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Hello

My name is John Cummings and I am a third year mechanical engineering student at Lehigh University minoring in aerospace engineering and business with a variety of out of classroom experience. Being involved in research, internships, and a Formula One style engineering team have provided me with the sense of intuition and collaborative skills required to solve complex engineering problems with ease.

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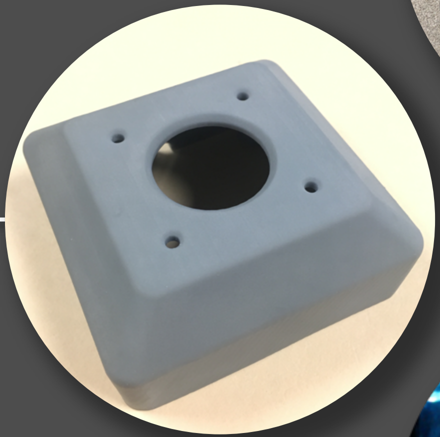
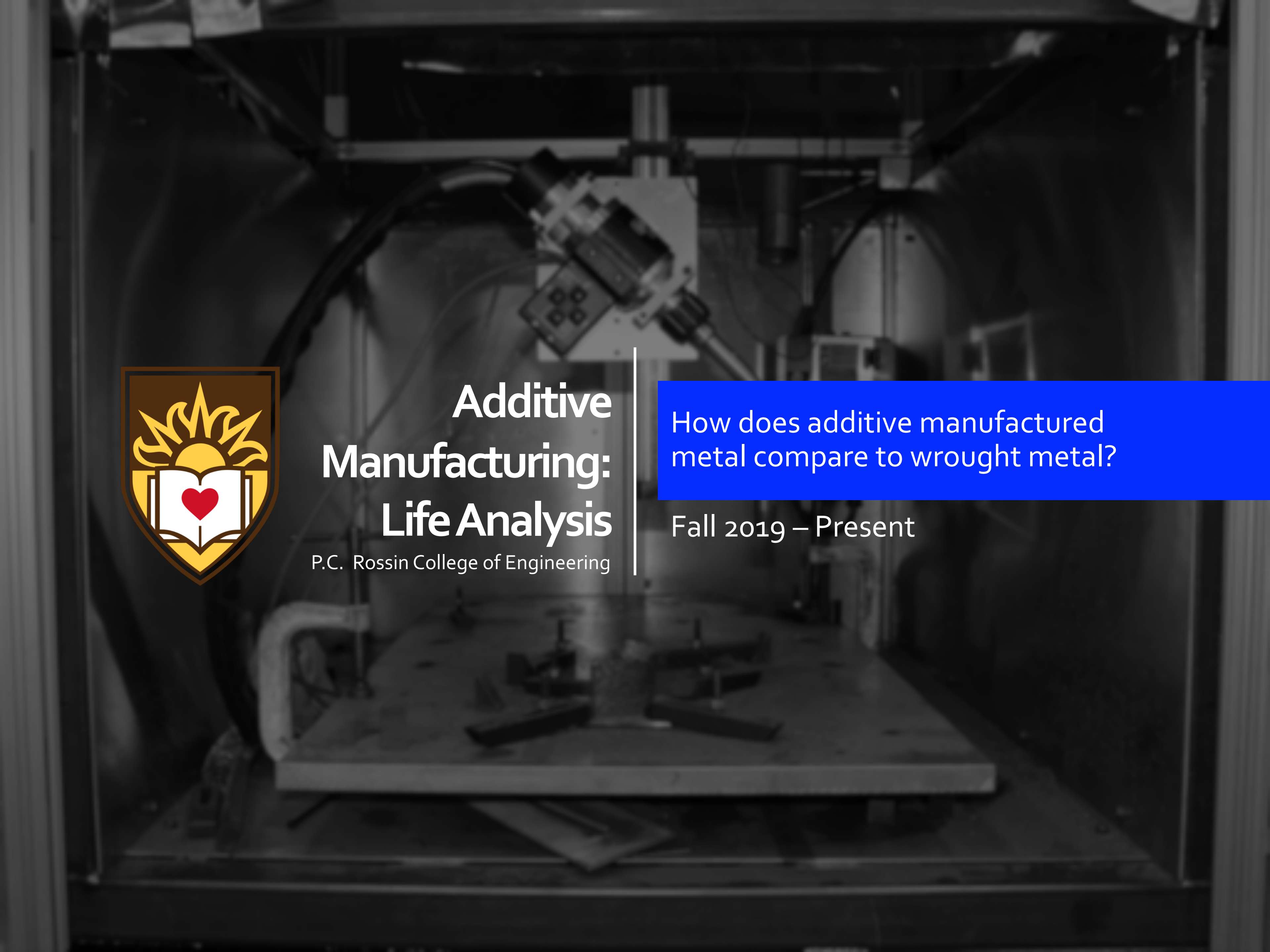
Lehigh Formula SAE's 2018-2019 Car



Accessibility Controller Housing

Prototype Airfoil in Homemade Wind Tunnel



Additive Manufacturing: Life Analysis

P.C. Rossin College of Engineering

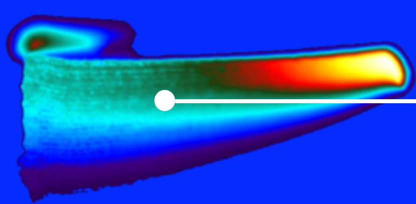
How does additive manufactured metal compare to wrought metal?

Fall 2019 – Present

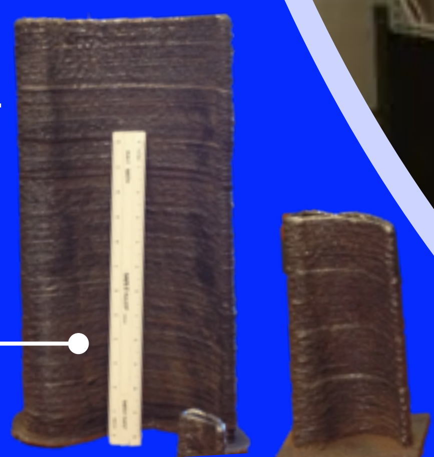
Research Overview

The use of an in-house gas metal arc welding (GMAW) printer allows my research group to understand the fundamental effects of additive manufacturing on a metal's microstructure. Using a variety of sensors, my team and I are determining how to best optimize grain growth in printed parts. My role on the team is to ensure hardware and software functionality, execute thermal data collection and evaluation, and assist with the implementation of LIDAR scanning as a means for error analysis.

