

Professor Blonder

FACULTY ADVISORS

Professor Hauser

Professor Pisano

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