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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. Experience 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.

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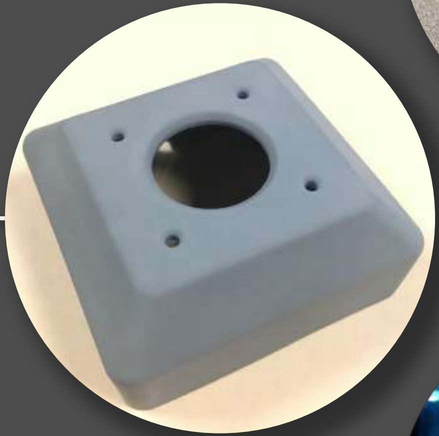
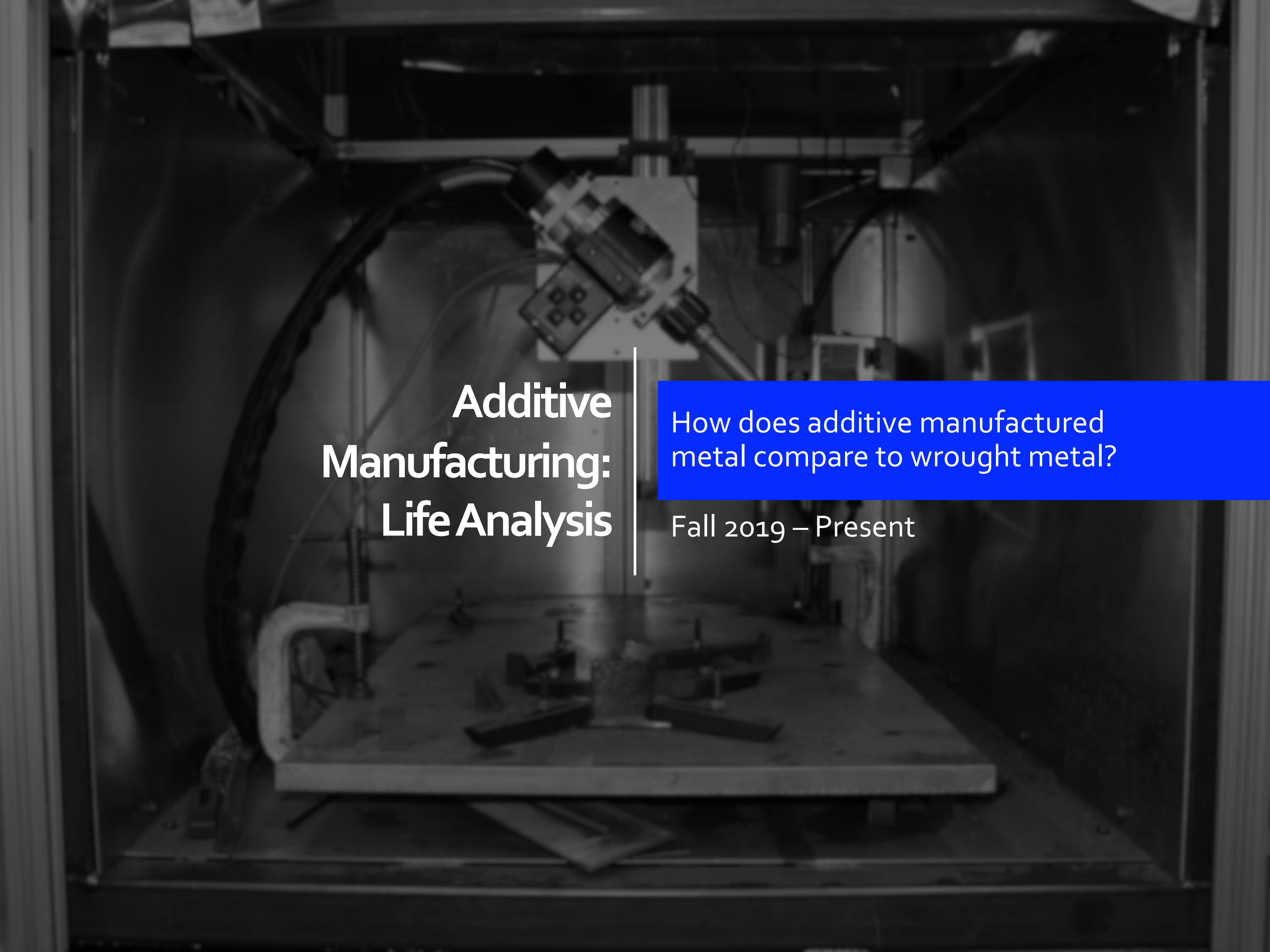
Lehigh Formula SAE's 2018-2019 Car



Accessibility Controller Housing

Prototype Airfoil in Homemade Wind Tunnel



Additive Manufacturing: Life Analysis

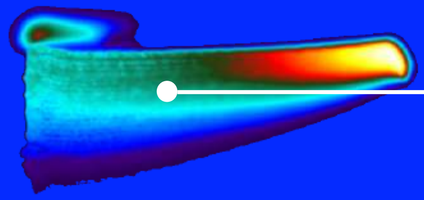
How does additive manufactured metal compare to wrought metal?

Fall 2019 – Present

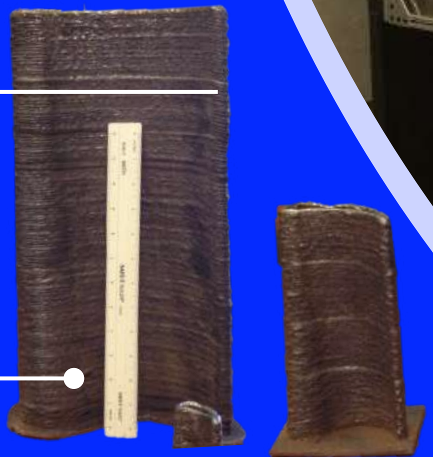
Research Overview

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 the metal's behavior. Using a variety of sensors, my team and I will determine how to best optimize grain growth in printed parts. My role on the team is to conduct overall fixes to the printer, assist with thermal data collection, and assist with the implementation of LIDAR scanning as a means for measuring bead width, and measuring layer height.