In-house custom built GMAW (Gas Metal Arc Welding) printer



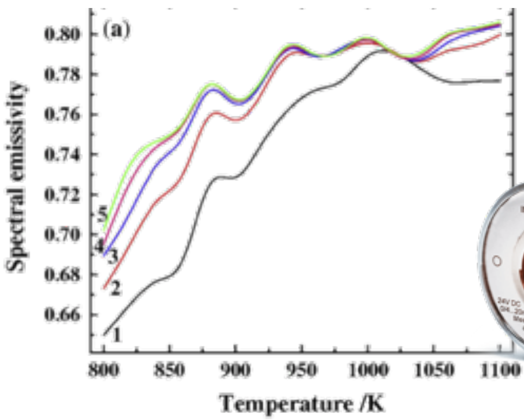
Live Thermal Image

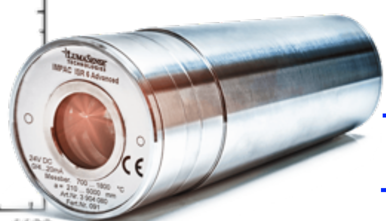


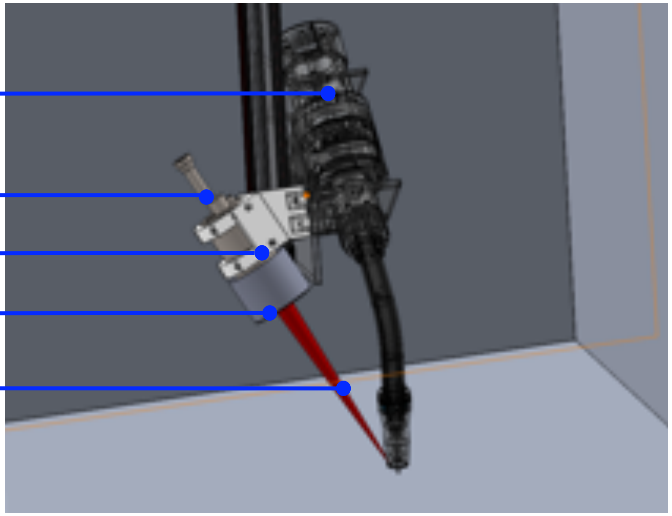
Steel 3D Printed Turbine Blades

Data Collection

In order to be able to strengthen GMAW printed parts, we must determine what variables cause grain growth. Two of the most important variables related to grain growth are the interpass and post weld temperatures. We hope to be able to use data collected from pyrometer sensors to determine how to optimize printing parameters to effect grain growth.







Research

The emissivity of molten steel changes significantly in the short amount of time after deposition, therefore standard emissivity dependent pyrometers would not be accurate.

Brainstorming

We determined that the best non-contact way of measuring temperature was with multi-wavelength pyrometers pointing at areas of interest.

Designing

To observe interpass and post weld temperatures, I plan to use multiple pyrometers aiming to collect interpass and post weld temperature.

End of Semester Goal

Develop a robust temperature collection system that uses interpass and post weld temperatures to adjust printing parameters for grain growth.

Printer Fixes

Structural Upgrades

Present

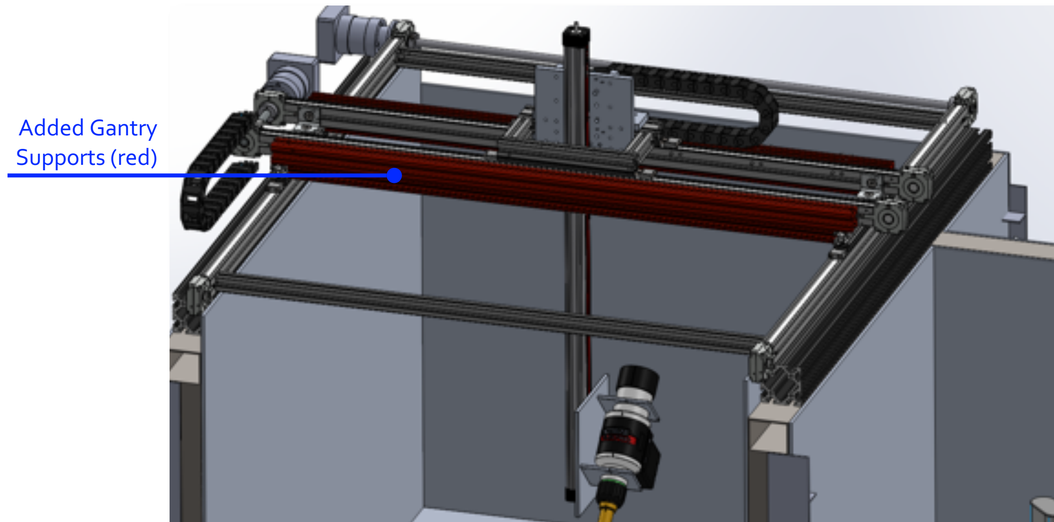
Stationary Testing

October 2019

December 2019

Hardware Upgrades

Since I have experience working with 3D printers, I was tasked with making electrical and hardware upgrades. These upgrades include, upgrading the gantry, fixing the electrical system, and creating mounts for the sensors.



Printer Fixes

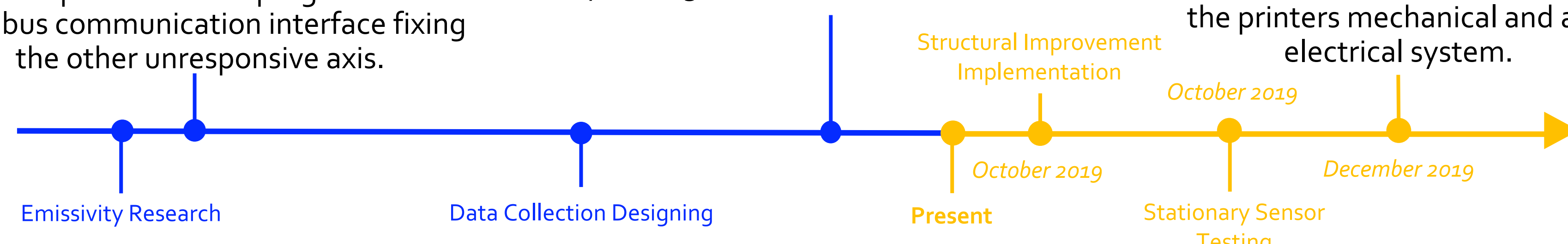
I rewired 80% of the electrical system of the printer, performing continuity checks and making new cables where necessary, fixing one of the printer axis. Reprogrammed the CAN bus communication interface fixing the other unresponsive axis.

Structural Upgrades

To reduce deflection in the gantry system during printing and allow for sensor hardware integration, I increased the structural stability by adding aluminum rails to the chassis.

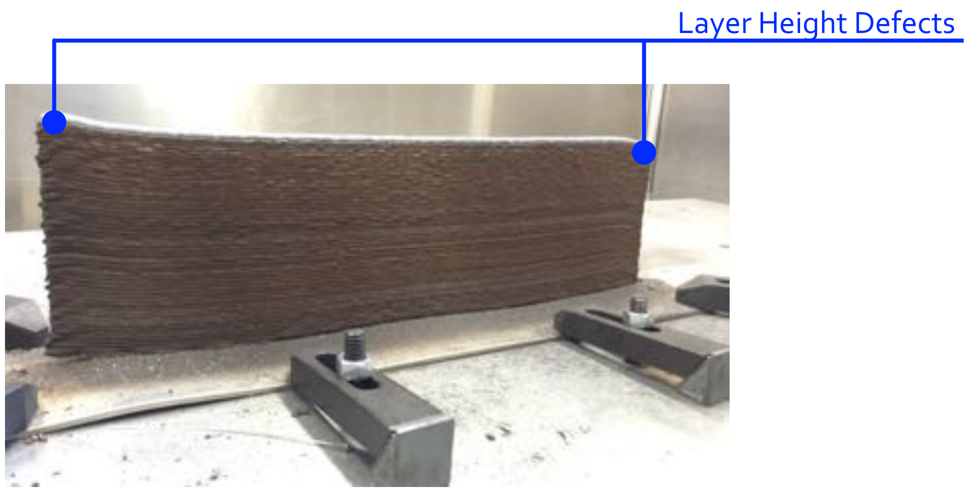
End of Semester Goal:

Through sensor mounts, mirror controls and programming, I hope to implement pyrometers, microphones and LIDAR into both the printers mechanical and and electrical system.



LIDAR Scanning

While many of the sensors we are using focus on live data collection, we do not have an objective way to link that data with printing quality. Using LIDAR, we plan to take scans of parts in between layers to measure layer height and bead width.



Contest

My group decided to enter the TiM 10K challenge to receive an LIDAR scanner for free for use in the competition. We will be competing with other university teams to showcase a new innovative use for a LIDAR scanner.

