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Project Portfolio

NISAL OVITIGALA

About Me

Who I am – I’m an International Student from Sri Lanka who is a current Senior at MIT working towards his Bachelors in Mechanical Engineering

My Passions – I am passionate about taking technology that exists and improving upon it to make it more accessible. I’ve also developed passion of mine is control theory and robotics. With those two passions, I’ve been working on projects related to automation and enhancing remote learning.

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Remote Microscope Access

Background

- MIT's Micro/Nano Engineering Lab runs a class where students extensively use compound light microscopes to analyze experimental data.
- Due to COVID-19 students are unable to come into lab and analyze data
- The goal of the project was to increase microscope functionality and give students access to the microscope so that they can control and obtain data through their computer at home
- Remote controlled pressure regulators were also made so that students can conduct microfluidic experiments remotely
- This project was conducted at home where the only shop tools I had access to were a pair of calipers and a 3D printer

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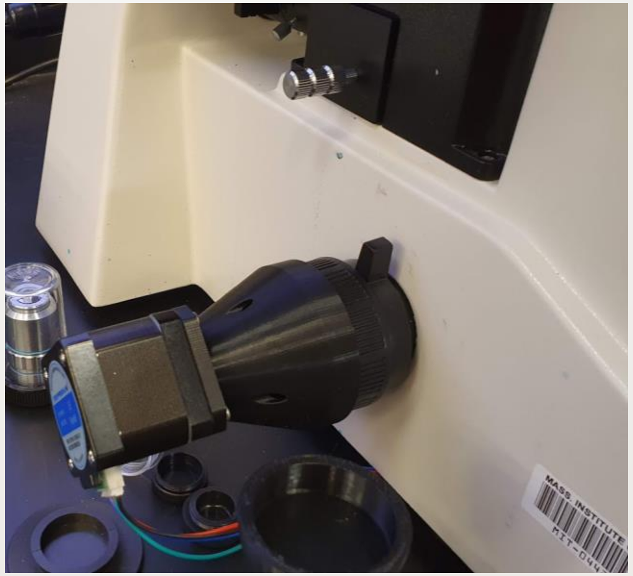
Hardware Component

- The X and Y axis was controlled with a combination of a belt drive and pulley system paired with NEMA17 stepper motors
- The focus stage was controlled with a minimally invasive, direct drive stepper motor meshed directly to the focus stage fine tuning shaft

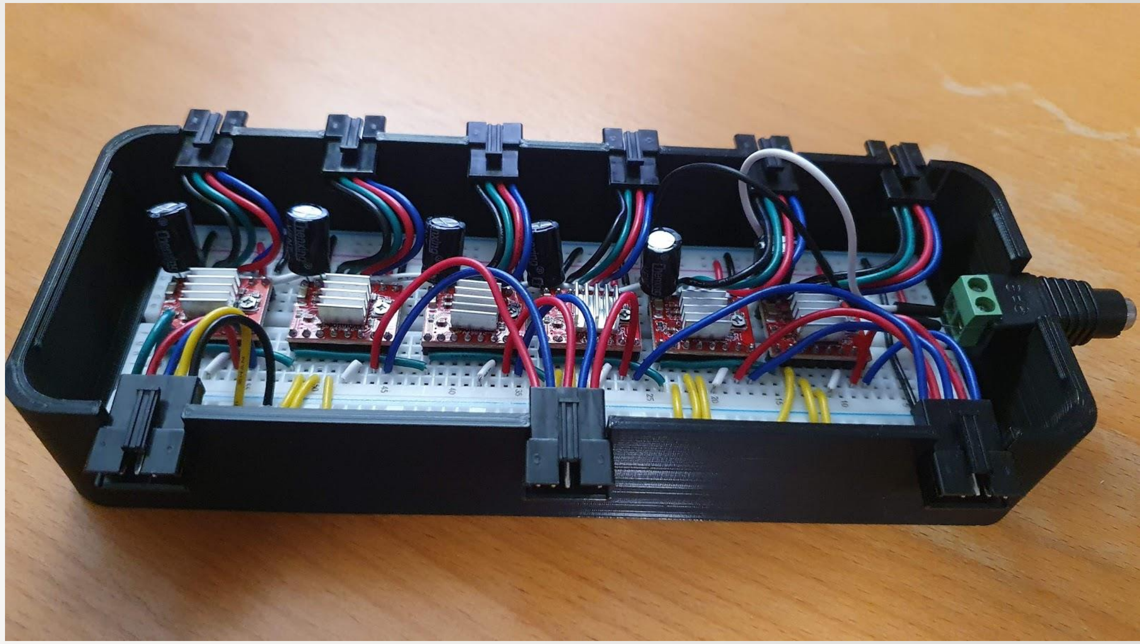


Focus Stage Control

X and Y axis Control

Interfacing Hardware with Software

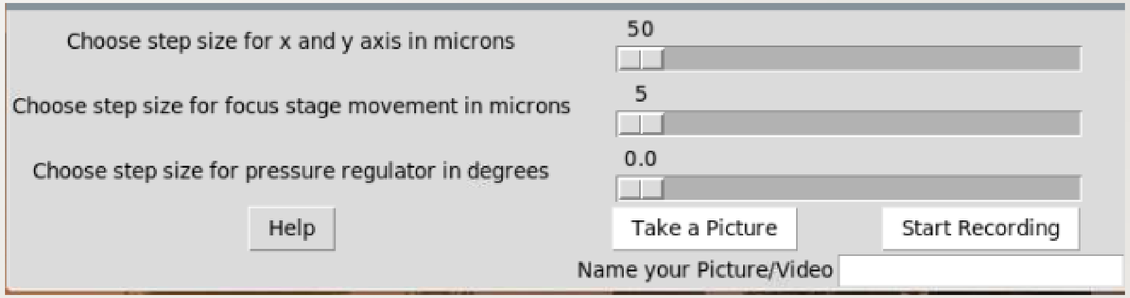
- The hardware was controlled using a Raspberry Pi 4 due to its effective multithreading capabilities
- The 6 stepper motors (3 for microscope, 3 for pressure regulators) were connected to a breadboard enclosure which contained the stepper motor drivers
- The microscopes output was captured using a HQ camera sensor paired with compatible lens