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



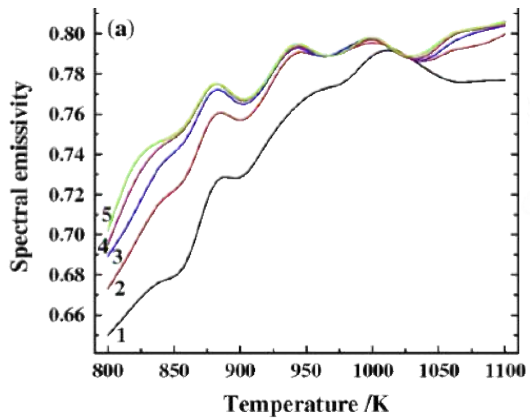
Live Thermal Image

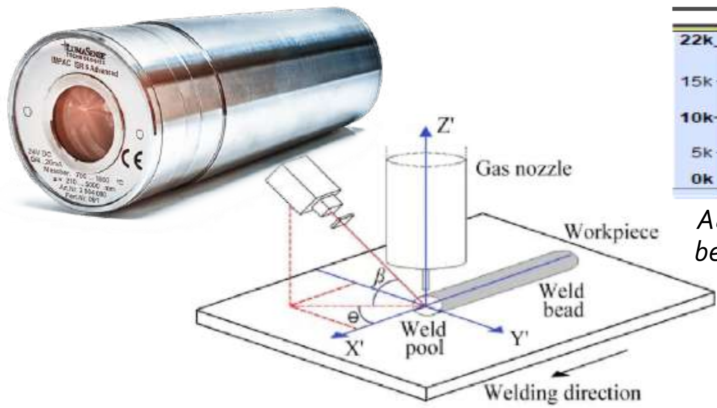


Steel 3D Printed Turbine Blades

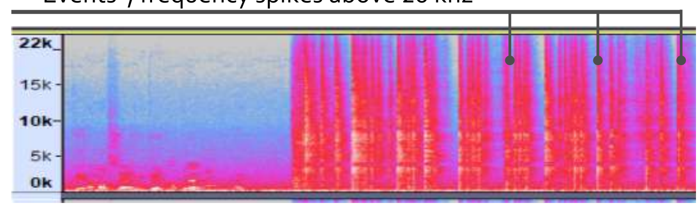
Data Collection

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 cause grain growth.





"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.

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.

Initial Designing

To observe interpass and post weld temperatures, I plan to use a series of mirrors controlled by an accelerometer to direct areas of measurement.

End of Semester Goal

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

Stationary Testing

Printer Fixes

Structural Upgrades

Present

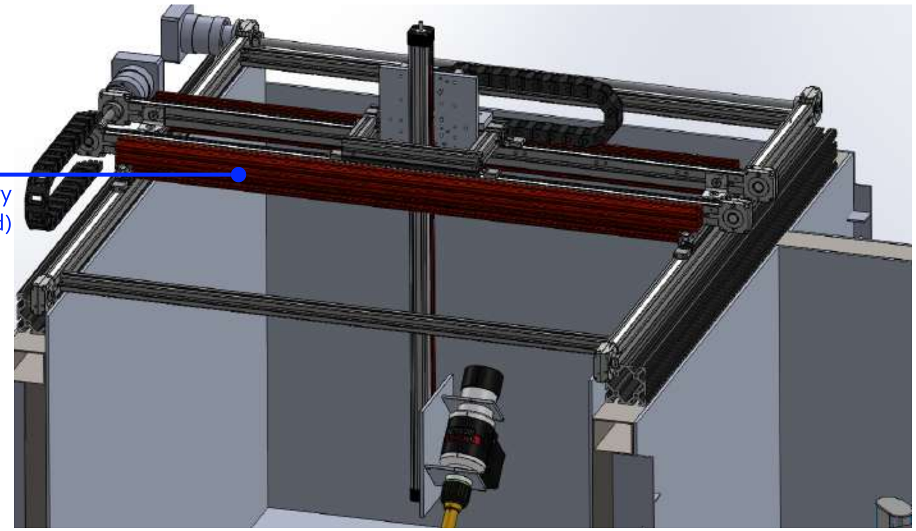
October 2019

December 2019

Hardware Upgrades

Due to electrical problems, for the past year the printer has been out of commission. Since I have experience working with 3D printers, I was tasked with making the printer operational again. Furthermore, hardware upgrades will also be performed to reduce deflection in the printing head and allow for more mounting of sensors.

Added Gantry Supports (red)



Printer Fixes

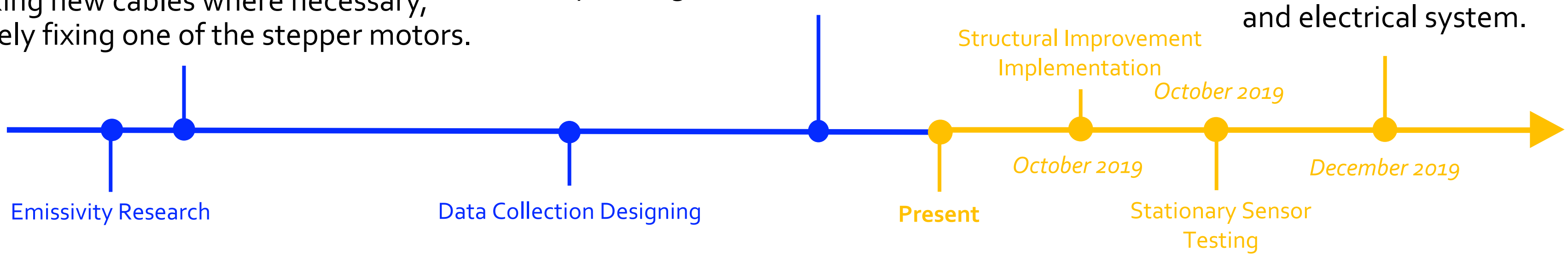
I rewired 80% of the electrical system of the printer, performing continuity checks and making new cables where necessary, ultimately fixing one of the stepper motors.

Structural Upgrades

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

End of Semester Goal:

Through hardware mounts, mirror controls and programming, I hope to implement pyrometers 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 measure layer height and bead width.

Layer Height Defects

Contest

As LIDAR scanners are very expensive, we decided to enter the TiM 10K challenge to receive an advanced LIDAR scanner for free. We will be competing with other university teams to come up with potential uses for this technology in the future.

Lidar Application

For this project, we plan to use the LIDAR to take a scan after the completion of 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 defects.

End of Semester Goal:

To begin to use the LIDAR for error detection in real time with the ability to combine LIDAR scans, thermal data, and audio information for root cause analysis of printing errors.

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 grain growth?

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.

Fall 2019

LIDAR Error Analysis

Develop a gantry system that moves the LIDAR over prints in between layers to measure bead width and thickness for use with live error analysis.

Spring 2020

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

Expand Material Selection

Expand printing materials to aluminum and titanium to generate printing model of other materials.