Lidar Application

For this project, we plan to use the LIDAR to scan each layer, measuring the bead width and layer height. We then plan to combine this information with thermal and audio data to determine the cause of printing defects and error analysis.

End of Semester Goal:

To begin to use the LIDAR for error detection in real time and combine LIDAR scans, thermal and audio data for the root cause evaluation of printing defects.

September 2019

October 2019

Present

November 2019

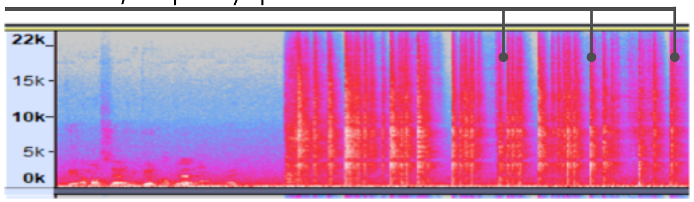
Stationary Measurement

December 2019

Long Term Goals

How can we use the sensors and strength models to adapt the printer in real time to optimize microstructure?

"Events", frequency spikes above 20 khz



Audio recordings of welding showing "events" that will be combined with thermal and LIDAR data for strength modelling and error analysis.

Strength Analysis

Perform static and dynamic tests on printed parts and develop models of the interaction of temperature, sound, bead width, and mechanical properties of printed parts.

Present

Laser Deposition Analysis

Use laser triangulation sensors to get accurate measurements for height and width of deposition beads for use with error detection and strength analysis.

Winter 2019

Live Error Correction

Use temperature data, sound information, and LIDAR scans, combined with strength models generated previously to control printer settings to optimize grain growth.

Spring 2020

Active Cooling Implementation

Implement active cooling of prints to increase heat transfer and reduce imperfections caused by a lack of heat dissipation.

Spring 2019

Expand Material Selection

Expand printing materials to aluminum and titanium to generate strength models for aerospace applications.

2020 -

Model “X-49”,
Our 2019 Car

Lehigh Formula SAE Racing Team

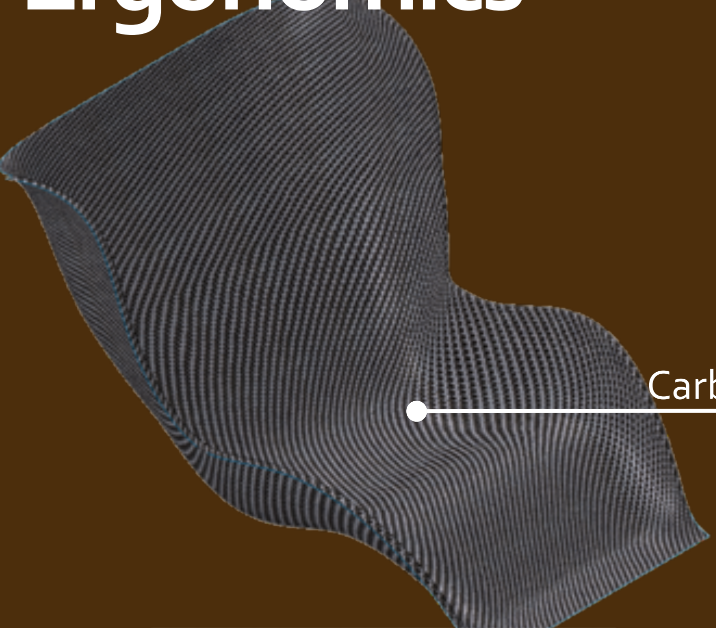
How can we maximize performance, while minimizing weight and cost?

