UCONN | SCHOOL OF ENGINEERING

SENIOR DESIGN

DEMONSTRATION DAY

HARRY A. GAMPEL PAVILION

MAY 3, 2019

seniordesign.uconn.edu

ECONOMIC IMPACT STARTS HERE

The capstone Senior Design Project Program is a hallmark of success for engineering seniors. In this one or two-semester course, senior students are mentored by faculty and industry engineers as they work to solve real-world engineering problems for company sponsors. Students learn about the principles of design, how ethics affect engineering decisions, how professionals communicate ideas and the day-to-day implications of intellectual property.

Each year, dozens of leading manufacturing companies, pharmaceutical and medical firms, consulting practices and utilities present the School of Engineering with design challenges or problems they are encountering in their business. For a modest fee, the companies suggest a particular problem and assign a technical representative from their company who will help guide and mentor the senior engineering students as they work to properly frame the problem and develop meaningful solutions.

The students research and analyze the problem, conceptualize alternate solutions, design and refine one device or method, construct a working prototype, and provide the sponsoring company with regular reports plus a working prototype. This true design experience allows the students to apply the technical skills they have acquired during their undergraduate years, and to stretch their abilities in analysis-based innovation and decision making.

For more information:

Charles Maric
Director of Business Development, Senior Design Projects
UConn School of Engineering
261 Glenbrook Road, Unit 3237
Storrs, CT 06269-3237
Office: (860) 461-2297 Mobile: (860) 428-2258
charles.maric@uconn.edu

MESSAGE FROM THE DEAN

ADDRESS A CHALLENGE OR EXPLORE A NEW IDEA

Sponsoring a Senior Design project allows sponsors to address a problem without the large investment.

STRATEGIC RECRUITING

Sponsors have nine months to collaborate with, cultivate and evaluate undergraduate students as prospective employees.

ACCESS TO UConn's UNIQUE RESOURCES

Senior Design Projects also give you access to UConn faculty, who have expertise and state-of-the-art laboratories and equipment.

VISIBILITY

As student teams and faculty gain exposure to your organization's resources, products/processes and culture, they will spread awareness of your organization.

VALUE

Business and organizations have meaningful access to talented engineering students who provide high-level insight and innovative technological solutions, for a small financial investment.

UConn President Susan Herbst (left), Founder of Black Girls CODE Kimberly Bryant (center), and UConn Engineering Dean Kazem Kazerounian (right) pose for a photo after the May 2018 Undergraduate Commencement ceremony. Bryant, who founded Black Girls CODE in 2011, received an honorary degree during the ceremony and served as commencement speaker.

GREETINGS AND WELCOME TO OUR SENIOR DESIGN DEMONSTRATION DAY!

The Senior Design Project is the final experience of our students' undergraduate career, a year-long process that provides a hands-on application of the principles and theories they have spent the previous three years honing. Students learn and apply the principles of design; the complex interplay among engineering solutions and societal, environmental, economic and ethical considerations; the language of industry; and the power of engineering to catalyze new solutions to entrenched problems such as sustainable energy, access to clean water, agriculture, transportation and health.

Each and every year, 75-plus organizations, large and small, partner with the UConn School of Engineering to not only fund projects, but also donate valuable mentorship time, as well as solidify the unique information-sharing pipeline that the School and University has with the engineering community. With the generous support of all of our sponsors, seniors get direct access to talented engineers in the industry, as well as valuable hands-on experience in a group setting. Additionally, by solving real-world problems, and creating innovative solutions for companies, the School of Engineering, and its students, drive significant economic impact towards the sponsoring companies and the state of Connecticut as a whole.

As you walk among the exhibits displayed here, which are summarized within this booklet, talk to our students. Learn about how they applied the knowledge they have worked so hard to gain. Share in their excitement for the discipline that has dominated their undergraduate career. Their experiences will afford you a deep understanding of the issues they encountered, the creativity and ingenuity they applied to their project, and the exceptional quality of their engineering skills.

These students will be graduating shortly. They will soon embark on the next portion of their engineering journey, whether that be graduate school or the beginning of their careers. They are the future of our discipline, and I am both proud of the role UConn has played in their development and humbled at the thought of what they can achieve.

KAZEM KAZEROUNIAN, DEAN

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www.bme.uconn.edu

BIOMEDICAL ENGINEERING

Kayla Sagan(Left), Marcus Klebart, Katherine Russo(Right)

BIOMEDICAL ENGINEERING

TEAM: 1

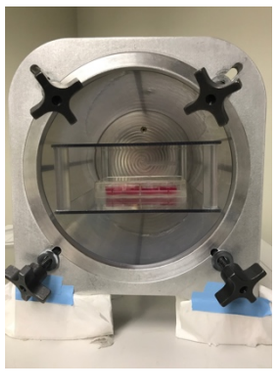
SPONSOR: University of Connecticut Health

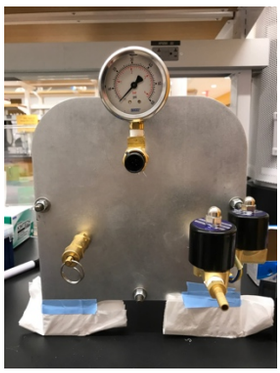
ADVISOR: Dr. Syam Nukavarapu

High Pressure Oxygen Chamber for Tissue Engineering

The use of hyperbaric oxygen treatment (HBOT) has shown to be an effective therapy for conditions including carbon monoxide and cyanide poisoning, gas embolism of the blood, and decompression sickness. It has also shown to be effective in wound healing applications. The effects of HBOT in wound healing is particularly interesting due to the behavioral changes it induces in different cell types, such as proliferation and differentiation changes. These cellular effects can be applied to tissue engineering. The bioreactor presented in this project uses hyperbaric oxygen to enhance the behavior of various cell types for tissue engineering applications. The chamber is a modified model of a previous prototype. The new design includes completely automatic pressurization and depressurization valves, digital and analog displays of the internal chamber pressure, and interfacing with a computer to control pressure level and duration of treatment. Additionally, cosmetic changes were made to the door to improve the ease of use of the device. The new design of the bioreactor can be operated by a single user, in which cell cultures are placed in the chamber and the pressure level and time duration are specified in the computer program. The device will pressurize and depressurize automatically without any manual operation by the user other than securing the door.

Cell culture studies are conducted to verify proof of concept. To conduct the twenty-one-day cell studies, cells are seeded on culture dishes and placed in the oxygen chamber. Oxygen flows into the chamber to a predetermined pressure, and the cells remain in the bioreactor for a predetermined amount of time. After the bioreactor is completely depressurized, the cells are removed and placed back into the incubator. The cells receive treatment for up to twenty-one days. Following treatment, various assays including Quantitative PCR, Picogreen, ALP assay, and Alizarin Red Staining, are used to evaluate cell proliferation and differentiation at various time points in the study.





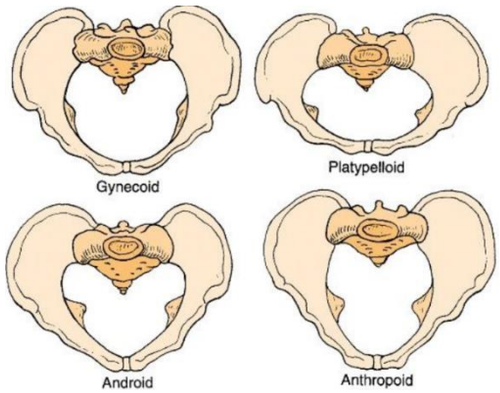
BIOMEDICAL ENGINEERING

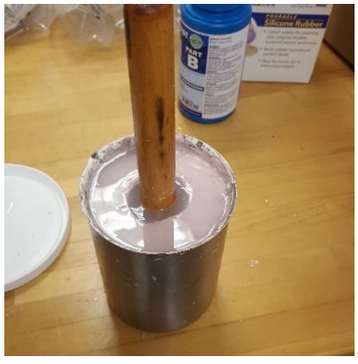
TEAM: 2
SPONSOR: UConn Health
ADVISOR: Dr. Krystyna Gielo-Perczak

Shreya Hegde, Tommy Jamdee, Matthew Hall, Qingqing Zhang, Zhouxuan Wang

UCONN HEALTH

THE POWER OF POSSIBLE.





Pelvimetry Model: A Training Tool for Better Obstetric Outcomes

The procedure of clinical pelvimetry examination is generally practiced to identify whether a woman's pelvic proportions can allow for a safe vaginal birth. It measures various diameters and distances in a female pelvis and compares that to the diameter of the fetal head. Female pelvis dimensions can be classified into four general types including gynecoid, anthropoid, android and platypelloid. Gynecoid pelvis is the most prevalent among the females and it has the highest success rate of vaginal delivery. In this practice, the pelvis is palpated through the vagina to feel for the bony landmarks associated with pelvic dimensions. The sequence and accuracy of hand placement are essential to the correct practice of pelvimetry.

Currently, medical educators lack an accurate pelvimetry model to teach medical students the practice of a pelvimetry examination. There is currently no female pelvic model on the market that combines both sensor feedback and accurate simulation of tissue and bony landmarks.

The goal of the project is to create a pelvimetry device that models a female gynecoid pelvis with realistic tissue simulation as well as sensors to detect the accurate performance of pelvimetry. There are three essential parts of the project to ensure a reliable device: a 3D print of a pelvis of good quality with fine details, tissue simulation to ensure accurate palpitation, and sensors and circuit design for optimal feedback. The pelvis is printed from CT scan data provided by UConn Health Center using 3D printing technology. The pelvis model is printed using polymer acrylonitrile butadiene styrene (ABS). The artificial soft tissues including vagina and cervix are fabricated using silicone-based rubber with different hardness. The feedback is obtained through sequential buttons connected through a circuit and controlled by an Arduino microcontroller.

This project will be serving as a fundamental medical device for future clinical pelvimetry training. Future studies could focus on modeling the other three types of pelvises with more advancements in materials fabrication and improvements on sensor feedback design.

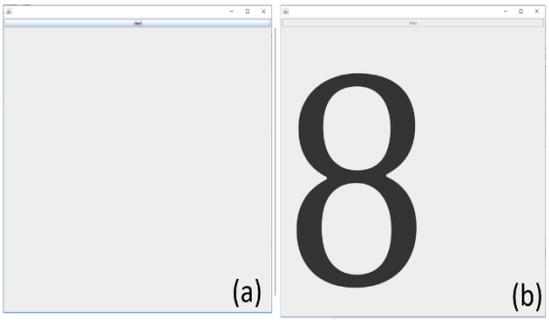
Left to right: Ashley Leung, Disha Mankodi, Masashi Azuma

BIOMEDICAL ENGINEERING

TEAM: 3
SPONSOR: United States Navy
ADVISOR: Ki Chon, Jeffrey Bolkhovsky

Physiological Monitoring of Fatigue and Stress

IMOTIONS®
BIOMETRIC RESEARCH PLATFORM



Professions in the military, in health care, in computer operations, and in other fields often induce fatigue due to a variety of mental and physical activities, which in turn reduces work performance and increases errors. Within the military, and in particular Navy submarines, many stressful hours and situations arise that push soldiers to their utmost limits performing physiologically taxing tasks on a computer. One such factor that influences stress and fatigue is cognitive load, or the amount of mental activity imposed on the working memory of the brain. The working memory is where information is stored before either getting processed into long term memory or being forgotten; it is limited by a certain capacity for holding information.

The objective of this project is to create an inexpensive system that can detect, process, and quantify stressors, particularly cognitive load (CL). CL is induced in subjects through their participation in the Delayed Digit Recall (n-back) Task. The n-back test starts once the participant hits the start button. N is defined as the number the participant needs to recall from N turns back. Only the 1-back and 2-back test are conducted for this experiment as 3-back has a very heavy flooring effect in terms of accuracy. Speed of the appearance of numbers is varied in the n-back test to induce varying cognitive loads. Subjects' facial markers and ocular physiology are collected using iMotions Human Behavior Research Software and Tobii Glasses: Wearable Eye Trackers.

The primary independent variable for this experiment will be # of n and the dependent variables will include pupil dilation, number of incorrect answers, vocal fluctuations, facial changes, and qualitative measure of stress through NASA-TLX. Correlation analysis will be employed to assess the strength of the relationships between independent and dependent variables. The t-test will be used to assess the statistical significance of the computed correlation coefficients (R) (the null hypothesis is that the product moment correlation coefficient is zero).The Bonferroni method will be used for correction of multiple comparisons (ANOVA, Friedman's, and correlation analysis). This analysis will be conducted to understand the correlation between physiological factors and cognitive load.

From left to right: Robert Silverman, Paige Woods, Samuel Ganem, Kyle Bystrianyk, and Bennett Propp

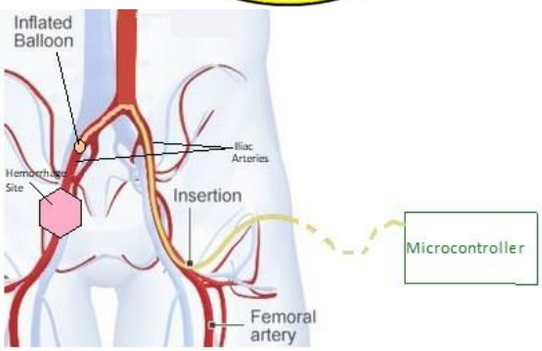
BIOMEDICAL ENGINEERING

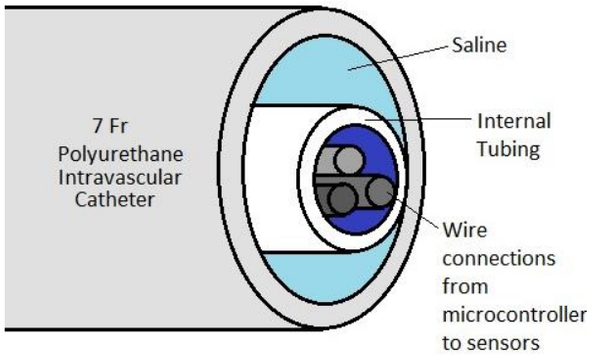
TEAM: 04

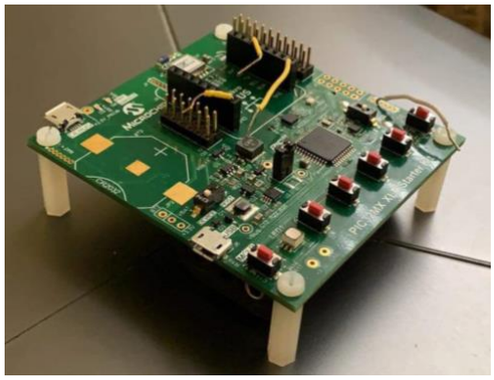
SPONSOR: Naval Submarine Medical Research Laboratory, Lt. Dr. Beardslee

ADVISOR: Dr. Ki Chon

Intravascular Hemorrhage Control Device for Trauma to the Iliac Arteries



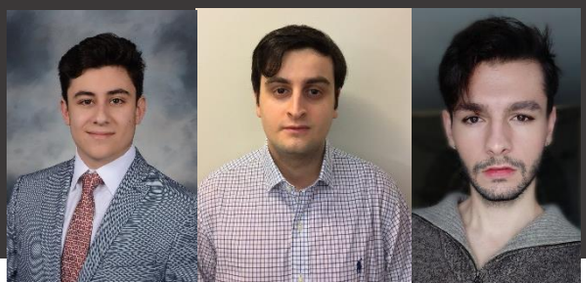




Today, the modern soldier is equipped with every piece of armor and protection that a normal human could possibly have on them. Among those are of course bulletproof vests and helmets. These pieces of equipment can only protect so much of your body and withstand so much force. Therefore it is necessary to identify, when protection fails, how the soldiers are dying. One of the most vulnerable spots in the soldier's armor is the lower abdomen and pelvis, which falls below the protection of the bulletproof vest and must be kept lightly covered for the soldier's mobility. Injuries to the lower abdomen and pelvic area can be devastating to the soldier and fatal if there is external or internal hemorrhaging, because non-compressible torso hemorrhages are very difficult to control and the patient's chance of surviving the transport to a medical facility is low. Unlike a injury to the extremities, bleeding in the torso cannot be controlled with a tourniquet.

For the purpose of this project, we are focusing on external hemorrhages that are due to puncture wounds to the external iliac arteries. This design team aims to improve the system and procedure used for the placement of an intravascular partial occlusion device for the purpose of improving treatment of non-compressible torso hemorrhage. This is done by incorporating pressure and flow sensors and radio frequency identification (RFID) tagging to a catheter with a stent and occlusion balloon on the internal end and a microcontroller to receive the binary RFID response and comparative pressure sensor data on the external end. The RFID is used to specify the location of the occlusion balloon in the artery and the pressure and flow sensors will help determine if the occlusion was successful. The data from these sensors will be transmitted via wiring in the catheter to a microcontroller (project image 3) that is used external to the patient's body.

The device and the system used to deploy it are minimally invasive, portable, and usable by trained medical personnel other than surgeons. Ideally the device would be operable in military field operations, first responder situations, developing communities, and other situations where hospital operating room technology and surgeons are unavailable.



BIOMEDICAL ENGINEERING

TEAM: 05

SPONSOR: University of Connecticut

ADVISOR: Dr. Bin Feng

Left to Right: Dimitrios Georgopalis, Anthony Sayegh, Peter Walczyk

Optimization for a Low-Cost Multi-Channel Neural Recording Device

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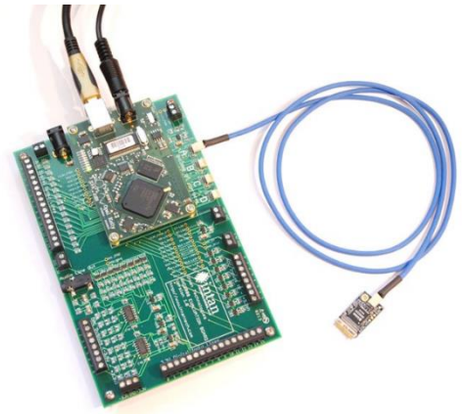

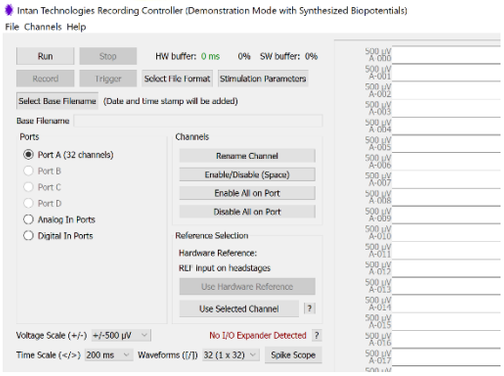

Neural recording devices have been undergoing a metamorphosis of improvement as technology in material science, computing, electronics, and biological analysis have grown. The accuracy and customizability of such devices has led to not only a growth in valuable data and discoveries within neuroscience, but also to the further narrowing of the field to only adequately funded programs and companies. Conducting experimental neural analysis requires high computing, neural acquisition devices, stimulating devices, biological subjects, trained lab members, and more, which results in a painstaking process of subsidizing a budget and retraction of portions of experimentation. Optimization of costs regarding certain tools used in neural recordings will not only open the field to a multitude of less funded project teams, but also increase the accumulation of data in a multitude of analyses. The goal of this project is to reduce overall cost of a recording setup whilst maintaining the viability, accuracy, and user-friendliness of such a station for all researchers.

The cost reduction focused on combining multiple systems components into one package. Components for neural recording systems are all sold separately, and connections are made between them. Component prices vary in expense and the data connections between them vary greatly; resulting in high costs only to be attributed by further costs for stability of data flow. Combination of a stimulus unit, recording unit, user display, GUI, and in-package post computing will physically and monetarily reduce the system. Data flow between components is streamlined, and experimental processing and output is cohesive. Recompiling current software and hardware applications into a Linux based system opened opportunities for easier development, integration, and low-cost alternatives for computing. Results had shown that cross-compilation of such applications was possible and implementation of a software controlled stimulus unit is viable through signal outputs using a BCM2835 processor. Signal outputs are converted through the in-house stimulus generator and can be edited within given parameters. Post processing of recordings is run within the system through a recompiled converter program that cuts out the need of expensive coding applications through a free open-source mathematics and visualization coding software. Reductions in cost vary, however, projected savings to comparable units average 20-30%, to allow further development for experienced labs, or to jumpstart a new one.

BIOMEDICAL ENGINEERING

TEAM: 6
SPONSOR: Hoshino Lab
ADVISOR: Kazunori Hoshino, PhD.

Krishna Dixit, Zoe Moscato, Quinn Shields

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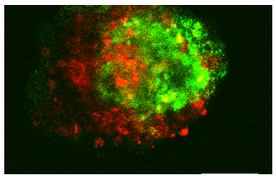
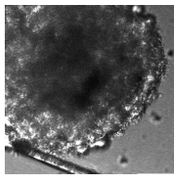
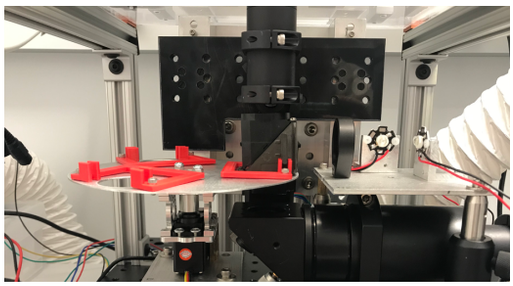
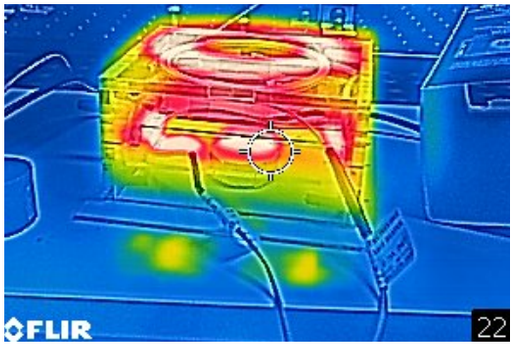
Mechanical Assay for the Evaluation of Breast Cancer Pharmaceuticals









According to the Susan G. Komen Foundation, there will be an estimated 271,270 new cases of invasive breast cancer and 42,260 breast cancer deaths in the United States in 2019. Statistics show that 10% of patients diagnosed with invasive breast cancer die within 5 years of diagnosis. Therefore, it is extremely pertinent to develop a more efficient and accurate system for anti-cancer pharmaceutical development. Current methods use three-dimensional cell colonies, known as spheroids, to model tumors *in vitro*, but face crucial limitations. Our new mechanical assay integrates micromanipulation and fluorescent microscopy to achieve real-time analysis of breast cancer spheroids during pharmaceutical testing.

While the Hoshino lab has quantified the Young's modulus of cancer spheroids, a parameter used to differentiate a healthy cell from a cancerous one, the analysis is currently restricted to end-point measurement only. Under the current method, spheroids must be removed from their sterile environment for analysis, and consequently can only be measured at one time point. Additionally, the spheroids used were composed solely of cancer cells, which do not accurately mimic the *in vivo* interaction of tumors with connective tissues. This can greatly impact the efficacy of drug delivery, and should therefore be taken into consideration for drug testing *in vitro*. This project aims to mitigate these issues through the development of a remote-controlled, sterile incubation system that incorporates novel, biocompatible microtweezers and a three-channel fluorescent microscope to enable real-time micromanipulation and analysis of fibroblast/tumor co-cultured spheroids. The addition of a multi-channel fluorescent microscope enables differentiation of cell types, as well as visualization of the uptake of fluorescent particles. The microscope images gathered can then be processed by the Hoshino lab's unique MATLAB software, which provides a strain map of the spheroid.

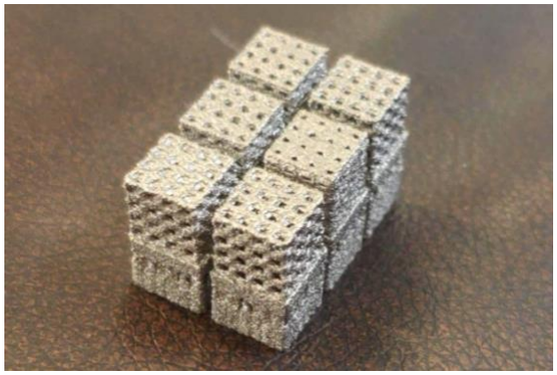
This real-time analysis incubation system will provide a robust experimental platform capable of assessing breast cancer spheroid development through a combination of microscopic and mechanical measurements. This mechanical assay increases the validity of experiments by eliminating confounding variables introduced by the removal of spheroids from their sterile environment, and by allowing multiple measurements to be taken of the same spheroid at different time points. It will decrease the waste of and need for expensive reagents used in current oncological assays, and will overall improve the testing of anti-cancer pharmaceuticals.

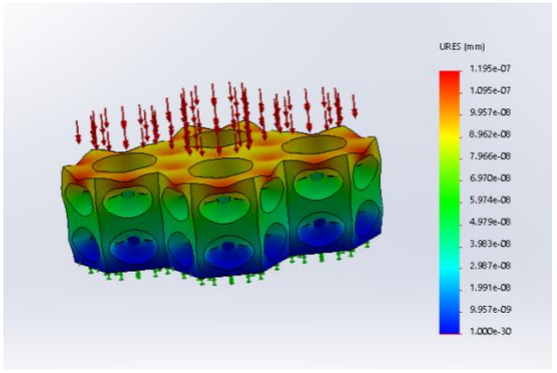
From left to right: Deirdre Hennessy, George Andrews III, Matthew McClintock, Paige Holden

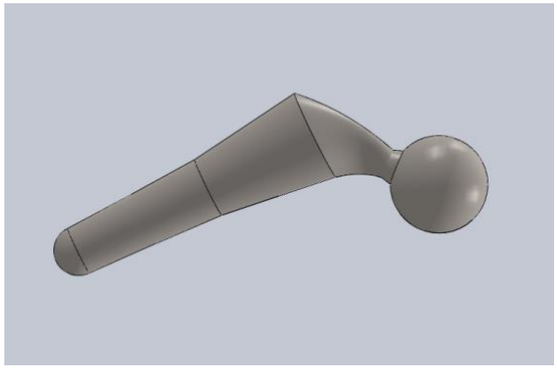
BIOMEDICAL ENGINEERING

TEAM: 7
SPONSOR: Hoshino Lab
ADVISOR: Dr. Kazunori Hoshino

3D Printed Porous Titanium for Smart Implant







In 2016, the American Joint Replacement Registry reported over 480,000 primary knee replacements and over 277,000 primary hip replacements, along with nearly 70,000 revision surgeries between the two joints [1]. This growing population of affected individuals has illustrated a number of limitations of current implant designs including wear due to frictional forces generated during natural motion and stress shielding due to a poor match in mechanical properties between metal and bone. Patients and surgeons alike are advocating for the development of improved products that can diminish or completely eliminate these complications.

This purpose of this project is to optimize major design elements offered by various materials to create a novel hip stem implant. Our hope is to make this implant surgery a more attractive, comfortable option for patients who need it.

The product is a combination of materials and design components that optimize nutrient transport, mechanical strength, and cell ingrowth. Choosing titanium for the implant material lowers the risk of infection due to the biocompatibility of titanium. The multi-scale porous design encourages maximal initial cell attachment and long-term proliferation. Using EBM additive manufacturing allows for an intricate, porous titanium scaffold that will maintain mechanical integrity in addition to lowering production costs and allowing the option of customizability of the implant. The titanium scaffold will be developed to match mechanical properties of the body, thereby preventing stress shielding. A hydroxyapatite coating promises faster cell ingrowth post-implantation, also increasing biocompatibility and reducing infection and rejection rates. A hydrogel core entraps nutrients essential for cell growth to promote increased tissue adhesion to the implant. These aspects together create a wholistic design that addresses the pitfalls in current technology.

Preliminary results from mechanical testing influenced adjustments made to the macroscale pore design. Diffusion analysis studies influenced the pore design on the microscale in order to enhance nutrient and waste transport between pores. *In vitro* cell studies will provide important information for further development of other elements of the design. The conclusion of this project will result in a porous titanium scaffold, optimized for osseointegration and mechanical strength, which can be 3D-printed to match the exact specifications of an individual patient. Ideally, this design will improve the longevity and effectiveness of current metal implants without disrupting well-established implantation procedures.

[1] American Joint Replacement Registry, "2017 Report to the Public About Hip and Knee Replacements," AJRR, Rosemont, 2017.

BIOMEDICAL ENGINEERING

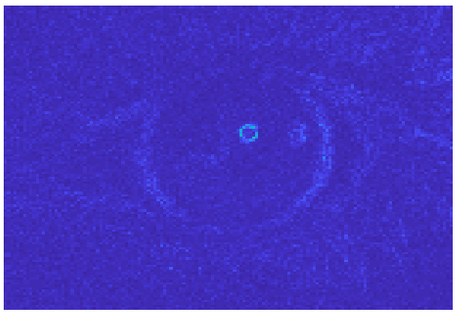
TEAM: 8
SPONSOR: UConn BME Department
ADVISOR: Patrick Kumavor

Smart Phone-Based Eye Tracking Device for Diagnosing Neurological Dysfunctions

Maigh Attre, Alexandra Liberti, and Xiaoqing Leng

Current methods of diagnosis of neurological dysfunctions such as imaging tests require medical professionals and expensive, bulky equipment that is time consuming to use. An alternative method of diagnosis is eye movement tracking. Studying eye movement is a simple way to gain insight into brain functioning because various different regions of the brain are involved in eye movement generation. Rapid eye movement between fixation points, called a saccade, is ideal for characterizing abnormal eye movement and thus neurological dysfunction. Using a smartphone device housed inside a portable goggle-like container, an app will simultaneously play a video to prompt a saccade and record images of the resulting eye movement. Angular displacement and velocity of the eye can then be calculated and compared to baseline healthy values in order to make a diagnosis. This system is portable, requires minimal, durable, and inexpensive equipment, and can be used by anyone – not just medical professionals.

This project aims to allow for automatic velocity and displacement calculation based on static images taken prior to and just after a visual stimulus triggering a saccade. There are many approaches used for this computational analysis. Locational markers on the eye are identified using automated machine learning-based approaches. Other image processing techniques such as filtering are also used in conjunction. Further packaging into a smartphone-based app is currently being explored as well as the further automation of the analysis.



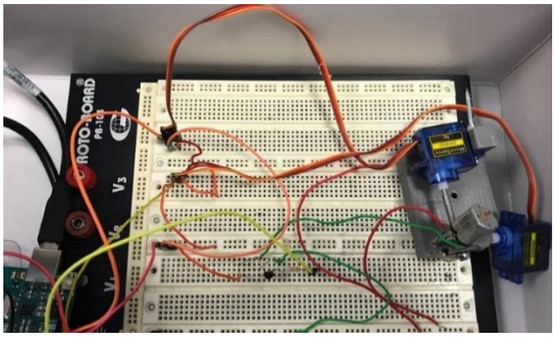
Hardware specifications include a goggle design similar to Google Cardboard which houses a smartphone equipped with the eye movement tracking app. This housing covers the eyes in order to shield external light and includes an LED light source to create contrast in the eye needed for proper pupil detection. It is compact, portable, and functions to minimize the physiological demands on the patient during testing.

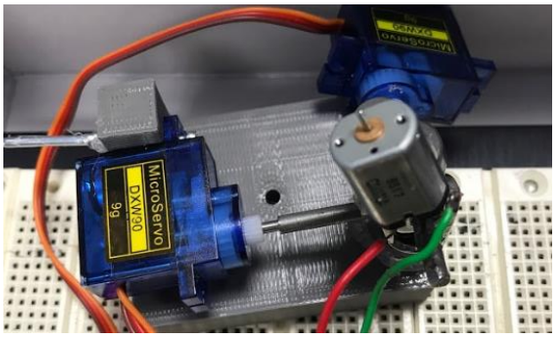
Reese Turovac, Kayanush Mistry, Morgan McKenna, and Katherine Atamanuk (from left to right).

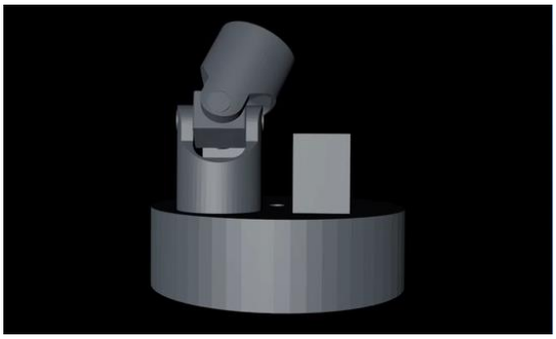
BIOMEDICAL ENGINEERING

TEAM: 9
SPONSOR: ZEISS
ADVISOR: Dr. Sina Shahbazmohamadi

Design and Fabrication of a Universal Sample Holder for Different Microscopy Techniques.







Scientific research can be done on practically any material, any living organism, and any tangible or intangible particle. To do research on a multitude of these items, many tools are used, including various microscopy techniques – from confocal microscopy, to scanning electron microscopy (SEM), to X-ray microscopy. Currently, there is no efficient way to move samples from system to system without having to load the specimen onto multiple sample holders. Being able to freely move between microscopes could revolutionize the field of microscopy. The current market for sample holders is vast, but to date, a single sample holder that can be used for multiple different types of microscopy techniques does not exist. Some companies advertise universal sample holders that are not interchangeable between numerous instruments, but instead are only capable of holding samples of various sizes. To fill the void that exists in this field and to yield a more efficient environment for conducting multiple measurements using various microscopes, a true universal sample holder was designed and fabricated. The goal of this universal sample holder is to seamlessly move a sample from instrument to instrument, whilst maintaining the optimal and desired imaging location on a sample. By using this sample holder, novice and professional users can move the sample in six planes of motion on a multitude of instruments without needing to mount samples multiple times and risk losing the area they wish to image.

Experimental testing using the X-ray system and a microchip sample was performed to determine the optimal imaging angles and adjustments to retrieve the best X-ray images. The microchip was mounted onto the universal sample holder and imaged at a variety of angles and configurations. These results allow for future coding to be done so that the sample holder automatically positions itself into the most ideal position on the X-ray system for any sample. This ability will enable novice users to capture X-ray images without spending hours practicing. In addition to the X-ray experiments, various weights (of a variety of sizes) were used to determine the maximum weight and height of samples that can be loaded onto the universal sample holder. Results from the experimentation showed that standard samples, such as microchips, are well within the constraints of the universal sample holder.

Left to Right: Michael Costello, Ryanne Ramadan, Kevin Side

BIOMEDICAL ENGINEERING

TEAM: BME 10
SPONSOR: UConn BME Department
ADVISOR: Patrick Kumavor

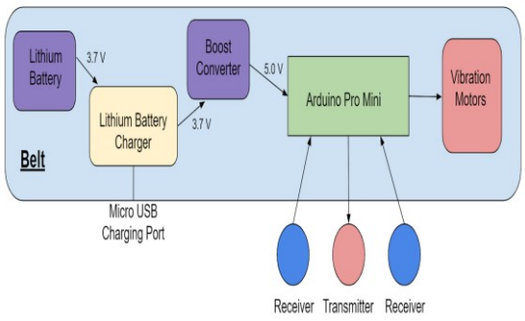
UCONN
UNIVERSITY OF CONNECTICUT

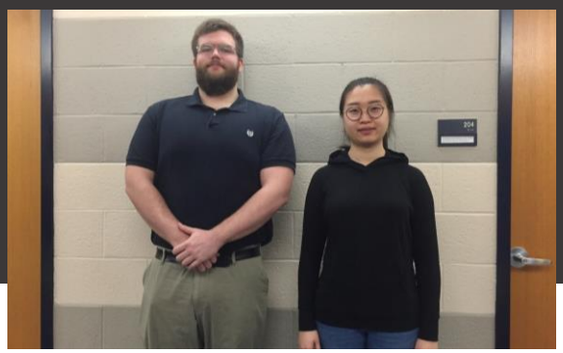
Acoustic-Mediated Wearable Navigation Device

There are many individuals throughout the world without sight and in need of effective methods of navigating their surrounding environment. This project proposes the creation of an acoustic mediated wearable navigation device that will utilize ultrasonic sensors in coordination with vibration motors in order to simultaneously detect obstacles in the user's path and notify them of their location and distance away from the individual. The main features of this device will be a sensor array featuring one transducer and two ultrasonic receivers, a 3.7V lithium battery power source, and six vibration motors spaced throughout a wearable belt that will vibrate in accordance to the location of and distance away from the object that would pose as an obstacle for the user.

The motivation for creating this device is the need for a comfortable, discreet, and more efficient method of navigation for individuals without sight that has the possibility of replacing seeing eye dogs and canes as the primary method for obstacle avoidance. The belt design makes this device very accommodating of all lifestyles and can help fight many of the prominent social stigmas against individuals without sight.

This device is designed to locate objects within a certain range of the wearer using ultrasonic technology. The object triangulation will be modeled after echolocation utilized by animals like bats. Two or more sensors will be placed strategically on the body to gain the optimal field of vision of objects the wearer may interact with or walk into. By using two sensors both the relative distance and direction of the target object may be ascertained. This location information will be fed into a circuit for processing the feedback signal. An auditory or haptic device will alert the wearer of the direction and distance of the object based on the location, intensity, and rate of the feedback signal. The overall system will provide even the most novice wearer to the location of a target object with no visual aid.



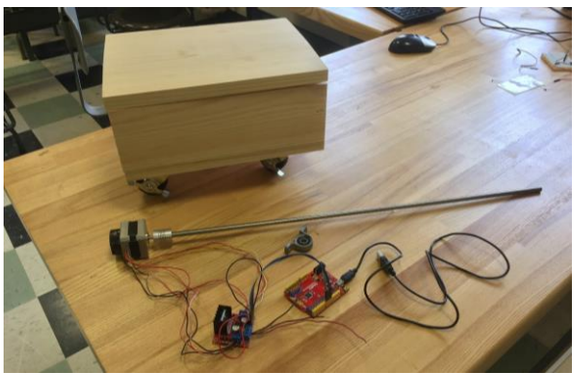


BME Team#11: John Casey (left), Ming Luo (right)

BIOMEDICAL ENGINEERING

TEAM: 11
SPONSOR: YouCOMM LLC.
ADVISOR: Dr. Patrick Kumavor

YouCOMM Mi9 Smart Stand for Patient Communication Devices



Currently, call bell systems are used for health care communication worldwide. Nevertheless, this system has serious constraints such as the possibility of chocking, the lack of accurate information etc. YouCOMM LLC is developing a clinical bedside communication system on a tablet, called YouCOMM Bed M8, to replace the current call bell system, providing a more efficient way for communication in a clinical environment. However, the current stand utilized to support the tablet has a lot of limitations and YouCOMM LLC is seeking the completion and successful operation of a fully operative YouCOMM Mi9 Smart Stand that is controlled by verbal commands or tablet application while preventing from hitting any obstacle in its movement path. YouCOMM is challenging our team to complete a successful and creative design of the product while keeping manufacturing cost and patient safety in perspective.

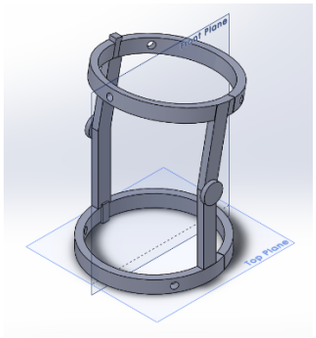
The YouCOMM Mi9 Smart Stand encompasses a sleek movable design, with the knowledges of electrical systems, Raspberry Pi coding, Arduino coding, mechanical systems, material science, motion sensors, and electromechanical motors. It provides two ranges of motion to bring the YouCOMM Bed M8 Tablet closer to the patient. The design itself will rise vertically and motion across the bed horizontally. This will provide optimal use of the product bed M8 product. The ultimate idea of our stand is that a patient that cannot operate many of their extremities can call our system towards them. The YouCOMM Mi9 Smart Stand will be universally appealing to all healthcare facilities including long-term care, rehabilitation, hospitals, and home care. The overall aim of the design will provide a sense of comfort for families and patients knowing that their loved ones are getting close one on one care.

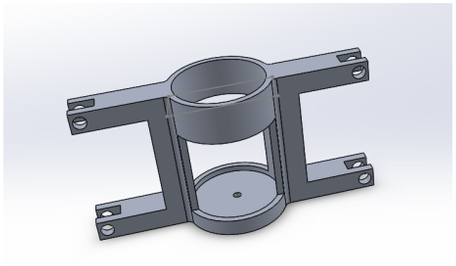
BIOMEDICAL ENGINEERING

TEAM: 12
SPONSOR: University of Connecticut
ADVISOR: Dr. David M. Pierce

Kathryn Morozov, Malik Marseille, Deja Fonseca, Adam Biolsi

Impact Device and Process to Test Cartilage Within Intact Knees





During a car accident or sports injury, the knees often undergo a serious impact. However, the subtleties of low-energy impact loading to articular cartilage in the knee remain largely unknown. Therefore, a need has arisen for experiments and simulations aimed at further understanding the adverse effects within the impact zones. Thus far, it's theorized that low-energy impact loading may initiate post-traumatic osteoarthritis, which has highly negative effects on normal daily activities such as walking and working [1]. Osteoarthritis is a condition that affects over 30 million patients worldwide and a cure has not yet been found [2]. Driven by this need, and lack of full knee impact testing devices suitable for human knees, the team has created a device capable of providing the data researchers' need to further analyze this issue.

Overall, this project focused on the analysis of microcracks in the cartilage of knees, one of the factors that may lead to osteoarthritis. The team created an impact testing device using real bovine knees. The device will allow researchers to drop known masses from specified heights to achieve desired impact energy densities. The team designed, prototyped, tested and created a protocol for operation and maintenance of the device. It is unique in that it is designed to accommodate both complete human and bovine knees as opposed to just small explants of cartilage, as is the case for the majority of current devices in use today. To mimic the in-vivo environment, the team added a water bath to keep the sample in a phosphate buffered saline solution (PBS). Furthermore, in order to properly control the experiment and limit variability in the results, the device allowed for controlling the flexion angle of the knee. This also helps improve the *in-vivo* like qualities of the device since the knee can be fixed to specific positions which represent the effects of different actions such as jumping or walking, rather than simply a straight, locked knee. With all these added features, this impact device will play a great role in future research regarding micocracks in articular cartilage.

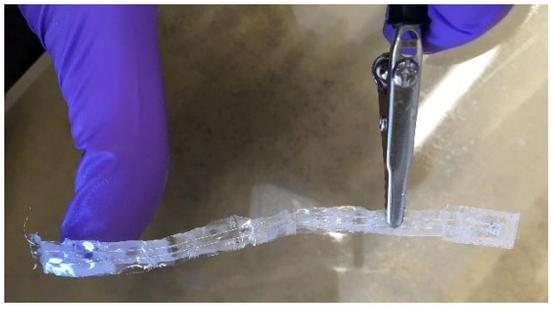
[1] C. C. Scott and K. A. Athanasiou, "Mechanical Impact and Articular Cartilage," *Critical Reviews™ in Biomedical Engineering*, vol. 34, no. 5, pp. 347–378, 2006.
[2] "Osteoarthritis Treatment," *www.arthritis.org*. [Online]

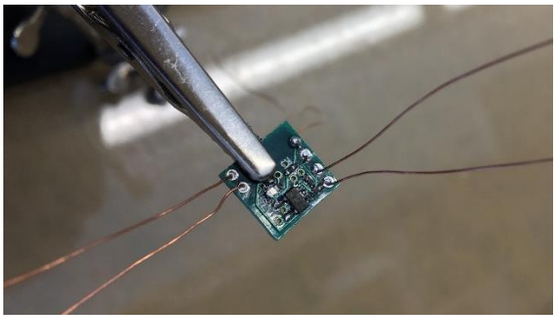
Damini Chelladurai and Anna Mechler

BIOMEDICAL ENGINEERING

TEAM: 13
SPONSOR: Dyadic Innovations
ADVISOR: Dr. R. Lucas, Dr. P. Kumavor

Breastfeeding Diagnostic Device

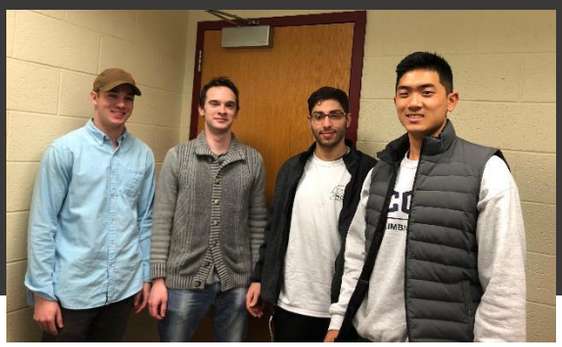




Breastfeeding an infant during the first six months after birth is important for the health and growth of the child. Breast milk contains all the necessary nutrients that a baby would need and protects against diseases and infections. The components of breast milk are also easily digestible for the baby. However, for a new mother, breastfeeding can be a challenge because it is difficult to determine how well the baby is feeding. This causes some mothers to switch over to formula within the first six months. In addition, for unhealthy newborns, knowing how well the baby is breastfeeding is important to understand whether the newborn is obtaining enough nutrients. This period of infancy is a crucial developmental stage for a baby and being able to collect data on how well the baby is breastfeeding can contribute to future therapies, treatments and help new mothers learn how to properly breastfeed their babies.

This project aims to create a device prototype that can measure the biomechanical markers of infant's jaw movement, intraoral pressure changes, contact force of infant nose, lip and jaw at the maternal breast and changes in breast turgor before, during and after a breastfeeding session. The end goal is to be able to use this device in conjunction with physiological measurements in the Neonatal Intensive Care Unit with unhealthy babies to improve growth and development.

The piezoelectric force sensors will be placed between the gum and lips of an infant's mouth as well on the breast of the mother. The force sensors are made with an electrospun piezoelectric component as well as NDA protected electrodes and a polymer encapsulating material. They will work in conjunction with the printed circuit board and the Bluetooth sensor to transmit data to a computer or smartphone for further physician analysis.



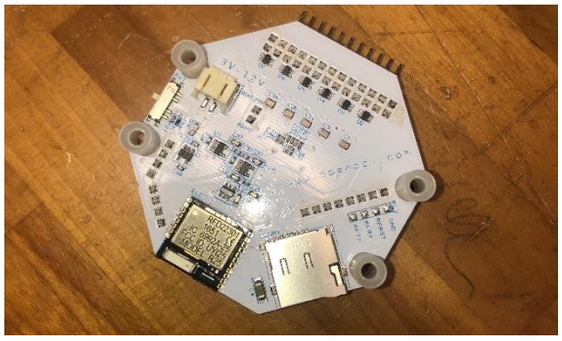
Left to right: Noah Kennedy, Cristian Barba, John Marji, Eric Pan

BIOMEDICAL ENGINEERING

TEAM: 14
SPONSOR: Institute for Collaboration on Health, Intervention, and Policy (InCHIP)
ADVISOR: Dr. Insoo Kim

Wearable technology for fatigue monitoring

Fatigue is a risk to a blue collar worker's safety and general health. At a higher level investors and insurance companies are beginning to see the impact of their workers' general health and safety on production and revenue. Fatigue can, and likely will impair a worker's ability to perform their duties safely. Fatigue is known to impair workplace performance in areas such as alertness, emotional stability, mental ability, and physical ability.
This sudden spike interest can mainly be attributed to the production being lost when a worker is injured or makes a mistake due to fatigue. The National Safety Council estimates that fatigue "cost employers about $136 billion a year in health-related lost productivity" [1]



For fatigue monitoring, our team has evaluated background research to explain what and how both fatigue and recovery take place and how they are currently tracked. Our project aims to tackle the problem of fatigue in the labor workforce in an attempt to limit the amount of workplace accidents among manual laborers. For this project, the goal is to create and test a real time working system which will compare metrics relatively to determine fatigue in workers. Major outputs from the system will include muscle recovery, fatigue monitoring, and fatigue magnitude. Inputs to be analyzed will primarily include continuous electromyography signals filtered through specific versions of Laplace transforms such as Power Spectral Density (PSD) to determine these outputs.

All present and future instrumentation will use surface electromyogram sensors to attain our data for our findings. Our preliminary findings show
that fatigue readings have a direct relation with the associated recovery time needed to be able to perform a job in the safest manner.
The real-time working system will include multiple surface-electromyogram (sEMG) sensors. The system will incorporate the NIOSH lifting equations as well as other proposed research to determine both the fatigue status and the recovery time of manual labor workers' muscles. We then aim to construct a mathematical model capable of determining muscle recovery, determine the correlation between magnitude of fatigue of recovery time.

The main physical design goal is to integrate such a system into a compression shirt which will be convenient to wear for manual laborers and not impede the movements necessary for general lifting.

Team 15: Joshua Moscow, Alyson March, Peter Disabella

BIOMEDICAL ENGINEERING

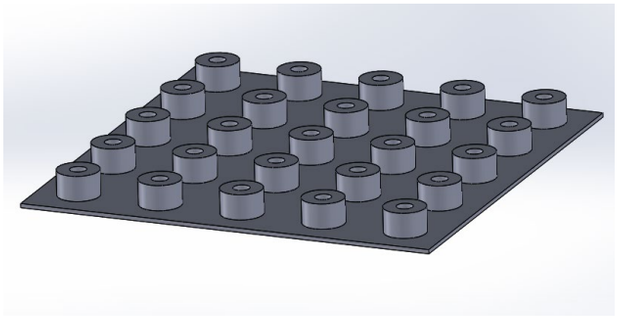
TEAM: 15

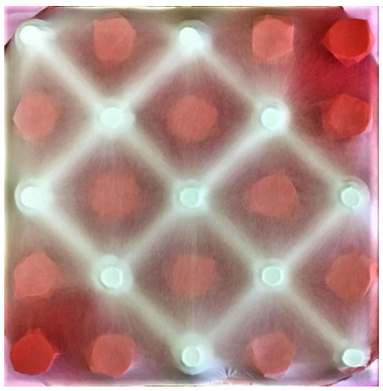
SPONSOR: Dr. Kumbar Laboratory, UConn Health

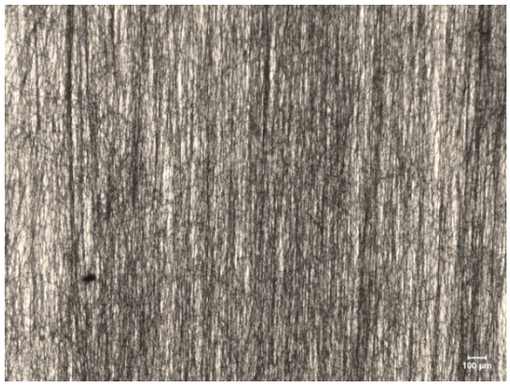
ADVISOR: Sangamesh G. Kumbar, Ph.D.

Device for Electrospun Fiber Orientation

UCONN HEALTH







Biomaterial scaffolds are a key aspect of tissue engineering which provide mechanical support and surface cues to promote cell attachment, proliferation and differentiation. Electrospun fiber matrices closely mimic the native extracellular matrix structurally and can be made with numerous materials. Fiber diameter and their orientation within the fiber matrix plays a significant role in the resulting matrix mechanical strength and greatly influence the cellular growth and orientation. Applied electrical potential ejects the fiber jets from the polymer droplet which are collected at the static target in random fashion. Alternatively, targeting a rotating mandrel at a very high speed allows creation of fiber matrices aligned along a particular orientation. Neither approach provides a way to create complex designs within a fiber matrix or create different repeat patterns. Therefore, the primary purpose of our project is to design a static collector target that presents controlled charge density to collect fiber matrices in defined orientations. The newly designed target presents several patterned ground electrodes to control the charge density. Altering these densities and distances between electrodes allows creation of different fiber patterns. This works by creating points of high charge density which attract the fibers ejected from the syringe, forcing them to selectively attach on the target causing a non-random angle of orientation. One distribution of the electrodes we have tested consists of the electrodes alternating in a 5 by 5 grid, such that the electrodes are closest along a diagonal. With the applied electrical potential of 15kv, the orientation of the fibers aligns with this diagonal created between the electrodes in a repeated pattern. For this electrospinning application, we are using a solution of 12.5% (w/v) polycaprolactone and cellulose acetate at a solid ratio of 80:20. Altering both target configuration and electrospinning parameters enables the creation of a wide range of fiber matrices. Ongoing studies are testing different target patterns and electrospinning parameters to analyze the fiber diameters and their orientations with an intention of creating predictive models. Additionally, we plan to seed these scaffolds with neuronal progenitors to see the effect of fiber diameter and orientation on their alignment and proliferation with the aim of being able to emulate complex neuronal networks which could have applications in studying cell-matrix interaction and tissue engineering.

Devon Thompson, Julia Podsen, Yannis Halkiadakis, Prateek Rana, and Kyle-Gabriel Tan.

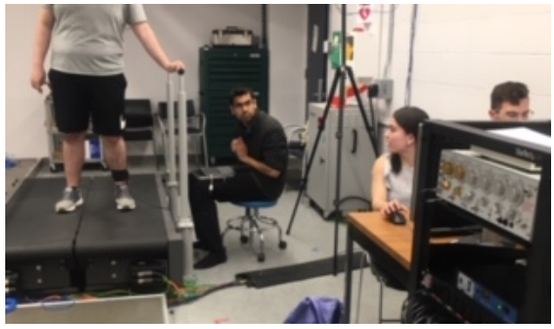
BIOMEDICAL ENGINEERING

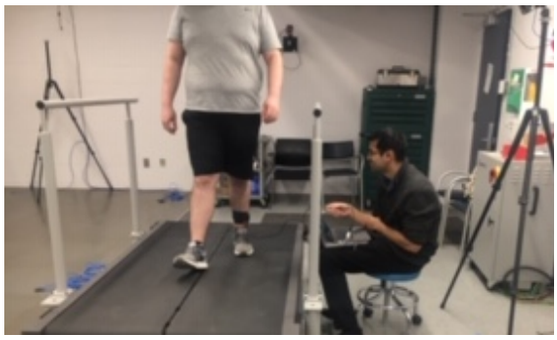
TEAM: 16
SPONSOR: General Dynamics Electric Boat
ADVISOR: Dr. Kristin Morgan

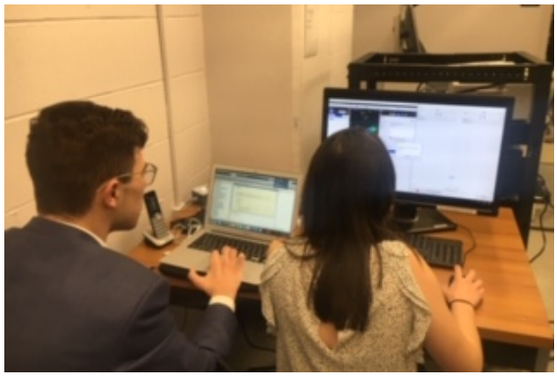
Data visualization integrated with wearable technology to identify alternate motor control strategies

GENERAL DYNAMICS
Electric Boat

The objective of our project was to differentiate between normal and abnormal gait patterns using sound in real-time. This project, which was sponsored by General Dynamics Electric Boat, involved constructing an acoustic sensor and analyzing the acoustic signal to detect differences in movement dynamics. To delineate between healthy and pathological gait, we conducted an experimental study where healthy controls and individuals with lower extremity injuries performed an asymmetric walking protocol. To validate our sensor data, we simultaneously collected joint kinematic and ground reaction force data using a 12 camera VICON motion capture system and Bertec instrumented split-belt treadmill. We then extracted time and frequency domain metrics from our acoustic signal and created an injury classification algorithm to delineate between those with healthy and pathological gait. The significance of this project was to develop a low-cost, non-invasive wearable device to detect movement abnormalities in individuals. Future work will see this device evolve into an early diagnostic tool to detect the early onset of fatigue and lower extremity injuries.







Our project involves using sound to differentiate between healthy gait, pathological gait, and fatigued gait. We are using real time analysis to differentiate between normal (healthy) walking patterns and abnormal walking patterns. These abnormal walking patterns may consist of pathological disorders, patellofemoral pain, or ACL injuries. We are creating a wearable sensor that collects sound data through a microphone. This data will use audio frequencies to differentiate between normal and abnormal gait in real-time. The data will gather heel-on and toe-off sound frequencies that will characterize the participants gait pattern and parameters. With a wearable device, there is a need for low-cost solutions that can be utilized by the common person. Sound is a prime solution for a low-cost injury detection device since audio data yields frequency data that can be analyzed in real time in order to determine gait parameters. Additionally, it will allow for the monitoring of fatigue in individuals wearing the sensor, thus preventing a possible fatigue related injury. The goal of this project is to be able to discern between abnormal and normal gait patterns. We wish to take it a step further and be able to discern between different injuries and disorders using the parameters of gait.

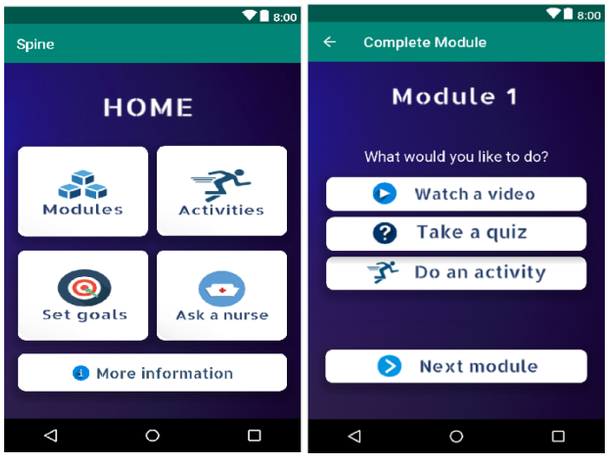
Alexa Kiernan, Amanda Johnson, Jeffrey DePinto Jr., Nicholas Monaco.

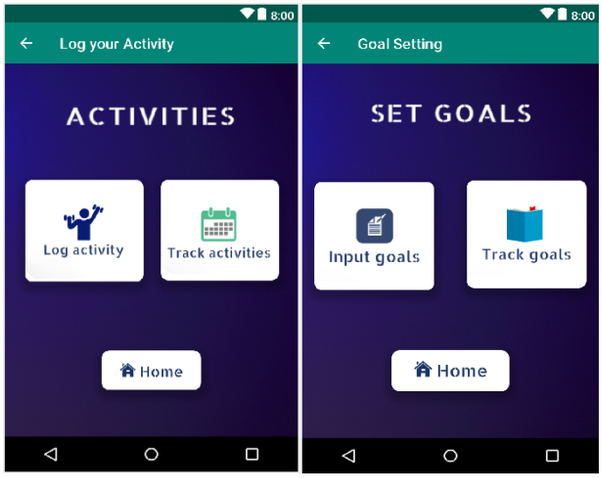
BIOMEDICAL ENGINEERING

TEAM: 17
SPONSOR: Dr. Kyounghae Kim (UConn SON)
ADVISOR: Dr. Guoan Zheng

UCONN
SCHOOL OF NURSING

Development of a SPINE Mobile Application to Improve Low Back Pain Self-Management





At any moment, about 31 million Americans experience lower back pain (LBP), and to treat this pain Americans spend about $50 billion per year. Individuals with LBP often seek medical attention which can become more costly than effective. There is a need to develop LBP treatment methods that can save individuals from time, money, and pain. LBP can be categorized as acute or chronic (lasting for 3 out of the last 6 months). A third of those with acute LBP who seek treatment report chronic LBP one year later. Mobile applications (apps) have been introduced to provide self-treatment to those suffering with LBP, but no study has been done focusing on self-management of acute LBP at risk of becoming chronic.

The goal of this project was to design and develop a mobile app to improve pain self-management and prevent the progression of acute LBP to chronic LBP in individuals ages 45-65 when chronic LBP susceptibility peaks. The app contains informative self-monitoring tools based off a theory-based, acute LBP self-management intervention: Sensitivity to Pain IN Me (SPINE). SPINE was originally set up as a web-based intervention program but was adapted to a more user-friendly and feasible mobile format (SPINE-M) to allow patients to meet their health care needs at the convenience of their own home or work. SPINE-M includes a section for learning modules, an activity and pain log, asking a nurse questions, goal-setting for motivation purposes, a game, and more information/resources. The previously web-based SPINE video modules were incorporated into the app to increase the individuals' pain self-management knowledge and self-efficacy and provide activities to enhance their learning. The app was developed using Android Studio and participant data will be stored on Amazon Web Services (AWS).

SPINE-M will be evaluated on usability to determine the participants' satisfaction in regards to easiness and acceptability. In functionality testing where participants use the app for 3 months, the goal is that participants will have a higher self-efficacy, higher self-regulation, higher levels of activation, and higher levels of coping, which then improve their physical activity and reduce pain. By building self-management skills through SPINE-M, the participants can prevent transitioning into chronic LBP which would significantly decrease their productivity and quality of life.

BIOMEDICAL ENGINEERING

TEAM: 18

SPONSOR: University of Connecticut

ADVISOR: Sabato Santaniello & Heather Read

Kevin Wu, Farrell Brown, Tanya Dimitrov, Kevin Cox

An EEG-Based Decision Support System for the Diagnosis of Epilepsy

Epilepsy is one of the most common and debilitating neurological disorders in the United States. It is diagnosed using routine scalp electroencephalography (EEG), which a clinician must search through by hand to mark short, pathological waveforms called interictal epileptiform discharges (IEDs). This process is time-consuming, especially when the EEG recording must last overnight or several days. The objective of the project is to develop a machine-learning based decision support system that automatically detects and presents IEDs to the clinician in real time.

Another analysis that may be used for diagnosis of epilepsy is changes in the morphology of Auditory Evoked Potentials (AEPs). These waveforms can be detected on frontal lobe EEG recordings when a short broadband sound is played. Changes in the morphology of this waveform may indicate a pathology that is useful for diagnosis. Therefore, our device will detect AEPs in real time and presents the clinician with the morphology of the waveforms.

Our design consists of two machine learning architectures (Figure 1) that operate in parallel to classify incoming EEG waveforms as IED and AEP events. The incoming EEG data will be analyzed in 600ms-long segments, the typical length of an IED. The IED detection module implements a template-based classification approach (Figure 2A). The templates are identified offline by combining multivariate feature computation, unsupervised feature-based clustering (DBSCAN algorithm), and modularity maximization (Louvain algorithm). The module of our system that detects AEP events implements a supervised classification approach (Figure 2B), which combines multivariate feature computation and support vector machine classification.

Our architecture was developed and tested on two rich datasets of multichannel EEG recordings. The IED detector is developed on 18-channel scalp EEG recordings from 33 children (age 2-16 y/o) collected at the Connecticut Children Medical Center in Hartford, CT (collaborator: Mark Schomer, MD). The AEP detector is developed using single-channel EEG recordings from 8 adults performing a standard auditory test and included in the public database PhysioNet [1, 2]. This detection algorithm was validated on single-channel EEG recordings collected on 4 adults with a sound stimulus presented through etymotic ER3 shielded transducer headphones (Figure 3). The AEP data was collected at the Cognitive Sciences Shared Electrophysiology Resource Lab (CSSERL) at the University of Connecticut.

[1] Silva & Epstein. J. Acoust. Soc. Am. 127(6):3629-3642; 2010.

[2] Goldberger et al, PhysioBank, PhysioToolkit, and PhysioNet: Components of a New Research Resource for Complex Physiologic Signals. Circulation 101(23):e215-e220; 2000.

Figure 1: Signal Classification Architecture

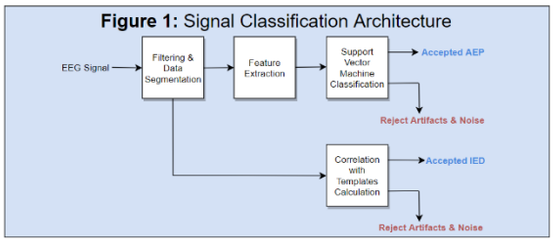


Figure 2: Machine Learning Training Routine

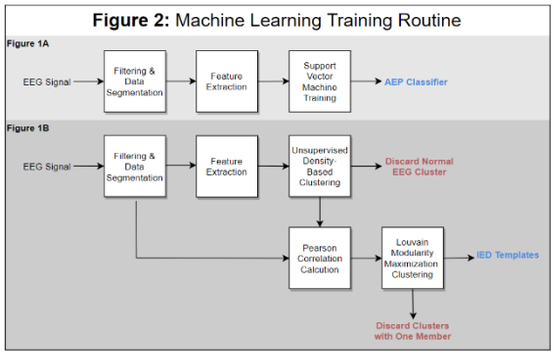
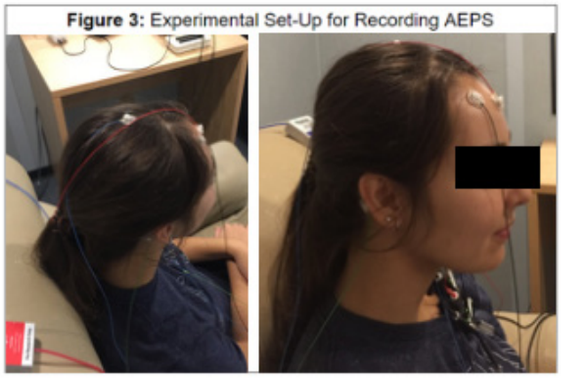


Figure 3: Experimental Set-Up for Recording AEPS



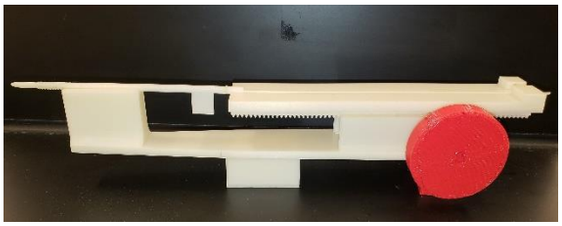
Back Row (L to R): I'jaaz Muhammad, Kendall Clark, Patrick Conroy.
Front Row (L to R): Emma Atkinson, Elaina Becher

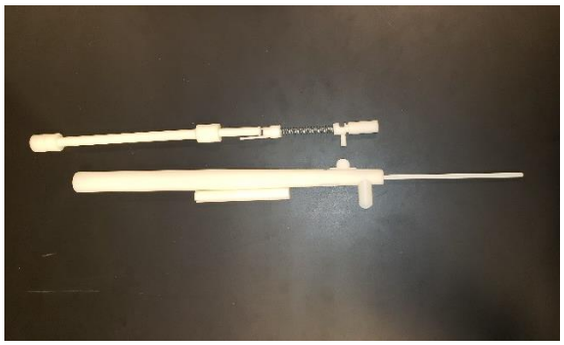
BIOMEDICAL ENGINEERING

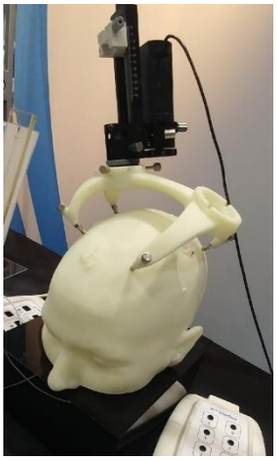
TEAM: 19
SPONSOR: Dr. Martin Han
ADVISOR: Dr. Martin Han

UConn Implantable NeuroTechnologies
Building 3D-Printed Surgical Inserters To Deliver Implantable Microelectrodes

Deep Brain and Intracortical Microelectrode Array Implantation Surgical Tools Development







[1]

Parkinson's Disease, spinal cord injuries, depression, obsessive compulsive disorder, loss of limb movement, and even bladder control are only some of the issues that can arise due to the loss of signals in or from/to the brain. Neural interface technologies, such as implantable microelectrodes, can provide therapies to treat symptoms neurological disorders in order to improve the quality of life of people struggling with these disorders. This project focuses on developing two surgical tools for the implantation of microelectrode arrays into the brain. One of the tools is characterized by slow insertion, which is surgically used for deep brain implantation of the microelectrode arrays. Potential clinical applications include tremors, Parkinson's disease, dystonia, severe depression, or other movement or neurological conditions. The second tool is used for fast insertion into the grey matter of the cerebral cortex. Potential applications include brain-machine interface for paraplegia and visual and auditory cortical prostheses.

The surgical tools developed in this project are used to help conduct preclinical research for the placement of microelectrodes in the rodents, which, subsequently may be scaled up for human surgeries. The biggest considerations we had when designing these tools were speed of insertion, insertion force, as well as measuring the displacement of the microelectrode. To do this we utilized Arduino, a displacement sensor, and a load cell. Our objectives included aiming for the tools to be user-friendly, reliable, sterilizable, modular, measurable, cost-effective, safe, and universal. We also had constraints that the tools need to be nontoxic and fit in a standard stereotactic coordinate system. A mock brain model composed of agar and a thin silicone layer, to simulate the strong dura covering the brain, were made for testing the instruments. We will test the surgical instruments my implanting microelectrodes into the mock brain model to obtain results about implantation speed, depth, and accuracy. This design process will ultimately lead to the development of two successful surgical implantation instruments for fast and slow implantation of electrodes for the benefit of neurological diseases.

References

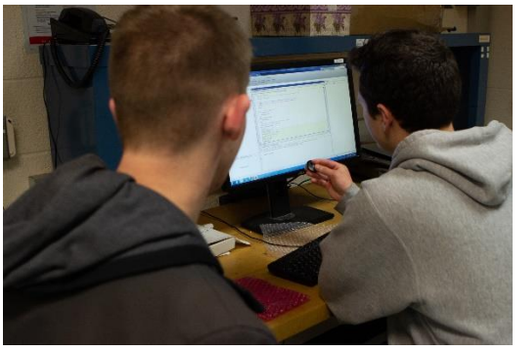
[1]"Surgical Instruments, new and refurbished Surgical Instruments", *Future Health Concepts*, 2019. [Online]. Available: https://www.futurehealthconcepts.com/surgical-instruments/. [Accessed: 04- Feb- 2019].

Left to Right: Jenna Clum-Russell, Tim Gutowski, Chris Imbriaco, Jared Hill

BIOMEDICAL ENGINEERING

TEAM: 20
SPONSOR: CCMC
ADVISOR: Matthew Solomito

Wearable Sensor to Track High Velocity Baseball Pitches for UCL Injury Prevention



Ulnar Collateral Ligament (UCL) injuries are among the most common and severe injuries that a baseball pitcher can sustain. Surgery to reconstruct the UCL, often referred to as “Tommy John Surgery”, involves replacing the torn ligament with a healthy tendon from another part of the body. The surgery requires an immense amount of recovery time and effort, and it is usually detrimental to the pitcher’s performance and ultimate success in the future. Overuse is known to be one of the primary contributing factors to UCL damage, and this damage often begins to occur long before symptoms are noticed. Many pitchers begin training at very young ages, often supplementing their team’s regular practices with private pitching lessons and other throwing practices during their team’s off-days. It is crucial to allow your body to heal in between pitching sessions, especially at a young age while your body is developing. Throwing an extreme number of high velocity pitches without allowing your body to rest and recover puts unnecessary stresses on the UCL which may gradually lead to an ultimate tear in the ligament.

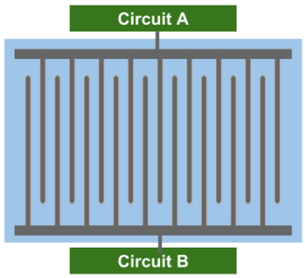
This project is focused on the development of a wearable device that is capable of accurately tracking high velocity throws performed by baseball pitchers throughout an entire baseball season, including those thrown in practice, games, and in the bullpen. It is essential that the device is able to differentiate between lower velocity throws and high velocity throws, which are approximately 80% or greater of the pitcher’s maximum velocity. Contrary to lower velocity throws, high velocity throws contribute to the overuse of the UCL because they cause a substantial amount of stress on the ligament. Our device will use a triaxial accelerometer and a gyroscope to gather raw data about the speed of the pitcher’s throwing arm during pitching. A built-in Bluetooth device will relay the data to an application which converts the data into a more practical and readable form. The application will keep a high velocity pitch count throughout a designated time period and will notify the coach when the pitcher’s maximum pitch count is approaching. This is useful because the coach will be able to utilize the pitcher efficiently and effectively without compromising the pitcher’s health and safety.

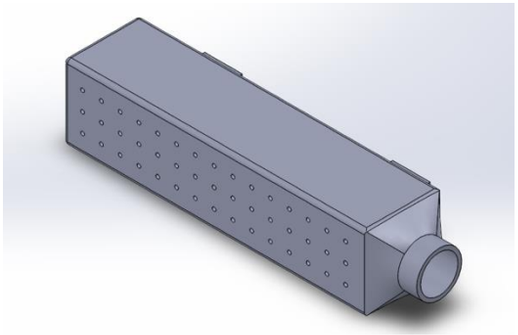
Kyle Trocki, Megan Heline, Ryan Padden

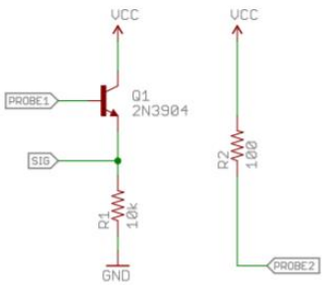
BIOMEDICAL ENGINEERING

TEAM: 21
SPONSOR: University of Connecticut
ADVISOR: Patrick Kumavor

Autonomous Portable Cleaning System for Incontinent Inpatients







In light of the increasing population of the elderly and disabled, both long-term and short-term care units need new methods of hygienic care to free up caregivers' time while promoting privacy and dignity for patients. Hygiene is essential for patients in order to maintain their highest quality of life. Often patients who suffer from fecal incontinence have accidents that go undetected for far too long. Continually sitting in feces is extremely unsanitary and can cause additional health issues for patients. Our device is focused on assisting those that are mobility impaired suffering from fecal incontinence within the hospital setting.

The device will detect accidents using a multi-pronged moisture sensor system, which will alert nurses an accident has occurred. The sensors detect changes in resistivity due to moisture that coincides with an accident. The sensors will be imbedded into a mat to keep the bed dry and contain the mess while constantly monitoring the moisture level under the patient. Once an accident has been detected nurses are alerted and they will confirm that an accident has occurred. Once confirmed, the patient is positioned for the autonomous cleaner to begin its cleaning process. A pulley system positions the patient on their back with their knees and hips at a 90-degree angle allowing the device access to effectively clean the patient.

Once the device has been set up, ultrasound sensors will be used to determine where the patient is located on the bed to properly position the cleaning apparatus. This will prevent water waste and excess cleaning or cleaning the wrong area of the patient. The cleaning mechanism implements a custom designed sprayer head attached to linear actuators. The sprayers have two-dimensional motion and are programmed algorithmically to clean according to the dimensions determined by the ultrasound sensing system. Customizable cleaning cycles for the patient can be designed.

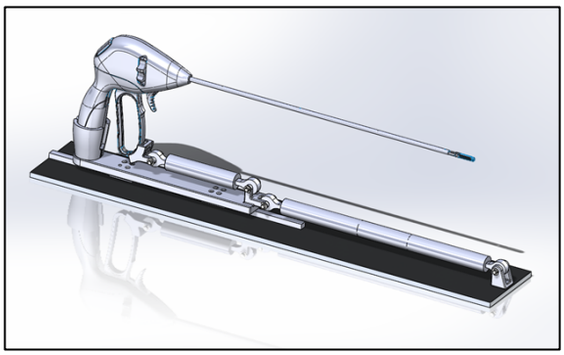
This device will improve the hygiene, comfort, and quality of life for any patients suffering from fecal incontinence.

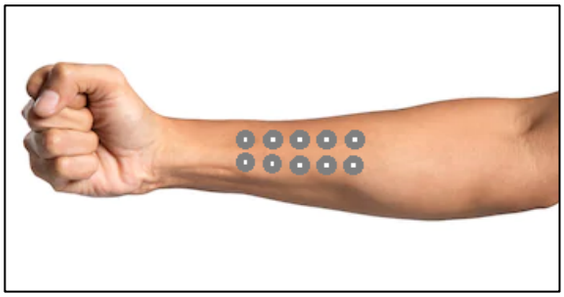
From left to right: Sneha Nalla, Jonathan Plourde, Victoria Blair

BIOMEDICAL ENGINEERING

TEAM: 22
SPONSOR: Medtronic
ADVISOR: Dr. Insoo Kim

Implementation of a Real-Time Haptic Feedback System for Laparoscopic Surgery





Current medical devices used for laparoscopic surgery provide a minimally invasive way for surgeons to operate on their patients without having to make a large incision. The LigaSure™ Blunt Tip Jaw is an example of one of the tools used during laparoscopic surgery that allows the surgeon to manipulate tissue. However, these devices often have drawbacks due to the lack of feedback since the handle and shaft form a physical separation between the surgeon and the patient. This separation has been shown to lead to errors that are not usually seen in traditional surgical techniques [1]. Although some surgeons argue that visual feedback is sufficient, there are concerns about unnecessary tissue damage from inaccurate application of force [2]. Incorporating a haptic feedback system would provide surgeons with a secondary input of information to ensure they are safely manipulating tissue while using such devices. The goal for this system is to measure the forces applied to the tissue by the jaw and relay this information wirelessly through vibrational stimulation. This instantaneous feedback will inform the surgeon of the amount of force they are applying to the tissue in order to prevent tissue damage.

This haptic feedback system is composed of two complimentary platforms that communicate in real-time through various functional subunits. This design allows a surgeon to operate in a different room while experiencing the sensations felt during traditional surgery. The user-interactive platform collects displacement for the back and forth movement of the device as well as the opening and closing of the jaw. The mimicking platform receives information wirelessly from the user-interactive platform via Bluetooth module wired to an Arduino board located within each handle. The laparoscopic device mounted to the mimicking platform moves in real-time via electric actuators in response to these commands. The jaw subunit functions as a key component to the mimicking platform since it directly measures the force applied to the tissue. A FlexiForce sensor is mounted to the modified jaw of the laparoscopic device and as the jaw closes around tissue, the force applied to the jaw is constantly monitored. The data gathered from both platforms is processed using an Arduino and Bluetooth subunit to provide the appropriate vibrational feedback to the user-interactive side of the system. An array of vibrational motors located on the surgeon's forearm is used to create intuitive patterns correlating to the forces applied to the tissue.

[1] Okamura, Allison M. "Haptic feedback in robot-assisted minimally invasive surgery" Current Opinion in Urology vol. 19,1 (2009): 102-7.
[2] Reiley, Carol E et al. "Effects of visual force feedback on robot-assisted surgical task performance" Journal of thoracic and cardiovascular surgery vol. 135,1 (2008): 196-202.

From left to right: Ashwin Karakal, William Hunt, Sidhant Athilat, Laura Sacco, Alexander Tkeshelashvili

BIOMEDICAL ENGINEERING

TEAM: 23

SPONSOR: Biomedical Engineering Department

ADVISOR: Krystyna Gielo-Perczak

Localized Vibrational Therapy of the arm for people with movement disorders

This project aims to create a device that can be used to assess the effects of a novel therapeutic method on individuals suffering from a wide variety of movement disorders. Current research suggests that there are two primary methods of treatment for symptoms associated with movement disorders: one treatment involves surgery and the other involves stimulus of the target muscle groups. This study focuses on the latter method, employing vibrational therapy to activate certain muscle groups responsible for the bulk of the issues presented by movement disorders. The eventual goal of this project is to assemble a full-arm brace that demonstrates improved arm muscle grip, wrist flexion and elbow flexion in subjects after six weeks of therapy. Movement Disorders on the whole are often caused by defects in the parts of the brain and/or nervous system that control coordinated movement. These defects in turn produce issues that predominantly arise during childhood and may cause difficulties in hearing, swallowing, speaking, vision, and motor function. Over the course of life for an individual with a movement disorder, their increasing inability to perform certain tasks paired with gradual atrophy caused the disuse of certain parts of the body result in a cycle that further weakens the individual's musculature and impairs their function. The hands are particularly susceptible to these functional issues, with vital everyday tasks like grasping and fine motor control heavily affected.

This full arm brace provides support and relief during everyday activities for those who have movement disorders. The device is intended to facilitate improvement in coordination, muscle power, and overall range of motion. Designed to be adjustable, the device can accommodate almost anyone no matter their size or condition. The overall design of the device incorporates a sleeve-type arm brace with localized muscle vibrational stimulators. Localizing vibration therapy to strategic spots within a brace represents a novel approach in improving muscle function for individuals with inhibited movement in the arm. To accommodate for the changed objectives in muscle activity, the brace design encompasses the forearm, elbow and upper arm, allowing for the vibrational motors to address more muscles.

The three project goals of increasing muscle interaction in patients, advancing device design and vibrational therapy regimes, and improving overall commercial potential look to refine an already reputable design.

BME Team #24: James Welch, Mitchell DuBuc, Alex Draper

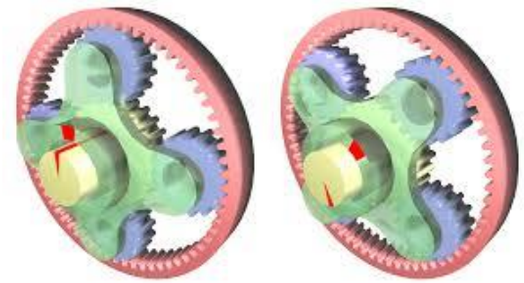
BIOMEDICAL ENGINEERING

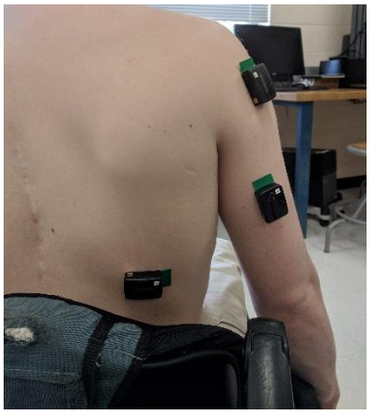
TEAM: 24

SPONSORS: Rowheels Inc., Numotion

ADVISOR: Dr. Krystyna Gielo-Perczak

Individualized Validation Method of Reverse and Conventional Manual Wheelchair Propulsion





A wide variety of disabilities necessitate the use of a wheelchair to ensure that the user retains their mobility. A great number of wheelchair users rely on manual wheelchairs in order to complete many of their ADLs (activities of daily living). The use of a manual wheelchair for an extended period of time can lead to a number of different upper extremity injuries. The most common injury seen is pain in the shoulders due to shoulder impingement. Injuries such as this lead more difficulty in maneuvering the wheelchair and an overall decrease in the mobility and independence of the user. Conventional push propulsion of a manual wheelchair causes a great deal of stress on the front of the shoulders and is the main cause for this shoulder impingement.

Rowheels Inc, based out of Wisconsin, has developed a set of manual wheelchair wheels that utilize a planetary gearing system (left) in order to reverse the direction of propulsion. Pulling, or rowing, motion has shown potential for reducing the stress seen at the front of the shoulder and reducing pain in manual wheelchair users.

Our group aims to propose a method of evaluation for an individual wheelchair user. We will measure muscle activation, acceleration, and mobility of users in both wheelchairs using conventional manual propulsion and state of the art manual reverse row propulsion. We plan to test multiple participants who have an array of disabilities that utilize wheelchairs in order to create a more individualized diagnosis of upper extremity stress evaluation and create a database of recommendations of which propulsion method and propulsion posture creates less stress for them specifically.

An experiment will be performed in which these participants perform specific maneuvers with both conventional and Rowheel manual wheels attached to their chair. EMG and accelerometer data will be gathered from muscles of the shoulder in order to examine the differences seen by a specific user. It is important to focus on the individuality of the user and their experience with the wheels in order to determine the best solution for them moving forward. We hope to gain insight into the complexity of the disability and develop ways to more effectively work with the affected individual in order to obtain the best results for their mobility.

Team 25, from left: Nikhita Bhasker, Sydney Stofflet, Megan Houlihan, Sarah Horbury, and Macy Nicol.

BIOMEDICAL ENGINEERING

TEAM: 25
SPONSOR: Hologic, Inc.
ADVISOR: Dr. Krystyna Gielo-Perczak

Stress of Patients under Compression of Hologic Paddle Designs for 3Dimensions™ Mammography System

HOLOGIC®

"Hologic's SmartCurve™ Breast Stabilization System improves comfort in 93% of patients who reported moderate to severe discomfort with standard compression."[1] However, previous studies have only required women to self-report their personal experience rather than capturing a quantitative characterization. Often, "the fear of pain prevents many women from making regular breast imaging appointments a priority."[1] Therefore, a methodology must be formulated to evaluate the patient's comfort when under examination by Hologic's SmartCurve™ Breast Stabilization System and a traditional flat paddle.

Hologic's 3Dimensions™ Mammography System[1]

Hologic's SmartCurve™ Breast Stabilization System[1]

In this study, the human-machine interaction invokes both physiological and psychological responses that must be accounted for to fully characterize the patient's comfort during a mammographic examination. Such indicators can be measured by the patient's center of pressure, muscle activation, galvanic skin response, blood pressure, and heart rate variability. This will be done using the AMTI Force Platform Accusway RS-232, Delsys Trigno™ system, and BIOPAC® MP36R, respectively. A shift in the patient's center of pressure, differences in muscle activation, and/or fluctuations in blood pressure, galvanic skin response, and heart rate variability can reflect the patient's comfort. Additionally, a questionnaire is presented to the patient asking a variety of questions before and after the examination, dealing with their apprehension towards the procedure, their history with mammograms, and details such as diet and sleep prior to the exam. Using multimodal non-invasive measurement techniques, the patient's experience will be quantified to compare two different paddle designs. The results of this study will serve to inform the dimensions on which comfort and patient experiences are effected by mammography options and provide quantitative information beyond simple self-assessment.

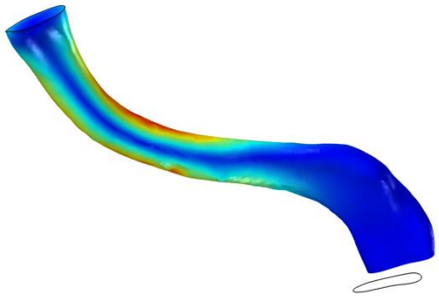
Referenced Works:
[1] "Breast & Skeletal Products," Hologic, Inc. [Online]. Available https://www.hologic.com/hologic-products/breast-skeletal.

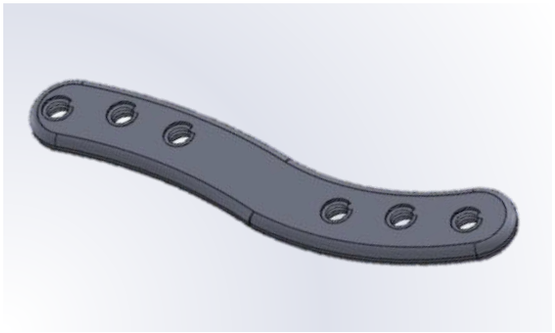
Left to Right: Sayan Basu, Danielle Caefer, and Devin Finnerty

BIOMEDICAL ENGINEERING

TEAM: 26
SPONSOR: Biomedical Engineering
ADVISOR: Dr. Krystyna Gielo-Perczak

Multifactorial Clavicle Plate Design and Strength Analysis





The objective of the following study was to improve the biomechanical efficiency and reduce the invasiveness of plate fixated midshaft fractures. Clavicle fractures are one of the most commonly fractured bones representing 10% of all reported fractures, and if not set properly for healing, patients are at risk for complications and malunion. The most common mechanism of injury is a direct fall or blow to the shoulder joint, which results in a force applied to the acromial articulation with the clavicle and ultimately a midshaft fracture. This type of injury frequently occurs in sports, traffic, and fall related accidents.

The most common treatment option for displaced clavicle fractures is surgical intervention to implement titanium plates on the superior face of the bone. This orientation can lead to poor patient outcomes including bacterial infection and malunion which can require an additional invasive procedure. Thus, our goal is to design an optimized fixation plate through investigating the efficacy of different fixation methods as well as different plate material compositions including biodegradable materials.

The project was comprised of four distinct phases; testing of cadaveric clavicles, finite element analysis using COMSOL Multiphysics 5.3a of both clavicle and plate designs, analysis of plating techniques, and finally, implementation of the ideal plate design for cadaveric testing.

Six human clavicles were cleaned, prepared, and measured for use in cantilever bending stress testing in order to obtain material properties for use in finite element analysis of plate designs. The ideal design will be implemented on six additional cadaveric clavicles with simulated fractures to investigate the efficacy of the design.

(From left to right) Eric D'Souza, Jeff Baroody, Ken Berkery

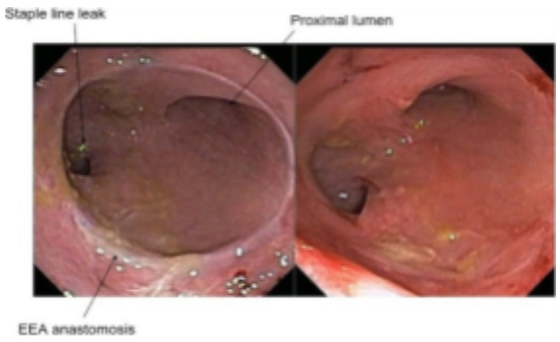
BIOMEDICAL ENGINEERING

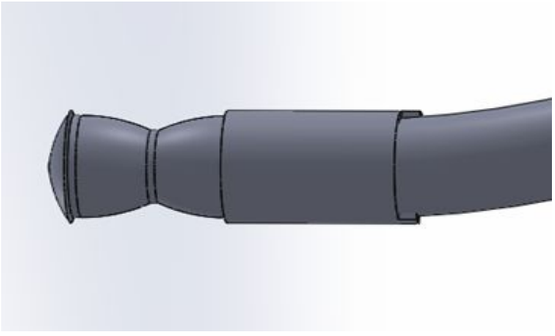
TEAM: 27

SPONSOR: Medtronic

ADVISOR: Professor Bin Feng, Ph. D.

DST™ Series EEA™ Stapler Staple Line Wound Protector





An anastomosis is defined as a connection between two hollow tubular structures. This project focuses on a more specific type of anastomosis, being an end-to-end anastomosis (EEA). EEAs are most often seen in the procedure known as a Lower Anterior Resection (LAR) which is utilized to combat Colorectal Cancer. EEA stapling devices have drastically improved the process of LAR's and in the process improved the outcome of the procedure. Unfortunately, this procedure does not have a 100% success rate. Leaks in the staple line post operatively can cause serious health issues in the patient. These leaks can be a result from necrosis of the tissue due to the lack of blood being delivered to the area during the surgery or a bacteria load developing at the site of the anastomosis.

The purpose of this project is focused around preventing bacteria load from causing leakage in a newly created End to End Anastomosis (EEA) for Medtronic's DST Series™ EEA™ Stapler. Team 27 has been tasked with creating a device to protect the staple line from bacteria load without eliciting any surgical or post operative complications. This solution is designed in a separate device to the current Medtronic stapler. The unique features of this project are derived from existing medical devices which inspired the solution Team 27 designed. Team 27 has researched the general design and application of stents that are used to treat Abdominal Aortic Aneurysms (AAA) in hopes of modifying them to solve the engineering problem of this project. Modifications to the AAA stent include delivery mechanism, deployment mechanism, and design of the stent itself. If Team 27 is successful, a new and exciting application of stents, as an EEA wound protector, will become prevalent in the medical world.

The final design of Team 27's device is broken into 4 main parts: An Outer Shell, Inner Mechanism, Cartridge, and Wound Protector. The objectives of this project can be broken into 3 different categories, Deployment methods, Integration Methods, and Fixation Methods. All of these objectives kept patient safety, reducing complications both during and post operatively, and protection of the staple line in mind to ensure that bacterial load does not cause failure.

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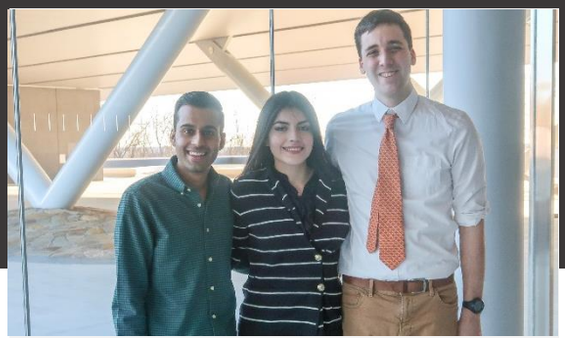
CHEMICAL & BIOMOLECULAR ENGINEERING

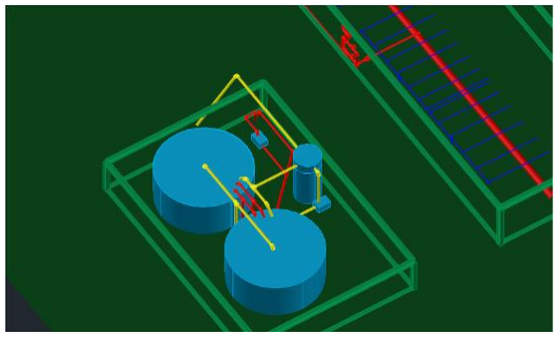


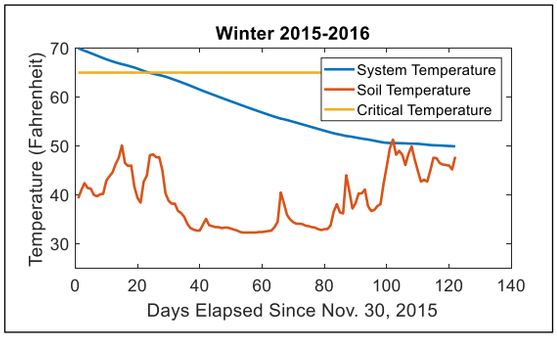
Bansi Rajpara, Linda Rivera, Bailey Horton

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 1
SPONSOR: Keney Park Sustainability Project
ADVISOR: Prof. Kristina Wagstrom

Optimization and Redesign of Keney Park Sustainability Project Aquaponics

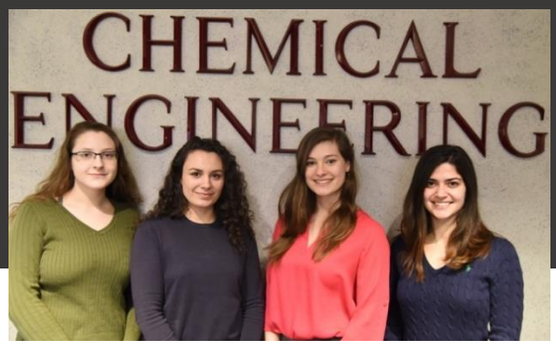




The mission of the Keney Park Sustainability Project (KPSP) is to provide support to the community to increase environmental awareness and introduce the practice of self-sustainability through community-based food systems, including aquaponics. Aquaponics is the practice of integrating hydroponic farming with aquaculture in order to increase the yield of both systems. Essentially, waste products produced by fish are converted to nutrients for the plants in the hydroponic system. In turn, plants provide a natural filtering effect to maintain clean water, which is more favorable for the aquatic life. However, the current design, consisting of two greenhouses and 50 vertical growing towers, has led to a lack of sufficient nutrients for lettuce and basil growth within the growing tower media. The supervisor also suggested we further automate the system to minimize daily check-ups and as a preventive measure against disturbances to the system.