Software

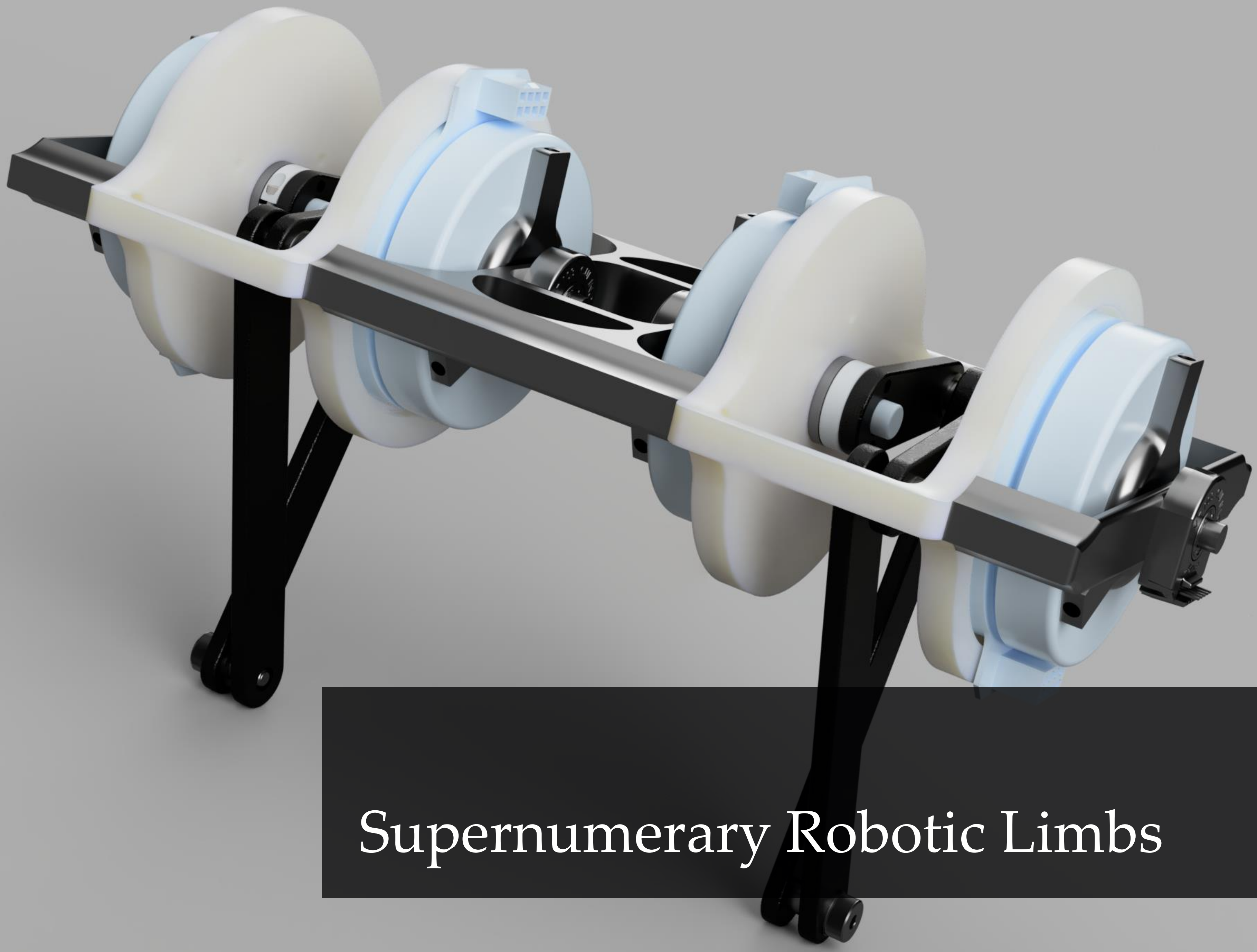
- Software contained 3 programs running in parallel – Keyboard listener, GUI and Video feed with HUD
- Introduced a coordinate system which can track microscope movement with micrometer precision
- GUI allows users to control microscope movement distance and take photos and videos
- After use, microscope moves back to home coordinates so lab staff can safely retrieve sample