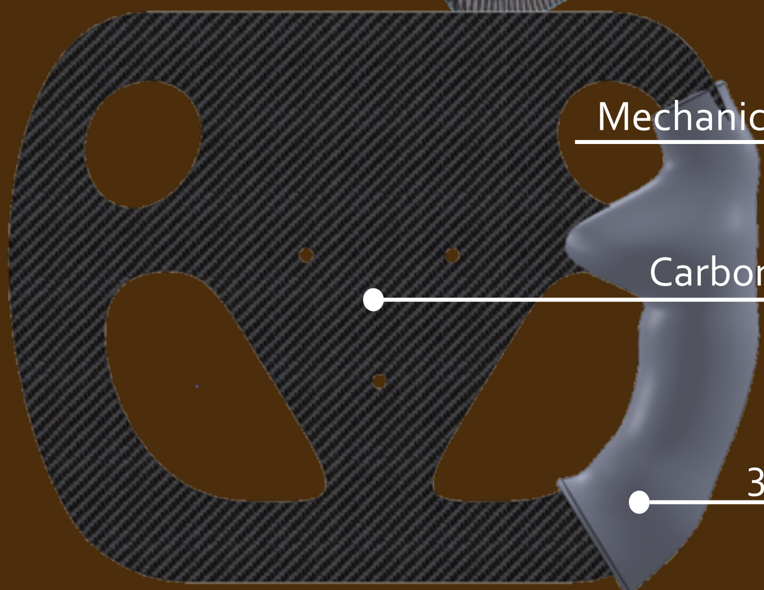
Fall 2017 - Present

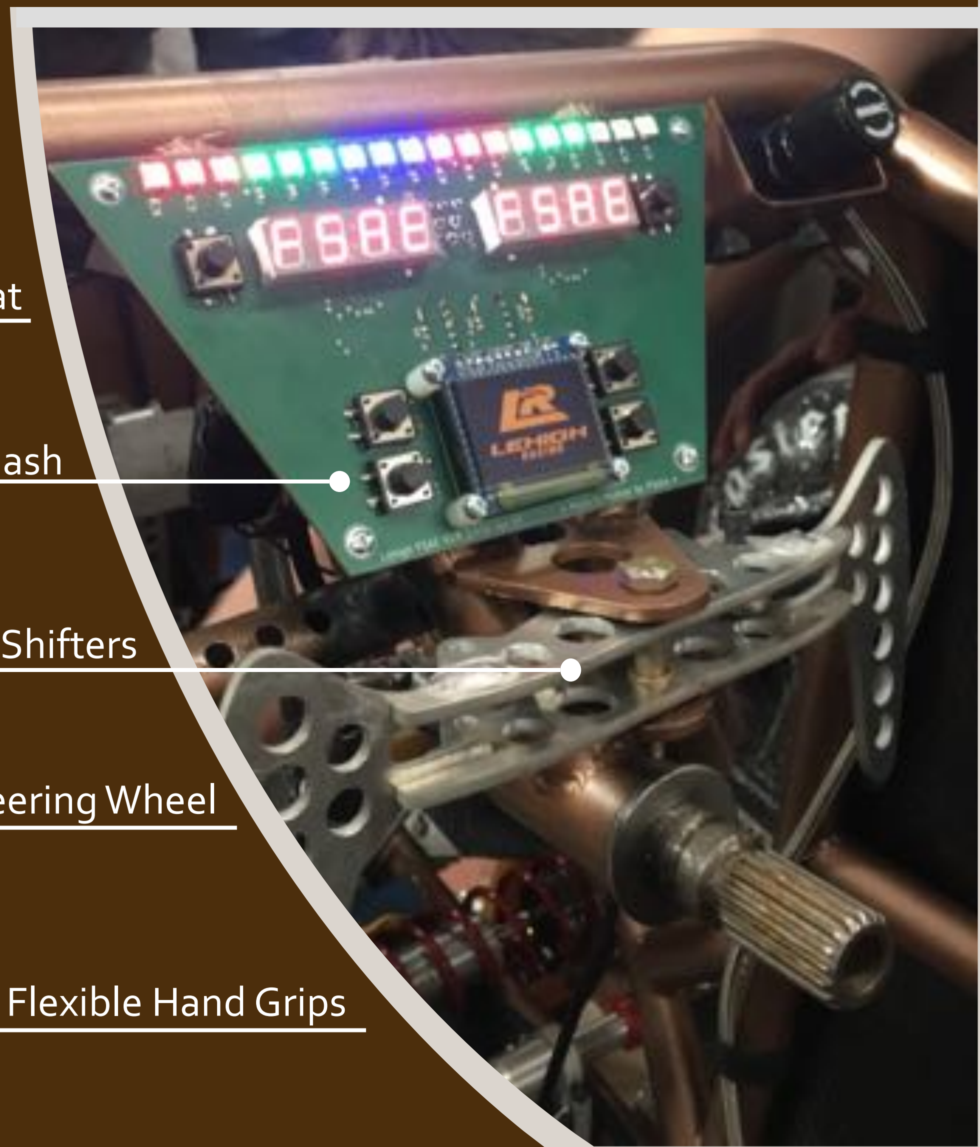
LEHIGH
RACING

X-49 Driver-Ergonomics

As the Driver Ergonomics team lead for the X49, our 2018-2019 car, I was responsible for not only many of the designing, but also for managing other members on associated projects. As the team lead, I successfully brought together those who were engineering the car and those were driving the car to ensure that the car achieved the ergonomic standards that would allow us to succeed at competition.

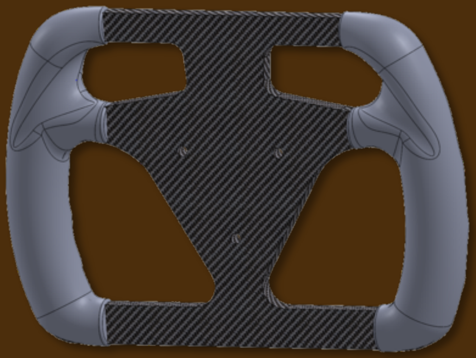


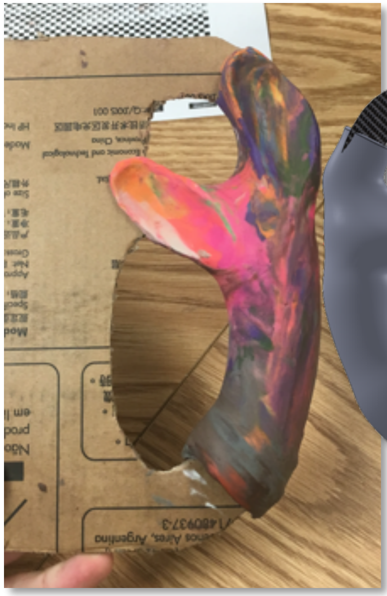


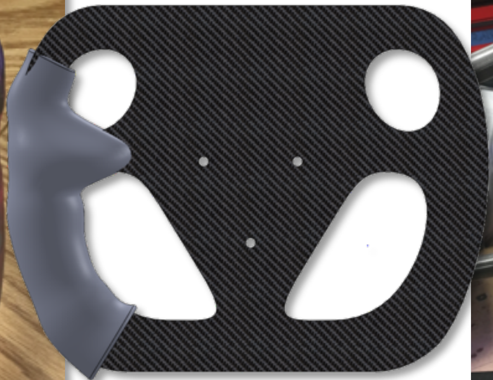


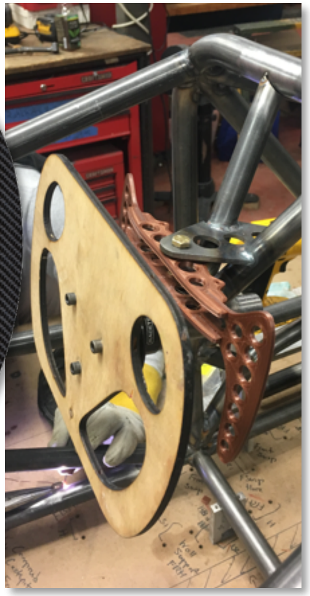
X-49 Steering System

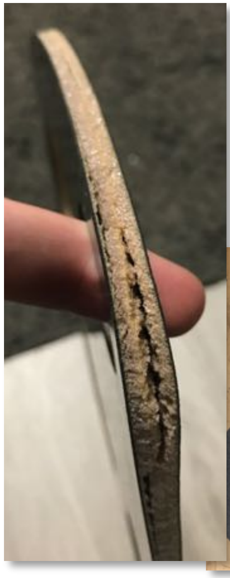
While the old steering wheel worked, it weighed 625 grams and had a large diameter, making it heavy and difficult for large drivers to fit in the car. My goal was to reduce the weight of the wheel, while increasing strength, optimizing packaging, and making it more ergonomic.











X50 Steering Wheel

After learning from the X49 steering wheel, a new design has been created that will be lighter, stronger, and more ergonomic for this years car.

Initial Design

A clay model was created of the handgrip to be 3D scanned and imported into SolidWorks to get an idea of what shape the drivers would like.

Further Design

Using the 3D scanned handgrip, a more robust steering wheel was designed with the base being a composite sandwich panel, allowing for maximum strength and minimum weight.

Prototyping

Wood models were then laser cut to see how the redesigned wheel would interact with other driver controls.

Analysis

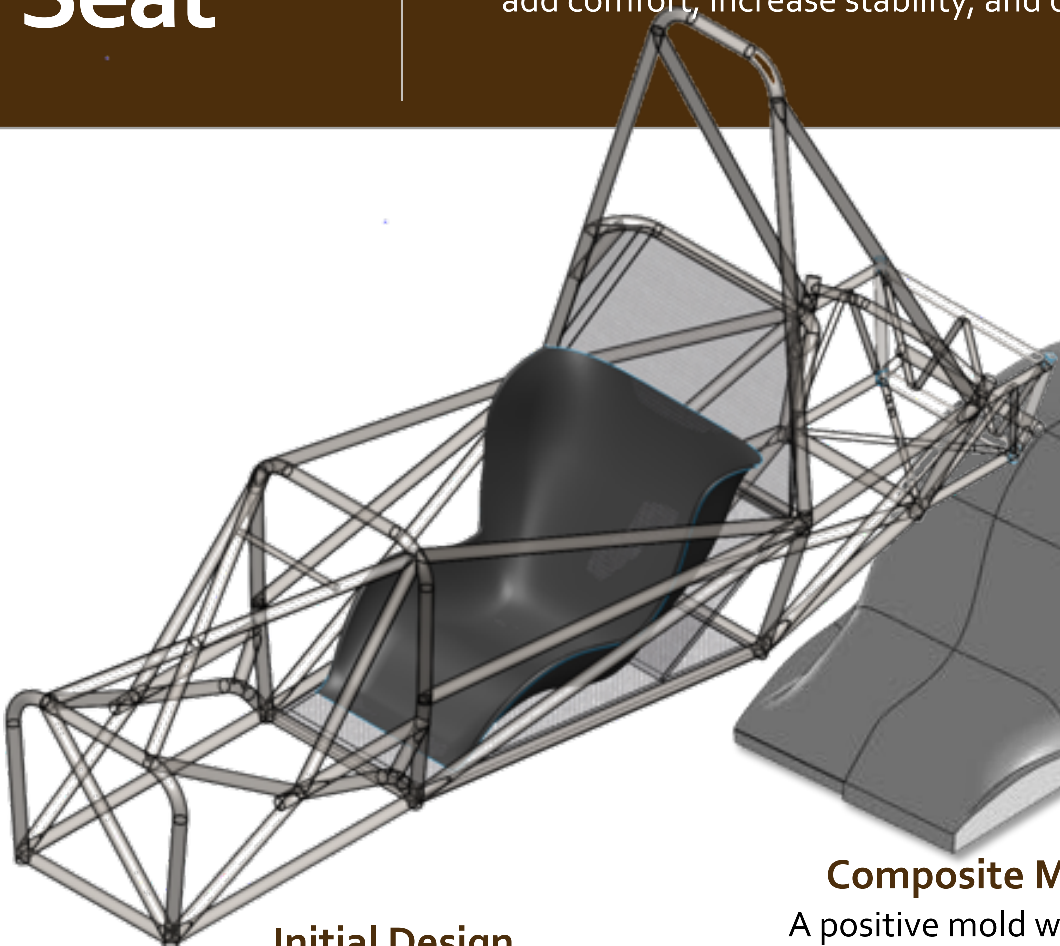
Three point bend tests were performed on various thicknesses of carbon and foam types giving us information on how to increase wheel strength.