2020 -

Present

Model “X-49”,
Our 2019 Car

Lehigh Formula SAE Racing Team

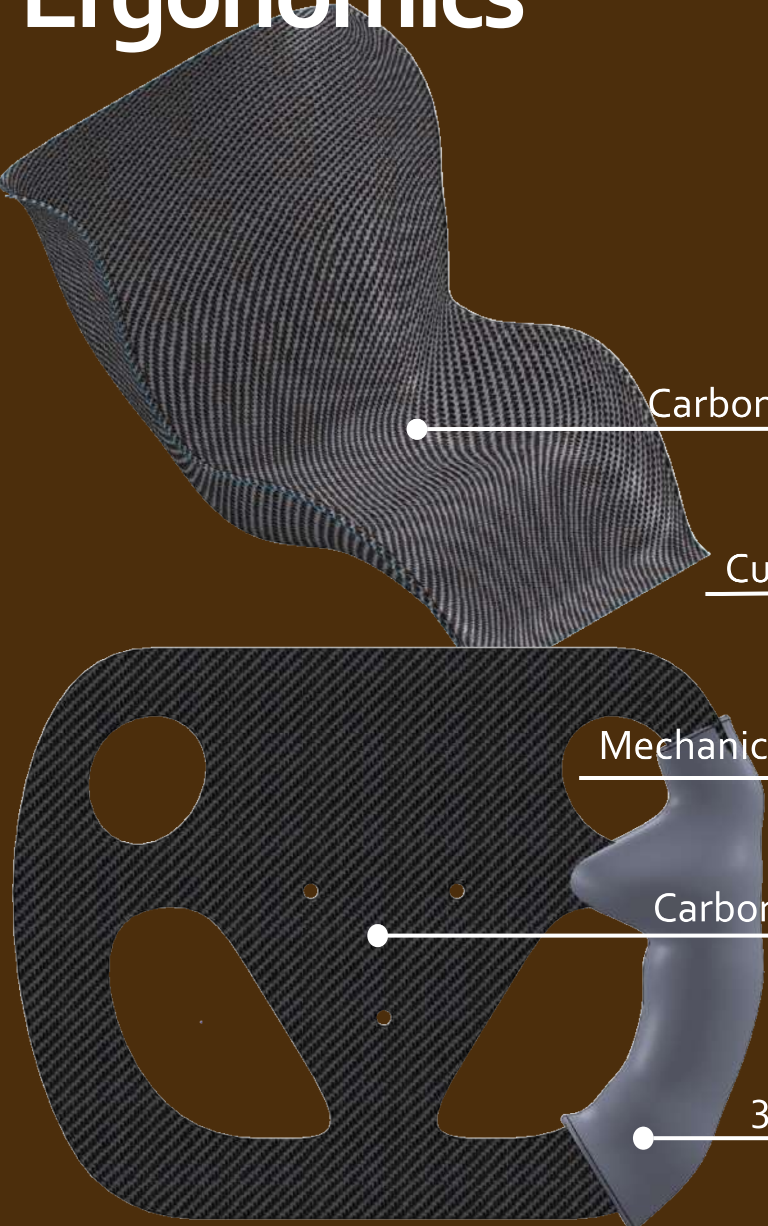
How can we maximize performance, while minimizing weight and cost?