Video Feed with HUD



GUI for Precision Control

Video Link for Microscope in use: https://photos.app.goo.gl/MnrQUth9yM7tdmUU7



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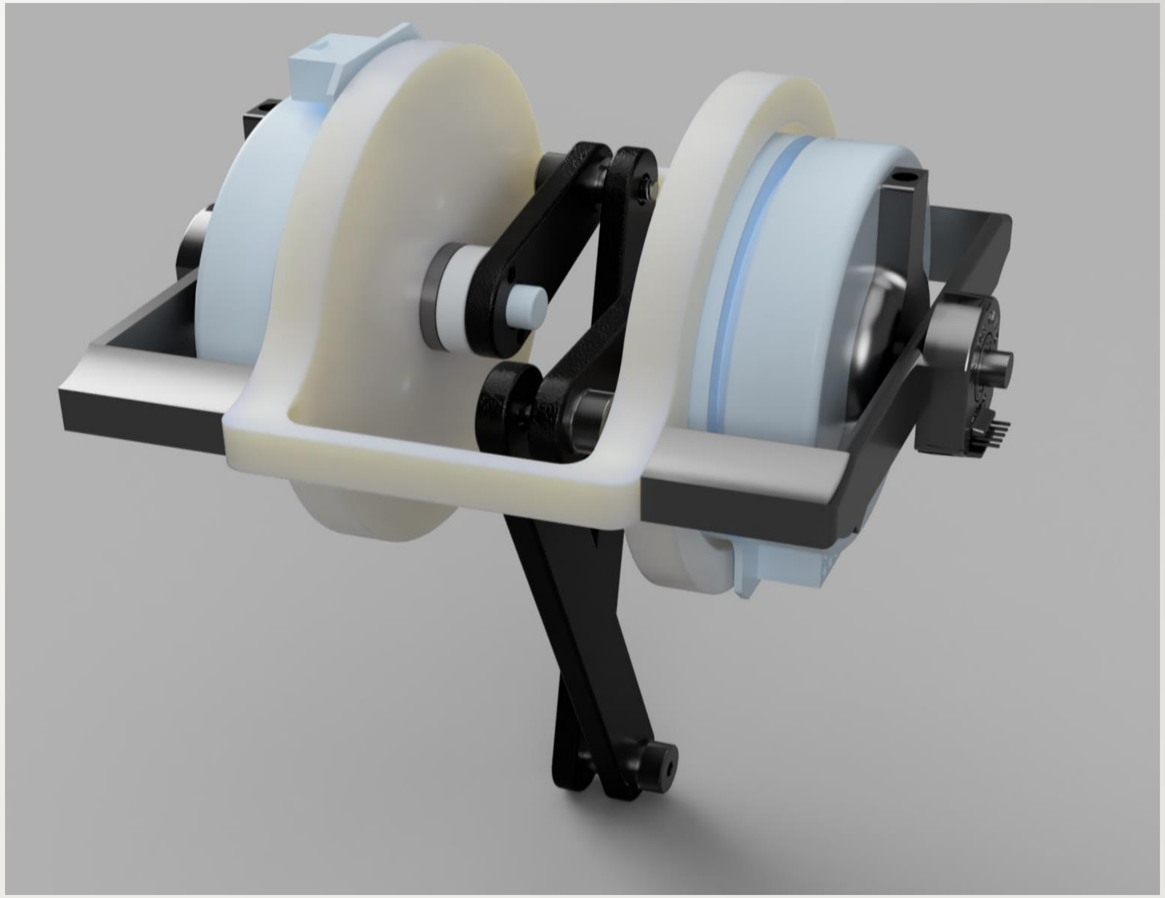
Supernumerary Robotic Limbs