The goal of this project is to redesign, optimize, and expand the current aquaponics system at KPSP to improve energy and crop efficiency. To complete this, we employed rigorous modelling to address issues using COMSOL, Aspen, and MATLAB. Along with hand calculations, these models provided sufficient information to determine the necessary modifications. We collected empirical data to evaluate the redesign using installed pressure gauges, a water testing kit, and temperature readings. We modelled the system on AutoCAD to design stable PVC piping configurations. We used COMSOL Multiphysics to model temperature gradients with various heaters to select an efficient method for temperature control and point-source modelling of temperature dispersion. We calculated heater sizing, to maintain tank temperature at optimal conditions for koi, through MATLAB using historic soil temperature data from the Connecticut area for extreme winter conditions.

Redesign decisions were based on thermodynamic, heat and mass, and fluid mechanic theory and modelling while meeting budget and time constraints. The capacity of the new system exceeds that of the previous structure through additions of new growing towers and increased equipment capacity. Overall, the redesign should allow for an improvement of product yield and elimination of system shutdown during the winter months.



Ewelina Bucior, Caylin Cyr, Francesca Holland, Kaihla Tomassi.

CHEMICAL & BIOMOLECULAR ENGINEERING

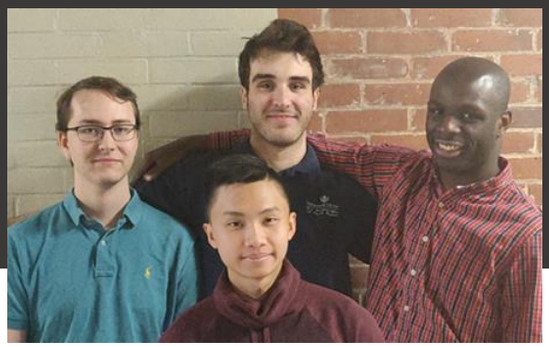
TEAM: 2
SPONSOR: The Maritime Aquarium at Norwalk
ADVISOR: Prof. Kristina Wagstrom

Horseshoe Crab Habitat Design

The Maritime Aquarium in Norwalk, Connecticut, received a donation to update and expand their dated horseshoe crab exhibit. This exhibit consisted of a main tank surrounded by minimal educational displays with a life support system that failed to keep the tank water at the optimal temperature for horseshoe crabs. Our team helped the Maritime fix these problems as well as accomplish an additional goal: conservation. Wild horseshoe crab populations are declining in number due to global warming and direct human intrusions. The Maritime wants to help keep the wild horseshoe crab population from decreasing in order to maintain biodiversity within the ecosystem and maintain the valuable medical resource horseshoe crabs have that humans cannot live without. In order to do this, we assisted in the design and build out of a breeding system in captivity for horseshoe crabs so as not to reduce their population in the wild.

Our team's goal of this project was to obtain real-world experience working with the different aspects that go into creating an exhibit like this. We worked on understanding why the original life support system did not work and figuring out how it can be fixed with a new design. We designed and built the breeding system by hand. We worked on developing educational displays and designing additional ideal designs so the aquarium can use them for grant applications.

We researched and observed the functions and properties of equipment that make up aquatic life support systems such as filters, heat exchangers, pumps, sumps, UV sterilizers, and pipes. Then, the equipment and process flow diagrams for each system had to be determined. We traveled to the aquarium many times to build part of the breeding system by hand: screwing together a stand, ordering PVC piping parts, planning out the process flow, and hand gluing all the pathways together. We mathematically validated each piece of equipment implemented for the system using heat transfer and fluid mechanics equations. Each system was modeled as a whole in Aspen PLUS and the resulting theoretical temperatures, flow rates, and other properties were compared to data taken from the systems in real life to ensure accuracy.



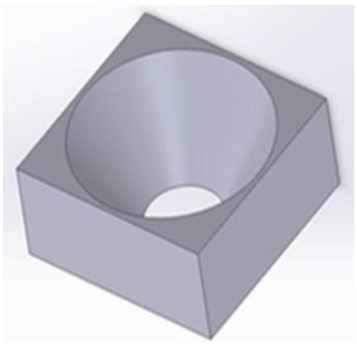
Pictured from Top, Clockwise: Connor Yanicky, Eric Noi Jr, Steven Lam, Ethan Chadwick

CHEMICAL & BIOMOLECULAR ENGINEERING

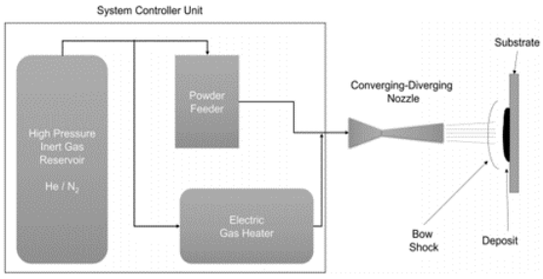
TEAM: 3
SPONSOR: MOOG Inc.
ADVISOR: Prof. Leslie Shor

Component Thread Repairs Using Supersonic Particle Deposition

Worn out metal parts on military vehicles have continually posed a large negative impact both economically and environmentally. Due to the importance of these vehicles to the country, their metal screw threads should to be as fresh as possible. The issue with trying to keep these parts fresh is that they are always in constant use. It is not feasible to simply restore these metal parts, so they end up being thrown out years prior to their true mechanical failing point. Once the metal piece is thrown out, the cost of creating a new part can be 10 times the cost of repairing the same piece. Even more, some of these pieces can erode over time and release hazardous byproducts in landfills. All of these negative factors have led to differing methods for dealing with these metal sections, including the focus of our project in cold spray deposition.



The main focus of our project with MOOG is to use supersonic particle deposition, more commonly known as cold spraying, to maximize the stripping strength of damaged metal threads. Cold spray deposition is the process of spraying a metal substrate with powdered metal at supersonic speeds to create adhesion. The cold sprayed piece can then be machined and polished in any desirable manner. The portion of the metal thread that will be cold sprayed is the inside of a chamfer, or conical borehole. Once the cold spray coating is completed, the next step is to test both the compressive and tensile strength of the resulting thread. The resulting strengths can then be compared to new models to see if these threads are efficient and fit performance results.



In addition to seeing whether cold spray holds up compared to new material, we are focusing on how certain variables can be altered to strengthen the sprayed thread. One variable that we observed was the carrier gas used to propel the powdered metal. Helium and nitrogen, the two main variables available, both had their pros and cons. These pros and cons ranged from cost to effectiveness. The second variable that will be tested are the angles of the conical chamfer sprayed. The three angles we decided to test were 30^{o}, 45^{o} and 60^{o}. From previous experiments, results proved that angles outside of this range have been shown to produce inconsistent results.

Group 4 (from left to right): Christopher Jablonka, Liam Evans, Annika Skov, and Jennifer Skoog

CHEMICAL & BIOMOLECULAR ENGINEERING

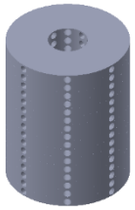
TEAM: 4

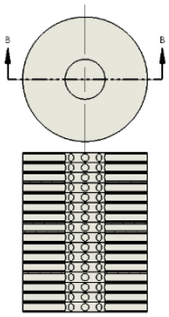
ADVISOR: Prof. Yongku Cho

UCONN
SCHOOL OF ENGINEERING

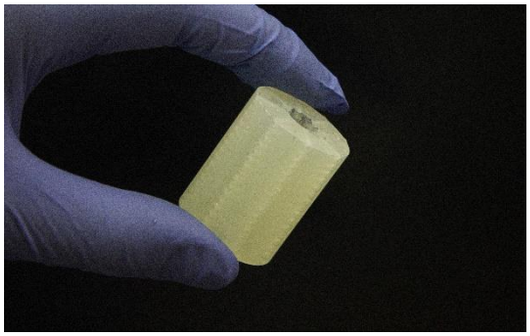
Design of a Bioreactor for Exopolysaccharide Production from Soil Bacteria.

EPS is a non-toxic, high molecular weight polymer that is produced and secreted naturally by plants, algae, fungi and bacteria. The biocompatibility of EPS makes it an attractive material for medical applications including tissue scaffolding, drug capsules, and dental impressions. The wide degree of applications of EPS elicit the need for a reliable method of *in vitro* growth on a large scale.

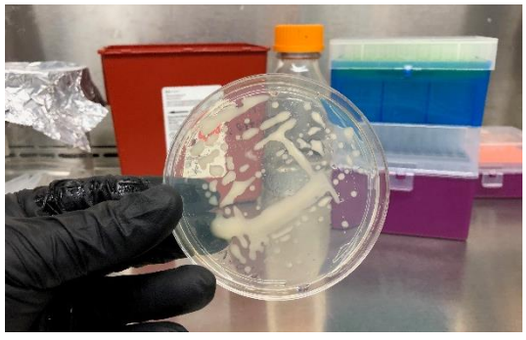




The goal of this project is to design a process for high-yield EPS production from the soil bacteria, *S. meliloti,* found in root nodules. *S. meliloti* are slow-growing and are not used in current industrial production processes. The scope of this project includes conducting small-scale experiments to identify and optimize important design parameters as well as analyzing the potential for scale-up. Bioreactor conditions, such as growth medium composition, temperature, pH, and mixing rate were considered and selected based on current literature. The group conducted laboratory experiments to determine growth rate parameters. These conditions were used to design a scaled-up bioreactor production of EPS. This process was designed with the aim of recreating the natural growth environment of these bacteria, which poses several differences from *in vitro*.



We used additive manufacturing to design a 3D printed insert that we introduced into the *in vitro* culture to simulate the bacteria *in vivo*. Pores in the insert extend radially inward, designed to provide an environment for cells to grow in close proximity to each other while adhering to a surface, much like the natural environment of a root in soil. We modeled mass transfer of medium nutrients within the insert in COMSOL to assess impacts on cell viability and to determine the pore size. The dimensions, shape, type of resin, and cleaning methods were considered during the design process. These small-scale laboratory studies were then used to design a seed train and scale-up for the bioreactor production of EPS. By combining laboratory experiments, additive manufacturing technology, and simulation software, we can develop new biotechnology for a more sustainable tomorrow.



From left to right: Kelly Rodgers, Thomas Clifford, Clark Stan, Anamol Regmi.

CHEMICAL & BIOMOLECULAR ENGINEERING

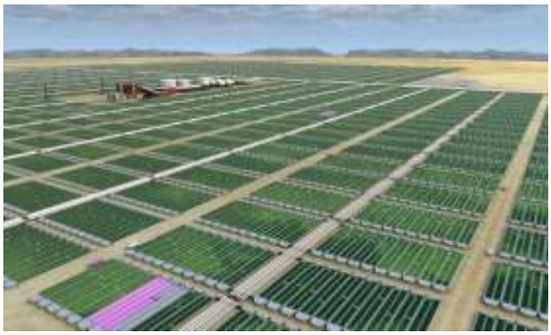
TEAM: 5

ADVISOR: Prof. Douglas Cooper

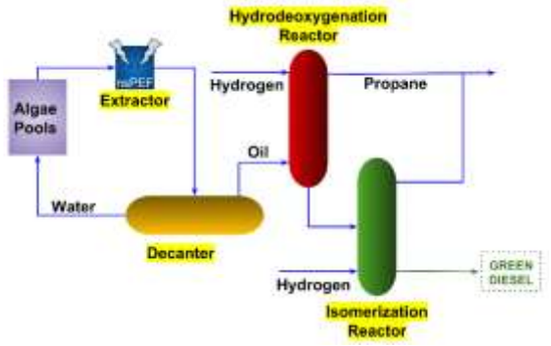
UCONN
SCHOOL OF ENGINEERING

Production of Green Diesel

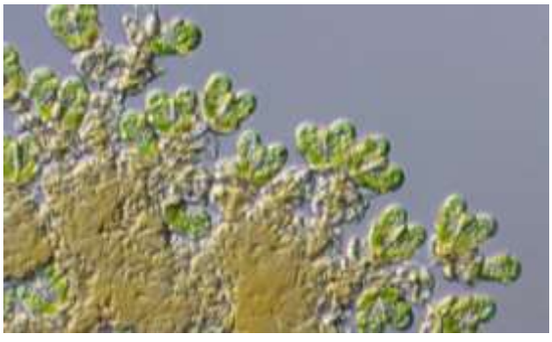
There is a growing demand for renewable sources of energy in the US. The oil industry is worth billions of dollars but their business model is unsustainable. Traditional petroleum diesels are considered to be in limited supply, but this concern can be mitigated by blending it with similarly-derived clean diesels. We plan to work with the oil industry to develop alternative fuel sources thus making a profit while increasing energy security.



The goal of this project is to design and simulate a continuous process to produce Green Diesel derived from algae oil for the purpose of blending into diesel stocks. Our production output will be set at 160 million gallons of Green Diesel per year. The product must achieve acceptable cold flow properties while also remaining chemically equivalent to traditional diesel. Our project will incorporate both business and engineering as we are modeling this project as an entrepreneurial start-up company. Our business plan will include multiple financial outlooks for at least fifteen years based on the final methodology determined with the simulation as well as the plant layout design. The success of this project is contingent on economic feasibility and ensured renewability throughout all steps of processing.



Our process occurs all in one place starting with in-house algae cultivation and finishing with biocrude oil refining. The first stage after cultivation uses a nanosecond pulsed electric field (nsPEF) to free oil from algae cell matrices. The next stage takes the algae oil and runs it through a hydrodeoxygenation reactor to reduce the fatty acids to saturated hydrocarbons. Then, an isomerization reactor branches the alkanes to produce a better burning fuel. The product stream is then reformed and distilled resulting in the desired Green Diesel product. The diesel is then delivered by pipelines to nearby refineries for immediate blending. This comprehensive solution allows for the existing energy industry to incorporate renewable fuels without requiring any changes to the current infrastructure.



Kyle Connelli, Evan Hale, Brendan MacIntyre, Jayson Gilbert

CHEMICAL & BIOMOLECULAR ENGINEERING

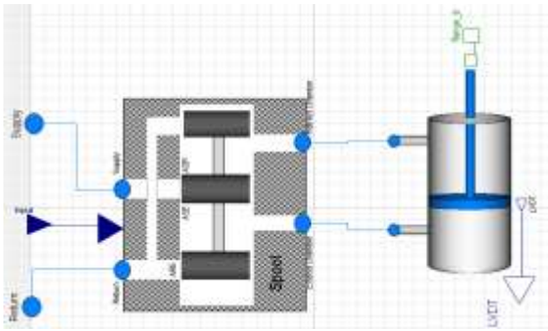
TEAM: 6
SPONSOR: UTC Institute for Advanced Systems Engineering
ADVISOR: Prof. George Bollas

United Technologies Corporation
Institute for Advanced Systems Engineering
UNIVERSITY OF CONNECTICUT

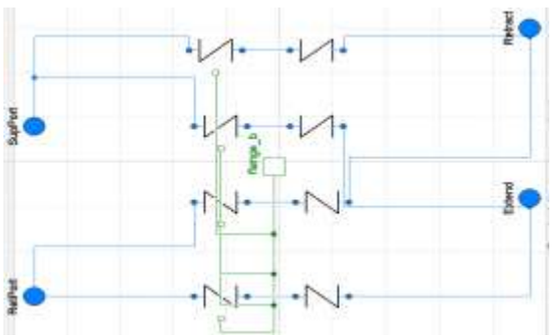
Pratt & Whitney Hydraulic Modeling and Control Analysis in Dymola

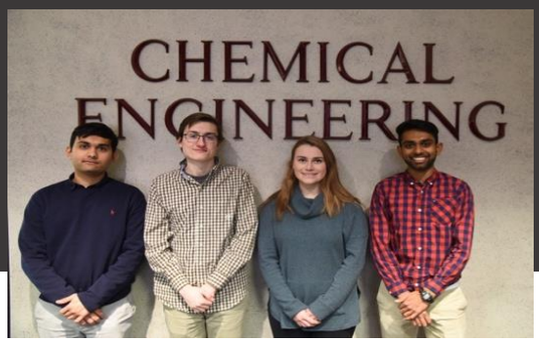
Pratt & Whitney uses a complex coding language called Modelica within a program called Dymola to simulate systems that involve their machine parts. Over the years, Pratt & Whitney have created a large library of machine parts that can be dragged and dropped into the Dymola simulation window and then connected together to form more complex components. These machine parts utilize code that has a large amount of ‘inheritance’, which means building upon simpler machine parts code to create a new machine part, thus saving time initially. ‘Inheritance’ causes many problems as over time though, as it makes it difficult to read an entire machine parts code and properly locate the variable / equations utilized as the reader must jump from machine part to machine part to piece together the full code.

The goal of this project is to create a small Modelica library of machine parts that can be assembled into a hydraulic actuator system that use little to no ‘inheritance’. The Modelica library must be built from the ground up starting with a media model, which is jet fuel in this case and eventually ending with assembly of a hydraulic cylinder and 4 way EHSV that will be combined to create a hydraulic actuator. In doing so, we both learn the coding language and the program itself, while creating a simple hydraulic actuator system for Pratt & Whitney that involves little to no inheritance. Once constructed, the hydraulic actuator will be tested against true hardware values provided by Pratt & Whitney to verify its functionality and plant dynamics and tune. Once the verification is finished, a linear model will be extracted from Dymola and used to size proportional gains and add a controller to the detailed model.




```
  mode = if free then Free else (if pre(mode) == Forward or pre(mode) ==
    Free or startForward) and v_relfric > 0 and s < (smax - L/2) then Forward
     else if (pre(mode) == Backward or pre(mode) == Free or startBackward)
     and v_relfric < 0 and s > (smin + L/2) then Backward else Stuck);
end PartialFrictionWithStop;
equation
  // Constant auxiliary variables
  f0 = (F_Coulomb + F_Stribeck);
  f0_max = f0*1.001;
  free = f0 <= 0 and F_prop == 0 and s > smin + L/2 and s < smax - L/2;
  // Velocity and acceleration of flanges
  v = der(s);
  a = der(v);
  v_relfric = v;
  a_relfric = a;
  // Equilibrium of forces
  0 = flange_a.f + flange_b.f - f - m*der(v);
  // Friction force
  f = if locked then sa*unitForce else if free then 0 else (if startForward
    then F_prop*v + F_Coulomb + F_Stribeck else if startBackward then F_prop*v -
    F_Coulomb - F_Stribeck else if pre(mode) == Forward then F_prop*v +
    F_Coulomb + F_Stribeck*exp(-exp*abs(v)) else F_prop*v - F_Coulomb -
    F_Stribeck*exp(-exp*abs(v)));
  lossPower = f*v_relfric;
```





From left to right: Dhruvit Patel, Max Tracy, Elizabeth Graves, Sricharan Kadimi

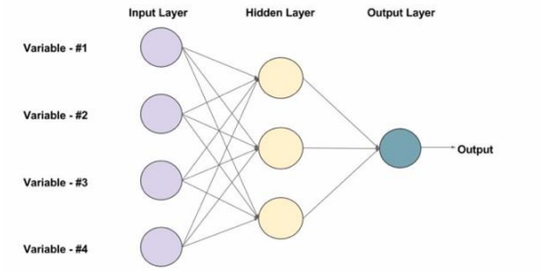
CHEMICAL & BIOMOLECULAR ENGINEERING

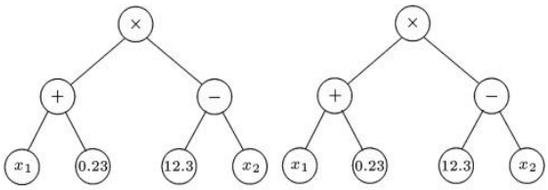
TEAM: 7
SPONSOR: UTC CCS/SCE
ADVISOR: Prof. George Bollas, Dr. Hari Srinivasan

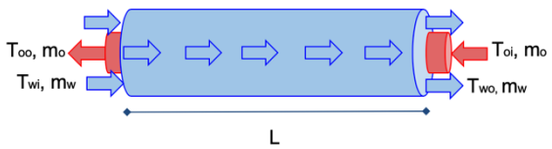
UTC-IASE Surrogate Modeling Methods Evaluation and Implementation for System Analysis

United Technologies Corporation
Institute for Advanced Systems Engineering
UNIVERSITY OF CONNECTICUT

Carrier







Engineers predict the performance and cost of their products using different models. These models can evaluate many different prototypes to find an optimal design. However, finding the optimal product design can often be a slow process, due to the computational complexity of physics-based modeling. Such complex models often have tens to hundreds of input parameters and similar amounts of output parameters, all governed by complex physical equations. These equations can often be simplified using surrogate models. Surrogate models are approximations of the original model that take sampled data and use it to predict new data. Surrogate models offer the advantage of being faster and simpler than the complex models they approximate, while retaining the accuracy of those complex models. Thus, surrogate models offer engineers a robust and flexible tool to speed up the design process.

The goal of this project is to implement surrogate models that predict the performance of a heating, ventilation, and air conditioning (HVAC) system. These surrogate models must be able to accommodate at least 100 input and output parameters. The surrogate models should also sample using a technique that gives accurate results for any reasonable input values. The surrogate models must be open source and implemented so that any engineer could easily use the model.

The surrogate models are currently being implemented in Python using open source toolkits such as scikit-learn. These toolkits offer different techniques such as polynomial response surfaces, radial basis functions, Gaussian processes, random forests, genetic programming, or neural networks, which are useful for surrogate modeling. The toolkits also offer different strategies for sampling data, including random, Sobol, and Latin hypercubes methods. Sampled data will be taken from a publicly available HVAC model and include inputs such as design parameters or environmental conditions, and outputs such as capacity or efficiency. While the surrogate models are developed specifically for HVAC systems, they will be adaptable to a variety of engineering problems, making them a versatile tool for engineers.

Left to Right: Collin Farrell, Samira Islam, Johneilia Bariffe

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 8

ADVISOR: Prof. Julia Valla

UCONN

SCHOOL OF ENGINEERING

Zinc Oxide Adsorption for the Desulfurization of Fuels

The desulfurization of fuels is becoming an important part of the fuel industry as stricter regulations are placed on the release of sulfur into the atmosphere. Sulfur, in most cases, comes in the form of sulfur-containing compounds such as hydrogen sulfide that, when burned, let off sulfur oxides into the air. These sulfur oxides enter the upper atmosphere where they contribute to acid rain which harms the environment. Preventing environmental harm is a key driving force in improving desulfurization techniques and is one of the main focuses of this project.

Figure 1: Zinc Oxide (ZnO) Pellets

The goal of this project is to create a process simulation in Aspen Plus that will evaluate the concentration gradients across an adsorption column, and display the effectiveness of zinc oxide as a sulfur adsorbent. Zinc oxide was the adsorption material of choice due to the extensive literature boasting about its capabilities in the removal of hydrogen sulfide from natural gas streams. Natural gas is the primary fuel for fuel cells which is the main application that our group is focusing on for the desulfurization process. When in the presence of hydrogen sulfide, fuel cells begin to sour which renders them unusable over time. Therefore, it is important that the process that our group develops allows for the complete elimination of sulfur from the gas stream.

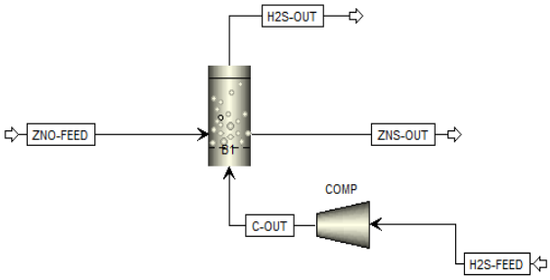
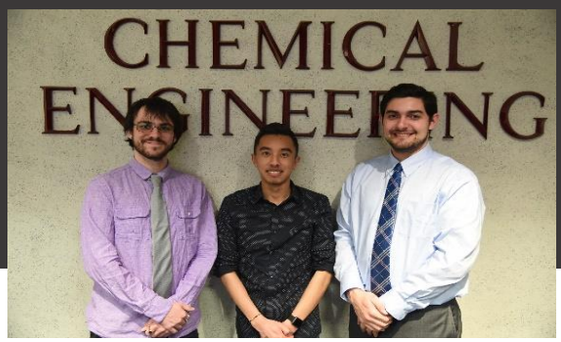


Figure 2: Adsorption Process from Aspen Plus

Sulfur is removed from the gas stream in the process by passing the natural gas over a zinc oxide bed in a fluidized bed reactor. Over time, the zinc oxide reacts with the hydrogen sulfide to create zinc sulfide and water vapor. Both zinc sulfide and water vapor are harmless to the environment and easy to remove from the outlet stream due to their physical properties. The zinc sulfide is a solid and remains in the adsorption column whereas the water vapor can be condensed and removed from the natural gas. This allows for a clean natural gas product stream that can be used immediately in fuel cells.

Figure 3: The Hydrogen Sulfide (H_2S) molecule

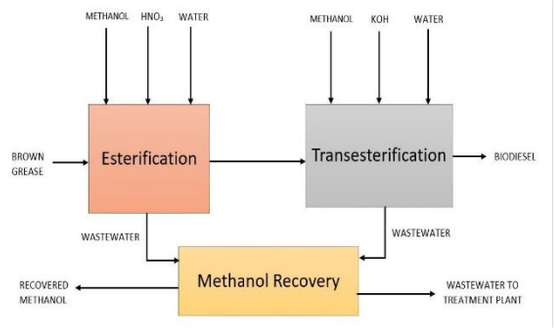


From left to right: Anthony Freligh, Heli Nguyen, Nicholas Norberg

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 9
SPONSOR: REA Resource Recovery
ADVISOR: Prof. Richard Parnas

Sewage Waste to Biodiesel



Wastewater treatment is currently an energy inefficient process in the United States. The goal of this project is to recover and convert energy-rich brown grease from wastewater treatment plants into high-grade biodiesel. Five million tons of brown grease is produced nationally every year with minimal energy recovery. This brown grease is filled with free fatty acids (consisting of triglycerides and glycerides) of which 75% of the brown grease produced is incinerated, and the remainder is processed via anaerobic digestion. REA Resource Recovery's proprietary production process offers a potential solution with environmental and economic benefits, turning refuse into revenue.

As a Senior Design team, we created an Aspen Plus process model of REA's existing biodiesel pilot plant. We scaled up our model to achieve an annual production of one million gallons of biodiesel. We estimated plant specifications and performed an economic analysis. Our work serves as the foundation for future expansion of this initiative.

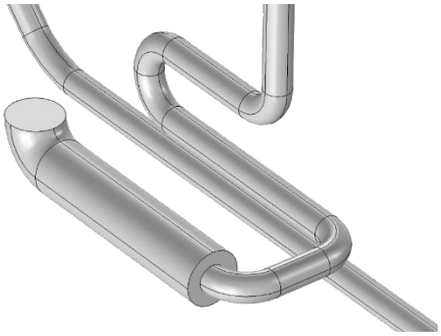
The brown grease enters a CSTR train from the wastewater treatment plant, where it is reacted with methanol in an esterification reaction. The outlet stream is then sent to a liquid-liquid extractor to separate the polar components from the produced biodiesel. This biodiesel stream is fed to an air stripper to remove the excess water. The dehydrated biodiesel then enters a proprietary transesterification reactor where it mixes with methanol to react remaining triglycerides. Methanol from process waste streams is recovered and recycled for capital savings, while valuable side-products are created for additional revenue. REA plans to sell their larger scale process to wastewater treatment facilities around the nation to eventually have a global impact.

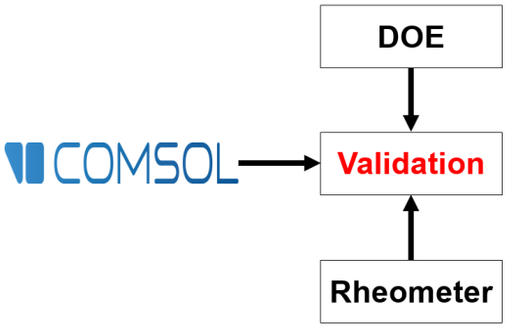
From Left to Right: Julie Fabrykiewicz, Yodonnic Etoria, Christopher Ennis, Said El-Bakhar.

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 10
SPONSOR: Unilever
ADVISOR: Prof. Anson Ma

Modeling Pipe Flow of Body Wash to Predict Process Sensitivity

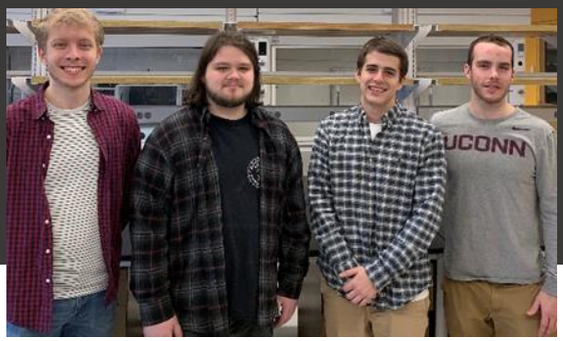




With seven out of ten households owning at least one of their products, Unilever is one of the largest consumer goods companies in the world. Every day, over 2 billion people use their products to feel good, look good, and get more out of life. To maintain high consumer retention and satisfaction, Unilever relies on consistent delivery of high-quality products. During the processing of these products, unexpected changes can cause the product to fall out of specification limits. One parameter that is under strict limits is the viscosity of body wash. This is because it is easily perceived by the consumer as the thickness of a fluid. By modeling body wash to predict process sensitivity, Unilever can limit viscosity variation for each production run.

This year's project built on the previous design group's work where product sensitivities at the filler nozzle were explored. They concluded that the filler nozzle was not the cause of the viscosity variation and recommended upstream investigation. Therefore, the goal of this project was to identify the sources of product sensitivities by analyzing fluid flow through post production pipe geometry. Using the simulation software, COMSOL, we were able to accurately model the behavior of the body wash. The results of the model capture the process sensitivities experienced by the body wash and highlighted areas of key concern. The use of simulation software extends Unilever's digital library initiative and can limit process uncertainty for future innovations.

For comparative validation of the COMSOL model, a Design of Experiment (DOE) and rheometer script were built. The DOE generated relationships between viscosity, shear rate and other key parameters using JMP statistical software. Using varying shear rate values, viscosity from the DOE was compared to values generated by our digital model. In the future, the DOE procedure can be applied to various brands and products in Unilever's arsenal. In addition to the DOE, a rheometer script was built to fully understand the shear history the body wash experiences. Experimental viscosity curves generated by the rheometer will be compared to the generated COMSOL values using average shear rates and residence times. Based on our results, this project has the potential to drive Unilever sustainability initiatives, increase customer satisfaction and retention, and spearhead their digital future.



From Left to Right: Kamil Wielechowski, James McLellan, Keith Loureiro, Ian Puckette

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 11
SPONSOR: Cabot Corporation
ADVISOR: Prof. George Bollas

United Technologies Corporation
Institute for Advanced Systems Engineering
UNIVERSITY OF CONNECTICUT

CABOT

Modeling the Fluidization of Carbon Black for Post-Production Treatment

Carbon black is one of the most abundant materials you see in everyday life that you never pay attention to. Its customizable physiochemical properties are key in many industries, including the manufacturing of electronics, pigments, and tires. After carbon black is produced, the particles must be chemically treated to achieve certain properties for use in a variety of industries.

Cabot Corporation, one of the world's leading manufacturers of carbon black, has been exploring methods of chemically treating their product to allow for greater surface modification in downstream processes. While Cabot currently uses liquid solid-mixers in their post-treatment process, they are now looking to investigate fluidized bed reactors as a more efficient alternative method of chemical treatment. Fluidized bed reactors are advantageous because they use a gas to fluidize particulate solids to allow for maximum contact area between the mobile and stationary phases. Fluidized bed reactors create unique gas-solid contacting regimes, which are determined through a variety of operating conditions such as particle size and porosity, reactor geometry, and gas flow rate, density, and temperature.

The goal of our project is to simulate a fluidized bed reactor in ANSYS Fluent software to determine minimum superficial velocity and optimal nitrogen flow as a function of pellet size distribution, dust fraction, bulk density, and bed temperature. Our simulation must output the centerline and wall effects of carbon black fluidization over a range of temperatures, flow rates, and pellet specifications. The model may then be used to determine the optimal nitrogen flow for steady state operation, minimize pellet entrainment to prevent product loss, and perform sensitivity analysis to understand the variable impact and model accuracy. Validating the simulation requires determining the Geldart classification of the carbon black products that Cabot has presented us. The Geldart classification determines how easily a particle will fluidize based on physical characteristics of the particles. With the Geldart classification, we can calculate a range of viable flow rates at which fluidization of carbon black occurs and then determine the expected contact regime. Furthermore, we can validate our simulation by performing lab experiments with a fluidized bed reactor and a sample batch of carbon black provided by Cabot.

Figure 1. *A close up image of a carbon black sample provided by Cabot for validation experiments.*

Figure 2. *A still image from a validation experiment of the fluidization of carbon black performed in a conical fluidized bed reactor.*

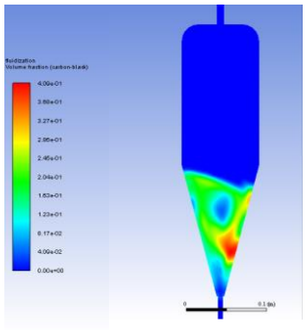


Figure 3. *A still from an ANSYS Fluent simulation of the fluidization of carbon black*

Left to right: Quynh-May Dao, Monica Zhang, Mengting Zhu, Nicholas Wolslegel

CHEMICAL & BIOMOLECULAR ENGINEERING

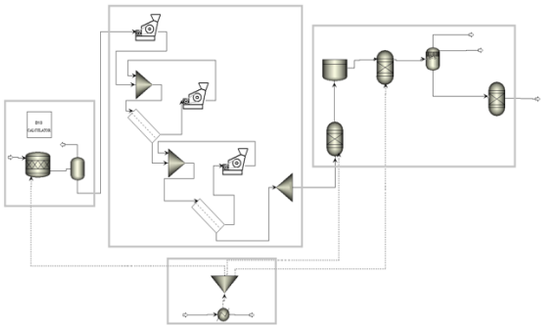
TEAM: 12

ADVISOR: Prof. Julia Valla

UCONN

SCHOOL OF ENGINEERING

Production of Activated Carbon from Dining Hall Food Waste



Food waste is a concerning problem that still challenges society. More than one third of the food produced in the world annually is either lost or wasted. Current management systems include sending the food waste to landfills or incinerators. However, each of these techniques is associated with its own set of issues. For example, rotting food waste in landfills can produce methane gas, which is 23 times more harmful as a greenhouse gas than carbon dioxide. Different food waste treatment processes are being explored in order to divert food waste from landfills, and to convert this waste into renewable energy. As such, food waste can be considered an untapped resource in the production of energy and other useful products.

The goal of this project is to develop a viable process that can convert food waste into activated carbon. Activated carbon, which is also known as activated charcoal, is a carbonaceous material that has been treated to increase its surface area and porosity, and as a result, its adsorption capacity. Due to its adsorptive nature, activated carbon has many applications in the industrial, chemical, and medical field.

The process of producing activated carbon from food waste can be broken into four steps: heating, crushing, pyrolysis, and activating. This will be modeled using Aspen Plus software. Food waste contains a high moisture content and will first go through a heater to reduce the water content. Afterwards, the dried food waste will pass through a sieve to reduce the particle size. A smaller particle size of around 180 - 335 μm is crucial for developing micropores on the surface of the activated carbon. Next, the crushed food waste will be treated in a pyrolysis process to maximize its carbon content. Pyrolysis is a type of thermal decomposition where organic materials are heated at elevated temperatures between 400°C - 800°C in an inert atmosphere without oxygen. The products of pyrolysis will be solid char, bio-oil, and syngas. The char must then be activated through either physical, chemical, or steam activation in order to obtain the final form of activated carbon. The activated carbon will be analyzed in order to quantify its absorption capacity.

From left to right: Connor Dion. Jacob Chicano, Natalie Krebs, Michael Castelpoggi

CHEMICAL & BIOMOLECULAR ENGINEERING

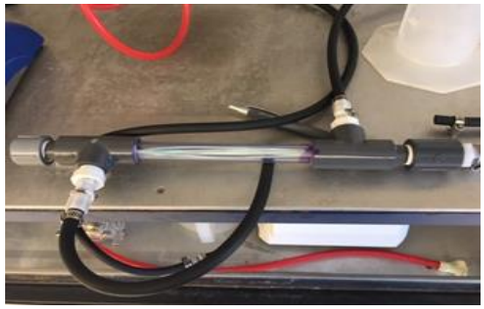
TEAM: 13

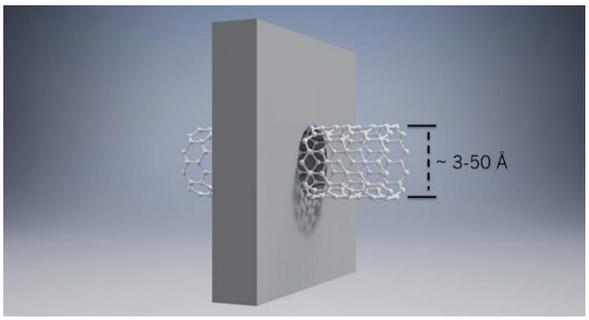
SPONSOR: Mattershift

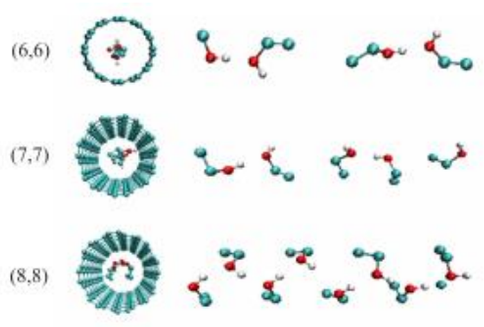
ADVISOR: Prof. Jeffrey McCutcheon

Economic Feasibility of Ethanol Dewatering via Carbon Nanotube Vapor Permeation

MATTERSHIFT







Ethanol/water distillation is a common separation in the production of fuel-grade ethanol (>99.5 wt% ethanol). However, the separation of these components is made difficult by the formation of an azeotrope at high ethanol concentrations and high energy demand at low ethanol concentration. These difficulties make distillation a costly commercial process with a large energy and carbon footprint. With the rapid growth of the biofuel market in recent years, and the low profit margin in ethanol production, new separation techniques that offer potential energy savings and reductions to carbon emissions are necessary.

Mattershift is a start-up company that is developing carbon nanotube (CNT) membranes that exhibit a unique advantage to ethanol dewatering: self-semi permeability. Contrary to typical membranes, CNT membranes show a higher selectivity to ethanol compared to water, despite ethanol being the larger molecule. Molecular simulations of ethanol-water separation through CNT membranes show near 100% separation with a CNT diameter less than 1.3 nm. By retrofitting an ethanol-water distillation plant with vapor permeation and CNT membranes in tandem, there is potential to produce fuel-grade ethanol at a fraction of the energy demand and carbon emissions.

To perform a full techno-economic assessment on the CNT technology, a cost estimate was developed for ethanol plants solely using distillation processes. From this basis, it is possible to assess the significance of changes that would result from implementing CNT membranes alongside distillation. Areas of interest included changes to capital expenses, operating cost, and CO_2 emissions. A hybrid ethanol plant that incorporates vapor permeation with distillation was created such that it could be easily implemented into an existing ethanol plant. Various operating parameters, feedstock options, number of membrane modules, and the phase of the influent ethanol-water mixture into the membrane were evaluated and selected in the goal to reduce the overall energy cost of a potential plant. The design shows a reduced energy footprint compared to current distillation methods.

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 14

ADVISOR: Prof. Matthew Stuber

Shaylin Cetegen, Alberto Aguillon, Alanna Gado

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Optimal Design of a Sustainable Intensified Food Production System

As global population growth intensifies, the increasing demand for food will outpace the capabilities of the traditional agriculture system. An alternative system is required to alleviate the stress placed on exhaustible natural resources, such as water and fossil fuels. Currently, the ability to grow crops is highly dependent on local climates and resource availability. This dependency limits year-round regional crop production, requiring long-distance shipments to deliver fresh food to consumers. An indoor intensified food production approach presents the opportunity to grow any crop in any location at any time of year. This enables increased local food production, improving food access and security by eliminating the need for long-distance shipments. This approach also ensures the delivery of high-quality nutrient-dense food to consumers. Decoupling crop growth from environmental conditions through intensified controlled-environment agriculture is the answer to sustainable food production and increased food security for the next generation.

The goal of this project is to design and optimize a sustainable intensified food production system. The system must be a repeatable and scalable unit suitable for global implementation. Additionally, the system must meet sustainability standards and fulfill nutritional requirements with a diverse crop portfolio. The design that meets these constraints must be rigorously assessed in order to determine its economic viability. Meeting these goals will demonstrate that the use of vertical growing can make a direct and long term positive impact on the future of farming.

To meet these goals, we designed a facility equipped with the required growing technology, water and waste-recovery systems, and automated harvesting equipment. We also created a 3D virtual walkthrough and a physical demonstration of the proposed vertical aeroponic growing technology. First-principles modeling was used to validate the sustainability of our process. The first-principles models were implemented within a constrained mathematical optimization model for identifying an optimal design by determining crop space allocations, site location, and facility production capacity which maximize the net present value of the operation over a 30-year period. Our comprehensive techno-economic assessment of this venture indicates a promising path forward to improved food security and sustainability through intensified food production.

From left to right: Andrea Naranjo-Soledad, Soha Nadeem, and Patrick Mascoli

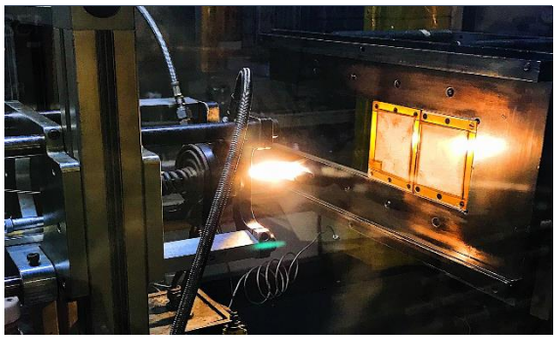
CHEMICAL & BIOMOLECULAR ENGINEERING

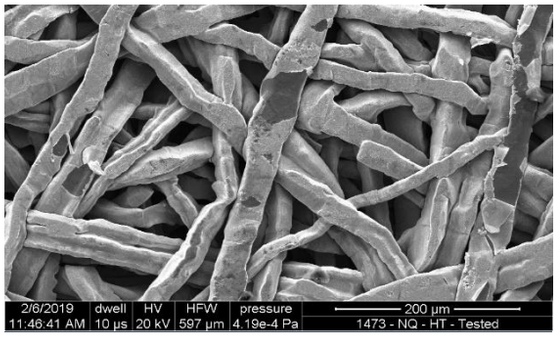
TEAM: 15

SPONSOR: Nel Hydrogen

ADVISOR: Prof. Radenka Maric

Nel Hydrogen: Reduction of Pt Loading in PEM Electrolyzers using RSDT





Hydrogen has a high specific energy, making it an intriguing fuel source as the world shifts away from fossil fuels. Pure hydrogen can be produced through electrolysis, a process that splits water molecules into oxygen and hydrogen gas using an applied current. Nel Hydrogen, the worldwide leading manufacturer of electrolyzers, uses proton exchange membrane (PEM) technology to accomplish this. Electrolyzers have a high cost resulting in their use being limited. The high cost can be attributed to the use of precious metals within the units, including platinum. Reducing platinum loading throughout an electrolyzer is needed in order to increase their viability. Through our partnership with Nel, we investigated methods to reduce the platinum loading on the anode side gas diffusion layer (GDL) found in their units. Lowering the platinum loading while maintaining performance will offer a sizable cost reduction in the production of Nel's units, contributing to the growth of the hydrogen economy.

Reactive Spray Deposition Technology (RSDT) was investigated as an alternative coating method to the standard electroplating method Nel currently uses. Electroplating fully saturates the GDL, depositing platinum on internal structures where it provides no performance benefit. RSDT uses a flame to combust a platinum organic precursor to produce platinum nanoparticles. As a result, it is possible to spray a thin layer of precious metal only on the surface of the GDL. Last year, the senior design team coated multiple samples using RSDT, however, there was a performance gap between electroplated and RSDT samples. The goal of this project was to remove this performance gap by an iterative method and then to scale-up to a larger electrolyzer. To eliminate this gap, various parameters were adjusted including new etching and drying procedures, spray time and set-up, and post spray heat treatment. At each iteration, the samples were analyzed using mechanical and electrochemical tests along with material characterization techniques. The testing metrics included Zwick resistance, long-term cell stability, flow impedance and polarization curve performance. Characterization methods included SEM, XRD, and EDX. Through our trials, we were able to eliminate the performance gap.

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 16

ADVISOR: Prof.Douglas Cooper

Luke Kinard, Juliette Nealon, Timothy Haddon

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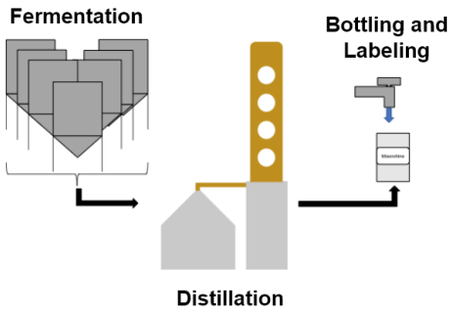
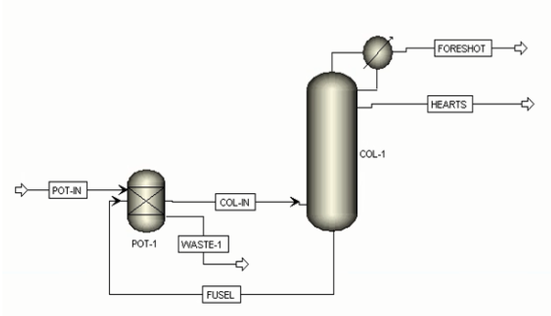
Design of a Commercial Craft Moonshine Distillery

Entering the craft liquor industry in the United States can be profitable if done correctly. Through the application of engineering intuition and proper planning, the market allows for successful startup distilleries. Specifically, moonshine is an ideal liquor market to enter because it is unsaturated, a quick to market product, and relatively inexpensive to produce. After operations have begun, moonshine can be produced and sold to the public in a matter of days. In addition, the raw material availability, commonality of equipment, and lack of aging necessary will ensure low initial costs to start the business.





The goal of this project is to design a craft moonshine distillery that produces 1000 gallons of moonshine per week. The production rate is set so the operation can make a profit without over producing and having a backlog of product. Through the analysis of existing processes of moonshine production, the team will develop a deeper understanding of unit operations along with the economics of a startup company. The team will also create a layout of the distillery that allows for tours as well as the logistics of production. At the end of the capstone project, the final deliverable will be a specified design that could represent a company proposal. This will include the process of production, a financial report, a layout of the distillery, and future steps of the company.

The production of moonshine will consist of three main steps fermentation, distillation, and condensation. First during fermentation, a mash is created where sugars are broken down by yeast to produce a mixture containing ethanol, methanol and other fusel alcohols. In the next stage, distillation, the mash is fed into a stripping column so the alcohols can be removed from water and any other impurities. Then it is further separated to isolate the ethanol, the desired product. Lastly, the ethanol is condensed and diluted it to the desired alcohol concentration. At this point the moonshine is bottled and sold with no further aging required. In addition, there are design constraint to consider, such as cost of production, working hours per week, and both local and federal regulations. With all of this in mind a craft moonshine distillery is designed to maximize profits, minimize costs, and create a desirable product.

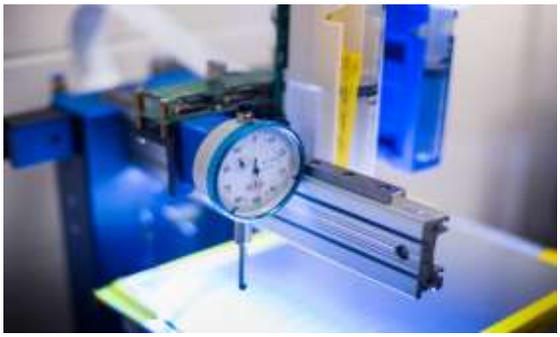
Gefan Xu, Nathan Peruta, Ronald LaMonica, Brian Goldstein

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 17
SPONSOR: US Army CCDC Soldier Center
ADVISOR: Prof. Anson Ma

US Army 3D Food Printing

The United States Army is currently investigating the possibility of providing customizable food rations for their Soldiers. The Army has a wide variety of jobs that Soldiers can perform, and each job requires a different amount of work and energy to complete. Combat arms specialties such as infantry Soldiers can require up to 4600 calories per day while operating in adverse climates like cold mountainous terrain or hot desert sands. Service support jobs such as quartermaster or transportation may require only 2200 calories per day. With the current Army field ration, all Soldiers receive the same 3600 calories per day from three Meals Ready-to-Eat (MRE) which provide, on average, 1200 calories per meal. 3D food printing is a novel process which allows the customization of shape, color, flavor and nutrition of the products. The Army is looking into 3D food printing as a solution to make customized food based on individual nutrient needs.



The goal of this project is to review different inlet stream properties such as particle density, water content, and mixture composition to determine what conditions are best suitable for 3D printing energy bars while ensuring that the designed mixtures meet certain criteria. The energy bars have customizable textures for various mouthfeel, which is accomplished through the addition of components like chopped nuts or oats. The bars must also be strong enough to support their own weight during and after the printing process.

Rheological data of different food mixtures is collected and analyzed to determine optimal operating conditions. Shear-thinning is one necessary aspect of printability that can be quantified through rheology. Addition of solid food particles to make the print material heterogeneous will also affect the rheology of the mixture and must be taken into account. For example, addition of particles increases the viscosity of the mixture and introduces the challenge of clogging. Another issue associated with a reciprocating pump type extruder is pressure drop within the syringe. This is related to the viscosity and the nozzle diameter, and incentivizes making the nozzle as small as possible while still allowing the particles to pass through. The smaller nozzle size also prevents the mixture from leaking out of the syringe due to gravity when printing is finished. Rheology allows us to predict the printability of each food mixture and make changes to optimize the final product.

From Left: Tori Danis, Howard Craig, John Yao, and Alexandra Oliveira

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 18

ADVISOR: Prof.Brian Willis

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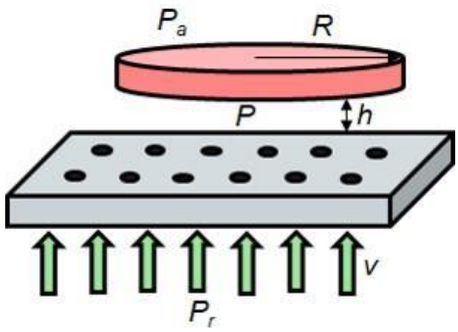
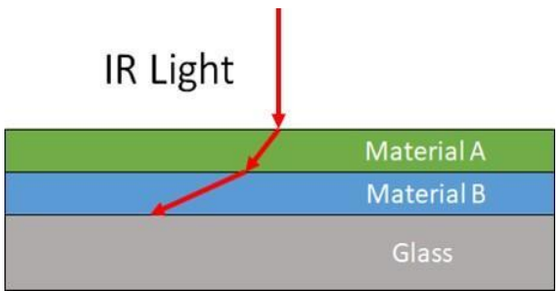
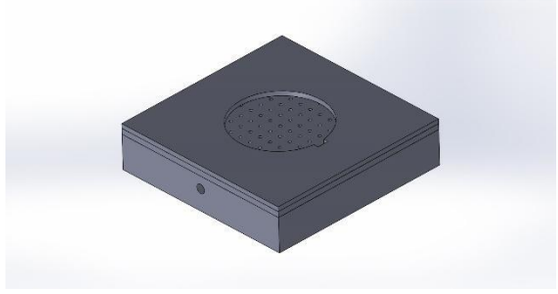
Spatial Atomic Layer Deposition Fluid Modeling for Thermal Glass Applications

Spatial Atomic Layer Deposition (SALD) is used for different glass coatings such as anti-reflective coatings for solar cells, hydrophobic coatings for phone screens, and thermal glass for insulation. We are applying SALD to architectural thermal glass for energy efficient buildings. While ALD allows for accurate tailoring of coating layer thicknesses, SALD eliminates the need for vacuum technology, increases deposition rate of the precursors, and increases overall throughput of the process. There is limited information shared on coating layers for thermal glass, therefore further development is needed to maximize the rate of deposition and scale-up to larger architectural substrates.

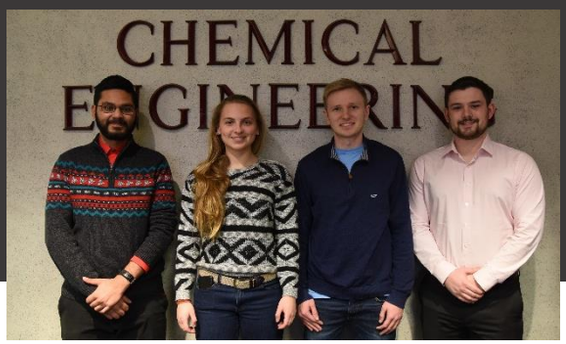




The goal of this project is to study the fluid mechanics required to float glass substrates above an air table, as well as evaluate the coating materials required to reflect infrared light from a surface. Research on the coating materials includes specifically what materials are used, in what order they are layered, and the individual thickness of each layer. The coating material enables low-emissivity glass production using SALD, which may provide future energy conservation solutions in commercial and residential buildings. This application to larger buildings includes a scale-up of the process that is justified both economically and environmentally.



A prototype of an air table reactor was designed with a reservoir charged with nitrogen until it flowed out through a porous above the reactor. A fluid mechanics model was used to predict the height of a wafer when varying several different parameters, including the mass and radius of the silicon wafer, the flow rate of nitrogen, and the hole design of the face plate over the reactor. Experiments were performed to measure the influence of these variables on the height in comparison to the model. Results showed that the height increased for higher nitrogen flow rates and larger radii, while it decreased when the mass of the wafer was increased. These results were then scaled up and deposition materials were studied to design a process that can be used to coat low-emissivity windows and provide future heating cost savings. The process scale-up for thermal glass using an air table reactor is a novel SALD application.



Left to Right: Rohit Kumar, Ugne Kirvelevicius, John Pettersen, Albert Tulli IV

CHEMICAL & BIOMOLECULAR ENGINEERING

TEAM: 19

ADVISOR: Prof. Mu-Ping Nieh

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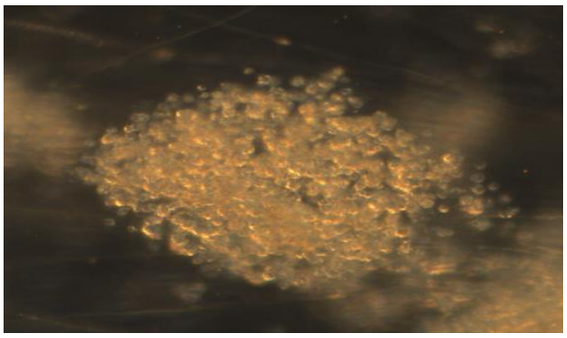
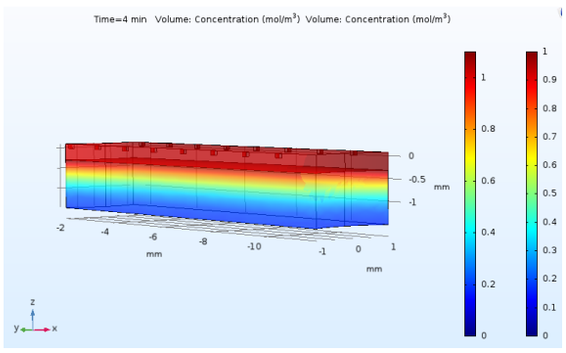
Tumor on a Chip





An estimated 1.7 million new cases of cancer and 600,000 deaths due to cancer occurred in United States in 2018 according to the National Cancer Institute. With these estimations only increasing year to year, it is extremely important to find effective cancer treatment timely. Therefore, developing a faster and effective way to test the efficacy of drugs becomes a challenge. Our senior design project aims at designing different types of tumor-on-a-chip devices to achieve the goal. The main objectives of our design project were to create a tumor on a chip to mimic the in vivo tumor environment, bridging clinical and in vitro cancer research and providing an effective platform for cancer drug screening. The anticipated benefits of this project include improved cancer treatment strategy, alternative methods for drug design, and real time analysis of cancer cell-drug interactions.

The tumor on a chip project focused on creating a microfluidic device to study the diffusion of nanoparticles into a cross linked hydrogel, mimicking the extracellular matrix of the tumor. The microfluidic devices or chips were designed using SolidWorks. One main channel, created to mimic a blood vessel, was used to transfer media to one or more of the chambers where the cancer cells are suspended and grown in the hydrogel. The device is composed of five layers made of two polystyrene film layers, two polystyrene tape layers, and a PMMA core. There are 5 different designs of the chips to study the effects of geometry and nanoparticle interactions on diffusion and cancer cell growth. Optical microscopy or digital microscopy is used to evaluate the transfer of nanoparticles from channel to in tumor. The experimental results were compared to simulation outcome with a COMSOL model that simulates the diffusion of nanoparticles through the hydrogel and fluid flow within the chip. The end goal of this project was to establish a diffusion model which agrees with the experimental findings. Moreover, we investigated the cancer metastasis using the uniquely designed device.

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CIVIL ENGINEERING

Team Members Left to Right: WenFeng Ethan Liu, Shannon Williams, Jennifer Newton, Nikhil Ramachandran

CIVIL ENGINEERING

TEAM: 01

SPONSOR: CT Department of Transportation

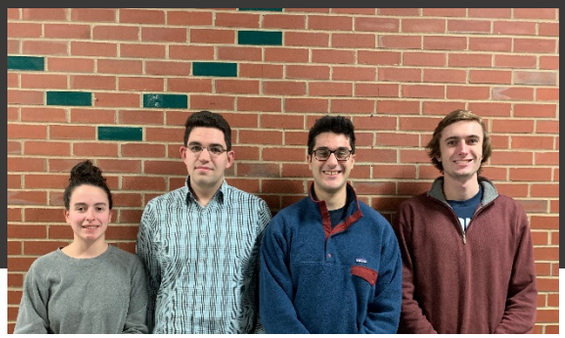
ADVISOR: Dr. John Ivan

Highway Capacity and Safety Improvements

The Connecticut Department of Transportation desires to update the intersection of Route 218 and Route 187 in Bloomfield to decrease the overall traffic congestion and improve the safety of the intersection. The main concern was finding the best intersection design to improve the flow of the westbound left turn to increase capacity. Acquiring some of the land nearby was considered for alternative designs, but there is restricted right of way availability due to sensitive and intensive land uses surrounding the intersection.

The three alternative designs considered originally are the addition of a second left turn lane from the westbound direction, a flyover ramp, and a roundabout. The addition of a second left turn lane would require a second receiving lane in the southbound direction and an overall increase in lane width. The installation of a flyover ramp would serve the left turn movement from the westbound direction. The roundabout would require two lanes in the circulating roadway, which is found to not be feasible due to space constraints, even though it would reduce the occurrence of serious injury and fatal crashes. An additional alternative is a two-way jughandle to alleviate congestion by removing left turn movements from the intersection. This design can eliminate phases in the signal timing and reduce the potential for turning crashes. For all designs, considerations were given to pedestrians by modifying sidewalks to meet ADA standards and decreasing the crossing length to reduce crossing time and pedestrian exposure.

The Connecticut Crash Repository was utilized to conduct an analysis of the intersection and nearby intersections within the last three years. Highway Capacity Software was used to develop models of the alternatives and compare delay for both current and projected volumes. Microstation was used to create the final design in aerial view. All the designs were analyzed in terms of anticipated cost, change in crashes, and change in intersection delay based on current and projected volumes for a no build condition. The final design was selected based on these criteria and satisfies the goal of reducing congestion and improving the safety of the intersection.

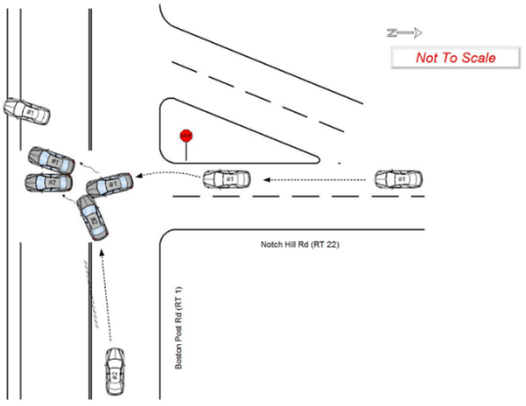


Katherine Gosselin, Matthew Mazzatto, Steven Luglio, Blake Widmer.

CIVIL ENGINEERING

TEAM: 02
SPONSOR: Connecticut DOT
ADVISOR: Dr. John Ivan

Highway Safety and Operational Improvement for U.S. Route 1 and CT Route 22 in North Branford, CT



In North Branford, Connecticut, US Route 1 intersects CT Route 22 just north of I-95. The existing intersection creates a T-shape with CT Rt. 22 ending when it reaches Rt. 1, and leaves drivers with the option of turning left or right (North and South, respectively) onto Rt. 1 from Rt. 22. The main issue that the intersection faced during peak hours was a long left-turn queue on Rt. 22 to turn Northbound onto Rt. 1. Because the intersection did not contain a signal, a consistent stream of cars on Rt. 1 meant that drivers had to wait at the Rt. 22 stop sign for much longer than normal.

A total of four alternatives were proposed. They included a signalized intersection without a protected left turn lane, a signalized intersection with a protected left turn lane, a roundabout without a right turn lane, and a roundabout with a right turn lane. Our group used traffic counts, crash history, and elevation maps provided by the CT DOT to analyze the existing intersection as well as the proposed alternatives. We conducted safety, capacity, cost-based, and environmental analysis, as well as drafted the alignment of each proposal. The goal of this was to come up with the most efficient design possible that solved the problems of the existing intersection and increased its functionality.

Early on, it became evident that installing a roundabout would be the course of action. The site area that we have to work with is well suited for the geometry of a roundabout, and a roundabout would cleanly fix the main issue with the intersection, which is the problematic travel delay from Rt. 22 Eastbound at the intersection while also addressing the safety concerns. Overall, it was the best way to fix the issues that are currently present with the intersection.

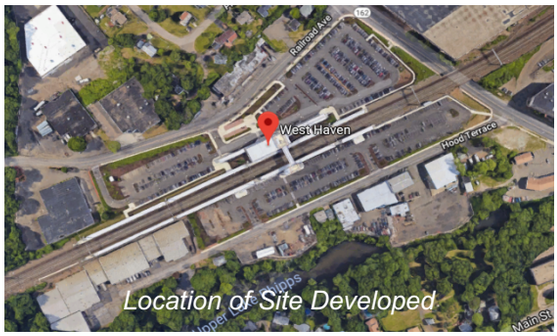
Engineer Team Members from left to right: Andrew Pires, Doris Boursiquot, Weiqi Wang, Sami Malhas.

CIVIL ENGINEERING

TEAM: 3
SPONSOR: Connecticut DOT
ADVISOR: Dr. Sarira Motaref

Fiber Reinforced Plastic Railroad Station Platform Study

The West Haven train station, opened in August 2013, is located on Railroad Ave in New Haven. The main purpose of the project is to find an alternative for the original design, which was built using concrete platform. The first phase includes a design of new platform and a new construction schedule. In the second phase, the construction cost will be estimated and will be compared against the original construction cost. In addition, the force account will be provided per sponsor's demand.



Location of Site Developed

The original design of concrete slabs have issues with corrosion and freezing. They also require high maintenance leading to high cost. The fiber reinforced plastic (FRP) material does not have these issues as a more sustainable material. FRP product is an innovative material which is corrosion resistant allowing for a longer lasting platform which eliminates maintenance. Additionally the platform is lightweight allowing for quick installation process on site of just placing the platform onto the existing structures. These advantages will allow for a lower construction cost and also shorter duration for the construction time. Furthermore, the new design will be significantly more sustainable than the current concrete platform. The geometry of the new platform was selected by using available design tables provided by provider factory. Then, the design was verified by using SAP2000 to control the load capacity of the supporting structure. This new design of the platform was then drafted in AutoCAD to display a cross section of the new platform on the supporting structure.

Existing Concrete Platform

The FRP platform design shall follow all applicable design standards such as ADA, AREMA and Metro-North, and the Connecticut Building Codes to be suitable for every user. The team have used data from original design of train station provided by Connecticut department of Transportation to set the construction schedule and the cost estimation of the new design.

Proposed Fiber Reinforced Plastic Platform

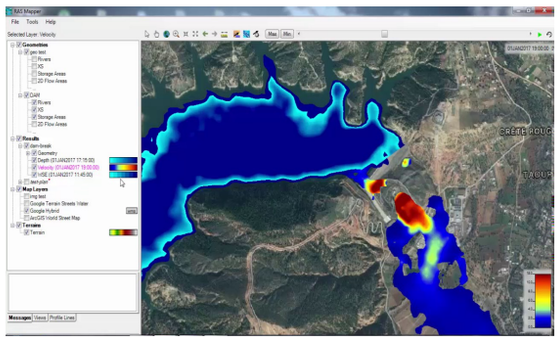
The team will provide the final platform design using FRP, construction schedule and cost estimation to the sponsor. In the final report, the construction methods, materials, duration, and cost of both platforms (using concrete versus FRP) will be compared to identify the most efficient option.

Keith Robbins, Alexander Murray, Douglas Morey

CIVIL ENGINEERING

TEAM: 4
SPONSOR: Town of Wethersfield
ADVISOR: Charles Elias

Bell Pond Dam Breach Analysis



The Town of Wethersfield contracted GZA GeoEnvironmental, Inc. to perform inspections on each of the town-owned dams in late 2016. Among those inspected was the Bell Pond dam, an 180-foot long earthen embankment dam, which was found to be in poor condition. Inspectors cited deterioration of the auxiliary spillway, excessive vegetation, unknown conditions at the intake and outlet works structures and gate valve, and deteriorated concrete at the former turbine housing structure as contributing to the dam's poor condition. The inspection concluded that a potential uncontrolled breach would greatly impact downstream residential areas as well as major state roads, particularly the Silas Deane Highway (Route 99) and Maple Street (Route 3); engineers have hence proposed raising the dam's CT DEEP Hazard Classification from Class BB (moderate) to Class B (significant) or even Class C (high) hazard potential.

Our team was hired by the Town of Wethersfield engineering office to perform an analysis of the potential breach and to identify the hazard a breach may present. The first step of this process was conducting our own field inspection, in which we found the dam's condition to have gradually worsened since the initial inspection two years prior. Our team's members then studied common dam breach mechanisms, making use of FEMA document P-946 (*Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures*). From this documentation, we found that a breach mechanism pertaining to an earthen embankment dam to be governed by overtopping failures, caused by the failure of a cohesive soil embankment usually on the downstream face which then extends upstream; its progression can be modeled linearly or by a sine wave.

Using this information, our team prepared a dam break model using the hydraulic modeling software HEC-RAS along with provided topographical and GIS data; from this model we were able to identify the scope and scale of a potential breach, zones of notable hazard levels, and other critical areas pertaining to the breach.

(From Left to Right) Daniel Terach, Gavin Metsack, Ben Jednak, Michael Pagano

CIVIL ENGINEERING

TEAM: 5
SPONSOR: Town of Wethersfield
ADVISOR: Nicholas Lownes

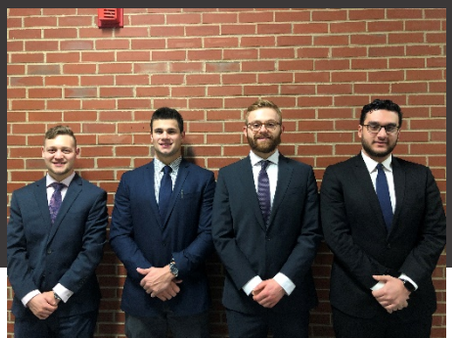
Traffic Sign Replacement Strategy and Intersection Design

Traffic signs are often a forgotten, but integral part of everyone's everyday life. Highly reflective traffic signs are extremely important in maintaining a high level of safety for those using the street, including crossing pedestrians and bicyclists. Reflectivity is imperative for all driving, especially night time and adverse weather conditions, where visibility is low and drivers rely more on the signs to guide. There are many different types of signs, including regulatory, warning, and guide signs. Regulatory signs are typically red and/or white and are used to reinforce or indicate traffic regulations or laws such as stop signs, no parking signs, yield signs, etc. Warning signs are typically yellow and guide signs, such as street name signs, are green.

The Town of Wethersfield engineering department, headed by Professional Engineer Derrick Gregor, tasked the four of us to work on a developed geographic information system (GIS) documenting traffic signs. This process required numerous field visits and extensive knowledge with the Manual on Uniform Traffic Control Devices (MUTCD). During inspection periods, we recorded the locations, various specifications, defects, and the conditions of each sign on high-traffic town roadways into the GIS database. In addition to the inspection process, we re-designed the roadside signage on multiple intersections to minimize traffic accidents, thus improving the safety of everyone using the roadway. To do this, we utilized the Connecticut Crash Data Repository (CTCDR) with the provided Average Daily Traffic (ADT) to determine the optimal locations for our designs. We also provided the town with a cost estimate for our intersection redesigns, including labor and material costs.

The Federal Highway Administration (FHWA) suggests that the average lifespan of a traffic sign is 7 to 15 years. This is only an estimate because different sheeting types, average weather, and damage/vandalization all affect the sign's lifespan. Combining this information with the data we recorded in the field, we were able to devise a cost estimate plan for the town for replacing and maintaining their traffic signs over the next few years.

Photos from Top to Bottom: A side-by-side comparison of similar sign types, but different conditions: left side needs to be replaced whereas the right side is still highly reflective, Ben Jednak on an inspection, Michael Pagano using a reflectometer to measure the reflectivity of the back sheeting of the warning sign



From left to right: Joshua Kaplan, Wesley Sekelsky, Matthew Dagenais, Mohamed Hashem.

CIVIL ENGINEERING

TEAM: 6
SPONSOR: Town of Stonington, CT
ADVISOR: Dr. Richard Christenson

Pawcatuck River Pedestrian Bridge

The Town of Stonington wishes to enrich its community. This presented a civil engineering opportunity to connect two states. As a foremost task, they desired a pedestrian bridge to be built over the Pawcatuck River from Pawcatuck, CT to Westerly, RI; unifying two cities, and thusly two states. The general target boundaries for construction of the pedestrian bridge are the Westerly Train Station, Canal Street, and Coggswell Street. Even though only this small area will be directly affected by the bridge, the installment effects of the bridge will reverberate outward to serve all the people of Westerly and Stonington.

Figure 1: Aerial view of the Stonington site.

Figure 2: Elevation view of the old railroad abutment on the Stonington side.

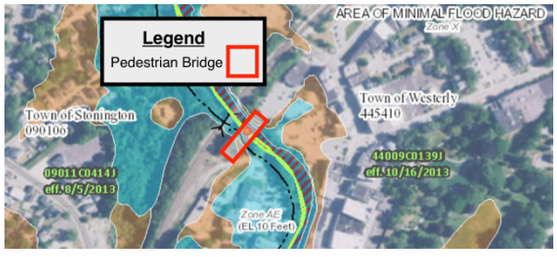


Figure 3: FEMA Flood Zone data around the bridge location at the old railroad abutments.

After consulting with our clients, advisor, and experts on the matter, we identified main issues that we would encounter when designing a suitable pedestrian bridge. Our first main task was to choose a location that could physically support the bridge, be clear of the floodplains, and be a viable walking alternative for pedestrians. Another main goal of the pedestrian bridge was to make it a Transit-Oriented Development (TOD) project, which centers pedestrian-oriented communities near public transportation, and also provides generous funding opportunities. Simply by itself, a pedestrian bridge cannot be deemed a TOD project; the addition of mixed-use apartments developed on the Stonington side, just south around Cogswell Street, are a future idea, pitched to us by our client. Thusly, the bridge will be the direct connection between the new housing projects and the Westerly Train Station located just over the river. The development of the community does not stop there; within a half-mile radius, neighborhoods, schools, and restaurants are all located, which once interconnected, will stimulate socio-economic growth, benefiting the both communities.

More so, through further research and consultation, we deemed a suitable location and type of bridge that would best serve the communities' needs. Using the old, existing railroad abutments, we designed a bridge to span the river, giving access for pedestrians to travel between Stonington and Rhode Island. With the chosen abutments already above the floodplains, limited grading needed to be completed. We also designed the approach paths for the bridge.

With a simple pedestrian bridge idea, we were able to construct a design that connects two cities and two states.

From left: Brendan Richardson, Derek Litty, Anthony Capuano, and Samuel Ulfsson

CIVIL ENGINEERING

TEAM: CE 07
SPONSOR: Town of Stonington, CT
ADVISOR: Jin Zhu, Ph.D.

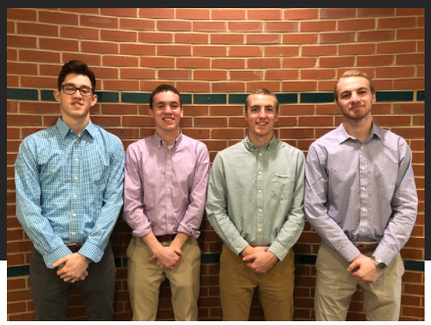
Mystic Railroad Station Parking Project

The town of Stonington, Connecticut has tasked us with designing a parking lot for the Mystic train station. The existing station, owned by Amtrak, has a relatively small parking capacity which often does not meet its daily needs. This discourages use of the station, which is problematic for both Amtrak and the town of Mystic. Planners from the town of Stonington have identified an unused acre of land behind the Mystic Fire Department, which is currently owned by Amtrak, for application in this project. Our primary objective was to design a parking lot in this area that satisfies the daily needs of the Amtrak station while simultaneously creating supplementary parking for the town of Mystic.

Additionally, the town of Stonington has asked us to prepare preliminary designs for other developments in the area, with the goal of improving the social and economic livelihood of Mystic. The current street network deters people from walking, as large sections of Roosevelt Avenue, Broadway Avenue and other streets near the Mystic train station do not have crosswalks or sidewalks. Additionally, no intersection exists between Roosevelt and Broadway, which further discourages crossing the street due to high automobile speeds. This led to our second objective: designing a street network that could improve pedestrian accessibility to the train station and other nearby businesses.

We were given contours and property lines from the town of Stonington to begin this project. While the Amtrak land is spacious enough for a parking lot, we were told that the dirt lot in the rear of the Mystic Fire Department was also available for use. Therefore, our design included two alternatives: one for the Amtrak-owned lot only, and one for the combined Amtrak and Mystic Fire Department lot. We used ITE Traffic Engineering Handbook as a reference during design. The designs of the parking lot, cross-sections of the sidewalk were done in AutoCAD, and designs of the overarching sidewalk network were done in ArcGIS. Preliminary intersection designs were also provided.

We would like to thank Dr. Zhu from the University of Connecticut for advising us throughout this process. We would also like to thank Jason Vincent and the planners from Stonington for giving us the opportunity and resources to work on this project.



CE Senior Design Team 8. From Left to Right David Wu, Chris Schwartz Kevin Sisco, and Chandler McLaughlin.

CIVIL ENGINEERING

TEAM: 08
SPONSOR: Town of Stonington
ADVISOR: Ross Bagtzoglou, Jason Vincent

The Pawcatuck Riverwalk

The Pawcatuck River runs along the borderline between Rhode Island and Connecticut. On the Connecticut side resides the small village of Pawcatuck, a CPD of the town of Stonington. Many years ago, Pawcatuck was an industrial area home to numerous mills and housing units for workers. The town wishes to rejuvenate the area making it more accessible and enticing for both locals and tourists. When tasked with this project, our team investigated various designs in order to find the optimal method to fulfill the town's requests. The team's final design included the proposed demolition of an existing cantilevered sidewalk. The sidewalk is being redesigned to be structurally sound, ADA compliant, and stretch farther than the previous one. This new sidewalk will allow more pedestrians to access the shops and restaurants along the riverfront. The second part of the project consisted of the reinforcement of an existing retaining wall. The design has the wall reinforced using a combination of soil screws and sprayed concrete. This addition to the cantilevered sidewalk and retaining wall is to be the foundation of the renovation of the Pawcatuck riverfront properties.

The previous design of the cantilevered sidewalk was using concrete slabs which are beginning to fail due to lack of consideration for the long term effects of additional weight, compared to the original design, on the existing support system. This is the most glaring issue with the current design and so with the teams' new design, the main consideration is weight and more importantly longevity of the replacement system. Across the bridge from the cantilevered sidewalk, the current retaining wall is beginning to crumble due to wear and tear from the river. In order to remediate this issue, our team has decided the best redesign route would be to use helical tiebacks combined with shotcrete or a concrete cap to restore the structural integrity of the retaining wall and increase the aesthetic component of the wall. Helical tiebacks are a more expensive alternative than simpler wall anchors, but with the limited space behind the wall, wall anchors are not a possibility. Demolishing and rebuilding the retaining wall is unnecessary and will have much higher excavation costs, wall costs, labor costs, and time consumed. By analyzing the drainage patterns behind the wall and drainage considerations already implemented into the wall, we needed to integrate a new drainage design into the existing wall to prevent cracking, crumbling, and excessive bearing capacity on the wall.

Team 9 Group Members (from left to right): Ajeet Sandhu, John Zapata, Robert Lupien, Giovanna Fusco

CIVIL ENGINEERING

TEAM: 9
SPONSOR: Fuss & O'Neill
ADVISOR: Dr. Norman Garrick

Hartford Pedestrian Safety Project

FUSS & O'NEILL
ENGINEERS • SCIENTISTS • PLANNERS

This project tasked us with studying various street segments within downtown Hartford in order to create ways to improve pedestrian safety. To do this, we proposed a variety of traffic calming patterns to make the area safer for non-motorized forms of transportation. Our area of study exists in Hartford's very busy downtown area, which is primarily car-oriented.

The area described above consists of a variety of vehicular, transit and pedestrian traffic. There are several bus stops located throughout Main and Market Street with lots of usage. Due to the existing roadway widths and available on-street parking, there is a large amount of vehicular traffic along this corridor. This creates potentially harmful situations for pedestrians when trying to cross certain intersections. Due to the lack of bike lanes, bicyclists are also in danger when trying to navigate the street networks that are very auto dominated.

Hartford, CT is a city that is very business oriented. A significant amount of traffic is due to commuters who live outside of Hartford. By focusing on the transportation needs of those who live outside of the city, the city leaves those who live in Hartford at a disadvantage. Our aim is to increase pedestrian safety, reduce vehicular traffic, and improve the transportation features within this corridor for all Harford residents. To do this, we created several different conceptual designs in our focus area.

One design focused on a mid-block crossing on Main Street between the Main Street/Pearl Street intersection and the Main Street/Gold Street intersection. The designs include incorporating a pinchpoint, median, and High intensity Activated crossWalK (HAWK) signal.

A design for improving the safety of the intersection of Main Street and Central Row was also developed, which implements bump outs at the street corners so pedestrians are more visible to motorists and have a smaller crossing distance on the road.

Group Members Left to Right: Javier Reyes, Anders Carlton, Genevieve Rigler, Thomas Sawtelle

CIVIL ENGINEERING

TEAM: #10 Fenton River Embankment Improvement
SPONSOR: Joshua's Trust
ADVISOR: Lanbo Liu

Fenton River Embankment Stabilization and Rehabilitation Project

Above: Site survey conducted on October 10, 2018

Above: The project site looking South towards the Gurleyville Grist Mill

Above: An example of the rip-rap erosion control technique

The problem presented to the team consisted of a prolonged embankment erosion along the Fenton River in Mansfield, Connecticut. Direct contact between the soil surface of the existing embankment and flowing water of the Fenton River caused erosion when historic storms occurred. The Joshua's trust's primary concern was that the site downstream of the erosion area contained the historic Gurleyville Grist Mill. Continued erosion could eventually compromise the soil underneath the foundation of this historic building and lead to structural problems in the future. The design team was tasked with two major design components while creating a plausible solution to the problem.

First, analysis was performed on the flow conditions of the river as well as the existing site conditions. A site survey along with existing LIDAR contours was used to generate elevation cross sections of the Fenton River adjacent to the embankment. From this site data, HEC-RAS as well as the USGS historic gauge heights of the Fenton River over the past 10 years allowed the team to create a model of the eroded river section. This model allowed the team to determine the flow conditions during historic 50 and 100 year storm events. In addition, the model allowed the team to validate any proposed post construction conditions to see any adverse effects of the design.

The second component to the project was to create a rip-rap bank stabilization design for the site. The conditions modeled in the analysis portion of the project were used to determine the appropriate rip-rap stone sizing in order to stabilize, strengthen, and restore the embankment. Final components of the design that were submitted to the Joshua's Trust included a detailed plan set of the design, a project cost estimate, and an engineering report consisting of the design methodologies as well as background information relevant to the project. The Joshua's Trust is currently working with Earth Dynamics, a local contractor from Coventry, Connecticut on starting the construction phase of the project.

Left to Right: Jacob Marganski, Benjamin Hipsky, Peter Kamianowski

CIVIL ENGINEERING

TEAM: CE 11: Airline Trail Bridge Project
SPONSOR: Town of Thompson, CT
ADVISOR: Prof. Howard Epstein

Airline Trail State Park, Thompson, CT. Crossing Route 193 North of the Thompson Dam.

The project took place just East of the West Thompson Dam, at coordinates 41.947427 N -71.885150E. The Airline Trail State Parks travels in a North/South direction crossing the East/West running CT-193. The concern for hikers, biker, and rider's safety had been raised and was addressed with this project. A structure was required to allow pedestrians to pass over CT-193 without endangering themselves or drivers. The road is currently speed limited to 35 miles per hour. However, traffic had been observed going almost twice the posted speed limit, which is not considered safe for crossing. Historically, a bridge was in place, as the railroad crossed the state route there. The abutments for the railroad have since been removed and the grade had been sloped back at roughly 12.5% slope from the edge of the pavement to where the trail leveled back out. The trail continues to the North and to the South to other destinations. The abutments and bridge designed, will be built to best replicate the previous structure, within the bounds of funds available. The project shall be built using prefabricated elements and be installed and inspected onsite by qualified personnel.

The site consisted of the two ends of the trails, slowly sloping downward from a total height of roughly 17 feet on each side above the sides of the road. The South and North trail ends do not directly line up, which was considered for the bridge itself. There were gates on each opening to the road, which will be removed before construction. There was also a sign containing the airline trail logo and park rules. This signage will be moved or replaced to be visible at the entrance of the bridge. The North entrance to the trail featured a more open area, with a drainage area to the east side. This drainage area is an assortment of large, loose rocks leading to a pipe going into the ground. However, the drainage was functioning poorly, and a large amount of ponding accumulated for many days after any rainfall. This has been addressed and treated. The south entrance is much narrower, entering the forested area of the trail much closer to the entrance. The trail itself was of lower quality in the area, being much more eroded. As a result, there was very rough ground, along with a damaged walkway. Both sides lowered downwards to the road at roughly the same slope, reaching a large metal gate on each side, denoting the entrances to the trail. It was notable that there was no type of pedestrian-safe crossings or sidewalk in the area, something that has been taken into consideration when designing any access point to the roadway.

From left to right: Elizabeth Tujak-Weiss, William Hughes, Erica Lucente, Tatiana Prevalla, Maeve Manfredi

CIVIL ENGINEERING

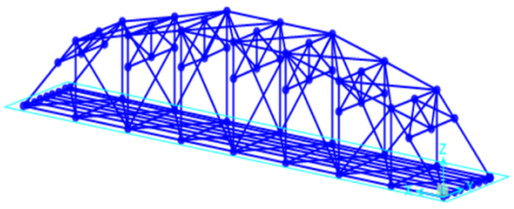
TEAM: 12

SPONSOR: CHA Consulting, Inc.

ADVISOR: Dr. Howard Epstein

Load Rating of Bridge No. 01487
Farmington, CT

design/construction solutions



Bridge 01487 is a through-truss bridge built in 1939 on route 177 in Farmington. The structure is in need of rehabilitation and has classified as structurally deficient in the last inspection report dated May 2018. Major section losses have led to decreased carrying capacity of the bridge. Current rehabilitation plans are being planned. A revised load rating has been conducted to determine the current status of the bridge to aid in the upcoming rehabilitation strategy. AASHTOWare BrR has been utilized to perform the load rating. Following the completion of the rating, rehabilitation scenarios were explored by removing or adding members.

The bridge measures 231 feet long and 48 feet wide. The existing substructure consists of two reinforced concrete abutments. There are two lanes of traffic, one in each direction, with a sidewalk on both sides. In 2018, the Estimated Average Daily Traffic (ADT) on Route 177 was approximately 15,700 vehicles.

All calculations followed the regulations of the 2007 version of the American Association of State Highway and Transportation Officials (AASHTO) LRDF Bridge Design Specifications. This included the consideration of the theoretical HL-93 vehicular live load, which is used as the design loading for highways and bridges in the USA.

The load rating calculates the safe live load capacity of the structure, especially for the critical members. Using the AASHTOWare BrR software, our team has input the bridge parameters, accounting for section loss, performed the load rating of the structure, and determined the overall capacity of the bridge.

From left: Mike Noiset, Will Strong, Carley Corbo, and Colin Cassidy

CIVIL ENGINEERING

TEAM: 13

SPONSOR: Town of Thompson

ADVISOR: Dr. Nicholas Lownes

Buckley Hill Road Intersection Redesigns

The town of Thompson brings attention to two unsafe intersections on Buckley Hill Road. One is located at Route 200 and the other at Route 12. Possible malfunctions include, but are not limited to, unsafe turns, improper sight distances, congestive tracker trailer traffic and a lack of pedestrian friendliness. Effective testing is required to obtain sufficient experimental and numerical data. This data will be used in a redesign of the intersections to ensure the safety of the major roadway is met.

Buckley Hill Road serves as a connector to Interstate 395 and therefore the town wants these intersections to better handle the larger volume of traffic and tractor-trailers seen from the interstate.

Routes 12 and 200 are both free flowing urban minor arterial roads traveling in the North/South directions. Buckley Hill Road is a stop controlled urban collector road that travels in the East/West directions. Routes 12 and 200 both intersect separate sections of Buckley Hill Road to form Y shaped intersections, with the Route 12 intersection split up by a center island.

For each intersection, it is imperative to minimize the amount of crashes compared to previous studies, increase signage in order to improve driver's awareness of points of conflict, as well as consider the traffic flow along with the surveying data to ensure the most effective decisions are created for the reconfiguration.

The goal of this project is to enhance the safety on Buckley Hill Road to accommodate vehicle and pedestrian traffic while staying within the town's budget.

In order to ensure the goal of this project is achieved, surveying data was obtained, traffic counts were taken, and a sufficient amount of research has been done in order to verify all safety requirements and standards are met throughout the design

Stephanie Bogue, Sheila Khayami, Yogesh Yagnik, Andrew Clark

CIVIL ENGINEERING

TEAM: 14
SPONSOR: Town of Essex, CT
ADVISOR: Dr. Norman Garrick

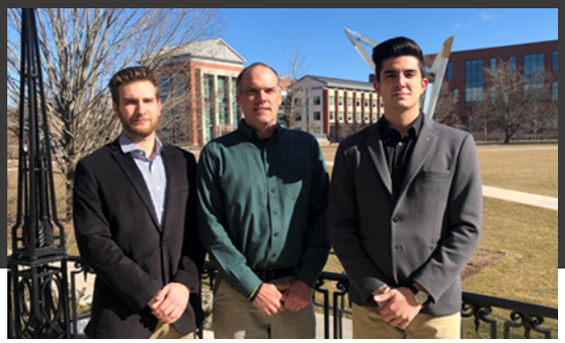
Parking, Biking, and Pedestrian Networks in Main Street, Essex Village

The Village of Essex in the small town of Essex has a Main Street district that is rich in atmosphere, history and culture. Restaurants, retail establishments, and marinas draw thousands to the area. The Economic Development Commission of the Town of Essex has expressed a need for better alternatives to the current systems of parking, bicycling, and pedestrian movement. This project aims to allow for better access, safety, and convenience. The intent of this design project is to enhance and highlight the historic nature of Essex Village.

The project consists of four main areas: Main Street, Ferry Street, Pratt Street, and the traffic circle at the village entrance. The existing street designs present opportunities for several improvements. Due to the inadequate usage of the existing on-street parallel parking, alternatives for on-street parking, public lots, and proper signage are to be explored. Improved wayfinding signs are to be considered, with the intention of properly directing tourists to Essex Village and within the Village.

Issues of vulnerable users, such as pedestrians and bicyclists, can be addressed with the implementation of traffic calming. The approaches we will explore include the use of varied street materials and the addition of bump-outs to the crosswalks. These elements, in combination with improved parking and pedestrian facilities, will enhance the safety and sense of place in Essex Village.

The Economic Development Commission will be presented with several design concepts. Each alternative will consist of a variety of features that maintain the historic sense of place and provide improved networks for parking, bicycling, and pedestrians. The committee and Town can select from these concepts which design treatment they believe will ultimately best serve the village.



Anton A. Kaminskiy, Eric T. Smith, Patrick R. Rizk

CIVIL ENGINEERING

TEAM: 15

SPONSOR: Lenard Engineering, Inc.

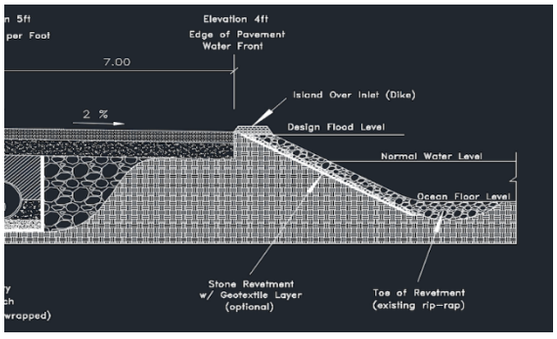
ADVISOR: Christine Kirchhoff, PhD, P.E.

Seawall Design and Road Realignment for Storm Flooding Protection in Groton, CT

Lenard Engineering, Inc.
Civil, Environmental and Hydrogeological Consultants

Lack of protection from seawater damage together with frequent flooding during storms and extreme high tides has compromised a section of road known as Island Circle in Groton Long Point, Connecticut. The Groton Long Point Association has sought a solution for stabilizing the road and preventing frequent overtopping of seawater during extreme storms. A stabilized road would facilitate investment in the replacement of underground water and sewer utilities which underlay the road, and which are at the end of their service life.

To provide stability and protection to this section of road, a riprap revetment was designed. The revetment, stone riprap, and underlayer were sized according to wave action, water depth, and wind measurements for a 10-year design storm. The road along the northwestern end of Island Circle is narrow; to preserve as much road width as possible, the steepest recommended slope of 1:2 was used for the revetment design. The riprap stones chosen for the design are blocky and angular. These stones create a rough surface which dissipates energy for less wave run-up and overtopping while preserving the natural beauty of the seashore. Heavier stones will be placed at the toe of the revetment to prevent slipping failure of the upper revetment. The revetment design includes additional berm stabilization to handle wave overtopping for extreme storms due to height constraints governed by the low-lying area in all directions. For additional protection, sea level rise projections to 2050 were used to guide road elevation. For compliance, the road will be raised to the elevation of the intersecting roads. The base and subbase layers of the road will be non-cohesive soils to provide rapid drainage and prevent the buildup of hydraulic pressure. A permeable geotextile layer will be placed between the newly prepared subgrade and the underlayer of the road and the revetment to prevent the movement of fine soils while allowing water to flow. The new asphalt road will be placed with a 2% cross slope toward the water for rapid drainage during flooding.

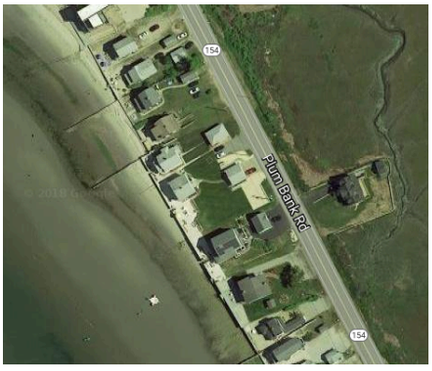


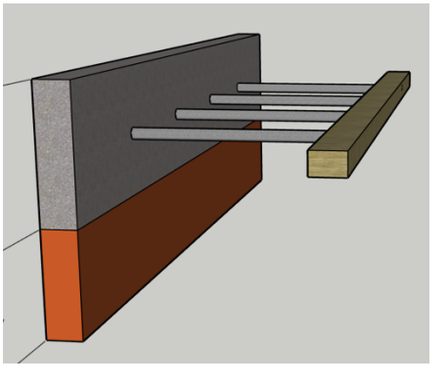
Hiram Olvera, Erica Gambino, Daniel Lubinitsky

CIVIL ENGINEERING

TEAM: 16
SPONSOR: Lenard Engineering, Inc.
ADVISOR: Christine Kirchhoff

Sea Retaining Wall Redesign and Replacement





Lenard Engineering, Inc. requested assistance in determining a solution to fix a damaged sea wall that spans four adjacent houses along the Long Island Sound in Old Saybrook, CT. The existing sea wall was damaged by hurricane Sandy. In considering potential solutions to fix the sea wall, the team considered the preservation of property value, homeowner's ocean view, suitability of materials for a coastal environment, permitting, cost, and constructability.

An anchored wall was determined to be the best choice for this project. An anchored wall design is narrower than the existing wall requiring less excavation, enabling replacement of the existing wall within the existing wall footprint, and improving constructability. Furthermore, constructing the anchor wall out of reinforced concrete offers corrosion resistance suitable for the site conditions.

The wall is designed to withstand a 50 year storm and is strong enough to resist both the force and moment created by wave action during a storm surge of this magnitude. This takes into consideration the projected sea level rise due to impending climate change.

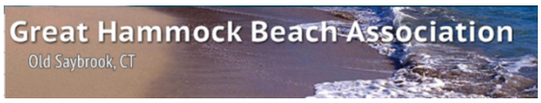
The design team guaranteed the client quality, efficiency, cost effectiveness, and value engineering throughout the sea retaining wall project. The team, composed of highly qualified engineers, provided the client with a quality end product. The redesign of the sea wall is both aesthetically and structurally effective.

Team 17 members from left to right: Frank Desimone, Haley Palmer, Connor Oakes, and Matthew Simon

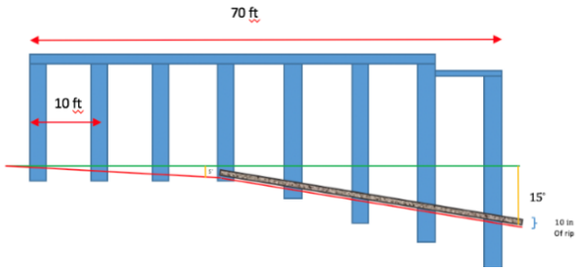
CIVIL ENGINEERING

TEAM 17: Boat Launch Design
SPONSOR: Great Hammock Beach Association
ADVISOR: Sarira Motaref

The Great Hammock Beach Association Boat Launch Renovation



View of site of interest



Dimensions of chosen design

Ramp showing siltation and algae buildup

The Great Hammock Beach Association (GHBA) is a local association of homeowners in Old Saybrook, CT that owns a private boat ramp on the Back River. The members of the Great Hammock Beach Association use the ramp for access to the floating dock nearby to dock their mid-sized boats for the season. The ramp is in a state of disrepair and needs to be renovated, as it cannot provide adequate traction for vehicles trying to launch their boats. Due to the high velocity of the river current, the bank behind the floating dock has eroded between six to eight feet in the last eight years. This erosion has caused the current to be directed back towards the shore and the boat ramp instead of along with the original flow of the river. During high tide, the current has carried the sediment from the river bank and deposited it on the surface of the boat ramp, burying the original concrete pad and changing the grading of the ramp. The deposited sediment, along with a large buildup of algae, has greatly reduced traction and created a risk of vehicles and trailers slipping into the water.