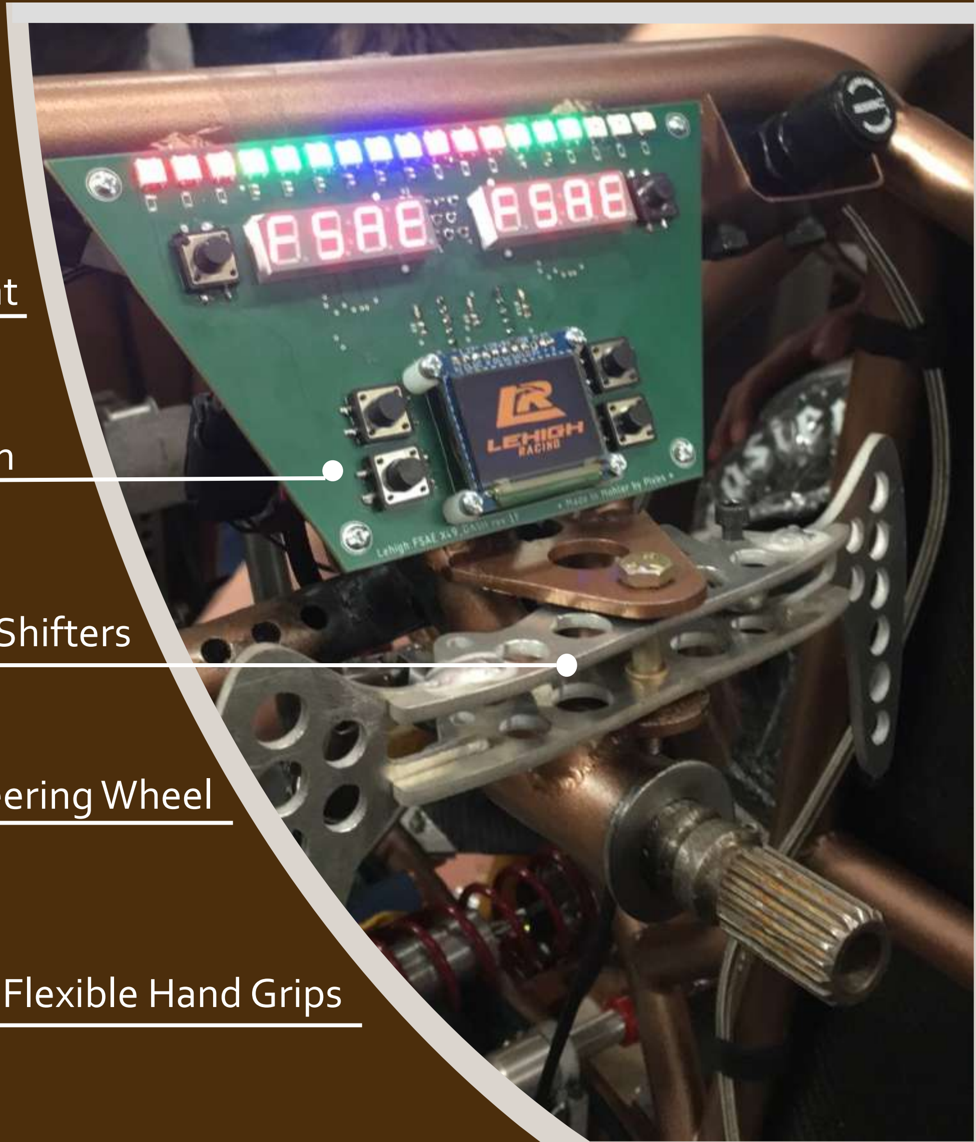
Fall 2017 - Present

LEHIGH RACING

X-49 Driver-Ergonomics

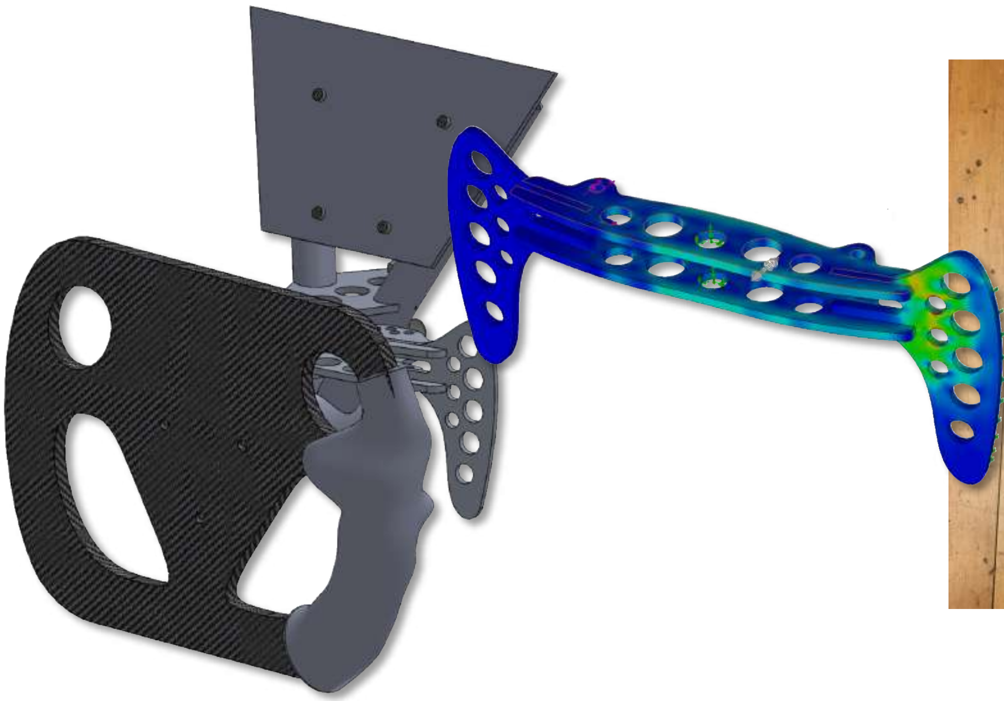
As the Driver Ergonomics team lead, I was responsible for not only many of the complex designs, but also for managing other members on associated projects. As the team lead, I successfully brought together those who were engineering the car and those were driving the car to ensure that the car achieved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

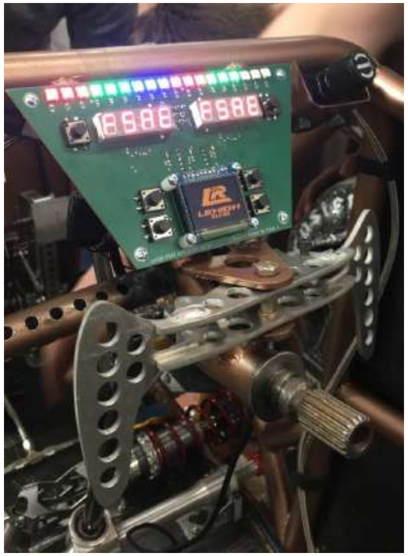




X-49 Shifting System

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.





Initial Design

The initial design was created with the intention to get a better understanding of design constraints, packaging, reachability, and strength.

FEA Analysis

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

Prototyping

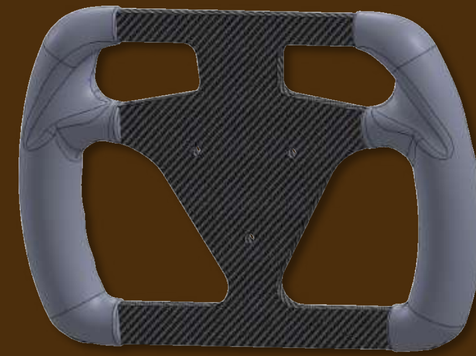
After changes in designs from strength analysis trials, multiple prototypes were 3D printed to check reachability and comfort.

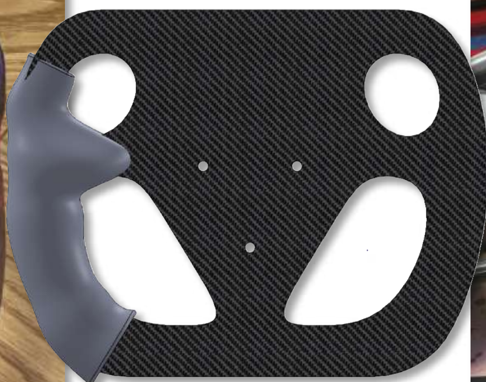
Final Result

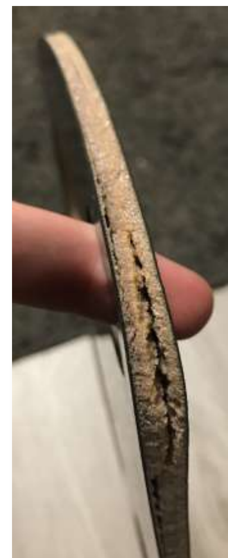
Changes dictated by testing gave us a final model which fulfilled all necessary requirements.

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, allowing for the new handgrips, and necessary constraint requirements.