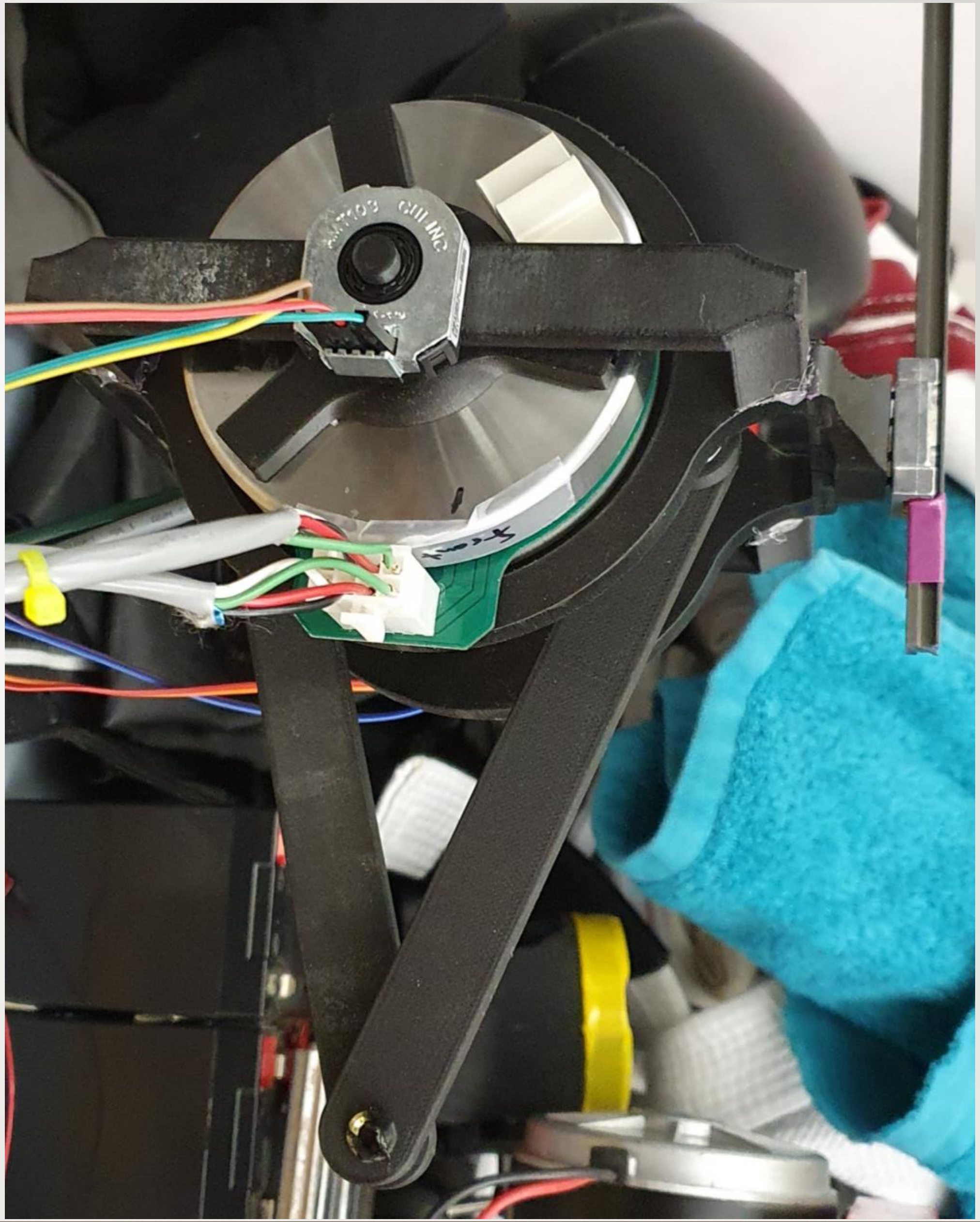
Background

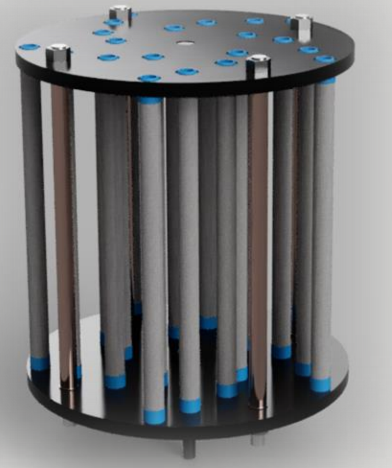
- Robotic limbs created by the d'Arbeloff laboratory are used to lighten workload for workers in welding companies
- My task was to make a scaled down design of the limbs to test walking algorithms to enhance features of the existing limbs



Process

- Chose a symmetric 5 bar linkage for 2 DOF motion
- Modelled workspace and torque requirements to spec motors
- CAD (as seen in last two images) was used to validate testing
- Wrote MATLAB and C++ code to communicate to microcontroller and control leg motion using a feedforward impedance controller

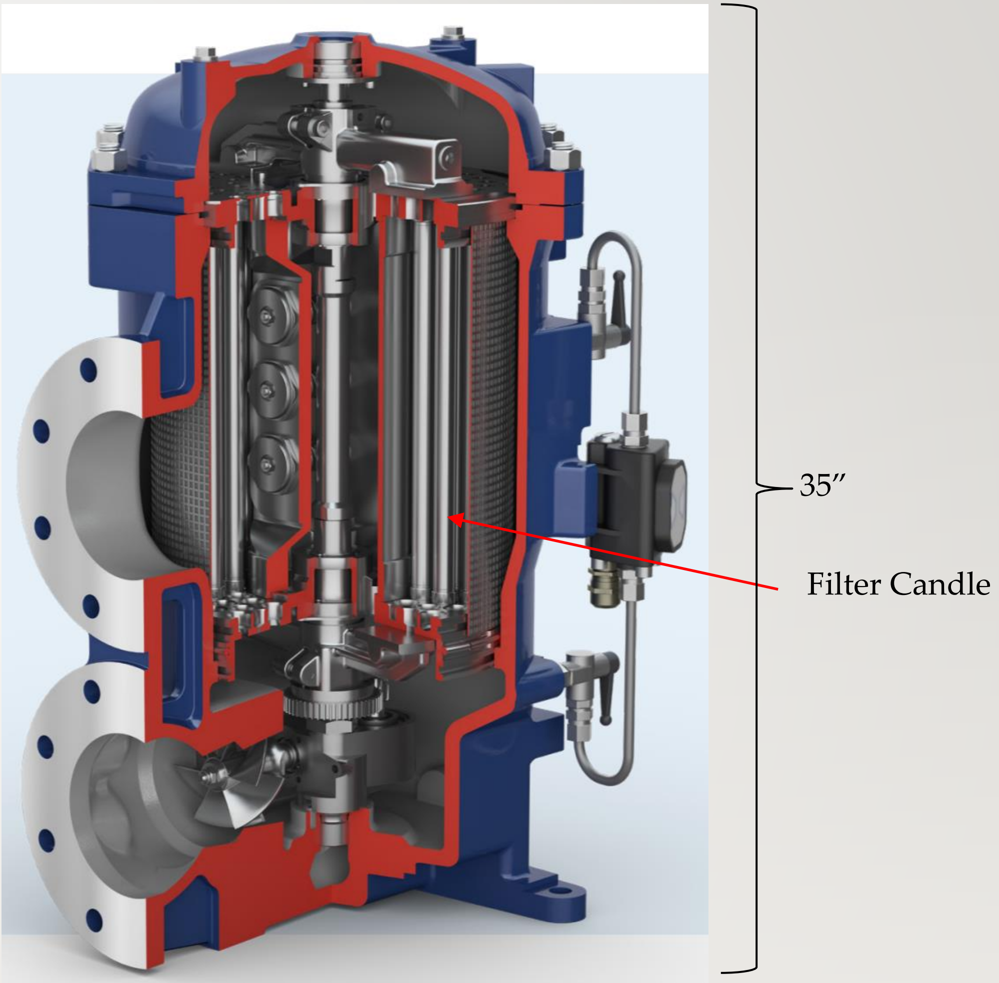




Oil Filter Cleaning Mechanism

Background

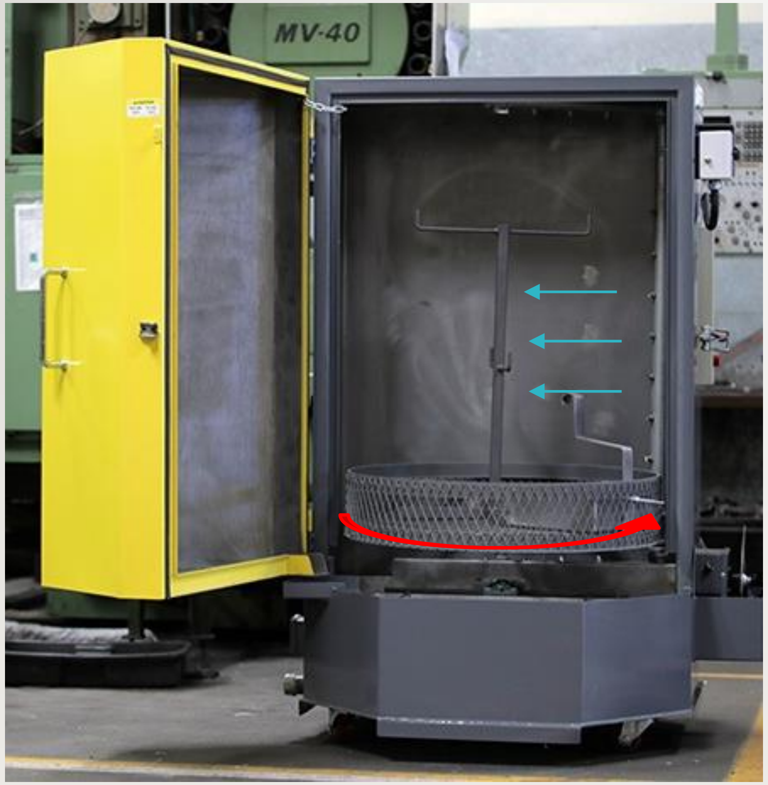
- Locomotive has an oil filter which is made up of 60 filter candle elements
- These elements are replaced every three years which costs $180,000 to replace all the filter candles in the whole fleet of locomotives
- My goal is to develop a cleaning mechanism so that the filter candles can be reused and have an increased service lifetime