After comprehensive research and analysis by the team, alternative solutions were proposed to address the existing issues of the site. Three new plans were proposed for the ramp: (1) a new full-length concrete pad, (2) a masonry block at the bottom of the launch and 4-5 inch riprap (crushed stone) for the remainder of the length, and (3) riprap stone for the entire length of the launch. Additionally, three solutions were offered to mitigate the effects of siltation on the ramp in the future: (1) regular cleanings of the launch, (2) a wood and rock design serving as a barrier for the soil deposit, and (3) a silt curtain serving as a net to collect the silt before reaching the ramp.

After presenting to the Great Hammock Beach Association, they chose a combination of the proposed solutions in order to best respond to all issues currently facing the boat ramp. The ramp design of 4-5 inch riprap stone along the entire length of the ramp as well as re-grading the area of work (dimensions shown to the left) was chosen for the launch. Also, the installation of a silt curtain and boulders along the edge of the dock were the methods chosen to reduce siltation. The students are responsible for a project proposal that includes multiple options for the ramp and reducing siltation, along with an in-depth design analysis of the sponsor's choice that includes detailed cost and schedule estimations.

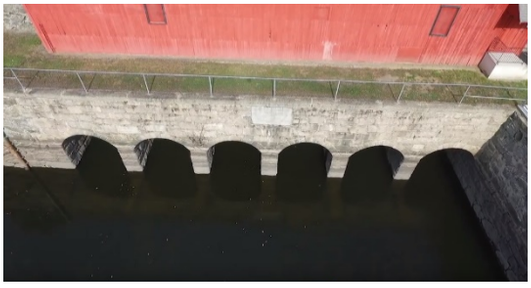
Jared Whittier, Brendan Gold, Rushin Patel, Alec Clark

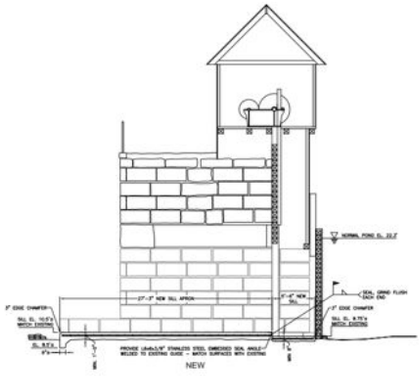
CIVIL ENGINEERING

TEAM: CE 18
SPONSOR: MATTERN Construction Inc.
ADVISOR: Charles Elias

Cofferdam Design Project

MATTERN
CONSTRUCTION INC.





The Greeneville Dam Hydroelectric Generation and Fish Lift Facility are located on 8th St. Norwich, CT. The dam is used by the town in order to generate hydroelectricity and is reliant upon the overflow gate beside it. The overflow gatehouse allows for control of the water flowing over the adjacent dam and prevents flooding. The gatehouse has large wooden gates that are used to control the amount of water allowed to pass down the overflow channel. After years of service, the flow of water had deteriorated the concrete sill that seals with the gates.

Our team was tasked to design a cofferdam to allow for safe working conditions to repair the sill of the gatehouse. A cofferdam is a watertight enclosure from which water is pumped to expose the bed of a body of water to permit the construction of a pier or other hydraulic work. The cofferdam must be able to resist horizontal forces from the surrounding body of water when the water inside is pumped from the cofferdam. The dam brought among many challenges, with remote access and high-water levels. It needed to be 10 feet wide and account for 12 feet of water. Our team has provided a design for a robust, watertight and mobile cofferdam to allow for the reconstruction of the concrete sill.

We considered a variety of solutions to meet the unique constraints of the cofferdam including the type of cofferdam, materials for the dam and installation techniques. This led us to use a variation of a gravity cofferdam which allowed for the mobility we needed by using lightweight materials and no heavy machinery. Also, it made it possible to be installed by only a pair of scuba divers making its implementation at our site realistic.

From left to right: Yi Liang, Rebecca Woods, Elysa Goldberg, Jason Ferrari

CIVIL ENGINEERING

TEAM: 19

SPONSOR: Bee and Thistle Inn – Dave Rufo and Tosh Urbowicz

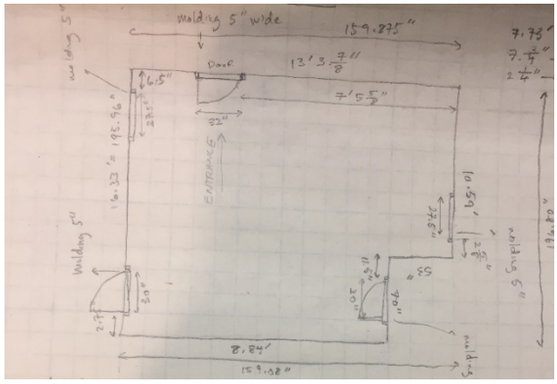
ADVISOR: Charles Elias

Restoration of the Historic Bee and Thistle Inn in Old Lyme, CT

Bee & Thistle Inn
EST. 1756
100 LYME STREET, OLD LYME, CT 06371

Exterior of the Bee and Thistle Inn

Retaining wall in need of repair



Hand drawing of measurements taken on site

The Bee and Thistle Inn is a landmark in Old Lyme, CT, and has hosted weddings and other events since its construction in 1756. Though the structure itself is beautiful in its aged appeal, the Inn has experienced great deterioration over its many years. A complete work of site drawings have been developed, outlining all interior and exterior measurements of the building. These drawings provide the owners with a detailed description of their building which includes: a master floor plan of each level, individual room floor plans, highlighted locations of structural concern and specifications of modifications our team has agreed would improve the structure from further deterioration. Our team has examined the entire structure, including the attic, all interior rooms, the basement and the exterior for signs of structural damage. We have made note of all the inconsistencies we observed on site and cataloged them in a photo journal. In addition, our team has investigated the land grade to pinpoint where moisture may be affecting the structure. We have made a contour map showing the gradation of the land as well as the building's proximity to the Lieutenant River located at the rear of the property.

A major component of the project consisted of creating a two dimensional model of the Bee and Thistle Inn in a computer space. With a large portion of the project hours focused on this task, necessary project management was first proposed in order to ensure completion. The selected project approach was to have high emphasis on the time component due to the strict time deadline. Using a Flexible Gantt Chart, we created a timeline based off milestones we pre-determined. Next, the team revised the timeline in correspondence with Bee and Thistle Staff to effectively plan site visits. Once approved, the team visited consistently over the next eight months during the modeling phase. The modeling phase consisted of 60% field work, and 40% computer modeling. Utilizing our knowledge of geospatial analysis, the team performed a dimensional analysis on each above ground floor as well as the outer perimeter in the Bee and Thistle Inn's main building. Using a laser tape measure, these measurements consisted of framework such as wall, door, and window dimensions. The complete paper drawings were then converted into a computer model using AutoCAD, a professional drafting software currently being used in industry practice. Once completed, the drawings were then collated into a CAD drawing Package for the owner to reference.

Argyrios Petkanas, Kelsey Farr, Briana Roy, Alexandra Schneider.

CIVIL ENGINEERING

TEAM: 20
SPONSOR: Manchester Land Trust
ADVISOR: Charles Elias

Case Mountain Park Dam Breach Analysis

Waterway Engineering has been contacted by the Manchester Land Trust in order to perform an analysis of Case Mountain Park Dam, located in Manchester, CT, with the town's intent to create an Emergency Action Plan (EAP). This EAP will list the necessary steps that the town will take in the unlikely event that a dam breach were to occur, including evacuation zones and or roadblocks. A complete breach of the dam will be analyzed given the waterway data during a 100 year storm. This storm will not be the cause of the breach, but rather will be occurring when our simulation is started. Waterway Engineering has taken on the task of creating 3-D inundation mapping and a simulation of the breach for the Land Trust.

The upper and lower Case Mountain Park dams have been classified as Class B dams, meaning that if the dam were to breach then it would result in significant hazardous potential. This can include possible loss of life, minor and major damage to surrounding infrastructure, and economic loss. The results of this analysis will highlight which areas, infrastructure, and residencies will be affected if the Case Mountain Park dam were to breach. Waterway Engineering has utilized the program HEC-RAS to draw up an inundation map of the area downstream of the dam, assuming a full breach during a 100 year storm event. The inundation map will display the flooded area and ground surfaces downstream of the dam, showing the probable encroachment by water released because of its failure resulting in abnormal flood flows released. Before conducting the analysis, a study of the watershed had to be conducted. The Case Dam was constructed over 100 years ago, meaning the watershed topography has changed significantly. With this data and the volume of the reservoir, a model of the breach was run, showing water levels at downstream locations at regular time intervals. Waterway Engineering has evaluated all potential factors and are confident we have presented the most accurate data possible.

Left to right: Jeffery Aselin, Ethan Belz, Andrew Myers, John Gorman

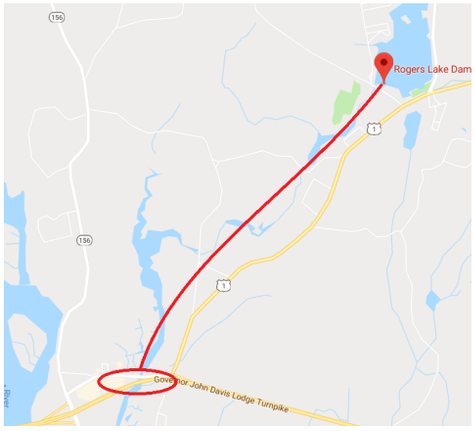
CIVIL ENGINEERING

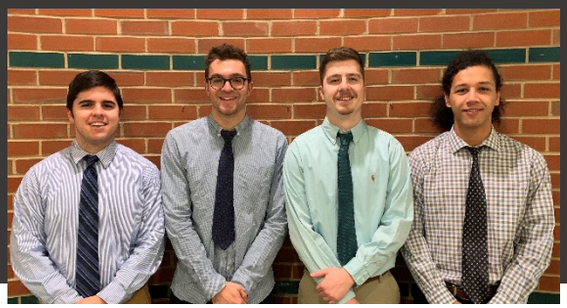
TEAM: Team 21
SPONSOR: Town of Old Lyme
ADVISOR: Charles Elias

Rogers Lake Dam Breach Analysis

Dams can be found in many areas and for many different purposes. These can range from relatively small scale such as the Rogers Lake dam, used for maintaining runoff from rain and for recreational purposes, to much larger projects like the hydroelectric Hoover dam. Regardless of the size, these dams require proper maintenance to ensure a breach never occurs. However, it helps to be prepared.

The Rogers Lake dam located in Old Lyme, Connecticut, could pose a significant danger to residents if it were to ever fail. Therefore, an emergency action plan is needed to denote the potential damage that may be caused, and the procedures for the day it should occur. To that end, we have prepared such a plan: Our procedure involves using HEC-RAS, a software developed by the Army Corps of Engineers, to determine the level of flooding in the land surrounding the dam; performing a structural analysis of the bridges carrying I-95 and Route 1 to determine if they wash out; determining the needs of the residents and how to properly evacuate/care for them in such an emergency.





From left to right: Cameron Criniti, Caleb Erhard, Trenton Kowalec, Robin Rittgers

CIVIL ENGINEERING

TEAM: 22 National Chromium Site Remediation

SPONSOR: AECOM

ADVISOR: Dr. Nefeli Bompoti

National Chromium Site Remediation

In 1940, the original National Chromium building was built and since then it has been used as storage for the company adjacent to the active plating facility. Due to previous industrial practices, the entire structure, along with the soil underneath the structure, had been exposed to plating wastes, resulting to elevated concentrations of metals in soils, groundwater, and wetland in the site. In response, the company has taken several interim remedial actions to mitigate chromium contamination including adopting best management practices for chemical storage and materials handling, upgrades to the metal finishing and wastewater treatment processes, and installation of a groundwater extraction well to control the groundwater plume.

The Civil Engineering team was tasked with evaluating the structural integrity of the existing building, perform a stormwater analysis, and conduct a soil solidification/stabilization study for soils remediation. In collaboration with the Environmental team, the Civil team was able to propose a plan to National Chromium Inc. to safely accommodate building renovations. The team evaluated two possible scenarios to renovate the existing structure while controlling the subsurface-contamination: a) Removal and replacement of the existing floor structure with a concrete cap that extends around the building footprint, or b) Demolition of the original building, creation of a cap to cover the contaminated soil, and placement of a new structure. Both of these options would involve a construction plan involving cut and fill calculations as well as building procedures to properly build the new structures.

Specifically, the team developed:

1. A step-by-step procedure and comparative budget analysis for the two alternative scenarios.
2. An updated topographic map that depicts the existing elevations of the site, footprints of the building, and parking lot.
3. A storm water analysis for the wetland and parking lot based on a 100-year storm frequency.

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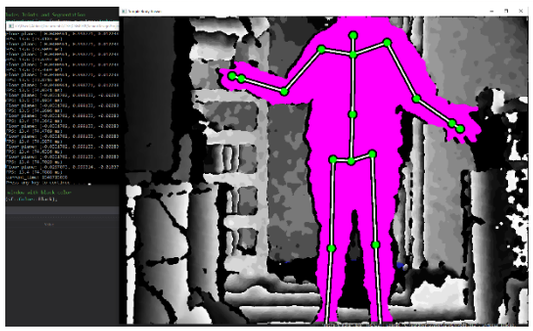
COMPUTER SCIENCE AND ENGINEERING

From left to right: Philip Murray, Ashim Ranjeet, Alden Richter, Patricia Alfonso.

COMPUTER SCIENCE & ENGINEERING

TEAM: 1
SPONSOR: Connecticut Children's Medical Center
SPONSOR ADVISOR: Dr. Matthew Solomito
FACULTY ADVISOR: Dr. Don Sheehy

Creation of a Mobile Motion Analysis Lab Using an X-box Kinect



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Left Hand position: (176.255, 93.3137, 1721)
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Right Hand position: (532.764, 176.074, 0)
Spine Middle position: (364.865, 153.151, 0)
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Right Knee position: (401.064, 356.688, 3690)
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Frame number: 118
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The traditional method of detecting scoliosis in children requires a trained professional watching a patient perform a test called the Adam's forward bend test and subjectively determining a diagnosis. A more advanced and objective methodology requires a large motion analysis lab. This method requires placing markers on different joints and having the patient perform tests while motion sensors monitor these markers. Once all the data are collected, it is possible to make calculations on whether the child may have scoliosis. The goal is to create a portable version of this motion analysis lab.

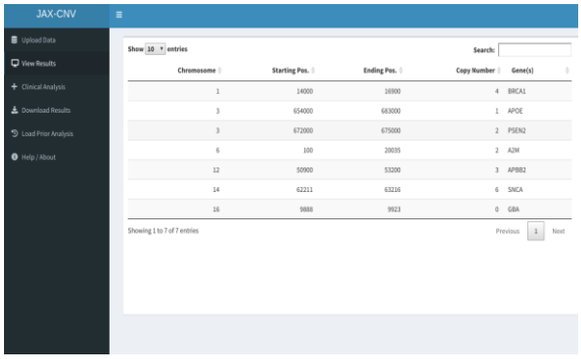
The Xbox Kinect contains hardware allowing for the collection of data necessary to build a mobile motion analysis lab, at a cheaper price and more portable than the current alternative. Another piece of hardware that has similar capabilities to the Kinect is the Orbbec Astra. Depth data is collected using the devices' cameras, translating the position of the joints in three dimensional coordinates. Using this information, a mobile motion analysis lab was developed to determine whether the patient is likely to have scoliosis. Once this app is calibrated, the results are given in a simple yes or no manner. At a routine checkup, the clinician will be able to setup the Astra or Kinect opposite the patient, and start the app and proceed as if it were the usual checkup. If the app determines the patient has scoliosis, the patient could be referred to a specialist. The program can also be used as a safety net, so that a pediatrician can get a second opinion on an unclear or negative Adam's bent test performed on the patient. Thus, the goal of the app is to allow a clinician to collect objective data about a patient and allow for an easier, clearer diagnosis, without changing the experience for the patient.

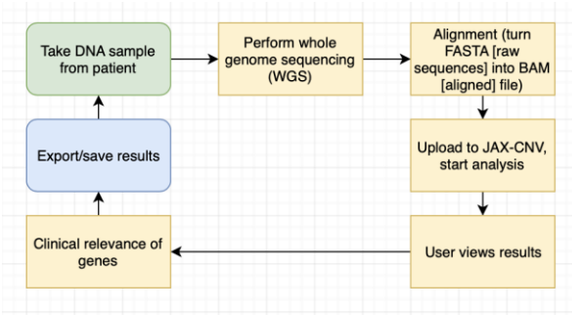
From left to right: Patrick Smith, James Steel, Eric Burt, Samuel Sledzieski.

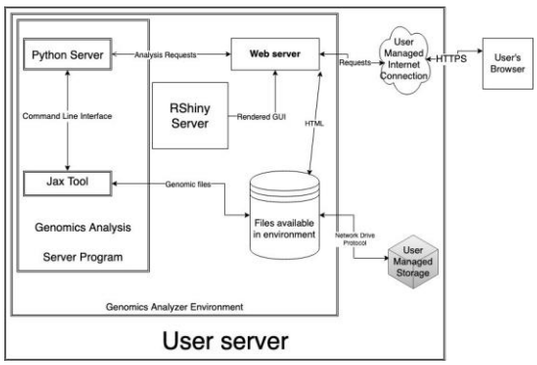
COMPUTER SCIENCE & ENGINEERING

TEAM: 2
SPONSOR: The Jackson Laboratory
SPONSOR ADVISOR: Dr. Charles Lee and Dr. Wan-Ping Lee
FACULTY ADVISOR: Dr. Dong-Guk Shin

A Web-Based Platform for Genomic Structural Variation Detection in a Clinical Setting







Copy number variations (CNVs) are a type of structural chromosomal aberration that results in the deletion or copying of large regions of the chromosome. CNVs account for a significant portion of variation in the human population and links have been found between CNVs and several diseases, including mental illness, developmental disorders, and cancer. CNV calling is the process of identifying copy number variations in an individual, and is often done in a clinical setting to identify a patient's propensity towards a disease. Widely used assays for detection of CNVs include FISH, PCR-based assays, chromosomal microarray analysis (CMA), and next generation sequencing (NGS). CMA is currently the recommended and most widely used assay to identify disabilities and disorders in patients.

High throughput NGS and advances in computing and data analysis have brought the ability to use whole genome sequencing (WGS) in health care research. Researchers at the Jackson Laboratory have developed a new method for CNV calling which accurately detects large (>50 kiloBase) deletions and duplications that are usually implicated to cause diseases. The goal is for this new CNV calling algorithm, JAX-CNV, to be adopted widely and to enable WGS as a first-tier diagnostic assay to replace CMA. The advanced ability for CNV calling will allow for more specific and sensitive identification of disease in patients and a more personalized health care experience.

To promote the adoption and use of best practices of JAX-CNV in a clinical setting, we develop a web-based application which allows physicians easy access to CNV calling using WGS. Web-based platforms for CNV calling currently exist, but none exist which provide access to state-of-the-art algorithms for CNV detection in a clinical setting. In addition to making the CNV calling workflow easily available to physicians, our application automatically cross references any copy number variations found with commonly-used clinical databases to identify CNVs in genes widely known to be associated with disease, and reports this disease identification to the user. Our application is built using the Shiny platform for R and our own server application written in Python, and will be deployed on Jackson Lab servers to be usable from any modern web browser. This architecture allows for flexible UI design, easily maintainable server management, and widespread accessibility of our tool and JAX-CNV.

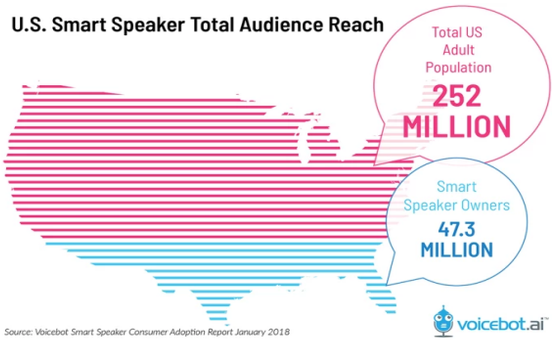
From left to right: Mariem Ouni, Richie Viscardi, Fitch Spencer and Zachary Galica

COMPUTER SCIENCE & ENGINEERING

TEAM: 3
SPONSOR: Synchrony Financial
SPONSOR ADVISOR: Daniel Murphy
FACULTY ADVISOR: Dr. Yufeng Wu

Synchrony Financial Voice Experience

Synchrony Financial serves over 60 million cardholders in thousands of retail stores across the United States. The company serves its customers through its MySynchrony web platform and mobile application that allows its users to view and manage their various credit accounts.



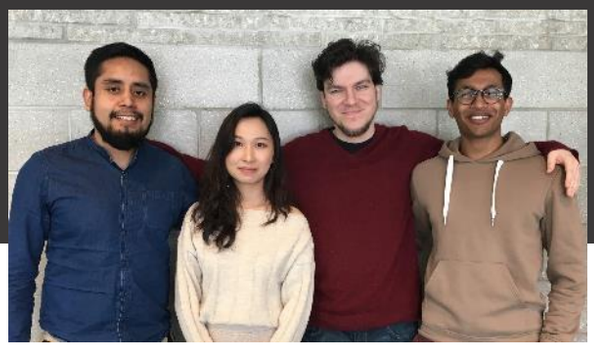
Product sales show that 30 million virtual assistant speakers were sold in 2017 alone, added to that, MarketsAndMarkets predicts that the virtual assistant market will be valued at 18.3 billion dollars by 2023. That's why Synchrony aims to provide basic account data and capabilities to their users over voice using Amazon Alexa and Google Assistant. And that's what our Senior Design Project is all about.

The language used for this project is Javascript and the main development environment is the Google Actions platform. We are also using Dialogflow and Firebase Functions.

The purpose of our project is to create a voice assistant experience that the financial company, Synchrony, can leverage to create a better user experience for their consumers. Currently, Synchrony has a basic voice experience in production. Our task is to expand upon these basic commands and come up with new creative ways that voice can be implemented for Synchrony needs. We implemented features such as:

Make a Payment
Unlock/Lock Card
Check Balance
Check Prior Transactions
Set a Pin

Adding to the features added to Google Assistant, we worked on leveraging multi-platform technology to take advantage of voice recognition technology and screen interfacing. We created a deep link to an Android app from Google Assistant Actions, which allows users to use voice commands to invoke features on the native Android Application.



From left to right: Eiby Angeles, Yanjing Xu, James Breslin, Sujay Alavala.

COMPUTER SCIENCE & ENGINEERING

TEAM: 4
SPONSOR: L&T Info Tech (LTI)
SPONSOR ADVISOR: Satya Pandey
FACULTY ADVISOR: Dr. Song Han

Connected Home

LTI, rated as one of the top 20 Global IT Services Companies, is seeking a connected insurance solution to leverage smart homes in the personal homeowner's insurance market. The world has never been more connected, in no small part due to the emerging Internet of Things (IoT). IoT offers many opportunities; connected smart homes are a revolutionizing technology for both underwriters as well as their customers in the insurance market. Insurance companies are moving from indemnification to real-time risk protection. The industry has already seen conceptual and implementation models in connected auto, and now in a connected home space.

Historically, insurance companies have relied on generalized, regional assessments of large areas of housing to perform risk assessment and determine insurance premiums. Such methods are inefficient, specifically they lack individual risk assessment based on abundant customer data. The volume of data that can be harnessed to price risks continues to grow exponentially. Fueling this unprecedented surge in risk data is the massive sensor proliferation across smartphones, wearables, and 'smart' home devices. To compete insurance markets will need the aggregation and analysis of huge volumes of personal, behavioral and contextual data delivered by IoT. This will allow innovation around product development and personalization, proactivity managing clients' risks for differentiated and superior underwriting, and will translate into higher revenues and profitability.

Traditional homeowners insurance protects a person's most expensive and important investments but only mediates disasters that have already taken place. Leveraging our Connected Home Insurance solution will provide novel innovation in the form of risk assessment, loss mitigation, and customer engagement. Ours is a scalable solution for large-scale smart home monitoring and data analysis. Collecting data from heating, burglar alarms, smoke or moisture sensors the system will stream and sort into a distributed SQL database using a Kafka-Spark Cluster. Real-time time analysis using machine learning with Spark is fed into a customized QlikView dashboard for both customers and underwriters. The solution system will ideally provide enhanced pricing accuracy through granular segmentation, focusing on energy conservation, safety, and damage mitigation. This will allow Insurance companies to provide personalized premiums based on risk performance, real time risk monitoring and alerts, tailored insurance coverage, and an understandable claim experience.

Dinelson Rosario, Allysa Garcia, Emil Abraham, William Reid, Andrew Philippi, Evan Langlais, Rania Chowdhury

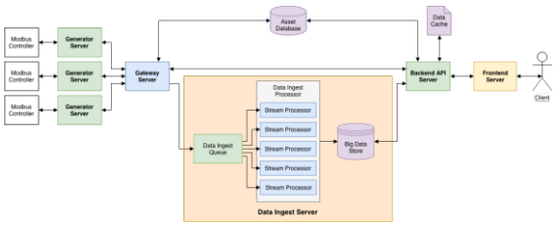
COMPUTER SCIENCE & ENGINEERING

TEAM: 5
SPONSOR: Kinsley Power Systems
SPONSOR ADVISOR: William Schneeloch
FACULTY ADVISOR: Dr. Song Han

Data Collection, Processing, and Visualization for Remote Emergency Generator Systems

KINSLEY
The Energy Solutions Company

Generators are a cornerstone of emergency power infrastructure that ensure critical systems are up and running during power failures due to outside forces such as inclement weather. Periodic generator monitoring and maintenance ensures that in the case of a sudden power failure, important resources are not cut from energy sources. In the event that this operation does not happen immediately and correctly, there can be immediate danger to equipment, data, and even human life. Regular monitoring and maintenance ensure these critical generators are in working order for when the unexpected strikes.



Currently, a technician must travel to a generator whenever it needs to be started, stopped, or monitored for any preemptive or reactionary reason. Kinsley power has a monitoring tool that runs on a laptop connected to the generator via a cable that facilitates the reading of data and events from the generator controller. A robust and responsive remote monitoring system would allow for technicians and clients to spot generator faults and problematic trends while saving the time and money associated with travel.

The primary goal of this project is to remove the requirement for Kinsley technicians and clients to always be at a generator's physical location to view its data. Technicians will access a website that will allow them to view real-time generator data and events, as well as interact with certain generator functions. Travel will still be necessary in the event of failure, and the system will be able to notify technicians when certain concerning events are received. Historical data collected by the system can also identify patterns of failure in order to anticipate when and where more technician attention might be necessary.

Our solution, the PowerPanel System, seeks to leverage several cloud technologies to ingest server data from thousands of remote generator systems using a Kafka cluster, processing that distributed data through Spark, and archiving all time series data in a big data storage cluster utilizing OpenTSDB. Once data is processed and ready for retrieval, a responsive website written in Angular 6 utilizes a Django RESTful API to authenticate clients and technicians to pull generator data for visualization and analysis.

From left to right: Stephen Sam, Warren Davis, Kyle Zielinski, Andrew Curtice

COMPUTER SCIENCE & ENGINEERING

TEAM: 6
SPONSOR: Charter Oak Environmental Services
SPONSOR ADVISOR: Kimberly Ewalt
FACULTY ADVISOR: Dr. Zhijie Jerry Shi

LOAD PM –

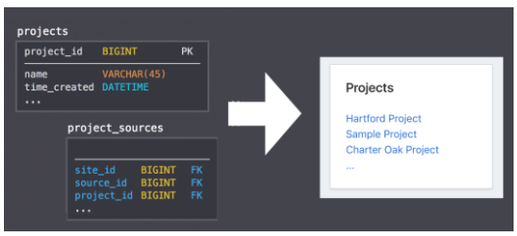
Live | Ownership/Operational | Activity/Analytic | Database | Project Management

Project Management tool with current development focused on a transport tracking application

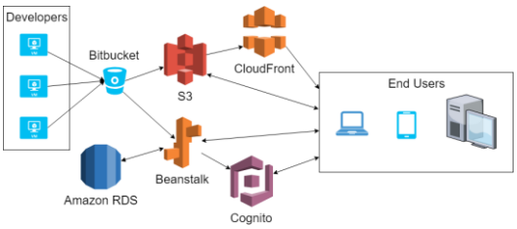
CHARTER OAK

Environment | Transportation | Technology

Charter Oak Environmental Services is a consulting and engineering firm that provides integrated and technical experience and expertise to the engineering, consulting, transportation and energy services sectors. A portion of Charter Oak's larger work comes from the transportation and disposal projects, where multiple different parties have to exchange many documents related to the project**.** Their current business transmits all of this data through various channels such as email, fax, text and exchange of paper copies.



The main purpose of this application is to streamline and automate day to day activities. The application delivered has two main functions: allow file exchange between parties and generate reports. As files get updated, the system will keep a record of all previous versions and recover them if necessary. Given the nature of some projects, each client will have varying levels of access depending on their role. When a party wants access to a particular document or project status, no longer will they need to email a Charter Oak representative to gain access.



We achieved our goal by creating an online portal that all stakeholders will be able to access either on their computers or on their mobile devices. To enable us to build such a system quickly, we relied on Amazon Web Services. This platform handles key challenges such as server/database management, authentication, and software upgrades so we can focus on what is important: the application. We used Python Flask to act as the server-side framework to interact with our database running PostgreSQL.

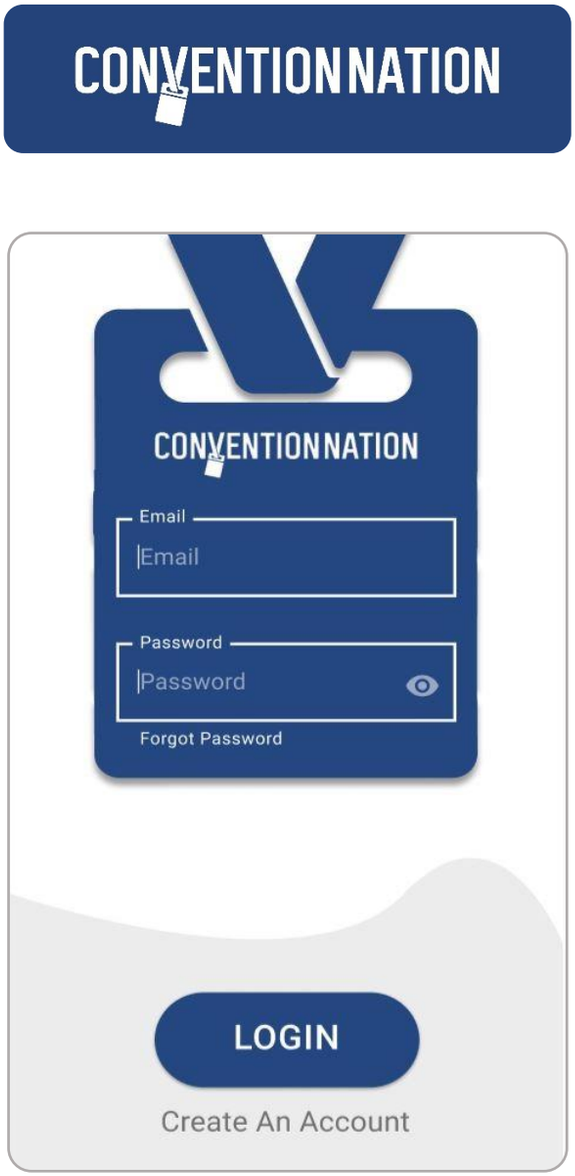
With the introduction of the new system and the automation that it provides, we foresee a number of key benefits. First, there will be reduction of repetitive work for the employees assigned to a project. Also, they can offload the correlation of manifests, weight slips, and truck usage information required for reports to the application. Thus, the same number of employees can support more projects resulting in an overall lower cost of doing business. These cost savings can be leveraged to offer more competitive rates on future project proposals. On-line, real-time access will differentiate Charter Oak from their competitors.

From left to right:
Dhigvijay Jeevanandam, Kenny Wei, Christopher Shank, Dmytro Haydamakha

COMPUTER SCIENCE & ENGINEERING

TEAM: 7
SPONSOR: Convention Nation
SPONSOR ADVISOR: Kim Estep, Shaun Gorneau
FACULTY ADVISOR: Dr. Bing Wang

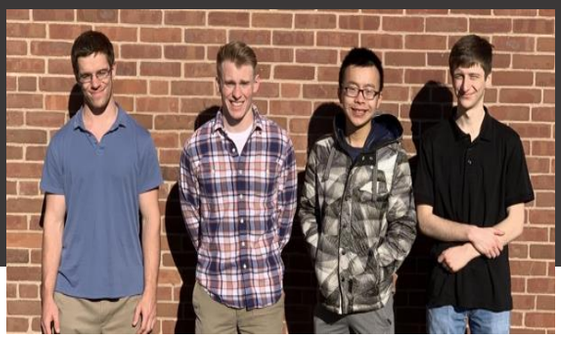
Mobile Event Cross Platform Application for Convention Nation



The main purpose of the project is to create a mobile application for Convention Nation so that the company can provide the service to a wider audience while also providing a more accessible alternative for users using Convention Nation's existing service. The goal was to help Convention Nation make it easy to find highly rated conferences, conventions, and tradeshows no matter where a user is, with the intent of providing attendees with the best possible experience when attending these events.

Convention Nation's mobile application was developed using React Native. We are also using Expo, which is a framework for React Native that allows for easier development and deployment of our application. This allows for a cross-platform distribution on IOS and Android platforms using a single code base. Furthermore, React Native allows us to encapsulate individual parts of our user interface into reusable, independent components. For example, we can program an event card component and reuse that throughout our application. Convention Nation has provided us with a RESTful API to access their event and user data.

A user of the application can sign up or login to the application. Once a user logs into the application, they can see events that are recommended to them based on their profile questions. In addition, a user can look up events that they are interested in that are not recommended. Any events that the user is interested in can be favorited and a user is able to declare that they are going to attend the event. Once a user attends an event, they can review that event. The reviews on events will provide Convention Nation with necessary feedback from the consumers. They can then use this information to optimize their service by generating and recommending better events for the user.

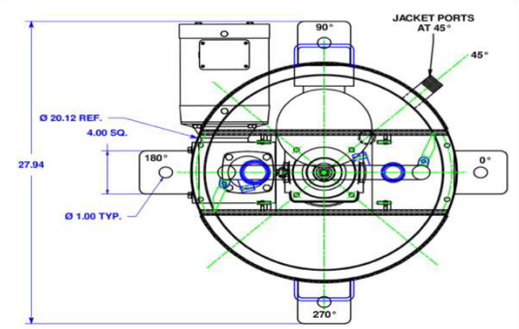


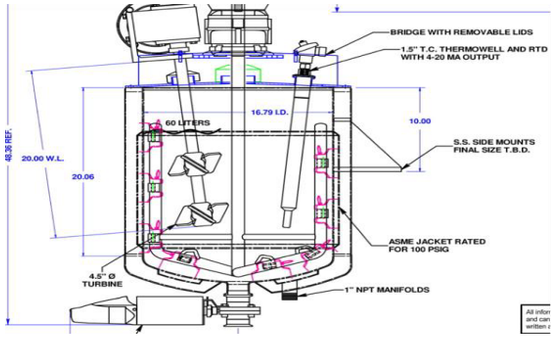
From left to right: Justin Furuness, Mark Violette, Yifei Han, Alex Williams.

COMPUTER SCIENCE & ENGINEERING

TEAM: 8
SPONSOR: Unilever
SPONSOR ADVISOR: Evan Smith
FACULTY ADVISOR: Dr. Wei Wei

Visualization of Process Equipment Setup in Manufacturing






```
    @staticmethod
    def format_attr_strings(input_string):
        def replace_func(replace_char, temp_string):
            temp_string = temp_string.replace(replace_char, "")
            return temp_string

        formatted_string = input_string.lower()
        replace_chars_list = [' ', '?', '&', '-', '%', '/', '(', ')', '\"']
        for char in replace_chars_list:
                formatted_string = replace_func(char, formatted_string)
        return formatted_string


csvfile = CSVFile()
csvfile.csv_from_excel()

tank_list = csvfile.pull_csv_data()
volume = float(tank_list[0].totalcapacityofmixer['data'])
diameter = (float(tank_list[0].vesseltankinternaldiameter['data']) / 1000)
r = diameter / 2
h = ((volume / (math.pi * r**2)) / 1000)
```

Our project was designed to provide visualization tools to engineers who run mixing procedures for Unilever's consumer products, giving them immediate reference for the volume and height of each batch mixture at a given time. The main problem that the engineers face is when the mixing blades overlap with the surface of the batch, creating a vortex and causing air bubbles to form in the mixture. This reduces the quality of the affected batch, making the blades a set of critical regions to avoid. Because the act of producing a batch is often dynamic, abstracting it into a program will make it easier for engineers to avoid mistakes while maintaining a high efficiency. To ensure a longer lifespan for the software, it must be able to read information on a specific mixer using existing spreadsheets, and automatically set up the simulation around that. Without this ability, the software would be limited to a small set of predefined environments, and eventually be discarded when the company decides to produce a new mixer design.

After the problem was understood, a demo for the project was developed in Blender, an open-source program that supports 3D modeling, animation, and scene manipulation. The key goals of this demo were to provide a proof-of-concept for reading the data via Python scripts, as well as create a basic simulation where the height of an object could be changed by user input. After examining the demo's results, we decided to go forward with this plan.

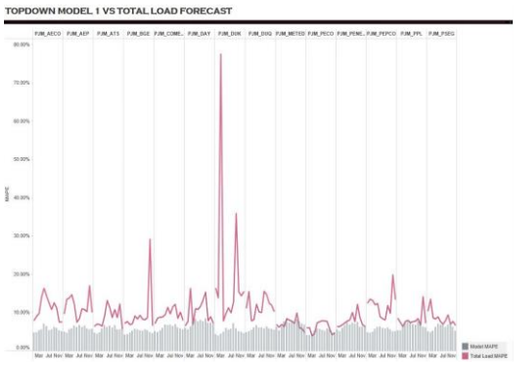
Another key topic of the project was finding a way to distribute this software throughout the company in an easy and efficient way. Rather than installing it on specific computers, the decision was made to store a WebGL build onto an online server, so that it could be accessed using a web browser. This raised another set of problems, however, because an interface was required for employees to reliably access the software without making it publicly accessible. As a solution to these problems, an interface was designed through Django, a web framework for Python. By using this toolset, an interface can be created to allow employees to login with credentials, filtering out unauthorized users while otherwise remaining accessible.

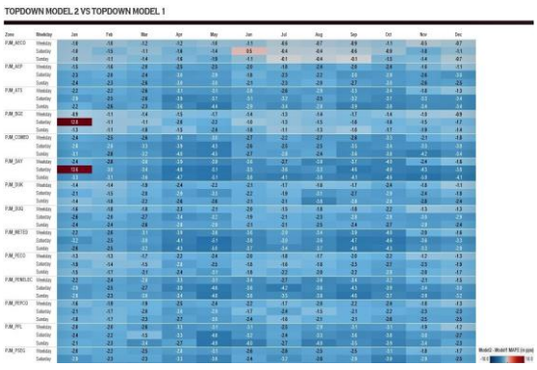
From left to right: Vickram Tulsie, Hayley Allard-Raucci, Jeffrey Eng, Alex Masi.

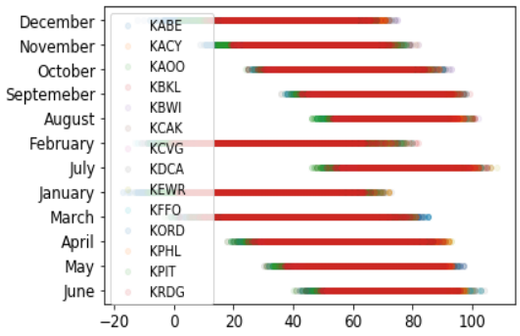
COMPUTER SCIENCE & ENGINEERING

TEAM: 9
SPONSOR: POWWR
SPONSOR ADVISOR: David Yegidis
FACULTY ADVISOR: Dr. Yufeng Wu

Energy Load Forecasting







We were asked to create a model that could predict future energy consumption in megawatt hours (MWh). To do this we utilized a machine learning technique called regression. This allows the model to predict future values based on similar recorded usage from the past. We strictly used recorded hourly usage and weather data from the past to form this model. Partitions along attributes of the large dataset are crucial to increase accuracy in the model. We first approached this problem by partitioning the data by weather station and month, then later adding day of the week. The days of the week were grouped by weekday versus Saturday versus Sunday. Weather station and month alone gave us 168 subsets of data to run our model on. The 168 subsets were obtained by using 14 weather stations within the regional energy transmission organization and the 12 months of the year. Once we split the data further into the days of the week, we got 504 subsets of data. By grouping the data by month and day, it allowed us to compare similar trends within the data. For example, this prevents us from comparing a data point in the month of January to a data point in July where the MWh consumption will differ due to weather anomalies.

One problem we needed to prevent was overfitting the data. Overfitting occurs when the model is too constrained and gives an accurate prediction for the trained data set but not for any other supplied data set. This in turn makes in a poor predictor of future data points. This was avoided by using 3-fold cross validation, which is a method that randomly assigns each of the 504 subsets into one of three categories. Two of the three categories are then used to train the model. The final category of data is then used to validate the model's accuracy. This process is repeated with each possible permutation of two training categories and one validation category. The final result is the average score of all the permutations scores.

In our model we used Random Forest Regressor, Extra Trees Regressor, and AdaBoost Regressor against all 504 subsets. The accuracy of our model was measured using mean absolute percentage error (MAPE). A lower MAPE score means a higher accuracy of the model. Our team was able to successfully achieve a model that produces a MAPE score of 3.63%, an improvement from our goal of 10% error.

From left to right: Michael Ballard, Jesse Meyer, Mason DeMelo, Renoj Varghes

COMPUTER SCIENCE & ENGINEERING

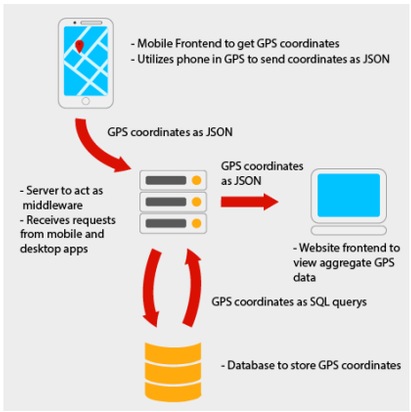
TEAM: 10

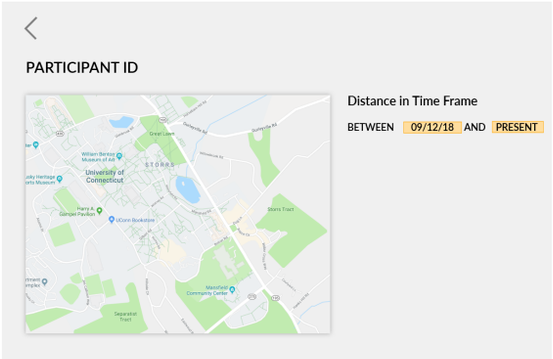
SPONSOR: UConn Kinesiology

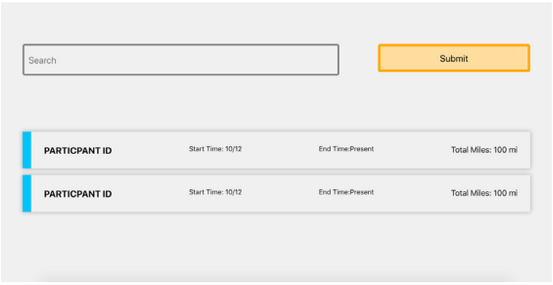
SPONSOR NAME: Dr. Steven Harrison

FACULTY ADVISOR: Dr. Steven Demurjian

UCONN
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES
KINESIOLOGY







HuskyTrack: GeoLocation Tracking Mobile Application

The HuskyTrack application is the combination of a mobile location tracking application and a webpage based access panel designed for the UConn Kinesiology Department to aid in future research projects that include the personal movement of volunteers across campus. This application will simply collect data from volunteers who have installed the application on where they are while the application is engaged. This information will then be transmitted to a database where it will be made available to the relevant project's researchers for analysis and study along with a visualization in the form of overlaying the data onto a map of campus, and plotting a path based on these data.

The application has been designed with compatibility for iOS and Android devices in order to reach as wide a base as possible. In order limit the effects that this application may have on the performance of mobile devices, it has been designed as simply as it can be, and only performs location data collection as intended. This not only helps keep requirements low, but also ensures that volunteers cannot see the data of other volunteers in the project.

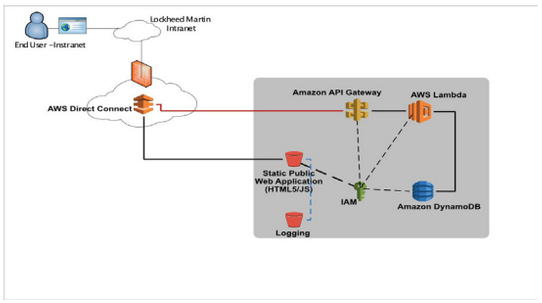
Researchers will predominantly make use of the web-based application that allows them to access the collected data in a meaningful format. All data is categorized per user, and each user is identified based on device only, to help maintain the privacy and objectivity of research data. From the web application, a researcher may search the data for particular fields and view this information, as indicated earlier, in a mapped visualization.

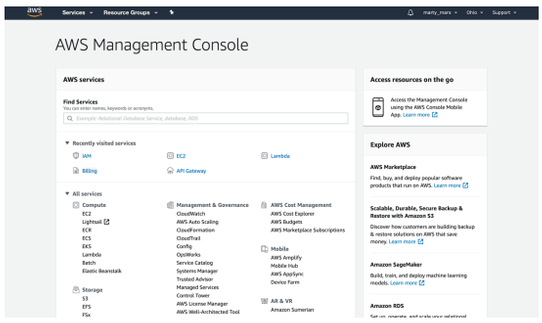
From left to right: Cathryn Jenner, Martin Marx, Andrew Latcherman.

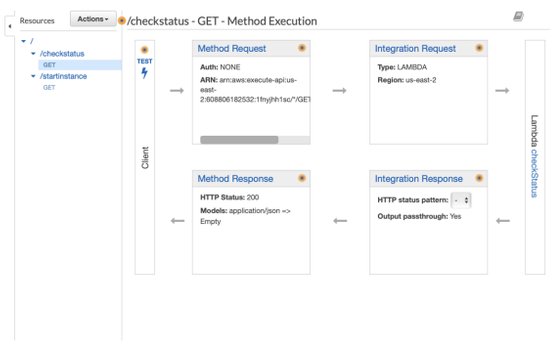
COMPUTER SCIENCE & ENGINEERING

TEAM: 11
SPONSOR: Lockheed Martin
SPONSOR ADVISOR: Patrick Manley & Jessica Chan
FACULTY ADVISOR: Dr. Song Han

Remote Server Automation and Configuration of Amazon Web Services Technology



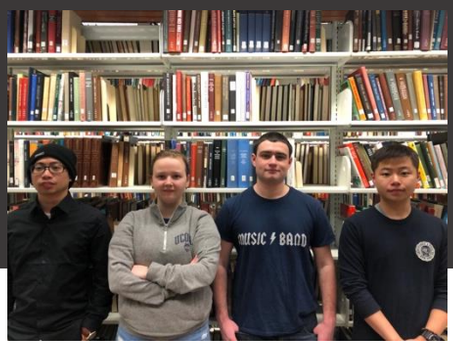




Hosting data carries a multitude of expenses including the power generated for the machinery, controlling server room temperature, maintenance costs, and security to prevent attacks from the outside. With this high paywall, only “tech giants” can afford to host their own servers. Disadvantageous to other companies, external hosting services created a barrier between control and computation. This leads people to ask the billion dollar question, "Why should I pay for runtime I'm not using?”. Amazon Web Services (AWS) provides a cloud computing platform for individuals and companies on a paid subscription basis.

Lockheed Martin is one of the companies that uses AWS servers. They recruited the help of the UConn Engineering program to build a system to remotely turn on and edit their testing environments. Lockheed Martin uses Elastic Cloud Computing (EC2) instances to test their software. Originally only the employees in charge of Amazon Web Services could alter the server configurations. This resulted in 4 AM calls from software developers needing to make urgent changes to their servers. Our application to automate the servers would give users the ability to start servers and edit their schedule. In addition, to save money, EC2 instances can be turned on and off almost instantly based on current demand. AWS will look at this schedule and start or stop an instance accordingly. When the instance is stopped, the company does not pay for it. This application was created in order to save on Lockheed Martin’s expenses and to give more freedom to users to edit their servers on their own time.

The back end of this web application uses multiple AWS services as well as python Lambda functions to communicate to the EC2 Instances. The static website that users see is hosted using AWS S3. Users IAM credentials are authenticated giving access to Amazon API Gateway providing an API we built to access the Lambda functions. Once the user logs in to the web portal, they will see a table of EC2 instances to interact with. These EC2 instances are computed options that Lockheed has stood up to perform various tasks.

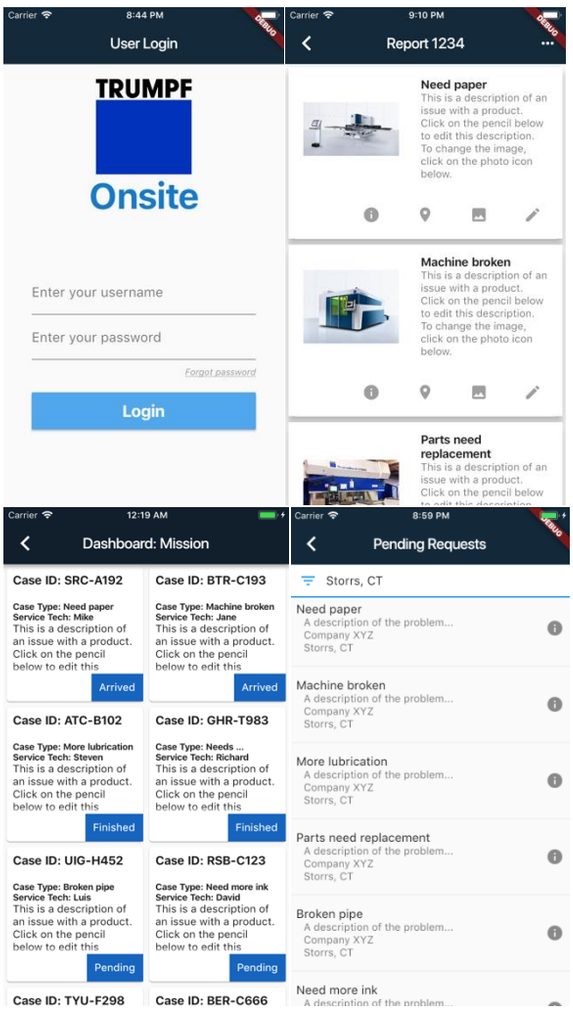


From left to right: Ronald Santos, Inese Duarte, Kyle Boyle, Qi Zhang

COMPUTER SCIENCE & ENGINEERING

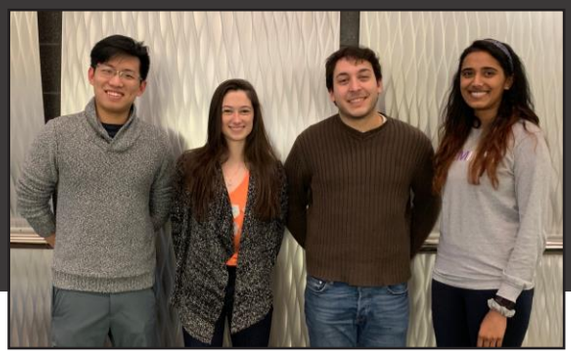
TEAM: 12
SPONSOR: TRUMPF, Inc.
SPONSOR ADVISOR: Theodore Kim
FACULTY ADVISOR: Dr. Bing Wang

TRUMPF Onsite: A Mobile App for Field Technicians



The goal of the project is developing *TRUMPF Onsite*, a mobile application used by service technicians for TRUMPF, Inc. This application will allow any service technician who is active in the field to create or edit a mission report based on a client-reported complaint. Pictures, notes, comments and other relevant information can be added to an existing report to resolve the client's issue. Complaints are usually issues encountered by a customer when working with one of TRUMPF's products but can also have different type classifications including machine breakdown, request and complaint prevention. Its core functionalities are expected to be used by service technicians and managers. Service technicians will be assigned missions based on their geographical regions and notify them of any upcoming reports that need to be submitted. Additional planned features will focus on the manager view, allowing access to functionalities within a dashboard, such as the ability to view the status of the missions and the service technicians on their team. Furthermore, the dashboard can display metrics related to the missions and service technicians. However, the main focus is on providing functionality to the service technicians. The overall goal is for the team to design a functional application that will display the necessary relevant and useful information related to the current task at hand in a concise and informative layout.

The application is designed with a client-server architecture in mind. The server provides a system for users to log in, get details about client requests that are assigned to them, and upload their completed mission reports. The server is written in C# using Microsoft ASP.NET Web API, and connects to the TRUMPF, Inc Service Information System (SIS) database to get client request details and to store completed reports. The Flutter framework, a cross-platform solution for mobile development, was utilized to develop for both Android and iOS devices simultaneously which reduced our overall development time. Additionally, Flutter provides its own user interface elements, so the design is cohesive across both platforms.



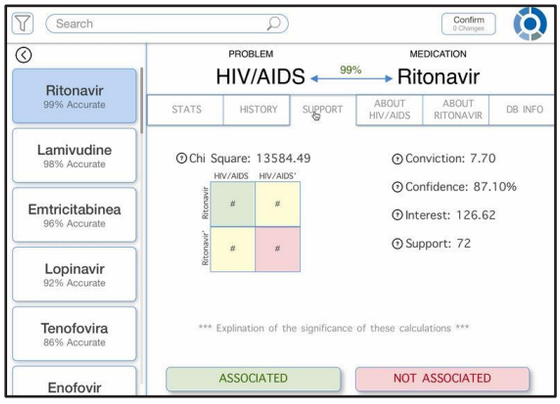
From left to right: Mingwei Zhang, Sophia Russell, Mattia Schiano, Susmitha Rayakota

COMPUTER SCIENCE & ENGINEERING

TEAM: 13
SPONSOR: Diameter Health
SPONSOR ADVISOR: Harvard Pan
FACULTY ADVISOR: Dr. Donald Sheehy

The Clinical Inference Project

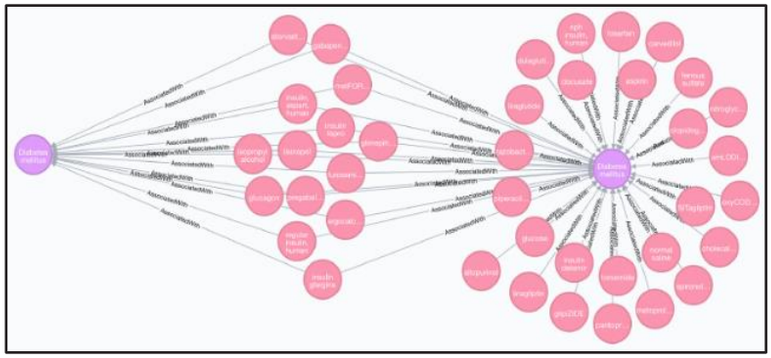
Diameter Health offers medical data normalization, deduplication, enrichment and visualization services for clinicians and analytics to better understand patients' medical information. Without creating a standard enriched data set, the information ends up being collected and viewed in various formats, leading to crucial data being easily missed by clinicians when treating their patients. Diameter Health's services address this problem with their API services. To further enhance their product offering, they would like to design a mechanism through which the system can suggest potentially missing information about a patient to the clinician, which is where our team comes in.



Using associations present in an existing medical dataset, our task is to design and implement a feature that allows users to evaluate these medical associations. These validations will enhance the existing dataset, which allows the machine learning models to produce more accurate results. Eventually, this continuously improving mechanism will be used to predict and suggest missing associations from existing patient records.

The User Interface (UI/UX) is an important design component to achieve success. While the algorithm can be executed to produce results, it is especially important that the results were meaningful to the clinicians who could then use the tool to validate the results. Our design included evidence for why and how the results were produced the way they were. We visualized these analyses with numerical calculations, existing medical data records, node-relationship graphs, and more.

We hope that our developed product will increase the value of the company's services making clinicians' technological experience more informed and efficient.



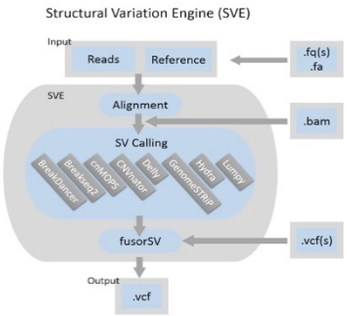
From left to right: Andy Guo, Max Efrat, Jake Shearman and Sam Li

COMPUTER SCIENCE & ENGINEERING

TEAM: 14
SPONSOR: The Jackson Laboratory
SPONSOR ADVISOR: Dr. Charles Lee and Dr. Ankit Malhotra
FACULTY ADVISOR: Dr. Dong-Guk Shin

Expansion of the Robustness and Accessibility of SV Detection Algorithm

The Jackson Laboratory




```
scallers = {sample:{} for sample in samples}
    for sample in samples:
        # add FusorSV since FusorSV data is always wanted
        scallers[sample][f_id] = callers[f_id]
        vcfs = glob.glob(sample+'/*vcf')
        for vcf in vcfs:
            # get caller ID from VCF
            s_id = su.id_trim(vcf)
            # don't use excluded callers
            if not s_id in exclude_callers:
                # make sure the ID is a valid caller
                if s_id in callers:
                    scallers[sample][s_id] = callers[s_id]
                else:
                    print("Warning: sample '%s' has unknown VCF caller ID '%s'"%(sample, s_id))
        # give a warning if there are no VCFs with valid caller IDs in the sample
        if not len(scallers[sample]) > 1:
            print("Warning: sample '%s' does not contain a VCF for any valid callers"%sample)
```

FUSORSV

Structural variations (SVs) are a large determinant of the Genetic diversity in humans. These variations, which can be categorized into deletions, duplications, inversions, or insertions, affect large sections of the genome. Despite their importance to genetics and disease, they remain poorly understood due to the lack of robust detection methods. The various existing state of the art algorithms, known as SV callers, have different specialties and detection methods, so they cannot individually detect all different types of SVs with high accuracy. As a solution to this problem, the Lee Lab at Jackson Laboratories has developed the Structural Variation Engine, or SVE, in collaboration with UConn CSE. The SVE utilizes a custom algorithm in order to optimally combine the results of the best known SV callers for maximum accuracy. The current version of SVE contains eight SV callers and FusorSV, a novel algorithm that compares SVE's output with a truth set of known SVs in order to determine the strengths and weaknesses of each caller. The increase of SV detection accuracy will have a large impact in the medical field, including, but not limited to, earlier detection of genetic diseases, as well as being able to provide personalized treatment on various conditions due to small genetic variances.

While the algorithm mentioned is effective as is, the SVE does not currently have enough robustness or user-side guidance to enable widespread use. This project focuses on expanding the capabilities and accessibility of the SVE, with the intent of getting the SVE closer to being practical in a clinical environment. This project consists of changes and additions to the SVE itself, as well as introducing new software platforms to be used in conjunction with FusorSV. Changes to the SVE include tasks such as widening valid input options and formats, reformatting the output for clarity, adding new SV callers to the list of ones FusorSV works with, and implementing a third-party population level genotyper (SVtyper). Usability and accessibility are amplified by the updating and testing of a Docker image that bundles SVE with all of its dependencies, as well as the beginning stages of a web portal that will enable a broader range of users to use the SVE to its fullest potential.

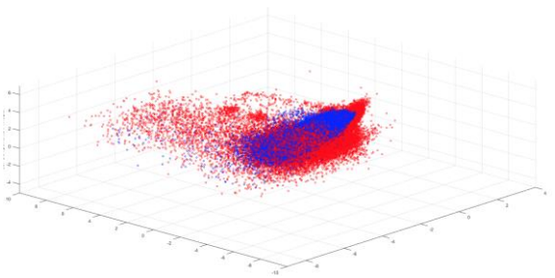
From left to right: Jenny Blessing, Mitchell Nethercott, Ryan Blau and Peng Chen

COMPUTER SCIENCE & ENGINEERING

TEAM: 15
SPONSOR: CGI
SPONSOR ADVISOR: Steven Lacroix
FACULTY ADVISOR: Dr. Yufeng Wu

Automation of Data Classification Using Machine Learning Models

```
t1 = datetime.datetime.now()
print("Start time: " + str(t1))
df = pd.read_excel('Data-Descriptive-Stats.xlsx', sheet_name='data_set')
df.drop(columns = ['APP_ID', 'APP_NM', 'TABLE_NM'], inplace=True)
df = df.fillna(' ')


count_vect = CountVectorizer()
features = np.array(df.drop(['RESTRICTED'], 1)).flatten()

count_vect = CountVectorizer() #This implements scikit learns more optimized version of bag of wo
X = count_vect.fit_transform(features)
X.shape

tfidf_transformer = TfidfTransformer() #Term Frequency times inverse document frequency. This rem
X = tfidf_transformer.fit_transform(X)
X.shape

y = np.array(df['RESTRICTED'])

X_train, X_test, y_train, y_test = model_selection.train_test_split(X, y, test_size=0.2)

if classifier == 'MNB':
    clf = MultinomialNB() #Takes about 15sec to run. ~.96 accuracy
    param_grid = {'alpha': [1e-3, 1e-2, 1e-1, 1, 10]}  #MNB param grid

if classifier == 'SVM':
    clf = svm.SVC(kernel='rbf', gamma='auto') #Takes about 15min to run. ~.9 accuracy
    param_grid = {'C': [1e-3, 1e-2]} #SVM param grid

clf = GridSearchCV(clf, param_grid, cv=5)
```



Machine learning (ML) is a field of computer science that lies at the intersection of statistics and artificial intelligence. Recent advancements in this field have the potential to provide enormous benefits to healthcare, an industry that collects a large amount of private and legally confidential information about patients, employees, and others. There is a heightened security and privacy risk involving this collected data because this information is commonly stored digitally in large databases where highly sensitive elements are often stored alongside less sensitive elements, and where a single event can cause a collective data breach.

Consequently, for both business and ethical reasons it is important that data is accurately classified based on the type of privacy restriction. Restricted categories include protected health information (PII), payment card industry (PCI) data security standard, personally identifiable information (PII), and Cigna intellectual property (IP). Data protection is easier for the company if it is simple to identify and locate the data that needs protecting.

Currently, CGI performs the classification of different types of privacy manually, a tedious and error-prone process. Automating this process through machine learning is a supervised learning problem, using a redacted spreadsheet containing metadata provided by CGI as the training dataset. The goal of this project is to test out various supervised machine learning models to efficiently automate this classification based on the given training data set. Models currently being explored include Support Vector Machine (SVM), Gaussian Naive Bayes, and Linear Regression.

Our intended final product is an efficient custom ML application that is able to generate a classification indicating whether or not a datapoint would fall under a restricted category with a high rate of precision. Due to the imbalanced nature of the dataset, where data elements are far more likely to be unrestricted than restricted, accuracy alone is an inadequate metric to quantify performance, and so we will also use precision and recall as measures of success.

From left to right: Wesley DeBrusk, Kyle Lockwood, Daniel Bownoth and Vedant Patel

COMPUTER SCIENCE & ENGINEERING

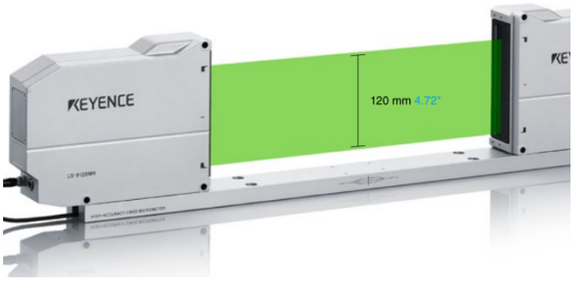
TEAM: 16

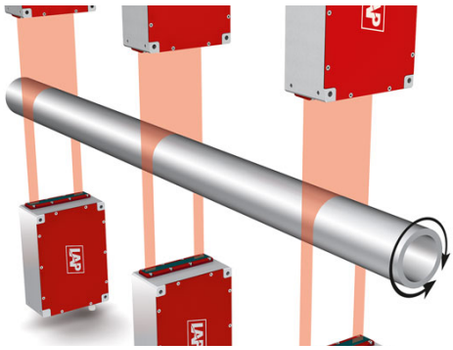
SPONSOR: Stanley Black & Decker

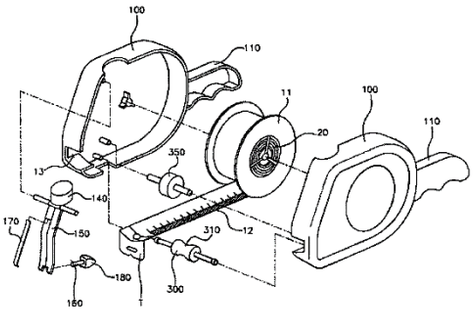
SPONSOR ADVISOR: Allan Gibson

FACULTY ADVISOR: Dr. Wei Wei

Optimization for Inline Camber Detection in Manufacturing







Stanley Black & Decker is a leading manufacturer of industrials tools and household hardware. Their New Britain factory is a large producer of their iconic tape measures. A big issue that arises during the manufacturing process is camber within the tape measure blades. Camber refers to a bend in the steel strip that makes up the blade of the tape measure. Steel strips that have camber cannot be used in the final product. Currently, testing for camber is done once the tape blades have gone through the entire process of heat treatment and tempering. If the blade is found to be outside of the given tolerances, then the blade can either be reworked a single time, or scrapped. Historically, Stanley Black & Decker has a camber rejection rate of around four percent. This solution will save Stanley Black & Decker a great deal of time and money.

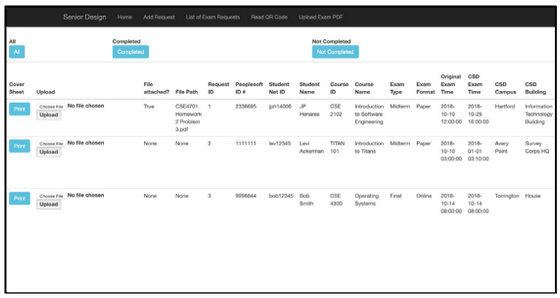
Our goal was to create an automated method for testing camber inline before the blades are processed. Our solution involves mounting specialized sensors at certain points in the blade manufacturing line. As the blades pass beneath the sensors, we will be able detect camber before the tape blades go through its final process so that adjustments can be made to correct the error. We will also use the sensors to collect data on the curvature of the steel strips and analyze that data to detect camber in future blades.

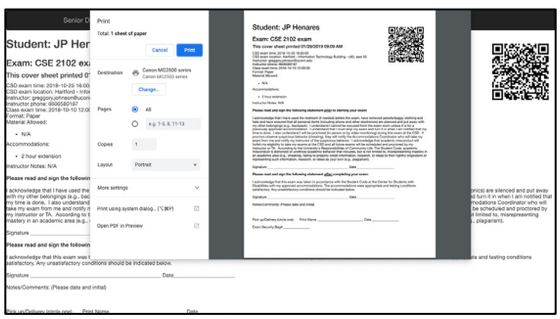
We turned to Keyence, a sensor and lasers company, to obtain high quality sensors that we could use in this project. Throughout the year, we contacted representatives from Keyence to identify a sensor that would best suit our needs, and demonstrate the product to us. The sensor that they identified as the most suitable for our problem is a high-speed 2D/3D laser profiler. This sensor is specifically designed for inline profile measurement at some of the fastest speeds on the market.

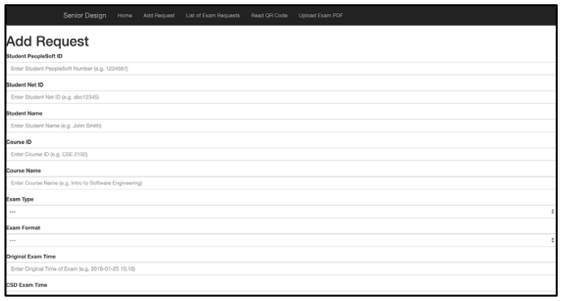
From left to right: Zyrene Adao, John Paul Henares, Lauren Donald and Jason Yip

COMPUTER SCIENCE & ENGINEERING
TEAM: 17
SPONSOR: Student Affairs Information Technology
SPONSOR ADVISORS: Michael Roberson and Valerie Puffet-Michel
FACULTY ADVISOR: Dr. Swapna Gokhale

Automated Web Application for Exam Accommodations







Every semester, the Center for Students with Disabilities administers thousands of exams for students with disabilities who require special exam accommodations. After an exam is completed and scanned into the system, staff at the Center for Students with Disabilities must open each scanned document, search for the appropriate student's exam request in the system, and manually attach the document to the exam request. With thousands of student requests every semester, manually scanning and attaching each exam becomes overwhelming. It can be time-consuming and prone to human error. Thus, in conjunction with the Center for Students with Disabilities, Student Affairs Information Technology would like to create a way to automate the process.

The Center for Students with Disabilities and Student Affairs Information Technology have previously collaborated to create the web application that creates and stores exam requests, with all of the important information associated with the exam. Instructors are able to open the exam request to view and edit information. Each exam administered through the Center for Students with Disabilities has a cover sheet, which contains all of the information associated with the exam, including class, time, accommodations, and so forth. The purpose of the senior design project is to add a feature to this system which would allow a user to upload a scanned exam, read the information directly off of the scanned document, and automatically attach the scanned document to the associated exam request.

The method used to facilitate the automation is to manipulate QR codes throughout the system. When an exam request is created, it is associated with a specific exam request ID. The exam request ID is encoded into a QR code, which is placed on the exam cover sheet. Thus, the QR code will be present when the cover sheet is printed, as well as when the cover sheet is scanned with the completed exam. When the exam is scanned into the system, the site will automatically scan the QR code, find the associated exam request through the exam request ID, and attach the document to the exam. Therefore, the Center for Students with Disabilities can save time by automatically attaching completed exams, rather than manually taking time to do so.

From left to right: Navarre Pratt, Sarah Torcellini, Vishal Cherian and Anthony Festa

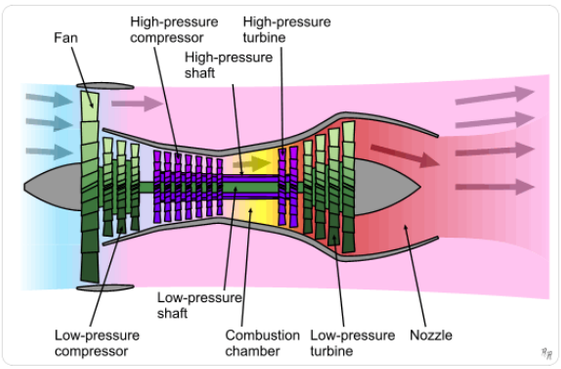
COMPUTER SCIENCE & ENGINEERING

TEAM: 18
SPONSOR: Pratt and Whitney
SPONSOR ADVISOR: Dr. Jeffrey Simmons
FACULTY ADVISOR: Dr. Wei Wei

Numerical Propulsion System Simulation Prognostics and Self-Healing

PRATT & WHITNEY DEPENDABLE ENGINES

GO BEYOND



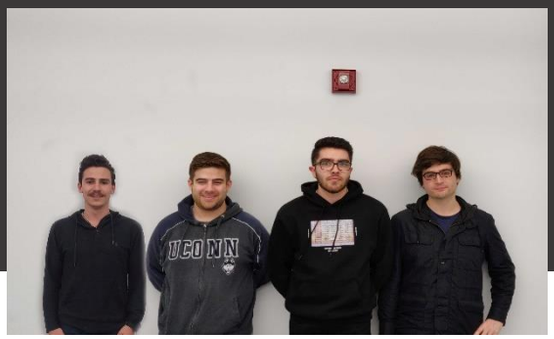
		INPUT FLOW W	Pt	Tt	ht	FAR	Wc	Ps
F010	InEng.Fl_I	100.00	5.272	444.43	106.17	0.0000	258.04	3.458
F010a	SpltFan.F>	100.00	5.246	444.43	106.17	0.0000	259.34	0.000
F120	CmpFSec.F>	83.33	5.246	444.43	106.17	0.0000	216.11	0.000
F110	B025in.Fl>	83.33	7.868	508.11	121.42	0.0000	154.05	0.000
F160	Dfan.Fl_I	83.33	7.868	508.11	121.42	0.0000	154.05	0.000
F165	BFanOB.Fl>	83.33	7.868	508.11	121.42	0.0000	154.05	0.000
F170	NozSec.Fl>	83.33	7.868	508.11	121.42	0.0000	154.05	0.000
F025	CmpL.Fl_I	16.67	5.246	444.43	106.17	0.0000	43.22	0.000
F0251	B025.Fl_I	16.67	15.737	632.47	151.28	0.0000	17.19	0.000
F0252	D025.Fl_I	16.67	15.737	632.47	151.28	0.0000	17.19	0.000
F0253	CmpH.Fl_I	16.67	15.737	632.47	151.28	0.0000	17.19	0.000
F030	BrnPri.Fl>	14.17	157.368	1296.48	316.04	0.0000	2.09	0.000
F041	B041.Fl_I	14.52	149.499	2828.75	765.48	0.0247	3.33	0.000
calHPT	TrbH.calH>	1.67	157.368	1296.48	316.04	0.0000	0.25	0.000
F041a	TrbH.Fl_I	14.52	149.499	2828.75	765.48	0.0247	3.33	0.000
F042	B042.Fl_I	16.18	45.763	2113.71	550.35	0.0221	10.49	0.000
F043	D043.Fl_I	16.85	45.763	2083.61	541.08	0.0212	10.85	41.251
F044	TrbL.Fl_I	16.85	43.933	2083.61	541.08	0.0212	11.30	0.000
F045	B045.Fl_I	16.85	14.790	1660.69	421.05	0.0212	29.96	0.000
F070	NozPri.Fl>	17.02	14.790	1654.40	419.22	0.0210	30.20	0.000
F090	FePri.Fl_I	17.02	14.790	1654.40	419.22	0.0210	30.20	3.458
F190	FeSec.Fl_I	83.33	7.868	508.11	121.42	0.0000	154.05	3.458
FL166	FeFanOB.F>	0.00	7.868	508.11	121.42	0.0000	0.00	0.000

The focus of our project is a gas-turbine simulation known as Numerical Propulsion System Simulation, or NPSS. Pratt and Whitney (PW), a subsidiary of United Technologies (UTC), is an American aerospace engineering firm located in East Hartford, Connecticut, and one of the largest in the world, being one of “The Big Three” aerospace firms (the other two being General Electric and Rolls-Royce).

NPSS is an object-oriented, multi-physics, engineering design and simulation environment that can be configured to model a gas turbine engine. At the heart of NPSS is an iterative numerical solver known as the Newton-Raphson method which during the course of its operation builds a matrix of partial derivatives or sensitivities, referred to as the Jacobian matrix. The Jacobian matrix provides the iteration with necessary direction and magnitude information to close the error terms to within a user specified tolerance thereby allowing the iteration to converge to a solution.

Gas turbine engines are designed to produce thrust while not exceeding certain safety limits on components, e.g. temperature of hot section components. It is further constrained by physical and hardware limits, e.g. how much air can be forced through the compressor, etc. Determining the cause of an NPSS failure can be challenging and, in many cases, the Jacobian matrix can be leveraged to aid in understanding the convergence issue. We will be analyzing these error-cases in order to abstract away the math and give a human-readable output. In order to do this, we must properly identify ill-behaved matrix definitions.

We are required to provide basic documentation of our work on the internal NPSS Solver and create better reporting capabilities for its diagnostics system. Creating a more understandable output will help those who use the simulation in the future comprehend the reason behind the failure. This will greatly reduce the time necessary for an employee to troubleshoot an issue, saving valuable salaried hours for the company and allowing better practices to be developed in the future.



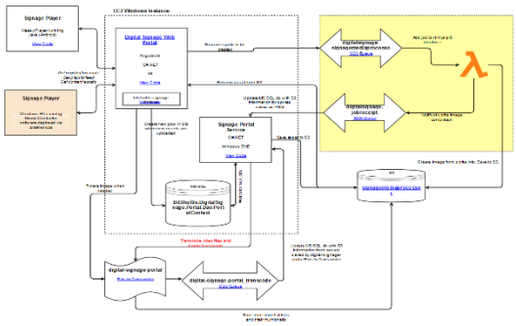
From left to right: Christopher Oldham, Adrian Zygadlo, Justin Auger, Zachary Caisse

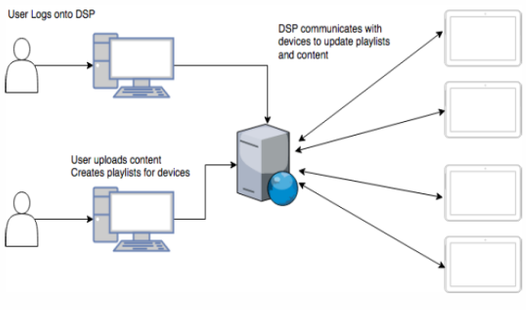
COMPUTER SCIENCE & ENGINEERING

TEAM: 19
SPONSOR: Reality Interactive
SPONSOR ADVISOR: Jack Nork
FACULTY ADVISOR: Dr. Zhijie Jerry Shi

Modernization of platform functions to improve scalability and reduce costs with AWS

reality INTERACTIVE





Reality Interactive assists companies provide product awareness not through advertising but through “experiences” these experiences come from the use of integrated technologies in the space of websites, kiosks, interactive displays and much more. Many retail stores use the portable Android powered displays that show off a product and provide useful insight into the functions and pricing of such a product. One issue with these devices is how to manage all the content that goes into a device, as it is not uncommon for a retail store to move the displays to highlight different products or cycle through a schedule seasonally. To bring a solution to this issue, Reality Interactive started to develop the Digital Signage Portal (DSP) in 2005. The solution supported the company for many years as it continued to grow and constantly increase the number of supported devices.

The aim for this project is to modernize the platform to leverage newer technologies and design patterns that will increase the reliability, scalability and extensibility of the platform as Reality’s customer base grows. To ensure such extensibility, two primary components were evaluated and improved upon. First, to ensure reliability, the process of generating images from the DSP has been replaced with a Lambda function for a massive performance boost from concurrent execution. Second, to better assist future customers, AWS Cognito is used to handle the integration of multiple user management systems, providing a Single Sign On solution that replaces the traditional database approach.

The inspiration for this project comes from the benefits that the new solution directly has with the nearly infinite scale, the ability to be modular with the components, and the reduced risk of bugs and errors. With the massive scale of Amazon Web Services, companies can design systems around a micro-service approach and reduce the need for complete evaluations of the entire system.

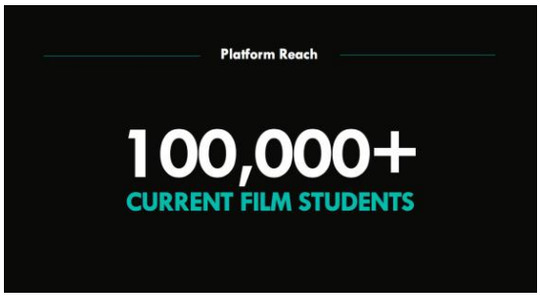
From left to right: Junaid Basdeo, Param Bidja, Dylan Brennan, Dance Zhou

COMPUTER SCIENCE & ENGINEERING

TEAM: 20
SPONSOR: DigiPops
SPONSOR ADVISOR: Konstantin Rubchinsky
FACULTY ADVISOR: Dr. Dong-Guk Shin

DigiPops TV Server-less Backend Google Cloud Pipeline

DigiPops is a community run film festival that democratizes film and filmmaker discovery. As a collaborative effort with Google Cloud, this product is unique because it provides a transparent voting process that recognizes stories that move by using shared experience of the community to democratically reward films for their cinematic and story strengths. The impact of such a platform is extremely large, especially in the short film making community as it will allow small scale creators to be recognized for their films in a democratic way.



Film festivals run in discrete units of time throughout the year, not continuously, so the problem is to build a functional back-end for this web-based platform that does not consume resources continuously but rather on an as-needed basis. Not only does the project require compute infrastructure at only some points throughout the year, but those compute resources must also scale with the size of the festivals. As the size of the festivals increase (# of users and films), the number and power of compute resources should scale proportionally with minimal human intervention.

Server-less compute resources provided by Google Cloud, called Functions, are the perfect solution for this problem. Server-less resources are temporary resources that can be called on an as-needed basis. This means that most of our back-end services, like account creation, video creation, etc. do not require dedicated server support but rather use Google Cloud Functions when those actions are needed. This solution requires us to build Functions that respond to distinct requests, like a Function for user creation, a Function for video uploads, etc. - these Functions act as micro-services.

The server-less approach is a novel and innovative approach, as only 21% cloud applications use such an architecture as of 2018. The current standard is dedicated compute resources, i.e. servers, which incur constant cost and require lots of maintenance. The server-less approach is the fastest growing cloud service, as it's expected to be adopted by 75% of all cloud applications in the next 18 months.

The server-less solution is technically sound as it has been tested in many large scale applications prior to ours, i.e Twitter. Server-less suits this project well as this project requires temporary compute resources that can scale, not consistently dedicated resources.

From left to right: Taimoor Khan, Brandon Keeler, Filip Bicki, Haarith Vohra

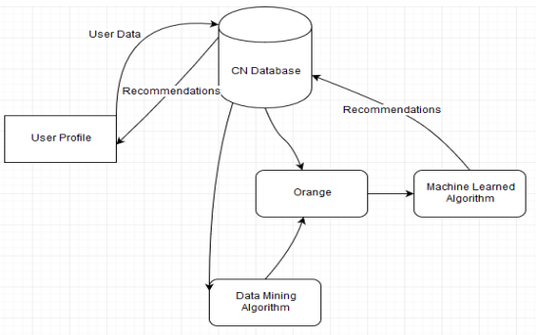
COMPUTER SCIENCE & ENGINEERING

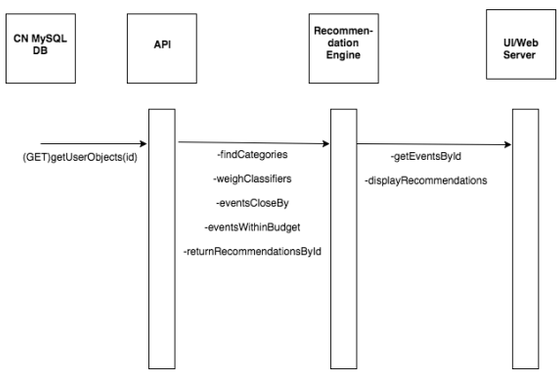
TEAM: 21
SPONSOR: Convention Nation
SPONSOR ADVISOR: Ms. Kim Estep
FACULTY ADVISOR: Dr. Steven Demurjian

Recommendation Engine

Convention Nation is a web-based marketplace that matches conference attendees with events that satisfy their needs. For this project, Convention Nation is seeking to create a Recommendation Engine for their website in order to help their users better find events tailored to a user's specific needs.

The data that users provide can be used very efficiently by this system to save attendees, and their companies, time and effort. There are so many companies that are able to use this data in order to better gain insight about attendees, their prospective customers. Amazon and YouTube are two big examples that use every ounce of data in order to better recommend products to their users. This is Convention Nation's goal: uncovering valuable events and conferences and then making recommendations to their community. Our project is to create a system which is able to do this. With advancements in machine learning and data mining, we set out to utilize the data users have already provided in order to find the way that leads us down this path.





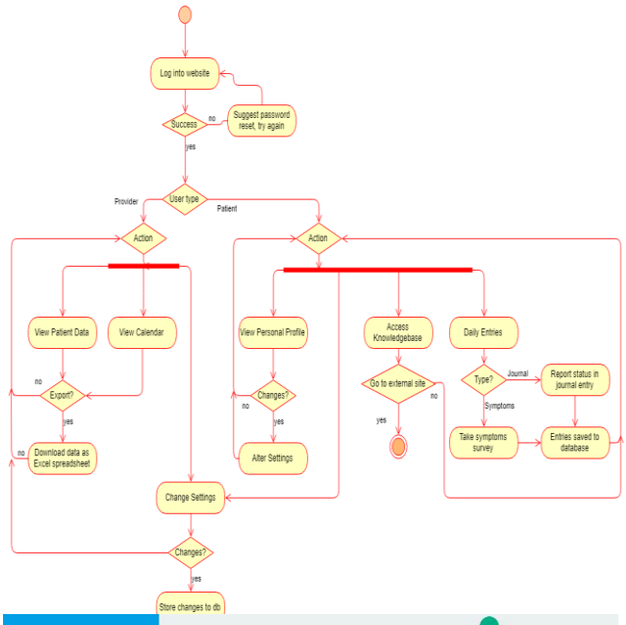
On top of this, we are also implementing a system for event holders to more easily add events to the website. We will be using this information for the other half of the recommendation system since we need as much data from both sides as we can get to make the best possible suggestion.

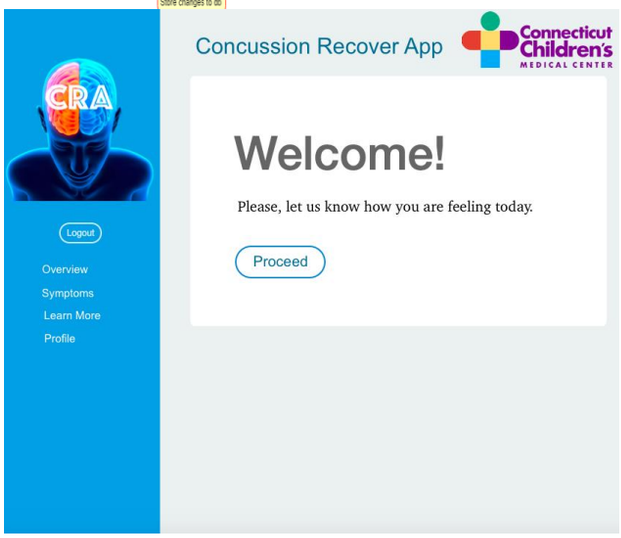
From left to right: Joshua Garby, Sawyer Conrad, Anastasia Kipor, Michael Belousov

COMPUTER SCIENCE & ENGINEERING

TEAM: 22
SPONSOR: Connecticut Children's Medical Center
SPONSOR ADVISOR: Dr. Kevin Young
FACULTY ADVISOR: Dr. Steven Demurjian

Concussion Recovery Management Study Companion Application





The Concussion Recovery App, henceforth referred to as CRA, is a web-based application designed to assist medical providers at Connecticut Children's Medical Center (CCMC) in conducting a feasibility study on the effects of psycho-education on the management and recovery of concussion patients. To this end, the application we are developing will be usable by both the patients and providers. The provider end will have control over the regular users, with the following features:

- Single account shared between all providers
- Ability to add new patients to the database
- Ability to view all patients' daily symptoms
  - ➢ Export symptom data to Excel files for easy data manipulation and management
- Automatic two week notification of patient trends
  - ➢ Can choose to continue monitoring or release from study depending on patient status
  - ➢ Removing patients removes clutter, but keeps data stored for observing long-term correlations

The patient interface is mostly different, and works as follows:

- Unique accounts for each user
  - ➢ Allows for unique patient data to be tracked (name, date of birth, contact information, etc.)
- Provider-endorsed knowledge base for information about what to expect from a concussion
  - ➢ Daily symptom report
  - ➢ Daily notifications to submit current symptoms
  - ➢ Ability to rate a variety of potential symptoms on a scale from 1-10
  - ➢ Ability to write a short report on how their status improves/worsens over time

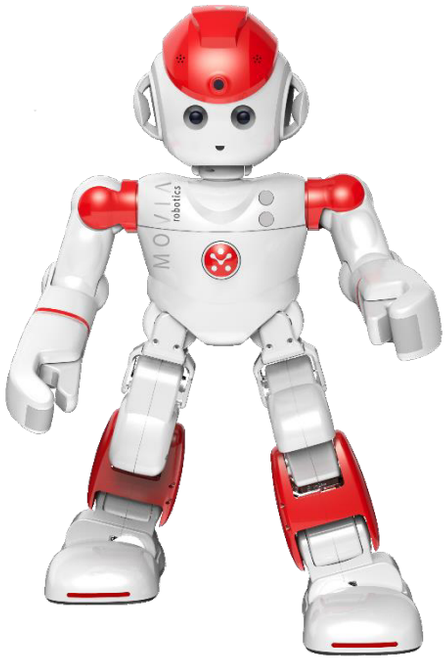
All of this data will be accessible by the provider account. The symptom report will automatically generate a graph for the providers to view, making it easy to observe changes over the 2-week study period. Both patients and providers will have access to additional necessary features, such as the abilities to edit their own information, change settings regarding notifications, change their registered passwords and email addresses, and other basic functionalities.

From left to right: Sara Sadiya Saulat, Mitchell Gross, Vernon Billington II, Pengyu Tan

COMPUTER SCIENCE & ENGINEERING

TEAM: 23
SPONSOR: Movia Robotics
SPONSOR ADVISOR: Timothy Gifford
FACULTY ADVISOR: Dr. Yufeng Wu

Depth Camera System for Capturing, Segmenting, and Characterizing Movement



Movia Robotics is a company based in Bristol, Connecticut which designs and develops robot assisted instruction systems to help educators, therapists and parents of children on the autism spectrum. Nearly 1 in 59 children are affected by autism; research has shown that early intervention and therapy for these children can improve their learning, communication and social skills. Movia's mission is to enable children with specials needs to reach their full potential.

Our project utilizes the Orbbec Astra, a depth camera, to capture, segment, and characterize movement specified by the end user. Making use of Unity, in conjunction with Orbbec's development kit, we have developed a mannequin model to mimic the movements captured by the camera.

Another important component provided by Unity is the collision detection portion of the physics engine. By utilizing this feature, we are able to import the skeletal data from the camera and use the mannequin to initiate events. These events include warnings of when the robot should stop movement, as well as granting the ability for the user to initiate the gesture tracking module. This module will record and store the various gestures that the user has performed.

One of the most critical features of this tracker is the implementation of storage. We preferred the exported data to be in a simple, easy to read format; for that reason we chose the .csv file type. These files will be stored and accessed through the data logger module, allowing a user to explore their database of gestures. This module also goes hand in hand with the collision detection, as if an unwanted collision occurs, then an event will be triggered and stored with the relevant details.

The end goal of this endeavor is to deliver code modules that can seamlessly be implemented into Movia's existing systems.
These modules will be part of our presentation which will include a demonstration of the mannequin model and the gesture tracker; this will allow a user to observe a skeletal representation of themselves which will mimic their movements.

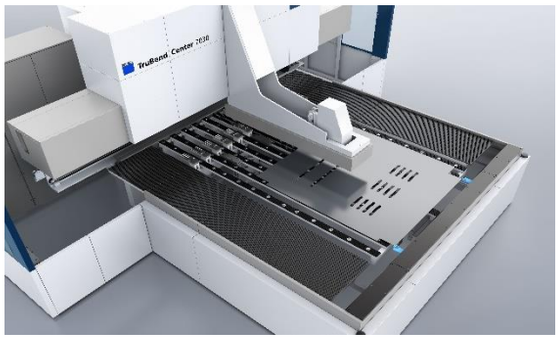
From left to right: Alif Albiruni, Luke Malinowski, Wentao Hu and Scott Gusciora

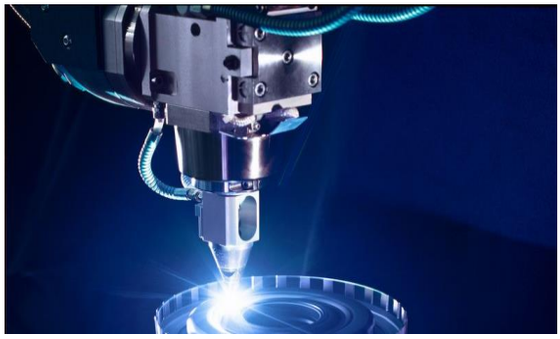
COMPUTER SCIENCE & ENGINEERING

TEAM: 24
SPONSOR: Trumpf, Inc.
SPONSOR ADVISOR: Austin McKay
FACULTY ADVISOR: Dr. Donald Sheehy

Laser Technology Table Monitoring Application

TRUMPF





Trumpf, Inc. is a leading company in the development of laser-cutting technology. They also provide a breadth of services for industrial purposes, including software and smart factory optimization.

Trumpf, Inc. is interested in the development of a web application to maximize efficiency and provide corporate and private users with an interface to pull standardized metrics for their laser machines. These metrics are calculated from their database, which pulls in thousands of queries by the second. They are also interested in moving their architecture to AWS (Amazon Web Services) as a shift from their existing architecture.

LaserTechTM serves as a reference for clients to find standardized metrics for their laser cutting machines. Users can also request a different set of metrics through a query-building page where filters are applied based off of each feature. The web application also features a statistics page which allows clients to draw inferences on existing datasets. LaserTechTM also has a built-in data simulator which generates sample data for testing purposes based off of the filtered data from the query builder.

This application is implemented through a LAMP stack (Linux, Apache, MySQL, and PHP). This allows us to transition easily to AWS's Elastic Beanstalk upon full deployment. Our framework for the LAMP Stack is Laravel, which is used for page generation, representing data, and querying the database. The front-end is implemented in Bootstrap with JavaScript and CSS.

Left to right: Tilun Wang, Alan Maynard, Rahul Kantesaria, Jonathan Duarte

COMPUTER SCIENCE & ENGINEERING

TEAM: 25
SPONSOR: Synchrony
SPONSOR ADVISORS: Daniel Murphy, Ramon Cadeaux and Quincy Chapman
FACULTY ADVISOR: Dr. Bing Wang

mySynchrony Watch Experience

The main purpose of this project is to develop a smart watch application for Synchrony to roll out to their over 60 million cardholders in order to provide them with an intuitive, engaging experience related to managing their accounts. The application will tie in with Synchrony's APIs and existing smartphone application, eliminating the need for their customers to download an additional smartphone application in order to use this new smartwatch companion application.

The application features an easy to use payment suite, through which users can monitor their accounts and pay bills from authorized bank accounts. This area of the application has been designed for speed and efficiency and requires no manual user input aside from tapping to control which balances are paid. This increases overall ease of use and eliminates much of the "hassle" associated with paying bills through mobile applications.

The mySynchrony Smart Watch Experience also features a credit wellness section of the application. This area allows users to track several key performance indicators of healthy credit, which will directly empower the user to be more fiscally responsible with their finances. As this feature is lacking in many of the applications provided by Synchrony's competitors, this aspect of the smart watch experience will enable Synchrony to become an industry leader in credit wellness and overall customer health.