Prototyping

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

Analysis

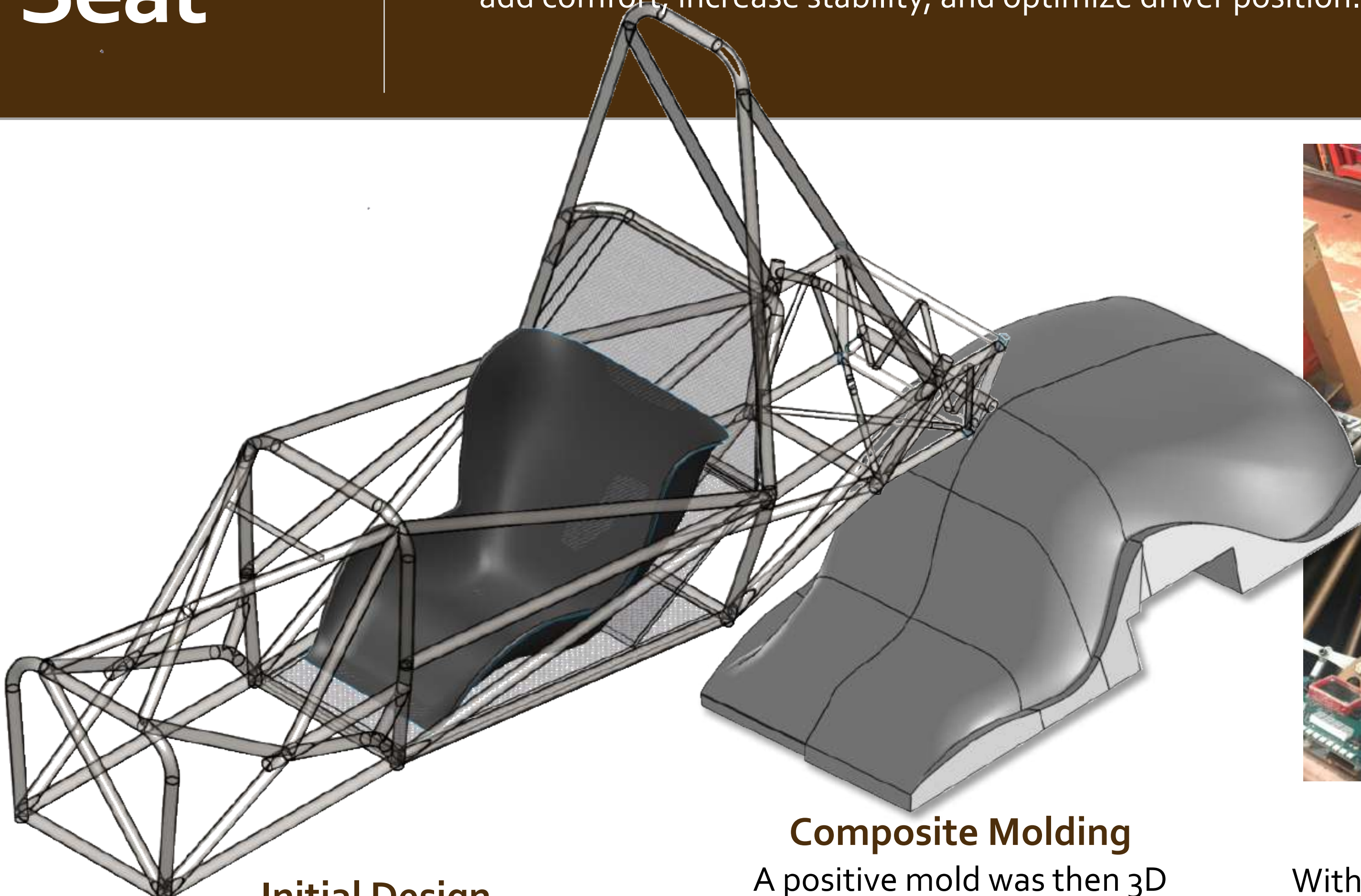
Three point bend tests were performed on various thicknesses of carbon and foam types giving us information on how to increase wheel strength.

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 loading during turning.

Composite Molding

A positive mold was then 3D printed and covered in release film. The mold was then covered with three 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 Aerodynamics

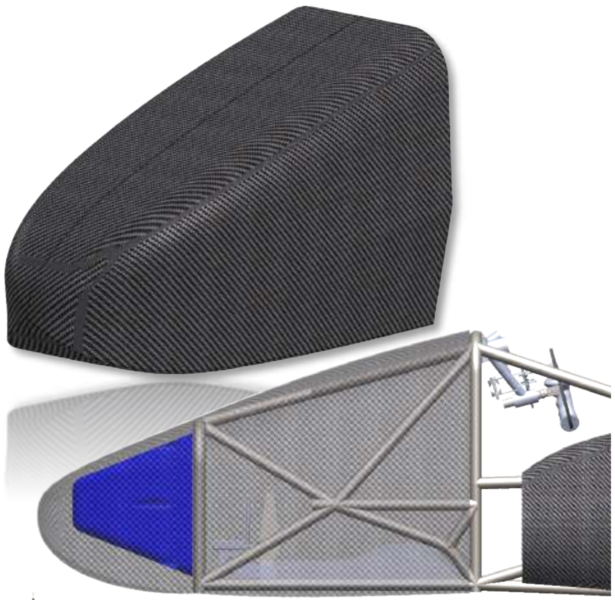
Composite Intake and Plenum

Aerodynamic Nose-Cone

Side Pods

X-49 Nose-Cone

In order to decrease drag, increase downforce, and conserve weight, a custom Nose-Cone needed to accommodate the restrictions of the space. An economic approach was taken towards this problem in comparison with



Design

Taking into account packaging, rules 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. Then 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 vacuum formed around the mold. The largest benefit was of the cost reduction, only being 150 dollars to manufacture, we were able to achieve what other teams did aerodynamically for less than a tenth of the cost.

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

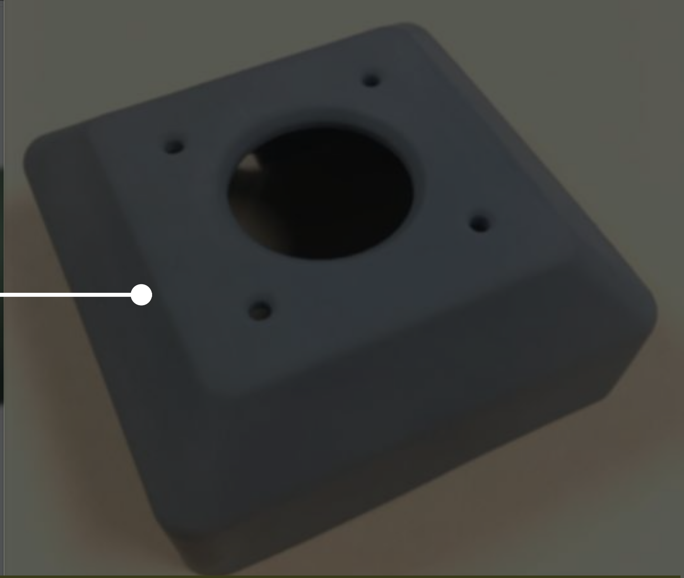
Due to the complex shapes and structural requirements of these parts, new manufacturing methods had to be developed. For the sidepods, we printed a multi part mold while for the intake a water dissolvable mold had to be used.

Molding

Although the sidepods and intake both had to be covered in carbon fiber, different techniques were used for each which effected the manufacturing of the molds. Since the sidepod was vacuum infused, the 3D printed shell had to be filled with expanding foam to resist the increase in pressure.

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 less cost.