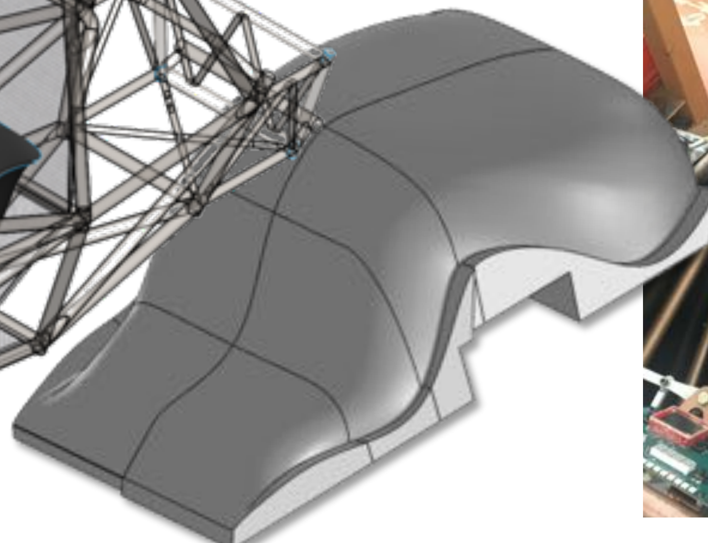
Final Result

After changing the design and manufacturing process, a new wheel was created weighing 360 grams, 41% of the original.

X-49 Seat

The forces on the driver during turns caused the driver to move around during tight turns and brake test, increasing fatigue and decreasing driver performance. Therefore, a seat was needed to add comfort, increase stability, and optimize driver position.





Initial Design

The initial design was created using surface lofting taking into account body measurements, seat belt placement, and forces while turning.

Composite Molding

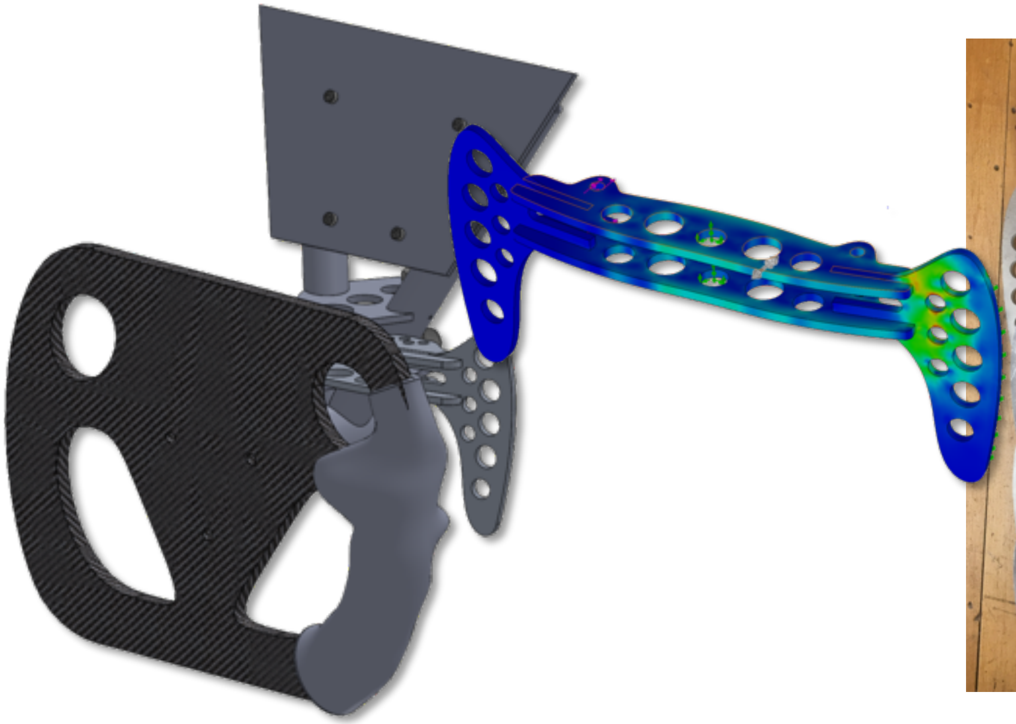
A positive mold was then 3D printed and covered in release film. The mold was then covered with multiple layers of Carbon fiber ensuring strength while still preserving weight

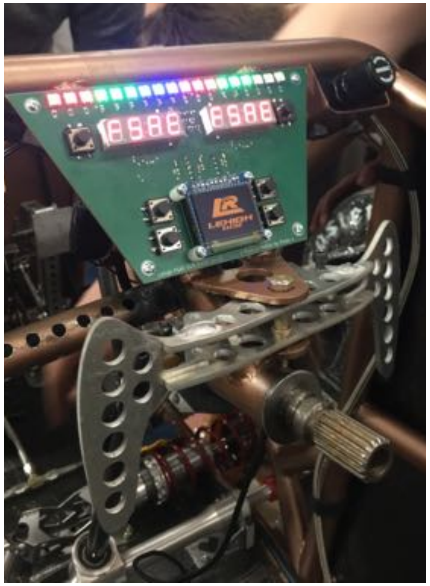
Final Result

With a weight of 3.2 pounds, this seat provided significantly more stability without sacrificing weight. Our hypothesis was proven by observing reductions in lap times.

X-49 Shifting System

After determining that shifting was slowing down our lap times, multiple design iterations, prototyping, and testing were performed to create an ergonomic paddle shifting system.





Design
The initial design was created with the intention to get a better understanding of design constraints, packaging, reachability, and strength. Further designs lead to weight reduction along the neutral axis.

FEA Analysis
The model was then put through multiple Finite Element Analysis trials to ensure acceptable strength with a factor of safety.

Prototyping
After changes in designs from static testing, prototypes were 3D printed to check reachability and packaging.

Final Result
Changes dictated by testing allowed us to produce a functional final model.

X-49 Aerodynamics

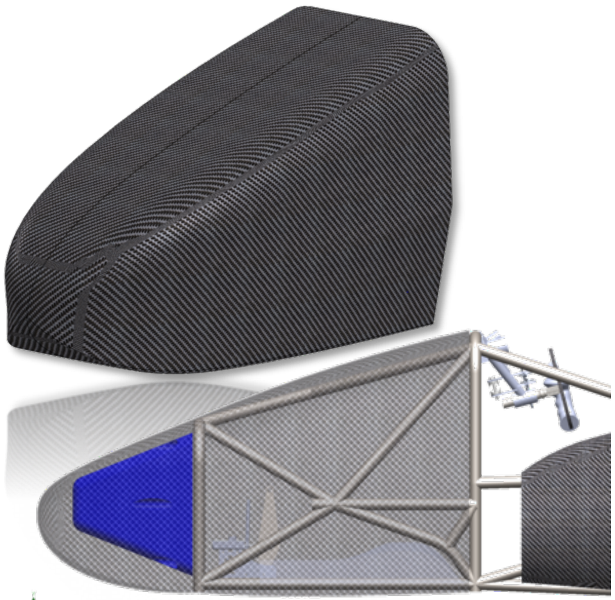
Composite Intake and Plenum

Aerodynamic Nose-Cone

Side Pods

X-49 Nose-Cone

In order to decrease drag, protect the driver, and conserve weight, a custom Nose-Cone was needed. An economic approach was taken towards this problem where we used 3D printing and foam hotwire cutting to manufacture the carbon fiber mold.