Throughout the application, visual stimuli, such as animated progress indicators and color-coded elements have been used in place of text where possible and appropriate, in order to provide users with a rich, eye-catching and informative experience, but without the clutter of having too much text on such a small screen.

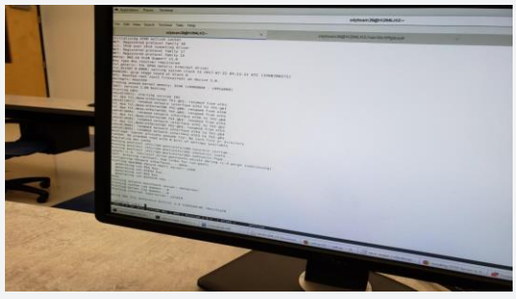
For this project, the main programming interface used was XCode, Apple's proprietary IDE for development on their platforms. In order to allow communication between an iOS application and our watchOS application, we leveraged the WatchConnectivity framework, which is available on both operating systems. Additionally, we used Jira project tracking to streamline development and organize implementation tasks according to agile methodologies.

From left to right: Brandon Renick, Cameron Morris, Killian Greene, and Jacob Boislard.

COMPUTER SCIENCE & ENGINEERING

TEAM: 26
SPONSOR: Pratt & Whitney
SPONSOR ADVISOR: Paul Adamski, Scott Beecher
FACULTY ADVISOR: Dr. Bing Wang

Secure Embedded Architecture for the T1042 Processor



Many industrial and commercial systems currently deployed in the real world utilize integrity checks for security, but there is no guarantee that the code that is being executed is from an authentic source. Furthermore, the loading techniques for these systems do not guarantee the confidentiality of neither the data being loaded nor the methods being used to load it. A solution to this issue is the development of a secure embedded architecture in which one could guarantee both the confidentiality and authenticity of the data and the methods that load it through a secure booting procedure.

We have been tasked with the design and implementation of a secure embedded architecture for UTC Pratt and Whitney. The primary goals for this security system are to protect against cyber security concerns including malicious code modification as well as loss of intellectual property and technology. This architecture will utilize a technique known as secure boot, which will allow us to protect the architecture itself as well as the code or information that it is being used for.

Security in embedded systems involves both physical and virtual protections and considerations, which must be taken into account when deciding how to implement such a system. This means that everything from the choice of which processor that is being used (in our case, the T1042) to the software that is put on it will be factored into the overall security of the device, and that it may be necessary to address traditionally hardware-based attacks from a software perspective in order to make up for the limitations of the physical platform being used. Our design must be tamper-resistant, protecting against simple physical attacks like fault injection or system bus probing. It must also allow for secure updating of both the application and the operating system running on it in such a way that it does not pose a threat to security.

The secure-boot process is a complicated procedure that takes place at a level lower than that of an operating system. With this in mind, we are programming in C and the PowerPC assembly language in order to interface with the processor's hardware more directly than other languages would allow us to. Although security is the ultimate goal of our project, we must also pay close attention to the performance of our architecture. In order to confirm that our finished product is not only complete but also practical, we will properly time each stage of the system so that we can analyze the performance costs of the security features that we implement.

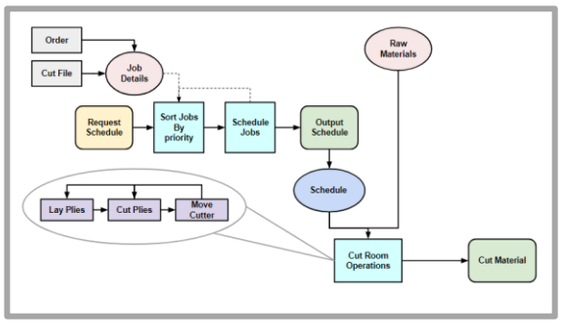
From left to right: Neng Zhang, Syed Asar, Toshiro Hackett and Katherine Tiernan

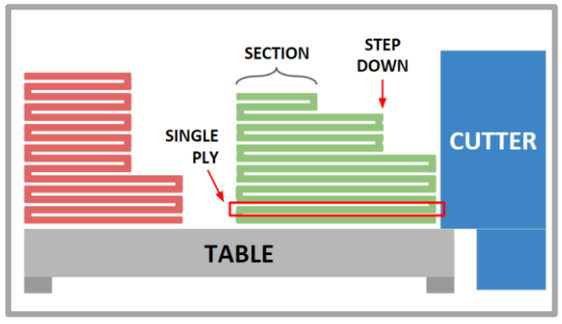
COMPUTER SCIENCE & ENGINEERING

TEAM: 27
SPONSOR: Interface Technologies
SPONSOR ADVISOR: Holly Beum
FACULTY ADVISOR: Dr. Zhijie Jerry Shi

Cut Room Scheduling Software

Interface Technologies

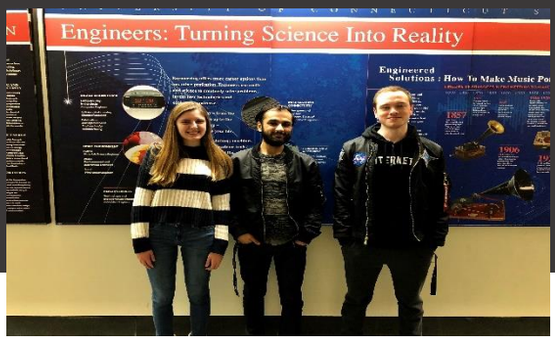




The global textile industry is one of the world's most important industries. With an ever-growing global population, the demand for the production of textiles and fabrics is increasing. This industry has historically been an extremely labor-intensive industry and has been taken advantage of to meet demands. In certain foreign countries workers are mistreated and brought into factories as children. Interface Technology has taken an initiative to solve this global issue through the use of software. This software has the potential to change the setting drastically by being more efficient than its labor-intensive counterpart altering the landscape of this industry.

Cut rooms are factory environments where the cutting of various materials such as fabrics takes place in order to fulfill consumer demands. The fabric is layered and compressed into plies which are then cut on the factory floor. These plies are placed onto tables by workers and are prepared to be cut. A cutter, which travels by rail, is then moved to the table and begins cutting the plies. This process then repeats for as long as there are orders. Currently, cut room managers manually schedule everything from what orders goes on what tables, where materials will be lined up, to where the cutting machine should be. As with anything, there are human errors, which leads to the waste of time and resources and to losses in profit for the company.

The goal of this project is to design and implement a scheduling algorithm that will properly distribute resources in a timely manner. The algorithm itself is a complex heuristic algorithm that has taken much time to devise. This software primarily focuses on the factory floor and utilizes manufacturing order data to generate a schedule for floor operations. The program schedules where and when to lay plies, where the cutter should operate, and when to move the cutter to operate at another table. By utilizing this software companies save time and resources.



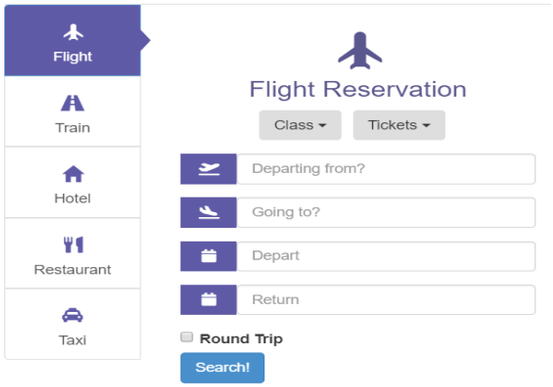
Left to Right: Callie Robinson, Sagar Gohel, Michael Search.

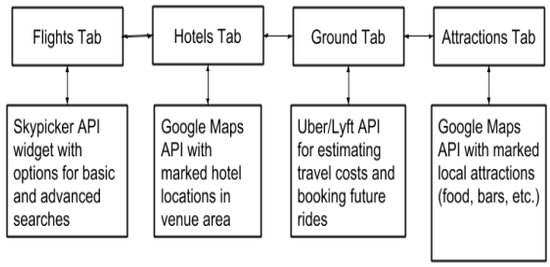
COMPUTER SCIENCE & ENGINEERING

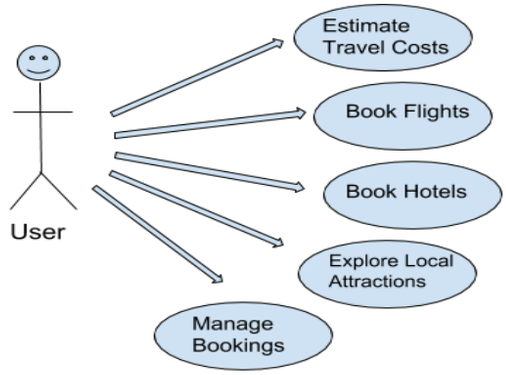
TEAM: 28
SPONSOR: Convention Nation
SPONSOR ADVISOR: Shaun Gorneau
FACULTY ADVISOR: Dr. Yufeng Wu

Integration Nation

CONVENTION NATION







Convention Nation (CN) is a platform that allows for the discovery and review of professional conferences, conventions, summits, and trade shows being held both on a domestic and international scale. In order to best help potential attendees and visitors of the site, CN is looking to incorporate a trip planning and booking aspect to their pages. This integration would include the suggestions on modes of travel as well as lodging to be utilized the duration of their time at the prospective event. This allows for greater convenience to the event-goer, promoting an effortlessness to the booking process and keeping users on the platform for longer.

This vendor integration system will be an enhancement on the existing CN event page module. This system will be intended to promote a better user experience for the attendee while keeping them inside the CN platform for as long as possible. Using this system, an attendee will be able to view a suggested itinerary for an event they are viewing. This itinerary will include travel and accommodation suggestions including, but not limited to, flights, hotels, and other ground transportation. In addition, nearby restaurants and bars could also be provided as a means of planning after-hours events. Ideally, a user would be able to book reservations from inside the CN site through heavy integration with third-party vendors. This would maximize a user's utility of the CN site and make them more inclined to use it for their travel needs in the future. However, simply providing travel options and sending the user to a third-party site to make the relevant bookings themselves would also be acceptable. The majority if this integration will occur on the event page in the form of locating accommodations nearby to the convention through calls to external APIs. The results will be collected on a map feature to be easily picked out by the user based on their personal preferences. Other results that can't be integrated into a map will be listed nearby, but separately.

From left to right: Taylore Westbrook, Winson Ye, Jeramy Jeffereis, Dr. Wei Wei

COMPUTER SCIENCE & ENGINEERING

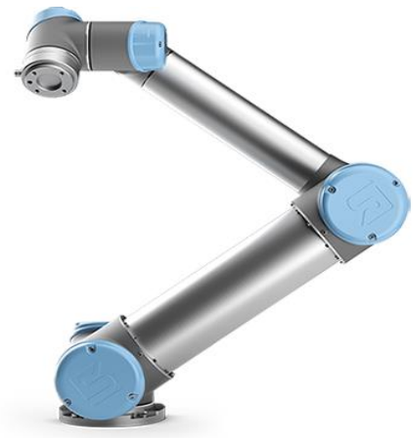
TEAM: 29
SPONSOR: Energid
SPONSOR ADVISOR: Jeff Sprenger
FACULTY ADVISOR: Dr. Wei Wei

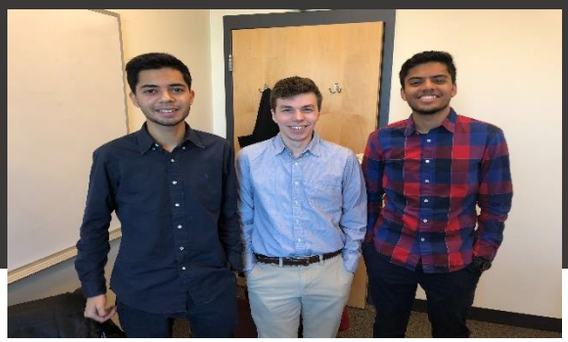
Developing Actin Example Applications

ENERGID
Robotics and Machine Vision

Actin is Energid's proprietary C++ robotic control software development kit. The engineers at Energid would like to develop another way for users to control robots that serves as an easier alternative to writing actual C++ code. Being able to quickly run demos and live tests right out of the box will allow Energid to craft a user-friendly product that can reach a much broader customer base and still accommodate those who want to dig into the code to perform more complex tasks. This kind of feature would also make Cyton robots an attractive candidate for robotics education in schools.

The team's task was to develop software that allowed Xbox controllers to interface with the Actin SDK in order to control a Cyton robotic arm online. The final product has different bindings associated with each button of the controller. There are also two main modes: joint movement mode (JMM) and end effector movement mode (EMM). The user switches between these modes using the left and right trigger buttons. For joint movement, the D-Pad can be used to cycle through the joints, and the joysticks can be used to move the joint. In EMM, the joysticks move the end effectors instead. In addition, when in EMM, the user can use the D-Pad to switch between 4 types of control sub-modes: translational movement, rotational movement, global movement, and local movement. Local movement means moving the end effector relative to the end effector frame and global movement means moving the end effector relative to the global coordinate system. The user can always save waypoints by clicking the joysticks and play them back using the *B* button on the controller. In regards to implementation, the team wrote custom C++ code and packaged it as a plugin for the Actin SDK so that the controller could communicate with the actuators in the Cyton.



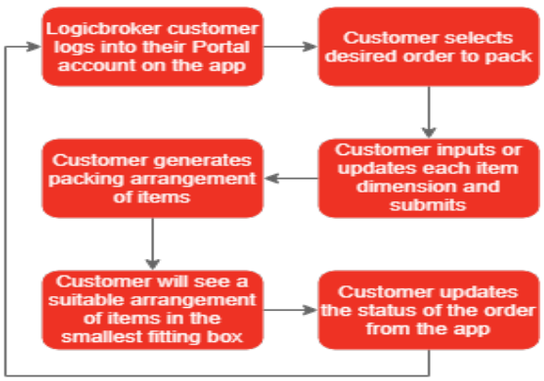


From left to right: Hamad Gul, Daniel Little, Jay Gala

COMPUTER SCIENCE & ENGINEERING

TEAM: 30
SPONSOR: Logicbroker
SPONSOR ADVISOR: Siena Biales
FACULTY ADVISOR: Dr. Donald Sheehy

PackABox: A Warehouse Box Packing App



In their current system, Logicbroker warehouse customers use a web-based portal to manage order status and shipping. While this system works, Logicbroker was interested in adding a more direct method for users to interact with their extensive API, which led to the creation of PackABox. PackABox is a mobile application designed to assist warehouse workers with efficiently packing and updating orders without accessing the web portal, all while keeping the simplicity of the system that the workers are used to. The goals of this project are to provide faster information to the workers, to help choose a suitable shipping box and the optimal arrangement of items in it, and to allow the workers to update the status of orders immediately after packing the box.

PackABox is a cross-platform application written using React Native, a JavaScript framework. The application will securely log the employee into their Logicbroker account to display the current orders and their items. PackABox will rely on internet connectivity, the Logicbroker API, and user input in order to initially get the dimensions of each item in the orders. However, those units will then be stored in a cloud-based service for future use across all users. The application will then take the dimensions and quantity of each item, as well as the shipping carrier of the order, to find an optimal shipping box for all the items. Once the box is packed, PackABox will display a suitable arrangement of the items in that box and allow the user to update the status of the order before displaying the remaining orders.

From left to right: John Buynak, Jackie Videira and Gabe Lopes

COMPUTER SCIENCE & ENGINEERING

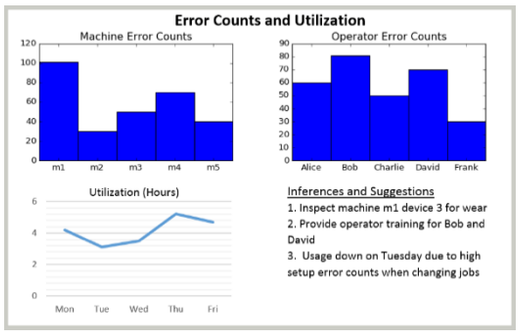
TEAM: 31
SPONSOR: Blue Crest
SPONSOR ADVISOR: Paul Mayer
FACULTY ADVISOR: Dr. Swapna Gokhale

Inferencing Based on Machine Stoppages using Machine Learning

BLUECREST

Production mail machines (*top picture*) are composed of a series of devices in a pipeline. The machines take material, runs it through several stages, and creates an output product. Data on the stoppages of these machines is collected by a control system. The errors may have been caused by a variety of reasons, including, but not limited to wear over time, operator errors, and setup errors.

In this project, a user-friendly GUI application was built that relies on statistical analysis and machine learning approaches in order to analyze the stoppage data. The application allows inferences and knowledge to be extracted from the data that can assist the company in making decisions regarding how to service and maintain these machines and address operators who may need additional training.



Once the data files are imported into the application, the back-end analysis engine will run and output the results as dashboards, which are collections of various figures, plots, and textual elements. The dashboards contain both inferences the analysis engine made and relevant information, and can also be exported (*middle picture*).

The machine learning component of the inference engine runs using an approach in machine learning model called a neural network. By using a neural network we'll be able to use many different machine learning algorithms to work together and process the complex data inputs from the user. This type of deep learning is also known as the "universal approximator" because it's able to approximate an unknown function by finding correlations between the input and the desired output. The system learns to perform analysis and inferencing tasks with out being programmed with any specific rules. This way, our program is able to make inferences on the machines, parts and operators by comparing it with other outputs as well as user feedback.

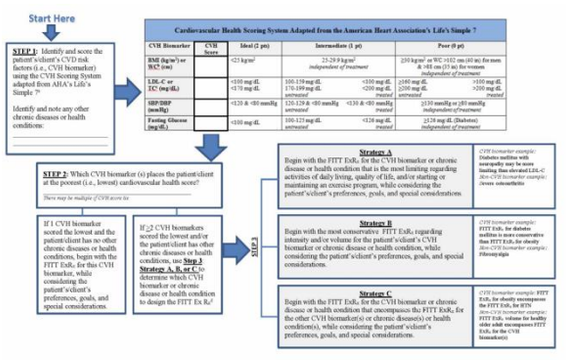
From left to right: Terry Pireaux, Timothy Henning and David Plank

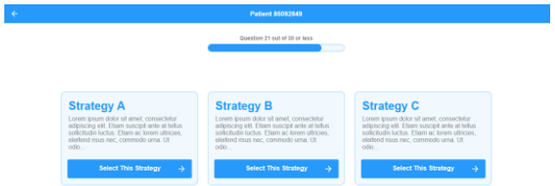
COMPUTER SCIENCE & ENGINEERING

TEAM: 32
SPONSOR: UConn Kinesiology
SPONSOR ADVISOR: Dr. Linda Pescatello
FACULTY ADVISOR: Dr. Swapna Gokhale

An Evidence-based Clinical Decision Support System for Exercise Prescription among Adults with Multiple Cardiovascular Disease Risk Factors

UCONN
COLLEGE OF AGRICULTURE, HEALTH AND NATURAL RESOURCES
KINESIOLOGY





Health care professionals (HCP) are faced with the challenge of developing exercise prescriptions (ExRx) for patients who present multiple cardiovascular disease (CVD) risk factors. Dr. Linda Pescatello and her team from UConn's Dept. of Kinesiology have developed an evidence-based, step wise decision guide to develop ExRx for patients with multiple CVD risk factors. Our application attempts to automate this process.

Dr. Pescatello saw an opportunity to develop an application to streamline an otherwise complicated ExRx process, and make it easily accessible to HCP. The software application is usable by students and HCP in the field, without having the need to analyze the input data and trace the paths through several complicated flow charts. The initial version of the application provides a simple mapping between the input data that are entered and specific ExRx alternatives at the output. Subsequent to this initial version, there is the potential for enhancing this project to include essential features such as a database to maintain patient IDs and former ExRx's, as well as aggregating data for future research. Maintaining the patient IDs will allow the tracking of how a patient's ExRx changes over the course of time.

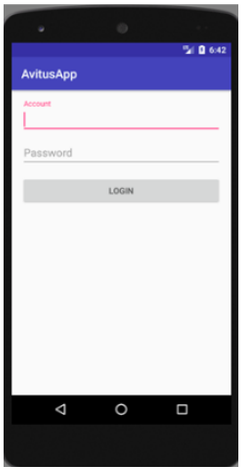
The implementation for this project is based on the Flask web framework, used for rapid prototyping of web based applications. Flask is considered a "micro framework" because it provides functional benefits to an application while being concise and lightweight. It comprises the minimal necessary functionality to get a web application going. A web application allows us to deploy a platform-independent solution, which can function for HCPs anywhere. Flask integrates well with the SQLite3 database system that we use to store patient data. The patient data are a collection of medical records used as inputs to the decision support system as well as the resulting ExRx.

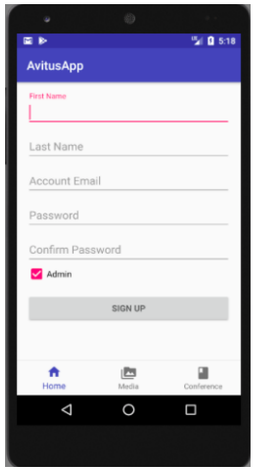
From left to right: Eric Mei, Richard Guo and Vidhi Pandit

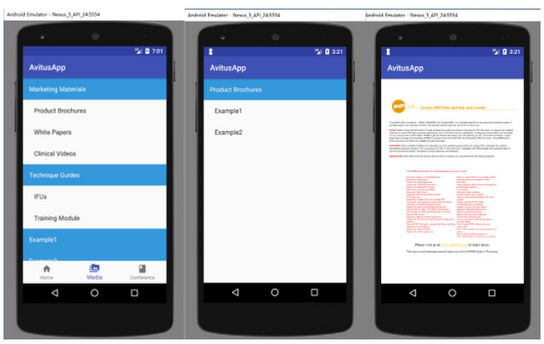
COMPUTER SCIENCE & ENGINEERING

TEAM: 33
SPONSOR: Avitus Orthopaedics
SPONSOR ADVISOR: Neil Shah and Maxim Budyansky
FACULTY ADVISOR: Dr. Swapna Gokhale

Development of a Mobile Solution for Medical Device Distribution Management



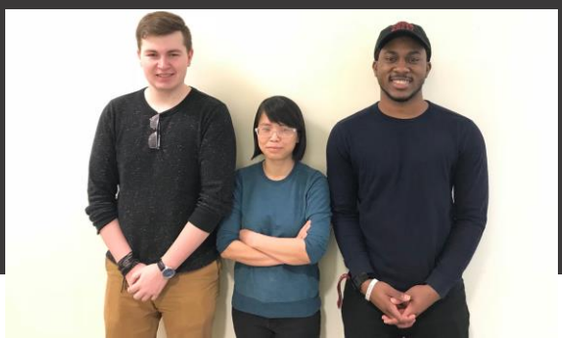




The objective of project is to work on a high-impact product that will be directly utilized by a fast-growing, CT based medical device company and its various distributors nationwide. The goal of this project is to develop a mobile app solution to solve an unmet need in the company. The mobile app must enable seamless transmission of data between the company and their sales representatives at various hospitals across the country. Distributors must be able to schedule surgery dates in which the company's products will be used and submit post-surgery data that will be used for tracking inventory, billing customers, and conducting important back-end data analytics. The mobile app will also integrate itself with the current inventory management system that is being developed by Avitus in order to allow Avitus representatives the option to quickly request and process forms on the go. We decided to create an Android app that will implement these requirements and these apps will be available for use by all of Avitus's distributors.

Avitus will distribute this app to external parties that will be able to log in and access Avitus materials as well as manipulate and view data from the main web-based inventory management system (IMS). The Avitus App should streamline basic functionalities and package them all together for customers, distributors, and Avitus representatives to use without the need to go through the hassle of acquiring and storing the information themselves. This App would also allow Avitus representatives and external parties to show, view and store offline media on their devices to showcase Avitus' works without the need of cellular or a WiFi connection.

The later versions of the Avitus App will also be able to connect to Avitus's IMS which will allow Avitus representatives to create input forms, generate PDFs, track shipment materials, serve as a means for Avitus employees and external parties to exchange information through an instant messaging feature as well as be able to process requested materials without needing access to a web-browser.



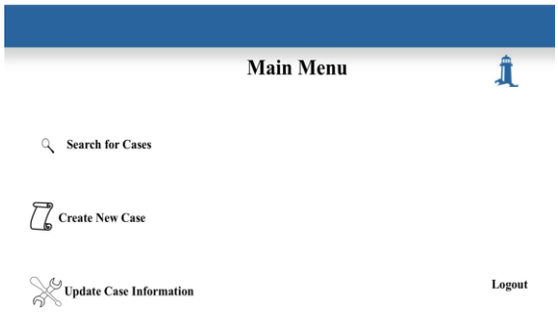
From left to right: Bryan Arnold, Duong Tran, Kevin Hunte.

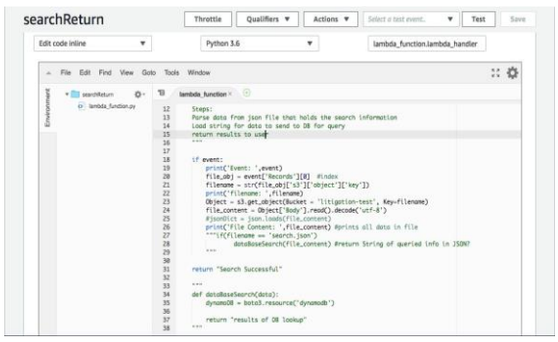
COMPUTER SCIENCE & ENGINEERING

TEAM: 34
SPONSOR: Nassau Re
SPONSOR ADVISOR: Scott Aaron Zweig
FACULTY ADVISOR: Dr. Swapna Gokhale

Litigation Database

NASSAU RE

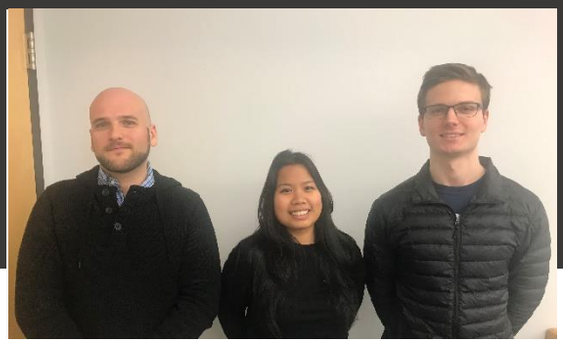




Nassau Re is a financial services company whose business covers four segments: insurance, reinsurance, distribution and asset management. Nassau Re moved its headquarters to Hartford in 2016 after it acquired Phoenix, an insurance company founded in Hartford in 1851. The Nassau Re Legal Department manages litigation relating to insurance as well as the other business areas.

Nassau Re's vision was to develop a user-friendly database to track and store information related to company litigation. This newly designed database would serve as a long-term solution to Nassau's litigation case management needs, with the ability to evolve over time. In addition to tracking case information, the database should have the ability to produce reports on any combination of data elements contained within the database, as well as provide calendar updates through Microsoft Outlook. Ideally, these reports could be exported to Excel or a formatted PDF. The reporting feature should include certain pre-programmed or canned reports as well as being able to be generated "on the fly". Being able to create at any time would allow for easy reuse of a report in the future. Although the primary focus is on functionality, the database should have an intuitive design and modern look.

Our solution is to make this database a web application that will be serverless and hosted on the cloud platform of Amazon Web Services (AWS). The three Amazon technologies that are used are Simple Space Storage, Lambda, and DynamoDB, which will handle static website hosting, data processing and queries, and data storage respectively. Features such as dynamic dropdown lists, single sign-on, and PDF generation of cases will be implemented into web pages with JavaScript/NodeJS.



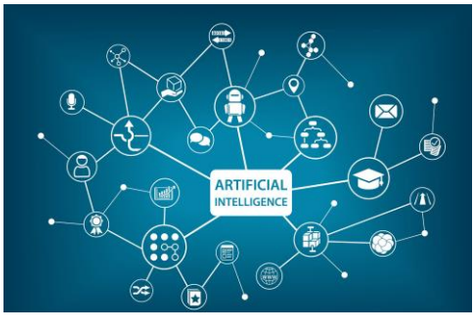
From left to right: Jeffrey Soule, Nurul Sauffian, and Volodymyr Shvydkyy

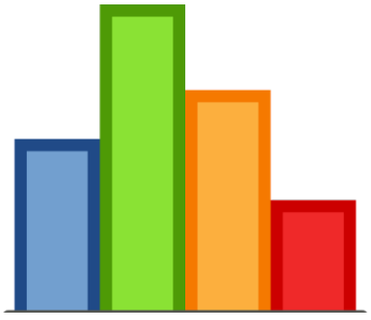
COMPUTER SCIENCE & ENGINEERING

TEAM: 35
SPONSOR: Cognizant Technology Solutions
SPONSOR ADVISOR: Ajit Tapaswi
FACULTY ADVISOR: Dr. Dong-Guk Shin

BOTs Development

Cognizant





Cognizant is a multinational corporation that provides IT services, including digital, technology, consulting, and operations services. Cognizant is uniquely positioned to help organizations transform their business, operating and technology models in the digital era. Cognizant advances its customer's services through the introduction of state of the art technologies such as BOTs. These BOTs are individual applications which are created in order to provide a solution tailored to the individual needs of Cognizant's clients. This implementation of machine learning techniques simulates a human activity to decrease level of effort and improves quality. Under the advisement of Cognizant, we (BotConn) developed different BOTs using Machine Learning Techniques from Incident Management and Process Automation standpoints.

User Case 1: Anomaly Detection BOT for build logs to process new system exceptions from the latest build (Quality Issue). This BOT can be used for predicting anomalies in a data feed if they don't confirm or there have invariable deviations from historical data feeds. Through a web application developed by BotConn, the BOT would then notify the end user if it had encountered data that fell outside of its expected range, yielding an anomaly.

Use Case 2: Regression testing can be expensive and may require significant script maintenance efforts. Test prioritization can be planned to achieve intended execution goals. Success of regression testing can be amplified by focusing effectual techniques like code coverage. This BOT can enable focused regression test selection in a smart way by considering the aligned parameters, generating intense benefits. BotConn is focusing on specific industry demand while building this BOT.

Use Case: 3 The Shadow Buddy / Ticket Analysis BOT is used to prioritize incoming ticket requests for a support team. This requires real time analysis and classification being performed on the incoming live request stream. Upon the sorting of the incoming requests, a curated list will be outputted for the support team.

These BOTs help software quality assurance beyond mere automation by moving toward a system of artificial intelligence (AI).

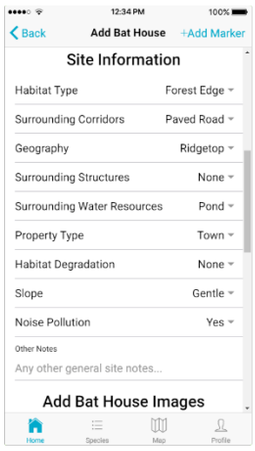
From left to right: Clayton Michael, Mark Cabanero, Samantha Gustafson and Ruicheng Li

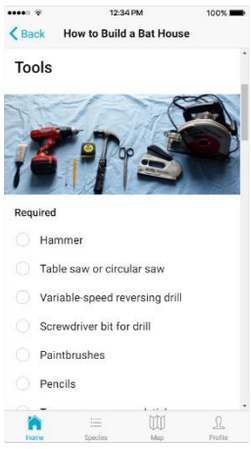
COMPUTER SCIENCE & ENGINEERING

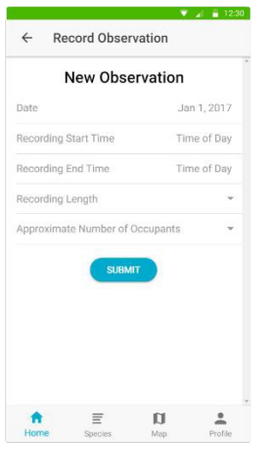
TEAM: 36
SPONSOR: UConn Natural Resources/Environment
SPONSOR NAME: Dr. Laura Cisneros
FACULTY ADVISOR: Dr. Steven Demurjian

Citizen Science Bat House Monitoring Application

BAT HOUSE MONITORING PROJECT







Bat population has taken a hit with the devastation from White-Nose Syndrome affecting many North American species. In attempts to help scientists understand the impact, it is important to monitor and record bat populations. With the Citizen Science Bat House Monitoring Application, we empower citizens to help in this effort. More specifically, this app gives scientists information on how different environment and landscape variables influence occupancy of bat houses by different bat species, as well as a way to monitor changes in population. The goal is to make this as intuitive and simple for citizens to use, while giving a large amount of data to scientists for further processing.

To make participation easy to as many citizens as possible, the app will be cross-platform for Android and iOS devices. Using modern web technologies, we aim to utilize single codebase to support both platforms for easier development and less overhead from maintaining multiple systems. This application will communicate with a REST API to not only let citizens store and retrieve their information but also enable scientists to query and analyze the data. With private information (location data) being communicated between app and server, secure transfer and responsible indicators will be used to protect user security.

For any app user, ease of use and simplicity is the goal to encourage interaction and repeated observations. Since bat population monitoring would not occur year-round, the app will support reminders for citizens to check. It will similarly alert scientists for potential leads to confirm the presence of bats with methods to record additional data (images, ultrasonic acoustic device recordings). The app also aims to assist citizens that are willing to help but do not know where to start. It will emphasize the importance and motivation for bat monitoring, instructions on how to build and install a bat house, as well as properly monitoring for bats.

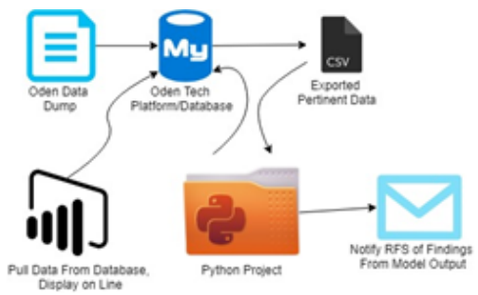
Overall, this application aims to aid scientists as well as keeping citizens involved. Data collection and aggregation for any statewide activity is already hard enough. However, with the capabilities of mobile phones and a small amount of citizens' time, we hope to aid scientists to study and understand best management practices to help protect North American bat species.

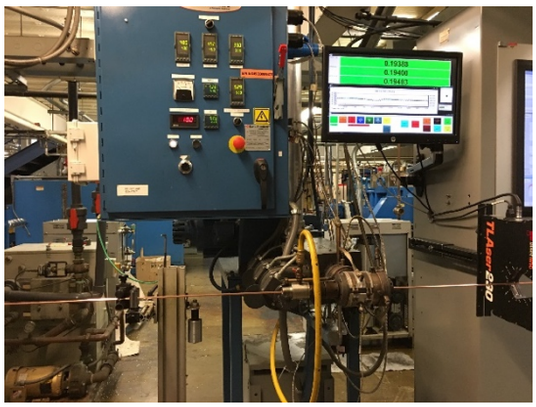
From left to right: Nathan Hom, Mike Marandino, Kyle Barry, and Jon Simonin

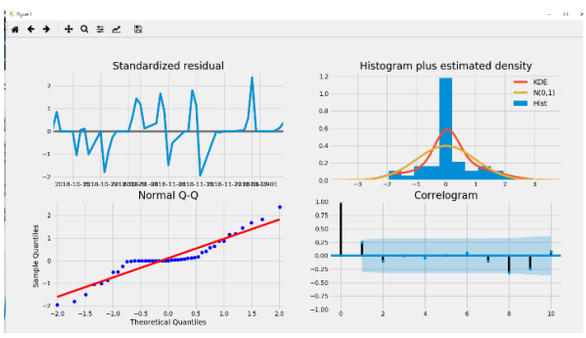
COMPUTER SCIENCE & ENGINEERING

TEAM: 37
SPONSOR: Radio Frequency Systems
SPONSOR ADVISOR: Joel Cacopardo
FACULTY ADVISOR: Drs. Song Han, Mousumi Roy

Predictive Maintenance through Digitalization of Manufacturing Indicators







First, humanity saw the agricultural revolution. People gradually went from hunter-gatherer livelihoods to cattle and farm sustenance. Then the first industrial revolution exploded onto the scene. Labor began to be supplemented by mechanical devices, and industry began to boom across the classes and continents. In efforts to get ahead of the next impending technological revolution, Industry 4.0 has been the driving term describing automation and data exchange in manufacturing technologies.

By focusing on existing sensor outputs from one particular foam extrusion cable manufacturing line, our team is developing a platform for operators and managers alike to turn illogical data into useful insights. This project allows Radio Frequency Systems (RFS) to act before catastrophic failure during manufacturing with more agility than ever before, by orders of magnitude over old systems. Such predictive analytic platforms serve for perpetual growth fueled by a proactive management.

Our project works by establishing a safe baseline using conventional statistical models. If any individual reading, from voltage to rpm, deviates from safety it is flagged. If the deviation strays too far, into the danger zone, it garners higher priority. By identifying indicators of potential failure along the manufacturing line, proactive measures can be taken on the floor to increase output and decrease waste in the form of damaged product. After establishing such baselines, the model turns to feed itself through machine learning algorithms. This allows flexibility of the baselines across production lines and over time, as equipment and worker habits slowly shift.

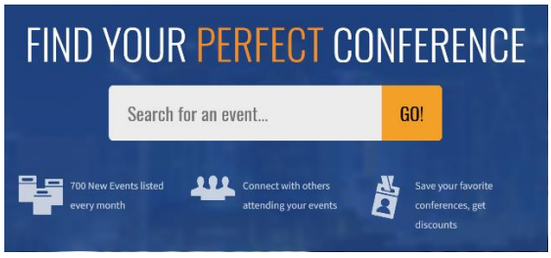
Monthly generated reports coupled with a live-time operator's dashboard allow management to stay in the loop on a less-integrated basis while enabling operators to understand the results and report and respond to irregularities as efficiently and effectively as possible, enabling RFS to drastically reduce waste product and enhance productive output across manufacturing lines.

Left to right: Eli Udler, Marissa Neiman, Alexander Slocum

COMPUTER SCIENCE & ENGINEERING

TEAM: 38
SPONSOR: Convention Nation
SPONSOR ADVISOR: Kim Estep
FACULTY ADVISOR: Dr. Bing Wang

Social Media Integration and Interaction Analysis Using Natural Language Processing



The goal of this project is to implement a customer reward system for Convention Nation, a company that provides its users with information about conventions that are relevant to them. The company would like to create incentives for users to interact with their online presence through gamification, which applies game-design principles to non-game contexts. For this project, this means the creation of a “point system” for users of Convention Nation’s website. These points will serve to incentivize interaction with Convention Nation’s online presence, including its Facebook page, Twitter account and LinkedIn profile. These interactions can include likes, comments and shares. When a user that has a profile on any of the aforementioned networks associated with their Convention Nation account interacts with any of Convention Nation’s profiles, the system will increase the user’s point count.

We focus on two aspects that are central to the project: The first is developing and implementing a framework that makes use of the APIs provided by Convention Nation and the three social networks (i.e., Facebook, Twitter and LinkedIn) to extract data from the social networks and transfer it to Convention Nation. The second is designing and implementing a system that analyzes the interactions and relays possible instances of abuse to Convention Nation. Specifically, our software will analyze the patterns in user interactions, noting suspicious activity, using natural language processing. Large numbers of interactions performed by a single user over a short period of time may indicate that the interactions are being generated by a bot. In addition to these precautions, we hope to discourage unproductive and inappropriate interactions by using natural language processing tools to perform sentiment analysis on comments and tweets.

The other component of the system is a server and a REST API for testing and presentation purposes, where the interactions are registered, and the users are assigned points based on the number of user interactions. People will be able to contribute to our project by interacting with our system, including social media profiles associated with our project.

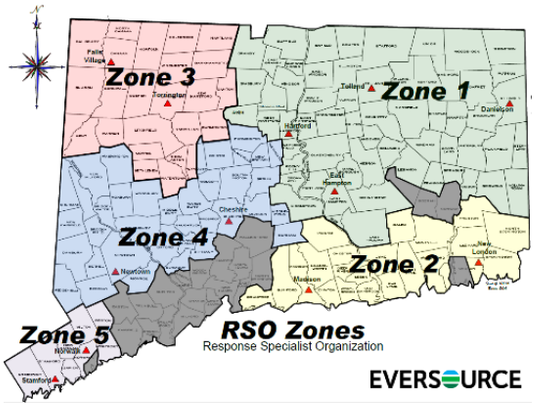
From left to right: Kyle Fujio and Finian O'Connor

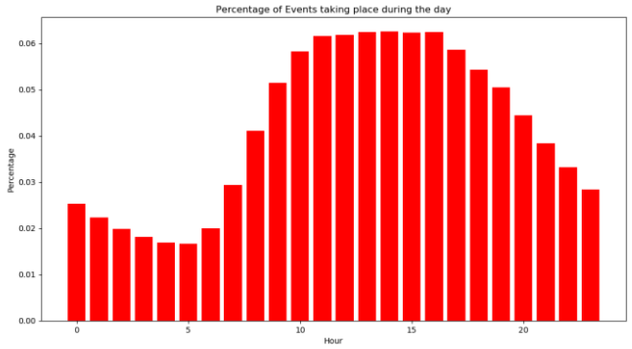
COMPUTER SCIENCE & ENGINEERING

TEAM: 39
SPONSOR: Eversource
SPONSOR ADVISOR: Diana Mahoney
FACULTY ADVISOR: Dr. Zhijie Jerry Shi

Eversource RSO Optimization Model to Reduce Average Customer Power Interruption

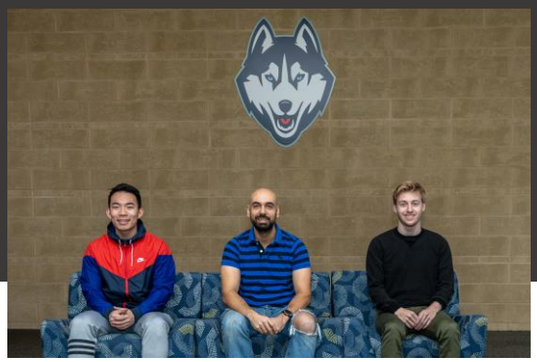
EVERSOURCE





Eversource is an electric, gas, and water delivery company serving Connecticut, Massachusetts, and New Hampshire. One of its duties is to respond to and service all outages to the electric distribution system. To respond to outage events, Eversource created a Response Specialist Organization (RSO). This organization works 24/7, traveling to reported outages and restoring power to all affected customers. The quicker the RSO restores power, the lower the CAIDI, an industry standard that measures the average time a customer is without power. In order to best respond to all outages, Response Specialist teams are split up by state, and in turn by zone. Each zone is a section of the state and is assigned a specific number of RSOs who respond to outage events in the zone. The main goal of this project is to determine the optimal allocation of RSO workers to assign across the state, while minimizing down time for customers and increasing productivity of the RSO.

The approach taken to create this optimization algorithm and perform data analysis involved the Anaconda platform in Python. In order to make accurate assumptions, Eversource supplied the team with outage data from 2015 to present. Since this data set is large (almost 350,000 different events), we started the process by examining the data and removing events that were not relevant to our project. After the data size was reduced, we analyzed trends in the data to learn more about outage events in Connecticut. We developed a program to look at each zone, find the median number of events for each day of the week in a month, and then calculate the average CAIDI by day, week, and month. Based on these results, the program determines how many events an RSO worker must manage and how the CAIDI of a zone correlates to the number of RSO workers. It can figure out which zone's CAIDI would increase the least when an RSO is removed, or which zone's CAIDI would decrease the most when an RSO is added. The answers to these two questions are then used to evaluate the impact on CAIDI if workers are removed, added, or moved from one zone to another. Based upon these findings, the program generates the optimal placement of RSO workers to minimize outage time for customers.



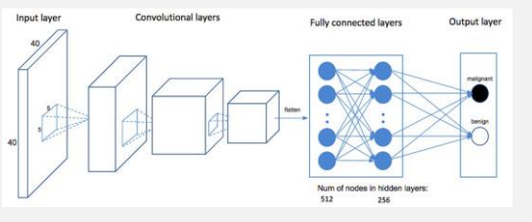
From left to right: Alan Kan, Frank Zappulla, Chris Dipietro

COMPUTER SCIENCE & ENGINEERING

TEAM: 40
SPONSOR: Naval Sea Warfare Center
SPONSOR ADVISOR: Gary Huntress
FACULTY ADVISOR: Dr. Wei Wei

Drone Detection via Acoustic Processing with Machine Learning

NAVSEA WARFARE CENTERS
NEWPORT



In the modern day technological landscape there has been a drastic increase in both the accessibility of data and the processing power of computers. These two factors have thusly enhanced the ability of machine learning systems to provide otherwise unavailable insights into the underlying patterns of the data of businesses, government, and our everyday lives. With support from the Naval Undersea Warfare Center (NUWC) our team is developing a project to apply a machine learning model to detect drones via acoustic information. Presently, drones are used by civilians as well as the military. Civilian drones are often relatively safe and used for the purposes of photography and videography, whereas military grade drones can carry out precision attacks remotely, removing the risk of injury or death to a human pilot. The Navy is thus highly motivated to develop a system to detecting drones and alert military personal of their presence. Making use of the machine learning libraries Tensorflow and Keras, our project aims to develop an acoustic classification system capable of identifying drones. In order to achieve a high level of accuracy we will employ the use many deep learning and advanced data preprocessing techniques.

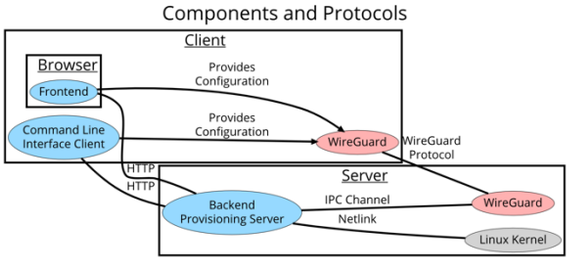
Our model's structure will be that of a supervised learning classification algorithm. We will collect and process acoustic drone data using our own Autel X-Star Premium quadcopter and audio data available on websites such as *youtube.com*. The model will be trained on said data and return a discrete output indicating the presence, or lack thereof, of a drone in a specific audio sample. Our hope is to eventually use a similar approach for identifying the location of the drone using closely related image classification techniques. We have elected to utilize a convolutional neural network (CNN) as the deep learning model for our project. This CNN will be built on top of an existing model designed to accomplish a similar task. Such a process is called transfer learning. This will reduce the time and data costs of training and will allow us to produce highly accurate results and a model that should easily generalize to the needs of the NUWC in their own future drone detection endeavors.

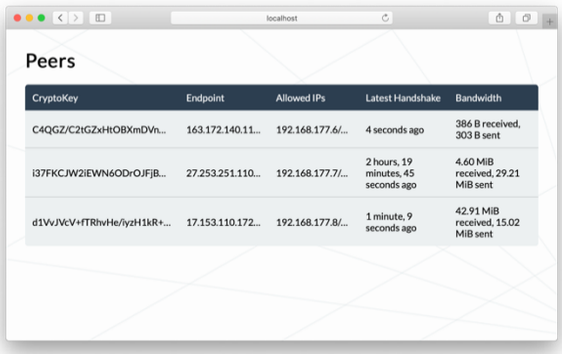
Brandon Cheng

COMPUTER SCIENCE & ENGINEERING

TEAM: 41
SPONSOR: UConn CSE Department
FACULTY ADVISOR: Dr. Bing Wang

WireGuard Web App Provisioning Server: Design and Implementation





The goal of the project is to develop a Web App Provisioning Server (WAPS) for the WireGuard Virtual Private Network (VPN) protocol. WAPS is designed as an open source, white-label software product which will interface with WireGuard to administer end-user network connections.

WireGuard itself is an emerging VPN solution that aims to be faster and simpler than existing alternatives. The protocol and its first-party software implementations have been in active development since 2016. Despite being a work in progress, it has been praised by Linus Torvalds as "a work of art" compared to OpenVPN and Cisco IPSec.

For VPN providers, the finished WAPS product will contain everything necessary to deploy a WireGuard network in a secure and easy manner. For subscribers to a VPN provider, the product will enable a user-friendly mechanism to retrieve configuration files for connection setup on personal devices. Since the protocol was announced only three years ago, few commercial providers currently offer it as a solution; WAPS has the potential of increasing WireGuard adoption dramatically by making it easier to setup for all types of users.

The architecture of the project is designed with a strong security focus. It is written with a Rust backend enabling WAPS to be fast while free from memory corruption vulnerabilities. A simple SQLite database is interfaced with the Diesel Object-relational Mapping (ORM) tool and stores users and network information. For distribution, it is packaged as a single command line binary package for Linux systems.

A demo is available at https://wireguard.brandoncheng.me

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ELECTRICAL AND COMPUTER ENGINEERING

ELECTRICAL AND COMPUTER ENGINEERING

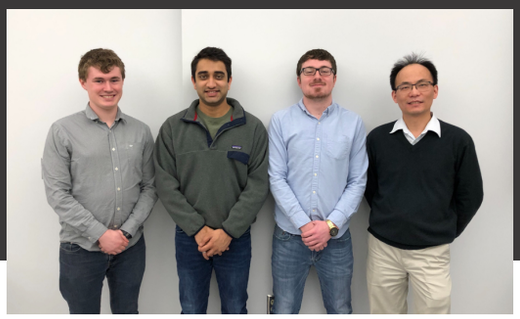
TEAM: 1901
SPONSOR: Sikorsky
ADVISOR: Dr. Ashwin Dani

Ryan Heilemann, Kerry Jones, and Joshua Steil

Autonomous Firefighting Drone

In today's world, forest fires are becoming more and more prevalent. Currently, the method for combating these forest fires involves manned aerial vehicles such as helicopters equipped with thermal imaging sensors and fire-retardant delivery systems. Sending a manned vehicle into dangerous situations such as these is a risk that could be avoided if the right technology was available. Obstacle detection research is currently being done in both sense-and-alert systems for piloted aircraft and sense-and-avoid systems for unpiloted aircraft. This type of obstacle avoidance and autonomous flight software on unmanned aerial vehicles (UAVs) will make fighting forest fires a much safer endeavor.

Our project is a small-scale implementation of an autonomous firefighting helicopter. It has obstacle avoidance in forward flight and is equipped with various instruments in order to detect and extinguish a fire. Our specific system consists of an autonomous octocopter that is capable of extinguishing a campfire-sized flame. On our ground control station, we input the approximate GPS coordinates of the fire, and the command is sent to the drone's flight controller, which begins the drone's pre-programmed mission. Once the drone takes off, it flies in a direct path to the location of the fire, while searching for and avoiding objects in its path. When the vehicle arrives to the set coordinates, it initializes a search pattern until the thermal imaging camera detects a flame. The drone then uses the camera to guide itself to a hovering position just above the flame, automatically releasing a fire extinguishing bomb to put the fire out. Once the sensor indicates that the flame has been extinguished, the drone returns to its takeoff location to land.



From left to right: Matthew Macesker, Sagar Mehta, Alex Brown, Dr. Shengli Zhou

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1902

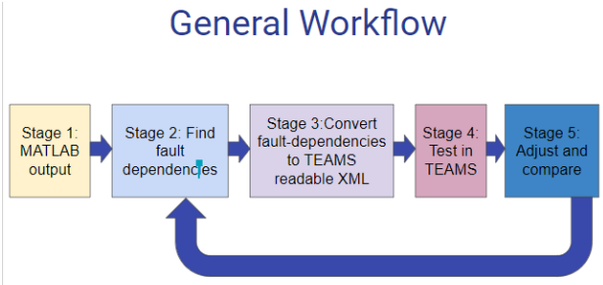
SPONSOR: Qualtech Systems

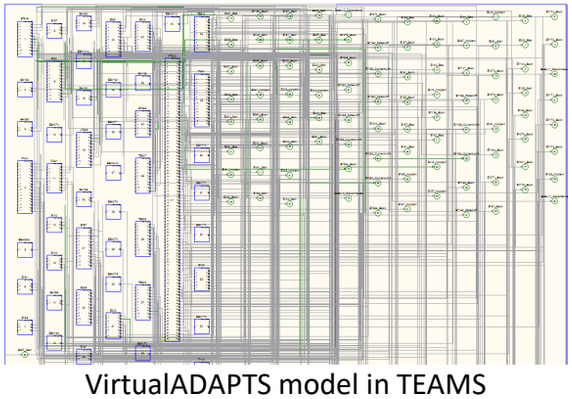
ADVISOR: Dr. Shengli Zhou

Conversion of System Health Diagnostics across Simulators

Qualtech Systems develops the TEAMS-Designer (Testability, Engineering and Maintenance System) Suite, hereafter referred to as T-D, which offers resources for modeling aspects of physical systems including its structure, the connections between components, and likely causes of failure. This modeling software tests a system's overall health and robustness. T-D incorporates new information and puts it toward future predictions, thus reducing company overhead for maintenance calls. Simulink, a simulation software created by Mathworks, has wide functionality and ease-of-use that makes it a versatile modeling tool for many companies. However, Simulink is inherently different from T-D, as it lacks native functionality to predict failures and their causes and then reduce overhead for fixing these failures. Since many of Qualtech's customers originally model their systems in Simulink, it would be very convenient if they were able to convert a system from Simulink to T-D, which would allow them to utilize the health diagnostic capabilities that T-D offers.

For our project, we are using NASA's VirtualADAPTs Simulink model for an extraterrestrial vehicle as a template. VirtualADAPTs offers a convenient way to inject faults into the system, provided via a custom-built graphical user interface (GUI), and see the results in the form of changed component values. This process consists of finding the failure modes of the system by injecting every fault programmatically and exporting the resulting component values into CSV files. These values, organized by fault injection type, are compared programmatically with a Python script against the nominal steady state values of the system. If they differ by a dynamically-defined threshold they are documented as failures in a CSV file. Next, a C# script takes all the parameters from this CSV file and organizes this into the DTD schema compatible with T-D. We verify our XML file with Oxygen, an XML editing tool, allowing us to import it into T-D and analyze metrics such as fault detection and isolation. This has produced a model in T-D that could be used to diagnose faults in VirtualADAPTS given a set of outputs, and could be demonstrated live using TEAMS-RDS. Completing this model conversion for VirtualADAPTS will serve as a proof of concept for other potential customers who seek to utilize T-D's diagnosis tools for their existing Simulink models.





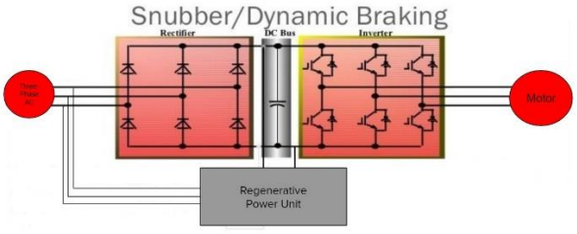
VirtualADAPTS model in TEAMS

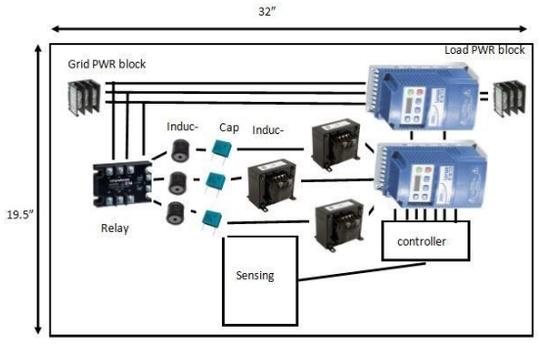
ECE Senior Design Team 1903. Ronald Ruselowski (left), Julian Trozzi (middle), and Aquins Varghese (right).

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1903
SPONSOR: Lenze Americas
ADVISOR: Sung-Yeul Park, Ph.D.

Three Phase AC Regenerative Power Supply



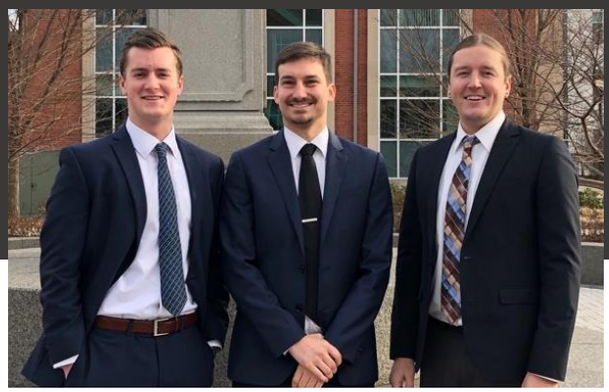


Lenze Americas makes Variable Speed Drives to power three phase induction motors. A problem occurs during rapid deceleration of a high inertia motor load. During the deceleration the rotating inertial load's energy ($E = \frac{1}{2} J \omega^2$) is returned to the drive via the six freewheeling diodes and "pumps up" the voltage on the DC capacitor bank. A similar problem occurs when the motor is attached to an overhauling load such as a descending elevator. Our solution is to create a regenerative power supply that returns the energy stored in the capacitor bank back to the three phase power line in a synchronized fashion and is separated in three parts.

An LCL filter is needed to interface between the inverter and grid and is used to achieve cost effective attenuation of the switching frequency harmonics. The LCL filter is comprised of a grid side inductor, capacitor and inverter side inductor. With the correct values the filter can successfully feed the grid with a high quality current supplied by inverter. A solid state relay is then used to connect the main grid lines to the LCL filter. This is needed to prevent back feeding when our circuit is not in use.

Voltage sensing is needed to let the controller know when to turn on the regenerative supply based on specific parameters. These parameters include DC voltage levels which dictate the optimal time to turn on the regenerative unit. The other parameters include AC voltage and current levels and are used by the controller to synchronize the excess power with the grid. The voltage sensing circuits are comprised of a voltage divider, differential op-amp circuit, and a scaling circuit. These circuits turn 350V input into a 0-3V output, suitable for a microcontroller. The AC current sensing will be directly borrowed from a preexisting Lenze Variable Speed Drive.

In order to send power effectively back to the grid we must have control over the phase and the voltage. We decided that software control was the best rather than hardware. We are using a TI-DSP to run the software. We chose TI-DSP compared to other microprocessor is based on speed requirements of the task and resources available online. Our approach for control is to build a mathematical model of the system and calculate the gain for the voltage and current controller. Based on the results from the mathematical model, a simulation can be made in PSIM. Test our mathematical model results so we can program the microcontroller. In PSIM, sections of the simulations can be converted into C-code blocks, and later the C-code blocks form PSIM can be converted into C - code for TI-DSP.



L to R: Hunter Malboeuf (EE), Greg Palmer (CMPE), Davis Meissner (EE)

ELECTRICAL AND COMPUTER ENGINEERING

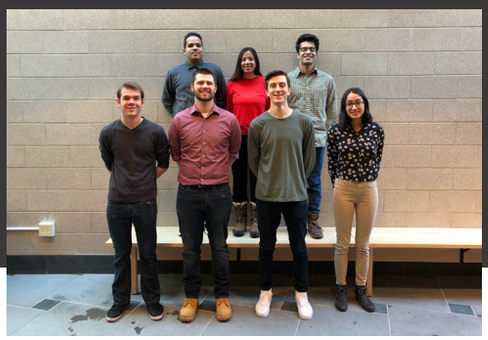
TEAM: 1904
SPONSOR: The MITRE Corporation
ADVISOR: Dr. Peter Willett

Enhancing Software Defined Radios for Underwater Acoustic Modem

The underwater acoustic communication channel is extremely challenging due to a low speed of sound, wide spreading in both Doppler and delay, and extreme geographical variability. Additionally, acoustic communication technology has previously lacked a capability for rapid prototyping and performance evaluation. Software-defined radios (SDR) allow for swift, robust development of radio frequency communication systems that can serve as a possible answer to the problems posed by underwater communications. They offer the advantages of operating at relatively low power and being inexpensive to implement in hardware. The goal of this project is to develop an underwater acoustic communication system utilizing two software-defined radios, focusing on waveform development. Our initial goal is to set up a communication channel in a bucket of water using two underwater transceivers. One SDR will function as the transmitter and the other will function as the receiver. System performance will be evaluated using a channel emulator that models the underwater channel effects before proceeding to underwater testing. Stretch goals include implementing a two-way SDR real-time communication system, as well as adding a convolutional coding error correction scheme and equalization techniques at the receiver. Signal modulation is focused on the development of a non-coherent differential phase shift keying (DPSK) waveform with the goal of sending and receiving small ASCII text messages that are read from a text file.

Our team began by developing and testing the waveform in MATLAB over an additive white gaussian noise channel. DPSK based modulation, interleaving, error correction, synchronization, and a single bit cyclical redundancy check have been implemented and tested successfully. The MATLAB test model was ported over to C++ before being loaded onto the UDOO boards. This code enables the UDOO boards to interact with the Ettus X310 modems in order to transmit and receive messages.

We expect to be able to successfully implement a one-way underwater communication system, adding equalization techniques based on an adaptive decision-feedback equalizer (DFE) if time allows.



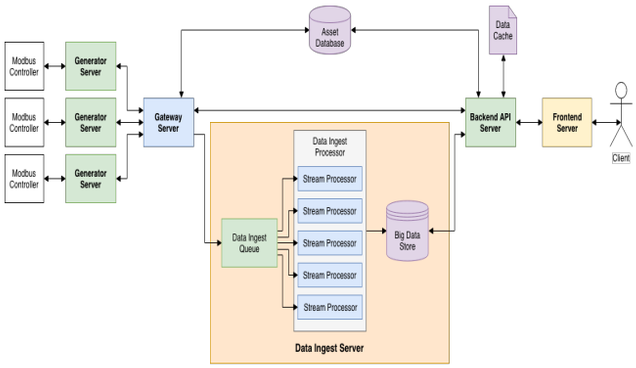
ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1905
SPONSOR: Kinsley Power Systems
SPONSOR ADVISOR: William Schneeloch
FACULTY ADVISOR: Dr. Helena Silva

Dinelson Rosario, Allysa Garcia, Emil Abraham, William Reid, Andrew Philippi, Evan Langlais, Rania Chowdhury

Data Collection, Processing, and Visualization for Remote Emergency Generator Systems

KINSLEY
The Energy Solutions Company



Generators are a cornerstone of the emergency power infrastructure that ensures critical systems are up and running during power failures due to outside forces such as inclement weather. Periodic generator monitoring and maintenance ensures that in the case of a sudden power failure, important resources are not cut from energy sources, which could lead to immediate danger to equipment, data, and even human life. Regular monitoring and maintenance ensure these critical generators are in working order for when the unexpected strikes.

Currently, a technician must travel to a generator whenever it needs to be started, stopped, or monitored for any preemptive or reactive reason. Kinsley power has a monitoring tool that runs on a laptop connected to the generator via a cable that facilitates the reading of data and events from the generator controller. A robust and responsive remote monitoring system would allow for technicians and clients to spot generator faults and problematic trends while saving the time and money associated with travel.

The primary goal of this project is to remove the requirement for Kinsley technicians and clients to always be at a generator's physical location to view its data. Technicians will access a website that will allow them to view real-time generator data and events, as well as interact with certain generator functions. Travel will still be necessary in the case of failure. The system will be able to notify technicians when certain concerning events like failure are received. Historical data collected by the system can also be used to identify patterns of failure in order to anticipate when and where more technician attention might be necessary.

Our solution, the PowerPanel System, seeks to leverage several cloud technologies to ingest server data from thousands of remote generator systems. This is done by connecting our module created from a raspberry pi, Arduino shield, and Modbus converter, to the generator's controller. Using a wired ethernet connection, it is possible to host a webserver that will continually monitor the generator's state. The raspberry pi is coded using Go Lang, powered by the generator, and placed inside the generator's controller.

Left to Right: John Ayers, Jeremy Baouche, Cullen Cole, Aaron Adap

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1906

SPONSOR: General Dynamics Electric Boat

ADVISOR: John Ayers

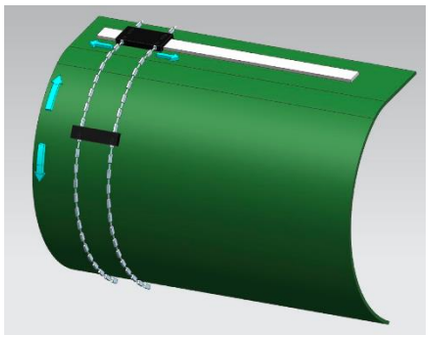
Cylindrical Inspection Rig

GENERAL DYNAMICS
Electric Boat

Located in Groton, CT, General Dynamics Electric Boat is one of two U.S. shipyards that are capable of building nuclear-powered vessels. They are the primary submarine builder for the United States Navy. The company built the first nuclear powered submarine, the USS Nautilus, and the first ballistic missile submarine, the USS George Washington. Currently the company is contracted for the design and construction of the Columbia class ballistic missile submarine as well as improving the current Virginia-class design.

The company has tasked a joint Mechanical and Electrical Engineering team to design and create an inspection rig. This rig is to be 20 ft. long and accommodate a 34 ft. diameter cylinder. The rig will be able to accurately position sensors to within an inch along the surface of the body. The operator of the rig should be able to communicate with the rig wirelessly to a range of 300 ft.

The electrical team is responsible for the wireless positional control of the inspection rig. To achieve wireless capability we used HC-12 transceivers which allow for theoretical ranges in excess of 3000ft. These modules are then connected to Arduino Uno boards which then communicate with the rig's onboard motors. These motors then will move either the inspection arm or the sensor package.

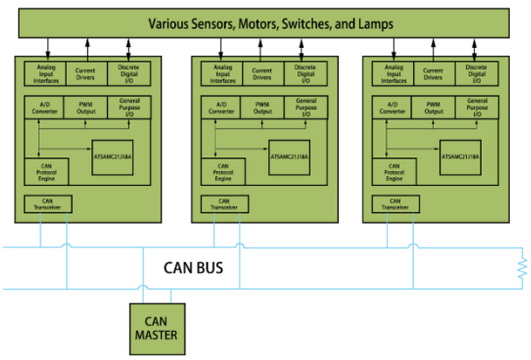


From left to right: Matthew Cox, Pawel Bezubik and John Nguyen

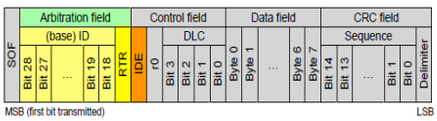
ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1907
SPONSOR: Collins Aerospace
ADVISOR: Dr. John Chandy

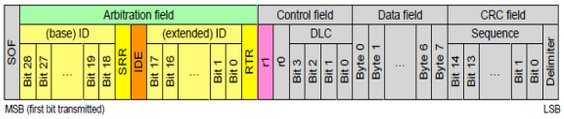
Networked CAN Bus Controller for Distributed Sensing and Control

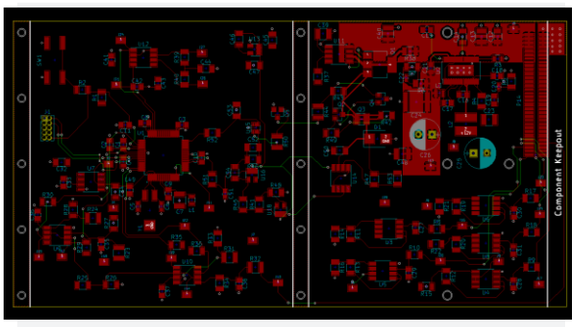


Base CAN data frame format



Extended CAN data frame format





The use of the Controller Area Network (CAN) bus protocol is ubiquitous in the automotive industry for its ability to create a communication network in vehicles that does not require a host computer. Further, the protocol is advantageous due to the low cost of implementation, robust physical layer and flexible message structure.

The goal of this project is to design and evaluate a CAN controller for use in the aerospace industry, specifically for a Peripheral Component Interconnect (PCI) rack card. The device will act as a hub for a set of local, predefined I/O modules and will allow these modules to monitored and controlled via the CAN Bus network.

The modules required for the initial design were a discrete I/O input stage, an analog input stage and a torque motor driver. The discrete input must interpret physical events by converting a power supply level voltage (16-32V) to a logic level (0-5V) signal for processing. Applications include electromechanical switches such as valve over-travel switches. The board must also have the capability to process analog inputs from local sensors by converting sensor output voltages at a 0-10V range down to a level that is processable by an on-board Analog to Digital Converter (ADC). Finally, the motor driver must be able to provide a variable current (0-200mA) to drive a solenoid coil and create a holding torque in the target device.

The board is controlled by an ATSAMC21 Cortex-M0+ Microcontroller (MCU) which includes a CAN bus peripheral to allow the device to easily interface with the network without requiring extra hardware.

The final deliverables include a four-layer printed circuit board (PCB) which is to fit the VITA-20 and IEEE 1386 standard for PCI mezzanine cards as well as the required software to operate the devices.

From left to right: Vincent Turnier(EE), Brendan Formanski(CmpE), Indrid Xhuti(EE)

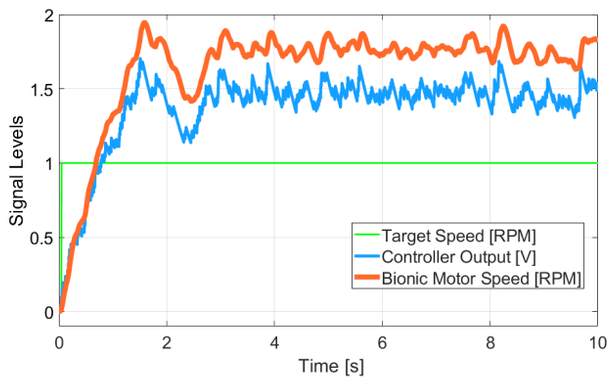
ELECTRICAL AND COMPUTER ENGINEERING

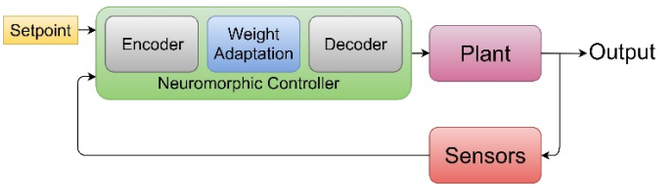
TEAM: 1908

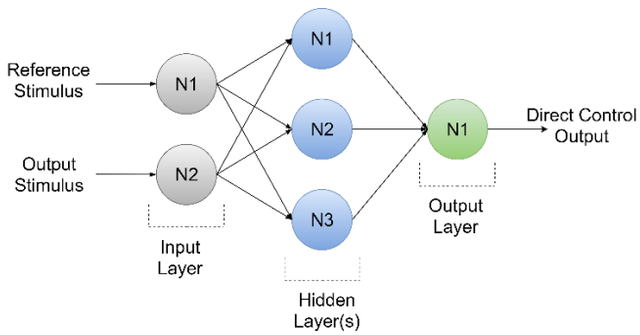
SPONSOR: United Technologies Aerospace Systems (UTAS)

ADVISOR: Abhishek Dutta

Model Predictive Control for Air-Cooled Chillers



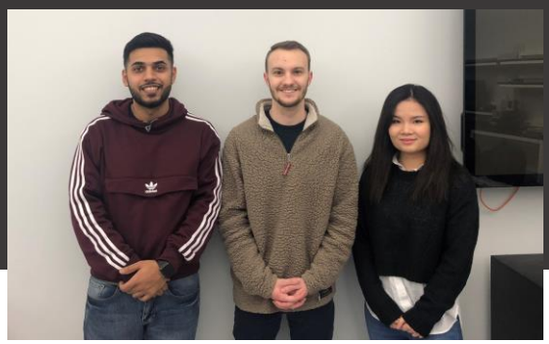




Model Predictive Control (MPC) is a systematic approach to handling problem with physical restraints. The application of MPC is widespread and conventional, as a direct result of its innate ability to optimize complications with real-world constraints. PID controllers and control logics are typically used to control chillers to meet cooling capacity demand while maintaining reliable and energy efficient operations for different cooling loads and ambient conditions. UTAS proposes MPC may provide a feasible solution to simultaneously handling cooling capacity, compressor protection and energy efficiency. The team decided to take two different approaches to this project, one in which an MPC design is implemented onto a traditional embedded system such as a microcontroller or FPGA. The other where a neuromorphic control system is deployed on an embedded chip designed by the team.

Initial research was conducted to gather information regarding MPC and neuromorphic control. Lower level simulation and modeling took place in MATLAB and Simulink to allow the team to get an idea for the design of control systems. The team then branched off to start designing separate systems for the two implementations of the solutions. The traditional implementation is designed in the C programming language and will be deployed on an Arduino board. The variables being manipulated are temperature, pressure, and energy consumption. Optimization is a key factor for MPC, and these values are tracked and refined through iterations of system executions.

The team's goals were set to realize a novel approach to control systems using spiking neural networks based on discrete active components and memristors purchased from KNOWM. This approach would be more power efficient than traditional embedded systems and more physically robust as computation is decentralized so the rest of the network can pick up the slack if a neuron or synapse fails. This is because the neuromorphic approach allows the system to adapt to changes due to how synaptic weights are weakened and strengthened between neurons which leads to the learning capabilities of neuromorphic systems. Future work would allow these neuromorphic systems to implement known control algorithms such as Proportional-Integral-Derivative (PID) or Model-Predictive-Control (MPC).



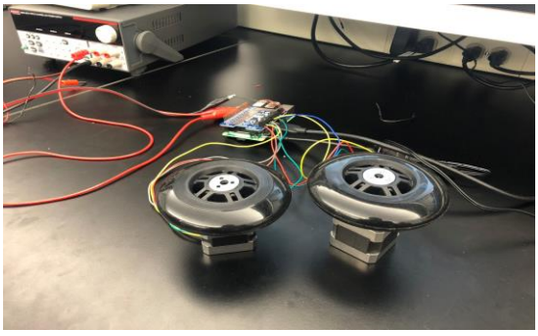
Yousuf Mian (left), Timo Fischer, Alice Pham

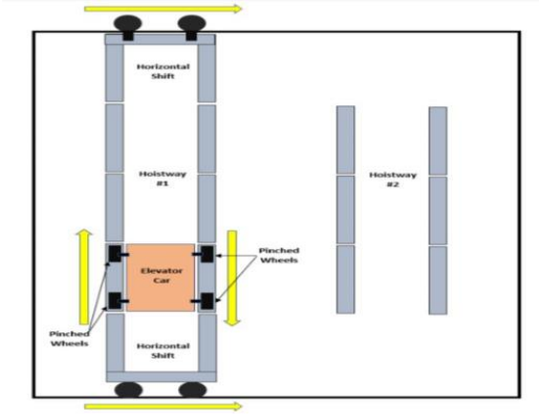
ELECTRICAL AND COMPUTER ENGINEERING

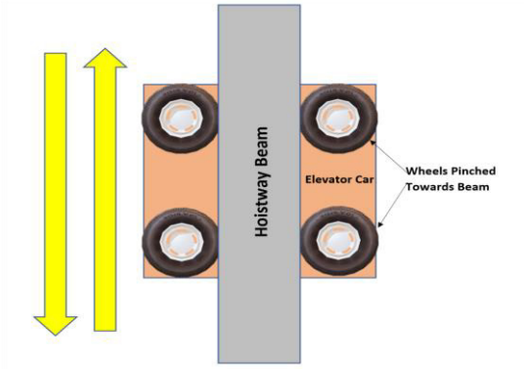
TEAM: 1909
SPONSOR: Otis Elevator Company
ADVISOR: Professor Abhishek Dutta

Self-Driving Vertical Beam Climbing Robot

OTIS



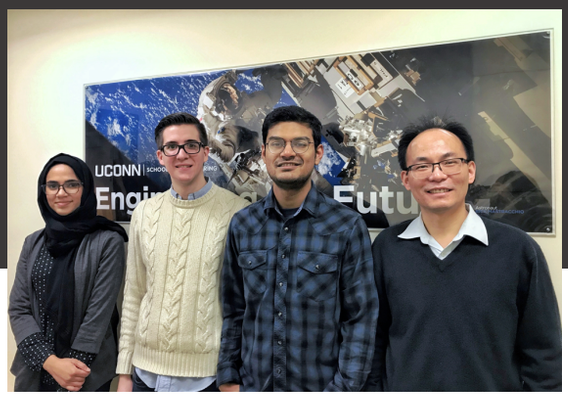




The scope of this research is to develop concepts for a vertical beam climbing robot that prove the feasibility of a self-propelled elevator. The robot must have an optimal ratio of its weight versus the payload weight. The goal of this project is to design a robot that is capable of climbing up and down, in order to replace the modern-day elevator system.

We have conceptualized a design using wheel hub motors. There will be two hoistways so we can demonstrate the capability of a horizontal shift. Each hoistway will consist of two beams in which an elevator car will sit in between. The beams will be used for the car to climb up and down. The outer frame will likely be about 6 feet tall and about 5 feet wide. Each floor can be about one foot tall with three main floors and two floors that allow for horizontal movement. The elevator car will be about 12 inches by 12 inches. The car will have four wheels on the front of the two beams and four wheels on the back of the two beams. These wheels will have rubber tires for traction, and each wheel on the front and back will pinch against the beam. The corresponding wheels pinching both sides of the beam will allow for the car to be self-propelled. Each wheel will be connected to a motor which will allow the wheels to move in the expected direction while keeping traction and remaining self-propelled. This will allow for the ascending and descending movement of the car in one hoistway.

There will be two sectional beam pieces which will have the capability to horizontally shift the car so it may be aligned with the other hoistway. The sectional pieces on top and bottom of the fixture are similar to the beams that are fixed, except these will not be connected to the mainframe. These will have a connection to the top and bottom of the frame and will have wheels to apply a similar pinched wheel application but for the horizontal direction. If the shift section is lined up with a hoistway, the car in that hoistway can climb up normally until it stops and remains suspended in the shift section. Later the horizontal shift section can move laterally until it aligns itself with the other hoistway. Once this is complete, the car can continue to ascend or descend to the desired floor. The figures to the left show the hoistway conceptual design.



From left to right: Anam Qureshi, Nicholas Cacace, Md Tanvirul Islam, Dr. Shengli Zhou

ELECTRICAL AND COMPUTER ENGINEERING

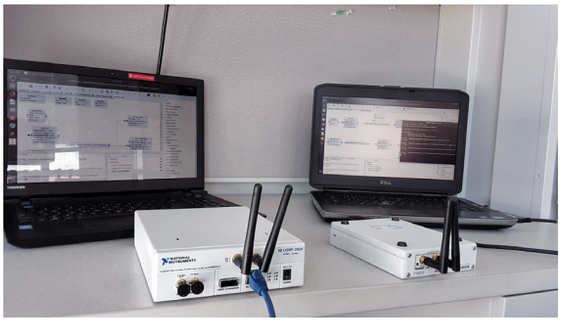
TEAM: 1910

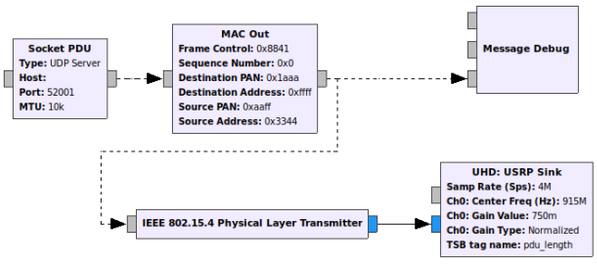
SPONSOR: UTRC

ADVISOR: Shengli Zhou

Real-time and Secure Wireless System based on Software Defined Radio

United Technologies Research Center





From the Internet of Things (IoT) used in smart homes to large-scale space shuttles, secure and robust wireless communication systems are one of the most fundamental requirements. Software-defined radio (SDR) is a radio communication system where components that have been typically implemented in hardware are instead implemented by means of software on a computer or reprogrammable embedded system. In this platform, all the physical layer operations and some network layer operations of the OSI network model are defined using software.

Our project focused on developing a real-time wireless communication network using software defined radio. The power of implementing modulation/demodulation components, mixers, filters, amplifiers, detectors, etc. using software makes it possible to implement different wireless communication standards with ease. These can be run using the same generic hardware unit. Throughout our project, the GNURadio software framework was used to code and implement IEEE 802.15.4 Physical (PHY) and Media Access Control (MAC) layer standards, as well as our implementation of a Time-Division Multiple Access (TDMA) MAC protocol. The communication modules were coded using Python and C++, leveraging the vast open-source APIs of GNURadio and Boost Library. We drew inspirations from the Wireless Measurement and Experimentation (WIME), an open-source project that uses SDR platform to build communication modules, and implemented our versions of the IEEE 802.15.4 protocol on the SDR platform capable of sending messages between computers. We benchmarked the performance of the system by testing packet loss ratios, successful transmissions against noise margins and distances, as well as GNURadio's CPU run-time.

In order to have reliable message transmissions regardless of distance and network-traffics, TDMA MAC was coded and implemented in the system on top of the existing PHY layer. Upon examining the security flaws within the implementation, the message integrity code of the system was increased using Symmetric Key Cryptography. This was done by incorporating the Advanced Encryption Standard (AES) Block cypher with a 128-bit key into the MAC layer of the system.

Mehdin Muratovic, Zacharya Samih and Stefan Bilyk

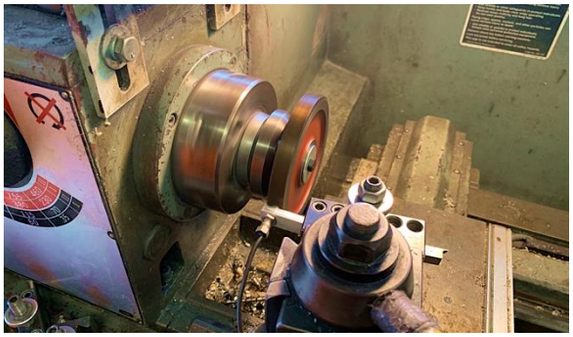
ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1911
SPONSOR: Triumph Engine Control Systems
ADVISOR: Dr. Helena Silva

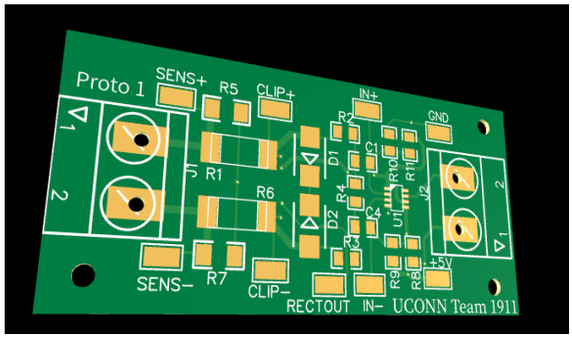
Applications of Distributed Control in Aerospace

Triumph Engine Control Systems
A Triumph Group Company

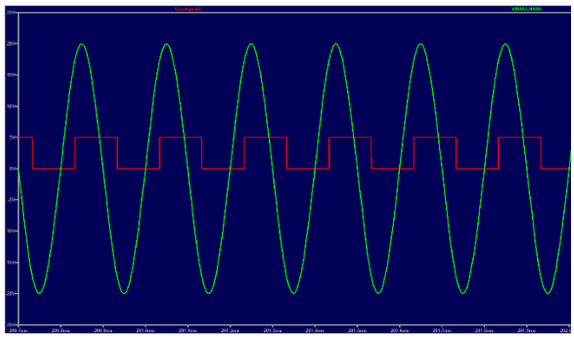
Triumph Engine Control Systems (TECS) in West Hartford, Connecticut, specializes in producing original equipment manufacturing (OEM) and aftermarket aerospace components for commercial and military customers. The components they produce include engine control systems, fuel pumps, fuel controls, and fuel metering units. TECS is sponsoring our project to create a “smart sensor” that will contribute towards their distributed control sensing technology development.



Distributed control sensing is widely used in consumer products such as drones, automobiles, and buildings. However, the aerospace industry has been slow in implementing this technology. Aircraft manufacturers strive to make aircraft as light and strong as possible without increasing the cost dramatically and this design project provides a step towards achieving that goal.



Our solution to develop a distributed control sensor consists of designing and connecting a conditioning circuit to a Commercial Off The Shelf (COTS) variable reluctance speed sensor. Together, this mimics a “smart sensor” that produces a digital equivalent of a sinusoidal output.



The digital equivalent output can be fed into a microcontroller unit (MCU) to compute the speed of the gear. The MCU transmits a digital speed readout to the engine control module (ECM) via controller area network (CAN) or any other serial communication.

This approach achieves electromagnetic interference (EMI) immunity and contributes to the reduction of engine harness weight. Engine harness weight will be decreased due to the reduction of non-essential EMI shrouding and protection. EMI immunity will increase the integrity and reliability of the signal received by the ECM, thus making the entire engine control system more accurate and reliable.

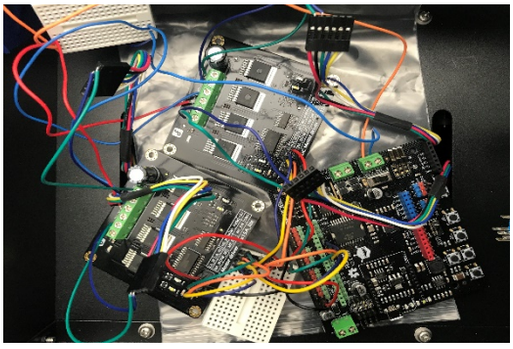
Some challenges that were overcome include ensuring that the “smart sensor” has the ability to power itself from a low speed as well as creating a small package that can easily be commercialized.

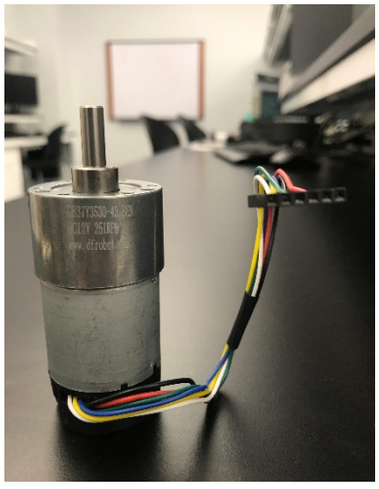
Patrick Villandry, Makena Lloyd, and Sana Khan

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1912
SPONSOR: Stanley Black & Decker
ADVISOR: Necmi Biyikli

Door Sensor Testing Using a Robot





Stanley Black & Decker is a manufacturer of industrial tools and household hardware. It has a production facility where they test all of their doors to improve efficiency. They usually have interns physically move the wooden blocks from one place to another to try and find out the range of door sensors. One of the processes would even involve the interns to travel on skateboards through the doors to test different speeds. As you can tell, the process was very tedious and also not as accurate as it can be. Unfortunately, it is quite dangerous and costly since you have to pay the interns to go through the testing every year. To avoid all of these drawbacks, the best option would be to automate the testing.

The proposed solution is to create a robot with a small mobile platform to carry the given object. We are planning on having the robot in a tank form meaning the sides move independently, and there are no axles. This accounts for steering and turning that the robot would have to perform. It should be able to detect various x and y coordinates. In order to comply with the American National Standards Institute (ANSI), automatic doors need to be able sense a variety of objects of varying humanoid shapes and sizes. The smallest required object is a block that is 10” wide, 6” deep, and 28” tall with a rounded top. We are given two sensors, a microwave sensor and a infrared sensor. A microwave sensor detects the object's motion in the outside area while infrared detects the presence of any object inside the field. Our group is going to be using those sensors to collect data regarding position in the given field to figure out their range.

Using Arduino, we want to create an edge detector for the sensors. With this, we can find the output values (HI/ LO) and check to see when the sensors detect presence/motion. We can also find out the specific heights of the ranges to find out how far and in what direction the sensor goes.

Mathew Cunningham, Joseph Dominick, Jimmy Chen, Kristjan Maandi, and Anthony Vournazos From Left to Right

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: ECE 1913 and ME 23

SPONSOR: Reverge Anselmo

ADVISOR: Professor Shalabh Gupta, Professor Chengyu Cao

IBIS Insect Killer

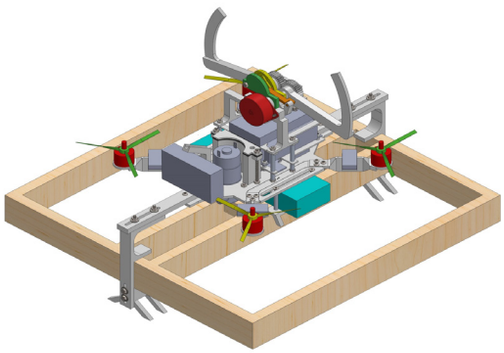
The IBIS insect killer is a drone that we have made that will feature a camera, sprayer, clamp, and payload.. The objective of this project was to make a drone, as small as possible and still keep the functions required, that will be able to fly around, controlled remotely by a user, and transmit a video feed back to the user's computer.

The motivation for this project is to have a solution for insect infestations in hard to access places. For example, a hornet or wasp nest is not only dangerous to interact with directly, but it is also often in hard to reach places such as the roof or a tree. The user will be able to remotely spray insect nests from a safe location. This concept is also highly applicable to other situations and not just the insect problem that we are tackling. The drone's camera and sprayer system can be used in any scenario where a live camera feed is necessary. For example, inspecting faults or cracks under bridges or on the side of dams can be done by our drone because of its small size and video streaming capabilities.

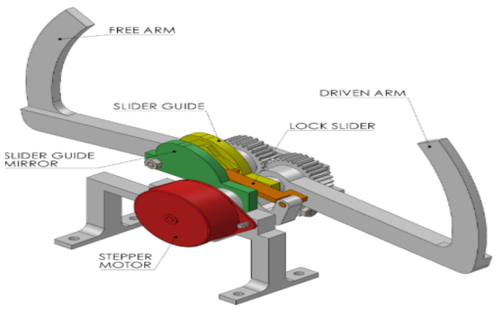
The drone frame and clamp were 3D printed using PLA. The main components of the drone are the Pixhawk4 Flight controller, the Odroid XU4, a camera, a mechanical sprayer, and arm. The Pixhawk4 and Odroid XU4 are used to control the drones flight with the Taranis X9D transmitter and the video feed. The mechanical clamp is controlled by the transmitter and the Odroid XU4, and is used for the drone to be able to clamp itself onto an object, like a tree branch.

The camera feed is displayed using TeamViewer 14, which is installed on the users PC and the Odroid XU4. We use QGroundQontrol to setup and control the Pixhawk 4, which is also stored on the users PC.

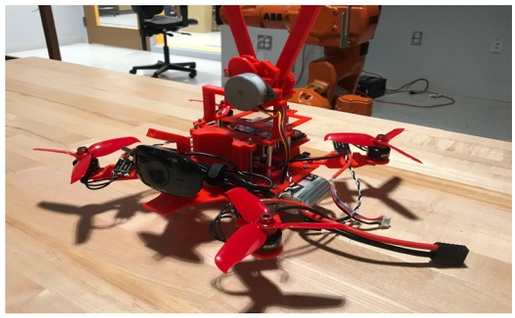
The drone was also required to carry an unknown payload of 18 ounces and 14" by 14.5". It has a system to maintain a tight grip on the payload so that it will not shift around or fall off. This payload is optional and if removed the performance of the drone will increase.



Model of our fully assembled drone.



Detailed model of our mechanical arm



Our drone as of 2/27/19

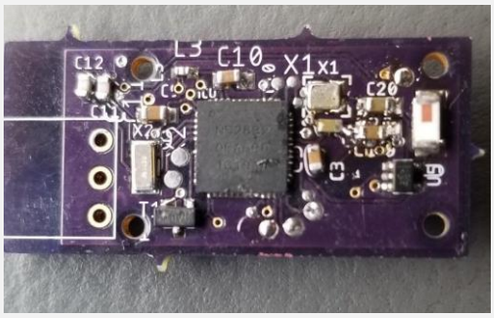
Left to Right:
Abhinav Patni, Luke Boylan, Jack Davidson

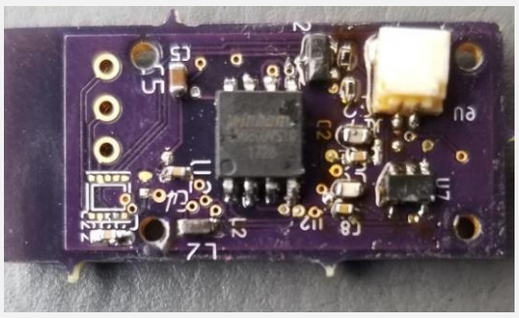
ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1914
SPONSOR: Biorasis
ADVISOR: Dr. Chandy

Wireless Device and App for Continuous Glucose Monitoring

Biorasis
Needle-Implantable, Wireless-Enabled Biosensors





Ever since the advent of glucose monitoring devices, biomedical industries have attempted to circumvent the arduous and invasive process of obtaining blood samples from diabetes patients. For many years the gold standard of the involved technology included finger-pricking for a sample of blood and analyzing it through a separate device to obtain a glucose reading. Today, industries go beyond this rather painful measure by offering implantable technology, where an electronic device is mounted to the diabetic patient's skin and a needle-sized implantable device continuously monitors the glucose levels in the patient's body. Companies offer many ways to integrate this technology into a user friendly interface, including wirelessly communicating the collected data with external devices, like smartwatches or directly to a user's mobile phone.

Biorasis has been developing a unique adaptation to a fully implantable, biosensor for glucose monitoring by realizing a design that communicates sensory data through Low-Energy Bluetooth (BLE) to an application on one's smartphone. The basic working principle of this design and our team's work focuses on obtaining a clean frequency reading from the proprietary biosensor. Our working knowledge of electrical signals and circuit board design and layout will be used to filter noise from the signal as efficiently as possible. This entails a design that uses the least power, provides the most accurate readings, and is time, space, and money-efficient. This collected frequency reading must be sent to the microcontroller for interpretation using embedded programing. This microcontroller must, in turn, supply real time glucose reading through BLE to an application on a smartphone, where one can see real-time data collection, and have a clear visual representation of the info being collected at some preset time interval.

Pictured from left to right: Christian Corwel, George Zoghbi, Stevan Webb

ELECTRICAL AND COMPUTER ENGINEERING

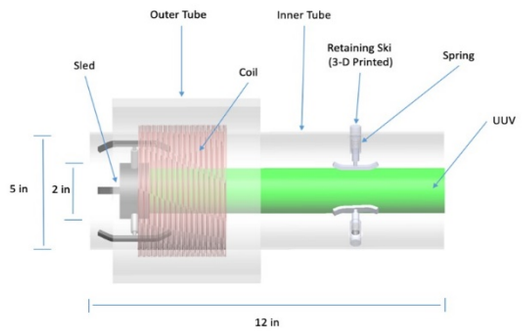
TEAM: 1915

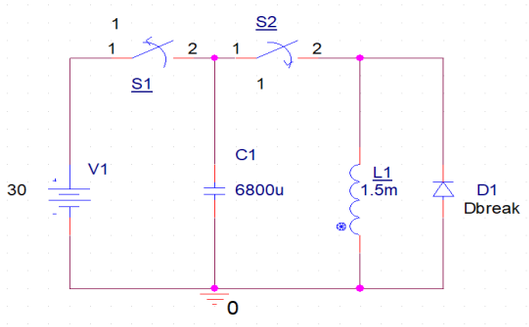
SPONSOR: Naval Undersea Warfare Center

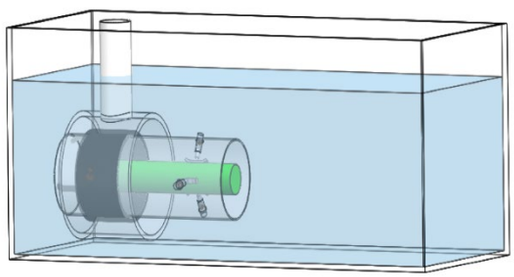
ADVISOR: Dr. Abhishek Dutta

NAVSEA WARFARE CENTERS NEWPORT

Electromagnetic Expulsion from an Outer Tube in an Undersea Environment







The ability to launch, or otherwise deploy, an object such as an unmanned vehicle, from an outer tube in an underwater environment continues to be of interest to the marine community. Applications of such technologies include the use of small unmanned underwater vehicles (UUV's) deployed from deep ocean craft to support oil exploration efforts or inspection of damaged infrastructure. Historically, these payloads are deployed from their containment tube through the use of a water slug generated from a pump which pushes the vehicle into the open ocean environment. The objectives of this project are to identify and demonstrate a method to launch a cylindrical body from the launch tube utilizing an Electromagnetic scheme.