Bollfilter Type 6.48

Cleaning Cabinet

66″



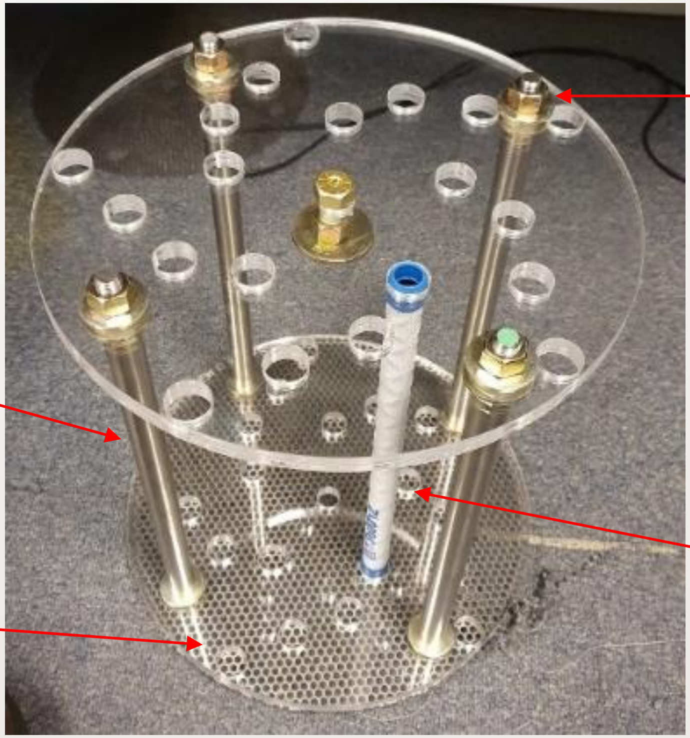
- A high pressure washing cabinet (Ranger RD500D) was chosen as the most cost efficient cleaning method with the lowest cleaning time
- Cleaner has a rotating base and can spray high pressure water mixed with soap
- Four filter holder can be held inside the cleaning cabinet at a given time

Prototype Design

12″

Reinforced stainless steel columns for reducing bending forces and corrosion resistance