SLA 3D Printed
Controller Housing

Work Experience

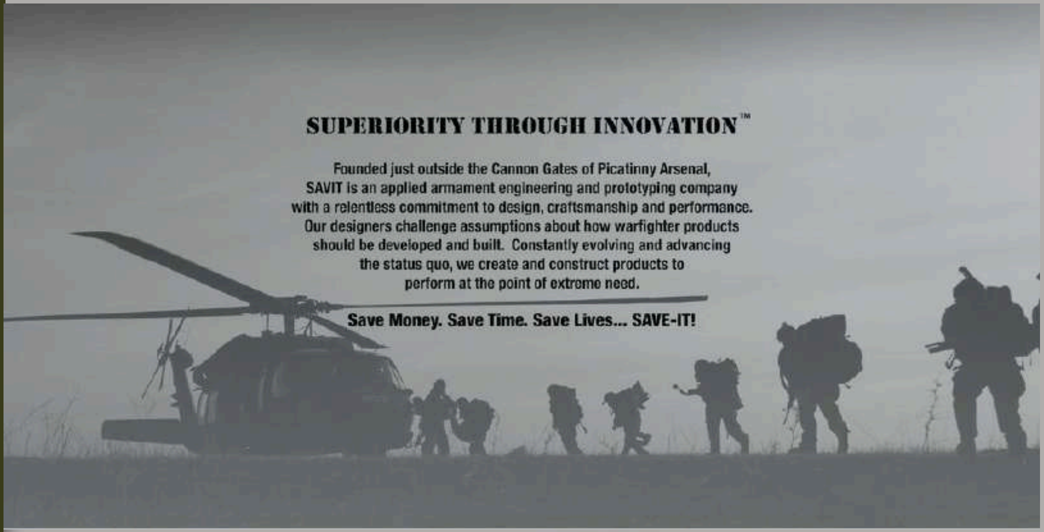
How can I apply skills learned in the classroom to real world problems?

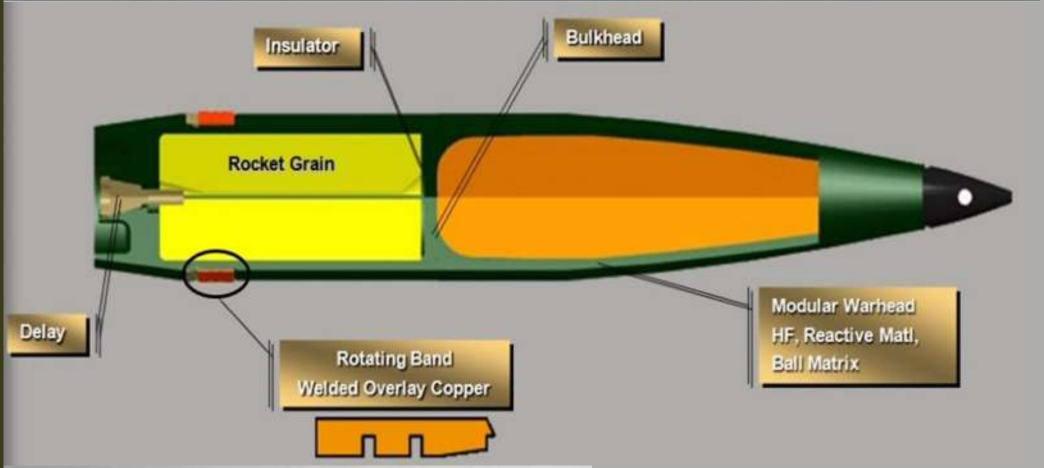
Summer 2019- Present

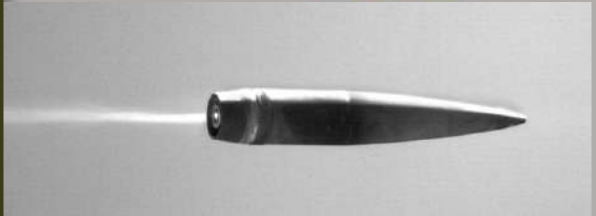
XM11-13 Rocket
Assisted Projectile

SAVIT Corporation Internship

- Interim security clearance, secret clearance pending.
- Learned how to use CREO Parametric and applied it to assist engineers with designing on a daily basis.
- Worked on various electromechanical prototypes.
- Assisted in the testing of PEEK printing for the military.
- Assisted in designing high torque fixtures for the XM11-13 Rocket Assisted Projectile.
- Designed a precision calibrating device for mortar aiming sights.
- Unfortunately, not allowed to put designs in this portfolio.
- Shadowed Engineers during meetings and gained valuable industry knowledge

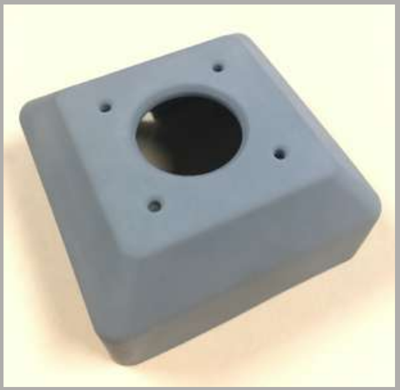




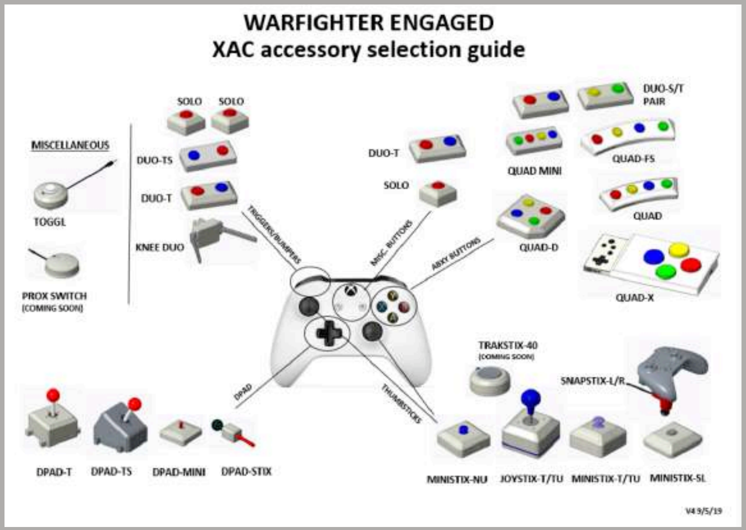


Warfighter Engaged Volunteering

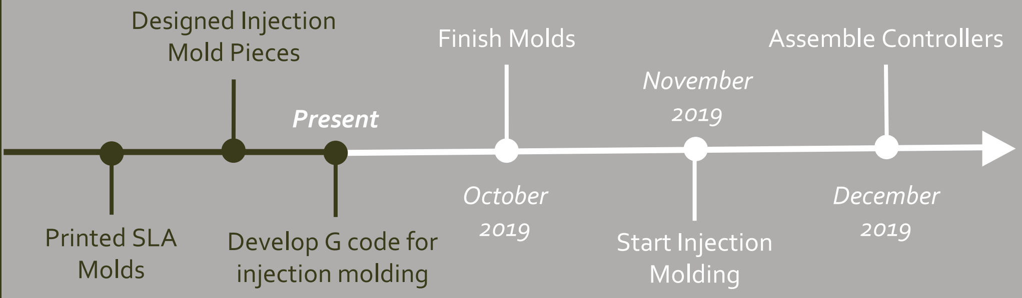
- A charity devoted to improving the lives of severely injured and disabled veterans with custom adapted recreational items and other solutions to provide greater independence.
- Assisted with creation of reusable molds for small scale production of controller housings through the printing of prototypes.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