The system will consist of an outer launch tube driven by an electromagnetic scheme, as well as a circuit to facilitate the launch. The goal is to create a new launch system which utilizes electromagnetic principles to propel a cylindrical object out of a tube, which will be energy efficient and require no mechanical movement to create the force. The system will be able to operate under water and deliver the payload without being damaged by the open ocean environment. The development of this system will serve as proof of electromagnetic concepts to then be used by the Naval Undersea Warfare Center in designing electromagnetic launchers.

To accomplish this goal, several systems were considered, and after careful deliberation the "Coilgun" design was chosen. This system works by running a high pulse of current through a solenoid coil wrapped around a tube, this in turn produces a high magnetic field that will launch any ferromagnetic objects placed within the tube. To make this system compatible for any UUV, regardless of build material, a ferromagnetic armature was designed. This allows non-ferromagnetic projectiles to be fired from the coil gun, as the armature will push out the payload. To facilitate this magnetic field, a high pulse of current was also required. Thus a circuit comprised of a power source, capacitor bank, the coil itself, several switches and a rectifier diode was designed. This will provide the solenoid the current it needs to create a strong magnetic field and launch the projectile.

Pictured from left to right: Elijah Anderson, Alexander Lavoie, and Mitchell Pavao.

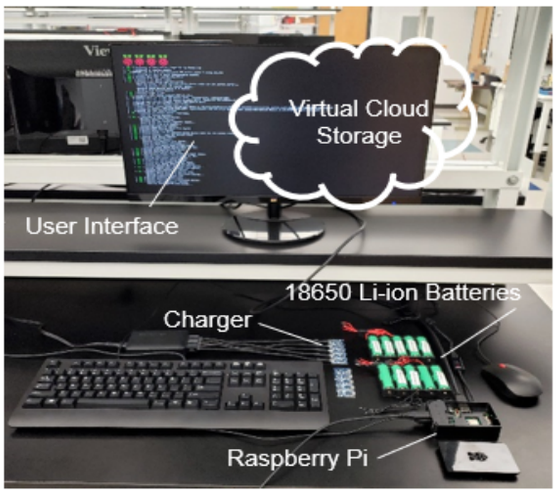
ELECTRICAL AND COMPUTER ENGINEERING

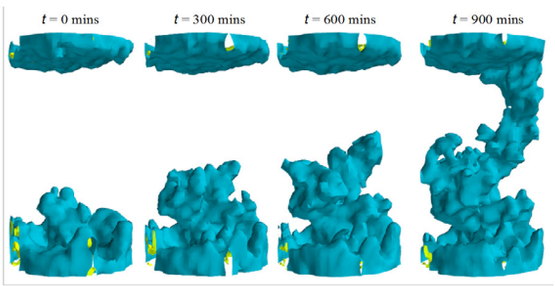
TEAM: 1916

SPONSOR: Undersea Warfighting Development Center

ADVISOR: Prof. Sung-Yeul Park

Advanced Energy Production and Storage





3D MRI image depicting gradual dendrite growth in a Li-ion battery.

Lithium-ion batteries are an enticing power storage method with the highest energy density available on the market. However, lithium-ion batteries are known to be dangerous and unpredictable, as they can deteriorate rapidly with little to no warning. This process is known as thermal runaway. Once this occurs, it is rarely contained to one cell and the entire system is at risk of catastrophic damage. Due to the demand of portable and safe energy storage as seen in the electric vehicle industry, there is considerable interest in better understanding the degradation mechanisms of these batteries.

Our project began with research regarding causes of battery failure. We found that the solid electrolyte interphase, or SEI, has a large impact on a battery's operating characteristics. The SEI is a film a few nanometers thick found on the anode. Most of its growth occurs during the initial charge/discharge cycles of the battery. After the initial stage, current flux through the anode is responsible for SEI growth. As the SEI grows, the permeability of lithium ions decreases, which results in capacity loss through irreversible lithium plating. While capacity loss is undesirable, the real problem occurs in tandem with SEI growth. During this process, dendrites tend to form on the anode as well. Dendrites can puncture the separator and result in a short circuit, which leads to thermal runaway. Detection of the SEI or dendritic growth can be difficult using today's battery management systems. In order to better assess the internal state of batteries, a non-invasive technique known as electrochemical impedance spectroscopy can be used. With the impedance spectrum of a battery it's possible to gain insight into the internal characteristics of a battery, such as its SEI layer.

Our project will feature a TP4056 CCCV battery charger to charge 2500mAH Samsung 18650 Li-Ion batteries. During the charge phase, we will take current and voltage measurements using an INA219 which features a 12-bit ADC and I2C for use with a Raspberry Pi. The Pi will be responsible for sending these measurements to Microsoft's cloud platform, Azure. With the data in the cloud, we will perform state of charge (SoC) calculations and create state of health (SoH) profiles based upon the voltage, capacity, and number of charge cycles for each battery. In the future, the SoH profile will also include impedance spectroscopy measurements for more accurate assessment of the battery's internal state to ensure safe operation.

Team Members from left to right:
Thomas Link, Patrick Guerrette, Kevin Musco

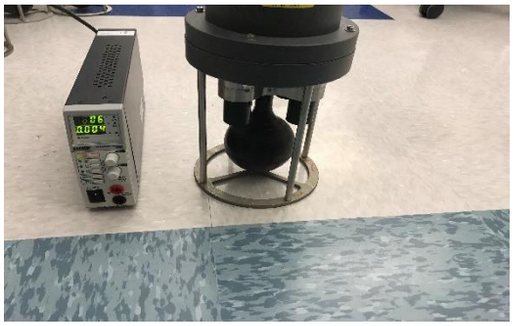
ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1917

SPONSOR: Undersea Warfighting Development Center

ADVISOR: Dr. Liang Zhang

Undersea Navigation and Precision Timing



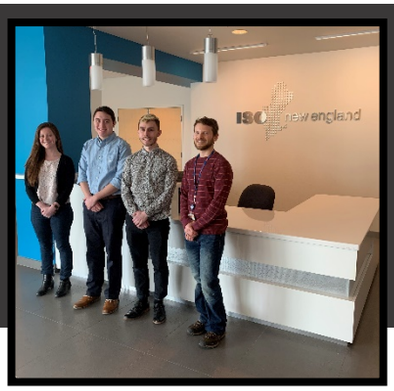
The Undersea Warfighting Development Center (UWDC), a division of the United States Navy based in Groton, CT, is interested in the research and development of innovative technologies to further increase their submarine abilities. We were tasked with finding new solutions related to precision navigation and timing. Specifically, our goal was to discover and potentially test devices which would allow for submarine tracking in areas deprived of a stable GPS signal.

Our foundational research revealed that conventional, modern means of radio communication would be ineffective underwater due to the high conductive properties of salt water. A simple solution for this issue would see a submarine surface briefly to reveal a radio antenna, but such would make the craft vulnerable. We then turned to acoustics.

Acoustic waves (sound waves) travel very well through sea water relative to radio waves. Therefore, the standard for communication to and from submarines has long been in the form of acoustic waves generated by a transducer and recorded by a device called a hydrophone. Despite large signal attenuation (loss of signal strength) over moderate distances and multi-path propagation, hydrophones are the current technology employed, so we looked for ways to test them.

We were graciously loaned hydrophones from the laboratory of Dr. Shengli Zhou, and we performed diagnostic tests and applied triangulation algorithms in an effort to track the source of a local sound signal. In this way, we simulated communication between submarines.

Due to the highly confidential nature of the United States Navy's submarine technology, we were unable to obtain a basis for the current research being performed at the UWDC in Groton, so we turned to academic literature and compiled them in our capstone, a research paper on current underwater communication methods. Please see our poster for more information.

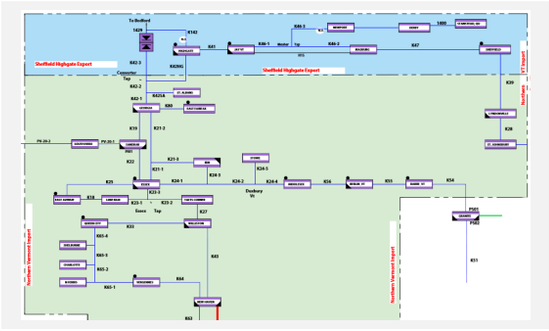


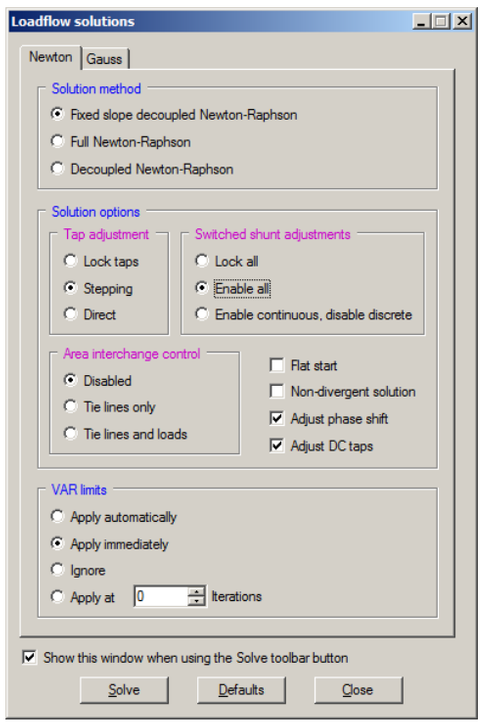
From left to right:
Tara Stokes, Noah Gonzalez, Benjamin Albano, Joseph Koltz

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1918
SPONSOR: ISO-NE
ADVISOR: Dr. Peng Zhang

Analysis of Constrained Pockets in the Transmission System

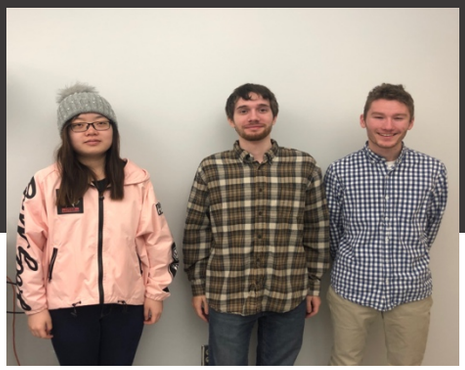




ISO New England is tasked with reliably operating the transmission system in New England. In order to do so, the ISO must control certain constrained “pockets” of generation and load that would otherwise suffer from unacceptable post-contingency voltage performance (low voltage), potential voltage collapse, or voltage / angular instability. These “pockets” are connected to the rest of the New England system via transmission interfaces. One of these “pockets” is in the northern Vermont area which consists of a very limited transmission system, a small amount of load and, a diverse mix of resources that includes significant renewables. The “pocket” is prone to very poor voltage performance which results in frequent generation resource constraints. System changes have occurred since last a study was performed and new interface limits must be established with this new infrastructure in place.

This project required us to perform analysis on this constrained area in northern Vermont through the use of PSSE (power system simulator for engineering) and Python. In order to perform the analysis base cases were established with parameters derived from the day with the highest load on the system in 2018. These base cases represent both normal operating conditions as well as stressed conditions that may occur due to outages or generation resource constraints. These simulation profiles must be created such that the system experiences the conditions whilst still solving to steady state within 40 iterations when the full Newton-Raphson solution algorithm was applied.

After creating the 32 individual base cases a number of contingencies were simulated to further stress the system. Automation of these failure conditions through Python expedited the process and allowed to form a model that revealed the most unstable contingency conditions. With this information, the limitations for this northern Vermont interchange can be newly and more aptly defined. Moving forward this will allow ISO New England to suggest changes in operating procedures or potential system changes that would assist in supporting the system.

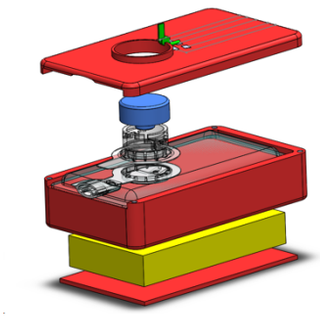


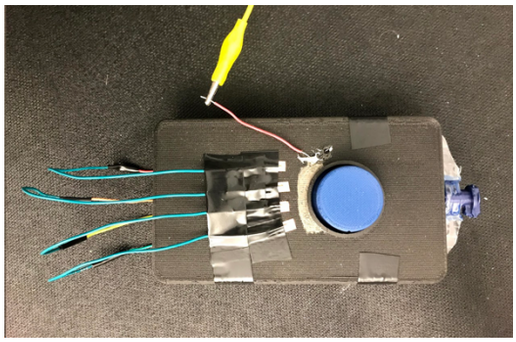
From left to right: Jiatong Liang, Max Steinnetz, Robert Alden

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1919
SPONSOR: Innovation Cooperative 3D (IC3D)
ADVISOR: Dr. Rajeev Bansal

Precise Adjustable Dispensing System





1TOUCH by Innovation Cooperative 3D (IC3D) is a patented measured dispensing system that is used to easily and accurately dispense any liquid with a single button press. Our team is working closely with IC3D to bring this product to the next level with a variety of additions to their original concept.

Team 1919 is also coordinating with Team 24 from the Mechanical Engineering (ME) department to make further improvements on the base product. The original design has only one standard dispense size, so the first feature required for this project was a means of adjusting the amount of fluid dispensed with each press of the button. The second required feature was a means of forcing the user to completely press the button down before attempting to press it again. And finally, the last major addon was a “smart system.” For this project, a smart system is defined as a means of detecting the amount of fluid being dispensed by the user and recording it on their phone through a custom application.

To meet the first two requirements, Team 24 created a dial that attaches directly to the pouch that provides the ability to change the stroke size via channels of varying depths. This dial also provides the ability to force a complete press of the button through a locking mechanism.

The main focus of Team 1919 was developing the smart system. The core of this feature is a PSoC 4200 BLE microcontroller used to receive, process and transmit the required information. To receive this information, a simple PCB was connected to the microcontroller to adjusts a voltage depending on the position of the dial using various resistors connected in parallel. Utilizing Bluetooth, the app then receives these various voltages from the microcontroller as simple values corresponding to the size of the stroke as well as the date and time the button was pressed. The application tracks and displays this information and provides the option to schedule reminders for future uses of the product.

All of the electronics (microcontroller, PCB, etc.) and the pouch are housed within a single case designed by Team 24.

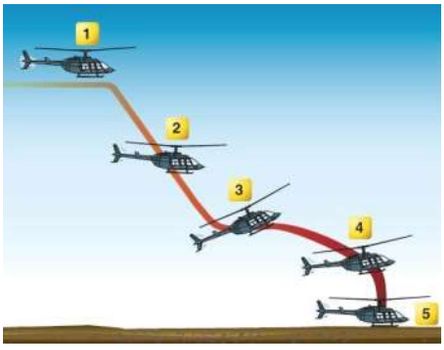
Innovation Cooperative 3D is located at the University of Connecticut in Farmington, CT and is part of the Technology Incubation Program (TIP).

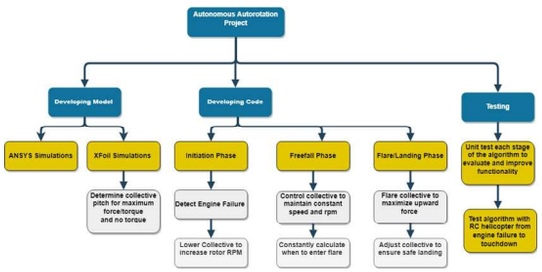
Ethan Opsahl, Michael D'Amico, Brian Chambers (shown left to right)

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1920
SPONSOR: Sikorsky
ADVISOR: Rajeev Bansal

Autonomous Autorotation



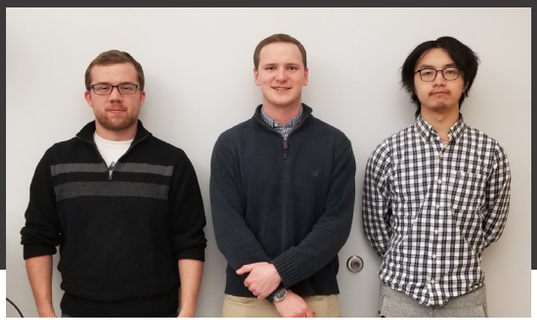


Autorotation is the maneuver used by pilots to land helicopters when they experience engine failure. This is done by adjusting the collective pitch, which is the pitch applied to all the blades. Turning the collective down allows energy to build up in the rotor system. This energy is then used to decelerate the aircraft and touch down safely when the blades are flared to create lift once again.

This process is difficult and can be dangerous for even for experienced pilots. One miscalculation can lead to damage to the aircraft and injury to those onboard. Additionally, the progression of materials technologies has decreased the inertia of helicopter rotors, which has further reduced the margin for error in this maneuver. In some cases the blades must be flared within less than a second of the optimal time or the aircraft will crash. The precision required has created an interest in developing a system that can autonomously land any helicopter that experiences engine failure and has enough energy stored in its rotor system.

Our team has been instructed by Sikorsky to develop software that autonomously controls the process of autorotation from initial detection of engine failure to the eventual safe landing of the aircraft. The scope of this project is limited to the vertical movement of the helicopter and as a result focuses only on the control of the helicopter's collective. In true autorotation, it is best for the aircraft to move laterally also, however incorporating this into our project would have been too much. The main deliverable for this project is the finished working code that will be able to theoretically land any helicopter in the event of engine failure. The goal of this project is to demonstrate the working software by using it to successfully land a model remote control (RC) helicopter.

To achieve our goal, the team has developed flight control code within the open source ArduPilot software. This software has been loaded on the Pixhawk 2.1 Cube flight computer and integrated, along with sensors, onto an RC helicopter. This code should autonomously perform autorotation, from detecting engine failure to touching down safely.

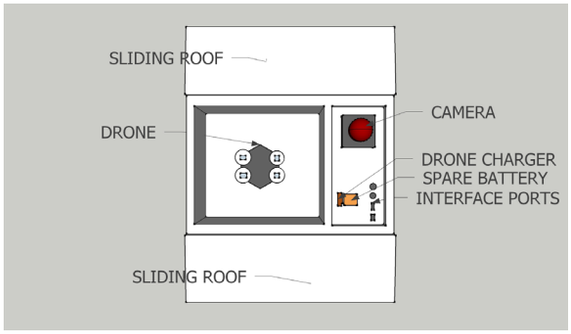


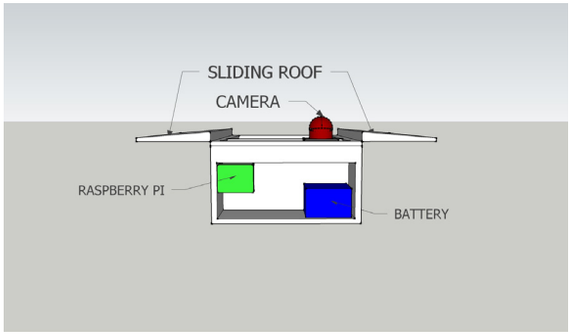
Nicholas Reagan, Evan Opsahl, Hongliang Zhao

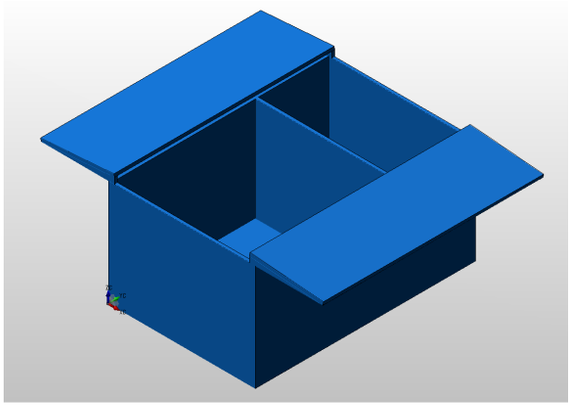
ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1921
SPONSOR: Candoo
ADVISOR: Helena Silva

Drone Docking Station







With the increased usage of drones in recent years, one issue that has become increasingly common is the necessity of drone pilots to be accompanied by a spotter while they are flying their aircrafts. While the goal of the drone pilot is primarily the monitoring of video or images captured through a camera mounted to the bottom of the drone, they are typically oblivious to obstacles on the sides of and above the drone while it is flying. This can result not only in damage to the drone, but it can also be dangerous to people nearby. A spotter solves this issue by keeping track of a drone's surroundings during flight and warning the pilot of any impending dangers. Candoo, a drone management company from Hartford, CT, is looking to remove the need for a human spotter through this project.

The aim of this project is to create a drone docking station responsible not only for charging and protecting a drone during transportation, but also tracking the drone during flight and alerting the user of impending obstacles. Candoo has developed the tracking software necessary to accomplish this and has tasked us with the hardware implementation.

A Raspberry Pi is the station's primary computational force and runs the tracking software and controls the movements of the camera. An onboard, rechargeable battery powers the case and systems and allows for the charging of the drone multiple times. The station is compatible with a variety of drone models and utilizes electromagnets to restrain the drone during transportation. The drone docking station also serves as a safe, waterproof location for a drone to land and be stored during transportation. The construction of the case has been accomplished with the help of the UConn Machine shop. The case will be made of plastic and will be equipped with autonomous doors.

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1922

SPONSOR: UBTech / Movia Robotic

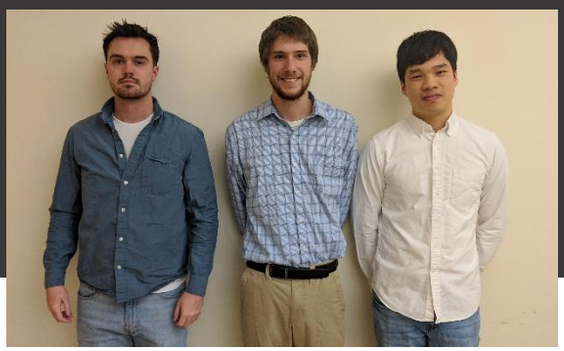
ADVISOR: Ashwin Dani

Katie Pham, Kaxiang Lin Justin Niezrecki,

User-Friendly Object Location for the Cruzr Robot

Robots play a key role in making our daily lives easier and better. From mass-production in industry, and within the medical field, robots are nowadays capable of tremendously. As technology developed, artificial intelligence has been used to make robots more capable of serving people in much more diverse areas and better than ever before. The Cruzr robot was designed by UBTech Robotics for the purposes of aiding businesses and various organization. Cruzr provides customized AI business services. Each of its robotic platforms can be configured for a wide range of applications to a company's specific needs for safe and easy access to virtually endless resources. It contains many different skills such as speech response, understanding and facial recognition. The system is very customizable and therefore makes it very versatile to use. The goal of this task is by adding to this already defined system for the robot to be received information from a user, recognize an object, and record the object location in a mapping database. The user can ask where an object is by name. The user could also ask to see the pictures of the objects and then select the desired object. Once selected the robot could then tell the user where the object is or lead them to it.

The Cruzr robot utilizes a number of features for users to interact with it. It contains a touch screen with its own given UI, it is capable of responding to speech, and it utilizes cameras and motors for physical recognition and interacting with the real world. One important component of the robot is that users should have a seamless interaction with something that feels very similar to interacting with a human. The hardware of the robot is complete and will likely not be going through any changes. Therefore in order to complete the task. The need is to focusing more on the software components of the robot. The firmware will still be going through changes by UBTech, so we were given to make changes at the app and SDK level of the project.



As Shown From Left To Right: Dennis May, Alexander Maneggia, Jeffrey Chen

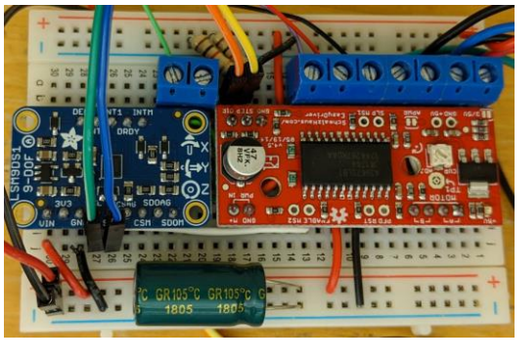
ELECTRICAL AND COMPUTER ENGINEERING

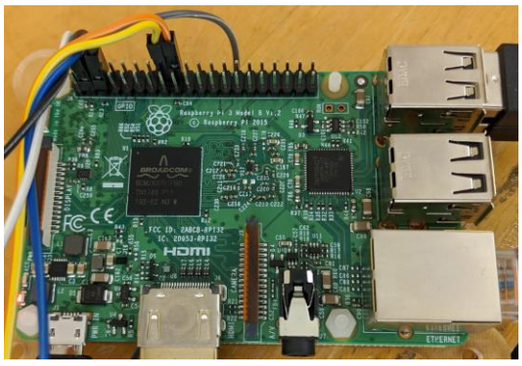
TEAM: 1923

SPONSOR: CENTER for the ECOLOGICAL STUDY of PERCEPTION and ACTION (CESPA)

ADVISOR: Dr. Necmi Biyikli

LIDAR Tracking of Human Location in Open Spaces





There have been many different techniques and methods to help people with disabilities. Some people may not have the ability to communicate effectively through speech and looking to body language may be insightful. Traditional methods for this approach are recording them using video cameras or having a body language expert observing a person's movements and what that may represent. A more analytical approach would be to use a LIDAR system to obtain data points of a person's activity and analyze those points to possibly look for movement patterns or cues.

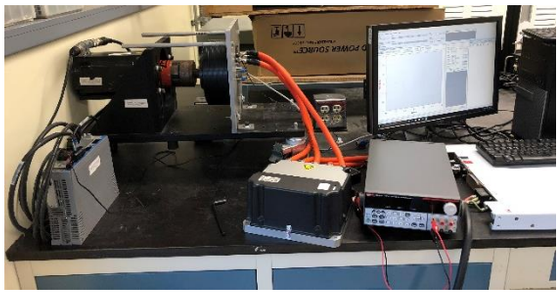
Our objective is to build a servo-controlled LIDAR sensor system that scan the local environment and to detect the orientation and direction that a person is moving within that space. Light Detection and Ranging (LIDAR) is a sensing method that uses light to determine the distance of an object by analyzing the time it takes for the emitted laser pulse to reflect off the object and return to the LIDAR receiver. Detection of objects and people is an important attribute of LIDAR and this can be applied to other fields, such as psychology in order to observe the behavior and movement of a person. The LIDAR device must be capable of tracking both the devices location as well as objects within the range of 2 cm to 40-60m. The LIDAR camera is mounted on top of a stepper motor so that the device can spin 360 degrees and collect coordinates for walls or objects in the environment. The entire apparatus is then attached to a helmet that the subject will wear and move around in the environment. The data points collected from the test will then be 2D mapped to provide a visual representation of the space and the subject's movement pattern.

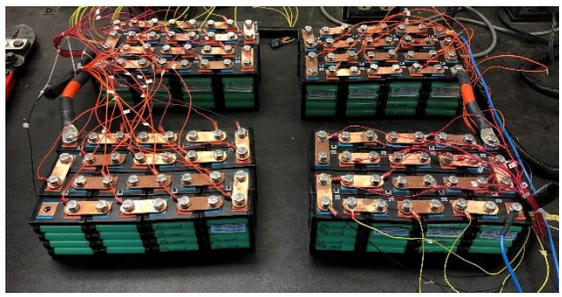
Left to right: Binhao Liu, Julia Comeau, Bryce Gallagher

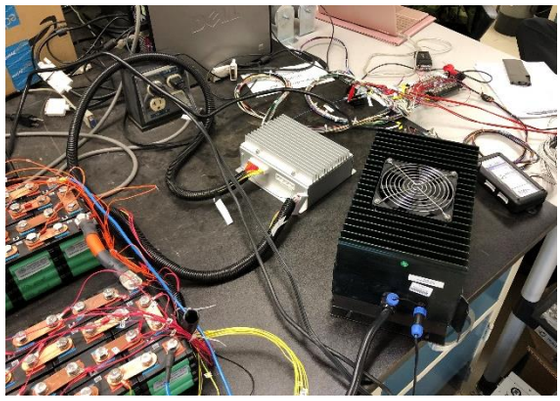
ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1924
SPONSOR: UConn Electric Motorsports
ADVISOR: Prof. Sung-Yeul Park

Evaluation of Motor Drive and Accumulator System for a Single-Seat Electric Vehicle



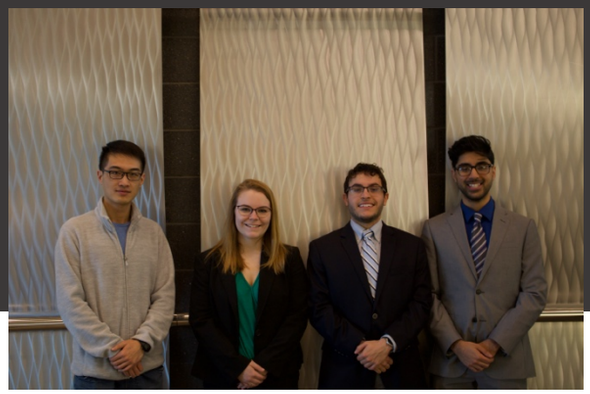




The UConn Electric Motorsport Club (UCEM) is in the process of building a single-seat electric race car to compete at national level Formula SAE Electric events. Due to this being a regulated competition, there are numerous guidelines set in place by the FSAE organization in order to keep the competition both fair and safe. These limitations include setting a maximum battery capacity, a maximum power draw from the accumulator system, and temperature sensing for the battery. Along these limitations, the UCEM team also wants a powertrain system that is capable of high speeds, high acceleration, and a long battery life. The powertrain must also be able to communicate with the on-board low voltage system, as well as deliver real-time information to the driver during operation. This project will examine the vehicle powertrain and attempt to give the best performance possible while staying within the aforementioned limits.

The electric vehicle will be powered by a high voltage accumulator system, which consists of 64 lithium ion battery packs, outputting a substantial voltage of 268 V. The batteries will be monitored and controlled through a battery management system (BMS), and charged via an off-board battery charging unit. The vehicle will be propelled by a single electric motor, which will be controlled through a motor controller. The motor drive system is capable of outputting a constant 40 horsepower during normal driving conditions. These systems must be integrated into the electric vehicle, and will interface via a CAN protocol. This interface is widely used, and can be easily monitored by the vehicle's control module and driver while in operation.

The scope of this project includes testing the accumulator and motor drive systems both separately and together. These tests will provide the team with information such as the expected power drawn from the batteries, expected speed and acceleration from the motor drive, and the anticipated performance during competitions. All data collected and research done will be shared with the team in order to help advance their progress with the vehicle, and put them in a better position to participate in upcoming Formula SAE Electric events.



Jiangwei Wang (graduate student), Katie L'Ecuyer, Zachary Sola, Hamza Malik

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1925

SPONSOR: UConn Power & Energy Lab

ADVISOR: Peng Zhang and Shengli Zhou

Underwater Power and Data Transfer via Common Inductive Coils

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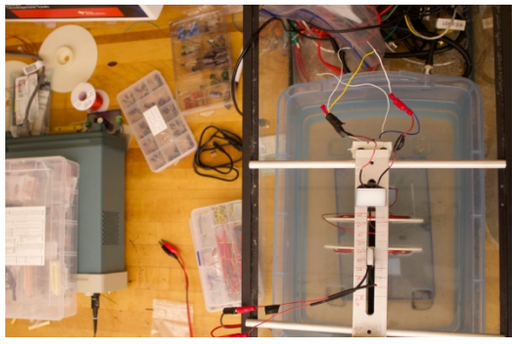

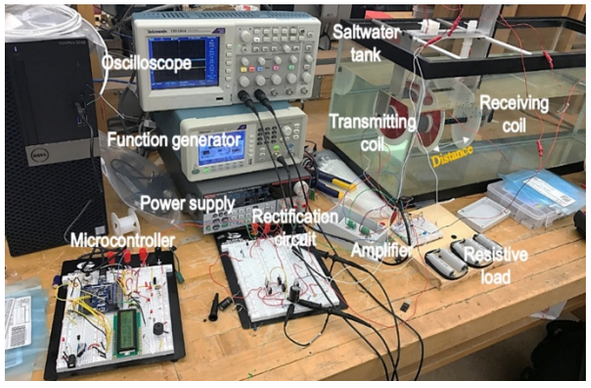

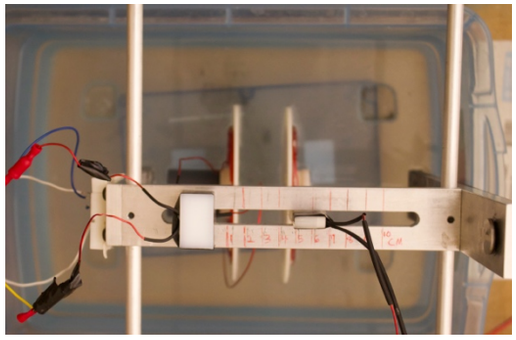

The development of smart ocean systems comprised of underwater sensors, ocean monitoring devices, and autonomous underwater vehicles (AUV), is in many ways, limited by the lack of secure communication and reliable energy supply. Recharging and replacing batteries is extremely time-consuming and disrupts the service and stealth of the AUVs. Wired connections are subject to corrosion and leaks. For power transfer, radio and acoustic frequencies are not capable of efficiently transferring the power necessary for sustainable operation. For data transfer, protocols such as Wi-Fi and Bluetooth operate outside the available bandwidth of water. Overall, the success of a robust smart ocean system requires a secure, compact, lightweight, and efficient underwater power *and* data transfer system.

The goal for this project was to develop an underwater wireless power and data transfer system (UWPDT) via a common inductive link. Previous senior design teams have developed standalone power and data transfer systems. Team 1925 expands on previous work by presenting a system that simultaneously transfers power and data wirelessly underwater, which can be practically scaled for high power underwater autonomous vehicles. Data transfer is achieved using frequency shift keying modulation and demodulation techniques. A digital signal processing board drives a digital signal synthesizer to generate two distinct high frequency signals that are passed through a flat spiral transmitting coil. The signals travel through the electromagnetic channel where it is received by a smaller flat spiral coil a few centimeters away. Each signal corresponds to a binary value, which are filtered and encoded at the receiver to realize the transferred data.

Power transfer is performed by means of a multi-stage power conversion system. First, a high-power operational amplifier circuit is used to generate a high voltage, magnetically resonant AC signal, which passes from transmitter to receiver coil, through the common inductive link. A rectifier circuit is then used to convert the received AC power to DC power. Finally, a novel, lightweight, inductorless, charge-pump switch capacitor converter is used to step down the DC voltage, with high efficiency, to charge a battery.

Results show that a high efficiency, secure, lightweight, and compact underwater wireless power and data transfer system can be achieved via a common inductive link.

Haokai Ma, Sean Berg, Brian Jaworowski
(shown from left to right)

ELECTRICAL AND COMPUTER ENGINEERING

TEAM: ECE-1926
SPONSOR: UConn ECE Department
ADVISOR: Shalabh Gupta

Unmanned Package Retrieval and Delivery Air Vehicle

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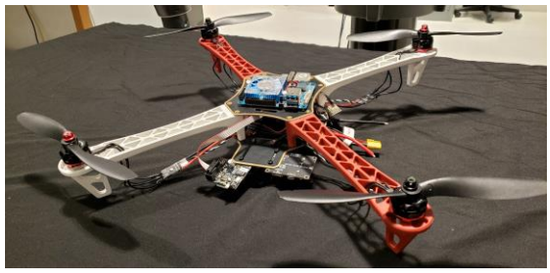
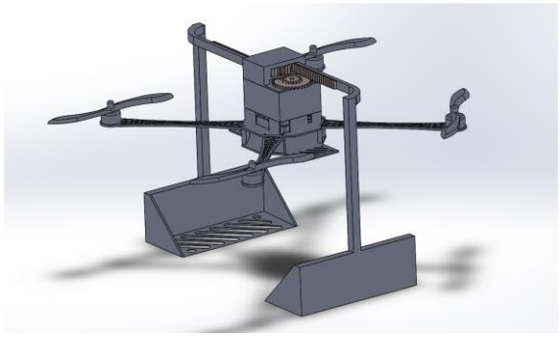
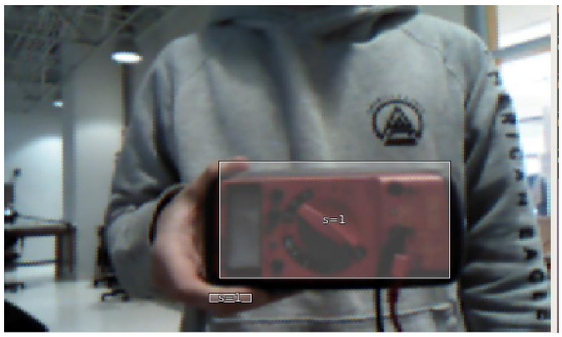






The potential uses of unmanned drones have exploded over the last decade, with many applications entering the commercial industry. One such application is package delivery. Businesses like Amazon are starting to utilize drones in order to deliver their products quickly and efficiently. A drone uses far less energy transporting a package than a car. Using drones to effectively lift, hold, and move products can transform the industry.

The goal of this project is to further the advancement of Unmanned Aerial Vehicle (UAV) technology. The UAV we have constructed must be capable of identifying, lifting, moving, and stacking boxes while avoiding obstacles. Our group would like to improve the package lifting method. We have investigated multiple methods for optimal package transportation, and have developed one that will be workable for a wide range of package dimensions. A servo motor will be attached to 3D printed, lightweight arms on the top side of the UAV. The motor will move the arms laterally to grip or release.

In order to identify packages and obstacles, the UAV needs to incorporate optical sensors into the design to ensure object identification and proximity. Our UAV uses one camera to identify packages and landing zones by color code. Another camera is used as a flow sensor for accurate positioning and trajectory during pickup/dropoff. This UAV is capable of autonomously sorting or delivering a variety of objects.

Left to right: James Balducci, Heather Fabian, and Ke Ma

ELECTRICAL AND COMPUTER ENGINEERING

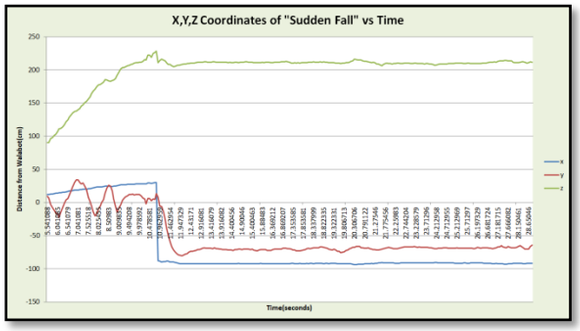
TEAM: 1927

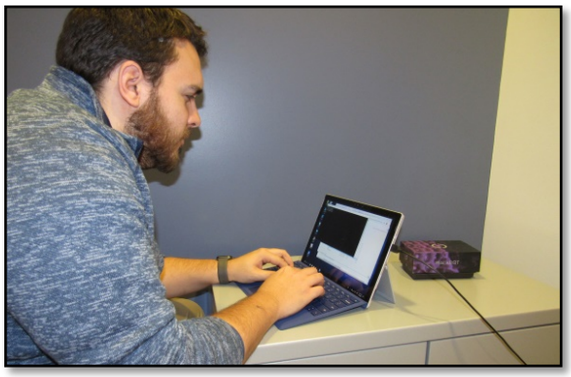
SPONSOR: Cigna

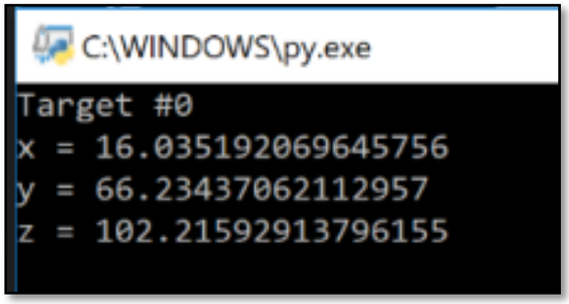
SPONSOR ADVISOR: Dr. Steve Mastrianni

ADVISOR: Necmi Biyikli

Detecting falls in the home







According to *Injury Facts*, the source for statistical data on unintentional injuries created by the National Safety Council, falls account for almost one-third of all non-fatal injuries in the United States. Falls can result in hurt feelings, skinned knees or broken bones, and for some, can even lead to death. Because the natural aging process can affect vision, strength and balance, adults 65 and older are at an elevated risk for falls. According to the Centers for Disease Control and Prevention, more than one in four older adults falls every year, over 3 million older adults are treated in emergency departments each year for fall injuries, and more than 80,000 patients are hospitalized each year because of a fall injury. According to AARP, almost 90 percent of Americans, 65 or older plan to stay in their homes as they age.

Cigna is a global health services company that helps individuals and families improve their health, well-being, and peace of mind. In support of that mission, Cigna continuously evaluates new technologies and solutions in an effort to improve the healthcare experience for their customers.

Our Senior Design team worked with Cigna to develop algorithms that could detect specific types of falls in the home. To detect a fall, we employed an RF transceiver capable of measuring the three dimensional coordinates of an object over time to derive the acceleration vectors. By experimenting and collecting data on different types of falls and coordinating the observed readings, we were able to construct a model that characterizes and categorizes various types of falls. This model was then used as the basis for a software program that will monitor individual's coordinate location in the home and alert a caregiver or friend if a fall has taken place. This model is not device dependent and therefore, can be used with any sensor capable of measuring three dimensional coordinates at variable sampling rates. This allows it to be easily integrated into a variety of different applications and solutions.

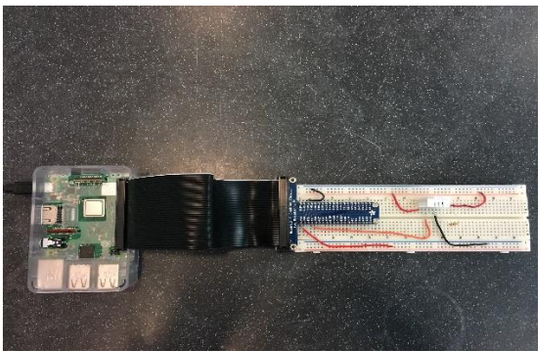
Team 1928: Andrew Ball (Left); Michael Platt (Right)

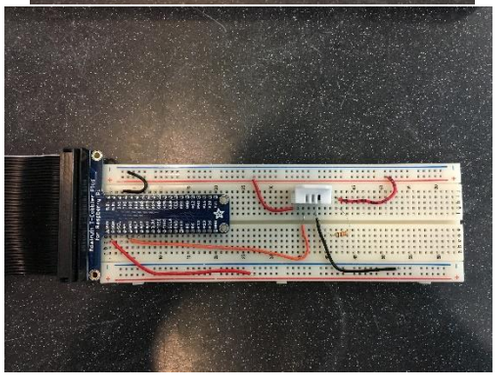
ELECTRICAL AND COMPUTER ENGINEERING

TEAM: 1928
SPONSOR: Stanley Black and Decker
ADVISOR: Professor Liang Zhang

Augmented Reality (AR) Maintenance Experience Design

StanleyBlack&Decker





Stanley Black and Decker uses retina machines that are used to validate various parts using conveyor belts, vibrating equipment, sensors, and cameras. Equipment failures can occur and are often due to minute errors in the equipment itself; troubleshooting these errors causes excessively long machine downtimes. Long machine downtimes hinder the output of parts, which in the long term, slows down the distribution of parts to sellers and decreases efficiency. The goal of this project is to diminish these downtimes using an efficient technology in the form of an augmented reality device to accurately determine the errors in machinery. The intended objective for this project is to augment a small scale model of a retina system to prove that preventative maintenance can be done on much larger scale.

Information from the small scale model is captured through data acquisition software in cooperation with Python. Within the same software this information is converted to a form that is easily understood by users; this converted information is then pointed towards an augmented reality software to be used in the augmentation of our small scale model. Augmentation is made possible by QR codes that are fashioned to the different components within the small scale model. Ultimately, this augmentation is performed by an AR capable device like an iOS phone or tablet; having this information readily available through AR allows for the quicker detection of issues within the system, which will allow for preventative maintenance to take place.

Data that is captured from the model will also be used to develop a digital twin. The digital twin will be realized as a dashboard that displays the system's pertinent health data. The dashboard will be accessed remotely to allow for awareness and issue detection in an infrastructure that is as large as Stanley Black and Decker's global network. Between this data acquisition, augmentation and digital twin development, the desired outcomes would be earlier error detection, quicker troubleshooting a decreased downtime for the overall system.

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environ.engr.uconn.edu

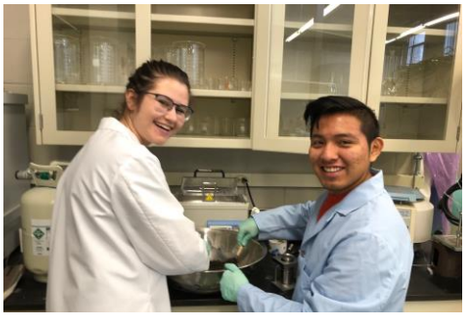
ENVIRONMENTAL ENGINEERING

Left to Right: Sikai Zheng, Ian Adomeit, Ginger Turner, Tony Arreaga

ENVIRONMENTAL ENGINEERING

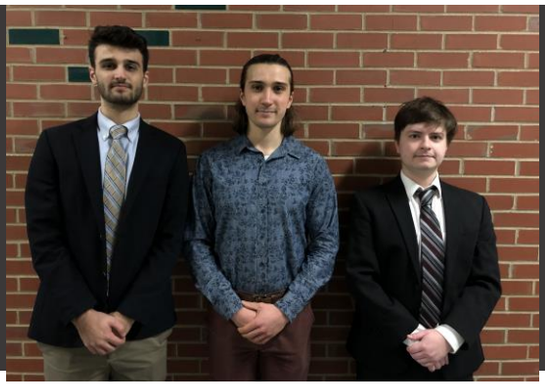
TEAM: ENVE Team 1
SPONSOR: AECOM
ADVISOR: Nefeli Bompoti

National Chromium Site Remediation



National Chromium Inc. is a metal finishing facility that has been in operation since 1940 and is located in the Town of Putnam, Connecticut. Due to the facility's prior discharge of chromium wastewater directly onto surrounding soils, a wetland immediately adjacent to the site has high levels of chromium contamination. Chromium, while in the trivalent form, is immobile and considered a nutrient in small doses. However, the concentrations of chromium in the soil exceed exposure limits in multiple locations within the wetland. This is a cause for concern particularly because hexavalent chromium, which is the oxidized form of chromium, is a water-soluble carcinogen. Therefore, the contaminant is highly mobile and poses a threat to surrounding water bodies. Furthermore, nearby residential areas could be affected by the contamination since the wetland feeds into a river that is used recreationally.

The environmental team was tasked with studying the extent of contamination in the wetland and proposing a feasible and cost effective remediation plan. Using X-Ray Fluorescence (XRF) data and soil samples procured throughout the first semester, a delineation of chromium contamination levels within the wetland was produced. The importance of the delineation was to understand the extent of the contamination as well as the effect of natural attenuation, by comparing the delineation to previous data. The stabilization and solidification of the wetland soil was a strong candidate for the remediation at the site due to the difficult issue of chromium removal. First, a soil stabilization study was performed in order to obtain the appropriate reagent-to-soil ratio and to test the feasibility considering the high saturation of the soil and leachability at each ratio. The study, which was performed in-house, involved mixing the predetermined ratios of Portland cement and wetland soil, compacting the mixtures into molds and left to cure, while excess reagent-soil mix was analyzed for leachability. The proposed solution was designed based on the direct exposure criteria and the pollutant mobility criteria in reference to trivalent chromium.

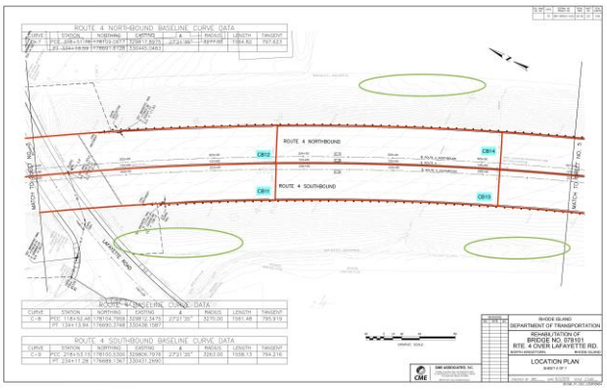


ENVIRONMENTAL ENGINEERING

TEAM: ENVE Team 2
SPONSOR: CME Associates
ADVISOR: Timothy Vadas

Team 2: Andrew Michalakis, Ian Giancarlo, Samuel Cote

Highway Stormwater Treatment

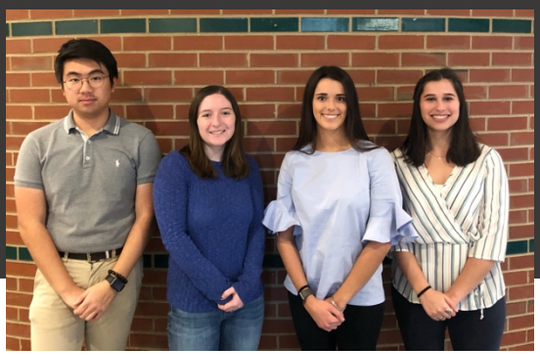


After failing to comply with water quality regulations outlined in the Clean Water Act, the Rhode Island Department of Transportation (RIDOT) was issued a consent decree by the Environmental Protection Agency (EPA). In this decree, the EPA mandated that RIDOT must improve their water quality practices by more closely following the Rhode Island Pollution Discharge Elimination System (RIPDES). This outlines the capture and detention of illicit discharges as well as water treatment or discharges entering an impaired water body.

CME Associates was tasked by RIDOT with reconstructing an existing bridge on Route 4 that spans across Lafayette Rd. in North Kingstown, RI. An additional half-mile strip of highway before and after the bridge is also to be repaved and re-milled during construction. Under RIPDES, stormwater leaving the site must be treated due to the nearby proximity of Belleville Pond, a surface water body impaired by phosphorus. CME Associates has tasked us with designing and proposing a treatment system to retain and remediate stormwater coming from the site.

We were provided with maps of the proposed construction site and asked to analyze them in order to best implement the proposed design. To accomplish this, an in-depth look at the local soil types, analysis of current stormwater volumes and flows, and review of the site topography were completed. In the end the proposed design must at least temporarily capture and retain stormwater coming from the site and be able to effectively remove phosphorus so that Belleville Pond's water quality is not impacted further.

Currently, the proposed system consists of an underground infiltration system located in the right of way on either side of Route 4, as well as multiple installments of pervious pavement within the highway itself. We also looked into augmenting these designs such that they will be further specialized for treating phosphorus. Chief among potential alterations is a layer of iron oxide, which will allow for better sorption of soluble phosphorus. The implementation of these treatment systems would reduce the levels of phosphorus in Route 4 runoff to acceptable levels consistent with the TMDL for Belleville Pond while maintaining or even improving upon previous levels of treatment for other roadway contaminants.

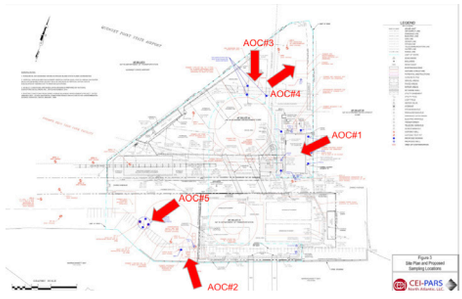


Anthony Poon, Jacqueline Montville, Bailey Dupont, Jaclyn Sidman

ENVIRONMENTAL ENGINEERING

TEAM: ENVE Team 3
SPONSOR: Comprehensive Environmental, Inc.
ADVISOR: Maria Chrysochoou

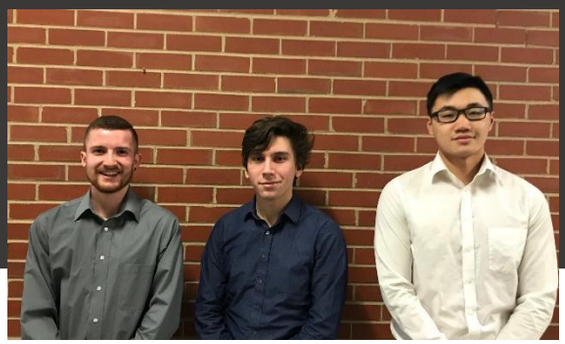
Atlantic Shellfish Site Remediation



Comprehensive Environmental Incorporated (CEI) is an environmental and civil engineering firm, with expertise in stormwater, remediation, drinking water, and water resources. They provide consulting and design work on the Federal, state, municipal, non-profit, and private level. They have been contracted by The U.S Army Corps of Engineers to remediate a Formerly Used Defense Site (FUDS) on the coast of Rhode Island.

The site, located in North Kingstown, RI is bounded by the Quonset Business Park and the Narragansett Bay. The site has been switching from an active to an inactive military site for about 125 years, being home to a militia encampment, World War II training grounds, and a naval air station (NAS). It has been leased by Atlantic Shellfish but it is unknown if they have ever occupied the site. In 1994 an environmental site assessment (ESA) was performed on the site that helped determine the boundaries of the parcel of land, and a subsurface site investigation was done in 1995 that helped determine areas of concern (AOCs). After the work done with CEI partnered with The University of Connecticut School of Engineering, an ecological risk assessment (ERS) was conducted to determine the threat to biota in the bay, and the risk of contaminants to other ecosystems. They also studied the contaminants of concern (COCs) found on the site.

The team has been tasked with the aid and observation of field work including water and soil sampling, monitoring well installation, and sample testing. Sampling was done based on the five areas of concern (AOCs) determined by CEI. These areas are an aboveground storage tank (AST), a dry-cleaning and laundry building, former pumping station, a vapor hot spot, and a radar station. The data collected from the AOCs were analyzed with EPA and Rhode Island Department of Environmental Management (RIDEM) regulatory limits to determine the level of remedial action required. The contaminant levels were determined and the team prepared a remedial action plan. This contains a summary of the field investigations and the subsequent data, as well as an analysis of risk, data gaps, suggested cleanup actions, and the associated cost.



Donald Curtiss, Aaron Golab, Charlie Yu

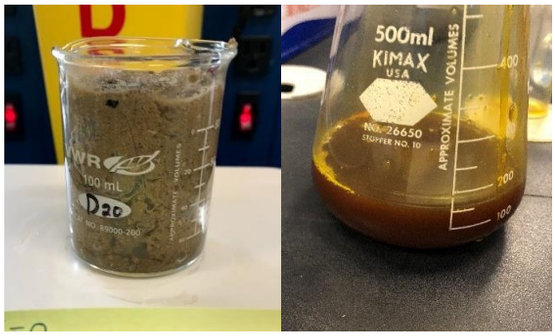
ENVIRONMENTAL ENGINEERING

TEAM: ENVE Team 4
SPONSOR: Quantum Biopower
ADVISOR: Baikun Li

Quantum Biopower FOG Treatment

Quantum Biopower is Connecticut's first anaerobic digester, processing over 40,000 tons of food waste annually, converting it into 1.2 megawatts of renewable energy as well as 10,000 tons of mulch, fertilizer, and soil amendments. Under anaerobic conditions, microorganisms that breakdown organic matter produce biogas which gets collected, treated and combusted to generate electrical power.

This process produces nitrogen rich wastewater which must be treated prior to discharge into the local municipal sanitary sewer system. Quantum's nutrient removal process converts nitrates into nitrogen gas via microbially facilitated denitrification. In order for this to occur, a supplementary carbon source suitable for use as an electron donor by denitrifying bacteria must be provided. Traditionally methanol is used to fill this need in the wastewater treatment industry, causing it to be in high demand. More economic alternatives such as waste glycerin from biodiesel production or molecular organic non-glycerol have been used at Quantum, however both have run into problems. These carbon sources result in the accumulation of salts within the system causing interference in ammonia testing among other problems. Because of this, it has been of great interest for Quantum to investigate alternative renewable carbon sources.



Our project involves using Fats, Oils, and Grease (FOG), a waste product from commercial and industrial operations, and converting it into a bioavailable source of carbon for denitrifying bacteria. This is accomplished by using a product originally created for use in breaking down FOG for disposal in sewer systems called Protein Matrix 4 (PM4). PM4 is a very basic chemical solution containing a plant-derived protein that cleaves triglycerides into glycerol and free fatty acids as well as stabilizes them in solution. Our system involves reacting PM4 and collected FOG to produce a "liquor" that is then filtered and allowed to settle, with the resulting glycerol suspension ready to be used as an electron donor.

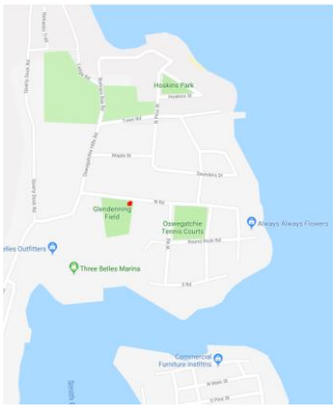
Extensive testing has yielded promising results, allowing us to design a FOG treatment system that can successfully convert a problematic waste product into a readily available, bioavailable carbon source for microbial systems.

From Left to Right: Joseph Ludemann, Dea Acorda, Christopher Falk, Roy Graham, Benjamin North

CIVIL & ENVIRONMENTAL ENGINEERING

TEAM: ENVE Team 5
SPONSOR: Prime AE
ADVISOR: Dr. Guiling Wang

Reduction in Nutrient Loading to Niantic Bay, CT



Evaluation of water from the Niantic River by UConn's Center for Land Use Education and Research (CLEAR) led to the discovery of excess nutrient loading into Niantic Bay, particularly nitrogen and phosphorous. Nitrogen loading can cause an increase in algal growth and consequently, hypoxia. The subsequent low-oxygen environment resulting from this excess is detrimental to the growing and living conditions of shellfish in the area, which in turn poses a significant threat to the local shellfish economy. It is well known that septic tanks poorly remove nitrogen constituents, the main nutrient causing pollution in the Niantic Bay – accordingly, it has been determined by CLEAR that approximately one third of the nutrient loading into the Niantic River is caused by septic seepage from old, improperly installed septic tanks, which are densely situated on small plots of land barely above the water table in the Saunders Point neighborhood. The goal of this project is to reduce the nutrient loading in Niantic Bay, with the overall intention of revitalizing the shellfish farming economy of Niantic.

It was determined that integrating the local Saunders Point neighborhood into a centralized sewer collection system is the most plausible solution to this issue. This involves routing this sewer collection system to a pump station in Glendenning Field (see red dot on the first figure) and then pumping the sewage under the entryway to Smith cove. This involves boring underneath this body of water in order to install the conveyance pipe. Proposed boring location can be seen in the second figure, with the proposed sewage pipe flowing from the top oval to the bottom. This solution also involves designing and installing a sewage pipe network in our subject area to link to the proposed pump station. After the pump station conveys the sewage to the existing sewer system in the pine grove neighborhood (across the water, second figure) the sewage would be transported to New London for treatment, as all sewage in Niantic is.

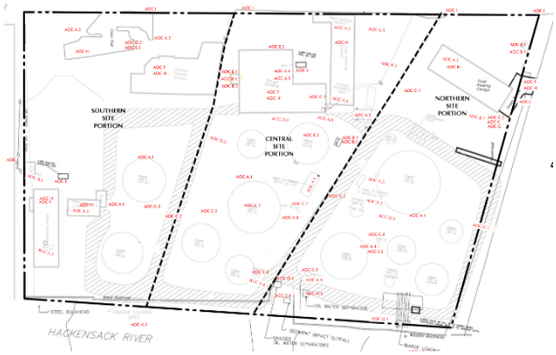
Team members from left to right: Katharine Katrichis, Daniel Zeigher, Jennifer Mulqueen

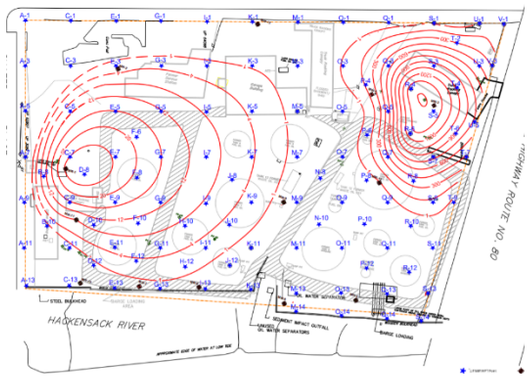
ENVIRONMENTAL ENGINEERING

TEAM: ENVE Team 6
SPONSOR: SESI Consulting Engineers
ADVISOR: Amine Dahmani

Remediation of an Oil Terminal Site

SESI CONSULTING ENGINEERS





SESI Consulting Engineers has been contracted to work on remediation of a former oil terminal in Hackensack, NJ in order to redevelop the site as a storage facility. During the operation of the terminal, it functioned as a retail gasoline station and tank farm. There have been at least seven discharges of hazardous substances including No. 2 fuel oil, No. 4 fuel oil, and gasoline. These substances seeped through the vadose zone, causing these light non-aqueous phase liquids (LNAPL) to persist at the top of the groundwater table. The LNAPL partially dissolved in groundwater and released toxic petroleum hydrocarbons. The major contaminants of concern at the site are benzene, methyl tert-butyl ether (MTBE), and tert-butyl alcohol (TBA). Based on the previous investigations at the site and existing data, the benzene is the most significant contaminant requiring remediation to NJDEP standards. Our group has been tasked with designing a remediation plan to address the groundwater contamination that will include physical, biological, and chemical remediation techniques.

Based on initial contamination levels and available technologies, we investigated an air sparging and soil vapor extraction system, chemical oxidation using persulfate or permanganate compounds, and aerobic and anaerobic degradation methods. The contaminants of interest are easily volatilized, suggesting air sparging and soil vapor extraction would be an effective technique. Off-gas treatment of the benzene vapor will also be required after soil vapor extraction is applied. Benzene is also amenable to chemical oxidation, and persulfate and permanganate were chosen because a review of past laboratory studies showed that they degraded petroleum hydrocarbons most effectively. These contaminants can be aerobically and anaerobically mineralized, so both methods were evaluated. Specifically, the use of oxygen release compounds and introduction of sulphate to promote degradation by sulfur reducing bacteria. The three design options were evaluated and a recommendation made for the best option for the site.

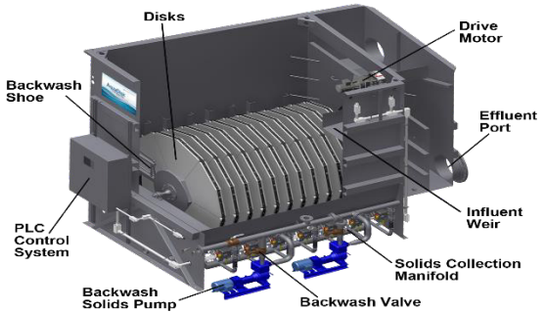
From left to right; Jun Ko, Ian Beattie, Jueda Shytko

ENVIRONMENTAL ENGINEERING

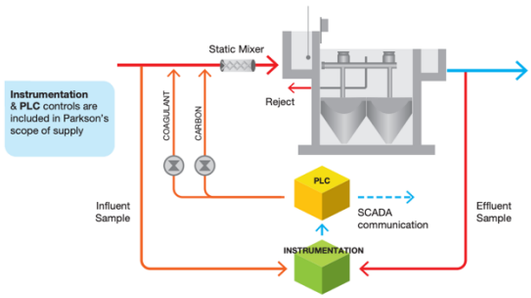
TEAM: ENVE Team 7
SPONSOR: Wright-Pierce
ADVISOR: Alexander Agrios

Phosphorus Removal at Plymouth, CT WWTP

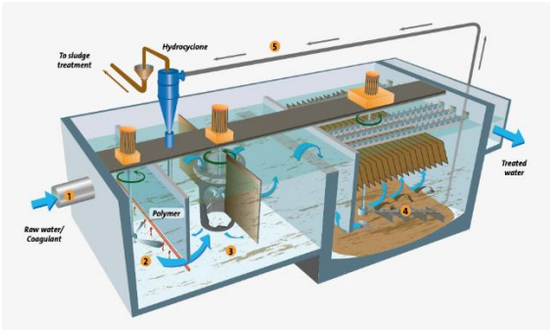
WRIGHT-PIERCE
Engineering a Better Environment



Aqua Aerobic – Aquadisk System (Cloth Disk Filter)



Parkson – DynaSand System (Granular Media Filter)



Kruger – Actiflo System (Ballasted Flocculation)

Excess nutrients (nitrogen and phosphorus) carried in overland flow from nonpoint pollution sources like farmlands may enter bodies of water and cause eutrophication. This can lead to rapid algal growth and a sharp decline in dissolved oxygen content, degrading the aquatic ecosystem. Due to the severe repercussions this can have on the environmental health of a watershed, nutrient removal is an area of concern to wastewater treatment plants (WWTPs). Regulations put forth by the EPA and CT DEEP have lowered the allowable effluent nutrient content several times in order to counteract the environmental impact of excessive nutrient usage. In some cases, it is necessary for plants to add tertiary processes to the system to meet effluent standards. This project focused on designing three typical tertiary processes, performing cost analyses for each, and discussing the benefits and concerns of implementation at the Plymouth, CT WWTP.

The Plymouth Water Pollution Control Facility (WPCF) receives flow primarily from the City of Plymouth. The facility is designed for 1.75 million gallons per day (MGD) flow, but typically receives approximately 1 MGD flow. This plant currently does not meet the phosphorus discharge limits that came into effect in 2019 and required the implementation of a tertiary process for phosphorus removal. The new regulations call for a performance limit of 0.5 mg/L total-P concentration and 4.38 lbs/day of total-P loading, down from the current average concentration of 3.47 mg/L and loading of 28.64 lbs/day at the design flow rate. In order to meet these regulations, three different tertiary processes were evaluated as options: cloth disk filters, sand filters, and ballasted flocculation. The three models of these systems that were used for design considerations are shown on the left. The phosphorus removal capacities, design parameters, and cost considerations for each process were then compared to create a recommendation.

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MANAGEMENT AND ENGINEERING FOR MANUFACTURING

From left to right:
Brian Triglione, Pieter Siebesma, Giovanni Alexis, Dr. Liang Zhang

MANAGEMENT & ENGINEERING FOR MANUFACTURING

TEAM: 1

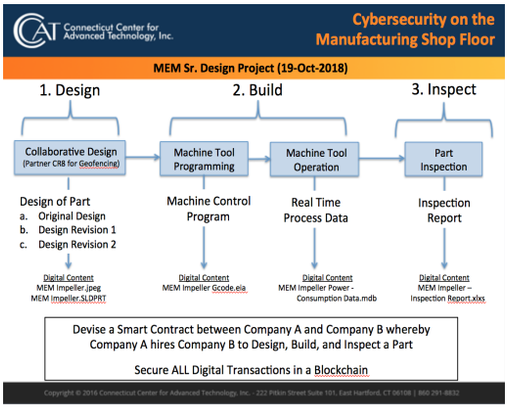
SPONSOR: Connecticut Center for Advanced Technology, Inc.

ADVISOR: Professor Liang Zhang

Securing Digital Transactions in the Manufacturing Supply Chain

Connecticut Center for Advanced Technology, Inc.

scroll



Manufacturing has become a global endeavor. And combined with the advent of “Big Data”, Internet-of-Things (IoT), and analytics in manufacturing operations, the manufacturing supply chains are becoming increasingly complex. With those complexities and prolific amounts of digital information, it is imperative to secure all digital transactions for corporate records and to protect the digital information from cyber threats. A blockchain solution may satisfy the security and protection requirements for global supply chains.

UConn, CCAT, and selected supply chain and technology partners will establish blockchain methodologies that are pertinent to manufacturing shop floor activities and contractual activities across organizations. The objective is to demonstrate a blockchain solution for a representative manufacturing workflow and to demonstrate the use of blockchain through “Smart Contracts”.

Blockchain is applicable to all industries that have digital data. In a world that runs off data and the IoT (Internet of Things) this is almost every single industry, including manufacturing. Blockchain is a decentralized technique to secure data. Each block in the chain holds its own specific data. Through the use of hash pointers and linked lists it takes all of these blocks and makes sure that it is cryptographically secure and immutable.

Smart Contracts are one of many features of blockchain. They use a framework that enables the parties involved to facilitate, verify, and enforce agreed upon terms of a contract. Smart Contracts are a focal point as they have the potential to drastically reduce costs especially in industries with complex supply chains.

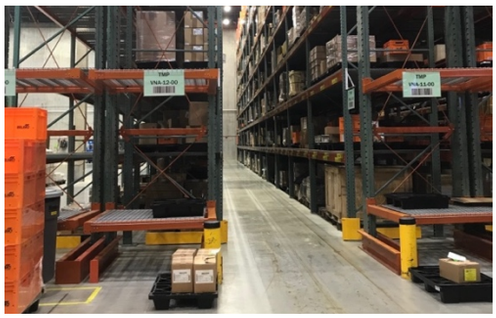
Throughout the duration of the project, we worked mainly with a startup venture out of New Haven, CT called Scroll Network to develop and build our blockchain prototype.

Pictured are Zeen Zhang, Kenneth Jordan, Victoria Marino & Dr. Mousumi Roy

MANAGEMENT & ENGINEERING FOR MANUFACTURING

TEAM: 2
SPONSOR: Belimo Americas
ADVISOR: Dr. Mousumi Roy

Logistics VNA Material Movement Analysis



Belimo Americas, located in Danbury, CT, is the global market leader in the development, production and marketing of actuator solutions for controlling heating, ventilation and air conditioning systems. Actuators, control valves and sensors make up the company's core business. *Belimo* has been setting standards in the fields of HVAC, actuator, and valve technology since 1975 with consistent orientation to market requirements and pioneering innovations. The *Belimo* Group spends around 7% of its net sales in HVAC research and development. *Belimo* has experienced growth in sales for 20 consecutive years.

Belimo has a Very Narrow Aisle (VNA) racking system used for the storage of both completed products and supplies that are either too large in size to store in their Automated Storage and Retrieval System (ASRS) or are not frequently picked. The VNA system consists of 3,960 storage locations which are broken down into 13 narrow aisles using Shaefer racking systems. Each of the aisles are 8 levels high. The Logistics Team at *Belimo* has tasked this Senior Design Team with creating a productivity measurement that will calculate cycle time for one pick in the VNA, guidelines to determine which storage system items belong in, as well as changes that can be made to the VNA that will decrease cycle time. The Logistics Team is also interested in the potential for semi-automation within the VNA system. It is their goal to enhance aspects of the system so that they decrease the amount of manual interaction in order to increase efficiency and productivity.

The Senior Design Team will help *Belimo* decrease pick-times and increase productivity. Very few changes have been made to the VNA system in recent years. By studying current VNA picking process and providing potential solutions, the Senior Design Team will be able to develop a definitive productivity measurement User Form to calculate Cycle Time and can increase the efficiency of this process. Improving this process will reduce movement waste and decrease lead times. The Senior Design Team proposed the implementation of Fleet Enhancement Software for the *Crown* Turret Trucks, which will allow for the Logistics Team to have access to real-time data about fleet utilization and productivity. Additionally, software is available that will semi-automate the trucks so that they can auto-position within different shelf-heights in the VNA racks. The Senior Design Team is also working to determine how to best add additional temporary storage locations so that the material handlers will have to spend less time picking for items manually on the floor.

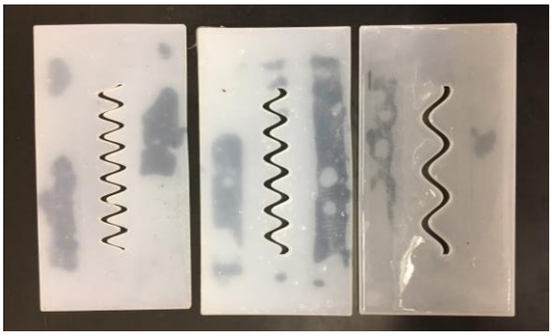
From left, Melissa Amuan, Lauren Kacmarcik, Samuel Bartlett, and Dr. Liang Zhang.

MANAGEMENT & ENGINEERING FOR MANUFACTURING

TEAM: 3
SPONSOR: UConn School of Nursing
ADVISOR: Dr. Liang Zhang

Glove Box Retrieval Guard

UCONN
SCHOOL OF NURSING



On average 20% of disposable gloves are wasted, amounting to millions of dollars of waste each year. Many industries use disposable gloves to protect employees, products, and patients from infection and contamination, and to comply with sanitary regulations. A typical box of disposable gloves has a wide opening to pull out gloves, which allows for wasted or contaminated gloves. A large source of glove waste is from multiple glove dispensing, because it is necessary to discard extra gloves after possible contamination from being handled or from touching an unclean surface. If possibly contaminated extra gloves are returned to the box instead of discarded, they have the potential to contaminate all gloves within the box. Disposable glove contamination may also lead to harmful complications like Hospital-acquired infections, cross-contamination, and foodborne illnesses. The goal of this project is to develop and test a prototype for ReduSeal, a product to decrease glove waste, by ensuring one-at-a-time dispensing, and has the potential to reduce spread of dangerous microbes from glove contamination.

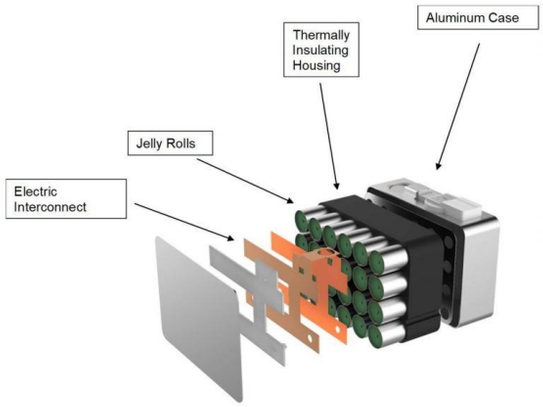
Preliminary testing using multiple ReduSeal prototype designs was completed to determine the design with the best geometric design, to ensure one glove is pulled from the box at a time. Design for manufacturability and assembly principles were used to make material and manufacturing process design decisions, to promote lower production and assembly costs. After preliminary testing and design decisions, the efficacy of ReduSeal will be tested in the UConn School of Nursing simulation labs. The School of Nursing simulation labs emulate the experience of being in a variety of clinical settings for the educational purposes of training nursing students. The simulation labs provide an ideal environment for preliminary consumer testing of ReduSeal, due to expectations that the participating students emulate nurses in clinical settings. Simulation lab testing will assess the ability of ReduSeal to accomplish the project goal of reducing glove waste by ensuring one-at-a-time dispensing, while also gaining user feedback on usability. Multiple metrics will be used to provide data on the efficacy of ReduSeal in terms of its waste-reduction capability as well as its ease-of-use. Cost analyses will be performed to determine what production cost is necessary in order for ReduSeal to provide cost savings to the consumer.

Luke Garneau, Cole Crawford, Karl Johnson, and Dr. Mousumi Roy

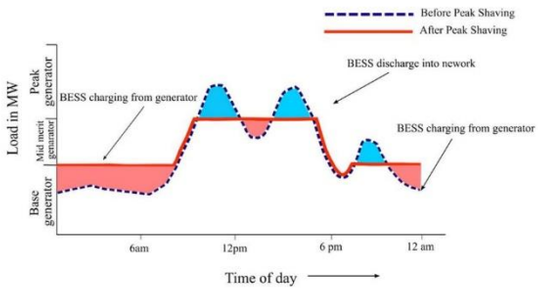
MANAGEMENT & ENGINEERING FOR MANUFACTURING

TEAM: 4
SPONSOR: Cadenza Innovation, Inc.
ADVISOR: Dr. Mousumi Roy

Marketing study for Commercial Lithium-ion Battery Storage Applications



Source: Cadenza Innovation, Inc.



Source: Uddin, M., Renewable and Sustainable Energy Reviews (2017)

Cadenza Innovation is poised to become a world leader in battery architecture, performance and safety, with a mission to solve big problems through innovation in technology. Lithium-ion batteries are commonplace today due to their high performance in a small package. The Cadenza supercell is a redesigned lithium-ion battery that has safety, cost and size (energy density) at the forefront of its design. Cadenza aims to use this technology for peak shaving applications. The use of batteries as storage is an effective way to store and release energy for renewable energy supplies. By discharging batteries during peak energy usage hours, Cadenza can help reduce the cost of energy for consumers. The scope of our first semester was to analyze market data along with outside research to generate a list of inputs for a financial model which can evaluate potential clientele. As students, we are studying every aspect of the BESS (Battery Energy Storage Systems) industry and market to bring creativity when interlinking parameters with engineering data.

We identified both independent and dependent variables that will come in handy for solving financial payback periods and break-even costs. In order to obtain positive benefits from energy arbitrage, the saving in electricity usage during peak hours should be more than the cost of additional electricity consumption used to charge the battery during off-peak hours. We identified many independent variables that need to be collected to evaluate a potential client. These input variables are organized into the following categories: customers, local markets and product needs. Our research suggests peak shaving applications are most beneficial for clients who use most of their energy during peak hours. If a consumer has minimal peak energy usage, there would be minimal cost savings by installing a BESS. Our team determined the dependent variables that the financial model would analyze are annual energy cost savings and percent reduction in yearly maximum peak load.

After determining key variables for BESS commercial applications, we analyzed competition in this market. Our research consisted of finding competitors in the global market and looking at their product specifications. Using the key variables, we will develop a comparative study of global energy storage products. We will then provide recommendations on product specifications for Cadenza's future large-scale installations.

Courtney Boulay, Eva Conte, Kevin Murillo, and Dr. Craig Calvert

MANAGEMENT & ENGINEERING FOR MANUFACTURING

TEAM: 5
SPONSOR: PepsiCo Frito-Lay
ADVISOR: Dr. Craig Calvert

Frito-Lay Food Safety Improvements

Frito-Lay must follow strict guidelines to ensure that they are producing high quality, safe foods that will be sold not only across the USA, but around the globe. The Food and Drug Administration (FDA) sets rules and limitations for how companies can manufacture food products to ensure safety is the highest priority. The FDA recently signed the Food Safety Modernization Act (FSMA) into law, which focuses on preventing foodborne illness rather than just responding to it.

Our project is to help identify any possible violations of FSMA or potential risks at the Frito-Lay Killingly facility and therefore prevent contaminated or at-risk products from being distributed. Potential risks in any food manufacturing facility include foreign matter contamination, condensation and cross-contamination. We took these risks along with any other potential threats we discovered and analyzed them to determine which risks were the highest priority. We considered what issues were most common, have the most effect on the company, and the location in the facility. With that information we decided which risks were worth investigating and found possible solutions. The benefits of our work include minimizing customer complaints, the costs that result from shutting down contaminated production lines and eliminating the potential of contaminated product leaving the Frito-Lay Killingly facility.

While some of our solutions involved creating an engineering design with testing, other solutions were more research based. For our engineering design, we enhanced a product line shield to eliminate cross-contamination events. Testing this solution involved replicating the manufacturing facility and collecting data to see improvements in cross-contamination. Another solution was tested within the Frito-Lay facility and data was periodically collected to record condensation risk reduction. Our research-based solutions include an X-Ray machine and industrial vacuum. The X-Ray machine examines full cases of product with potential contamination to identify tainted product, reduces the cost of destruction and keeps consumers safe. An industrial vacuum will be used to eliminate cross contamination when cleaning the production lines. For both solutions we conducted a cost analysis and organized demonstrations to determine the feasibility of the solutions. All of these solutions look to reduce costs of destroyed product and create a higher standard of food safety in the facility.

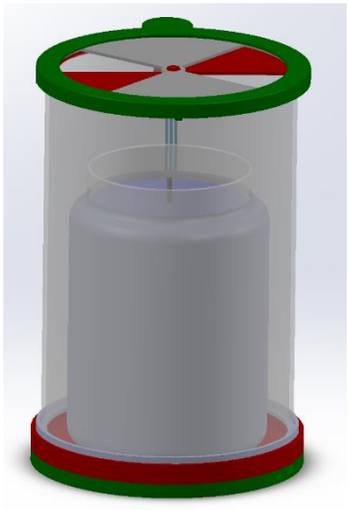
From Left: Raymond Fagan, Max Aronow, Justin Cooper (students), and Dr. Liang Zhang (faculty)

MANAGEMENT & ENGINEERING FOR MANUFACTURING

TEAM: 6
SPONSOR: WickAway
ADVISOR: Dr. Liang Zhang

WickAway Smart Automatic Candle Extinguisher

WickAway



In the United States, there are an estimated 25 candle fires per day, with damages totaling close to $300 million annually. *WickAway*'s goal is to create a product that is easy to use, allowing a user to "set and forget" it without worrying about starting a candle fire.

WickAway's Smart Automatic Candle Extinguisher (SACE) prevents candle fires by using an automated timer to close the lid's shutter. When the user-selected time runs out, the shutter will automatically close, cutting out the oxygen supply and subsequently extinguishing the candle flame. The shutter and glass are heat resistant to allow up to four continuous hours of burning time before asphyxiating the candle.

The SACE will incorporate smart technology, allowing a user to control the device from their smartphone. They will be able to set the duration of the candle's burn and/or immediately close the shutter from an app.

The device fits over a standard jar candle and uses a combination of metal and ceramic to keep the top cool while retaining functionality. At the project beginning, the original prototype was constructed out of 3D-printed PLA plastic. Throughout the project, we have implemented final materials suitable for candle burning. We also made a number of changes to the product design in order to improve functionality, reliability, and aesthetics.

In addition to the selection of final materials, our team was tasked with creating a manufacturing plan that encompasses a cost analysis as well as locating suppliers. Specifically, WickAway wanted to know the tradeoffs between different materials and suppliers to find the appropriate material at the right cost.

From left to right: Suzana Amaral, Omkar Patel, and Dr. Craig Calvert

MANAGEMENT & ENGINEERING FOR MANUFACTURING

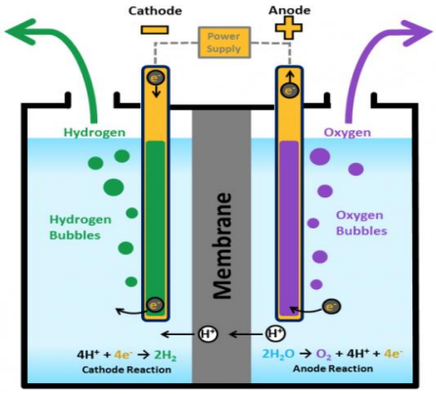
TEAM: 7
SPONSOR: Proton OnSite
ADVISOR: Dr. Craig Calvert

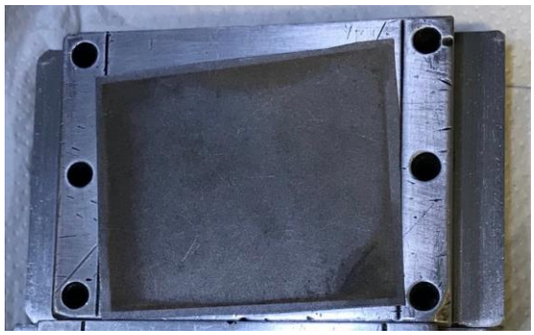
Cost and Risk Analysis for Nano-coating Process of PEM Electrolyzers

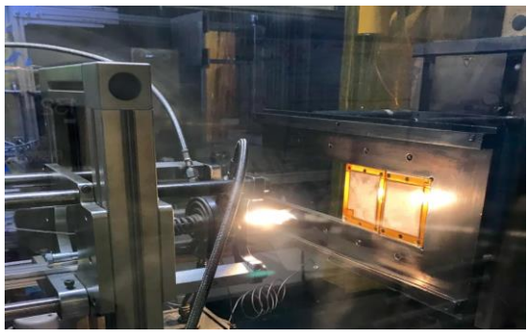
The demand for fuel cells is increasing and its projected to triple to $12 billion by 2022. Despite the rise in demand, producing polymer electrolyte membrane (PEM) electrolyzers comes at a high cost and manufacturers are seeking alternative opportunities to improve their processes. Precious metals, such as platinum, is a significant cost of the PEM electrolyzers. They are used as catalysts for the cathode chamber and as a protective anti-corrosion material for the gas diffusion layer (GDL) in the anode. Proton OnSite specializes in manufacturing fuel cells using proton exchange membrane (PEM) technology. Our group was given the task to establish a cost and risk analysis for the new electroplating deposition technique established and optimized by our cohort.

The new electroplating deposition uses a nano-coating technique called Reactive Spray Deposition Technology (RSDT). The process involves a flame-based deposition of platinum using a platinum acetylacetonate precursor. The precursor is deposited as nano-particles onto a titanium GDL, thus targeting the platinum deposited strictly to the GDL's contact points. By reducing the amount of platinum deposited, we see a direct correlation to the cost savings of the new process.

The cost analysis was created from the perspective of establishing the RSDT process as a mature industrial production line. Therefore, it is important to highlight the risks associated with creating a new product line as well as the research of the new process.





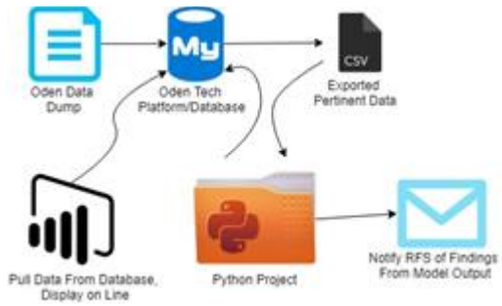


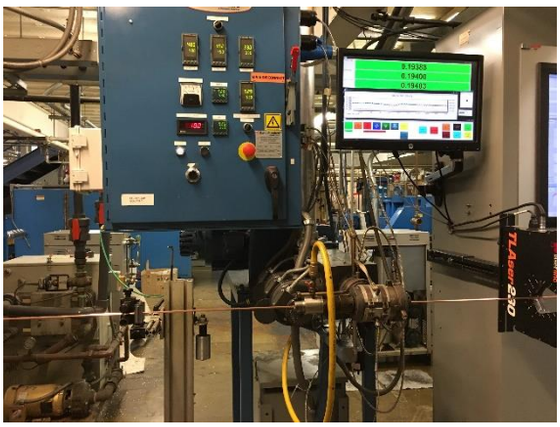
From left: Nathan Hom, Mike Marandino, and Dr. Mousumi Roy
Not pictured: Jon Simonin, Kyle Barry

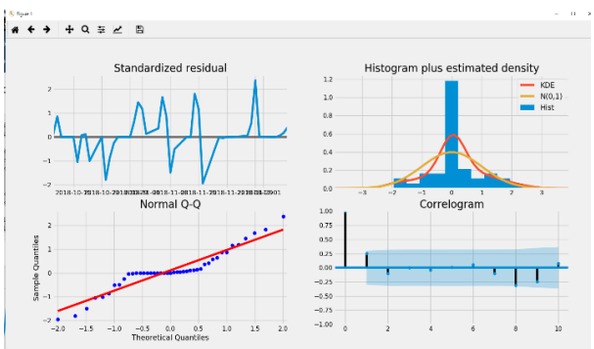
MANAGEMENT & ENGINEERING FOR MANUFACTURING

TEAM: 8
SPONSOR: Radio Frequency Systems
ADVISOR: Drs. Mousumi Roy, Song Han

IoT for Predictive Maintenance







Radio Frequency Systems, GmbH (RFS) is a global corporation specializing in the design and manufacturing of coaxial cables, antenna, tower systems, and passive RF filters. Employing over 1,800, RFS operates ten manufacturing centers and 36 technical support and sales offices across seven continents. The Meriden, CT production facility produces a high volume of commercial coaxial cables in lengths spanning miles at a time. When manufacturing processes enter unplanned downtime, there is wasted product and lost productive time that eats up the company's bottom line.

By focusing on existing sensor outputs from one particular foam extrusion cable manufacturing line, our team utilized diverse talents from both MEM and CSE backgrounds to developed a user platform for operators and managers alike to turn illogical data into useful insights. This "crystal ball" allows RFS to act before catastrophic failure during manufacturing with more agility than ever before, by orders of magnitude over old systems. Such predictive analytic platforms serve for perpetual growth fueled by a proactive management.

Our platform works by establishing a safe baseline using conventional statistical models received by sensor feeds of specific variables on the production line, like voltage or RPM. If any individual reading deviates from safety it is flagged. If the deviation strays too far, into the danger zone, it garners higher priority. By identifying indicators of potential failure along the manufacturing line, proactive measures can be taken on the floor to increase output and decrease waste in the form of damaged product. After establishing such baselines, our model turns to feed itself through the power of machine learning in order to continuously improve the accuracy of its predictions. This allows flexibility of the baselines across production lines over time, as equipment and worker habits slowly shift.

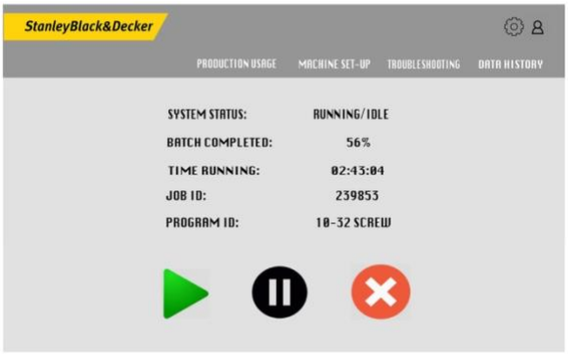
Monthly generated reports coupled with a live-time operator's dashboard allow management to stay in the loop on a less-integrated basis while enabling operators to understand the results in order to report and respond to irregularities as efficiently and effectively as possible. This enables RFS to drastically reduce waste product and enhance productive output across manufacturing lines.

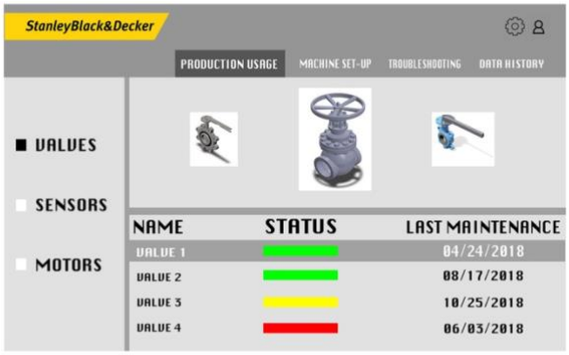
MANAGEMENT & ENGINEERING FOR MANUFACTURING

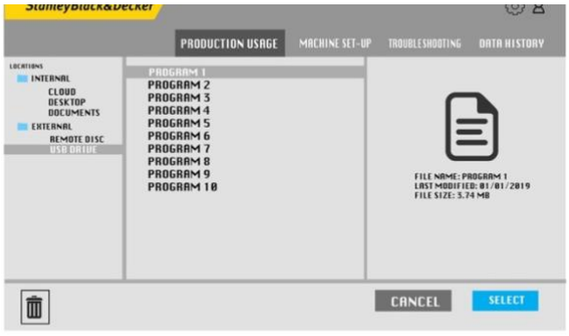
TEAM: 9
SPONSOR: Stanley Black & Decker
ADVISOR: Dr. Mousumi Roy

Andrew Martinez, Jonathan Bigos, Kunal Kothari, and Dr. Mousumi Roy

Process Specific Human Machine Interface (HMI) Design Standardization







Stanley was founded in 1843 in New Britain, Connecticut as a hardware manufacturer. Since then, the brand has grown into a global manufacturer and in 2010 merged with the company Black & Decker to become Stanley Black & Decker. Together, the company owns notable brands such as Craftsman, DeWalt and Mac Tools. This summer, the company opened a new office in downtown Hartford, focused on Industry 4.0 technology.

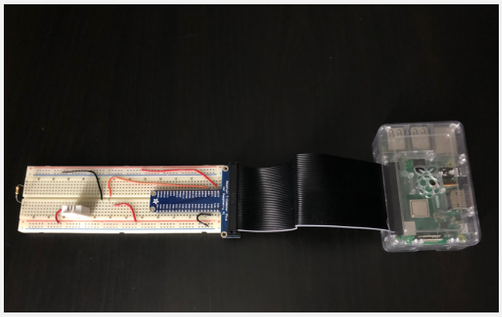
As part of their Industry 4.0 initiative, Stanley has tasked us with the creation of a Human Machine Interface. Human Machine Interfaces, or HMIs, are used to link machine systems and their human operators. This can be as simple as a keypad, or as complex as highly sophisticated touch screens that have become common in recent years. Improvements in HMI technology as well as an increased presence of automated equipment in the workplace has increased the need for process specific HMI designs in modern manufacturing. Even outside of the manufacturing industry, people are interacting with HMIs every day, through their laptops, phones and even in modern vehicles. Among these systems there are certain common features that allow a new user to adapt to a wide variety of specific processes with relative ease. These include common icons, alerts and sounds or other dynamic actions that aid the user. Collectively, these effective systems are known as HMI best practices.

When creating our design, we needed to take a variety of factors into account. Though we knew that they would be used for a proprietary robotics system, these machines could be programmed for a wide variety of tasks. Therefore, having a design that was easily adapted to different processes was the key. It was also important to us that our design be intuitive and capable of being mastered by both entry level operators as well engineers in charge of programming. Color, size and function placement all factored into our final design, as did practical concerns such as software security. It was important to us and our sponsors that settings which compromised safety or could lead to production issues couldn't be accessed by unauthorized personnel. Completed, our system should help reduce training times for machine operators and allow the implementation of automated equipment that will improve manufacturing efficiency.

Left to Right: Ryan Johnson, Bennett Tiesinga, & Dr. Mousumi Roy
Not Shown: Andrew Ball & Michael Platt

TEAM: 10
SPONSOR: Stanley Black & Decker
ADVISOR: Drs. Mousumi Roy & Liang Zhang

StanleyBlack&Decker



Augmented Reality (AR) Maintenance

Augmented Reality is quickly becoming one of the most viable and resourceful applied technologies in the manufacturing industry. In collaboration with Stanley Black & Decker and their Hartford “Manufactory 4.0” Facility our joint MEM & ECE team has been tasked with developing an Augmented Reality maintenance system. With this system Stanley Black & Decker strives to become a manufacturing industry leader in Augmented Reality technology using standards set by Industry 4.0

In order to achieve this status, we began development of a scalable AR system that Stanley Black & Decker will be able to universally integrate throughout their manufacturing systems. The first step of our system construction was development of a baseline model sensor wired to a Raspberry Pi computer. Data recorded by the sensor is transmitted to the computer and to a cloud data storage platform. The next phase of our scope involved developing a 3D CAD model and digital twin of our system with CAD software, allowing users to view augmented health data via a user interface. Using QR code recognition, this same data transmitted to 3D modeling software can be displayed on a user interface like an iPad. Stanley Black & Decker plans to first integrate our team’s system into go/no-go retina machines which test various part for manufacturing errors. Our system will allow Stanley Black & Decker to capture information including cycles until required maintinence, remaining useful life, among other maintenance related data.