Perforated stainless steel base for solvent drainage

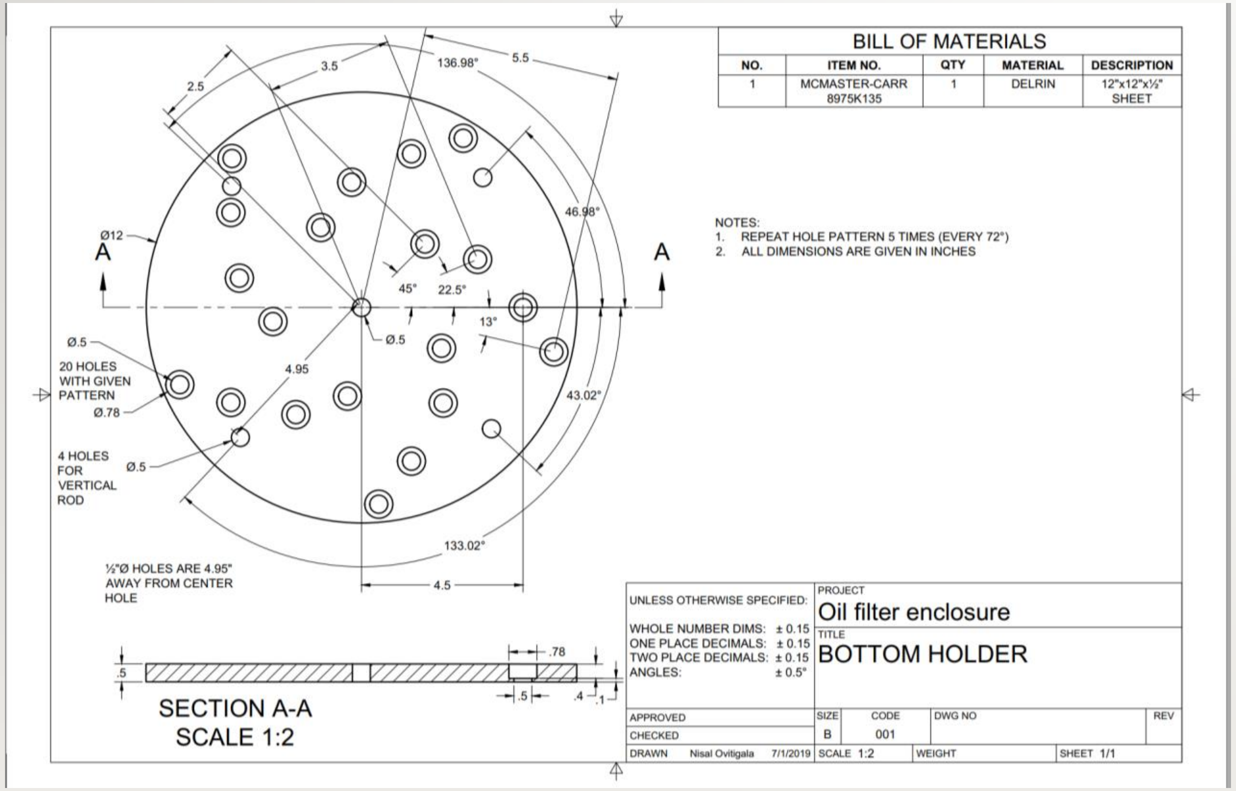


14.5″

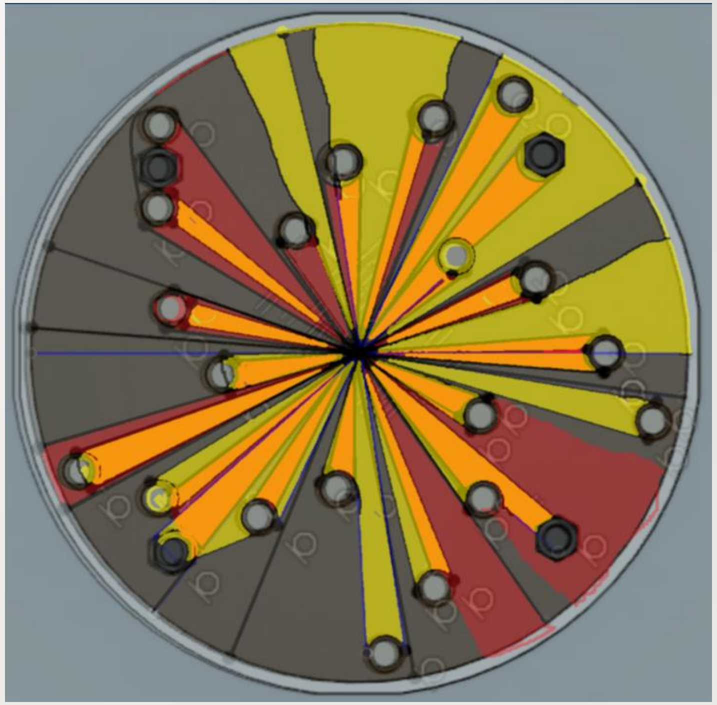
Grade 8 nuts, bolts and washers used for high corrosion resistance