SLA Printed Master Model



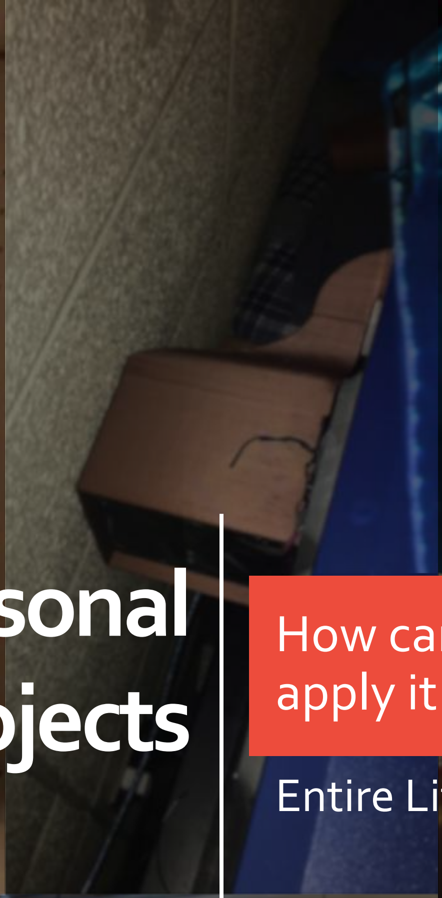
Product Selection Showing Part Use

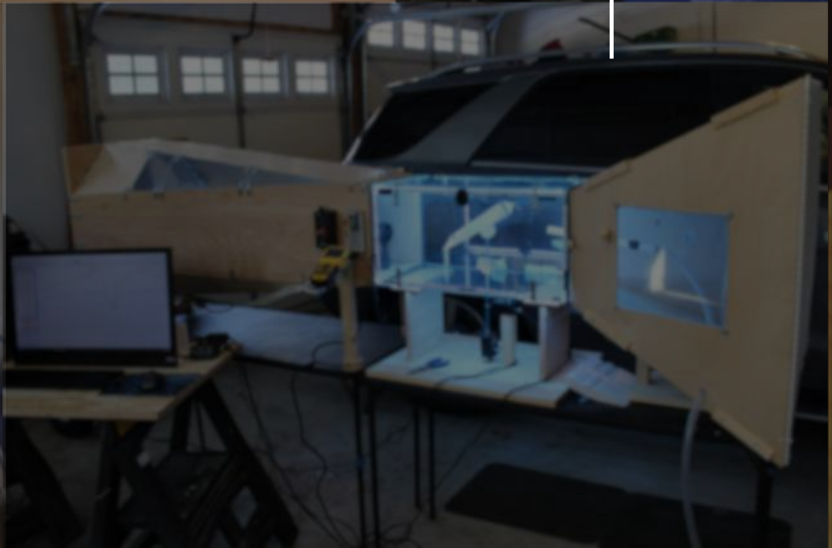


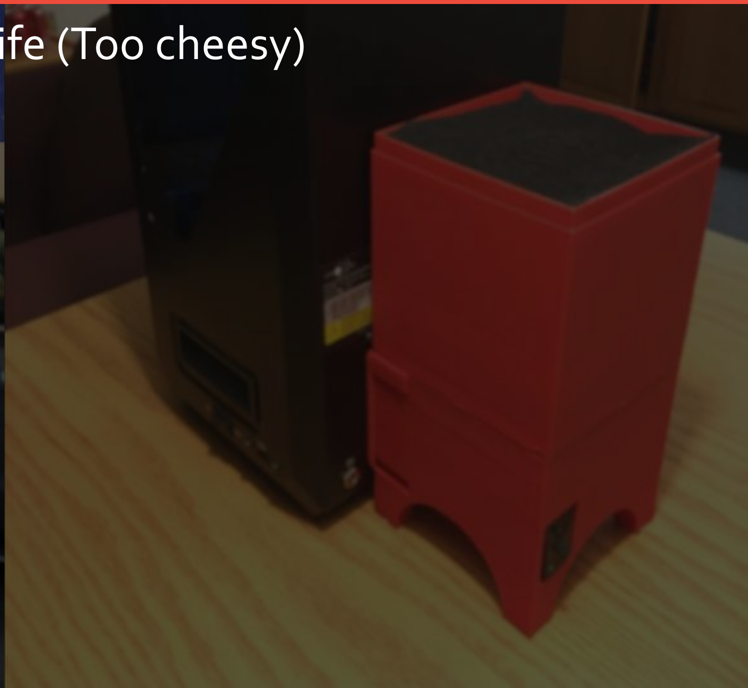
Personal Projects

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

Entire Life (Too cheesy)