A successful outcome of this project is a system scalable and adaptable across many platforms. A major focus of “Industry 4.0” is instant access to information from anywhere which was previously unachievable with local data storage. Our projects potential for scalability will allow Stanley Black & Decker to capture maintenance related data to ultimately reduce machine downtime and maximize manufacturing efficiency.

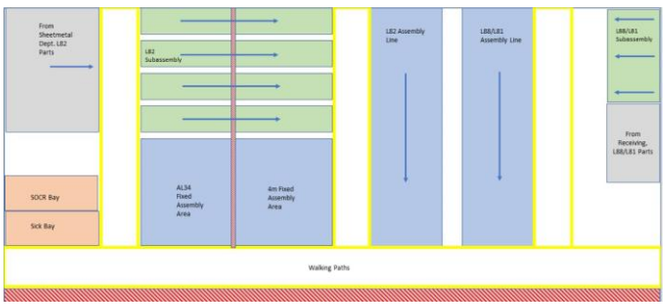
From Left to Right: Bryce Decker, Benjamin Foodman, and Dr. Mousumi Roy.

MANAGEMENT & ENGINEERING FOR MANUFACTURING

TEAM: 11
SPONSOR: TRUMPF Inc.
ADVISOR: Dr. Mousumi Roy

Floorplan Reconfiguration and Optimization

TRUMPF

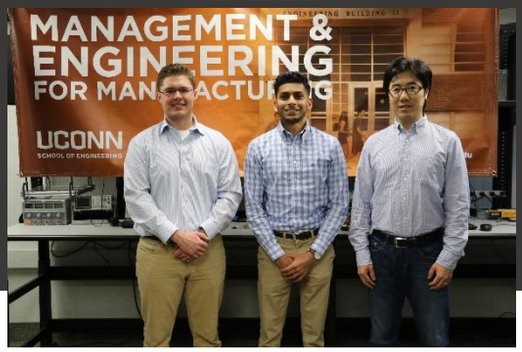


TRUMPF Inc. is one the world's leading manufacturers of sheet metal processing and fabrication equipment. Headquartered in Ditzingen, Germany; TRUMPF will be celebrating their 100th anniversary in 2023. Since their establishment, they have expanded across the globe, including their manufacturing plant in Farmington, CT where they primarily produce 2D bed laser machines for cutting sheet metal.

The goal of this project is to reconfigure the TRUMPF machine assembly floor in order to better support the new generation of laser machines to be built in the coming year. This will be delivered as two unique layouts, one layout for the short-term, that can act as an interim layout while both generations of machines are built concurrently. The layout will be designed to yield to the next generation machines as more of them are introduced into the production plan each month. The lean-inspired project involved benchmarking the existing machine floor in order to create a layout that saves time and reduces material travel distance, while incorporating a greater productivity ratio, as defined by productive square feet divided by total square footage.

The interim layout will be derived heavily from mathematical calculations in order to prove the layout reduces distance, increases productivity and emphasizes work area affinities. This is done by complex part and work cell relationship mapping, part and assembly tracking, as well as big data analytics collected by the plant management every day. Combining these data sets allows for relationship calculations as well as productivity zones., These will help pinpoint locations that may be struggling on the shop floor or can confirm that certain layouts are functioning to a standard. Once delivered, the interim layout is to be effective immediately, and will aid in the transition to the following layout for the next fiscal year.

The second layout is to be designed for two fiscal years from now when only the next generation of machines are being manufactured. This reduces the amount of constraints in the design, while increasing the flexibility of the floor space. This layout will tend to be more theoretical and incorporate a greater degree of design freedom allowing for more ideal lean application.



From left to right: Andrew Naumec, Vasu Viroja, and Professor Liang Zhang

MANAGEMENT & ENGINEERING FOR MANUFACTURING

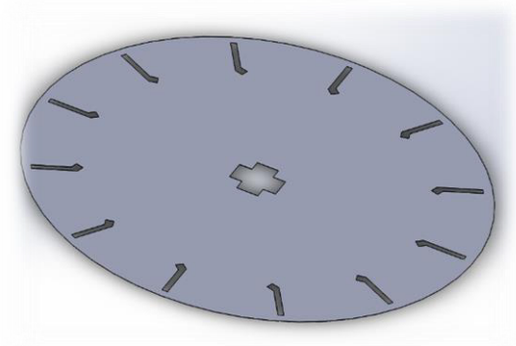
TEAM: 12

SPONSOR: Atlas Stamping & Manufacturing

ADVISOR: Dr. Liang Zhang

Bringing Innovation to Atlas Stamping & Manufacturing

ATLAS STAMPING & MANUFACTURING



The primary objective of this project is to research, analyze and design improvements to the electrochemical etching process as well as supporting operations. The entire shop is controlled by the current production rate of this process and is a roadblock which must be overcome in order for Atlas to continue growing at the rate which they desire. Upon completion of this project, Atlas will be better suited to take on larger contracts while reducing the likelihood of backordered products. Since Atlas is fined by consumers they have contracts with when they fail to meet contractual demand, it is imperative that they increase the production of these machines.

Atlas is currently using the Monode AM10A electrochemical etcher to perform the part etching for roughly 90% of all the products they create in-house. Although they are meeting the current demand, they do struggle to do so and will not be able to increase production to meet growing demand if the production rate is not increased.

The Monode AM10A electrochemical etching machine has the capability to etch 1200 parts per hour. Atlas currently has two of these etching machines, each manned by one employee for 8 hours per day. However, the current rate Atlas operators are etching parts is 350 per hour, which is well below the machine's maximum capability.

In order to increase the output of the etching process, a new method for etching will be introduced to the Atlas shop floor. In this new method and design, the operator would manually load and unload the parts into a constantly rotating circular fixture. As the fixture rotates the parts, a distance sensor would detect when a part is in place with the etcher and will signal for the table to stop turning. At this point, the Monode AM10A head would lower down to etch the part. The turntable would then begin rotation again until the next part is detected. This design will allow for the parts to fall into the neutralizing bath on their own and will minimize the operator interaction required in this process.

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MATERIALS SCIENCE AND ENGINEERING

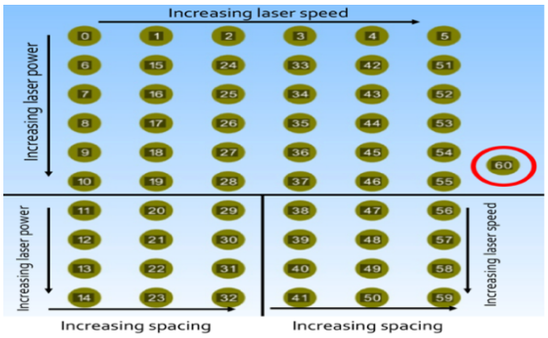
Mikaela Whittington-Baschoff, Anna McDonald, Baylee Loewen

MATERIALS SCIENCE & ENGINEERING

TEAM: 1
SPONSOR: Stanadyne, LLC
ADVISOR: Dr. Rainer Hebert

Additive Manufacturing for Prototype Components

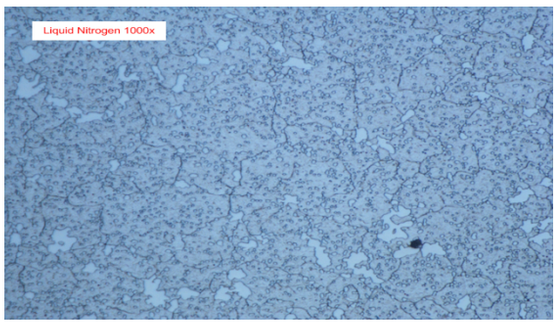
Stanadyne wishes to determine if additive manufacturing (AM) using 440C stainless steel can be used to manufacture prototype components for a gasoline direct injector (GDI). In order to be considered viable, the process must produce components that meet specific tolerances and criteria (porosity, hardness, surface finish). Additionally, AM must have a better lead-time time to generate usable components. The additive manufacturing machine used to produce the components is the Pro300X (located in the Innovation Partnership Building).



This project focuses on three key internal components. In order for the printed components to be deemed successful by Stanadyne, each part must withstand 1000 hours of cyclic stress, the support structures necessary to print the part must be removable/machinable, and the machined surfaces must match the specific tolerance criteria. In addition, the overall printing, and post processing should take no longer than 4 weeks.

The main design aspects of this project include finding the ideal build plate orientation for each component, finding the optimal laser parameters for 440C stainless steel, and successfully processing the printed components to achieve required tolerances and criteria. Essentially, the ideal orientation of the parts is one where the number of required supports needed is minimized, the optimal parameters reduce over porosity, unmelts, and distortions, and successful post processing includes machining and heat treating.

The laser parameters being explored are distance (or spacing), power, and speed. The simultaneous modification of these parameters effects the quality of the printed part. The heat treatment processes being explored are a double temper treatment and a cryogenic treatment. The cryogenic (deep freeze) process involves heating the components to a set temperature, cooling them as quickly as possible without quenching, then submerging them in liquid nitrogen before tempering them once. The two processes produce similar results; however, the deep freeze process is more efficient and can improve the wear resistance more than the double temper process. After treatment, the components are machined to reduce surface roughness and measured for dimensional accuracy.



The results are promising. Additive Manufacturing is an extremely efficient process once the proper parameters are determined. The modification of these parameters along with proper processing, produces components with properties and tolerances required by Stanadyne.

Dean Mazzola, Tyler MacLean, Janos Kanyo, Tochukwu Njoku

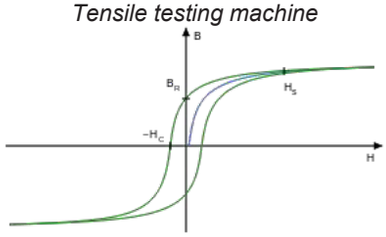
MATERIALS SCIENCE & ENGINEERING

TEAM: 2
SPONSOR: Stanadyne LLC
ADVISOR: Puxian Gao

Hardenable Stainless Steels and Magnetism

Gasoline direct injection (GDI) pumps contain valves that are subject to cyclic loading which necessitates materials that can withstand the high fatigue stresses that occurs. While Stanadyne has industry leading GDI pumps that are made of high-end stainless steels with mechanical properties capable of withstanding this environment, this project is mainly focused on finding less commonly used stainless steels that may be implemented in Stanadyne's new GDI pumps to increase efficiency and performance. More specifically, there are two different sets of parameters that we are focusing on. The first is finding a stainless steel that displays non-magnetic behavior, similar to that of an austenitic steel, while having sufficient strength and toughness. Along with these non-magnetic properties this steel needs to respond well to heat treatment, meaning maintaining or increasing the physical properties of the steel after being held at elevated temperatures. The second set of parameters outline the goal to find a soft magnetic stainless steel that responds well to heat treatment while maintaining mechanical properties and soft magnetic properties, meaning a strong response to both the introduction and removal of an external magnetic field. The results of these findings will be used simultaneously in the control valve for the new GDI pumps.

Tensile testing machine



B-H curve to display magnetic properties

The literature review of publicly known and reliable stainless steel data led to the creation of a selection matrix of as many promising stainless steels as could be found. This created a gradient of steels ranging from high mechanical properties and hard magnetic properties to poor mechanical properties and soft magnetic properties. Due to the nature of metal alloying, the most promising steels represent a compromise between the desired soft magnetic and ideal mechanical properties. Properties in the steel were optimized through heat treatments.

Magnetic testing devices in Uconn graduate labs

Mechanical testing of these stainless steels was completed using a tensile testing machine equipped with two extensometers to collect yield strength, elongation, and young's modulus. Using data collected during mechanical testing, shear modulus was calculated. Magnetic testing was completed using the magnetic testing device in the graduate labs at UConn. B-H curves were created to show the various points of magnetic data in question. At the end of this testing, we will have a complete selection matrix and suggestion for Stanadyne.

Matthew Prue, Michael Fazzino, and Nicholas Wells Group Photo.

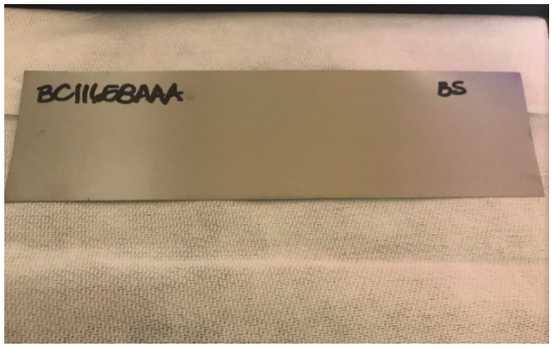
MATERIALS SCIENCE & ENGINEERING

TEAM: 3

SPONSOR: Ulbrich Stainless Steels and Special Metals

ADVISOR: Keith Grayeb, Sean Ketchum

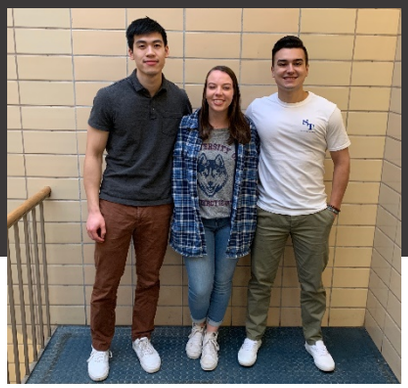
Characterization of Effects of NSCT Scotchbriting Process



From Top to Bottom: Ulbrich Stainless Steel and Special Metals Wallingford Facility, Scotchbrite Pad, Ti 35-A Sample

Ulbrich Stainless Steels and Special Metals uses a machine called NSCT Scotchbrite to achieve a product surface finish that is like other industry standard practices such as pickling. The desired surface properties include a high surface cleanliness free of oxides or other contaminants, and a uniform surface roughness. However, a full understanding of the surface properties processed by NSCT Scotchbrite is not available. In order to understand the effect of Scotchbrite on the surface quality of an alloy, the group plans to characterize the effects of Scotchbrite processing (under different process conditions) including oxide presence and depth, and to compare the surface properties achieved by the Scotchbrite with other industry standard methods such as pickling. Based on the correlations established between surface process and surface properties, it is expected that the project will also offer insights on how to improve Scotchbrite processing. Ulbrich Stainless Steels and Special Metals has employed a NSCT Scotchbrite machine for over twenty years for product surface processing. Despite achieving an acceptable surface finish accomplished by empirical experience, a clear understanding of how the Scotchbrite process's effects surface properties is still lacking. Ulbrich has been considering the Scotchbrite processed surface as a special surface finish that is similar to that of pickling, which removes surface oxide.

This assumption has not been validated first hand due to Ulbrich's limited access to advanced surface characterization equipment such as Scanning Electron Microscopy or X-Ray Diffraction. A comprehensive characterization of the surface properties has been challenging with limited equipment available in the facility at Ulbrich. To account for this, this project plans to characterize the similarities and differences between NSCT Scotchbrite and comparable methods in addition to designing a method for Ulbrich to quantify the success of an individual pass on the machine. This project will allow Ulbrich to accurately inform customers as to exactly what the outcome of their processes are to their product.

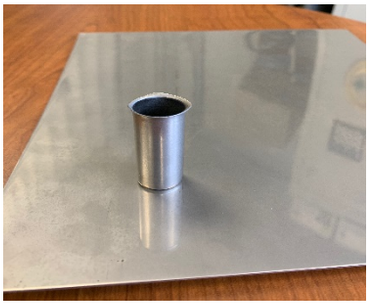


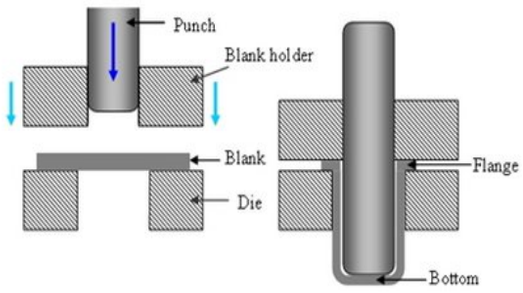
Steven Kha, Grace Quinlan, Joao Carlos Barbosa

MATERIALS SCIENCE & ENGINEERING

TEAM: 4
SPONSOR: Ulbrich Stainless Steels & Specialty Metals
ADVISOR: Dr. Lesley Frame

Sheet Metal Properties and their Effects on Deep Drawing



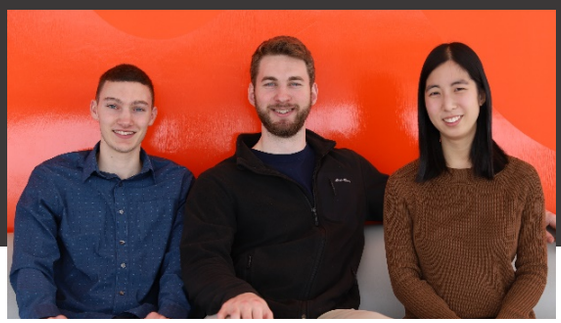


Ulbrich Stainless Steel and Specialty Metals is a company that modifies sheet metals so they can be used for niche applications. Coils of sheet metal are slit to customer specified widths before cold rolling and annealing to achieve desired final properties. Ulbrich's customers produce a wide variety of items including blender blades, nuts, bolts, tubes, cups and pans from the cold rolled sheets.

The main objective of this project is to optimize the processes of cold rolling and annealing for deep drawing of 305 stainless steel as well as determine the limit for deep draw depth after cold rolling. Cold rolling results in the formation of dislocations, which increase the material strength; this process is also called strain hardening. Annealing the material after cold rolling allows for nucleation and grain growth of new grains; thereby increasing the ductility and making deep drawing possible. However, the amount of cold rolling performed prior to annealing can affect deep drawing because a large amount of strain hardening results in a higher tendency for the material to be anisotropic. Anisotropy is undesirable during deep drawing because it causes different grains to have different directional properties. Therefore, it is crucial to optimize the grain structure through defined cold rolling procedures and subsequent heat treatments.

Deep drawing is a process when a metal sheet is radially drawn into a forming die by a punch. Properties that allow for a better deep drawn product include high ductility and high strength. There are many different parameters to take into consideration in order to get a successfully deep drawn part. Parameters of interest include the deep draw ratio, depth of the cavity, punch force and the clamping force. Defects to be avoided during deep drawing include, wrinkling, tearing, galling and earring. Of these four defects, the most common are earring and tearing. Earring is due to the planar anisotropic nature of the sheet which projects unevenness formed along the edge of the flange. Tearing is caused by an increase in tensile stresses which leads to thinning and failure of the metal.

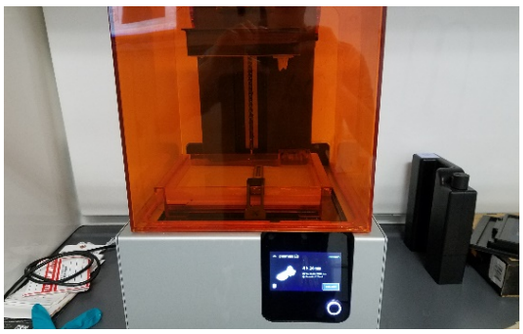
This design project involves cold rolling experiments using different starting thicknesses of 305 stainless steel and different annealing temperatures. After each cold rolling reduction and each anneal, samples are cut and mounted to undergo optical microscopy to track the grain elongation. These samples are compared to already cold rolled and annealed samples provided by Ulbrich in 20-60% reductions. In order to determine the optimal reductions for deep drawing, mechanical testing is done on the samples; specifically tensile testing in 3 different orientations relative to the rolling direction. To test for drawability, a deep draw rig is designed and machined. Abaqus CAE is used to model the deep draw rig and determine ideal parameters for the drawing process. Each reduction is tested on this rig using three different draw ratios. The three draw ratios are further tested by drawing to three different depths to ultimately find the relationship between processing of 305 stainless steel sheet and drawability.

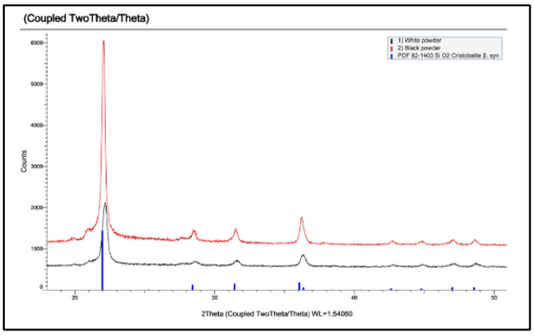


MATERIALS SCIENCE & ENGINEERING
TEAM: 5
SPONSOR: Precision Combustion Inc.
ADVISOR: Dr. Pamir Alpay
Dr. Jeff Weissman (PCI)

Ryan Corbett, Andrew Spak, Kenna Ritter

Process Design for 3D Printing of Ceramic Components



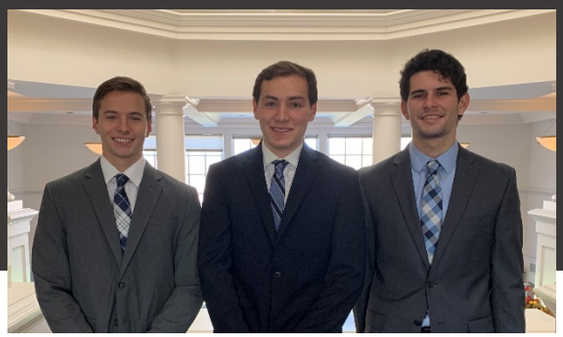


Ceramic 3D printing is a new, advanced manufacturing technique. This technique brings the benefits of additive manufacturing such as rapid prototyping, the ability to create complex geometries, and low material waste to ceramic materials. If processed correctly, the printed ceramic components will have all the benefits and potential applications of typical ceramic materials. The process investigated in this project is stereolithography (SLA) printing which is a type of vat photo-polymerization.

Ceramic printing with stereolithography is an additive technology that involves a slurry of ceramic particles in a UV (ultraviolet) curable resin. A UV light will raster across the surface of a pool of the slurry to solidify layers of the resin. The printer builds layer by layer moving the build plate to accommodate new layers of slurry for the UV light to solidify. Once printed, the part is called a “green body”. This green body then has to undergo a complex firing process to finish the product. First, the polymer matrix (the resin) must be burnt out in a process called pyrolysis. After the polymer is gone, the component must then be heated to a sintering temperature. After the ceramic particles are sintered the component can be cooled down.

Precision Combustion Inc. is a clean energy technology company. Their products are used in many fields such as aerospace, gas turbines, fuel cell systems, chemical manufacturing, agriculture, and more. These products fall into four main groups: fuel processors, air cleaners, combustors, and burners/oxidizers. The technologies require materials that can withstand high temperatures and do not react with any of the substances created during these processes.

Precision Combustion Inc. currently uses alumina tubes for their high-temperature reactor that converts gas into fuels. Inside the reactor is a methane-oxygen reaction. The temperatures reach over 800°C, a temperature at which metal tubes would catalyze a combustion reaction necessitating an inert reactor material. The alumina tubes are made of 99.5% alumina with 50% porosity. The goal of this project is to print suitable, fully dense end caps for this tube to contain the reaction. The ceramic particles used in the ceramic-resin slurry are silica, which is compatible with the alumina tube because of their similar thermal conductivities.



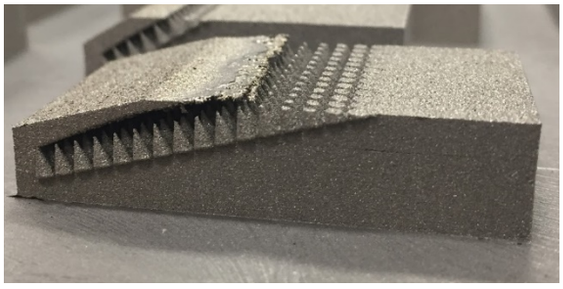
Cayman Cushing (left), William Howard (middle), and Andrew Gagnon (right).

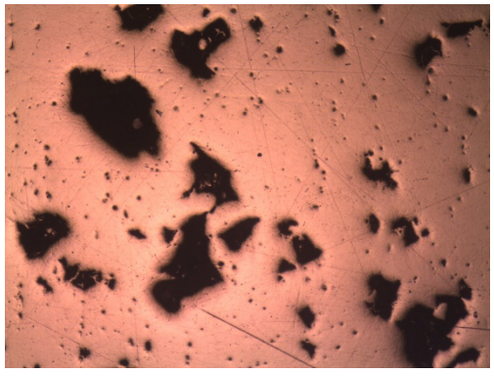
MATERIALS SCIENCE & ENGINEERING

TEAM: 6
SPONSOR: Collins Aerospace
ADVISOR: Colette Fennessy & Loren Brandenburg

Support Structure Design for Powder Bed Additive Manufacturing

Collins Aerospace
A United Technologies Company





During powder bed additive manufacturing, samples have to be built on build plates. The common practice is to use support structures to anchor the parts to the build plate. Special software aid in the design of the support structures and offer numerous design options. Support structures can be solid, lattice grid structures, blades, or cones; many more options exist. Since support structures will need to be removed from the part after the additive manufacturing process, thin walled supports are often desired because they can be removed manually, involving simple hand tools.

The residual stresses that develop during the additive manufacturing process limit the design of thin support structures. Overwhelming residual stresses can cause the support structures to break, causing the samples to warp and the build, eventually, to fail as the machine will stop. The project aims at developing design guidelines for support structures that can be removed manually. Machine parameters, sample geometries, and layout options need to be considered for the specific case of a 3D Systems ProX300 machine.

At the end of the year, the goal of the project is to formulate an additive manufacturing scaffolding guideline for a variety of different geometries. The purpose of the guideline is to have a broad set of rules that should be followed to minimize post-processing time and to ultimately cut down on cost. The scaffold guideline should serve two main functions: bridging the part and holding down the part resisting residual stress-induced deformation. The design should work to find a balance between the two functions. For each of the part geometries, there will be a desired surface finish which correlates to the ease of removal. A balance between surface finish and ease of removal will be factored in the overall guideline.

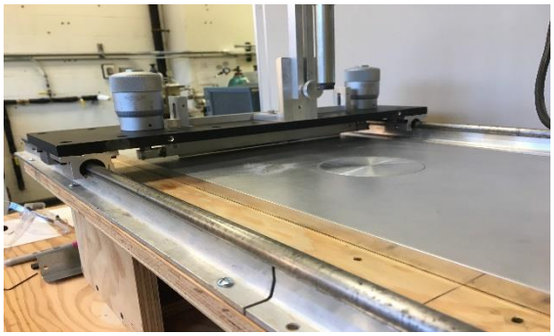
Kierstyn Raines, Tatsuki Katakura, and Meghan Van Wie

MATERIALS SCIENCE & ENGINEERING

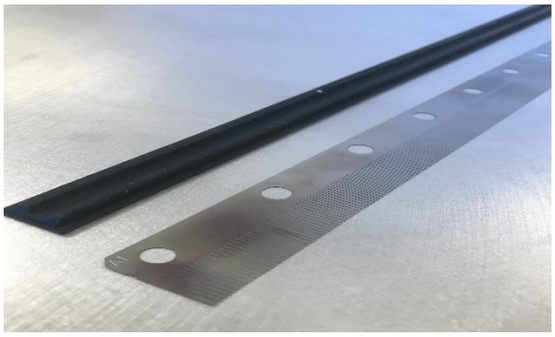
TEAM: 7
SPONSOR: Pratt & Whitney
ADVISOR: Dr. Rainer Hebert

Design and Evaluation of Recoater Systems for Powder Bed Additive Manufacturing

Pratt & Whitney
A United Technologies Company



Apparatus of experiments with build plate and metal blade



Recoater blades: rubber and metal comb

Powder bed additive manufacturing using selective laser melting is a growing field, offering an alternative to the traditional subtractive machining processes. The main benefits include the high flexibility in design and acute understanding of the part production process. Building each part layer-by-layer allows for control over internal properties. This can translate to varying mechanical behaviors and part overall longevity. This method is a generally newer manufacturing technique, thus there is a need for Pratt & Whitney to improve viability of parts and understand possible variations in parameters that contribute towards part quality. Such parameters include recoater blades, powder mesh size, bed density, and layer repeatability.

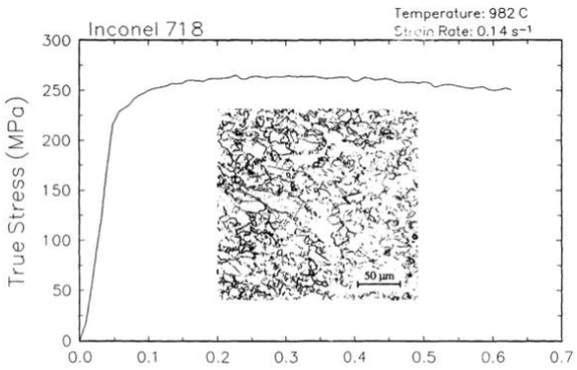
With a focus on quantifying the variability of powder bed formation, different powders and recoaters can be experimentally tested to evaluate the response. The four types of recoater arm blades are tested in a powder bed simulation apparatus while a camera captures images of powder formation on the build plate. The density and porosity can be determined by this distribution and form the correlation to the overall quality in part printing process. The project explores how to maximize layer repeatability in powder beds. It is known that higher powder bed density minimizes porosity levels which equates to stronger mechanical properties. Additionally, better integrity of printed parts means wider usability of additive manufacturing both in prototyping and product production.

MATERIALS SCIENCE & ENGINEERING

TEAM: 8
SPONSOR: Pratt & Whitney
ADVISOR: Dr. Rainer Hebert

Aubrey Tang, Bert Lu, & Steven Gomez

Optimization & Data Analysis of high temperature, high strain rate compression tests with Gleeble Systems



CHAUDHURY, P., & ZHAO, D. (1992). Atlas of formability: INCONEL 718(Final Report, 30 Apr.- 31 Jul. 1992).

This project has three main objectives. The first main objective is to optimize the interface condition between samples and anvil caps with a systematic study of lubricants in the Gleeble 3500 system. Secondly, this project also aims to achieve uniform temperature distribution within the sample during adiabatic heating. The third objective of this project is to develop an efficient way of achieving the desired strains and strain rates during the compression test.

In order to determine the best lubricants to use in order to optimize the interface condition between the samples and anvil caps, the group chose lubricants that meet the project's requirements. Lubricants selected for this project must be able to withstand high temperatures, as the experiments will be run at above 900℃, and be electrically conductive as the machine passes a current through the sample via direct resistance heating. The group selected to use tantalum foil and graphite foil while also utilizing nickel paste as an adhesive. These lubricants are all able to withstand the temperature the group would like to test, and they are also electrically conductive.

The experimentation involves careful preparation of the sample itself. Thermocouples are used in order to determine the temperature in the specimen and in this experimentation. Two pairs of thermocouples will be used to determine the temperature in the center of the sample and at the edge of the sample as a way to check if there is any uneven heating throughout the specimen.

The critical constraints for this project is time and machine availability. Each test requires 20-30 minutes to complete, which means the total amount of time required for testing is estimated to be 16-25 hours. The Gleeble 3500 is shared among different groups, and the availability of the machine is also limited. In order to successfully complete this project, the group must figure out a method to reduce testing time.

Left to right: Beril Tonyali, Avery Gray, Lara Huapaya Rojas

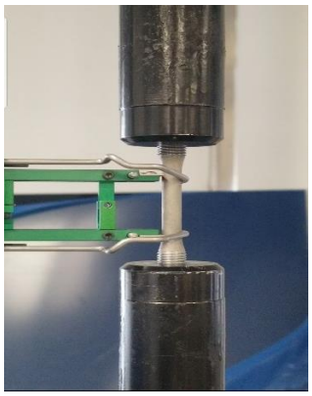
MATERIALS SCIENCE & ENGINEERING

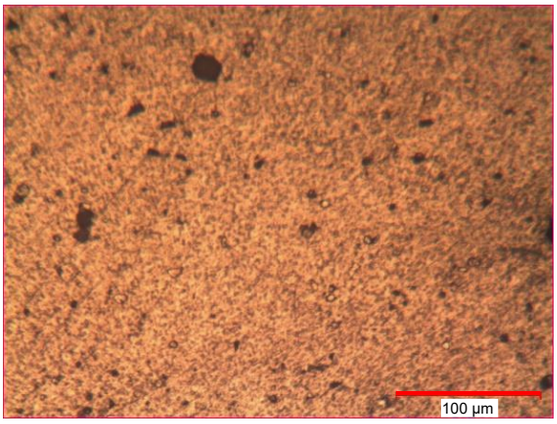
TEAM: 9

SPONSOR: Sikorsky

ADVISOR: Dr. Seok-Woo Lee (Faculty)
Tom Derco, Bill Fallon (Industry)

Post-Processing Heat Treatments of Additively Manufactured Aluminum Alloy, AlSi10Mg





Additive manufacturing (AM) has fostered a lot of interest in the aerospace industry recently because of its printing efficiency, reduced costs, minimal material waste, and higher quality final products. The AM technique known as direct metal laser sintering (DMLS) uses a laser to melt metallic powder particles together. Desired geometries are produced by working in thin layers of powder deposits along the surface, melting them, and building up from the platform in this way until the final product is achieved.

Aluminum alloys are the materials being explored for use in AM technology because it is lightweight, has high strength, and has the ability to be easily alloyed with other elements to enhance or eliminate specific material properties. Wrought 6061 Aluminum is currently the most commonly used alloy in aerospace since it has phenomenal mechanical properties, however its adhesion properties are poor. Although much weaker, AlSi10Mg is one of the first additively available powders to be used as an alternative to wrought Al 6061 because of its excellent bonding capabilities, which is key for AM purposes. Sikorsky is interested in determining what kinds of processing techniques can be used to further improve AlSi10Mg alloys to achieve mechanical properties comparable to those of wrought Al 6061.

The purpose of this project is to understand the structure-properties-processing relationships of heat-treated AlSi10Mg in order to substantially improve the mechanical properties of the alloy. This will eventually lead to a far superior material that can be utilized for additive manufacturing purposes. The approach for this project is to create a design of experiments to test heat treatments varying in time and print orientation. Samples were provided by Sikorsky, where they were printed in XY or ZX orientation. Once received at UConn, samples underwent post-processing heat treatments. Solutionization heat treatments with varying times were the main concern. Heat treated samples were then tested using a tensile tester, and evaluated microstructurally to draw conclusions on structure-properties-processing relationships, and determine optimal post-processing heat treatments.

Images: AM sample obtained from Sikorsky, ready for heat treatment *(top)*. Sample undergoing a tensile test for measurement of mechanical properties *(middle)*. Microstructure of AlSi10Mg that underwent heat treatment at 530°C for 1 hour, 200x magnification. Silicon particles apparent in microstructure *(bottom)*.

Left to right: Jonathan Gager, Spencer Matonis, Zachary Putney, Ryan Wrobel

MATERIALS SCIENCE & ENGINEERING

TEAM: 10

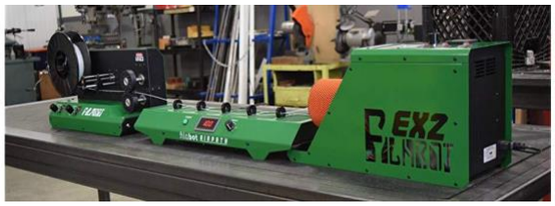
SPONSOR: NASA

ADVISOR: Dr. Volkan Ortalan (Faculty Advisor)

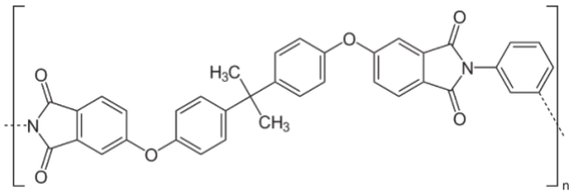
Tracie Prater, Curtis Hill, Jennifer Edmunson (Industry Advisor)

Development of Novel Feedstocks for In-Space Additive Manufacturing

Currently, there is a sizeable gap between the mechanical properties of plastic versus metal additively manufactured components. The goal of this project is to bridge this gap by doping various thermoplastic materials to enhance the mechanical properties of the composite filament. Along with enhancement of mechanical properties, NASA has shown interest in being able to add functionality to these feedstocks, including a conductive or dielectric filament that could be used in electrical applications.



The primary matrix material being considered is polyetherimide (PEI), commercially known as Ultem. This high-temperature thermoplastic exhibits exceptional mechanical strength, has a high strength-to-weight ratio, and has an exceptional flame, smoke and toxicity (FST) rating. There are two payloads currently on the International Space Station (ISS) that work with Ultem: the Additive Manufacturing Center from Made In Space and the Refabricator from Tethers Unlimited. Potential matrix materials under consideration for electrical applications include polyvinylidene difluoride (PVDF) and high-density polyethylene (HDPE) for their standalone dielectric properties. Commercially well-characterized polymers such as polycarbonate (PC) and acrylonitrile butadiene styrene (ABS) may also be considered and tested.



Dopant materials to improve mechanical strength include short carbon fibers, silicon carbide (SiC) whiskers, graphene, and carbon nanotubes. Dopant particles for electrical applications include graphene and barium titanate ($BaTiO_3$). NASA is also interested in incorporating in-situ resources into the novel feedstocks. Ferromagnetic particles from a lunar simulant could potentially be used in a conductive feedstock, while the non-ferromagnetic particles could be used to improve mechanical properties. Nickel, a common element that is found in Martian regolith, will also be tested for electrical properties.

To achieve adequate particle dispersion through the matrix, a dissolution method is being practiced. This involves dissolving the thermoplastic matrix using a chemical solvent and adding particles to the solution. The solute-solvent ratio is critical to identify an optimum viscosity to suspend particles within the polymer. Once the particles are dispersed through the matrix, the solvent can be boiled off to prevent significant moisture from being in the composite. The composite is then pelletized and fed into the hopper of a Filabot EX2 extruder to create a filament. Data from differential scanning calorimetry and melt flow index testing are used to identify the critical temperature at which each individual composite must be extruded for adequate properties.

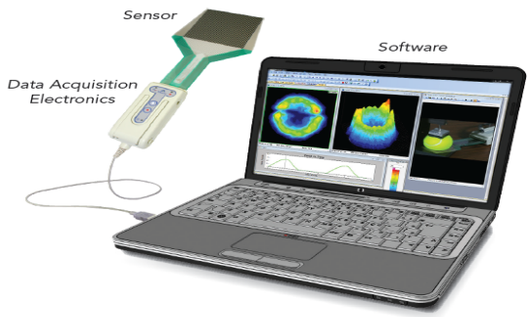
The student team (left to right): Piotr Chaber, Brendan Kristie, Chase Sheeley

MATERIALS SCIENCE & ENGINEERING

TEAM: 11
SPONSOR: Ensign-Bickford Aerospace & Defense
ADVISOR: Prof. George Rossetti Jr

Design of Improved Methods for Tubing Deformation and Powder Distribution Characterization in Linear Shaped Charges

EBAD Ensign-Bickford Aerospace & Defense
RIGHT FOR YOUR MISSION



I-Scan System: Includes software, data acquisition electronics, & sensors (standard Evolution® system shown)

Ensign-Bickford Aerospace & Defense (EBA&D) is a precision explosives manufacturer located in Simsbury, CT. The company is a subsidiary of Ensign-Bickford Industries, Inc. EBA&D has tasked the project team with achieving two major objectives. The first objective is to develop a deformation process for their linear shaped charges (LSC) that allows for manufacturing using copper or a copper-based alloy without introducing defects, such as cracks or thinned walls, during shaping. The second objective is to develop a characterization method for quantifying the packing uniformity of the explosive powder that is contained within the various types of LSCs that the company manufactures.

EBA&D currently manufactures LSCs from aluminum tubing. Transitioning to copper tubing opens new opportunities to expand these products into other markets. LSCs made of lead have shown strong performance, but pose health and environmental risks. Copper is known to perform better than aluminum, but cannot be formed using the current manufacturing process. Adapting the forming process for use with copper or a copper-based alloy would satisfy safety requirements while meeting performance standards for current and future applications. EBA&D also needs a reliable method to quantify the packing of the explosive powder after forming, which greatly affects detonation and the efficiency of the explosive jet, and so is an important quality control metric. An accurate, reproducible and cost-effective method for characterizing powder uniformity does not currently exist within the company.

Major constraints on the solutions to these problems are imposed by the explosive nature of the product. The replacement tube materials must be COTS, fabrication processes must utilize EBA&D's existing manufacturing facilities, and heat treatment is prohibited. Powder characterization methods must be inexpensive and implemented in-house. The adopted approach involves mechanically testing different types of copper in order to gather data showing which is the most ductile and the most susceptible to the cold working done in the current EBA&D shaping process. Greater formability is favorable. Critical parameters in the current process were identified and are analyzed in the project so that adjustments can be made to successfully form LSCs with copper. The powder characterization approach involves scanning by a piezoelectric sensor, which uses software to convert pressure detection into a colored map of density variation.

Adam Li, Jordan Gomes, and Iwona Wrobel.

MATERIALS SCIENCE & ENGINEERING

TEAM: 12
SPONSOR: KX Technologies
ADVISOR: Dr. Stefan Schafföener

Compression Molding of Carbon Block Filters

KX Technologies LLC is a company that specializes in filtration using activated Carbon. Their products are used in multiple common house hold appliances such as refrigerator filters and Brita water purifiers. KX Technologies creates the filters by mixing activated Carbon with a binding agent and then extruding it into a long cylinder. This cylinder is then divided into shorter pieces that form the basis of the filter. The processing technique of extrusion is extremely productive and time efficient, but it also requires a large amount of material to perform. This means that an alternative process must be used if small batches for research needed to be created. As a result, KX Technologies has tasked our group with determining if the compression molding process is suitable for making small batches of their filters.

Compression molding is a processing technique where a mold containing a powder is heated and then pressurized in order to initiate binding and create a singular solid product. For this design project activated Carbon is mixed with a binding agent inside of a cylindrical mold. By applying heat and pressure, the binding agent fuses the powder into a solid cylindrical filter. The disadvantages of compression molding are that it is limited by the size of the mold and that it takes far more time than extrusion. However, compression molding is a good choice for small research samples because it allows for variation without using a large amount of material. The compression molded samples created here at UConn were tested for mechanical properties like porosity, strength, and hardness and then be compared to KX Technologies' extruded samples. If the compression molding technique is deemed viable by KX Technologies they will be able to test new binding agents as well as different compositions for experimental filters.

Hetal D. Patel

MATERIALS SCIENCE & ENGINEERING

TEAM: 13
SPONSOR: Computational Materials and Mechanics Group (CMMG)
ADVISOR: Dr. Avinash Dongare

Design of a Machine Learning Algorithm to Design/Discover Layered Materials for Battery Applications

UCONN CMMG
COMPUTATIONAL MATERIALS AND MECHANICS GROUP

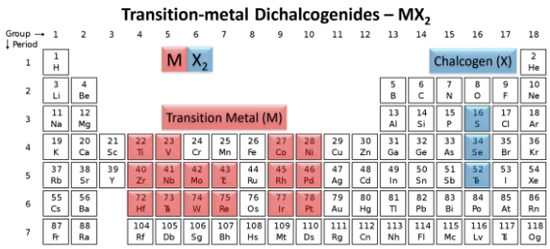


Figure 1. Periodic table highlighting 16 transition metals and 3 chalcogen atoms.

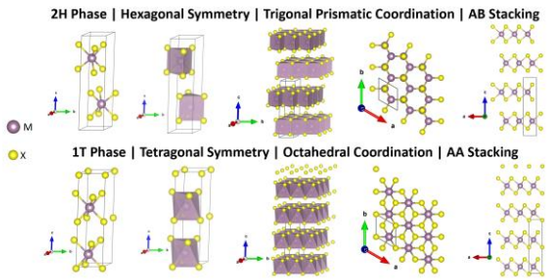


Figure 2. Schematics of 2H and 1T phases of 2D layered TMD materials.

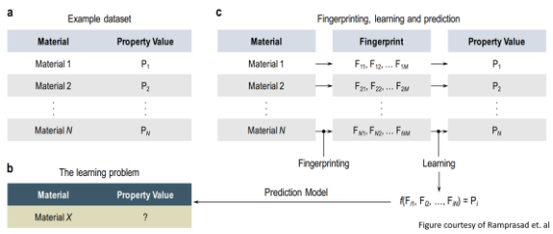


Figure 3. Key elements of machine learning in materials science.

Graphite (layered sheets of carbon atoms) based lithium ion batteries are today's ultimate rechargeable energy storage technology. They have now become the main power supply for laptops, cameras, mobile phones and electric vehicles. However, graphite's low charge capacity will not meet the high demands of the next-generation energy storage capacities. Moreover, the current challenges with the costs and availability of lithium have triggered efforts toward design and discovery of alternative materials to graphene and lithium for battery applications.

Recently, two-dimensional (2D) transition metal dichalcogenides (TMDs) have attracted intensive research activities (Fig. 1). Their excellent electrochemical properties and 2D layered structure like that of graphite show a great promise to be used as a next generation of energy storage material. Characterization of all possible TMDs through experimentation is extremely expensive and time consuming. As a result, present study utilizes powerful computer models and machine learning tools to screen hundreds of TMDs with the goal of computationally guiding experimental work in order to ultimately accelerate the design and discovery process of layered materials for battery applications.

Density functional theory (DFT) is a sophisticated quantum mechanical modelling method that simulate the physics of materials at an atomic level. DFT simulations are used to calculate fundamental properties of over 160 TMD's for its two different phases (Fig. 2) using high performance computational resources at UConn. Results of DFT simulations lead to determination of structural energetics, phase stability, phase transformation, and volumetric expansion of the TMD's upon insertion of lithium, sodium and potassium ions in between the interlayer spacing.

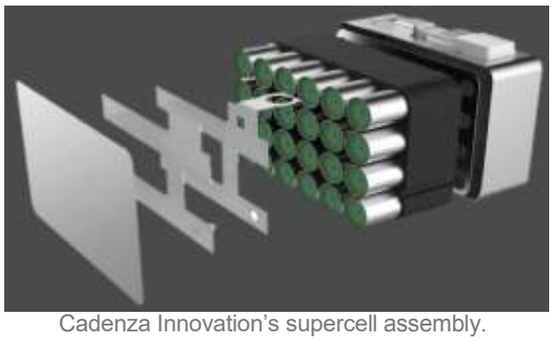
Large datasets built using DFT calculation data were then analyzed using machine learning (Fig. 3) to make correlations between atomic scale descriptors and phase energetics, transformation behavior as well as volumetric expansion due to intercalation. This work set a framework for future DFT and machine learning based discovery/design of layered materials in CMMG in collaboration with EaglePicher LLC.

Left to right: Timothy Ketelhut, Kevin Knowles, John Eron, Justin Greenwood, Rory McCormick

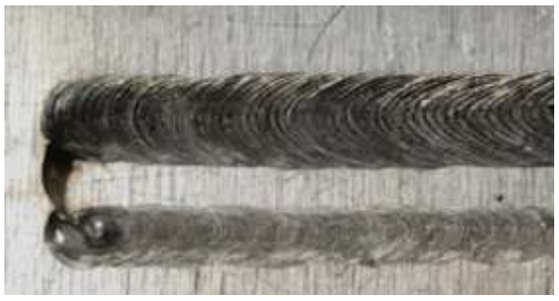
MATERIALS SCIENCE & ENGINEERING

TEAM: MSE 14 (ME 69)
SPONSOR: Cadenza Innovation
ADVISOR: Jasna Jankovic, Ph.D.

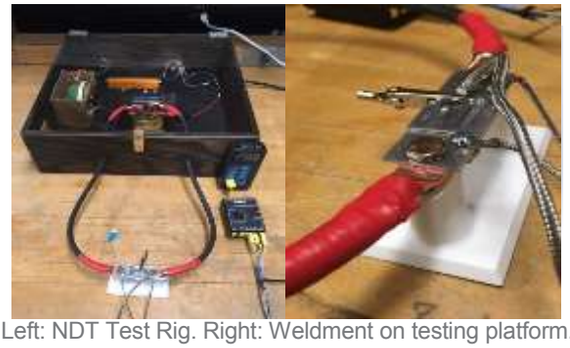
Optimization of Laser Welding Parameters for Electrical Conductivity



Cadenza Innovation's supercell assembly.



Laser weld pattern on Al3003-H14 sample.



Left: NDT Test Rig. Right: Weldment on testing platform.

The foremost significant obstacle that stands in the way of conventionalization of electric vehicles is their insufficient range; which could be improved by increasing the energy density of battery cells. Cadenza Innovation, a pioneer in low cost, high energy density, lithium-ion cell technologies, has been implementing their improved 'jellyroll' battery design and novel packaging of "jellyrolls" into a supercell system to address the issue. The company is dedicated to provide the market with safe and reliable lithium-ion cell assemblies.

The main objective of the project is to reduce the joule heating effect in aluminum weld joints of the lithium-ion supercell system. The resistive heating of the welds directly affects the efficiency of the system; which is the most important factor for the emerging electric vehicle technology. Furthermore, Cadenza Innovation requires the formulation and design of a non-destructive testing method to electrically assess the weld joints in their assembly line as the company aims to not only develop the most efficient battery system but also to develop a process that is applicable to mass manufacturing with competitive profitability margins.

Our design team has worked diligently to understand, investigate, and solve the undesired heating effect in the welds of the cell assembly. Through theory and modeling, different combinations of laser welding parameters were arrived at and tested to yield the most favorable microstructure for electrical conductivity. The optimal microstructure for electrical conductivity is found to be when there are large, oriented grains with no intermetallic compounds present at the grain boundaries. However, achieving this is easier said than done when dealing with very fast non-equilibrium heat transport.

The secondary goal of this project is to develop a method for non-destructive testing (NDT) of the welds. The physical deliverable for this is in the form of a prototype NDT rig meant to be used in the assembly line for weld verification. The test rig contains an electrical resistivity testing system, specifically designed to ensure that the resistivity of the weld is low enough to carry the high current load without excessive heating.

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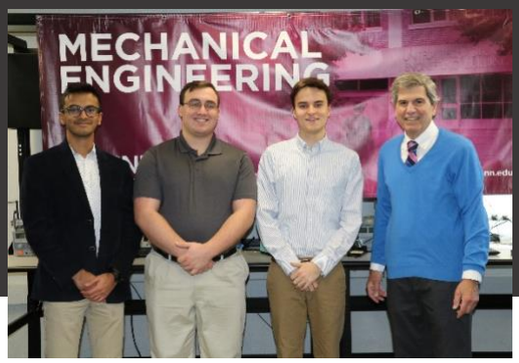


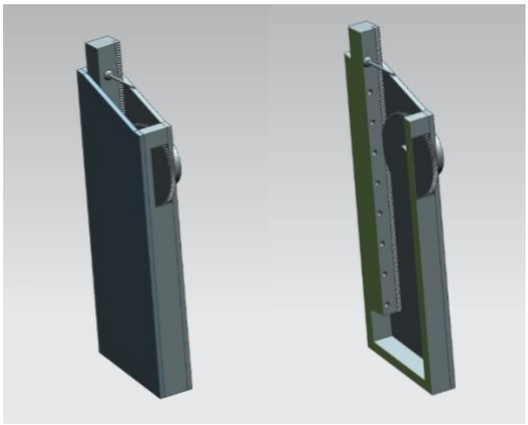
From left: Imran Ullah, Quincy McGee, Jack Debek, Professor. Vito Moreno

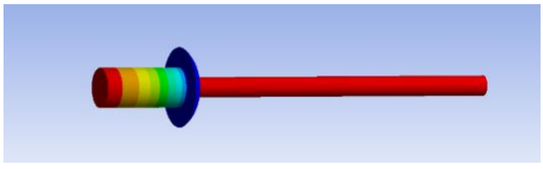
MECHANICAL ENGINEERING

TEAM: ME 01
SPONSOR: Mr. Terry Jensen
ADVISOR: Professor Vito Moreno

Riveting Operations of Aerospace Assemblies

ACMT

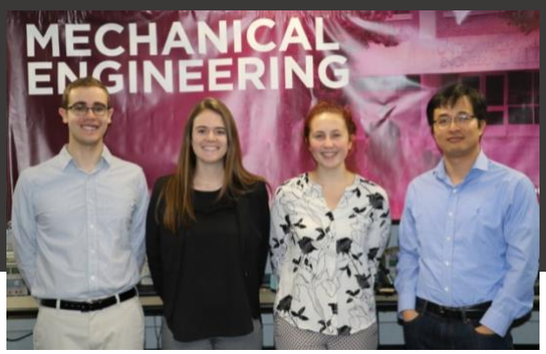




Advanced Composites & Metalforming Technologies (ACMT) is a firm that both designs and manufactures a variety of jet engine components for the world's most advanced aerospace applications. ACMT produces a range of OEM (original engine manufacturer) and MRO (repair operations) products whose end-users are everything from military fighter jet fleets, to commercial airlines. One of the staple procedures used during ACMT's operations is riveting, which is a method of joining two sheet metal bodies together by deforming one end of a thin cylinder that extends through both bodies. As a result of ACMT's consistent growth, the company projects its annual usage of rivets to triple as early as next year. Any augmentation to the riveting process at ACMT can provide major cost savings to the company.

As a part of their mission to being the leading innovator in aerospace manufacturing technologies, ACMT sought to create a new device that could aid in the operation of riveting. Our team investigated how blind rivets, the variety that ACMT almost exclusively uses, are installed, how they deform under their installation load, what their installation apparatus is, and their failure modes to understand how the process could be improved. Upon viewing how ACMT currently installs rivets, we deemed the most practical and effective means of reducing cycle time of each rivet installation to be creating an external rivet magazine for use with the installation apparatus. The current rivet installation process has a human operator manually inserting each rivet into the nose of the apparatus. By creating an external magazine, the operator could simply place the nose of the device in front of the magazine and index a new rivet from there, eliminating the need to manually load a rivet and the motions associated with aligning their hand to the nose.

Once the objective of the new device was determined, a design to accomplish that goal was drafted. After examining how other mechanisms in various other products work, our team went through a series of design iterations, with each design taking advantage of a different central mechanism. These have been prototyped by using 3D printers at the sponsor's site, and tested by our team mostly to determine durability and its effectiveness at minimizing cycle time.



From left to right: Steven Olenski, Julie Daniels, Cleo Alberts, and Professor Xu Chen.

MECHANICAL ENGINEERING

TEAM: ME 02
SPONSOR: Dr. Richard Fu
ADVISOR: Professor Xu Chen

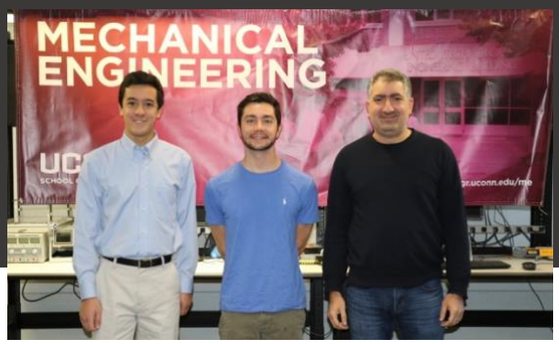
Development of an Automated Indoor Vertical Farming System

agrivolution

Agrivolution LLC is an agri-technology company based out of South Windsor, Connecticut that specializes in innovative and sustainable farming solutions in controlled environment agriculture (CEA). Agrivolutions mission is to promote sustainable agriculture through innovation and technology, by preserving farmland and creating healthy food manufacturing. The goal of this project is to create a prototype of an automated indoor vertical farming system that allows the growth of vegetables, mainly leafy greens, to grow with minimal human interaction from seedling to harvest. This also includes determining the full-scale feasibility of the chosen design. Vertical farming provides a year-round solution to farming in climates where it is not viable; the automation of this process seeks to reduce labor costs and space needed for growing.

The prototype contains a control system to power and move the plants along different nodes. Each node represents a different stage of growth of the plant. The prototype is integrated with an ebb and flow irrigation system to periodically flood and drain the plants, allowing them to grow to harvest between 25-35 days.

Market research was conducted to determine the need and competition in the vertical farming sector. The results yielded the basis for the teams prototype design idea. The final prototype design, being 4 feet long and 2 feet wide, was chosen after confirming budget and feasibility for the projected full-scale model. A full-scale model would ideally be 40 feet in length and contain multiple tiers. The prototype design control system uses Arduino; the movement of the carriages is based on positioning sensors and plant growth. The carriages each have a motor, receiver, batteries, and four wheels that sit on an aluminum extrusion track. The plants are then transferred based on need to different nodes on the system. These nodes contain irrigation lines with differing nutrient content to apply at different times in the growing timeline. The LED lighting duration and pump timing is automated by Arduino and was calculated based on plant science requirements. The team primarily focused on growing butter crunch lettuce. Throughout the project duration, the team concluded that the prototype is an accurate small-scale projection of a full-scale model; Agrivolution plans to continue this project and potentially market the automated system.

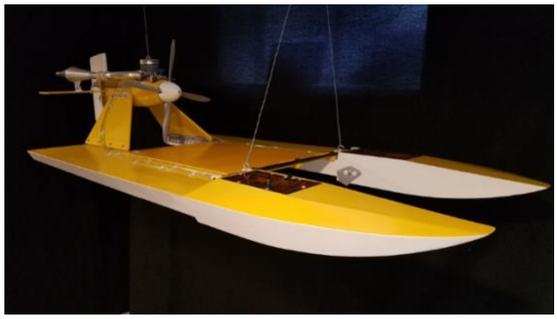


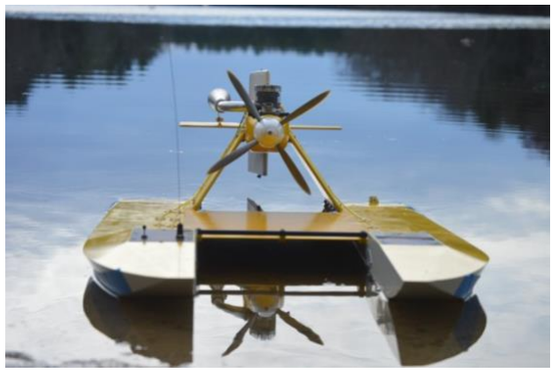
From left: Andrew Yin, Connor McNaboe, Dr. Georgios Matheou

MECHANICAL ENGINEERING

TEAM: ME 03
SPONSOR: Charles Gray
ADVISOR: Georgios Matheou

Analysis and Optimization of a High-Speed Catamaran Airboat

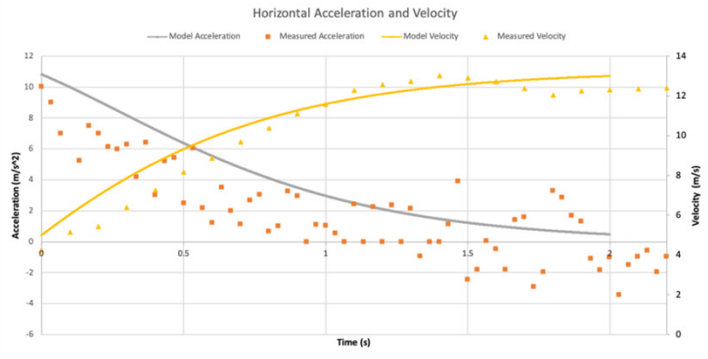


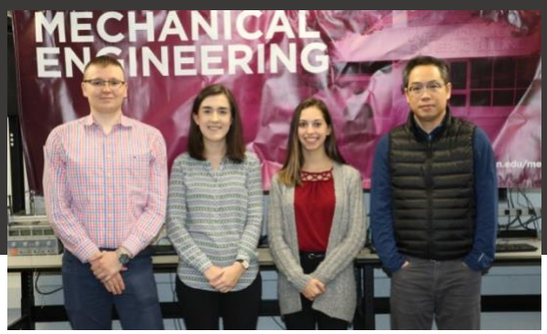


UConn Mechanical Engineering Alumni Charles Gray designed and constructed an airboat as an independent study in his senior year. After graduation, he built an improved airboat to be used in future Mechanical Engineering Senior Design projects. After twenty years of small improvements, he believed that the current design could be further optimized to increase performance.

Detailed analysis of the current airboat was performed to predict aerodynamic and hydrodynamic drag and lift as a function of its speed. Using MATLAB, a numerical simulation of the current airboat was developed to characterize its straight line behavior from idle to max speed and is to be validated with baseline tests. Qualitative analysis of this computer model was performed in order to provide insight on the parameters and design aspects that influence the performance of the airboat with regard to stability, acceleration, and top speed. The effects of aileron position, propeller diameter and pitch, center of gravity, and other parameters on the performance of the airboat were simulated and tested in order to develop an optimized configuration that performs better than the previous model.

An accurate parametric model enabled the team to investigate the previously defined parameters. It was found that adjusting aileron position, center of gravity, skeg configuration, rudder position, nacelle location and angle had minimal effect on the performance of the airboat. A far more significant improvement in the airboat's acceleration and top speed came from changing the propeller type, however its stability was significantly impaired by propellers that generated higher thrusts.





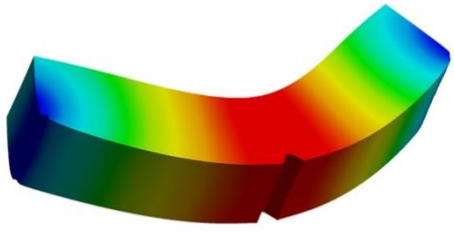
From Left: Dmytro Andriyenko, Lakin McEvoy, Christina Santa Lucia, Professor Tai-Hsi Fan

MECHANICAL ENGINEERING

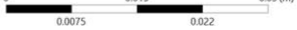
TEAM: ME 04
SPONSOR: ASML
ADVISOR: Professor Tai-Hsi Fan

Advanced Additive Manufacturing Material Characterization

TWINSCAN NXE:3350B ©ASML



Charpy Impact Test using ANSYS



ASML, or Advanced Semiconductors Materials Lithography, is a company headquartered in Veldhoven, Netherlands with a local branch of the company residing in Wilton, CT. ASML holds majority market share in the lithography industry at 85.4% with large customers such as Intel, Samsung, TSMC, and GlobalFoundries. ASML is creating its new generation of Extreme Ultraviolet Lithography (EUV) machines, which requires optimization and study of the materials to be used within the machine. The company is looking to convert a large, heavyweight component within the EUV machine to 3D printed siliconized silicon carbide, commonly known as SiSiC. The properties of this material are known in solid form, but are unknown when in varying volume concentrations of its 3D printed form. This material will reduce the weight significantly, while continuing to sustain a high level of performance. Specifically, the SiSiC must withstand 20 Gs of force as well as be resistant to particle release due to the vacuum environment of the EUV machine.

To determine the advanced ceramic's feasibility in the machine, mechanical testing was performed to verify properties of the material. Mechanical properties of concern include stress, strain, Young's modulus, yield strength, ultimate strength, impact toughness, cycles to failure, and resistance to particle release. These properties were determined by performing tensile and fatigue testing, charpy (impact) testing, defectivity testing, and tribology (friction resistance) testing.

It was determined that the 3D printed SiSiC meets ASML's requirements, making it an effective material replacement for the EUV machine component. Though our findings, it can be seen that the 3D printed material was not as durable or as strong as its solid form, and that the material has negligible particle release. With these properties, 3D printed siliconized silicon carbide is an effective alternative to the current material in use in ASML's future EUV machines. This will allow them to further optimize their processes to keep Moore's Law alive.

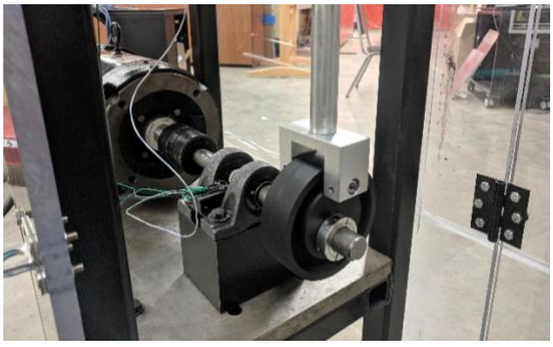
From Left: Rochelle Horanzy, Alen Bihorac, Professor Tom Mealy

MECHANICAL ENGINEERING

TEAM: ME05
SPONSOR: Jason Sicotte
ADVISOR: Mr. Tom Mealy

Associated Spring Fatigue Tester

Associated Spring
A business of BARNES GROUP INC

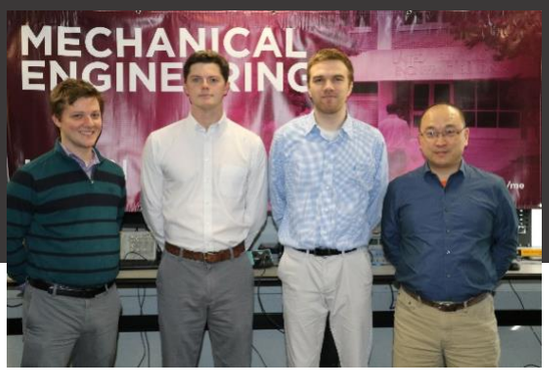


Associated Spring focuses on advanced engineered springs and precision metals. The main component that this company manufactures are high precision spring stampings for automotive industry use. This is used from various products ranging from custom valve springs for top fuel dragster engines, to internal springs used in multi speed transmissions.

Each spring is made with different manufacturing variables, such as different levels of Rockwell hardness, heat treatment, and shot-peening. S-N curves will be generated based on the fatigue limit of the coupons to determine how each variable affects the fatigue life.

The goal of our project was to improve upon the original fatigue tester design, which did not operate in a safe manner. Plexiglass shields were placed around the inner mechanism. The tester would also vibrate dangerously after approximately 520 revolutions per minute, causing parts to break off. To counter this, a cam roller-follower mechanism was created using Solidworks to act as a replacement.

Before running tests, the system was verified with strain gauges. Three gauges were placed along a coupon and readings were taken with the coupon clamped in place and by moving the end by hand. The gauge reading will take place in the area where the test coupon will crack on the trapezoidal surface. Based on the frequency and deflection height selected, certain strain values are expected. Several tests were done to see if the values obtained from these tests were similar to the ANSYS model simulations. Since these results matched to a certain degree of accuracy, the machine has been proven to produce repeatable results and we will use it to produce S-N data based on different manufacturing variables.



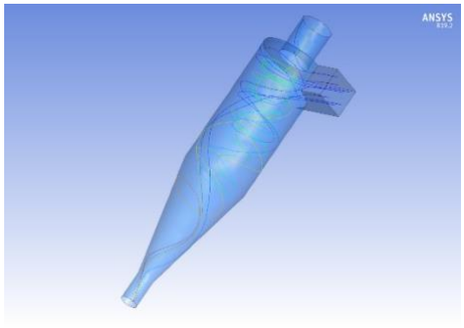
From Left: Brandon Tracy, Jeffrey Ashton, Matthew Frederick, Prof. Tianfeng Lu

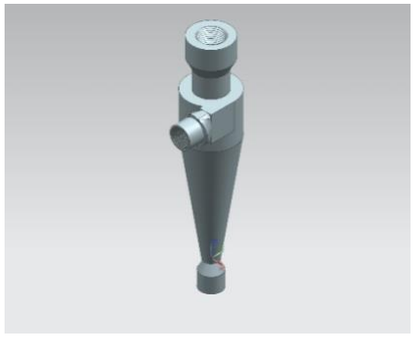
MECHANICAL ENGINEERING

TEAM: ME 06
SPONSOR: Paul Omichinski
ADVISOR: Prof. Tianfeng Lu

Barnes Grinding Filter Study

Barnes AEROSPACE
A business of BARNES GROUP INC





Creep feed grinding is a manufacturing process used by Barnes Aerospace, an OEM based in Windsor, CT. During this process, a rotating grinding wheel cuts into high temperature nickel superalloys. The cutting edge is sprayed with coolant to prevent the wheel and metal from overheating and remove solid abrasive and particulate coming off of the wheel and the metal workpiece respectively. This dirty coolant is then fed through a filter to remove the solid particulate and abrasive ('swarf') to be reused at the cutting edge. Filtration is a critical process; otherwise, coolant that is too dirty will damage hoses, pumps, and interfere with the surface finish of the workpiece.

Prior to this project, Barnes Aerospace used disposable paper media to filter the coolant, resulting in high disposal costs and insufficient filtering. They tasked the team with investigating an alternative filtration method that would cut costs and provide a superior level of filtration. The team conducted preliminary research into the current filtration process as well as a variety of possible alternatives. Upon a thorough down-selection process, the team decided to proceed with the investigation of a hydrocyclone filtration solution.

Hydrocyclone filters rely on a rotating fluid to induce centripetal acceleration to separate the lower-density solids within them. This causes the solids to move outwards and eventually slide down the walls of the cyclone, separated from the cleaned fluid. These devices are often employed in gas-solid separation, but due to low maintenance costs, the team was interested in investigating its viability in liquid-solid separation.

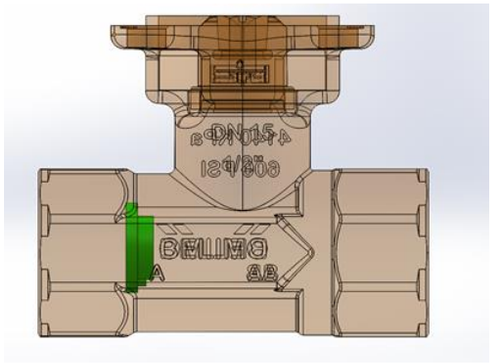
The team designed a high-efficiency hydrocyclone to increase the residency time of the swarf, which results in a longer time subjected to separating forces. The team used particle-tracking in ANSYS to predict mass separation efficiency and the overall filtration effectiveness for a prototype .The team used a 3D Printer at Barnes' R&D Lab to fabricate the prototype out of acrylic-like plastic. From here, the team created a test rig apparatus to verify the ANSYS simulations to confirm the viability of analytical hydrocyclone models. Upon verifying the analytical models, the team was able to confidently assert that the prototype accurately represents an industrial-scale model with superior filtration performance over the current disposable paper.

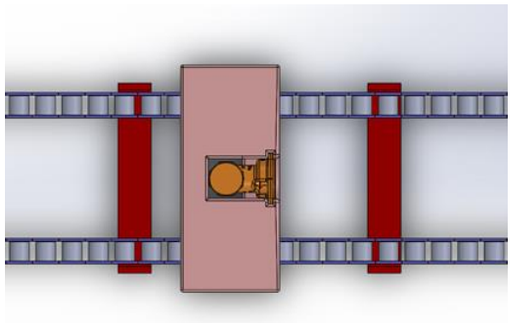
From Left: Sanjay Rajan, Patrick Madaus, Chris Cybart, Julian Norato

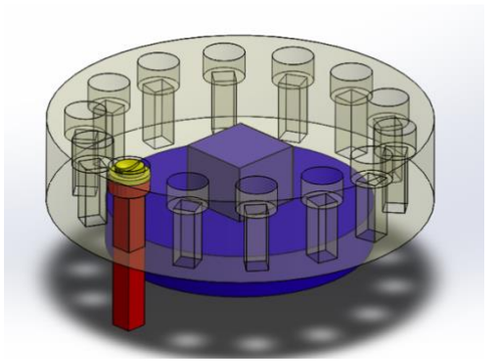
MECHANICAL ENGINEERING

TEAM: ME07
SPONSOR: Belimo
ADVISOR: Julian Norato

Disk Insertion Process Automation



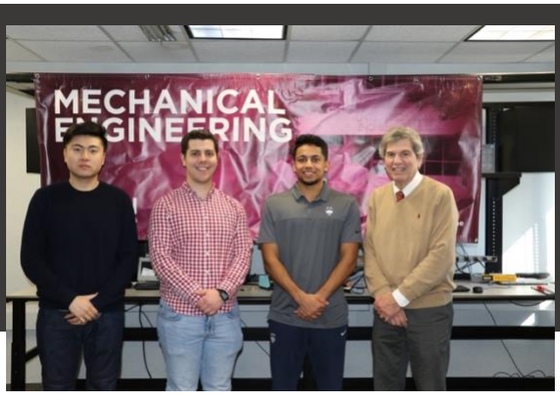




Belimo is a Swiss-based manufacturer and distributor of actuators, sensors, and control valves for heating, ventilation, and air conditioning (HVAC) systems. Based in Danbury, Connecticut, Belimo mainly manufactures ball valves which are widely used throughout the United States. In HVAC systems ball valves are connected to electronic actuators which control the position of the valve and in turn the flow of water. There are instances where the actuator must finely turn the valve in order to reach the desired flow rate. The issue with ball valves is that the cross-sectional area of the ball opening opens too rapidly for there to be any precise control. To combat this issue, Belimo has developed plastic disks that are inserted into the flow section of the valve. These disks have unique profile cutouts that allow the flow rates to be controlled more precisely. With their disks, Belimo continues to ensure that their HVAC systems operate at the highest efficiency.

Currently, the disk insertion process is done manually by technicians, usually two to three at a time. It is a not an ergonomic process as it requires the technicians to make repeated motions over the course of many hours. In addition, there are many areas where failures can occur and decrease the efficiency of the process. Belimo has tasked our team with developing a semi-automated system to replace their current system. The disks must be inserted in the proper orientation without making any changes to the disk or valve design.

Our team has created a semi-automated system using a cart and track. The cart houses the valve and slides down a track covered in high-density polyethylene, a material with an extremely low coefficient of friction. Along the track there are stations for the disk insertion, ring insertion, and valve positioning. The disk is inserted from underneath the cart by a linear rail connected to a motor while the ring is still inserted manually by technicians. Once the cart reaches the end of the track the valve positioning system will slide automatically into the valve and will turn the valve until it is fully closed. Our system has accomplished the goal of reducing the strain on the technicians while at the same time automating the process without compromising on anything.

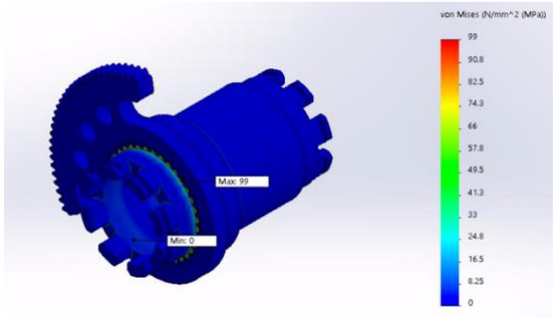


From Left: Zeyuan Chen, Ryan Young, Nabeel Khan, Professor Vito Moreno

MECHANICAL ENGINEERING

TEAM: ME 08
SPONSOR: Belimo
ADVISOR: Professor Vito Moreno

Gear Segment Assembly for a Hollow Valve Body



Belimo is a manufacturer and distributor of building automation, energy management, HVAC systems and equipment, lighting controls, motors/drives, and air quality products located in Danbury Connecticut. Currently very old hydraulic presses are used to permanently join a gear segment onto a hollow axle of an actuator. There is a desire to replace the presses with new technology, in the hopes of eliminating the hydraulics as well as to create a standardized measurement of how much force should be required to pull off the gear once attached to the axle. The objective of this project is to identify a method of installing the gear on the valve body that is more efficient and provides a reduction in noise level as well as in required floor space. In order to improve the accuracy of our results, we modeled the real product in SoildWorks and conducted a static simulation to analyze the current assembly model. From our simulation analysis, we need at least 12.96 KN force to permanently deform the teeth of axle.

The results that team gear will find will assist Belimo on their decision to purchase a new type of press. The results that we come to, will be documented by Belimo and provide valuable information regarding the needs that this press and even a press they will purchase in the future must meet. This will also be beneficial to Belimo as they wish to use these results to test their product intermittently throughout the day.

After testing in ANSYS and Solidworks was completed testing commenced initially with testing the amount of force to remove the gear which was attached via Belimo's current presses. Next, testing continued using different geometry of the press head, to demonstrate that the required number isn't the amount of force to attach the gear, but to remove it. As for practical reasons this is the more valuable number for the assembly's lifespan.

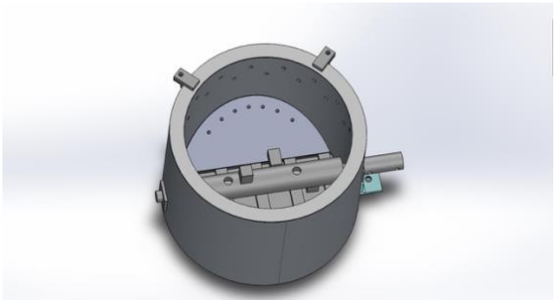
From Left: Gregory Grasso, Andrew Kelemen, Jacob Kowalski, Prof. Bryan Weber

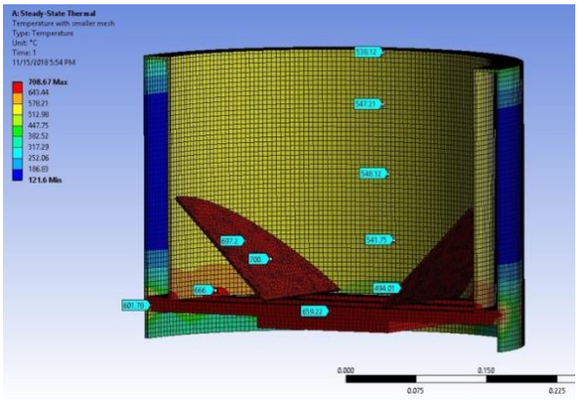
MECHANICAL ENGINEERING

TEAM: ME 09
SPONSOR: Dr. Taylor Myers
ADVISOR: Dr. Bryan Weber

Improving Cost and Durability of a Pyrolysis Pot Design for High Moisture Fuels

BIOMASS CONTROLS





Biomass Controls is a company operating out of Putnam, CT, that strives to solve water and sanitation challenges around the world. Their biogenic refinery utilizes pyrolysis to thermochemically treat waste biosolids such as fecal sludge and manure. This treatment destroys pathogens, reduces volume, and produces biochar which can be used as a soil amendment. The biogenic refinery helps to meet community scale sanitation needs, especially in the developing world. Within the refinery, the pyrolysis pot is the location where pyrolysis occurs and biochar is produced. This component was the focus of our project. Our team was given the task of decreasing the cost of the pot by 30% and the weight of the pot by 60%, without sacrificing durability. The required weight reduction was such that a single person could pick up and install the pot into the refinery. In terms of durability, it is important that the pyrolysis pot is capable of at least 3000 hours of cyclical operation prior to the point of inoperable corrosion.

In order to meet the project goals, our team primarily focused on reducing the thickness of specific pot components and adjusting materials where possible. The wall thicknesses were decreased by over 50% which resulted in a significant weight reduction. The inner wall material was unchanged as an expensive, high corrosion resistance component was required. However, we were able to change the outer wall to a less costly material that maintained its corrosion resistance at a lower temperature. These alterations were informed by material testing conducted in the refinery. Various thicknesses of several alloys were tested to determine how well each resisted corrosion under temperatures approaching 900-1000 degrees Celsius. Based on these results our team was able to justify reducing the thickness of the walls as well as several other smaller components without a loss of durability.

Additionally, we ran several simulations using ANSYS to analyze the temperature profile of the pyrolysis pot. Boundary conditions were chosen through research and information gathered by attaching thermocouples to the device during operation. These results showed that the outer wall experienced much lower temperatures than the pot interior, supporting our material adjustment decision. Our group collaborated with ME10 to ensure our final design met the company's cost, weight, and durability goals.

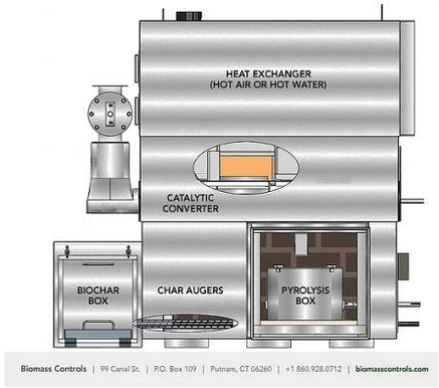
From Left: Tiffany Nguyen, Ryan Marchesseault, Ryan Berton, Prof. Bryan Weber.

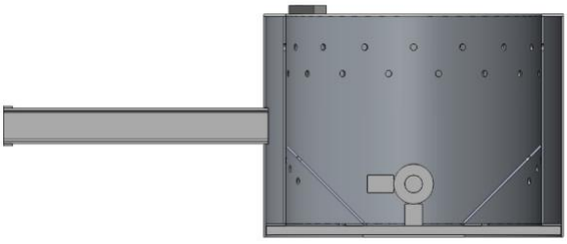
MECHANICAL ENGINEERING

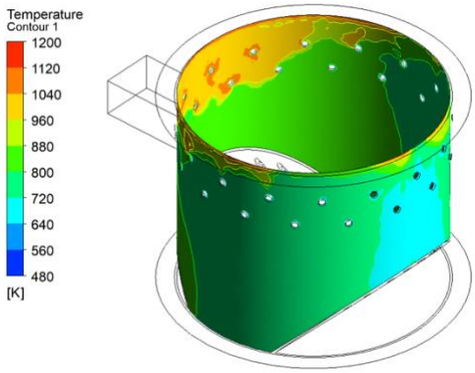
TEAM: ME10
SPONSOR: Biomass Controls
ADVISOR: Prof. Bryan Weber

Optimization of Air Flow for the Pyrolysis of High Moisture Feedstocks

BIOMASS CONTROLS







Biomass Controls is an environmental service company based in Putnam, Connecticut. Their goal is to develop solutions for health, sanitation, and environmental problems across the globe. Biomass Controls wants to tackle the sanitation crisis using their innovative Biogenic Refinery. This refinery is a thermal treatment solution that processes organic waste and converts them to pathogen-free biochar.

A major component of the Biogenic Refinery is the pyrolysis pot. This component is responsible for converting incoming biomass to biochar by a process called pyrolysis, where fuel is reacted in an oxygen-limited, high-temperature environment.

The goal of this project was to increase the amount of biomass the refinery can process while increasing biochar production. We accomplished this by optimizing the current pot to use a two-phase combustion process. This process was implemented by controlling the oxygen distribution throughout the pot. To do this, our team implemented specific hole patterns along the interior wall of the pot to direct incoming air flow. Our hole design resulted in channeling approximately 20% of incoming oxygen to the bottom of the pot, while remaining oxygen was directed to the top of the pot to react with volatiles and combust.

Controlling the oxygen throughout the pot is essential because biochar is susceptible to combustion. As a result, limiting the amount of oxygen introduced to the biomass hinders this reaction, resulting in more biochar.

Extensive analysis was conducted using ANSYS Fluent prior to the manufacturing of a redesigned pot. These simulations focused on temperature distributions resulting from newly implemented hole patterns. Additionally, these simulations encompassed both steady state and transient simulations. Furthermore, the team collaborated with ME09 to incorporate their design iterations and simulation data.

Further testing was conducted in Putnam, CT to measure the temperature distribution, mass flow rates, and biochar production of the prototype pyrolysis pot. This data was then used to validate the team's initial simulation results. After testing and performing additional simulations, we gathered the necessary information to adjust the prototype and finalize a redesign that is capable of increasing the biochar production of the pyrolysis pot.

From Left: Samuel Schulman, Professor Thanh Nguyen

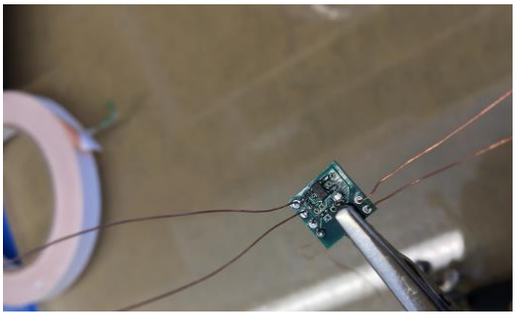
MECHANICAL ENGINEERING

TEAM: ME 11
SPONSOR: Dyadic Innovations
ADVISOR: Professor Thanh Nguyen

Breastfeeding Diagnostic Device

Dyadic Innovations is a startup company by Dr. Ruth Lucas (School of Nursing, University of Connecticut) and Dr. Jimi Francis (Department of Health and Kinesiology, University of Texas-Tyler) developing analytical and therapeutic tools to understand and promote infant health.

Our objective was to design, build, and test an integrated system of piezoelectric sensors to analyze the biomechanical processes of breastfeeding in real time. The data that the system collects can be used by clinicians to diagnose abnormalities in the breastfeeding process and recommend physical or medicinal therapies. This was a joint project with the Biomedical Engineering Department and coordinated with a Dyadic Innovations research group at the University of Texas.



Device Measurements:

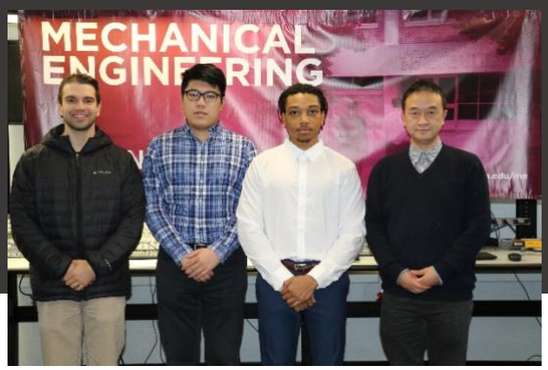
- Intra-oral negative pressure (vacuum caused by suckling)
- Changes in breast turgor (swelling and contraction of the breast)
- Swallowing, respiration, and heart rate of the infant
- Jaw movement

In order to obtain this data, parts of the device came in contact with the skin of the infants and mothers and well as the interior of the infants' mouths. To ensure the safety of all participants in our studies, all of the materials used are FDA-approved and non-toxic. Additionally, for ease of use and reusability, the materials are non-biodegradable and the data can be delivered wirelessly to a clinician via Bluetooth.

Materials:

- PMMA: Poly(methyl methacrylate), also known as Acrylic, was used to encapsulate the sensors
- PLLA: poly-L-lactide, was our piezoelectric element
- Silver was used for our electrodes

This Spring we held clinical trials of the device in order to begin establishing a baseline of data from healthy, normally-feeding infants and mothers. As more clinical trials are performed, the baseline data will be strengthened and abnormal behavior will be more easily distinguished and understood.



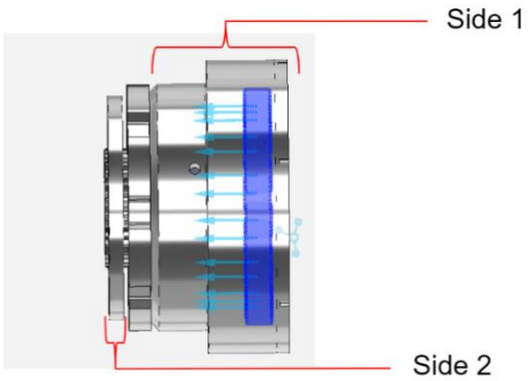
MECHANICAL ENGINEERING

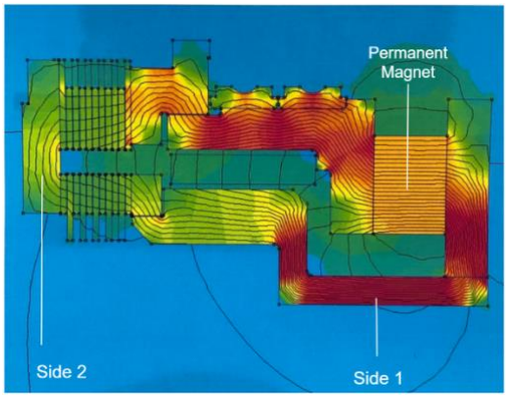
TEAM: ME 12
SPONSOR: Carlyle Johnson
ADVISOR: Professor Chengyu Cao

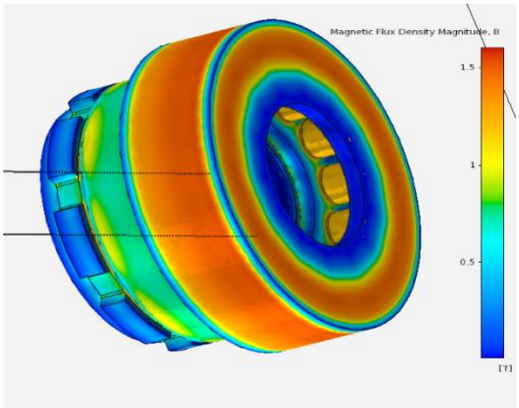
Seamus Ashburner, Yichen Shen, Michael Djanie, Professor Chengyu Cao

Optimization of an Electromagnetic Brake

THE CARLYLE JOHNSON MACHINE COMPANY



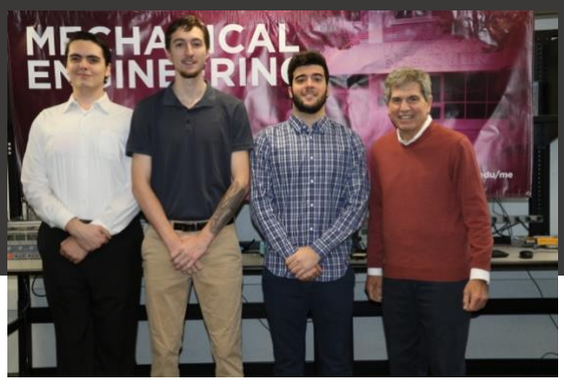




Carlyle Johnson Machine Company is based out of Bolton, Connecticut and has been an industry leader in clutch, brake, and power transmission products for over 100 years. The company designed a permanent magnet brake which is actuated by an electromagnetic coil. The permanent magnets create a field which clamps the brake together in order to slow a spinning shaft that runs through the center. The electromagnet is then activated in order to block the field of the permanent magnets and to allow the shaft to spin freely. The benefit of this electromagnetic actuation is that the brake has variable torque capabilities. The benefits of a permanent magnet brake include that it is self-contained, has no backlash, has fewer moving parts, and that it does not use fluids.

The team was tasked with optimizing Carlyle Johnson's initial brake design. Optimization made the brake provide more torque output in a smaller package, which allows it to be used in a wider range of applications. While improving the torque output has been a focus, functionality was also an important design consideration. The brake had to be able to counter the permanent magnet field with the electromagnetic coil without requiring too high of a power input to the coil. The stress on the bearings was also to be kept to a minimum in order to preserve the life of the brake. Through modeling iterations in SolidWorks and simulation in ANSYS, the team has found a design that increases torque while decreasing the overall size, without compromising functionality or manufacturability.

Another focus of this optimization was to find a way to lessen the decay of the permanent magnets over time. In order to lessen the decay, the team designed a sort of faraday cage to go around the magnets. This keeps external magnetic fields away from the magnets, which in turn keeps their magnetic strength relatively constant over time.



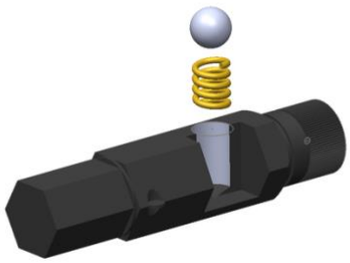
From Left: James Dignan, Andrew Gilmore, Michael Tashjian, Prof. Vito Moreno

MECHANICAL ENGINEERING

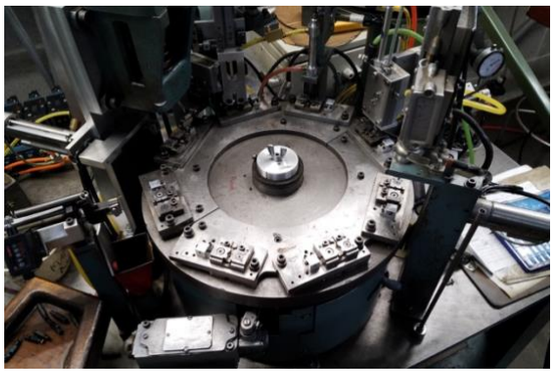
TEAM: ME 13
SPONSOR: Chapman Manufacturing
ADVISOR: Prof. Vito Moreno

Process Improvement for Automated Ball Machine

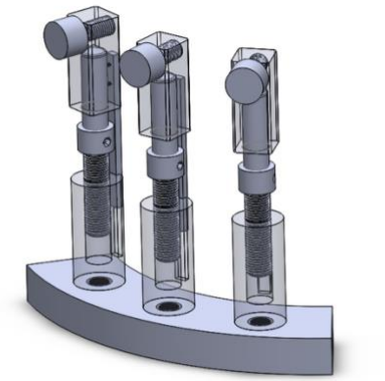
Chapman Manufacturing is located in Durham, CT and makes high quality screwdriver bits with a unique ball and spring retention system. Parts they don't make in house are sourced from American manufacturers and they have been in business for over 70 years. The ball and spring retention system makes the bits ESD (electro static discharge) safe for working on sensitive electronic equipment that is vulnerable to static discharge. Their product is used in industries including automotive, medical, and manufacturing. They also supply numerous government agencies.

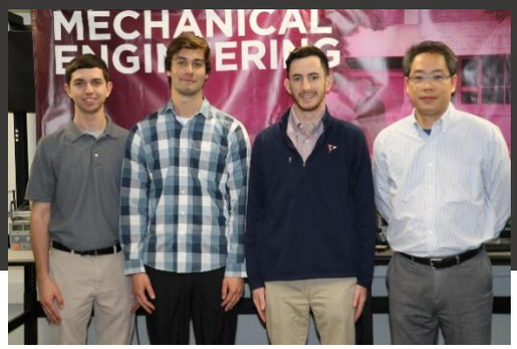


Chapman's ball machines perform the finishing operations that assemble the ball retention mechanism before the bits are packaged into a kit. An unfinished tool bit is placed in a fixture attached to a circular index table which rotates to move the bit to different operations. After each operation there is a check to ensure that it was completed successfully. After the case is machined, the spring and the ball are inserted into a hole. Then a punch deforms the metal around the hole to keep the ball in place. This process was a bottleneck in Chapman's operation. They tasked ME13 with identifying issues with the ball machine and providing solutions to improve the process of ball and spring insertion to raise the number of successful parts above 90%.



ME13 identified the primary cause of failed parts was springs dropping off center. The force of the punch would cause a deflection of the index table. This deflection, along with tight tolerances between the bit hole and spring dimensions, would cause the springs to fall out of the bits during the insertion process. Previously, the table was solely supported by a bushing around the shaft running through the center of the table, and a stop underneath the punch that did not maintain contact with the table. ME13 designed an additional support to prevent deflection of the index table. This support uses a roller design to reduce friction on the table. The new design allows the support to be put in contact with the bottom of the index table, making it easier to adjust as well as providing better support.



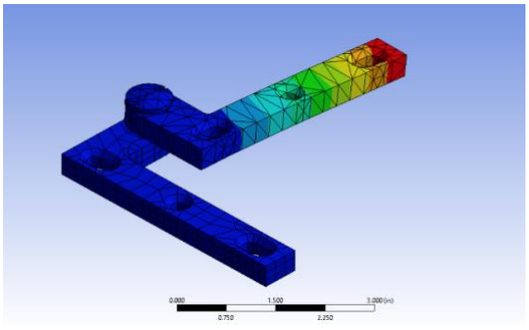


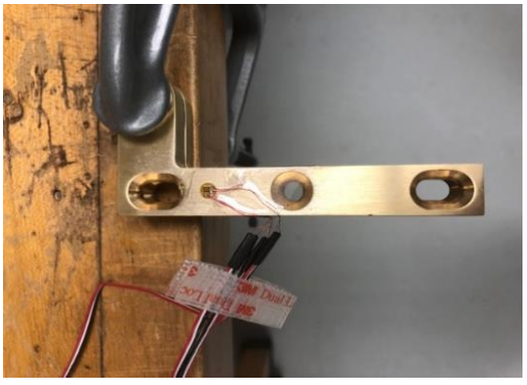
From Left: Nathan Hock, Andrew Ventres, Matthew Bonner, Professor Fan

MECHANICAL ENGINEERING

TEAM: ME 14
SPONSOR: Colonial Bronze Co.
ADVISOR: Professor Fan

Maximum Load Testing of No.6 Pivot Hinge and New Bearing Recommendation





Colonial Bronze Co. is a company based out of Torrington, Connecticut that specializes in producing and selling high quality brass hardware. Since 1930, the company has aimed to produce 100 percent domestic hardware, including their popular No.6 brass pivot hinge. These pivot hinges are used in applications with heavy doors, some of which can weigh up to 200 lbs. Inside of these hinges is a pressed-fit B56 needle bearing which helps to facilitate the rotating motion of the hinge. Colonial Bronze has designed these hinges to be reliable, durable and long-lasting, making them an exceptional choice for a variety of applications.