Filter candles to be placed into holes of holder

Design Features

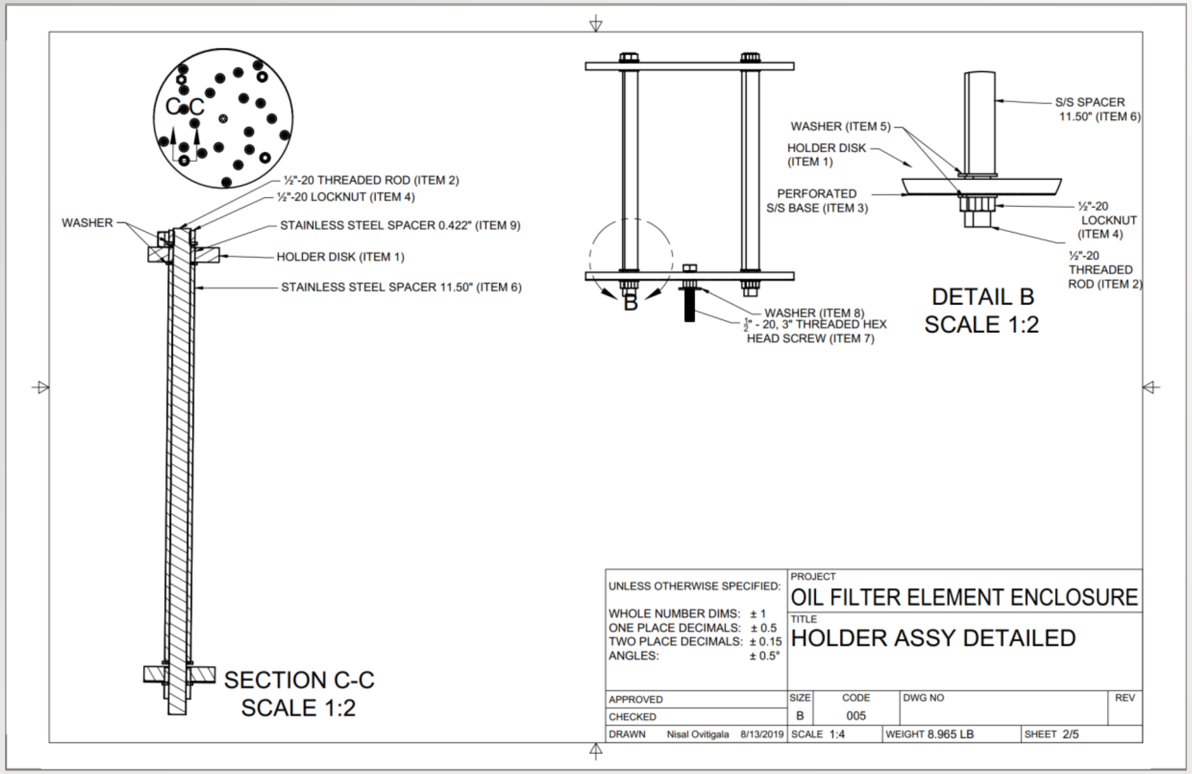


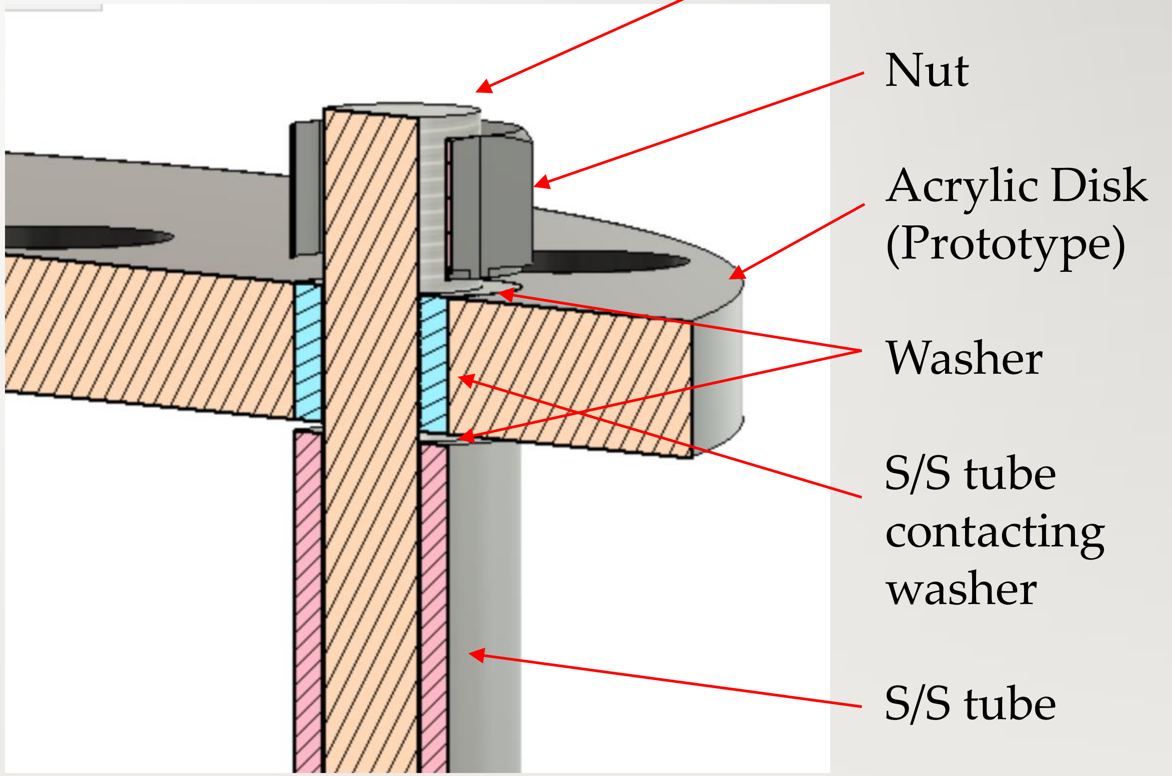
Technical drawing of hole pattern for ease of manufacturing