Design

Taking into account aerodynamics, packaging requirements, and driver visibility, a Nose-Cone was designed which aimed to reduce drag, direct air to the sidepods, and increase downforce.

Manufacturing

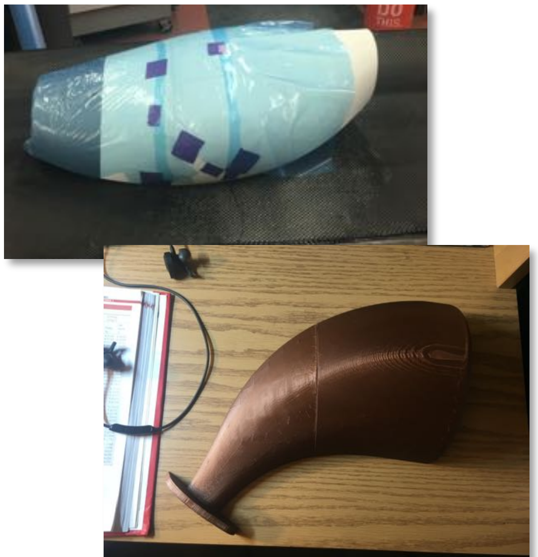
Wood ribs were waterjet and put on a support beam with foam insulation between the layers. A semi flexible hot wire was run around the wood ribs to organically cut the foam. Since the tip had complex geometry not conducive to hot wire cutting, it was 3D printed and glued to the foam.

Final Result

After creating the mold, layers of carbon fiber were formed around it. We were able to accomplish what other teams did aerodynamically with our nosecone for a fraction of what it cost them to make theirs due to our novel manufacturing methods.

X-49 Side Pods and Intake

To create parts cost effectively and precisely, additive manufacturing had to been used innovatively to create composite molds. This technique allows for parts to be made hollow with the mold dissolvable, strong enough to be vacuum formed, and fast enough to meet our deadlines.



3D Printing Molds

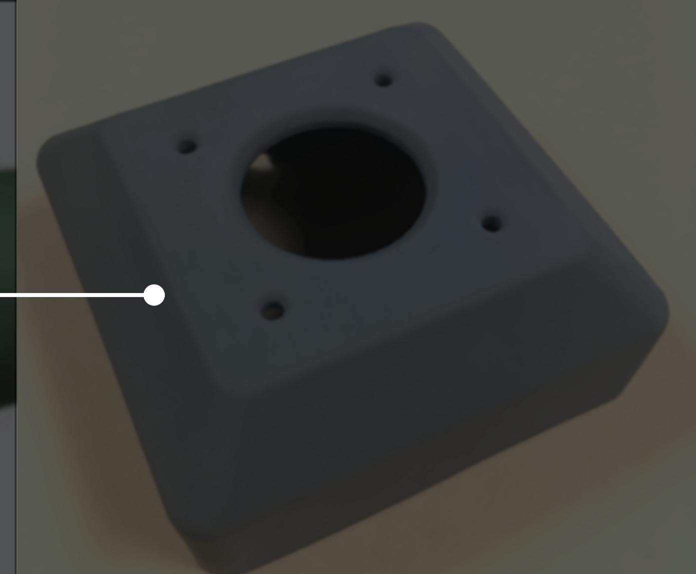
Due to the complex shapes and structural requirements of these parts, new manufacturing methods had to be developed. For the sidepods, we printed a multi part mold while for the intake a water dissolvable mold had to be used.

Molding

For the sidepods, 3D printed molds were used with an expanded foam core to provide the strength to resist the vacuum created by the vacuum forming process. For the intake, a water dissolvable mold was printed as the geometry did not allow for the removal of a conventional mold.

Final Result

The processes that we used to manufacture these parts were not only beneficial for the aerodynamics of the car, but also to the teams budget. While many teams machine these same molds out of aluminum, printing them provides us with most of the benefits for a much lower cost.

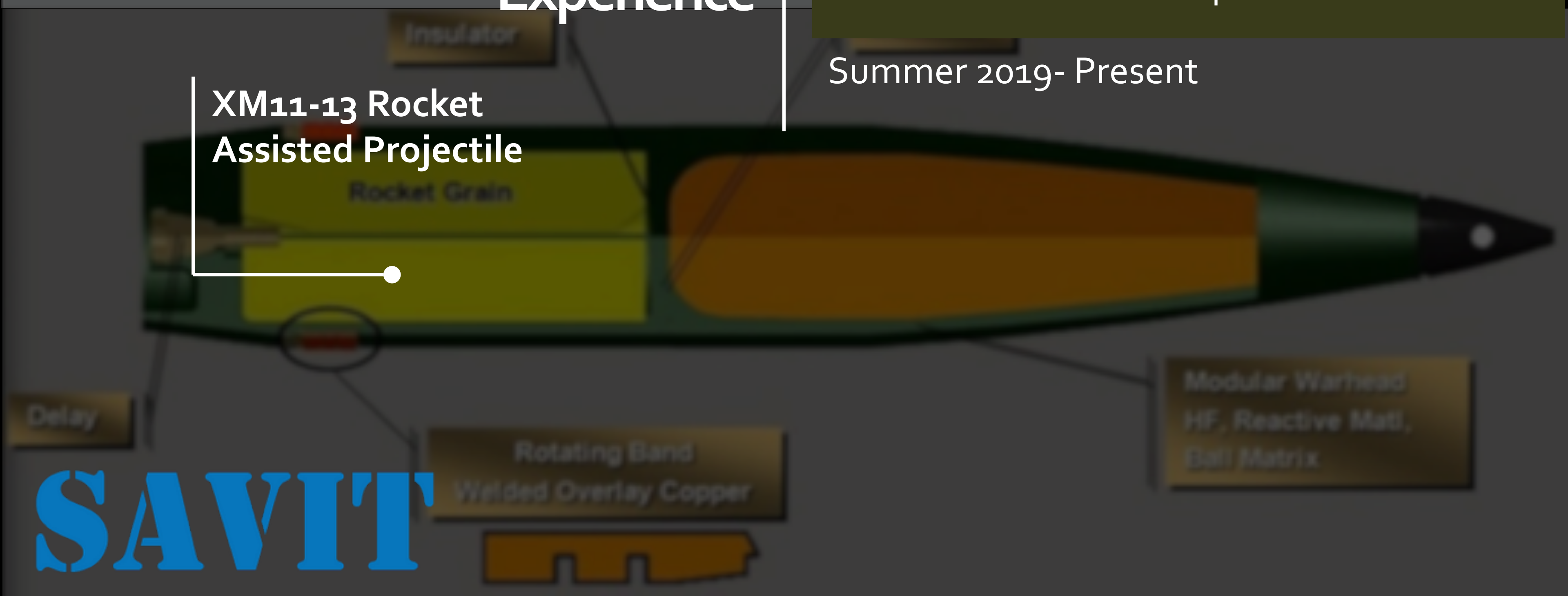


SLA 3D Printed
Controller Housing

Work Experience

How can I apply skills learned in the classroom to real world problems?