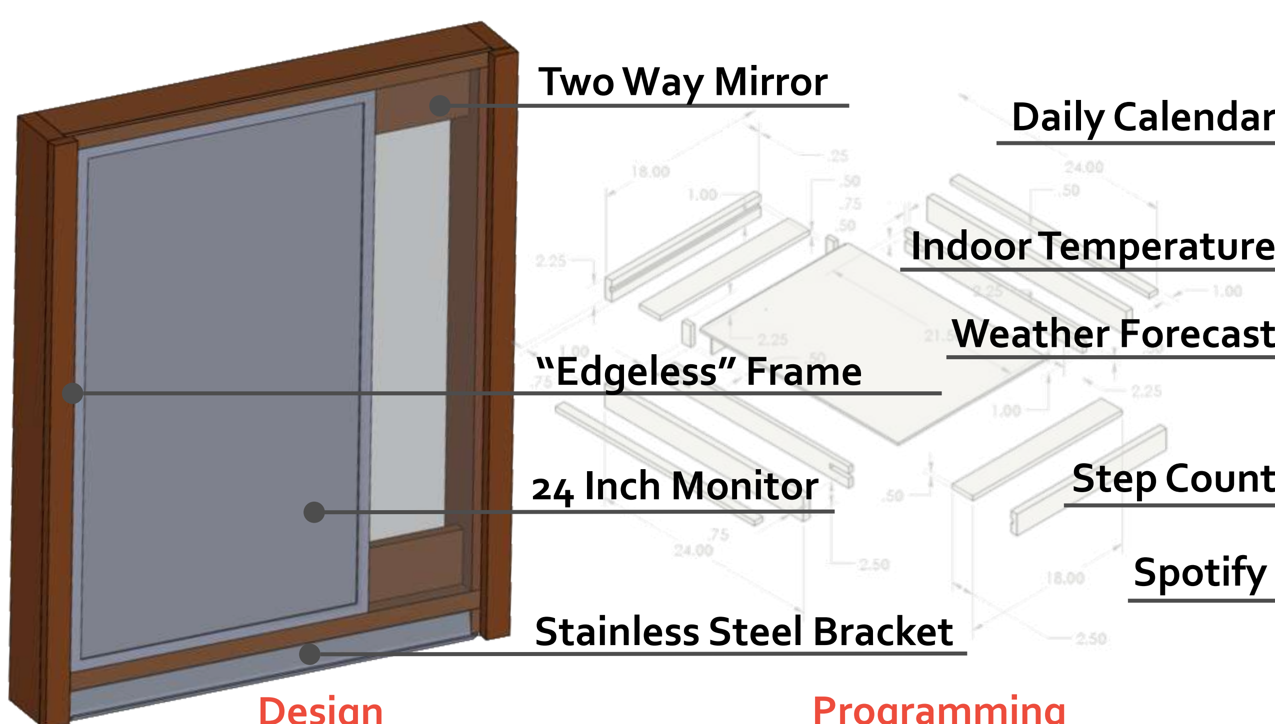






Smart Mirror

After years of having to check 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

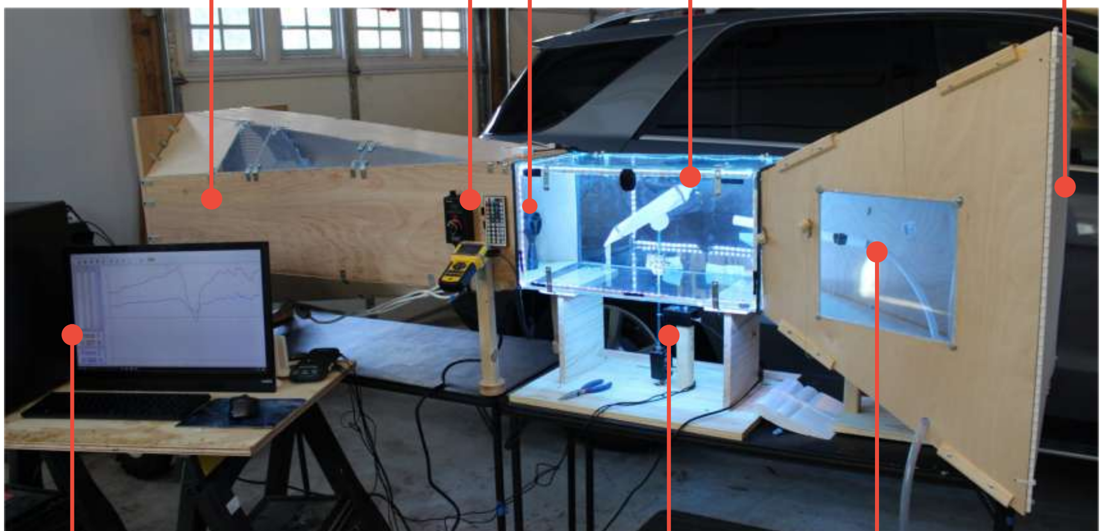
I wanted a design that was simple, yet strong enough to hold the heavy mirror, large monitor, and raspberry pi, while making it seem like there was nothing behind the mirror at all.

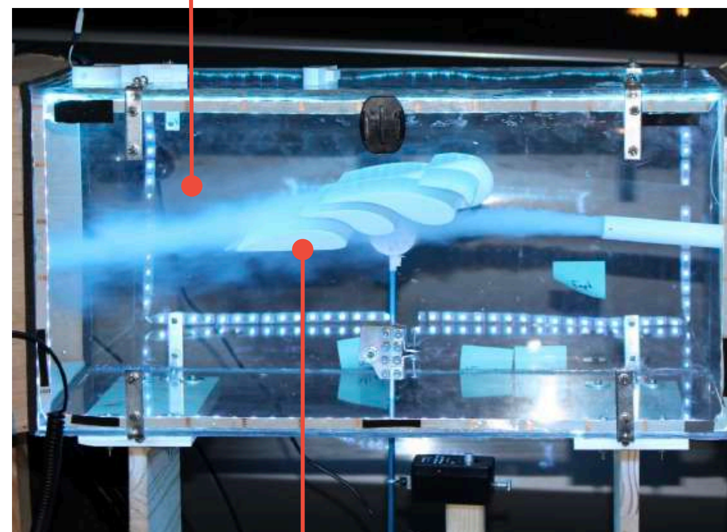
Programming

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

Run by a Raspberry Pi, and with an

Testing

Run by a Raspberry Pi, and with an open source.

3D Printer Air Filters

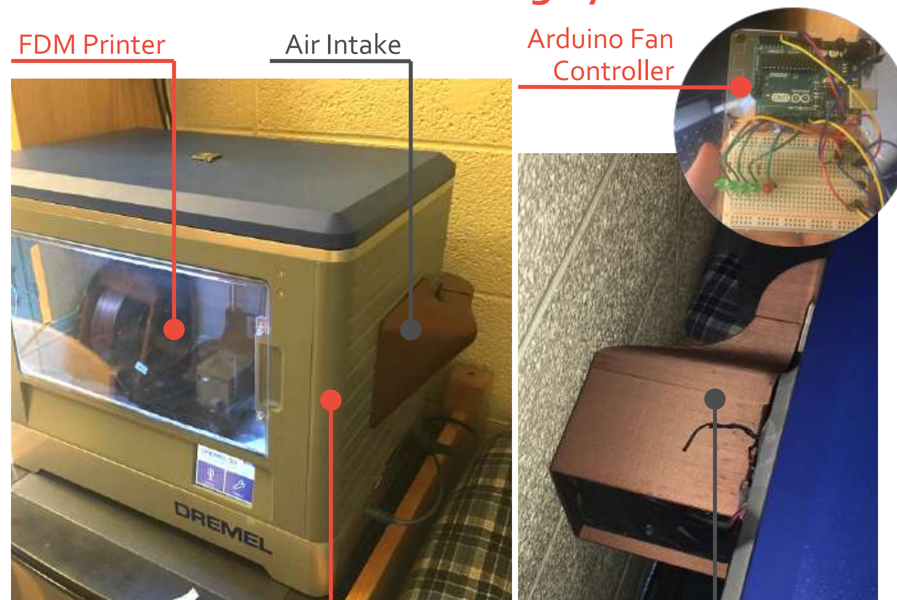
Since making my first 3D printer in High School, I have always been wondering how I could making prints come out better. While this initially started with changing minor things, I wanted to see how temperature affected FDM printing by using an Arduino and thermistors to control the speed of a ventilation 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.