Colonial Bronze does not currently have the data to show the maximum loading that the no. 6 pivot hinges can support. Our team was given the task of designing a test rig to measure this maximum load. Also, since the B56 needle bearings that are currently in use are no longer readily available and have been contributing to some of the failures at higher loads, the team was tasked with finding a suitable replacement.

A simulation of the hinges assembled with a standard sized door under varied loading was conducted using ANSYS. Deformation results of the bottom hinge are displayed in the image third from the top. These results were used to determine an estimate of the maximum functional load.

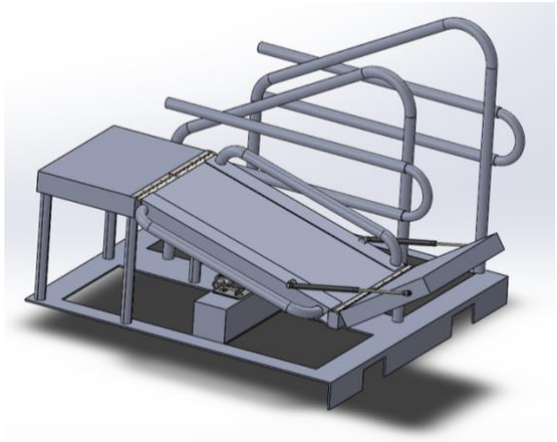
A test of the no. 6 pivot hinge with the B56 needle bearing was conducted until there was failure. At this point of failure the maximum load was noted. The bearing replacement candidates were then pressed into the pivot hinge and tested. The trials of the substitute bearings highlighted that the candidates were able withstand more weight than the original B56 needle bearing. These candidates were recommended to the sponsor. The team decided to recommend strengthening the washer within the no. 6 pivot hinge as well, by replacing it with a thrust needle bearing. This thrust bearing not only increased the maximum vertical load, but it helps to withstand from angled loads and moments caused by the door opening and closing.

From Left: Jacob Tvaronaitis, Alexander Boguszewski, Shannon Fortier, Professor Thomas Mealy

MECHANICAL ENGINEERING

TEAM: ME15
SPONSOR: Mr. Mike Payton
ADVISOR: Professor Thomas Mealy

Accessible Transfer Device for Boaters with Disabilities

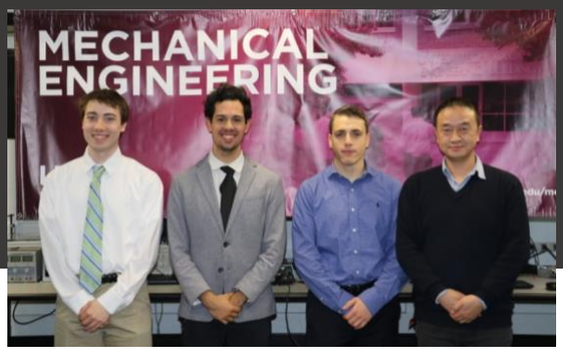


The Connecticut Department of Energy and Environmental Protection (DEEP) is charged with conserving, improving and protecting the natural resources and the environment of the state of Connecticut as well as making cheaper, cleaner and more reliable energy available for the people and businesses of the state.

Our objective was to fabricate a transfer device that will allow a person who is disabled to board a boat independently. This will be accomplished by the boater by moving from their wheelchair to the device and easing themselves down the ramp into the boat. The focus of this project is young disabled veterans who want to retain their independence.

The device is four feet wide because a boat dock is only eight feet wide. The height of the transfer seat is 17 inches above the dock to comply with the ADA seating requirement for transfer seats from wheelchairs. All materials used on the transfer device are vandal proof. Thus, stainless steel was used on the prototype and rivets are used to connect the transfer device together and to the dock. The usage of a weatherproof scissor jack allows for the height of the ramp to change. A parallel linkage system is utilized to allow for the seat to always be parallel to the water when in use, and in a retracted position otherwise. All parts of the transfer device are lightweight because they will be moved by people with various levels of mobility. Additionally, in order to account for the chance that the device will be left in the extended position, a retraction device was attached to allow for the device to retract the seat once back on the dock. The transfer device isn't mechanized as the sponsor wants it to be as simple to use as possible.

The DEEP indicated that they want to have an open patent on the transfer device so that many manufacturers can produce them without a monopoly on the market. This allows the transfer device to be affordable and available for widespread use throughout the country. There are currently no ADA standards for the docks to have a method to assist boaters into their boats, so this is the first of its kind in the public domain.



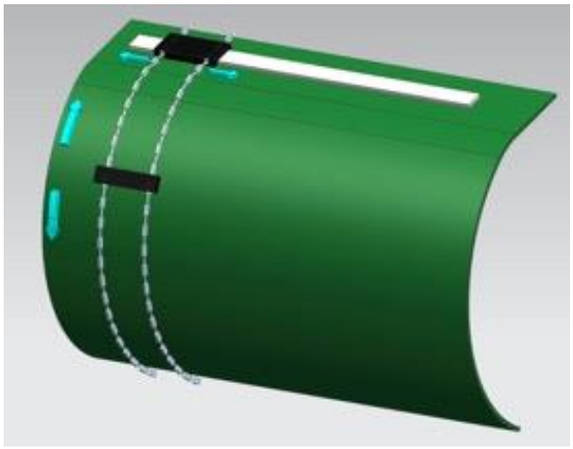
From Left: Aidan Boyce, Nick Alzamora, Jesse DeLuca, Professor Cao

MECHANICAL ENGINEERING

TEAM: ME 16
SPONSOR: Electric Boat
ADVISOR: Professor Chengyu Cao

Cylindrical Positioning System

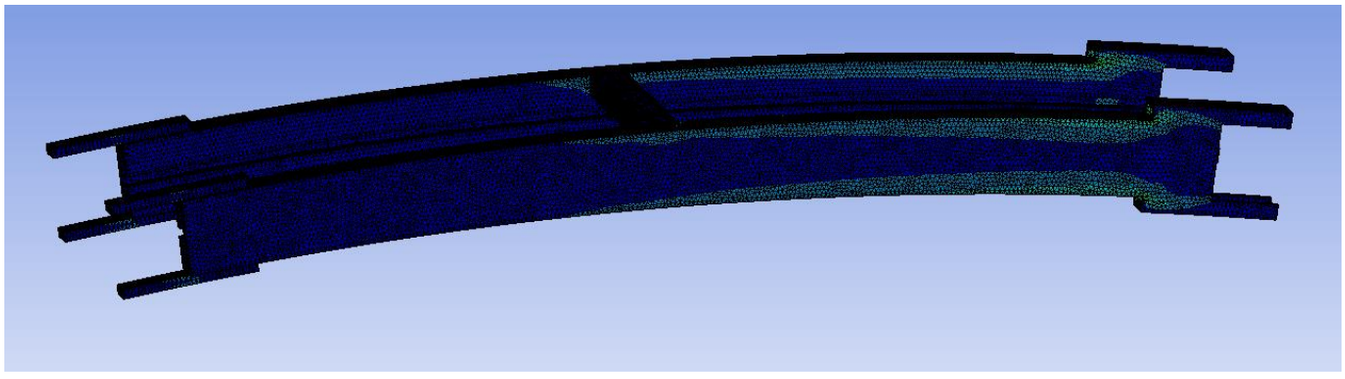
GENERAL DYNAMICS
Electric Boat

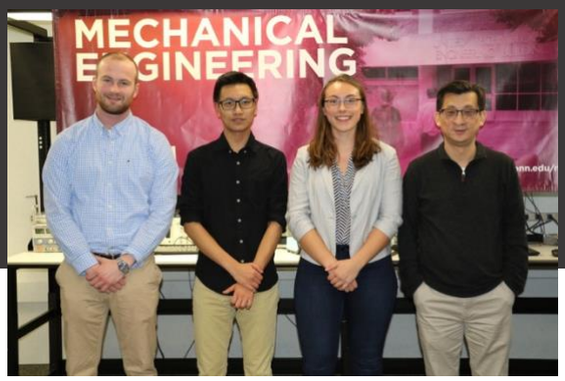


In order to analyze cylindrical objects with any type of sensor, Electric Boat has to spend lots of resources and time using a process that is inefficient and time consuming. These cylinders are a fixed radius of about 17 feet. The solution is a portable, automated system that is placed on the cylinder before analysis to move a sensor along the 3 feet of the cylinder at a time.

Our design is divided into three parts: the track, the rib and the sensor box. The track sits on top of the cylinder and moves across the top of the cylinder. It is made up of two sliders that only slide along this axis. These sliders are both controlled by belts attached to the same motor so they move simultaneously. The rib is attached to these sliders by a connector that allows the user to attach or detach rib sections. The rib goes off the side of the track perpendicularly and down the side of the cylinder that is to be analyzed. The rib is curved to fit the cylinder. Our rib is made out of Aluminum 2052-O allowing the rib to be lightweight, easily machined, and rust-resistant. Eight rib sections together weigh less than 100lbs, allowing the track to remain on the top of the cylinder without the track slipping off the top of the cylinder.

The sensor box is attached to the rib and slides down the rib on 4 wheels. A chain powered by an electric motor and spool moves the sensor box. This motor is also on the track. The box is waterproof, and fits an 8” by 11” by 6” sensor. Both motors are controlled via radio signals, and can be controlled from up to 500 feet away. The positioning system can move the sensor accurately in steps of 1” in both the circumferential axis and along the length of the cylinder.



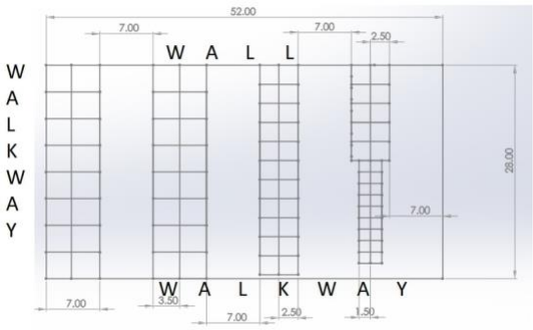


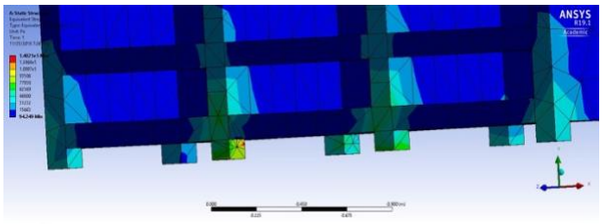
From Left: Lewis Carroll, Stephen Nieh, Emily Sweeney, Professor Jiong Tang

MECHANICAL ENGINEERING

TEAM: ME 17
SPONSOR: EDAC Technologies
ADVISOR: Professor Jiong Tang

Smart Storage of Aerospace Engine Components





EDAC Technologies Corporation is a New England based engineering company that produces precision engineered solutions and parts for a worldwide customer base. The Newington branch of EDAC houses their Aero Rotating Components division, which produces disks, shafts, blisks, and more for the aerospace industry. This project was initiated due to a lack of floor space in Newington for many incoming orders. When looking at the need for available space, it was also noted that the parts on the production floor lacked a system of organization. Parts were in unlabeled boxes and placed in any available area found between processes. Given the lack of space, boxes were often stacked 2 or 3 high, leaving anything but the top part unidentifiable.

The team was asked to design and fabricate a storage system that would increase available floor space and improve process and part tracking around the production floor. In doing so, the team deemed it necessary to redesign the boxes the parts traveled in, create a shelving system for easier access to parts, and introduce a method of trackability aligned with the goals of Industry 4.0.

In order to fix the storage and transport issues, the team designed an integrated storage system consisting of modular shelving, new ‘right-sized’ boxes, and Radio Frequency Identification (RFID) technology. The new boxes are made of ABS plastic, come in three different sizes, and will include a sleeve on the outside for storing a transport card with part information. The box also has a passive RFID chip which stores vital part information, and allows the box and part to be tracked with high precision and accuracy around the shop floor. These chips are affixed to the boxes and can be reprogrammed depending on the part inside. New shelves have also been designed so that the boxes will not be stacked and individual parts will be more accessible.

For demonstration purposes, a scaled model of the smart storage system has been built. The shelves and boxes are scaled from our CAD models and our chosen RFID system is Wi-fi based, resulting in the need for a router. In order for the part tracking to work, each box has also been outfitted with its own passive RFID chip. From any Wi-fi connected device, and with the appropriate software, the part location can be searched by part number and found in minutes. The RFID chip can also be read by an RFID scanner to produce up to date part and process data.

MECHANICAL ENGINEERING

TEAM: ME 18
SPONSOR: ABB
ADVISOR: Professor Vito Moreno

Heavy Duty Safety Switch Handle Redesign

George Wales, Ryan Osak, Areef Chaudary
Professor Vito Moreno

ABB

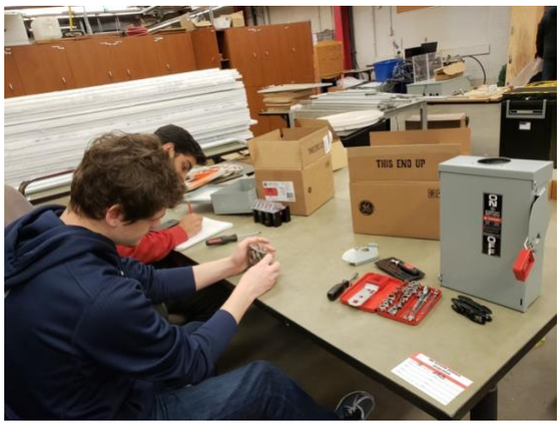
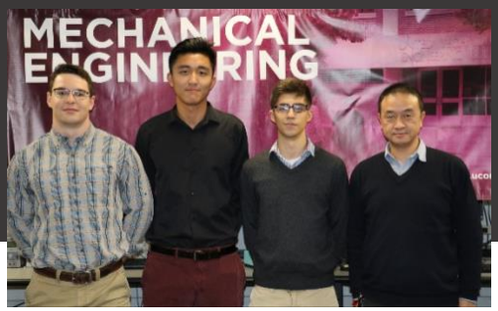


ABB aims to reduce volume in the shipping boxes of its line of Heavy Duty and General Duty safety switches by redesigning the switches' handle mechanism. The current configuration allows for excess height in the shipping boxes. This excess volume causes the boxes to collapse when they are stacked during the shipping process. The damaged packaging causes for customers or distributors to return the product. The goal of the redesign is to reduce that excess height caused by the handle in the shipping box in order to save volume and prevent the boxes from caving in.

ABB tasked ME 18 to come up with a minimum-change short-term solution, along with an alternate long-term major redesign. The short-term solution involves the handle's height to be lowered to the height of the pouch. This solution requires a minor change to the internal mechanism and a minor change to the pouch. The alteration to the mechanism allows for the handle to pivot more pass the ON position, allowing for the height of the handle to be lowered. To incorporate this increased range of motion, a slot needed to be added to the pouch so that the handle can reach that lowered position.

The long-term solution involves lowering the handle's height to the door of the switch. This solution also involves a similar alteration to the interior mechanism along with a major redesign of the pouch. An alternate pouch was designed by the team which maintains all functionalities and requirements of the current pouch. The main purpose of the pouch is for padlocking. This new pouch has an additional part that can slide up and along its base, allowing for the pouch to be level with the door of the switch when not in use. These changes allow for the handle to pivot down into the SHIP position, at the height of the switches door.

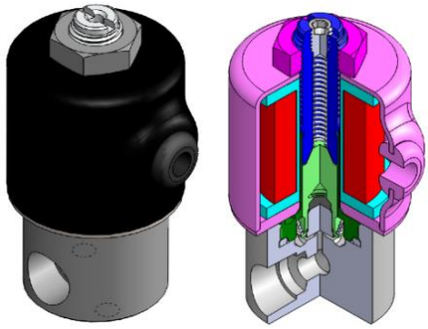


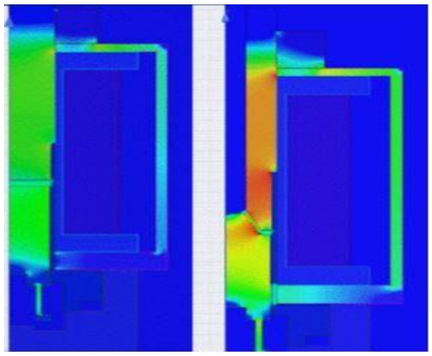
Ben Swartzell, Vincent Zhang, Luke Nichols, Professor Chengyu Cao

MECHANICAL ENGINEERING

TEAM: ME 19
SPONSOR: Gems Sensors & Controls
ADVISOR: Professor Chengyu Cao

Design of a Proportional Flow Solenoid Valve



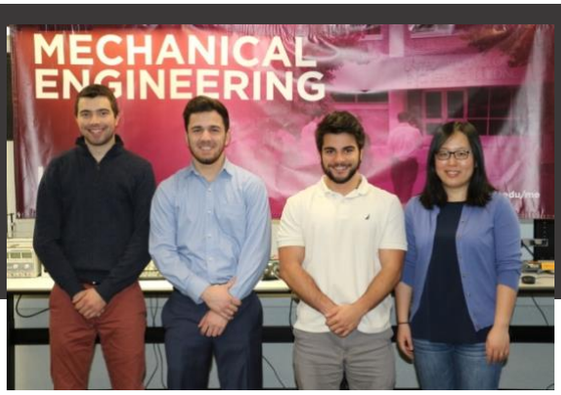


The objective of this project is to modify Gems Sensors and Controls existing B-Series miniature solenoid valve into a proportional control valve. The proportional control valve provides a range of flows between the opening and the closing of the valve. The flow will be proportional to inlet pressure and the amount of voltage supplied to the solenoid winding. This modified product meets Gems growing customer needs and expands Gems product line.

Gems Sensors and Controls both designs and manufactures miniature solenoid valves, sensors, switches, and preassembled fluidic systems. Team ME19 was tasked with modifying the existing Gems Sensors Miniature Solenoid B-Series valve so that it provides a range of flows at the valve outlet from open to close. The Gems B-Series valve our design was based on only operates as a general purpose on and off valve.

The Gems B-Series miniature solenoid valve product line provides a simple open or closed valve. This valve has no ability to control the flow through the orifice at any point between switching it on and off. Gems customers have expressed a need for a valve that would allow proportional flow: a proportional control valve would allow the end user to adjust flow through the valve by increasing or decreasing the input voltage.

The focal points in the design of our proportional control valve primarily include the redesign of the solenoid actuator, spring system, and valve plunger. The modified spring system and solenoid control the height of the plunger in a predictable manner. The modifications made to the plunger result in a more evenly distributed, stronger magnetic force on the plunger, allowing for better control. Analysis, testing, and calculations have been conducted to display a correlation between input voltage and pressure. These were used to compare predicted flow rates at the outlet of the solenoid valve to the results gathered. The analytical portion was performed via ANSYS simulation and is based on modifications that were designed in SolidWorks. Calculations were performed via governing equations, namely Ampere's law. Testing was performed with a validated test rig primarily consisting of an air compressor, flowmeter, the B-Series valve, and pressure gauges.



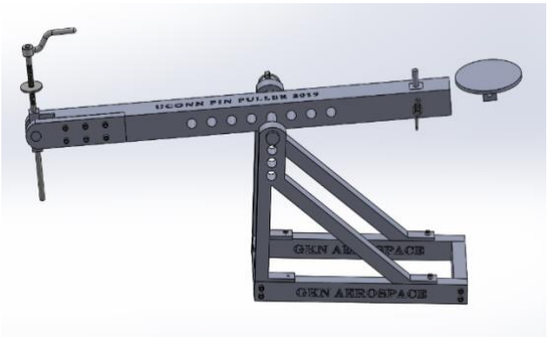
From Left: Daniel Jacobs, Christopher Woods, Daniel Izadi, Professor Dianyun Zhang

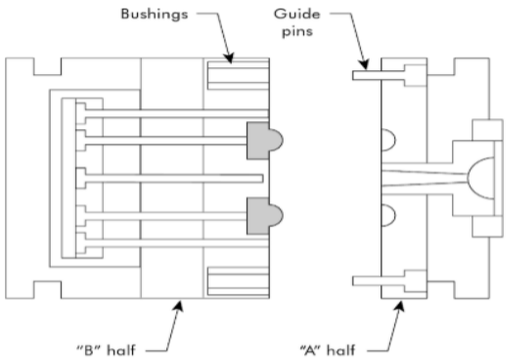
MECHANICAL ENGINEERING

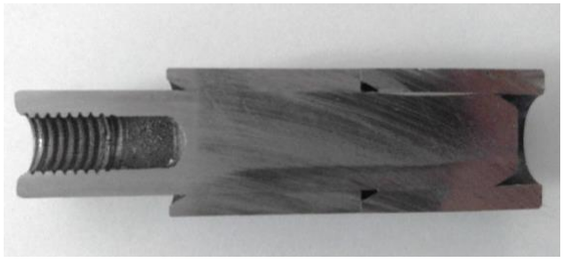
TEAM: ME 20
SPONSOR: Mr. Steven Hayse
ADVISOR: Professor Dianyun Zhang

Design of an Industrial Strength Pin Puller

GKN AEROSPACE



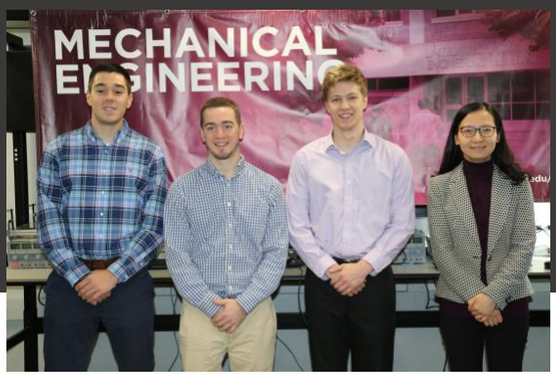




The design of an industrial strength pin pulling mechanism for use during the manufacturing process at GKN was tasked by our company sponsor Steven Hayse. As an advanced composite manufacturing company for the aerospace industry, GKN is constantly looking to optimize the tooling and processes that are associated with their manufacturing operation. The current tooling and methodology for the pin removal process at GKN has caused notable Environment, Health, and Safety concerns due to high ergonomic stress on their technicians. In an effort to solve this problem, they have tasked us with designing new tooling for the process that can improve ergonomics and increase pin pulling ability.

We began our design project by conducting research on the key factors associated with the resistive forces when removing the pin. Once these factors were established, we designed experiments that isolated each parameter in order to quantify them and create design requirements for our tool. We chose to create a lever-like tool that utilizes mechanical advantage to amplify the force administered to the tool by the technician. The tool design has adjustability in both the vertical and horizonal directions to ensure it can reach all pins in the given mold design. Thorough analysis on the tool was performed in ANSYS to ensure that it would not yield to the expected load. Tool performance was measured in terms of pin removal effectiveness, efficiency, and ergonomic stress on the tool operator.

The design is fabricated using 8020 extruded aluminum for the frame, and steel for the lever arm, pivot bar, and tool adapters. The design is modular for ease of manufacturing and to allow for changes to be made in the future. It also features an adapter on the end that can be swapped to either mount an air hammer or to be used with a sledgehammer. The entire rig will be mounted to a 1,000 pound capacity turntable, with the capability to turn 360°, move up and down, and be rolled away from the mold.



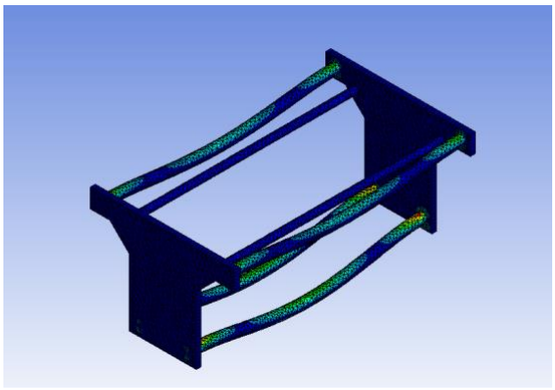
From Left: Cameron Nick, Connor Plvan, Caleb Bridge, Professor Zhanzhan Jia

MECHANICAL ENGINEERING

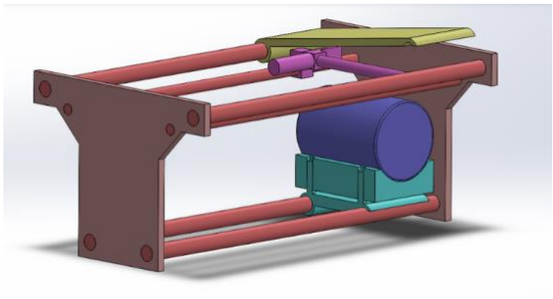
TEAM: ME 21
SPONSOR: Holo Krome
ADVISOR: Professor Zhanzhan Jia

Holo Krome Tooling Handling Device to Reduce the Change Over Time

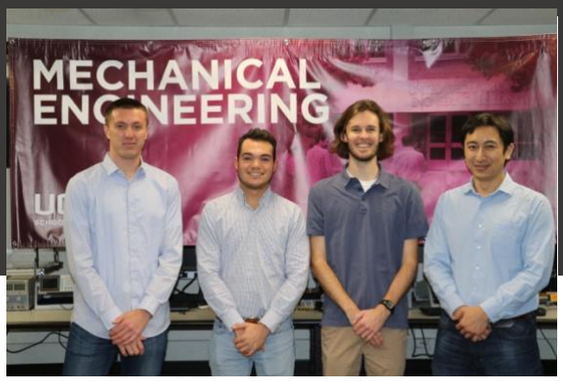
Holo-Krome is a company in Wallingford, CT that specializes in the manufacturing of bolts for critical applications. The cold-forging machines that produce the bolts use a blow-die system to progressively form the bolts. The dies must be changed out weekly as new-dimensioned bolts are used. Changing the 60 lb. dies out used to take an average of 8 hours and was an enormous ergonomic strain on the machine operators. Long downtimes on the machines lead to inefficiency and loss of operation time. Our challenge was to design a mechanism that could eliminate the safety risks for the operators and reduce the tool changeover time by at least 20%.



A die cradle was designed with the intention of transporting all four dies into and out of the machine at once via crane. Because of slight dimensional differences between the target machines, the cradle design was made to be adjustable in both the horizontal and vertical directions. This adjustability enables the cradle to be used on both machines, despite their differences. Additionally, standing platforms, tooling, and setting plates for the respective machines were designed to ensure safety and expedite the adjustment process. The cradle material was chosen to be structural steel due to its machinability, weldability, and high stress tolerance.



To validate the cradle concept, SolidWorks models were drawn and ANSYS simulations were run. These all showed that the design's movements were feasible and the cradle could easily support the necessary weight with a material stress factor of safety of 17. We also worked with our sponsor and the operators of the machine to design a prototype that would best fit the solution of the project. The first prototype was 3-D printed at 40 percent of the full-scale size to demonstrate the cradle's movements. We then made a full-size model of the cradle and tested it on-site. The result of this project was a safer, more time-efficient method of performing a tooling changeover at Holo-Krome.



From Left: Tommy Conti, Matthew Varney, Connor Grant, and Professor Jason Lee

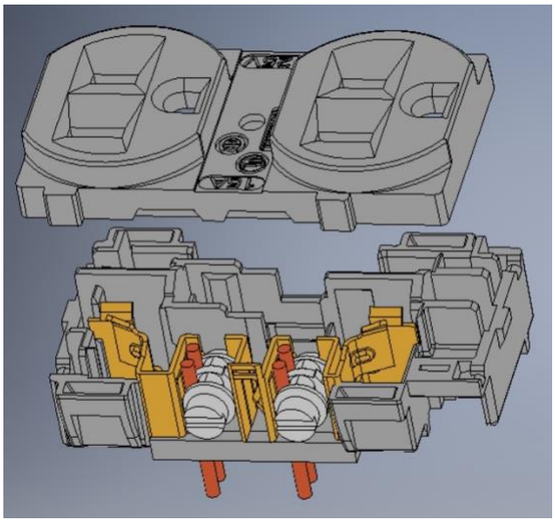
MECHANICAL ENGINEERING

TEAM: ME 22
SPONSOR: Thomas Scanzillo
ADVISOR: Professor Jason Lee

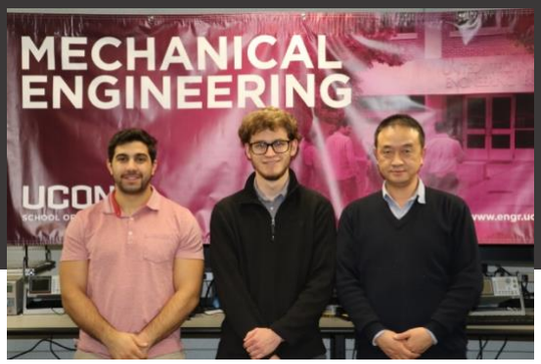
Innovative Receptacle Terminations

Hubbell Incorporated is a global leader in the design and manufacturing of electrical equipment with manufacturing facilities and subsidiaries all around the world. Hubbell's Wiring Systems Division, which is located in Shelton, CT, has tasked us with the design, development and fabrication of a brand new electric termination method to be used in 15/20A, 110V household and building receptacles. We utilized principles of creative thinking, constant iterative improvement, and rigorous testing to expand on the current designs. Our new receptacle involves a quicker and easier to use cam system, which meets all of the current requirements of the UL Safety and Security Standards.

Our main goal was to understand and attempt to improve upon the current wire securing methods. Initial testing was completed to gather data on the holding forces and the time required to insert and secure the wires. We found that the wire-binding screw method secured the wire well beyond the UL requirement, but the method was very tedious and time consuming. We also tested the much simpler push-wire insertion method and found that it held the wire just as well, but with much easier installation time. However, this method is not very consistent, and would need to also be improved upon. We learned that going forward our method would need to be secure, repeatable, and easy.



With our results from analyzing the current wire termination methods, we separated the different forces at work that hold the wire. After understanding that bending, compressing, and cutting into the wire were the forces at play, we set out to create a system that would incorporate all three. In our new design, we decided on a cam that would bend the wire against a sharp edge of the brass contact, while also compressing it against the flat surface of the contact. In order to test the capabilities of the cam and to determine the dimensions for it to be effective, we created an adjustable test rig with interchangeable cams. By adjusting the cam distance and shape, we eventually determined the best one. In addition to this, the rig would allow us to test different methods for applying torque to rotate the cam into the wire. Our final design incorporated our best design and our best method to actuate the cam.



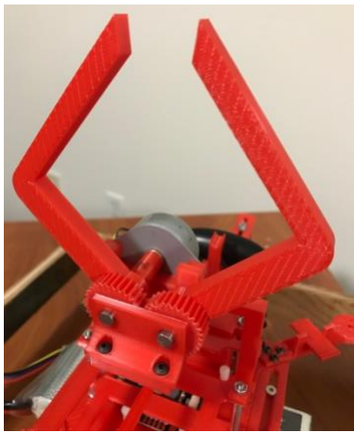
From Left: Anthony Vournazos, Kristjan Maandi, Professor Chengyu Cao

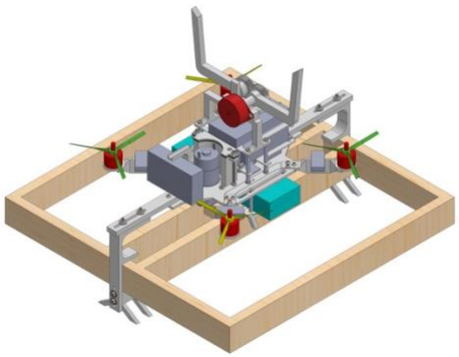
MECHANICAL ENGINEERING

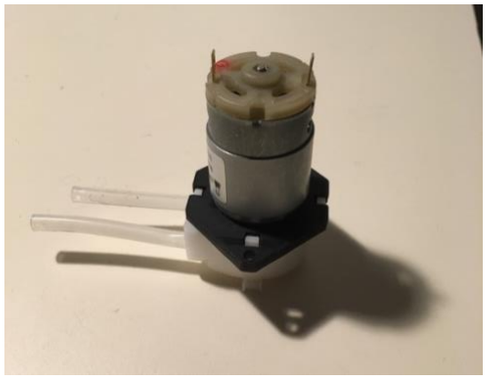
TEAM: ME 23
SPONSOR: Reverge Anselmo
ADVISOR: Professor Chengyu Cao

Ibis Insect Killer

UCONN
SCHOOL OF ENGINEERING







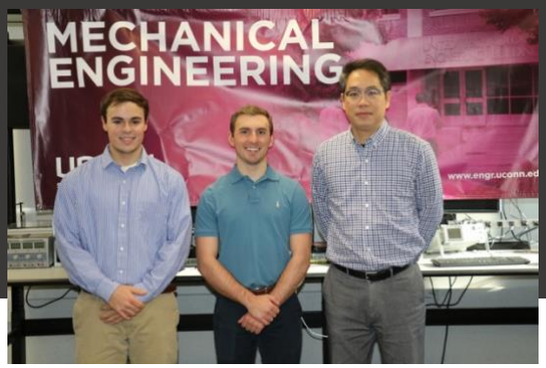
The Ibis insect killer is a custom drone built for three purposes – to eliminate invasive insect nests around the home, to cling to tree branches up to 2 inches in diameter, and to carry a payload. It is able to do this with several commercially available parts mounted on a custom 3D printed frame. With its four powerful motors, the Ibis is capable of conducting its mission with a total flight time comparable to drones currently on the market.

Using small rubber grips, the attachment system for the payload maintains a tight grip during flight for payloads up to 14” x 14” x 1.5” in size and 18 oz in weight. If the user decides carrying a payload is unnecessary for a given mission, the attachment system can be removed to significantly reduce the size of the drone.

In order to eliminate insects, the Ibis uses a small water pump. The drone is equipped with a tank filled with insecticide. One of the sprayer’s tubes is in the tank while the other is used to aim at the nest.

A motorized system at the top of the drone operates two arms that can easily grasp objects up to 2 inches in diameter. Pushing a button on the remote control activates the arms to close so that the drone can cling to a tree branch while consuming little battery power. When ready to fly again, sending a command to the onboard microcontroller from the remote control opens the arms and allows the Ibis to continue its mission.

The Ibis replaces the need for a human to directly interact with any unwanted insect nests. With the robot arm, the Ibis can hang and last longer in the field without consuming much battery power. If needed, the ability to carry a payload can expand functions of the drone.

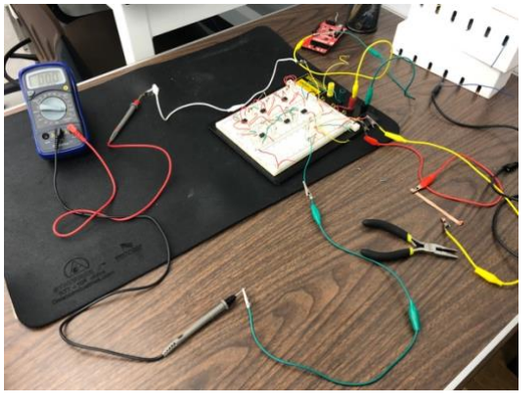


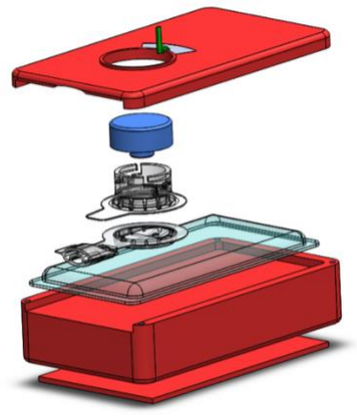
From Left: Neil Chamberland, Matthew Grasso, Professor Tai-His Fan

MECHANICAL ENGINEERING

TEAM: ME 24
SPONSOR: InnovationCooperative3D
ADVISOR: Professor Tai-Hsi Fan

Design Update to the 1TOUCH Precise Adjustable Dispensing System





The Design Update to the 1TOUCH Precise Adjustable Dispensing System project is an effort initiated by sponsor company InnovationCooperative3D (IC3D). The 1TOUCH Liquid Dispensing System is an idea that has been developed and refined by IC3D for the past ten years. Its purpose is to revolutionize the liquid dispensing market with a better dispensing system that can be used in a variety of applications and settings. The 1TOUCH dispensing system is accurate (dispenses a consistent volume of material), eco-friendly (soft plastic pouch and pump, 85% less material vs. conventional bottle and closure), easy to use (single finger press action), efficient (evacuates over 98% of dispensed liquid), and airless (does not take up unwanted space, can be used in any orientation, and preserves product). All of these aspects offer advantages over present day liquid dispensing devices.

The sponsor wants to improve the 1TOUCH idea by incorporating new features onto the preexisting design. An updated 1TOUCH system has been developed that can adjust the amount of liquid being dispensed, prevent the user from improperly dispensing a non-complete dose, and wirelessly communicate valuable data through a smartphone app. Team members from the Mechanical Engineering (ME) department were tasked with finding solutions to the adjustability, complete-stroke verification, and mechanical-to-electrical communication aspects of the project. To accomplish this, an iterative design process was conducted. Various CAD models of possible designs were made using SolidWorks and then were brought to life using 3D printing. From these 3D prints, design updates were made until a working prototype was developed. Team members from the Electrical and Computer Engineering (ECE) department were tasked with developing the smartphone application, wireless connectivity, and circuit components. To accomplish this, a printed circuit board that attaches to a Bluetooth microcontroller was developed. A smartphone app was also developed by the ECE team members using Flutter. The microcontroller wirelessly communicates with the app, which sends important data to the user's phone. These electrical components were then integrated with the mechanical design, resulting in a final proof-of-concept for IC3D.

From Left: Jacob Parent, Henry Courchaine, Garrett Murphy, Spencer Padget, Professor Thomas Mealy

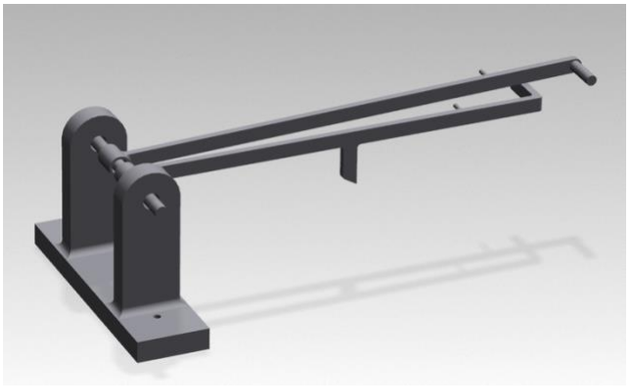
MECHANICAL ENGINEERING

TEAM: ME26

SPONSOR: Department of Public Works, City of Hartford

ADVISOR: Professor Thomas Mealy

Restoration of the Keney Memorial Tower Clock Mechanism



The Keney Memorial Clock Tower is located in Hartford CT at the crossroads of Main, Ely and Albany Street. The Clock Tower was established in 1898 and dedicated to Henry Keney's mother for the foundation of Keney Park. It is 130 feet tall and contains a clock and chime/bell mechanism built by the I.T. Verdin Co. The mechanism is original to the tower but the motors and system control were changed over the past 100 years in an attempt to keep the mechanism operational. However, the clock has been inoperable for the past few years and the Department of Public Works of the City of Hartford tasked our team with restoring the clock, hour bell and chimes mechanism back to operational condition.

Initial evaluations of the clock lead to the discovery of multiple failures throughout the mechanism including seized faces, missing linkage arms, damaged gears and an inoperable control unit. Of the four faces on the clock, three were brought to full function after one of the faces was determined to be unsafe to repair. The linkage arms inside the mechanism are responsible for activating the bell and chimes at appropriate times of day. Using the remaining portions of the mechanisms we designed and fabricated new linkage arms to reconnect the chime/ bell to the clock mechanism. After research and consultation with The Electric Time Company, a new control unit and drive motor were chosen to replace the existing inoperable unit. In conjunction with this controller, the bell and chimes mechanism were wired into a timing system, in order to prevent them from activating during night time hours of operation.

By combining the modern controls of today with the historic mechanisms of the clock we hope this project will help continue the rich history of the clock tower. The organizations sponsoring this project have great ideas to continue the improvement of the park and we believe this project will help them to build. The modern controls provide more options for future music and chiming options and a plan for the remaining clock face will provide a solid starting point for those repairs to be safely conducted.

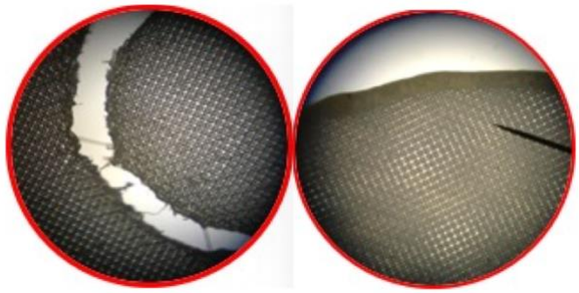
Left to Right: Kalie Pasqualicchio, Michael Freebairn, Justin Hoyt, Professor Savas Tasoglu

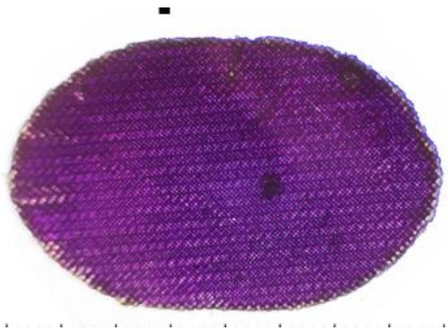
MECHANICAL ENGINEERING

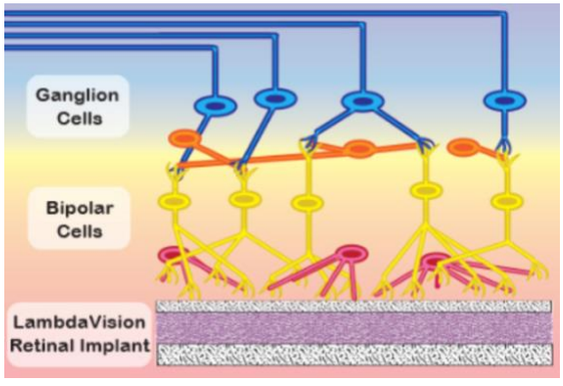
TEAM: ME 27
SPONSOR: Dr. Jordan Greco
ADVISOR: Professor Savas Tasoglu

Heat Sealing Apparatus for an Artificial Retina

LambdaVision



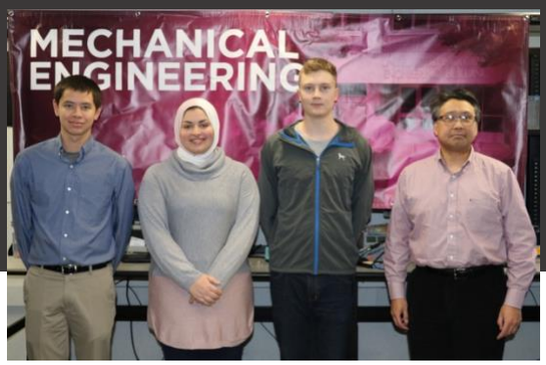




Lambda Vision is a company working with the protein Bacteriorhodopsin in order to replace lost photoreceptor cells within the retina to help people with Age Related Macular Degeneration and Retinitis Pigmentosa to regain vision. In order to implant this fabricated protein into the eye it must be sealed with the polymer Mylar to prevent the bacteriorhodopsin from becoming unviable, rubbing off, or separating. ME 27 was tasked with designing a way in which to both cut out the proper sized implant while also sealing it to the Mylar. The challenges of this comes from the different sizes for both the human implant and the rat implant as well as the differences in melting temperatures and temperature capacities of the two materials. The human implant is 4 mm x 2.5 mm while the rat implant is 1.5 mm x 0.75 mm. The small size of the rat implant makes cutting with smooth and consistent edges very difficult. In addition, the Mylar melts and therefore seals at a temperature of 200°C however the Bacteriorhodopsin becomes unviable at temperatures above 80°C. This is problematic because the implant must be sealed while still maintaining the desired and required surface area of protein.

To solve this problem our initial design idea was to use a chuck drill press and heat the attached die using either 26g nichrome wire or a heating coil and a voltage source. Due to insulation, accuracy, and repeatability concerns it was decided that another approach was needed. The final design became using a laser cutter at 10W of power and a very low speed setting for the human implant in order to allow for sealing and cutting to occur without causing extensive damage to the protein. For the rat implant a combination of the original design idea and laser cutter is used because the laser could not cut out a radius as small as the rat requirements. The implant is first cut and sealed by the laser cutter at an even lower speed setting but with a bigger area than desired. The slower speed allows for more singeing to occur which creates more sealed area with a smaller area of viable protein. The implant is then moved to the chuck drill press where the final cut is made bringing the implant to the desired size.

In addition to the creation of these processes, developments of quality control were created in order to determine a way to deem a successful implant versus an unsuccessful one.



From Left: Austin Gallimore, Menna Elfouly, Liam Perkins, Professor Wilson Chiu

MECHANICAL ENGINEERING

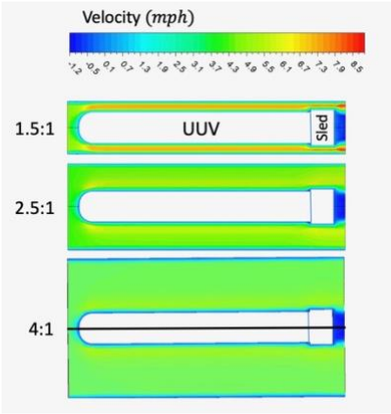
TEAM: ME28

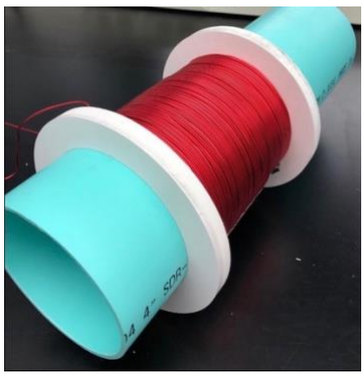
SPONSOR: Naval Undersea Warfare Center

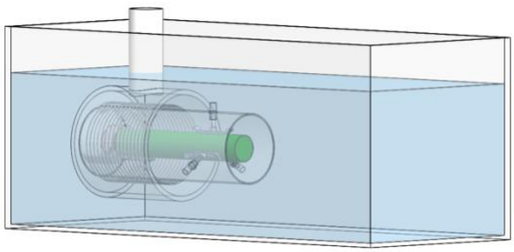
ADVISOR: Professor Wilson Chiu

Electromagnetic Expulsion of Unmanned Underwater Vehicles

NAVSEA WARFARE CENTERS
NEWPORT







The Naval Undersea Warfare Center (NUWC) is the United States Navy's research division. NUWC develops, improves, engineers, and tests technologies to aid the nation's fleet of naval vessels. A current area of research is the launching of unmanned underwater vehicles (UUV's) from surface vessels and submarines. These UUV's are used for reconnaissance missions, surveillance and mine detection, so launching them from submarines is optimal. Our group has been tasked with determining the feasibility of using an electromagnetic scheme to launch UUV's from submarines to replace a current method water slug method.

To test the feasibility, we have designed and built several prototype concepts and analyzed different design iterations' performances. Our design utilizes a fully waterproofed coil with an integrated circuit and control system to generate a magnetic field. This magnetic field propels an sled that is held in the center of the launch tube. The sled in turn expels the UUV.

With this design we can obtain a predictable amount of force without relying upon the magnetic properties of the UUV itself. We have been able to optimize the coil and circuit design, sled design, and UUV restraint system design to ensure smooth and predictable launches. Factors include coil geometry, number of coil turns, and the material/shape of the sled to optimize magnetic field, magnetic permeability, and friction forces. The restraint system of the UUV has also been optimized to securely hold and release the UUV before and during launching. A fluid simulation study, helped us minimize fluid drag to ensure that the most of the generated force was being exerted onto the UUV.

The sled material most ideal for this application is a high carbon steel. It is held in the center of the coil/tube using a pipe crawler type system to allow for axial motion. Once fired the sled moves through the coil, pushing the UUV, and eventually hitting stops to ensure it stays within the tube. This fully expels the UUV after which it can engage independent propulsion systems.

Left to Right: Rafael Almeida, John Kostal, Joshua Rubino, Professor Nejat Olgac

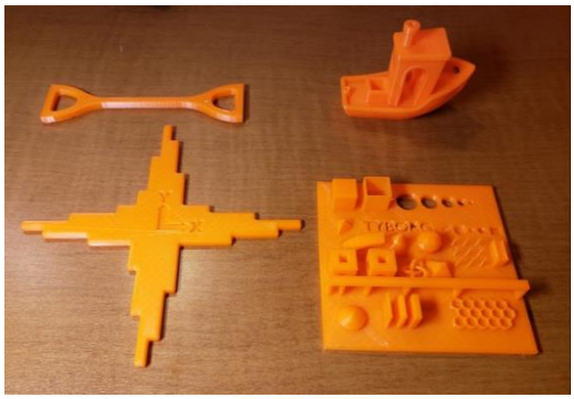
MECHANICAL ENGINEERING

TEAM: ME 29

SPONSOR: Naval Undersea Warfare Center

ADVISOR: Professor Nejat Olgac

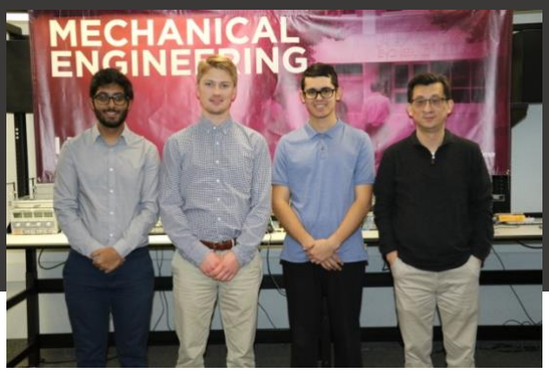
Stabilizing a 3D Printer in a Dynamic Environment



The Naval Undersea Warfare Center (NUWC) is the United States Navy's main source of research and development, test and evaluation, engineering, and offensive and defensive weapons systems. 3D printing, an additive manufacturing process, is becoming increasingly desirable due to reduced cost and high accuracy capabilities for prototyping and production. In order to use such a device on naval vessels, technology will need to be implemented that allows additive manufacturing in a non-stationary environment subject to dynamic motion.

Given the high demand for precision parts and the fact that naval vessels spend weeks to months away from shore, 3D printing is an attractive alternative to stocking up on pricey replacement parts. Surface ships are subject to six degrees of freedom, that translation and rotation along and around the x-, y-, and z- axes. Three degrees of freedom have little impact on printing conditions, so pitch, heave, and roll are the focus for developing a stabilization system. The two sources of dynamic motion on a ship come from the low amplitude, high frequency vibration of machinery, and the varying motion caused by ocean waves. These two sources of motion must be tackled separately in order to produce an acceptable stabilization system.

The printer's stabilization system consists of three linear actuators programmed to counter the vessels heave, roll and pitch. Sensors along the base of the printer communicate the inclination of the base to the actuators. The actuators will then correct for this motion, and leave the printer in an upright position. Vibration isolators are mounted between the printer and the printer base to damp any external vibrations from inside the vessel. Tensile and dimensional accuracy tests are implemented to ensure homogeneity among parts in both static and dynamic operating conditions. This allows printed parts of complex geometries to be dimensionally accurate while being homogeneous and robust.

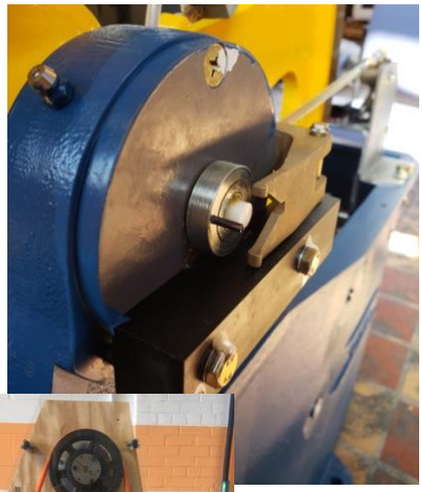


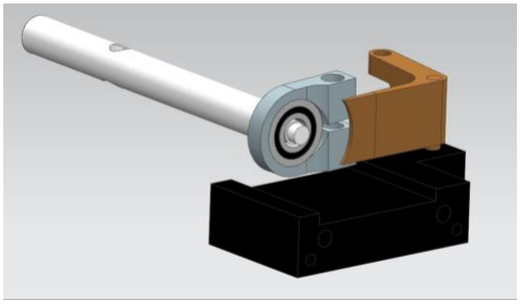
From Left: Sami Mahmud, Chris Milne, Derek Falcon, Professor Jiong Tang

MECHANICAL ENGINEERING

TEAM: ME 30
SPONSOR: Randy Dube
ADVISOR: Professor Jiong Tang

Elevator Overspeed Governor Modification

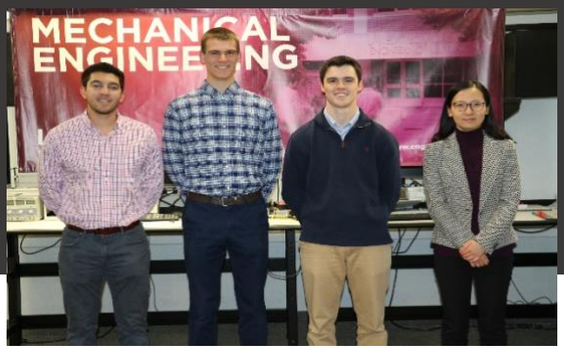




The Otis Elevator Company designs and manufactures elevators for international customers for a wide range of applications. In an elevator system, an overspeed governor is a safety device connected to the elevator that actuates an Over Speed switch and safety devices in response to an elevator car exceeding preset speeds. The control system, depending on the magnitude of speed, either cuts off the power supply to the elevator motor and applies a motor brake, or if that fails and the elevator continues to accelerate, the governor trips a latch which allows a jaw to drop. When the governor jaw drops, it clamps the elevator rope between it and another jaw, which engages safety devices with the guide rails to decelerate the elevator car safely.

Currently, nearly all governors have the same up and down speed limits. Tall buildings generate revenue through tourist visits to top floor observation decks. Passenger comfort limits the down direction speeds, but the up direction speeds can be greater. Therefore, the objective of this project was to modify an existing governor to allow a higher speed in the up direction without actuating the existing down direction Over Speed switch or tripping the governor jaw. Additionally, down direction operation was to be kept the same and a new Over Speed switch was added for a higher speed operation in the up direction.

In the original design, as the sheave rotation increased, a bearing traveled axially outward and perpendicular, with respect to a mechanism, eventually impacting and turning a bell crank. For the modification, a bearing clamp, designed in NX, was used to change the rotational orientation of the bearing with respect to the bell crank. The bearing clamp was fastened to a replacement bearing. In the down direction, the clamp impacts and turns the bell crank, while in the up direction the bearing clamp rotates to avoid contact with the bell crank. We created a test rig with a data acquisition system that replicates an elevator rotating the governor sheave. This fundamentally mechanical design allows for a robust design with limited complication and no need for electrical parts.



From Left: Reilly Eldredge, Ryan Wendt, Connor Gaffney, Professor Zhanzhan Jia

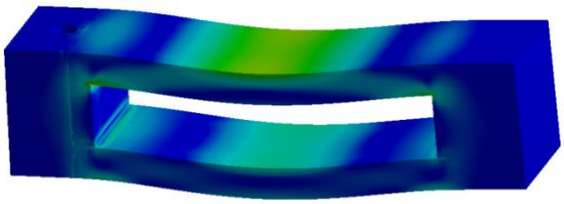
MECHANICAL ENGINEERING

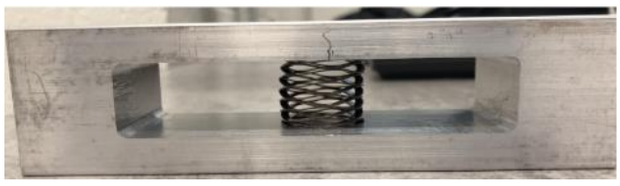
TEAM: ME 31
SPONSOR: Pratt & Whitney
ADVISOR: Professor Zhanzhan Jia

Damping Vibrations of a Double Cantilever Beam

Pratt & Whitney
A United Technologies Company

HALO Seal

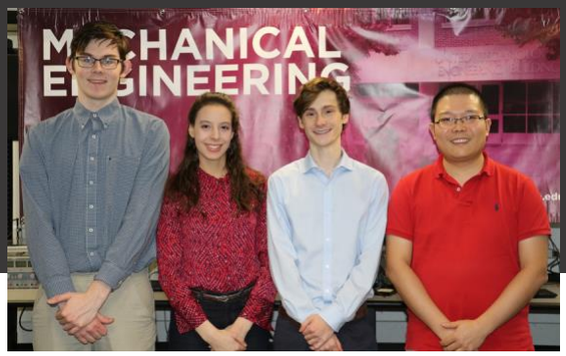




Pratt & Whitney is one of the world's largest producers of jet engines, with a wide variety of applications. The goal of this project was to increase the lifespan of a HALO seal – a part contained inside Pratt & Whitney engines. This project was focused on damping vibrations in the double cantilever beam structure that appears in the HALO seal by placing a damper between the beam's arms. The main purpose was to assess the viability of using springs as damping devices in the beam. Additionally, we tested synthetic dampers to evaluate ideal damping methods, understanding that the material would not be viable in an actual engine. The motivation for using spring dampers was to minimize deflection in the beam while vibrating as this reduces the high cycle fatigue of the part and increases lifespan.

In order to test this, we designed and built a model structure of the beam and tested a variety of springs to determine their effectiveness. The model did not have the same dimensions but contained the same overall geometry and structure of the real beam. We simulated the beam being in operating conditions by mounting the beam to a shaker table platform for testing. To approximate the operating conditions of the seal, the beam was vibrated with one end fixed to the shaker and the other end free.

Furthermore, testing was done to determine if the addition of springs made a significant impact on the resonant frequencies of the beam. An impulse response test was done on each beam-damper configuration to measure resonant frequencies. With this information we were able to better inform Pratt & Whitney how adding springs to the beam affected resonance frequencies.



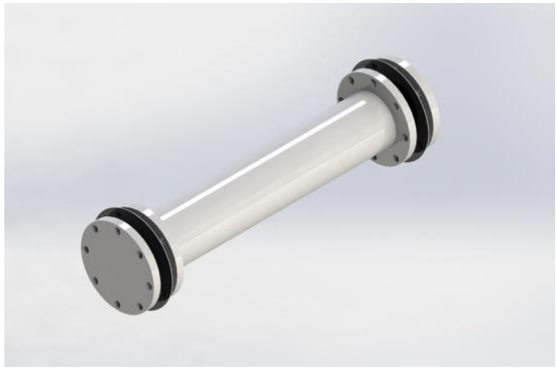
From Left: Nikita Noskov, Leena Chacrone, Ethan D'Orio, Professor Ying Li

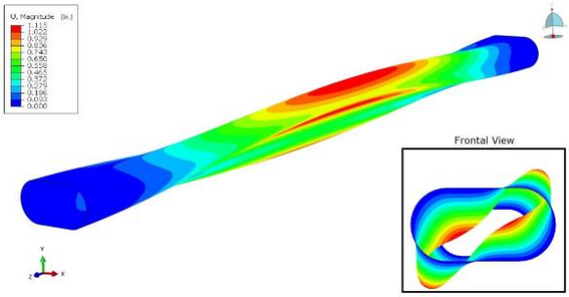
MECHANICAL ENGINEERING

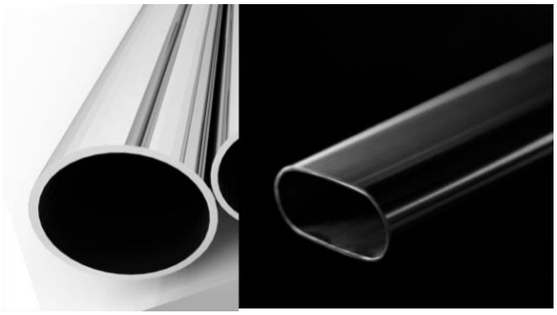
TEAM: ME 32
SPONSOR: Pratt & Whitney
ADVISOR: Professor Ying Li

Buckling of Non-Round Pressure Vessels

Pratt & Whitney
A United Technologies Company



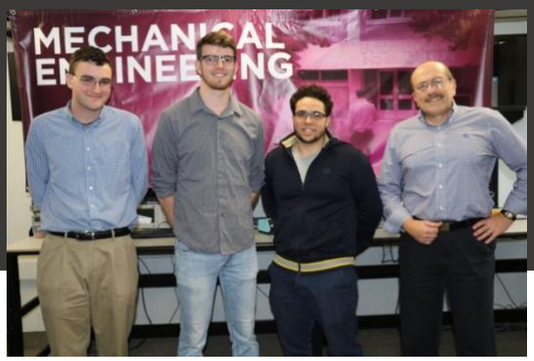




United Technologies Corporation is an American multinational conglomerate in many fields such as aerospace and climate controls. Pratt and Whitney is a subsidiary of the United Technologies Corporation that focuses on designing and manufacturing aerospace engines and auxiliary power units. With headquarters in East Hartford, Connecticut, Pratt and Whitney is a global company with customers in 180 countries and over 30,000 employees. The company works on both commercial and military engines.

These engines are complex systems with multiple piping networks for delivering fuel, oil, and coolant. Due to the compact nature of these engines, there are size constraints that affect the design process. Sometimes these constraints cause pipes to be designed with non-circular cross sections. While this is ideal for space considerations, the non-circular geometries of these sections buckle at lower pressures than their circular counterparts. The buckling of any pipe on the engine is catastrophic and could lead to total engine failure. The purpose of this senior design project is to investigate the critical buckling pressure of various non-circular cross sections of pipe, and develop a prediction model to help determine when these segments will buckle.

In order to fulfill the requirements of this project, our team has used analytical, simulation, and experimental methods to explore the properties of non-circular pipe segments. Baseline analytical calculations were done to verify the critical pressure of circular sections of pipe, taking into consideration the effects of radius, wall thickness, and length. These results were then compared to a buckling simulation performed in ABAQUS. After these results were verified, the team began investigating the critical pressures and associated buckling modes of non-circular sections. Lastly, the team designed a sealed pressure chamber that could simply support 3-foot sections of pipe to test the critical pressures of varying sections of pipe experimentally. The results of the simulations and experiments were combined to develop a predictive buckling chart. This chart will allow Pratt and Whitney to determine the critical buckling pressure of a pipe based on its geometric features.



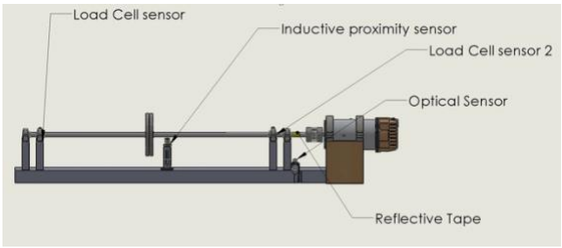
From Left: Asher Freedman, Russell Andrew III, Jose Grullon, and Professor Nejat Olgac

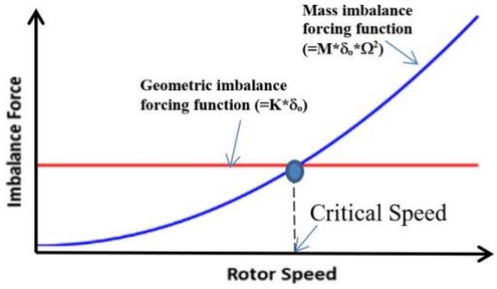
MECHANICAL ENGINEERING

TEAM: ME 33
SPONSOR: Pratt & Whitney
ADVISOR: Professor Nejat Olgac

Evaluating the Effects of Geometric and Mass Imbalance on a Jeffcott Rotor System

Pratt & Whitney
A United Technologies Company

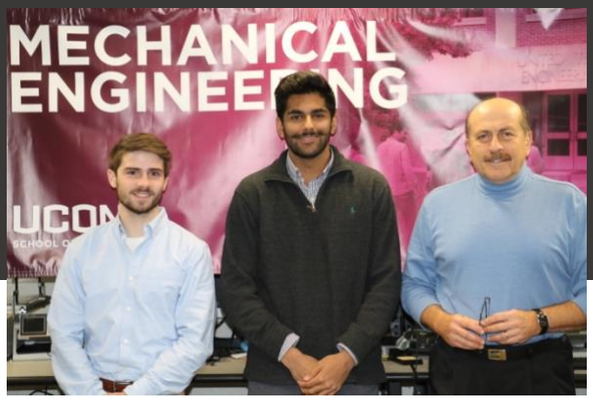




Pratt and Whitney is a fortune 500 company based in East Hartford, Connecticut which makes engines for civil and military aviation. Central to most airplane engines is a large rotor system, in which even minute deviations from the design parameters can cause a decrease in efficiency. One form of deviations is an imbalance. The most common and researched form of unbalance is the mass imbalance, which causes a centripetal force from the central axis which causes an effect called whirling. Whirling is a source of inefficiency in engine design, and is therefore avoided. Mass Imbalance is well investigated, and so there are many known ways to minimize its effects. A similar effect, geometric imbalance, is caused by a bending of the axis of rotation in a rotor. This effect, however, is much less well defined and researched. Pratt and Whitney believe that the geometric imbalance would be canceled out by a mass imbalance which produces the a total inertia in the direction opposite the imbalance when the vectors of the imbalance force equal and cancel the geometric imbalances displacement.

Given the lack of knowledge available on geometric imbalance with regards to its effects on rotor systems, our team was given the task of constructing a rig and testing the geometric imbalance's effect on the rotation of the rotor, and to investigate if it can be corrected with a mass imbalance. Additionally, we were to test and verify the known effects of mass imbalance on our system, at several different rotational speeds to ensure a wide breadth of data.

We constructed a rig with a set of four bearings, the innermost of which had a variable height, which introduced a bend in the shaft of our rotor. Our design further included a bored ring on the outside of the rotor's disc, which we used to balance the rotor before testing the effects of the imbalances we aimed to introduce. Using this rig we were able to evaluate the effects of the mass imbalance on the geometric imbalance, and were able to confirm our proposed relationship.



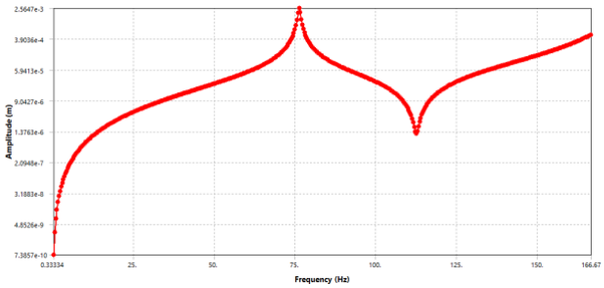
From Left: Michael Rutledge, Abdullah Choudhry, Professor Nejat Olgac

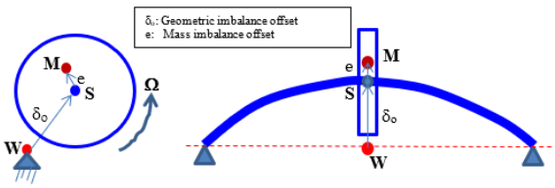
MECHANICAL ENGINEERING

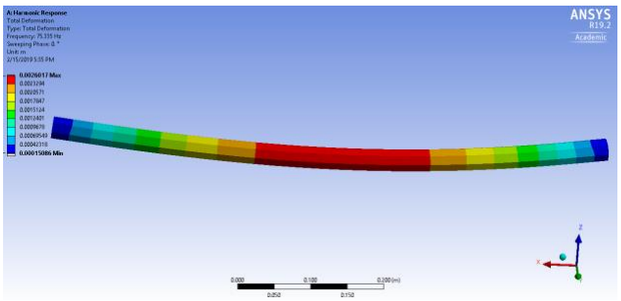
TEAM: ME 34
SPONSOR: Pratt and Whitney
ADVISOR: Professor Nejat Olgac

Analytical Geometric Imbalance Investigation

Pratt & Whitney
A United Technologies Company







The investigation of geometric and mass imbalances on jet engine shafts is paramount in order to keep people safe. Mass imbalances are introduced by the deviation of the center of mass from the spinning center. When this occurs the force of the imbalance will increase as a function of the rotational speed squared. This phenomenon has been resolved with balancing weights, or additive/subtractive manufacturing. Another phenomenon that is not so easily fixable is a geometric imbalance. This imbalance occurs due to a deviation of the shafts spinning center from the bearing axis. This causes the shaft to bend slightly. The bend can be caused by stacking of rotors, a temperature gradient, or loads from acceleration. These can cause whirling of the shaft, which is the extreme amplification of the shaft. The shaft whirls about the bearing centerline as its axis, which isn't necessarily the same as the spinning axis of the shaft. What we had to do was solve this geometric imbalance by introducing a mass imbalance, or balancing weight. By introducing a mass imbalance, this force of the eccentric mass balances the geometric imbalance when the force of the mass imbalance moves out of phase with the shaft.

A study into the critical speeds of shafts was also conducted. Critical speeds are the angular velocity of the shaft that excites the natural frequency and results in the largest deflection of the shaft. This can be noted in the frequency vs amplitude graph. The large jumps in amplitude are the critical speeds of this particular shaft.

This project aims to analytically compare the vibration response of mass imbalances and geometric imbalances and determine whether geometric imbalances can be offset by introducing mass imbalances. Team ME 34 simultaneously worked with ME 33, which carried out an experimental analysis of these phenomenon.

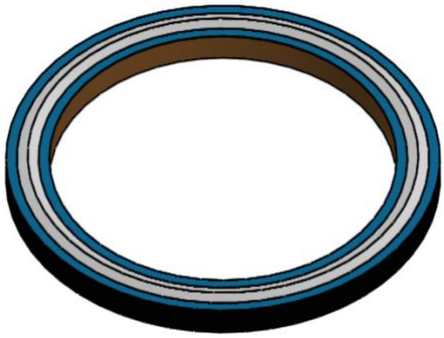
From Left: Vasyl Davydov, Joshua Rahal, Arthur Brizido, Professor Ryan Cooper

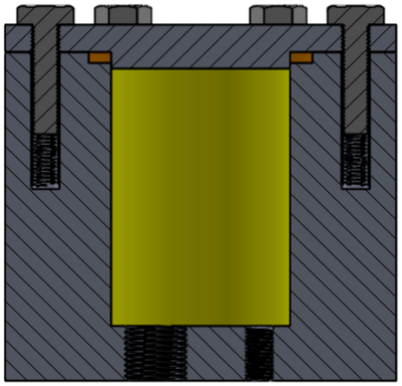
MECHANICAL ENGINEERING

TEAM: ME 35
SPONSOR: Pratt & Whitney
ADVISOR: Professor Ryan Cooper

Graphite Gasket Test Rig

Pratt & Whitney
A United Technologies Company





Pratt & Whitney is an American aerospace manufacturer that specializes in design, manufacturing, and service of aircraft engines and auxiliary power units. Our team has been given the opportunity to support Pratt & Whitney's mission by conducting analytical and experimental evaluations on graphite gaskets. The teams' mission is to determine whether graphite gaskets are a viable alternative to metal spiral wound gaskets by designing and fabricating a leakage test rig.

Inside of Pratt & Whitney's engines are bearing compartments that require gaskets to prevent oil leakages and contaminations towards other flow paths. Currently, metal spiral wound gaskets are being used to seal these bearing compartments. These gaskets require a great amount of force and a high number of bolts to fully compress the gasket for a perfect seal in the system. Therefore, graphite has been chosen as an alternative because it has the capability to withstand high pressures and temperatures just as well as a spiral wound gasket. Graphite has a smaller compressive strength which leads to a smaller crush force required to completely seal the bearing compartment. This will decrease the number of bolts required and reduce the weight in the turbine engine.

A leakage test rig is designed and fabricated according to the design of the graphite gasket. The circular graphite gasket design includes crush caps on both top and bottom. These crush caps will provide extra sealability as well as act as a filler material to correct any imperfections on the surface of the leakage test rig. Examination of the graphite gaskets pressure capabilities include conducting a 1000 psi pressure test using an Enerpac handpump. Results have shown that graphite has the capability of withstanding such high pressure. Followed by this examination, an endurance test of 0 to 50 psi for up to 1000 cycles is conducted using an automatic pump and solenoid valve. No leakages were experienced during testing, which made this experiment a success. From these results, it can be concluded that graphite gaskets are a viable alternative to metal spiral wound gaskets.

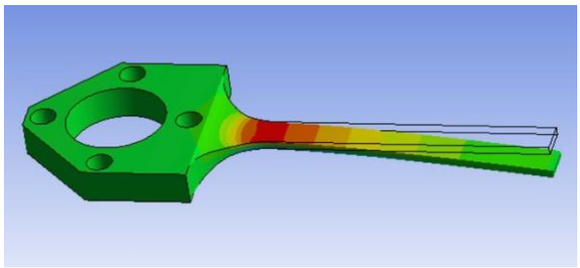
From Left: Matthew Wilson, Miranda Sommer, Julia Scanzillo, and Professor Ryan Cooper

MECHANICAL ENGINEERING

TEAM: ME 36
SPONSOR: Pratt & Whitney
ADVISOR: Professor Ryan Cooper

Effects of Plastic Deformation on High Cycle Fatigue (HCF) Capability in Fan Blades

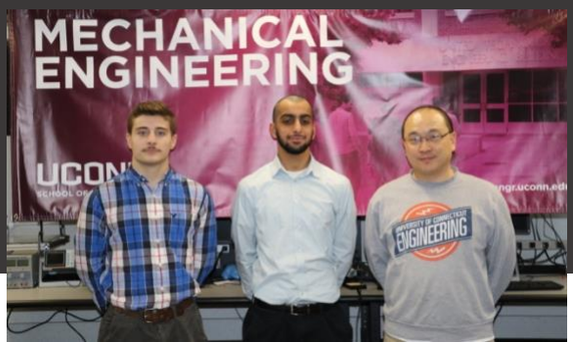
Pratt & Whitney
A United Technologies Company



The performance of fan blades within Pratt & Whitney jet engines is critical. Blade failures are expensive and time-consuming to repair, and cause disruption to airline service. Blade structural performance is affected by material properties, mechanical properties, cyclic conditions, and varying fatigue stresses. These blades also experience varying degrees of plastic deformation and residual plastic strain resulting from the ingestion of debris such as birds, rocks and ice striking a blade during engine operation. Once plastic deformation occurs, the residual blade stresses and vibratory capability of the blade changes. This affects a blade's ability to withstand the cyclic loading conditions it experiences during operation. Engineers at Pratt & Whitney will be able to better understand the high cycle fatigue (HCF) capabilities of their blades by implementing our mathematical trends and models into their mechanical designs, thus increasing durability and reliability.

Cantilever beam specimens to represent blades produced by Pratt & Whitney were fabricated from Al-6061-T6. ANSYS simulations ensured that the specimens' lives could be consumed during planned project testing at relevant vibratory stress levels when tested at their first natural frequency. The impact on blade life was studied with an analytical model and experimental shaker table data, considering the residual stresses and deformed beam geometry selected to simulate in-service blade damage.

Tests of undamaged, damaged, and damaged but stress relieved specimens were performed on a shaker table to determine fatigue failure. Specimens were damaged using an indenter to simulate foreign object damage and the resulting residual stress. Some damaged specimens were also stress relieved using heat treatment to eliminate the residual stress to allow for analysis and testing of only damaged and altered geometry. Fatigue data were plotted on a diagram of stress vs. cycles to failure (i.e. an S-N diagram). Comparison of fatigue capabilities was accomplished by correcting for residual stress effects, and comparing undamaged, damaged, and damaged with stress relieved lives.

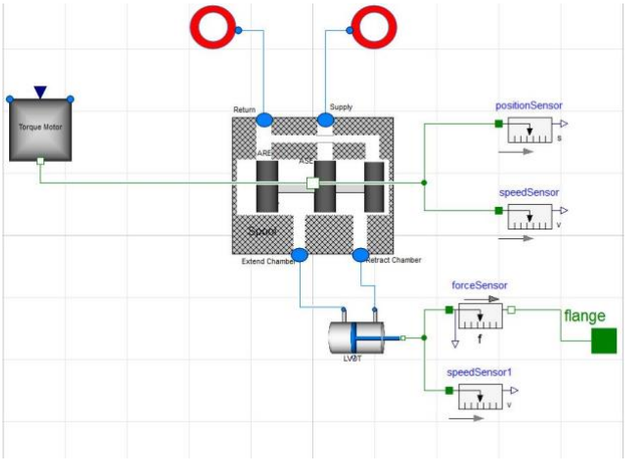


From Left: Dylan Palin, Aheed Chaudary, Professor Tianfang Lu

MECHANICAL ENGINEERING

TEAM: ME 37
SPONSOR: Pratt & Whitney
ADVISOR: Professor Tianfang Lu

Hydraulic Modeling and Controls Analysis



Pratt & Whitney is an international jet engine manufacturer. The engineering design process has become more technological in the past years. Computers and the development of software have streamlined designing, data analytics, and project management. Pratt & Whitney takes advantage of the advancements in technology throughout the jet engine design and build process. Pratt & Whitney Controls and Diagnostics Systems (CDS) has been using Object-Oriented Modeling (OOM) to model hydraulic actuation systems. OOM allows for ease with complex system modelling.

Dymola is a specialized software that uses Functional Mock-Up Interface (FMI). FMI is a developing standard for object-oriented modelling established in 2010. Within Dymola, systems and system components can be modeled with boundary parameters, properties, and equations. Within this software, ME37 was tasked with building up a standard library for hydraulic actuation systems. The foundation included fundamental components like orifices and a media model. The library was built and used to develop a functional hydraulic actuation system model. This included an electro-hydraulic servo valve (EHSV) and a hydraulic piston cylinder.

The final deliverables of this project included a Hydraulic Library where the basic hydraulic elements, sub-components, and components could easily be accessed and utilized. The deliverables also included an Actuator Model with a controller that was developed in MATLAB & Simulink. Plant verification data, linear model data, gain sizing results, and bode plots of the detailed actuator model were also included, proving the Hydraulic Library was in fact functional.

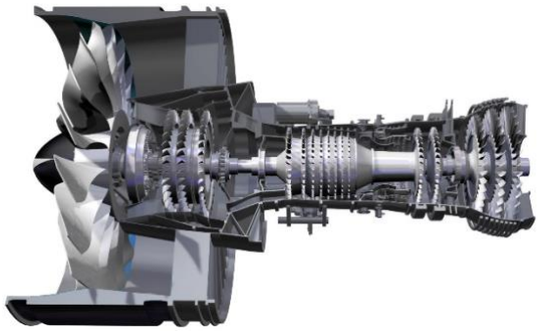
From Left: Adam Boislard, Joeshua Ligutom, Professor Baki Cetegen

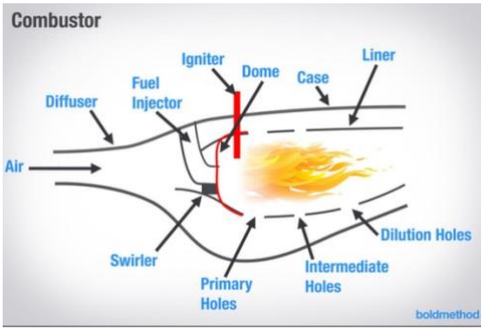
MECHANICAL ENGINEERING

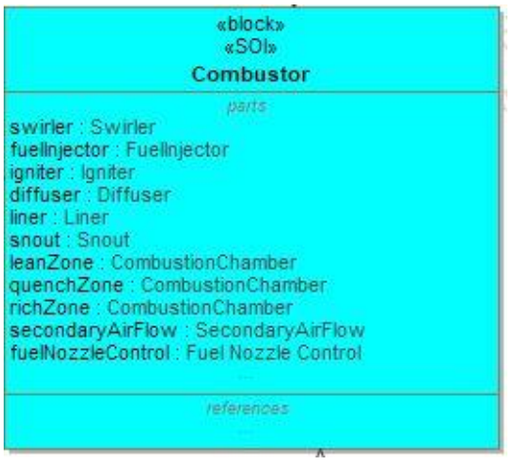
TEAM: ME 38
SPONSOR: Pratt & Whitney
ADVISOR: Professor Baki Cetegen

Model Based Systems Engineering for a Research Gas Turbine

Pratt & Whitney
A United Technologies Company

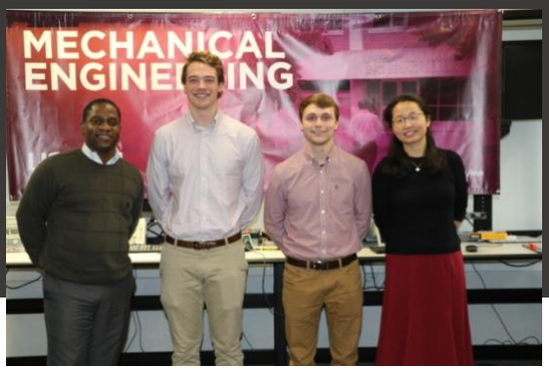






Pratt & Whitney is an aerospace company based in East Hartford, CT. They specialize in the design, manufacturing and servicing of aircraft engines and auxiliary power units. Currently, the company employs document-based systems engineering to describe the system specification and design information of products. This approach suffers from a lack of consistency and traceability across a range of texts, informal drawings and spreadsheets. This group's objective is to employ model-based systems engineering (MBSE) to describe the behavior, structure, and parametrics of the combustor module in a generic research gas turbine engine. Three different engines were analyzed in constructing the model diagrams – the Pratt & Whitney Geared Turbofan engine, the GE LEAP-X, and the Pratt & Whitney JT9D. This approach to systems engineering unifies the design, system specification and validation into a single model that moves away from older document centric approaches.

To create a foundation for the large-scale project at Pratt & Whitney, structural and behavioral diagrams were created for the three aforementioned engines. The block definition diagram (BDD) defines the structure of the system of interest – in this case, the combustor – and its surroundings. The internal block diagram (IBD) shows the interactions between all the parts of the combustor. This includes all matter, energy, signal, and data flow from one block to another. The behavioral diagrams – the use case, activity, and state machine – describe how the combustor behaves under various conditions. The state machine diagram defines said conditions. The use case diagram describes the actions of the combustor and how external systems interact. The activity diagram shows the flow of control and transformation of inputs to outputs as the combustor runs. In order to validate the diagrams created, a list of measures of effectiveness (MoE) – cost, durability, as well as performance measures – was created. A set of normalized equations for each MoE was generated to measure the effectiveness of the combustor. These MoEs and equations set the foundation for creating the parametric diagram. From this point, Pratt & Whitney systems engineers will continue to build diagrams for components across the entire engine.



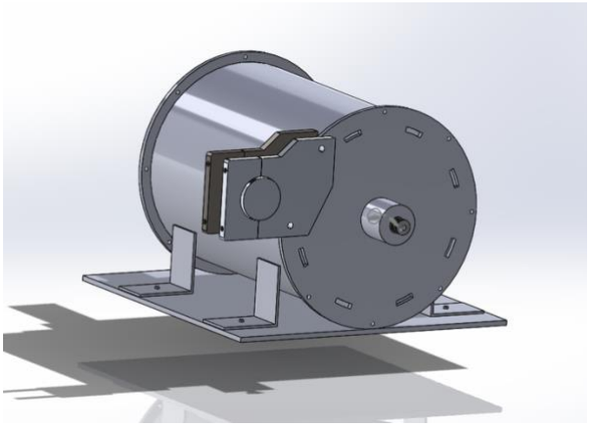
From Left: Keno Hunter, Tyler Pepin, Haydon Kalm, Professor Xinyu Zhao

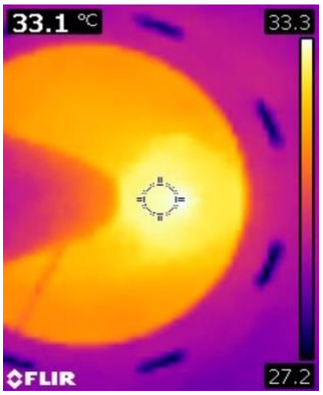
MECHANICAL ENGINEERING

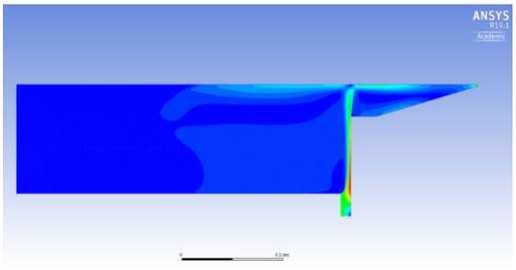
TEAM: ME 39
SPONSOR: Pratt & Whitney
ADVISOR: Professor Xinyu Zhao

Rotating Disk Heat Transfer Coefficients

Pratt & Whitney
A United Technologies Company







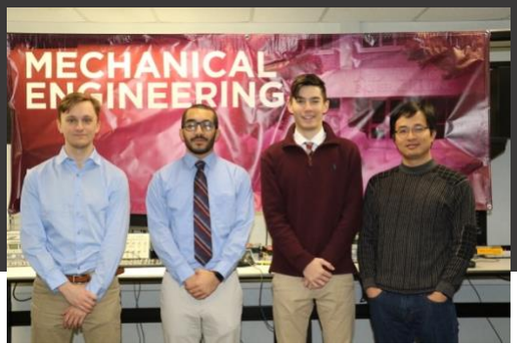
The objective of this project is to modify an existing test rig that measures heat transfer coefficients on a rotating disk. The main goal is to increase the operational Reynolds number of the rig. The reason for these modifications is to make the data more applicable to turbine and compressor disks in modern aero engines. The heat transfer coefficient is determined by estimating the temperature gradient on the surface of the disk using a classical one-dimensional response of a semi-infinite medium to determine the sudden step application of a convecting fluid. Pratt & Whitney's current data is antiquated, and testing at their facilities is expensive and time consuming. Pratt & Whitney wants a smaller, table-top testing rig to cut down on cost, time and improve ease of use during testing.

Another imperative aspect of this project is creating and running computational fluid dynamics simulations using Ansys Fluent. These simulations will help us to validate the experimental data and also provide an additional method for acquiring heat transfer coefficients along the disk.

To experimentally calculate the heat transfer coefficients, we developed a MATLAB function that will curve fit our experimental data to a governing equation in order to back out the heat transfer coefficients. This function fits the response data of the disk surface to the governing equation.

The current rig spins an acrylic disk encased in an aluminum retaining disk at 3,000 RPM while applying heat to it via an inlet pipe at 30°C inside of a steel containment cylinder. An IR camera is then used to measure the temperature distribution across the disk in order to calculate the heat transfer coefficients. The modifications we performed included improving the overall safety of the rig and enhancing the ease of use by creating a LabView dashboard for output data. We also installed a new, more powerful motor to spin the disk at 14,000 RPM which included design and fabrication of a new mounting fixture.

Ultimately, we want to collect data to form a Nusselt number correlation involving the Reynolds number and the heat transfer coefficient. Pratt & Whitney will be able to use this correlation to predict heat transfer coefficients across compressor and turbine disks during the flight cycle of their engines.



From Left: Edward Kloczko, Andrew Botros, Timothy Dau, Professor Xu Chen.

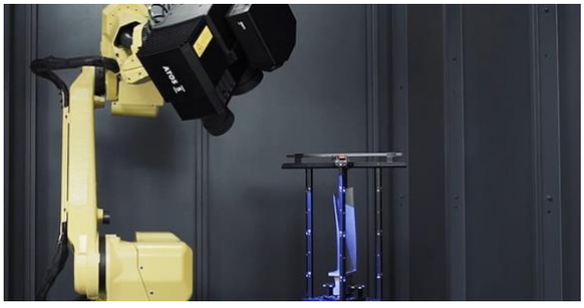
MECHANICAL ENGINEERING

TEAM: ME 40
SPONSOR: Pratt & Whitney
ADVISOR: Professor Xu Chen

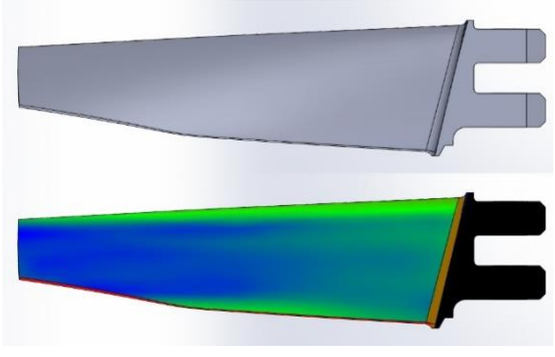
Automation of Coating for Structured Light Scanning

Pratt & Whitney uses structured light scanning in order to build complex and accurate 3D geometries of their engine components. This technology can be affected when used on reflective metals and alloys commonly used in aerospace parts. The problem was originally remedied by manually spraying a dulling material on parts that were being prepared for light scanning. This method is not suitable for widespread use - it requires training and makes it impossible to achieve uniform or consistent coatings.

Team ME40 was tasked with developing an automated spraying process that could uniformly and consistently coat various engine components - but primarily airfoils. The team decided on designing a spray system that would be fixed on the end of a robotic arm. This allows for scaling of the process and the ability for operators to program a different set of movements to coat each individual part geometry.



The final product consisted of a two-fluid air-atomizing nozzle fixed to a 5-axis robotic arm. The nozzle was then fed a dulling material via a pressure tank. The movements of the robotic arm were coded in Python and coupled with electronically controlled on/off valves on both the air and the liquid that allowed for precise control over the spraying. Preset movements were developed to be used for a variety of different airfoil shapes. These movements and the resulting spray patterns were successfully tested on 3D printed airfoils designed by the team that were modeled after compressor blades. Validation of these tests were completed by spraying multiple copies of the same airfoil. These specimens were taken to Pratt & Whitney and measured under their structured light scanning machine to check if the coating thicknesses fell within a desired tolerance.



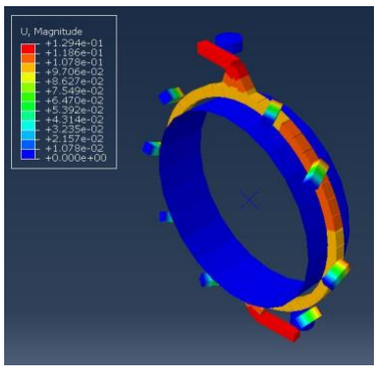
From Left: Jonathan Williams, Robert Kenez, Professor Horea Ilies

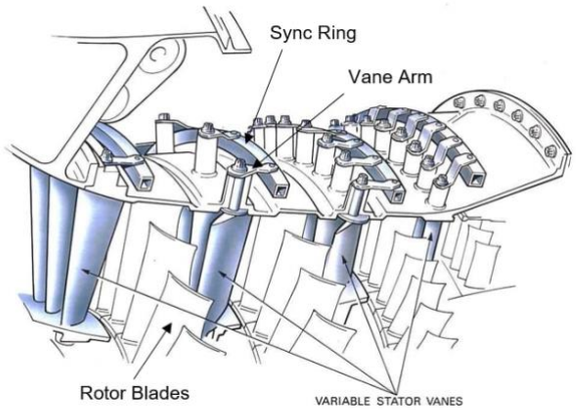
MECHANICAL ENGINEERING

TEAM: ME 41
SPONSOR: Pratt & Whitney
ADVISOR: Professor Horea Ilies

Variable Stator Vane Sync Ring Analysis and Optimization

Pratt & Whitney
A United Technologies Company





In modern gas turbine engines, the performance of high pressure compressors is enhanced by the incorporation of variable stator vanes that adjust the inlet and exit air angles at various flight operating conditions. An actuator and synchronizing ring system controls and actuates the vane sets. While the rotors rotate at high speeds around the central shaft, the stator vanes are fixed and do not move circumferentially. The vanes prevent stall and surge, which can lead to engine failure, by rotating about their own axis to increase pressure and keep the flow parallel to the central shaft. Bumpers are placed between the sync ring and the compressor casing to minimize friction. The sync ring deforms in different ways depending on whether a single or dual actuated system was used as well as the bumper count and location. When the sync ring deforms, the vane to vane angle difference and therefore system accuracy are affected. The objective of this project is to develop an analysis method for more efficient model changes and analysis and to conduct optimization studies on the configuration. The configuration was modeled in Abaqus and was produced by a macro that asked for the inputs. Many iterations were done using the macro to run the optimization studies on the configuration. The optimization studies were on the effect on system accuracy (vane to vane angle difference) for a single vs. duel actuated system and the optimal bumper count and location.

The configuration with the smallest vane to vane angle difference is the most optimal for the system. This difference changes for both differently actuated sync rings and different bumper configurations. After the Abaqus model was ran with many alterations of the configuration of the system, several results were analyzed such as the stresses and displacements of the sync ring. The team chose the configuration that displayed the smallest vane to vane angle difference, and recommended Pratt & Whitney this more optimal sync ring.

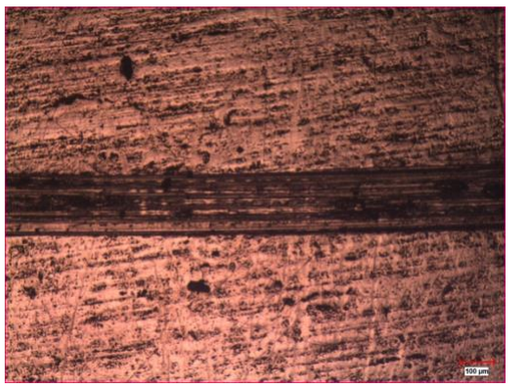
From Left: David DeLashmutt, Max Medas, Matt Cyr, Professor David Giblin

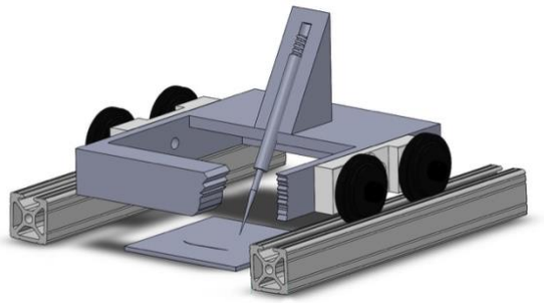
MECHANICAL ENGINEERING

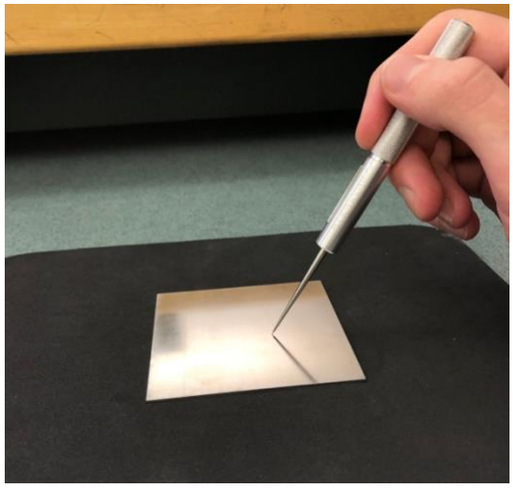
TEAM: ME42
SPONSOR: Pratt & Whitney
ADVISOR: Professor David Giblin

Automation of Visual Inspection Process

Pratt & Whitney
A United Technologies Company







Pratt & Whitney is a leading manufacturer of commercial and military jet engines. The Quality Assurance department at Pratt & Whitney is responsible for inspecting parts for damage and defects. Pratt & Whitney Quality Assurance personnel visually inspect each part for damage or defects. If a defect is identified, the inspectors determine the acceptability of the part by pushing a handheld stylus over the defect. If the inspector senses that the stylus “hesitates” as it passes over the defect, the part is deemed unacceptable. The senior design team’s objective is to quantify the “hesitation” with a measurable output to support the sponsor’s interest in automating the inspection process.