Summer 2019- Present



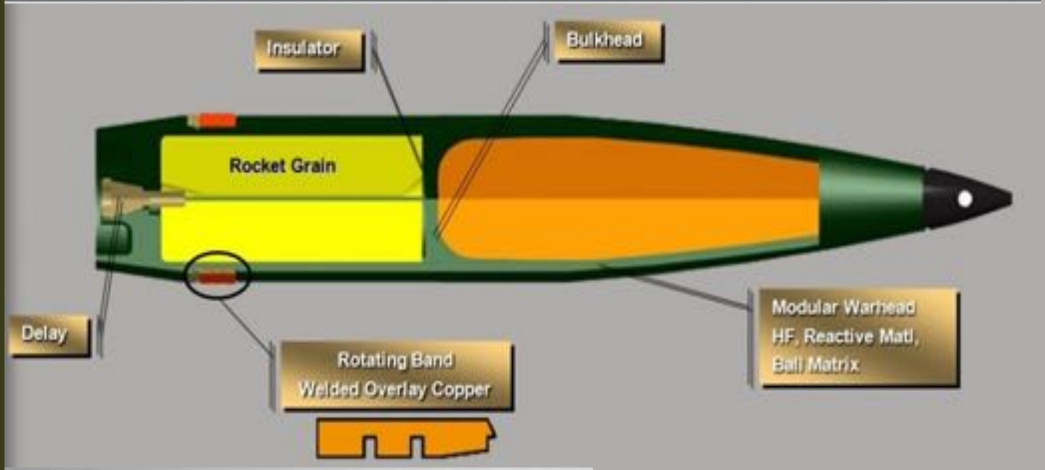
XM11-13 Rocket
Assisted Projectile

SAVIT Corporation Internship

Interim Security Clearance, Secret Pending

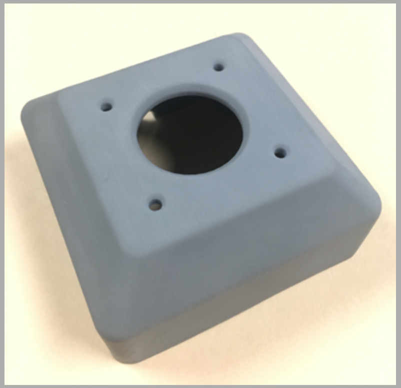
- Learned how to use CREO Parametric and applied it to assist other engineers with designing on a daily basis.
- Assisted with Geometric Dimensioning and Tolerancing (GD&T) of designs.
- Produced various functional electromechanical prototypes.
- Assisted in the testing of PEEK 3D printing.
- Assisted in designing high torque fixtures for the XM11-13 Rocket Assisted Projectile.
- Designed a precision calibrating device for mortar aiming sights.
- Shadowed Engineers during meetings and gained valuable industry knowledge.

SAVIT CORPORATION

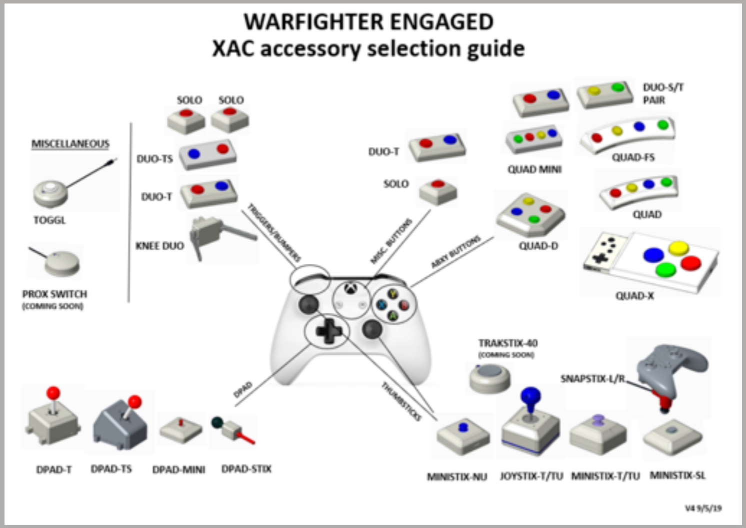


Warfighter Engaged Volunteering

- A charity devoted to improving the lives of severely injured and disabled veterans with custom adapted recreational items and other solutions to provide greater independence.
- Assisted with creation of reusable molds for small scale production of controller housings through the printing of prototypes.
- Currently working producing aluminum molds for large scale injection molding of controller housings.



SLA Printed Master Model



Product Selection Showing Part Use

Printed SLA Molds

Designed Injection Mold Pieces

Present

Develop G code for injection molding

Finish Molds

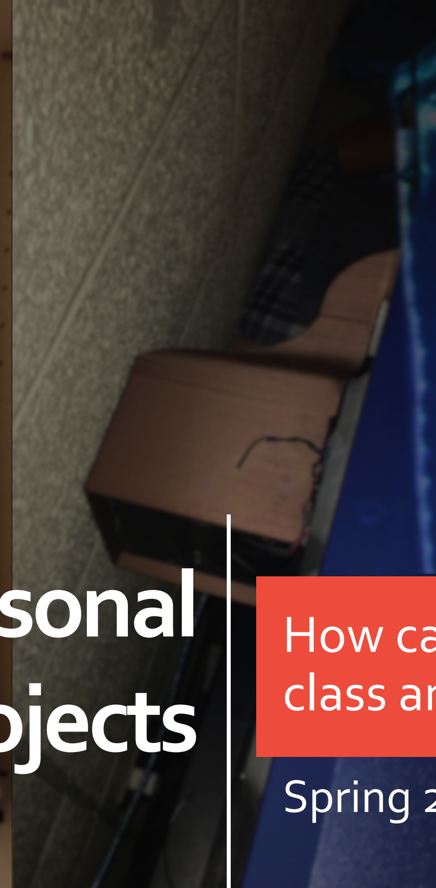
October 2019

November 2019

Start Injection Molding

Assemble Controllers

December 2019



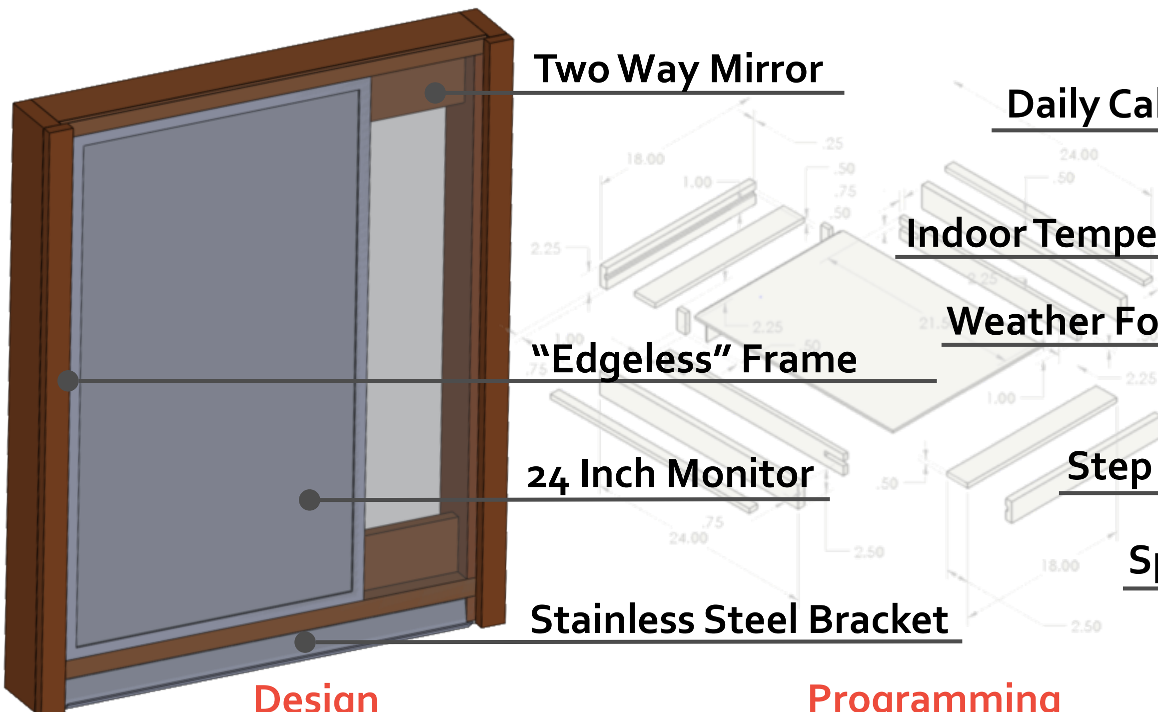
Personal Projects

How can I take what I learn in class and apply it to what I enjoy?

Spring 2016- Present

Smart Mirror

After years of checking my phone every morning to see what my calendar was like, the weather, notifications, and the news, I decided that making a smart mirror that could do this for me would be a good way to substantially brighten up my mornings.



Design

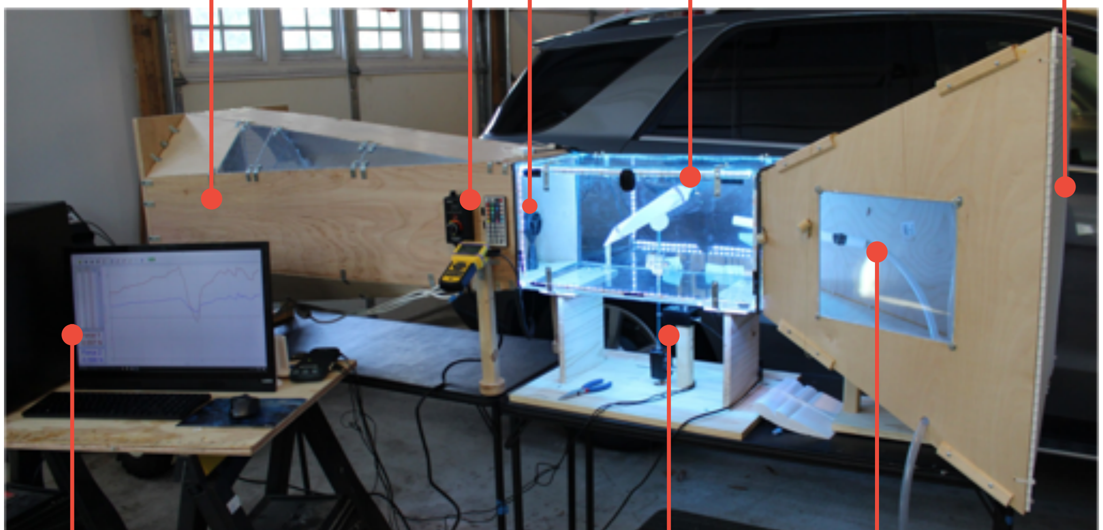
I wanted a design that was simple, yet strong enough to hold the heavy mirror, large monitor, and raspberry pi, while making it seem like there was nothing behind the mirror at all.

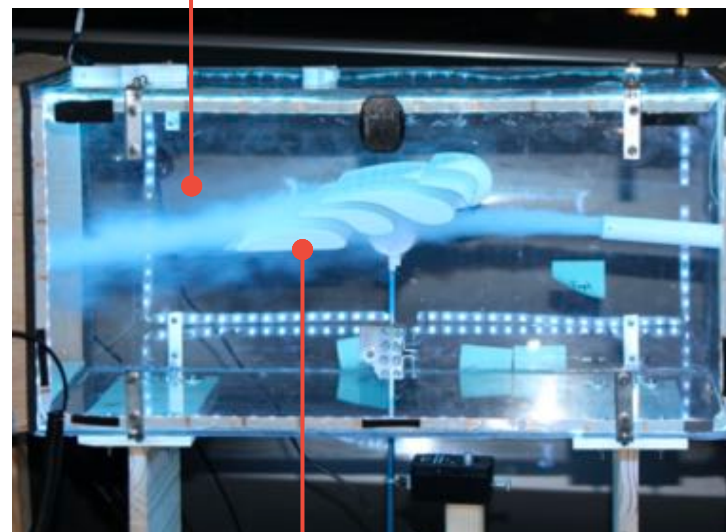
Programming

Run by a Raspberry Pi, and with an open source framework on GitHub, the integration of the modules was quite difficult, considering my lack of coding experience. However, I was able to successfully integrate many modules to function together.

Wind Tunnel

For my International Baccalaureate Extended Essay I chose to study the aerodynamic effects of 3D printing a morphing airfoil. I constructed a Wind Tunnel to test the test airfoils.





Design

To test the modular, I designed a 12 foot long wind tunnel capable of producing an airspeed of 50 mph, flow visualization, and lift and drag data collection.

Construction

Taking around two months to design and another three to build, this wind tunnel was extremely successful because of its accuracy which was proven through the verification of known data.

Testing

Although the results of my experiments testing my airfoil design were negative, I was able to prove the disadvantages of my design for further design iterations.

3D Printer Air Filters

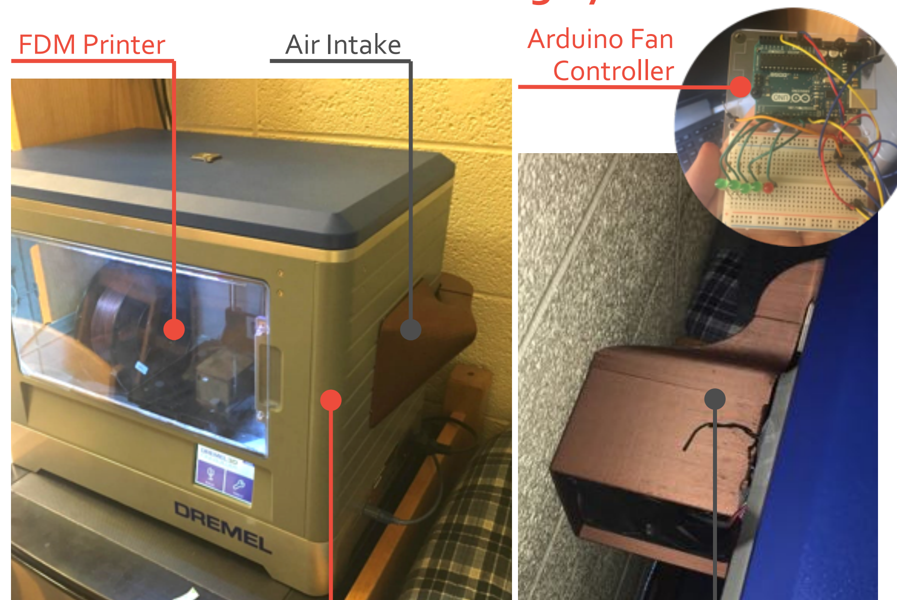
Since making my first 3D printer in High School, I have always been wondering how I could making prints come out better. While this initially started with changing minor things, I wanted to see how temperature affected FDM printing by using an Arduino and thermistors to control the speed of a ventilation fan. Recently to mitigate the fumes caused by resin printing, I have made an air filtration system for my DLP printer, allowing me to use it in my dorm room.

DLP Printer Air Purifier

Purification Design

For my Anycubic Photon resin 3D printer, I made an air purification system that pulls the air through 4 inches of carbon filters, completely reducing the irritating smell associated with printing. I plan to test the amount of volatile organic compounds (VOC) that the filter reduces by collaborating with the biology department.

FDM Printer Cooling System



Filtration and Cooling Design

For my Dremel FDM Printer, I made an Arduino controlled air filtration and cooling system that uses a thermistor to control the fan speed. Air is pulled out of the printer through both a HEPA particulate filter and carbon VOC filters. Additionally, air is pulled through a particulate filter going into the printer to reduce dust going into it.