The senior design team gathered data to quantify the acceptability of a defect by creating a system to consistently move a stylus over defects and measure output forces. This data was correlated to the acceptability of these defects, as determined using the existing method, to determine a threshold value that distinguishes between acceptable and not acceptable. The team was provided with five test plates that each had six prescribed defects of varying type/size. These defects were all inspected by three different Pratt & Whitney Quality Assurance Inspectors to record whether or not they felt a hesitation.

The team developed a test apparatus to move the stylus across the test plate consistently and record the forces acting along the axis of the stylus. The forces needed to translate it over the nominal surface of the test plate was then compared to the forces needed to move across nicks, dents, or scratches. This apparatus includes a cart to hold the stylus as well as a track system to allow linear motion of the cart. The apparatus holds the stylus at a fixed angle that was determined based on the inspection process instructions. The cart is rolled along the track allowing the tip of the stylus to pass over the defect. The apparatus is fitted with a force transducer to detect the change in force on the stylus as it moves across the defects.

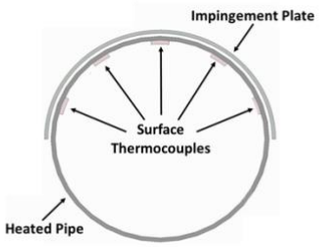
From Left: Margaret Hudson, Jedidiah Kang, Mitchell Wright, Professor Bryan Weber

MECHANICAL ENGINEERING

TEAM: ME 43
SPONSOR: Pratt & Whitney Puerto Rico
ADVISOR: Professor Bryan Weber

Optimizing Impingement Cooling Design to Control Gas Turbine Clearances

Pratt & Whitney is one of the largest jet engine manufacturers in the world. Pratt & Whitney Puerto Rico specializes in gas turbine engines. This is the fourth year that a UCONN Senior Design team will be working with Pratt & Whitney Puerto Rico (formerly Infotech Aerospace Services). Last year's team designed and fabricated a test rig to study temperature change of surfaces subjected to impingement cooling. Impingement cooling is a form of forced convection heat transfer where jets of fluid at a high velocity are sprayed onto a heated surface for cooling.



The main focus of this project was to expand the data collection of the impingement rig to include variable striking distance, cooling jet velocity, impingement hole size, the impingement hole spacing and the number of impingement holes. The team defined success as finding parameters that would result in a temperature drop of 100° F of the impinged surface before and after the surface was cooled. By comparing the data collected the team was able to identify the optimal combination of parameters.

The team's redesign of the rig improved efficiency of data collection by 50 percent. The new rig allowed for a more flexible range of testing parameters with higher accuracy. The expanded data set will be used to validate CFD models that will help streamline the design process of impingement cooling systems. The team collected 24 data sets using the improved rig in half the time the old rig took, and reduced the error in data collection by 10 percent. These data are valuable to validate CFD models for Pratt & Whitney to use to improve Active Clearance Control. This will improve engine efficiency by reducing blade tip clearances.

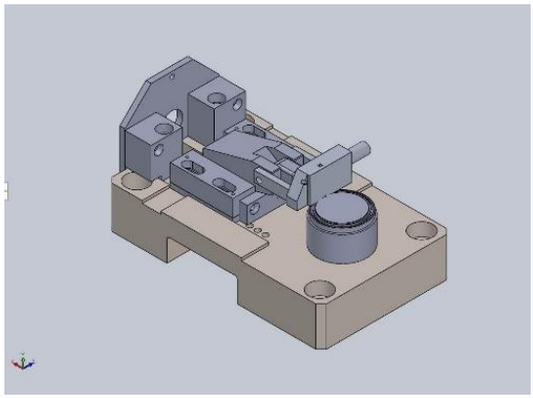
From Left: Parker Haupt, Ken Brown, AJ Lorenzetti, Professor Vito Moreno

MECHANICAL ENGINEERING

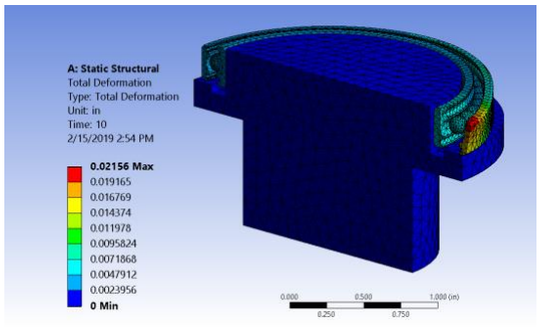
TEAM: ME 44
SPONSOR: RBC Aircraft Products Inc.
ADVISOR: Professor Vito Moreno

RBC Full Complement Bearing Assembly

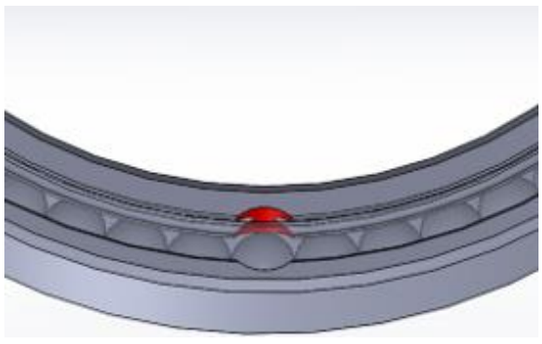
The Roller Bearing Company™ (RBC) is an industrial and aerospace ball bearing manufacturer, located in Torrington, CT. Their current full complement loading process is both slow and exhausting for the machine operator, as each ball must be inserted by giving it multiple strikes with a handheld, weighted punch, and some bearings have as many as 50 balls. Therefore, the current procedure had to be improved through both automation and by redesigning each operation, thereby making it less arduous for the operator.



A semi-automated process was designed to solve this problem where an operator can stretch the ring and press a ball into the bearing more consistently and more quickly than the original manual process allowed. Additionally, work was done to fully automate the process by timing the individual steps with a Programmable Logic Controller (PLC).



To load a bearing first, a set of matched races is placed on the die, partially loaded by hand with half of the required balls. The tooling is then pulled back using a constant force, in turn stretching the outer race enough to insert a ball between the two loading notches. Once the ball is moved away from the load notches by the operator, the loading continues until the ring must be de-flexed in order to reset the balls. This process repeats until the bearing is full.



While RBC's previous process had the outer race being pushed, the new process redesigned the tooling so that the race is now pulled, allowing the operator to have more room to move the balls from the load slot. It also allowed a lever clamp to be added to the backside of the bearing to keep the load notches aligned. The final product provided more consistent assembly while reducing total assembly time.

From Left: Andrew Caratenuto, Eric Voket, Christian Schirmer, Professor David J. Giblin

MECHANICAL ENGINEERING

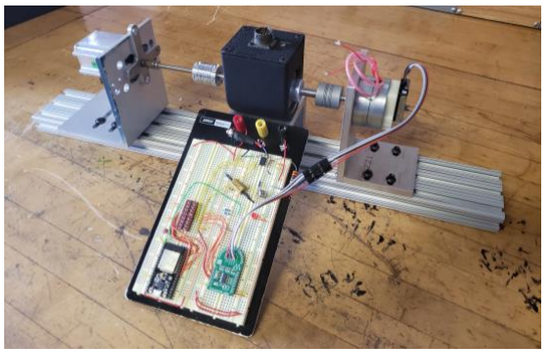
TEAM: ME 45

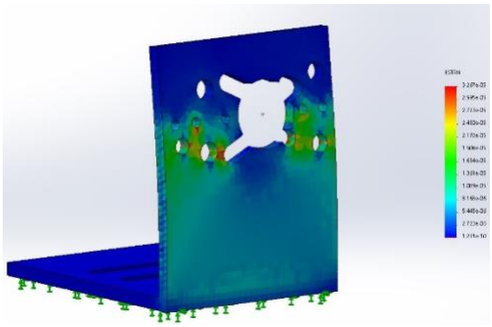
SPONSOR: Radio Frequency Systems

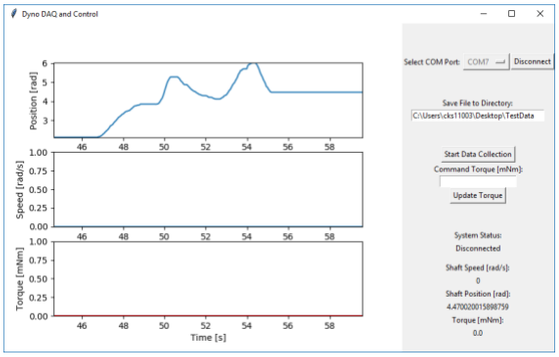
ADVISOR: Professor David J. Giblin

Design and Analysis of Stepper Motor Test Instrument

Radio Frequency Systems







Radio Frequency Systems (RFS) is a designer and manufacturer of wireless broadcasting equipment. RFS produces radio antennas, which use small stepper motors to remotely adjust beam tilt. As these antennas are located outdoors, they must be able to perform to specification under a large range of temperature conditions. This project aims to deliver a tool to RFS that can be used to verify the operating characteristics of different motors under different temperature conditions.

When evaluating the suitability of a certain motor for use in any application, it is important to know how much torque it can deliver from a stop, and at different speeds. In order to measure the torque output of the motors, this design utilizes a torque transducer and an electromagnetic particle brake, which can both be dynamically adjusted during the testing process. As the motors are pushed closer to their torque limits, the likelihood of missed steps (losing angular position) increases. Since these stepper motors do not incorporate position feedback, this will lead to error in shaft positioning. Our design incorporates the use of an encoder, which will be able to detect the any missed steps during cycle testing and allow limit conditions to be identified.

In order to apply different temperature conditions to the motor, our test instrument will interface with an environmental test chamber. With the motor housed inside the chamber and the rest of the components outside, the motor can be subjected to a wide range of temperatures while keeping the test rig and electronics safe.

In order to control the test rig and collect data, a microcontroller and PC with front-end software will be used. The microcontroller runs custom-written firmware for data acquisition and closed-loop torque control. All data is sent to the PC software, which gives the user the ability to set the loading torque and view test data in real time. In addition, all test data is saved, which allows for more in-depth analysis.

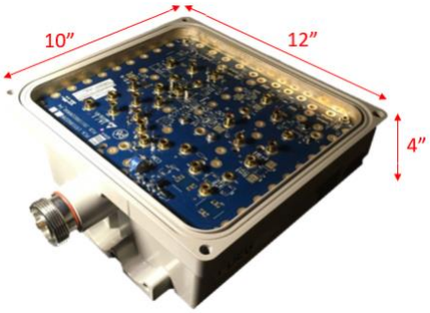
From Left: Robert Bickley, Jonathon Jacobs, Matthew Kramer, Professor Bryan Weber

MECHANICAL ENGINEERING

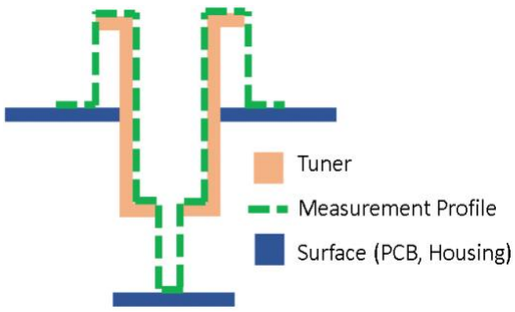
TEAM: ME 46
SPONSOR: Radio Frequency Systems
ADVISOR: Professor Bryan Weber

Automated Positioning System to Take High Precision Measurements on a Radio Frequency Filter

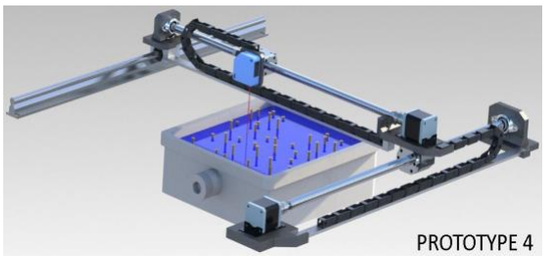
Radio Frequency Systems is a worldwide leading provider of innovative wireless and broadcast infrastructure products and solutions. The radio frequency (RF) filter, pictured left, is one of their primary products and is a key component in any broadcast application. Its purpose is to clean the signal passing through it by filtering out unwanted frequencies.



The RF filter contains a printed circuit board (PCB), into which as many as 80 brass tuners may be inserted. The depths which these tuners sit in the PCB determines the frequencies that are filtered by the device. Previously, RFS engineers had to adjust these positions from scratch and without a reliable reference for each filter produced. Since the frequencies filtered are sensitive to changes in tuner depth of 0.005”, this process is time consuming, inefficient and highly skill-based. However, team ME46 was tasked under the guidance of faculty advisor Professor Weber to improve this process of RF filter frequency calibration.



This problem called for an automated solution to accurately measure the tuner depths of a properly-calibrated RF filter, and to report the measured depths to the production line. To do this, team ME46 has designed and constructed an automated positioning measurement system that acquires the tuner depths within a 0.005” tolerance. The sensor, a Wenglor OPT2006 parallax laser distance sensor, is mounted to a custom 3D printed adapter which is driven by two controlled stepper motors to facilitate the planar translation. The system creates a measurement profile, pictured left, by continuously measuring the vertical distance as the sensor translates across each tuner. The computer logic system analyzes the profile to calculate each tuner depth. Once complete, the automated system outputs a file containing the tuner identifiers and their depths. Operators can then use the file to ensure optimal presetting, which will make the final tuning calibration quicker and more efficient.



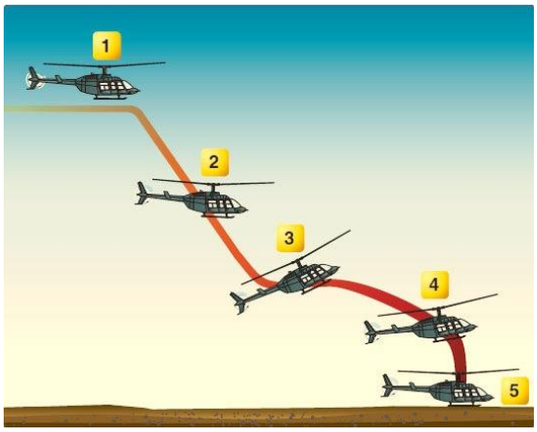
From Left: Alexis Coppola, Ali Hussain, Thomas Gross, Professor Nejat Olgac.

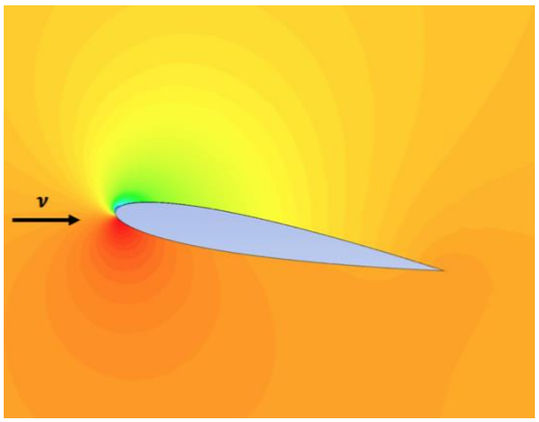
MECHANICAL ENGINEERING

TEAM: ME 47
SPONSOR: Nolan Birtwell
ADVISOR: Professor Nejat Olgac

Autonomous Autorotation Control System

SIKORSKY
A LOCKHEED MARTIN COMPANY





Sikorsky is a manufacturer of commercial and military helicopters. As an industry leader in rotary aircraft, they are interested in developing autonomous systems to assist pilots in a variety of situations. For example, in the event of engine failure. A pilot in a falling helicopter can use a maneuver called autorotation to land safely, but this requires fast reflexes and a good sense of timing to prevent injury to passengers and damage to the vehicle. Sikorsky asked ME47 to create an autonomous system that could detect engine failure, guide a helicopter through controlled descent, and land gently. They also asked that the system be demonstrated on an RC model helicopter.

When the engine of a helicopter fails, there is no other onboard source of power to cause the rotor to spin. Instead, the pilot must use the force of air flowing through the blades to keep the rotor spinning. Autorotation is this flight state where the blades are driven without needing an engine. In an emergency, this allows the pilot to store kinetic energy in the rotor and then disperse it in a maneuver called a flare to bring the vehicle to a stop as it reaches the ground.

The group broke autorotation into steps: detecting engine failure, optimal blade pitch, optimal flare altitude and landing. To determine the optimal pitch of the blades, as well as the height to perform the flare, ME47 derived equations to describe the motion of a helicopter. These equations showed that optimal pitch is dependent on the coefficients of lift and drag. Using numerical solvers in ANSYS Fluent and XFOIL, the team determined optimal functions to use as control signals.

ME47 chose an off the shelf model helicopter and autopilot system which they then modified with sensors and code to control autorotation. Integrating the signals into the control system, they successfully demonstrated autorotation on the RC helicopter. If this system was integrated into a full-size helicopter, it would prevent accidents and save lives that might be lost in helicopter crashes.

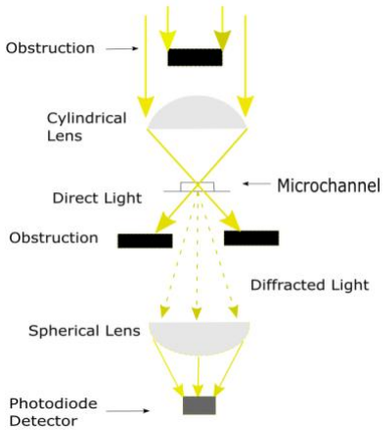
From Left: Puzhen Li, Tianxiang Zhu, Professor George Lykotrafitis

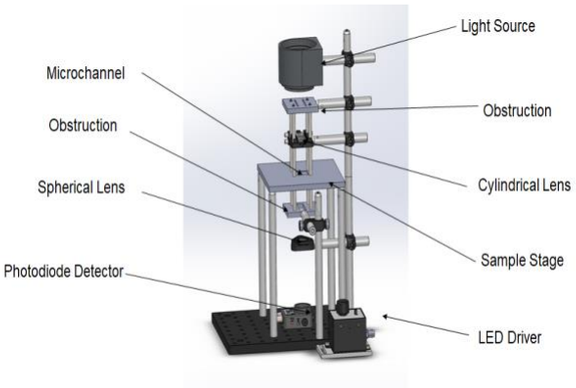
MECHANICAL ENGINEERING

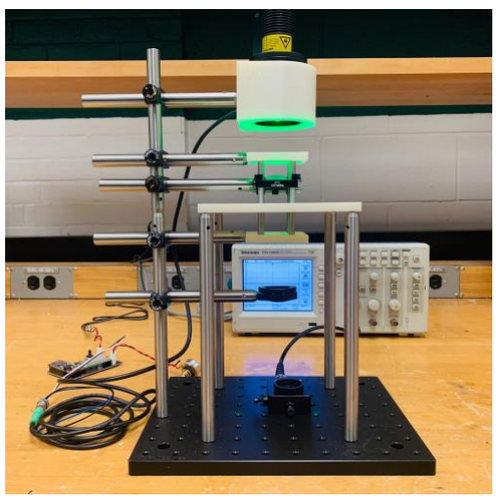
TEAM: ME 48
SPONSOR: Simvize LLC
ADVISOR: Professor George Lykotrafitis

SIMVIZE

Flow Velocity Measurement of Clear Liquids







The flow velocity measurement of clear liquids is a project initialed by Simvize LLC. Simvize LLC, which is a company in Storrs, CT that was founded by Professor George Lykotrafitis, mainly focuses on the liquid viscosity measurement. Simvize LLC has developed a patent pending technology to measure the position and velocity of non-transparent liquid as it traverses a microchannel. Currently used approach is based on the amount of diffracted light absorbed by the photodiode detector. This technology doesn't work when the liquid is transparent because the transparent liquid doesn't block significant amount of light.

In order to handle the situation when the liquid is transparent, our team was given the task of developing a new method to measure the position and velocity of transparent liquid by using dark field microscopy. The project involved both experimental approach and analytical analysis. The experimental approach involved assembling a prototype of dark field microscopy. The analytical approach was performed by MATLAB. Team 48 learned how to use Solidworks and created a dark field microscopy model in Solidworks. The model in Solidworks was identical to the functioning stationary setup which can be performed the analytical analysis. Team 48 purchased the parts of dark field microscopy from a website which was called Thorlabs and assembled it according to the Solidworks model. Team 48 researched some physical principles of the light path and how the liquid was driven by capillary pressure in the microchannel.

After the design and assembling, Team 48 calculated the amount of light that was collected by the photodiode detector. At the same time, Team 48 simulated the light path of dark field microscopy by using Zemax, collected the data by using photodiode detector and obtained the graph in oscilloscope. The data was analyzed by Team 48 using Matlab and Team 48 adjusted the design.

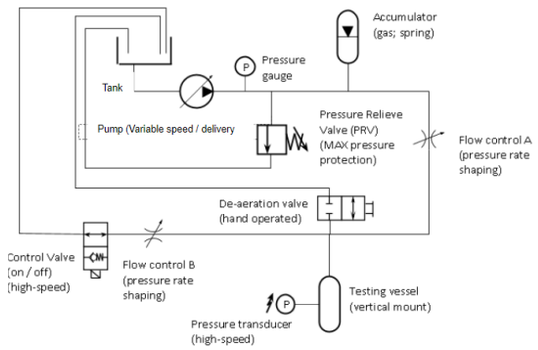
Kevin Drexler, Griffin Carr, Connor Bell, Prof. Ryan Cooper

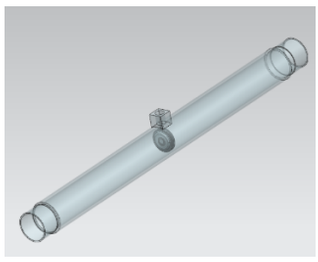
MECHANICAL ENGINEERING

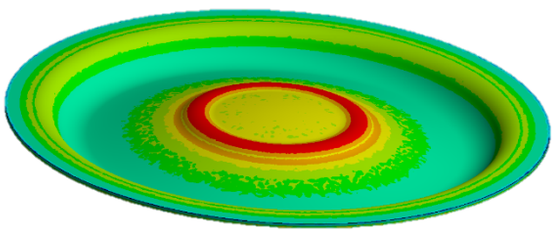
TEAM: ME49
SPONSOR: Richard Pellini
ADVISOR: Prof. Ryan Cooper

Fatigue Life of the Accumulator Assembly of a GDI Pump

Stanadyne®



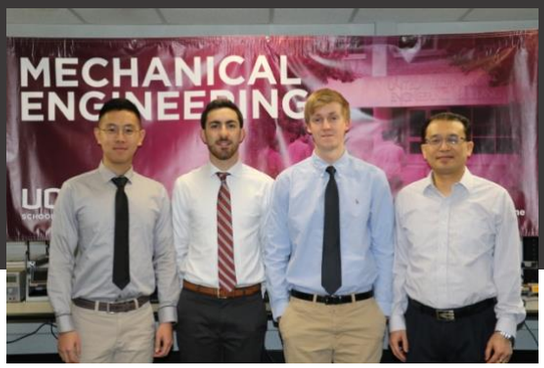




Founded in 1876, Stanadyne is a developer and manufacturer of fuel pumps and fuel injector pumps which are used in a variety of applications ranging from automotive to construction. The team was tasked with finding the fatigue life of an accumulator and designing a test rig for fatigue life determination that can be applied to future designs. While the accumulator fatigue life is known for fuel pump injectors in current production, knowing the fatigue life of accumulators in fuel pump injectors in current development is vital for both internal and client use. In order to solve this issue, the team was tasked to create both an analytical and experimental model that could determine the product life the accumulator.

The experimental portion of this project was to create a test rig that could test a large sample size of accumulators until failure. In order to construct the test rig, multiple components had to be designed including a pressure vessel, pressure vessel caps, and a fixture for a control valve. When the test rig is assembled and running, the accumulators become subjected to pressure pulsations at a high frequency, resulting in eventual failure which can be detected by a change of the mass of the accumulator. From a large sample size, an approximate life cycle is determined for the part.

In order to verify the experimental results, a static structural analysis was performed in ANSYS. Using the maximum external and internal pressures the accumulator faced in the experimental portion of the testing, the finite element analysis calculated the maximum stress and predicted life of the part. This analysis allowed the team to predict the cycles to failure of the part, as well as to confirm that the experimental analysis was within the expected range.

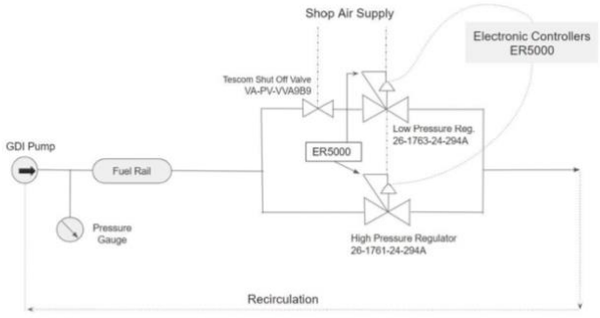


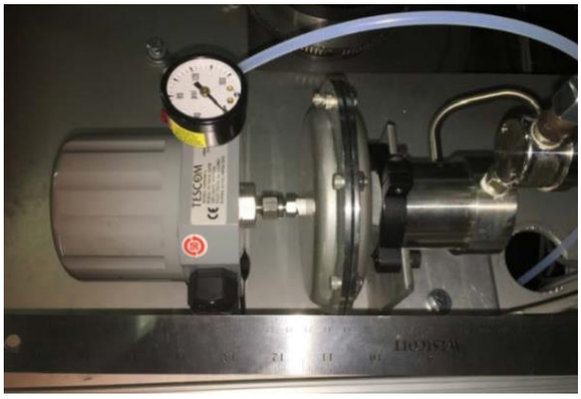
From Left: Lupeng Wang, Brian Ramm, Brenton Cantliffe, Dr. Chih-Jen (Jackie) Sung

MECHANICAL ENGINEERING

TEAM: ME 50
SPONSOR: Shelby Thompson
ADVISOR: Professor Chih-Jen Sung

Pressure Regulation Strategy for GDI Fuel Pump Testing



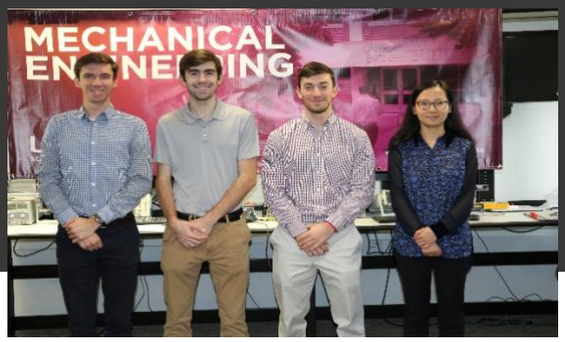


Stanadyne is a global fuel systems technology leader with headquarters in Windsor, CT. Their product line includes the design and production of direct-injection fuel pumps for gasoline and diesel engines. The fuel pumps are then used in a variety of commercial and industrial applications.

Our team tasked with redesigning the pressure regulation system on their research and development test bench. Their current test bench stand is limited in its accuracy to control pressure at a wide enough range of conditions to complete all of their testing. The primary concern was to improve the fidelity of testing for low-end pressure under 100 bar without losing the high-end capability that they have currently. Stanadyne was also interested in any ideas our team might have to improve the durability and cost efficiency of the system.

After much deliberation and research, team 50 designed a solution that could split the flow into two back pressure regulators simultaneously. One of these regulators would be sized to handle high-pressure flow from 100-650 bar and the other would handle flow at pressures of 2-150 bar. A shut off valve in front of the low-pressure regulator would close if flow reached 125 bar so that flow would only be controlled by the high-pressure regulator. ANSYS Fluent was used to simulate the flow redirect and if a significant pressure spike would occur at the valve shut off point and it was deemed to not be a concern.

Extensive research was done to analyze the purchase of a regulator and shut off valve that could handle a flow rate of 150 L/h. The pressure regulation rig using the new regulator and valve was built at UConn then transported to Stanadyne. It was designed to fit inside the currently used Stanadyne test bench and plug in addition to the current fuel line. The new pressure regulation system will then be tested by Stanadyne technicians as final adjustments are made to their new and improved fuel pump test bench.

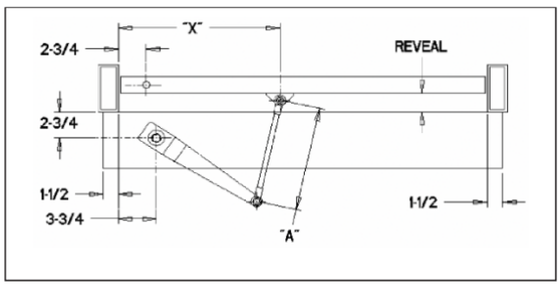


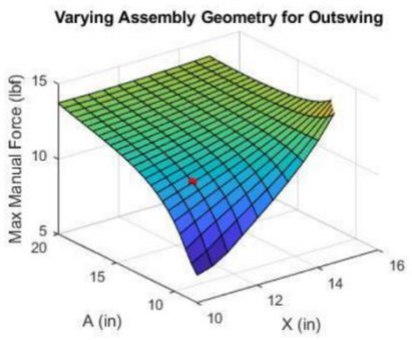
From Left: Benedict Stevens, Gerald LaPenta, Matthew Milne, Professor Zhanzhan Jia.

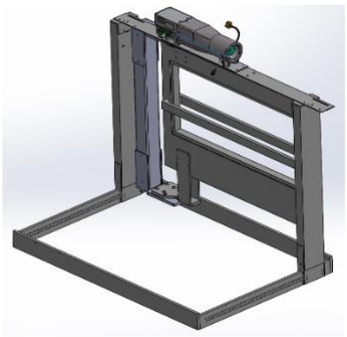
MECHANICAL ENGINEERING

TEAM: ME 51
SPONSOR: Stanley Access Technologies
ADVISOR: Professor Zhanzhan Jia

Swing Door Arm Applications Guide Evaluation

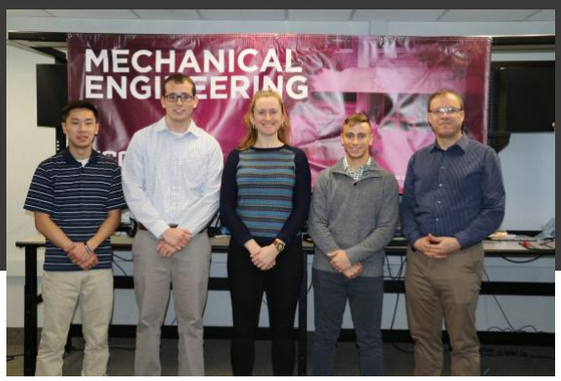






Swing Door Arm Applications Guide Evaluation is a project brought to attention by sponsor company Stanley Access Technologies in an effort to improve their door installation process. Stanley Access Technologies aims to provide accessible automatic doors for all different types of customers and situations, some of which include doors for large pedestrian access such as grocery and hardware stores. Industry standard requires that, in the case of an emergency where there is a power failure to the door's operator, no more than a certain threshold of manual opening force is required to open the door fully. Taking these safety requirements into consideration, Stanley Access Technologies created an installation guide for the different door configurations to ensure that industry standards are followed. This guide had been found to be insufficiently detailed and inaccurate in certain door configurations, and resulted in doors that failed to meet the manual force requirement or did not open fully. This project focused on improving the installation guide by mathematically predicting the force required to open each type of door through static and kinematic analyses. The project entailed wrapping this mathematical model into a program which will help Stanley Access Technologies' engineers, and which can be later implemented into a mobile application replacement for the current guide. The code returns to the technician the optimal assembly geometry given the door dimensions, hinge type, and swing direction.

After an extensive kinematic and static analysis of every door type in the current installation guide was completed, a tabletop test fixture was created to validate the model. The table top test fixture can replicate each type of hinge Stanley Access Technologies uses with its doors, and offers a high degree of adjustability. It reads out how much force is required to open the door. It will be used by the employees at Stanley Access Technologies to validate the correct door linkage geometry should a technician or customer have an issue with their door.



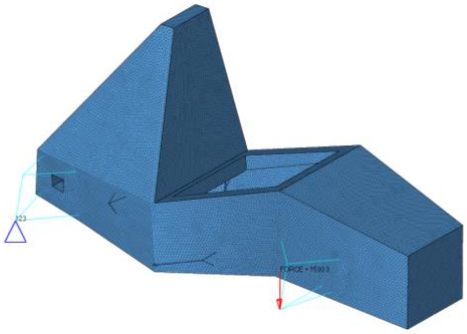
From Left: Hao Xu, Wilson Nickel, Emma Stark, Nick Ciriello, Professor Julian Norato

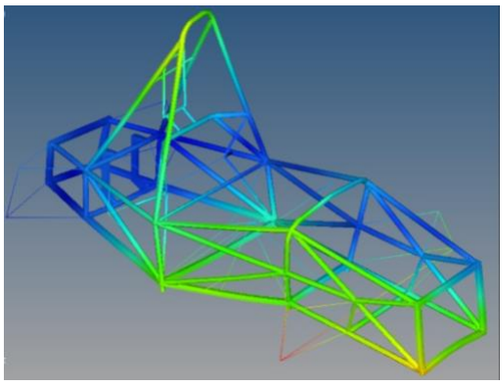
UCONN
UNIVERSITY OF CONNECTICUT

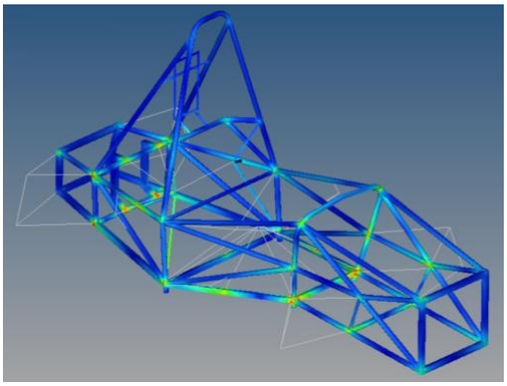
MECHANICAL ENGINEERING

TEAM: ME 52
SPONSOR: University of Connecticut
ADVISOR: Professor Julian Norato

Tubular Chassis Redesign Using Topology Optimization







UConn's Formula SAE team can gain a competitive edge on their competition with a weight reduced chassis. The difficulty in the chassis redesign was choosing where to position each tubular member for optimal rigidity. This had to be done without obstructing the placement of the vehicle components and driver. Additional FSAE rulebook regulations had to be considered to ensure the safety of the driver in the event of a rollover or buckling of the tubular members.

Topology optimization was used to develop two design concepts. Given a specified design region, topology software places structural members in ideal locations to effectively distribute the loading conditions. These conditions account for the torsional, bending, and acceleration loadings experienced by the vehicle chassis during a race. Both designs were created to maintain the same structural integrity while reducing the weight of the former chassis by ten percent. FEA was conducted on the previous chassis frame to serve as the baseline for structural requirements of the new designs.

The two designs were each created with a different type of topology optimization software. Dr. Norato's current research is involved with developing topology optimization software that generates cost-efficient designs. Instead of producing an organic-shaped optimization, this software creates the structure from a set of easily manufacturable components. The commercially available software, Altair OptiStruct, required the resulting design to be modified before reaching its manufacturable state. The structure generated from this software was used as a reference to create the final commercial software design. In addition, a cost analysis was conducted on the commercial and research topology optimization designs. Since both designs have the same structural integrity, the design with the lowest weight, lowest cost, and easiest manufacturability is the best design.

From Left: Jacob Lamore, Mitchell Uretsky, Carmelo E. Figueroa, Professor. Reza Sheikhi

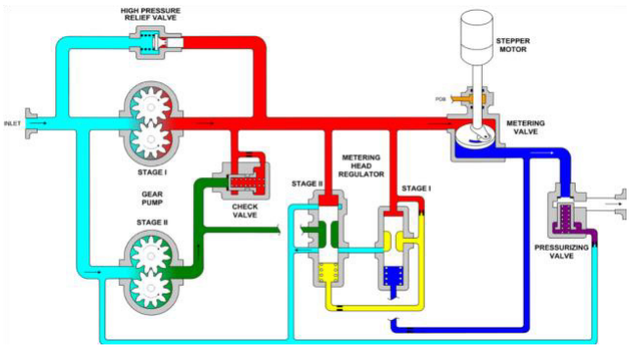
MECHANICAL ENGINEERING

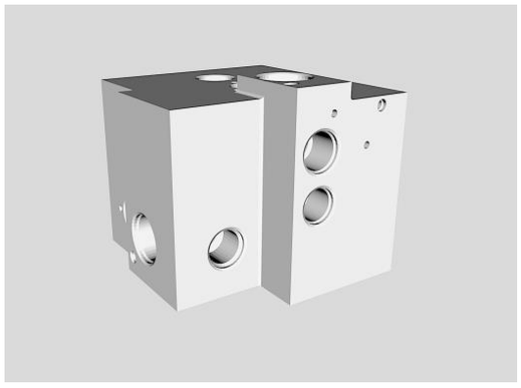
TEAM: ME 53
SPONSOR: Bill Dalton
ADVISOR: Professor Reza Sheikhi

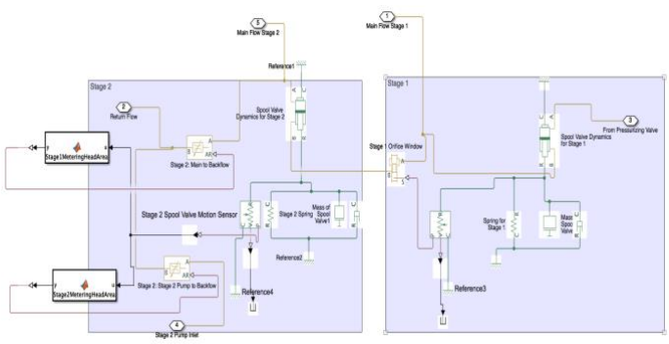
Investigation of Thermally Efficient Gear Pump System

Triumph Engine Control Systems

A Triumph Group Company



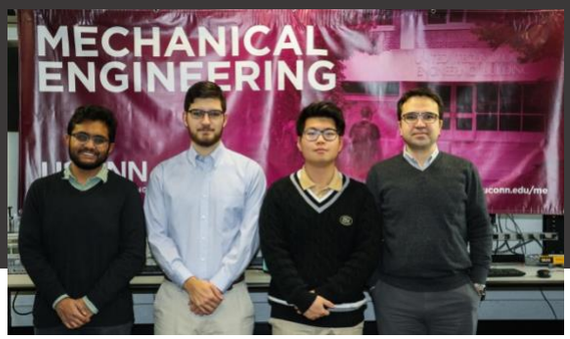




Triumph Engine Control Systems (TECS) is a division of Triumph Group Inc. They specialize in aircraft fuel systems, fuel pumps, and electronic engine control units for fixed- wing aircraft. Gas turbine engines found in aircraft use pumps to send fuel to the engine. Currently, most fuel delivery systems use a single gear pump. These gear pumps must be sized for its most demanding conditions where the flow/speed ratio is at a maximum. A single-stage gear pump must be able to meet the most demanding conditions the system will face. This result in excess flow and heat energy generated due to the gear pump being oversized for settings such as cruise. By utilizing two pumps operating in parallel, the flow from the second gear pump can be cut off from the main flow and recirculate the excess flow. For less demanding operating conditions, this reduces the excess work necessary to pressurize wasted flow.

The objective of this project was to investigate the increase in thermal efficiency of a two-stage gear pump fuel system compared to a one-stage system. Experimental data was collected and used to validate the computational model created.

Using MATLAB's Simulink software, a two-stage gear pump system was designed to show get results that show a two-stage gear pump system is more efficient than a one-stage system. A test was performed on the test rig that involved measuring pressure differentials and temperatures across specific components (metering valve, check valve, etc.). The data obtained from the experiment was used to obtain results to compare to the Simulink model. Given that the results from the Simulink model match the results from the experiments, we can conclude that a two-stage gear pump system is more thermally efficient than a one-stage gear pump system. A CFD analysis of flow through the check valve was also performed using ANSYS fluent software to confirm that there were no significant inefficiencies present in that component.

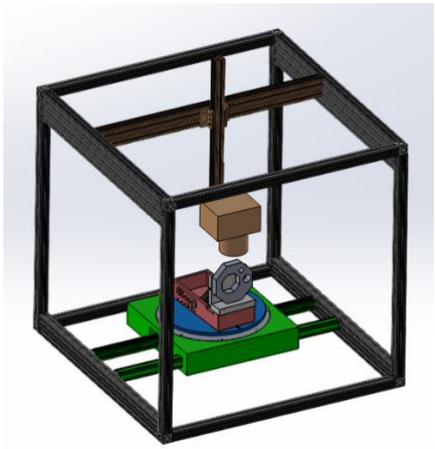


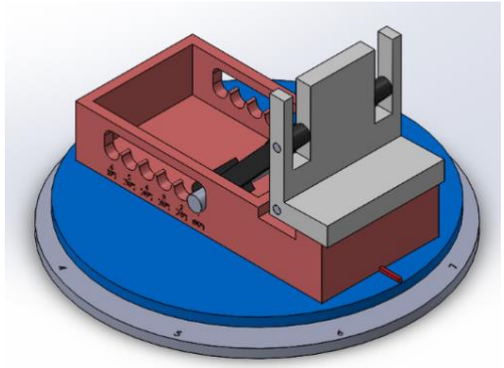
From Left: Akshat Misra, Christopher Grogan, Jae-Kyung Lee, Professor Ugur Pasaogullari

MECHANICAL ENGINEERING

TEAM: ME 54
SPONSOR: TRUMPF Inc.
ADVISOR: Professor Ugur Pasaogullari

Design and Implementation of Photo Box for Cut Samples



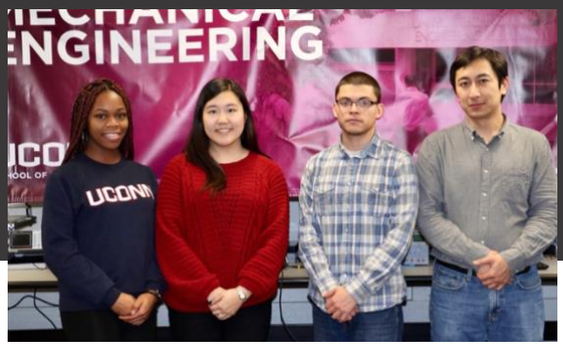


TRUMPF Inc. in Farmington, Connecticut, is the North American subsidiary of the German company TRUMPF GmbH + Co. KG. As a world leader in the manufacture of sheet metal fabrication machinery and industrial lasers, TRUMPF needs to continuously monitor the cutting and hole drilling performance of their laser machines. The most effective method of carrying out this review process is by obtaining magnified, high-resolution images of cut edges of samples using a camera system. However, due to factors such as lighting, depth of focus, and scaling, it is difficult to capture standardized photographs across that can be compared across departments and between TRUMPF's many global locations.

To improve the effectiveness of the quality assurance process, ME54 designed a complete image capture workflow. This includes a prototype Photo Box apparatus with inbuilt lighting system, a DSLR camera fitted with a specialty macro lens, and an integrated image capture and analysis software process. Using this system, TRUMPF is able to consistently capture detailed images that are repeatable for comparison at a reasonable cost.

The Photo Box frame, custom camera mount, and sample holding fixture were first modeled in SOLIDWORKS and then simulated by ANSYS, a finite element analysis software, to confirm that the apparatus could stabilize the camera system and safely support samples up to 8" x 8" x 1.5" in size and 30 lbs. in weight. This box was also fitted with a self-contained lighting system consisting of LED tube lights and various materials selected for their respective abilities to absorb and reflect light at different locations. When combined with the opaque frame, the complete box is able to brightly and evenly illuminate the sample, while eliminating ambient light and vibrations. The resulting images are location-agnostic and provide sufficient detail for analysis and comparison.

The final product and process that our team presented to TRUMPF is a prototype, but thorough tests of the system across a variety of scenarios demonstrated that the required details in cut samples were able to be captured.



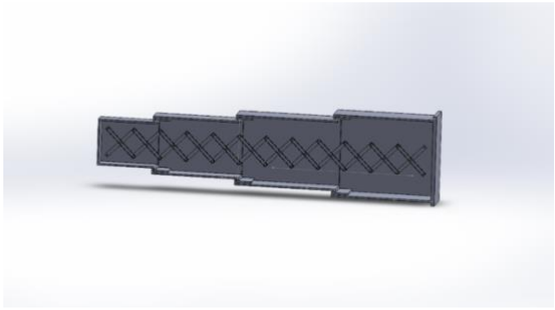
From Left: Hermana Henry, Christine Bae, Cristian Martinez, Professor Jason Lee

MECHANICAL ENGINEERING

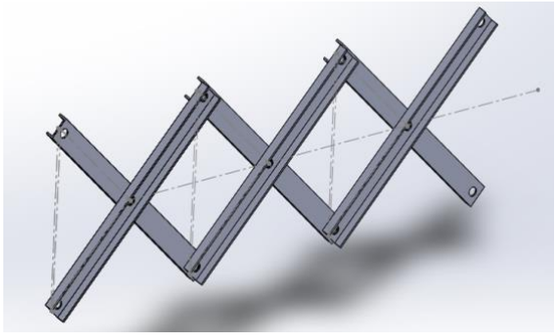
TEAM: ME 55
SPONSOR: Universal Safety Net Solution
ADVISOR: Professor Jason Lee

Safety Stop Device for School Bus

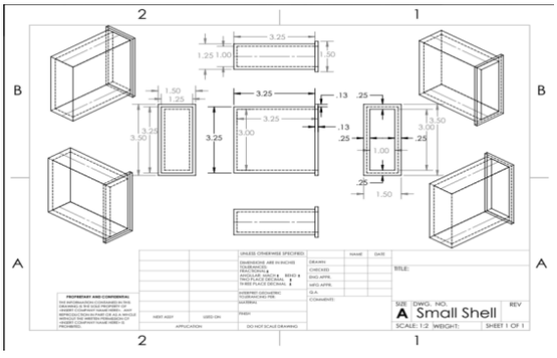
Universal Safety Net Solutions is a start-up company that aims to increase the safety of students traveling on public transportation services. Students are at risk every day while being loaded and unloaded from school buses. Studies show that since 2001, over 1300 students have been struck by passing cars. Knowing this, Universal Safety Net Solutions has devised a prototype to improve the safety of students using public transporting systems.



Our team was assigned to model and create a telescoping arm that will be attached to the rear hip of the school bus. Its attachment location was intended to deter impatient cars from trying to pass the stopped bus. The device will telescope out perpendicular to the street and stretch across eight feet. The apparatus would be fitted with lights, signage, an alarm sound, and a motion detecting camera to capture cars that may try to pass.



The deployment of the telescoping device at full scale was designed to be within 10 seconds. Using the advised requirements, research in traffic and safety laws, as well as various privacy laws, ten prototypes were created, then downsized to five, and later to one final prototype that would be scaled up. Manufacturability and overall integrity of the idea were tested. All parts of the prototype would have to be able to be handled by up to two persons to be attached to the school bus if it were to be distributed as an aftermarket bus accessory. ANSYS Fluent simulations for the prototype shell and inner mechanisms were also modeled to ensure the integrity of the prototype if a car were to hit it. The full-scale prototype is around eight feet long and sagging is a concern that was analyzed in ANSYS as well as mathematical hand calculations to verify the results. Taking these factors into account, a scissoring mechanism powered by a linear actuator was chosen as the inner mechanical workings of the prototype. The scissoring mechanism was designed to be made of steel for strength while the outer shell was designed with PVC plastic for weatherproofing, cost efficiency and durability.



The development of this prototype will allow students who use public transportation to travel safer and for other drivers to be more aware of a stopped bus when driving.

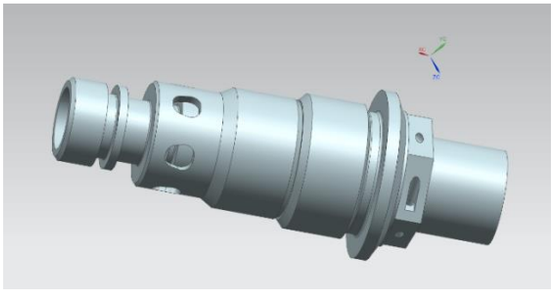
From Left: Matthew Lesner, Łukasz Burek, Professor Horea Ilies

MECHANICAL ENGINEERING

TEAM: ME 56
SPONSOR: Collins Aerospace
ADVISOR: Professor Horea Ilies

Design-Based Auto-Draw Algorithm of a Pressure-Relief Valve

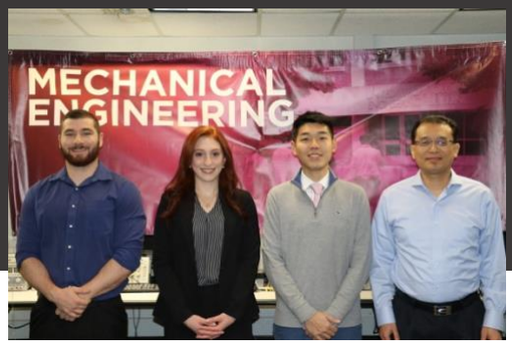
Collins Aerospace
A United Technologies Company



Collins Aerospace is a world-renowned aerospace and defense company, created recently by the 2018 merge of UTC Aerospace Systems and Rockwell Collins. One of their many technologies is the fuel metering system, which is responsible for controlling the air/fuel ratio of a turbine engine. This system operates with the use of hydraulic and electronic feedback controls that efficiently manage the fuel consumption. These controls also contain pressure-relief valves that bypass high-pressure fuel out of the system.

The goal of this project was designing an algorithm that re-sizes a computer model of a metering system's pressure-relief valve. The purpose was to re-size the valve based on its operating conditions, including the fuel flow rate entering the system, the pressure of the system, and the temperature extremes it may experience. The algorithm takes into consideration all these factors so that the valve is re-sized accordingly. For instance, a higher fuel flow rate would lead to a larger sized valve so that it may fit the flow rate, a more highly-pressurized fuel would require stronger structural components, and the temperature changes must account for the valve material's coefficients of thermal expansion so that the valve's interior components can fit properly.

The valve was modeled using Siemens NX, and the model was linked to an Excel spreadsheet containing the algorithm. Each dimension of the valve is contained in the spreadsheet. These dimensions are functional values of the valve's operating conditions and geometric relationships. Listed in the spreadsheet is each operating parameter, which when altered, updates the entire valve model. The Siemens NX software allows for easy integration of the Excel spreadsheet with the model so that the model is re-sized at the push of a button.



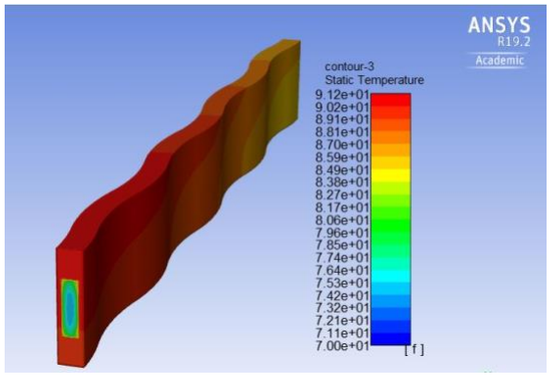
From Left: Justin Longton, Katrina Awad, Vincent Chen, and Professor Chih-Jen (Jackie) Sung.

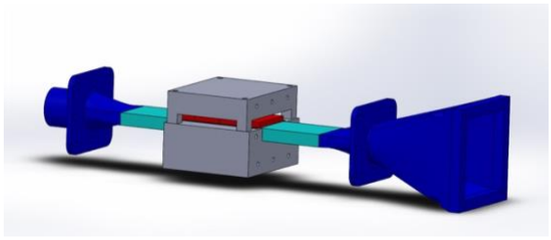
MECHANICAL ENGINEERING

TEAM: ME 57
SPONSOR: Collins Aerospace
ADVISOR: Professor Chih-Jen Sung

Surface Finish Impact on Heat Transfer and Pressure Drop for Additively Manufactured Fins

Collins Aerospace

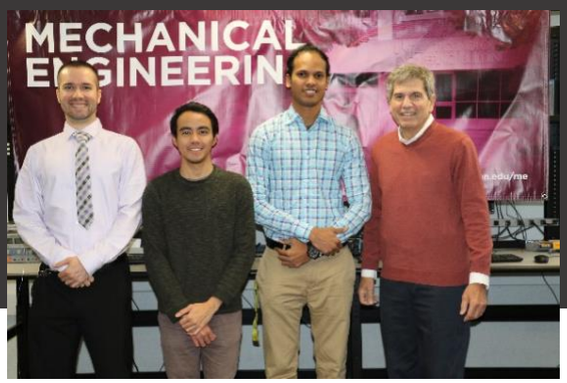




Collins Aerospace is Worldwide supplier of many aerospace and defense products. At Collins Aerospace, controlling the flow of heat generated by on-board electronics is essential for the design of spacecrafts. Currently, Collins Aerospace creates their compact heat exchanger (HEX) fins through a technique that precisely punches and bends sheet metal until the desired shape is formed. Once the fins is shaped, a final HEX fin-plate assembly also requires complex, tight-tolerance brazing techniques.

In order to combat the current lengthy traditional manufacturing method, Collins Aerospace wants to employ Additive Manufacturing (AM), which is a process that uses powdered metal to build an object layer by layer, for the production of their plate-fin HEX assemblies. Collins Aerospace, however, is concerned that higher surface roughness created by the AM process will negatively impact the pressure drop of the system. In order to make AM a viable manufacturing method for HEX fins, Team ME57 was tasked with examining the effects of surface roughness on heat transfer and pressure differentials across HEX foil fins manufactured by two different methods and recommending an enhanced method to reduce the surface roughness.

Through Computational Fluid Dynamics analysis, the pressure drop as well as the heat transfer rate predictions were made and further validated through physical testing. A modular test rig with air running through the fin was built to measure the fluid pressure differential from inlet to outlet using a U-tube manometer. A heating component on top of the fin was added as well, to monitor the fluid temperature changes and fin wall temperature changes with the use of thermocouples. Three different fin HEX assemblies were tested: a fin created by traditional manufacturing methods, a standard AM fin, and post-processed AM fin. After testing, it was found that a post-processing technique known as chemical milling applied to an AM Fin gives pressure differentials very close to Collins Aerospace's traditional fin. Additionally, an AM Fin with post-processing slightly exceeds the heat transfer rate given by a traditional HEX fin. Therefore, it is acceptable for Collins Aerospace to use AM for their manufacturing method, if chemical milling is applied as a secondary step.



From Left: Vincent Marotta, Neil Jay C. Lopez, Aminul Chowdhury, and Vito Moreno

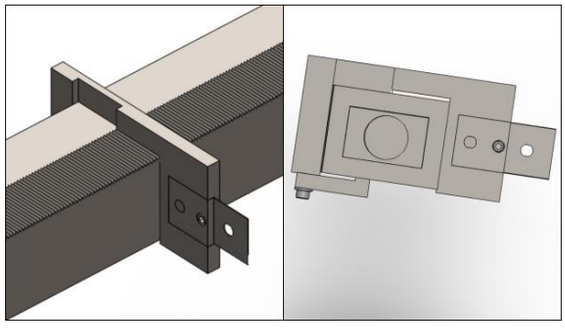
MECHANICAL ENGINEERING

TEAM: ME 58
SPONSOR: Web Industries
ADVISOR: Professor Vito Moreno

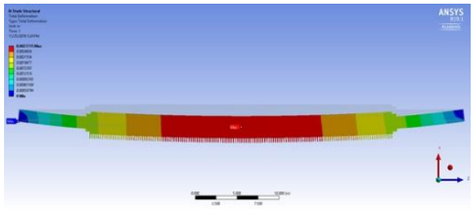
Line-2 Blade Bar Redesign

webindustries
Listen. Create. Deliver.

Blade bar redesign full length.



(Left) Spacer in place (Right) Side view of spacer.



ANSYS Simulation of the Blade Bar Deformation

Team ME58 was tasked by sponsor Chintesh Patel with redesigning a Web Industries blade bar which cuts one large sheet of specialty film in to many smaller long strips. Problems with the original blade bar involve its high weight (80 lbs), timely setup and installation process, and the difficulties the operator must endure while manually holding and reaching across the entire machine in order to place it in position. Two additional options addressed is to create an assisted lifting device to allow an operator to install the blade bar more safely, and a redesign of the blade bar cart which houses both the bar and its components for ease of assembly.

Web Industries is a leader in outsourcing and manufacturing of composites, plastics, and specialty films. When a company needs to incorporate such products in their design, they seek out Web Industries to handle the manufacturing and production of these materials, so that they can then be used to bring innovative and complex ideas to reality. The refinement of most of their products happens in-house on location. If a client needs a specific material manufactured in a specific way, Web Industries finds ways to produce and prepare this material.

The use of the blade bar is pivotal in cutting the specialty film to specified sizes. For the original design, many spacers were selected and stacked along the entire bar. Razor blades were then compressed between spacers much like a bookmark between pages. The result was a heavy cumbersome blade bar.

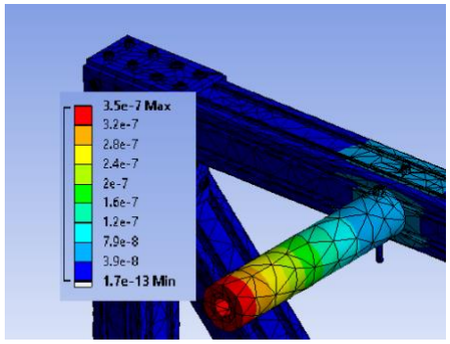
After many design iterations, simulations, and experiments, the ME58 team decided to forego the heavy stacks of spacers, and instead designed individual ¼" spacers which hold a razor blade in place. Where needed, one spacer is aligned and secured in position, resulting in roughly 20 spacers with blades (versus the original blade bar which often used 144 heavy spacers). The end result is a significantly lighter blade bar which can be as light as 20 lbs! In addition to this, a crane-like device attaches to the redesigned blade bar cart to lift and install the new blade bar for the operator. The result is a lighter blade bar which is faster and safer to use and operate.

From Left: Matthew Petrucci, Tom Kennedy, Justin Hufnagel, Professor David Giblin

MECHANICAL ENGINEERING

TEAM: ME 59
SPONSOR: Web Industries
ADVISOR: Professor David Giblin

Spool Removal Assistance Cart



Web Industries - located in Dayville, CT - specializes in precision converting of technically advanced flexible materials. They process many different materials including composites, plastics, nonwovens and specialty films. Their end products are materials that have been slit, cut, printed, or, in our project's case, spooled. Applications range from commercial airliners to juice boxes, extension cords, and medical testing consumables.

Web is currently designing new facilities to centralize their production. As they continue to grow, they will need to increase their productivity. To improve the current process, our project is to design a spool removal and transportation cart (doff cart) to improve the process flow of a material splicing operation at Web Industries. Currently, the operation runs with an uptime of only 50%, due to the splicing machine sitting idle while the operators unload, label, and bag the produced spools. As Web Industries upgrades their facility to include an automatic pneumatic unloading system, they seek a cart to receive and transport the spools, freeing up space on the machine to run a second cycle while the operators process the spools. This process of unloading wound spools and reloading empty spools onto a spool winding machine is known as doffing.

Our team designed a doff cart that can receive all the spools and transport them to the staging area. Working alongside Web as they finalized their new factory plans, we created a cart to integrate into the winding workflow, greatly reducing the machine downtime. In order to ensure the design worked, we developed different prototypes until deciding on one to fabricate, continuously improving the cart's design over time. Design of the prototype focused on simplistic construction methods, along with a strong frame to ensure industrial grade strength. Through prototyping, worker surveys, and ANSYS modeling, we designed a cart that would be able to receive and transport six spools and last for years. In using ANSYS, we were able to determine that there would be very small levels of deformation throughout the cart, as seen in the bottom image. In addition to greatly improving the efficiency of the spool winding process, the cart will reduce the stresses of the job on workers and increase how ergonomic their roles are. We are very grateful for the opportunity to be a part of this project and contribute to the process improvement team at Web Industries.

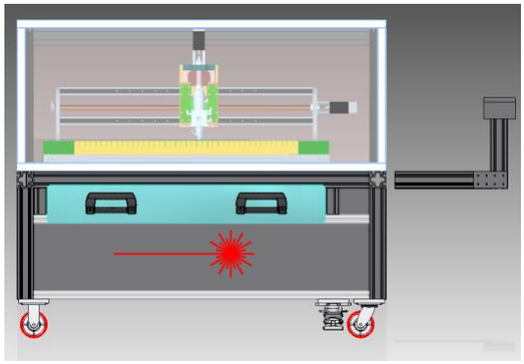
From Left: Eli Gates, Leah Morasutti, Michelle Reinert, Professor Vito Moreno

MECHANICAL ENGINEERING

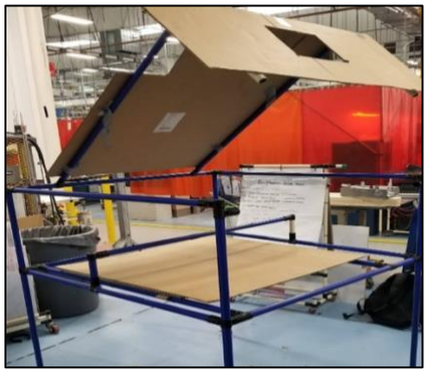
TEAM: ME 60
SPONSOR: Allen Roy
ADVISOR: Professor Vito Moreno

Design, Development and Fabrication of a Right Sized Flat Pattern Laser Cutter

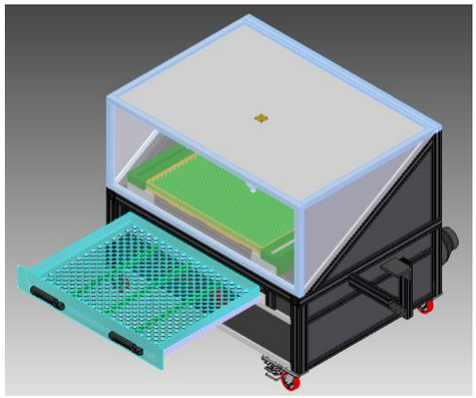
Whitcraft LLC is a company based out of Eastford, CT and specializes in the production of formed, machined, and fabricated sheet metal components for aerospace applications. Being world leaders in lean manufacturing, continuous improvement is a company-wide strategy.



Out team was tasked with designing, fabricating, and validating a 3-axis flat pattern laser cutter. The laser needed to be “right-sized” which means it has the ability to perform all required machine functions necessary without creating wasted space. Initial design requirements included a 75% reduction in floor space, improved ergonomics and ease of maintenance. Our design meets all required specifications set forth by Whitcraft. The purpose of this laser was to be able to place the laser within the bracket flow line on the Whitcraft shop floor and utilize Whitcraft’s scrap metal to cut parts. This allows for JIT (just-in-time) production and a reduction in the MLT (manufacturing lead time), greatly increasing the overall manufacturing efficiency.



Our final design consists of a 300W fiber laser from IPG Photonics with a 220V power source. This will operate with a capacitive height sensing laser head from Haas Laser Technologies with a 0.006-inch spot size. The laser will be air cooled and vented using a FA1-E fume extractor, filter and spark arrestor from Fumex. The new machine is less than 20 square feet. It will be controlled with a Delta Tau PMAC motion controller, using G-code. The laser head moves along a 3-axis Cartesian gantry system and is operated using ball-screws and servo motors, moving the laser up to approximately 12 in/s. The laser bed consists of triangular metal slats which are designed to hold up a sheet of honeycomb. The top of the machine lifts up ergonomically and polycarbonate is used for the front window to block harmful wavelengths between 600-700 nm. Many of the frame materials and the bed slats were cut in-house from sheet metal. This laser has a class 1 enclosure and meets all OSHA compliance requirements.



Our overall approach was to ensure that behind every design decision was the drive to provide Whitcraft with an efficiently running “right-sized” 3-axis laser cutter.

From Left: Stephen LoPresti, Guillermo Mercado, Theodore Blake, Professor David M Pierce

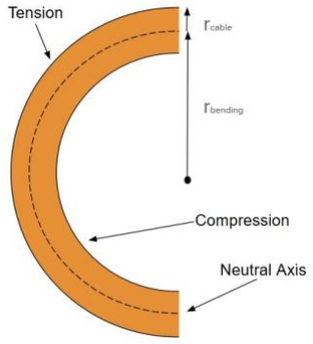
MECHANICAL ENGINEERING

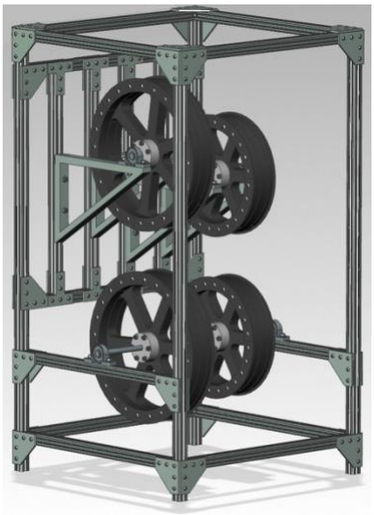
TEAM: ME62
SPONSOR: Shishir Sirohi
ADVISOR: Professor David M. Pierce

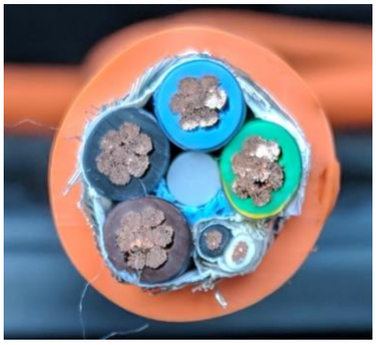
Alternative Cable Fatigue Testing Machine

Winchester Interconnect

We Energize Innovation.



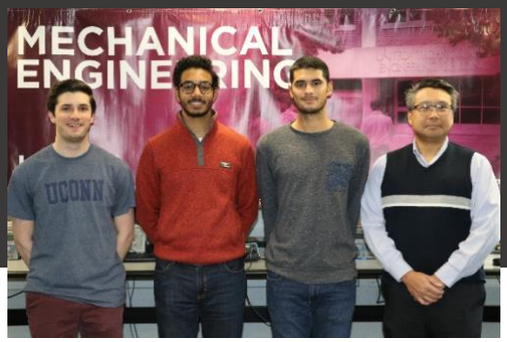




Winchester Interconnect is an international company specializing in creating precision-engineered connections for the toughest industries and environments. Their Dayville, CT location manufactures and tests custom cables and assemblies. These cables must be rigorously tested for millions of cycles to verify their durability and reliability. Currently, Winchester Interconnect utilizes a C-Track machine for their dynamic bending fatigue testing. This machine completes a bending cycle approximately every five seconds meaning that a twenty million cycle test requires years to complete. The cable fails the test if the outer jacket cracks or there is a break in the electrical continuity of any inner wires.

Winchester Interconnect tasked our team to design, fabricate, and validate an alternative cable fatigue testing machine that increases the cycle rate to one dynamic bending cycle every half second, at least ten times faster than the current machine. It is critical that the alternative machine induce an equivalent strain on the cable as the current machine. In addition, the alternative machine should be easily adjustable to allow Winchester Interconnect to add testing features in the future. Desirable design characteristics include a decrease in size, ability to run several different cables at once, low cost, and a professional aesthetic for display to customers.

Our team first conducted an in-depth analysis of the current machine to understand the mechanism and every applied force. Then, we proposed several alternative designs, and selected one to be the best based on the given requirements and desired characteristics. This design utilizes a continuous pulley system that allows the cable to continuously rotate in the same direction, in contrast to the current machine where the direction reverses every cycle. We fabricated the alternative machine with easily alterable materials and then validated it against the current machine using both analytical models and experimental strain data.



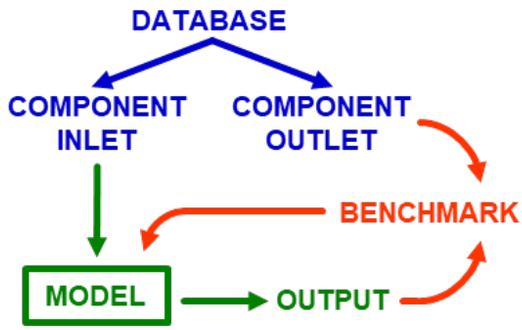
From Left: Eric Lepowsky, Numad Cheema, Nelson Duque, Professor Wilson Chiu

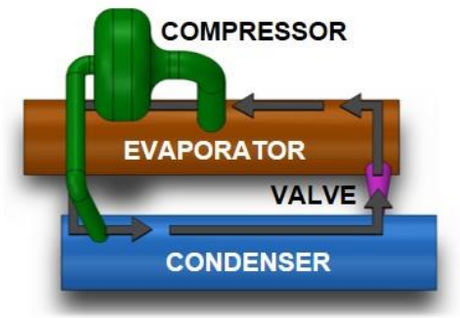
MECHANICAL ENGINEERING

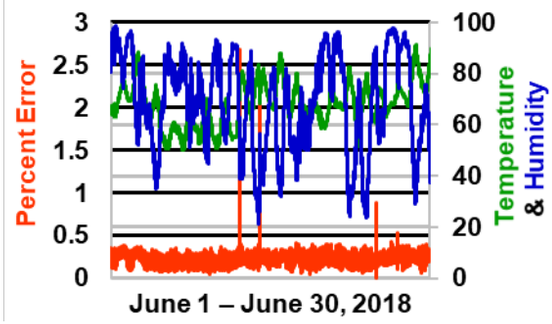
TEAM: ME 63
SPONSOR: Zachry Nuclear Engineering
ADVISOR: Professor Wilson Chiu

Analysis of Cogeneration Chiller System Performance via Component-Level Modeling

ZACHRY NUMERICAL APPLICATIONS
A DIVISION OF ZACHRY NUCLEAR ENGINEERING, INC.







Zachry Nuclear Engineering, located in Stonington, CT, provides design and project management services to the nuclear power plant industry. In nuclear power plants, chiller systems are often overdesigned to accommodate for unexpected overloads. The chiller must be large enough to maintain the environment within crucial areas of the plant, such as the control room where plant operators work, by providing chilled air even in the event of a catastrophic accident. The large capacity of chillers within the nuclear power plants prevent these critical rooms from overheating at the expensive of operating at low-loading conditions. Thorough analysis of chiller system performance under off-design conditions has not been previously examined, yet these conditions are common within the nuclear power plant industry. In this context, on-design conditions are prescribed by the chiller manufacturer; deviations from these conditions are considered to be off-design (low-loading, high-loading, and rapid temperature changes).

The goal of this project was to develop component-level analytical models in order to assess chiller system performance in both on-design and off-design conditions. Operational data was obtained from the University of Connecticut Cogeneration Plant in order to construct component models which are benchmarked to real-world operational conditions. The four key components of the chiller system which were modeled include: the expansion valve (refrigerant expands from subcooled liquid to a two-phase mixture), the evaporator (refrigerant absorbs heat from the chilled water supply), the compressor (increases the pressure and enthalpy of superheated refrigerant), and the condenser (refrigerant expels heat to cooling water).

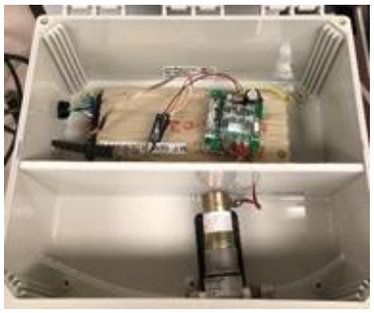
Zachry Nuclear Engineering was ultimately provided with a full-system network of the developed analytical component-level models of the selected steam-driven chiller, along with datasets (2+ million data points) for benchmarking these models. With component-level operating data as inputs, this network outputs both component-level and system-level performance for various loading and environmental conditions.

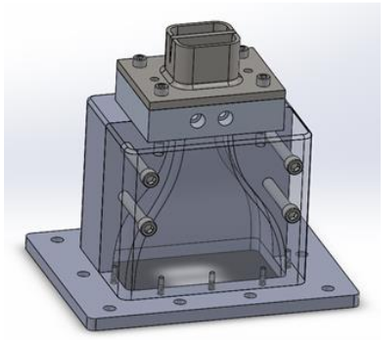
From Left: Peter Antonicelli and Professor Baki Cetegen

MECHANICAL ENGINEERING

TEAM: ME 64
SPONSOR: UConn School of Engineering
ADVISOR: Professor Baki Cetegen

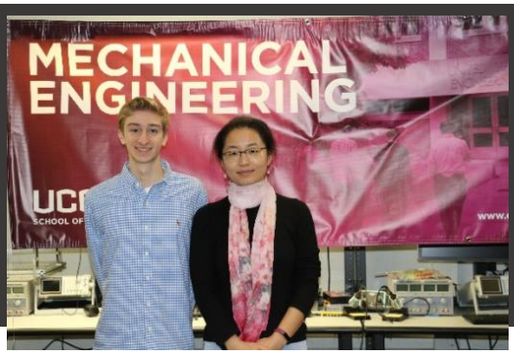
Design of Variable Flow Rate Fuel Atomizer and Liquid Fuel Flame Burner





In the field of combustion research, it has become accepted that lean, premixed, and turbulent flames are necessary for a reduction in pollution emissions and engine size. Particularly, burning fuel at lower equivalence ratios reduces flame temperature and thus brings down production of harmful NO_x gases. Adding upstream turbulence increases fuel-air mixing and allows for a smaller combustor, which is helpful for industrial applications. The downside to this approach, however, is that with increased turbulence intensity and low equivalence ratio, a flame becomes far less stable. A phenomenon known as flame blowoff often occurs in which a lean flame encounters high levels of turbulence and loses its ability to stay lit at a fixed base. Given this information, a wide range of research has been dedicated to analyzing the effect of upstream turbulence on flame characteristics at equivalence ratios close to the point of blowoff. Dr. Baki Cetegen and the students of the Combustion and Gas Dynamics Laboratory use experimental laser diagnostics, numerical methods, and image processing to analyze complex combustion processes.

The purpose of this Senior Design Project was to enable the Combustion and Gas Dynamics Laboratory with the ability to research and analyze liquid fuel combustion processes. Specifically, the laboratory - previously limited to gas fueled combustion - needed a liquid fuel injection system consisting of a pump and a fuel atomizer, a heating section for vaporization of the atomized fuel droplets, a new flame burner to withstand the temperatures required for the prevaporization, and an improved ventilation system to keep the toxic fumes out of the laboratory. In the end, an atomizer block with two hypodermic tubing inlets was created to accept separate fuel and air streams. At the outlet of the block, the fuel stream is blasted with the high-velocity air stream to completely atomize the fuel into a fine, uniform droplet spray. The bulk air flow is heated by a 6 kW in-line air heater to anywhere between 100 – 200 C. With these temperatures, the fine droplet spray is completely vaporized upstream of the outlet. The flame burner was then re-designed such that it's complex geometry could be easily machined out of aluminum and stainless steel. With this complete, the Combustion and Gas Dynamics Laboratory is prepared to research liquid fuel combustion.



MECHANICAL ENGINEERING

TEAM: ME 65
SPONSOR: UCONN
ADVISOR: Professor Xinyu Zhao

From Left: Sam Calello, Professor Xinyu Zhao

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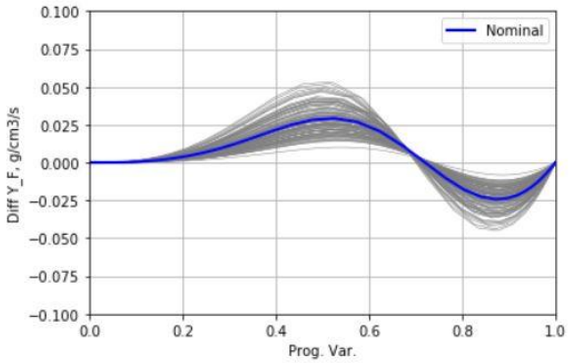
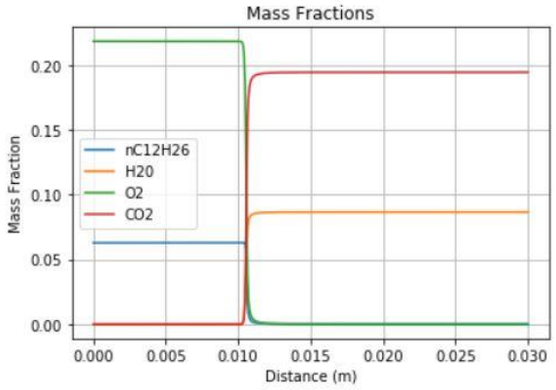
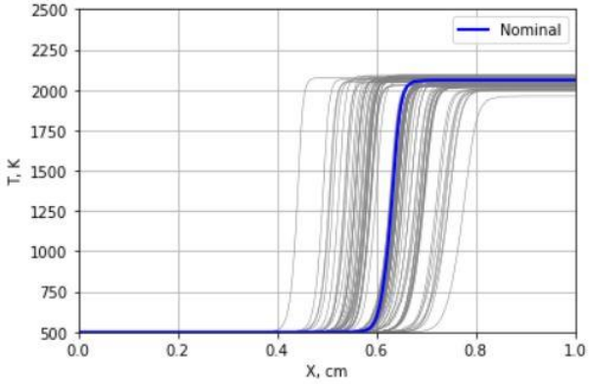
Development and Testing of An Intrusive Method for Uncertainty Quantification in Chemical Kinetic Models







Dr. Zhao is the lab director for the Computational Thermal Fluids Laboratory (CTFL) at the University of Connecticut. The lab works on many of the premier challenges that face combustion modeling. One particular challenge that is the focus of this project has to do with quantifying uncertainties in chemical kinetic models. The chemical models that are used for combustion analysis are inherently complex and currently have significant sources of uncertainty. This is problematic because uncertainties can lead to very different qualitative outcomes, which is why it is useful to identify and minimize these uncertainties. Uncertainty quantification has been found to be an extremely useful tool to develop reliable models.

Chemical kinetics are particular flame characteristics from combustion simulations such as reaction rate, laminar flame speed, temperature, density, and fuel mass fraction. These are vital characteristics that are important to track through a combustion simulation. Two types of flames are being considered in this project, a 1-D laminar freely propagating flame, and a twin premixed counterflow flame. For these simulations, a one-step chemical mechanism file for n-dodecane will be used. The nominal pre-exponential factor will be perturbed 100 times, and the results will be plotted and analyzed to see what changes occur in the chemical kinetic parameters. The purpose is to see how the flame characteristics change with perturbations to the initial conditions, in order to quantify the uncertainties found.

The objective of this project is to develop and test an intrusive method to quantify uncertainties in order to improve the design and optimization of combustion devices by allowing for more accurate estimations and predictions to be made. The difference between the two approaches is that intrusive methods require the reconstruction of the governing equations that describe the motion and behavior of a system, whereas non-intrusive methods leave the governing equations untouched. Intrusive methods have benefits over non-intrusive methods such as better convergence, and the ability to handle complex, more computationally expensive problems more efficiently. The intrusive analysis being tested here is a transported probability density function (PDF) method. The goal is to develop a reliable intrusive PDF method that produces accurate results with computational improvements over the traditional Monte Carlo method.

From Left: Joseph Squeo, Professor Xinyu Zhao

MECHANICAL ENGINEERING

TEAM: ME 66
SPONSOR: FM Global
ADVISOR: Professor Xinyu Zhao

Optimization of Model Parameters for Laminar Sooting Flames

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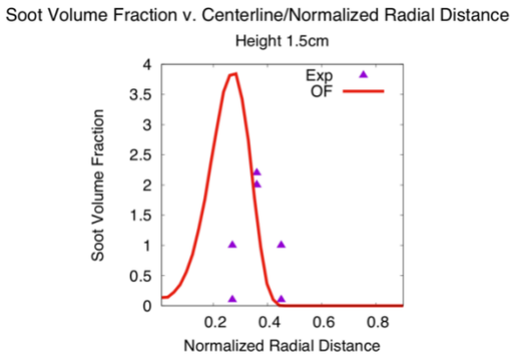
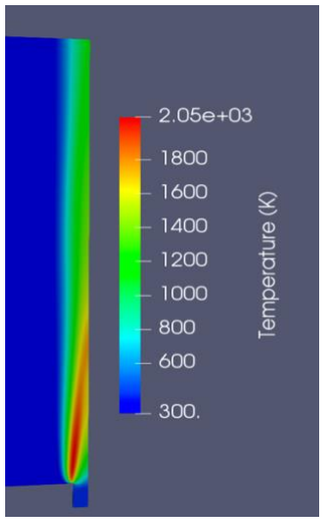




Accurate modeling of fire is extremely difficult, although very important to predict flame growth, improve fire suppression, prevent property damage and save lives. Fire prediction can be done using computational fluid dynamic simulations, and further improved by optimizing the soot prediction used in the radiation model. Soot is a black carbonaceous substance composed of very fine particles that is a product of incomplete combustion of a hydrocarbon fuel. Soot contributes significantly to radiative heat transfer, which drives flame growth and fire spread; therefore, implementing an improved soot prediction model into a fire simulation will provide more a more accurate flame simulation. Unfortunately, no modern soot model exists that can be universally applied to any fuel source with high accuracy.

The goal of my research was to investigate the sensitivity of model parameters for soot prediction and construct methods to optimize the model parameters leveraging experimental results. Following an extensive literature review of soot prediction models, data assimilation and model parameter optimization, a sensitivity analysis of the parameters was completed. Quantifying the sensitivity of each model parameter provided a better understanding of the effect of each parameter on the output of the model. Thus, appropriate modification and optimization of the model can be accomplished without detrimentally affecting the output.

Additionally, a method of data assimilation using the ensemble Kalman filter was investigated as a means to optimize the model parameters. Data assimilation is an optimized algorithm that combines a numerical model, measurements and uncertainty to obtain an improved estimate of the state. A MATLAB data assimilation toolbox has been and will continue to be used to predict an improved soot volume fraction of the model. Research is still ongoing and will continue into the summer and next semester to calculate an improved state estimate of the soot volume fraction.

A series of laminar diffusion flames were simulated in OpenFOAM using a modified combustion solver. Gas species, flame temperature and soot volume fractions were compared with experimental measurements found in literature. The results were post-processed to obtain soot volume fraction from the simulation and plotted against available experimental data, as shown in the first plot to the left. A contour plot of the flame temperature along the centerline axis is shown to the left.

Future research as a graduate student at UConn will involve implementation of the data assimilation algorithm into OpenFOAM. Numerous flame simulations will be performed to ensure accuracy of the simulation. The goal will be to improve the accuracy of the soot prediction in OpenFOAM solver for a more accurate prediction of radiation effects in the simulation.

From Left: Kirsten Yapp and Dr. Ugur Pasaogullari

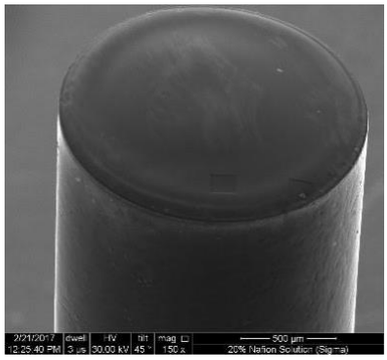
MECHANICAL ENGINEERING

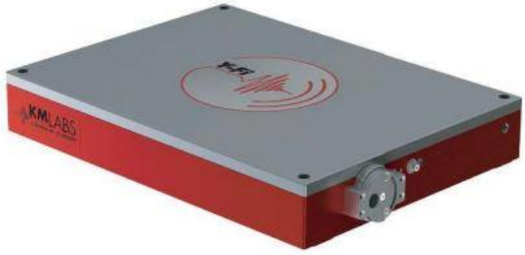
TEAM: ME 67

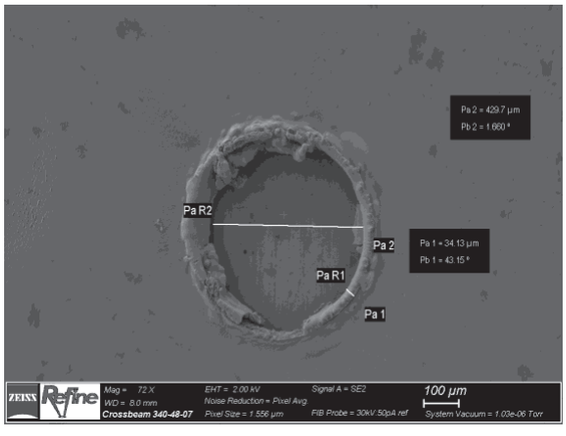
SPONSOR: Center for Clean Energy Engineering

ADVISOR: Dr. Ugur Pasaogullari

Micro Drilling of Nafion using Laser Patterning 375 words





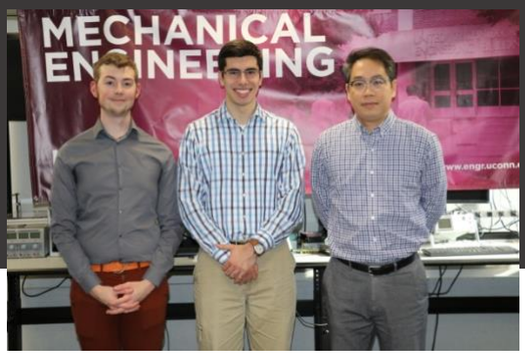


The Center for Clean Energy Engineering (C2E2) is a research center housed at the University of Connecticut's depot campus. They are a multidisciplinary center focused on innovation and the advancement of energy systems. Their goal is to educate and train engineers and scientists in order to be a leading force in the global sustainable energy economy.

Prior to the development of this project, C2E2 was tasked with creating a Hydrogen Contaminant Detector (HCD) to be implemented in the gas lines designed for refueling automotive fuel cells. The goal of the HCD is to detect when the fuel entering the gas lines has impurity limits above industry standards. It was shown that when the electrolyte layer was too thick, the response time was delayed, but when too thin, the layer was ripped apart after one run of testing. This issue now serves as the motivation for this project.

We have been tasked with increasing the gas permeability of the Nafion electrolyte layer on the HCD while maintaining the ionic conductivity necessary for sensor functionality. It was determined that laser patterning would be the most appropriate for the sensor. Research into the wavelength necessary to properly ablate the Nafion structural bonds, and the type of beam (pulsed or continuous) that would result in the least damage to the area of membrane surrounding the drilled holes. Initially samples were drilled in order to obtain proof of concept. From there, conductivity testing was done to compare the drilled membrane ionic conductivity to the known values for undamaged Nafion. The test showed little reduction in the ionic conductivity which allowed the project to progress.

KMLabs aided in the selection of the most appropriate laser for this niche specific project, the Y-Fi fiber laser. Optics lenses, boards, and safety features were determined based upon the criteria set by the wavelength, power, and desired spot size. Additionally, a mount specific to the HCD was assembled to ensure that the system is specific to the sensor design. A protocol was generated including all necessary laser, optics, and mount equipment to ensure repeatability for when drilling is done at different sites by engineers unfamiliar with this project.

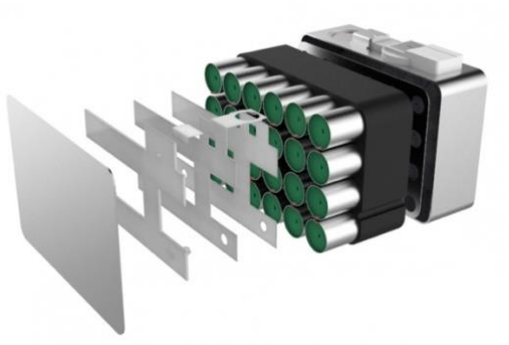


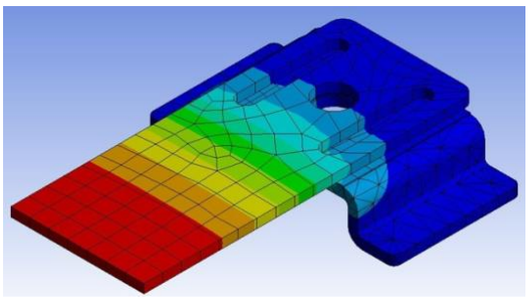
From Left: Rory McCormick, Justin Greenwood, Professor Tai-Hsi Fan

MECHANICAL ENGINEERING

TEAM: ME 69
SPONSOR: Cadenza Innovation
ADVISOR: Professor Tai-Hsi Fan

Laser Welding Optimization for Lithium-Ion Batteries





Cadenza Innovation is a company based out of Bethel, Connecticut that is an up and coming leader in the energy storage industry. The batteries designed by Cadenza are targeted for the automotive industry as well as for applications in mass grid energy storage. As such, an innovative and aggressive new design was required to safely store energy while still achieving maximum energy density and energy efficiency. These Lithium Ion supercells are connected in parallel by welding the terminals of the batteries together with an Aluminum busbar to further improve the electrical current rating. Consequently, the quality of the weld connecting the battery terminal to the busbar is paramount, as the efficiency of the entire system reaches a bottle neck at the battery's ability to efficiently transport the current into the circuit from the cell.

In order to optimize the weldment, the team has utilized both analytical and experimental techniques. The team compared weldment quality through two different experiments: electrical resistance and thermal response. The thermal response test was conducted by running high current through the weldment and recording the steady state temperature of the system at three different locations. Higher temperatures were associated with lower electrical conductivity as more of the electrical energy was used to produce heat. The other test was a resistance test, where the electrical resistance of the entire weldment was measured. The experimental data for heat production and resistances of each weld was then used and compared against an ANSYS simulation to validate the best-case and worst-case scenario for bulk conductivity that would meet industry standards. In addition, cross sections of the sample welds were also taken to understand what grain orientations facilitate the best electrical conductivities.

Using this information, the team was able to recommend welding parameters to the sponsor that would yield the lowest heat production as well as the lowest electrical resistance.

SENIOR DESIGN CONTACTS

Biomedical Engineering
Ki Chon
Department Head
www.bme.uconn.edu
(860) 486-5838

Chemical and Biomolecular Engineering
Ranjan Srivastava
Department Head
www.cbe.engr.uconn.edu
(860) 486-4019

Civil and Environmental Engineering
Marisa Chrysochoou
Department Head
cee.engr.uconn.edu
(860) 486-2992

Computer Science and Engineering
Sanguthevar Rajasekaran
Department Head
www.cse.uconn.edu
(860) 486-3719

Electrical and Computer Engineering
John Chandy
Department Head
www.ee.uconn.edu
(860) 486-0080

Management and Engineering for Manufacturing
Jiong Tang
Program Co-Director
www.mem.uconn.edu
(860) 486-2221

Materials Science and Engineering
Bryan Huey
Department Head
www.mse.engr.uconn.edu
(860) 486-4620

Mechanical Engineering
Horea Ilies
Department Head
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Vito Moreno
Professor in Residence
me.engr.uconn.edu
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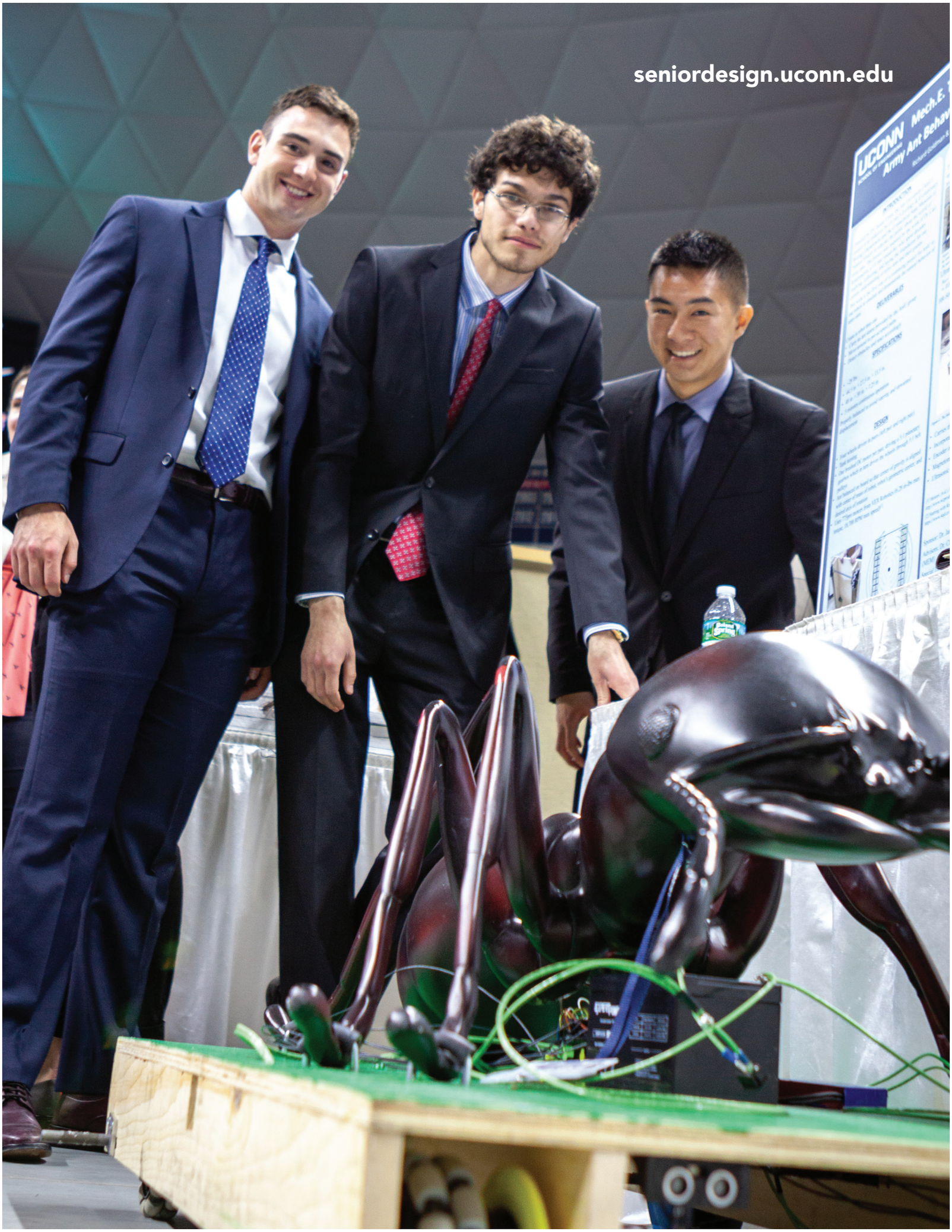
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