Optimized hole pattern for maximal cleaning potential

Design Features



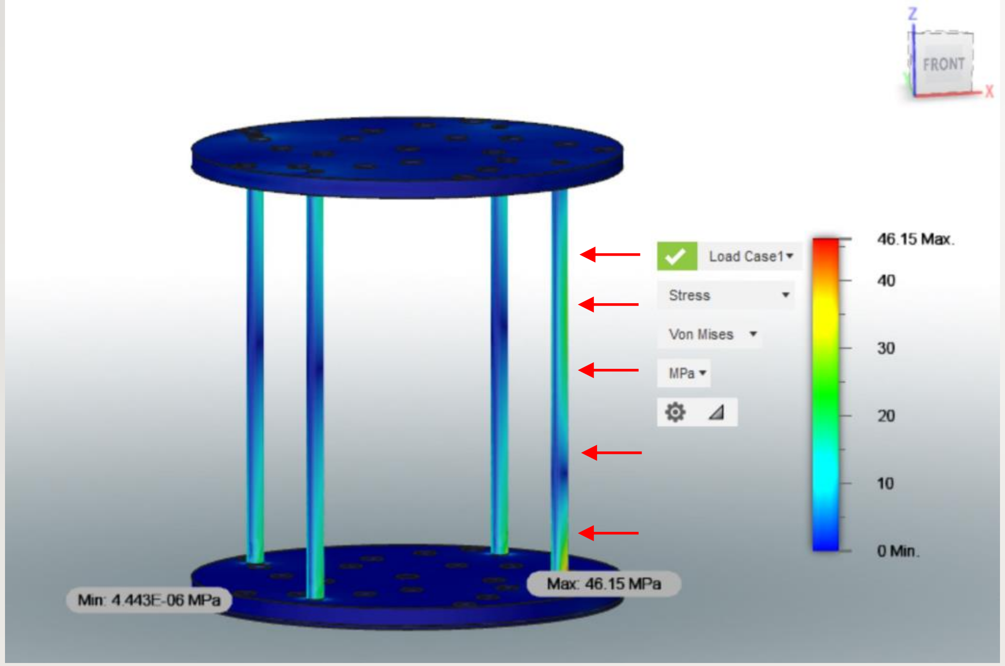


Section analysis of component shows full metal to metal contact

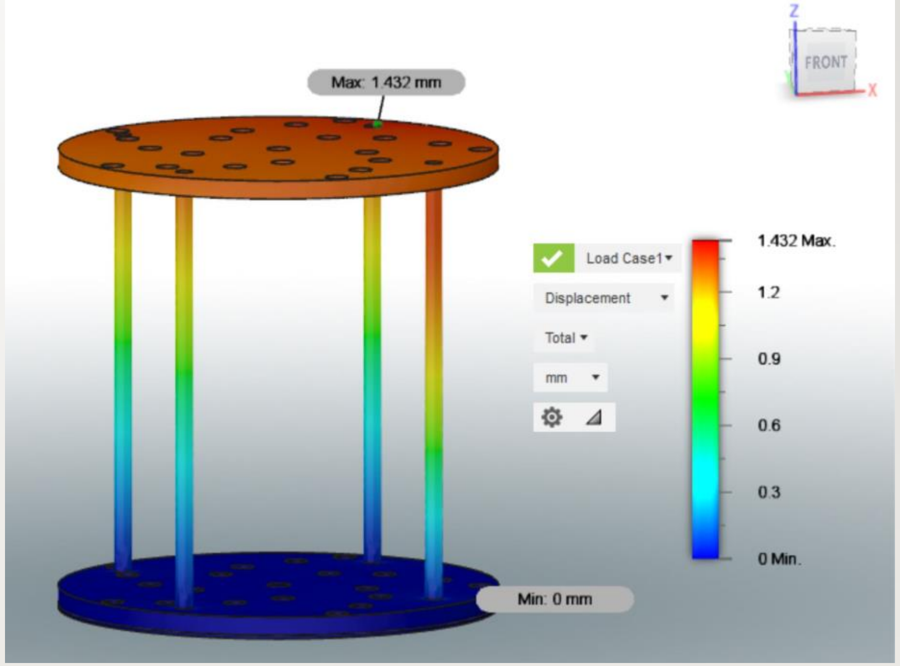
Metal to metal contact design was used to eliminate compression forces on acrylic disk

Analysis

Load case is a horizontal distributed force of 50N. Force was selected from the 75PSI water jet with a safety factor of 3. From FEA, maximum displacement was found to be 1.4mm which determined tolerance of holes in holder

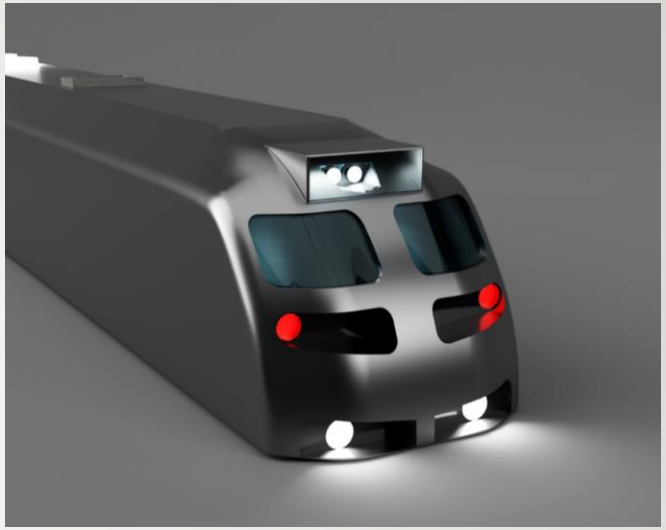


Stress Analysis



Displacement Analysis

Locomotive Headlight Cover



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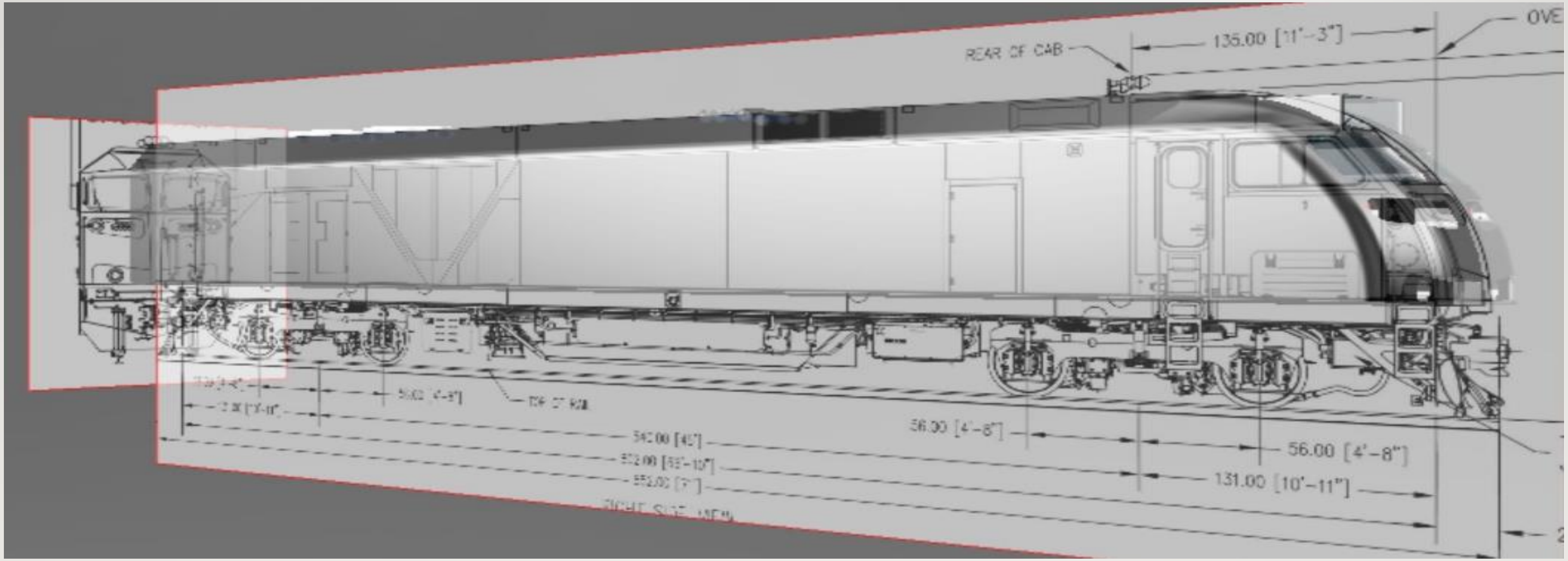
Background

- Locomotive exhaust covers headlight with soot which greatly reduces effective luminosity
- Headlight seal leaks water during heavy rains causing failure of cabin electronics
- My goal is to remediate these issues by building a headlight enclosure which stops soot from blocking the headlight and acts as an additional barrier against rainwater entry

Soot covering headlight of locomotive

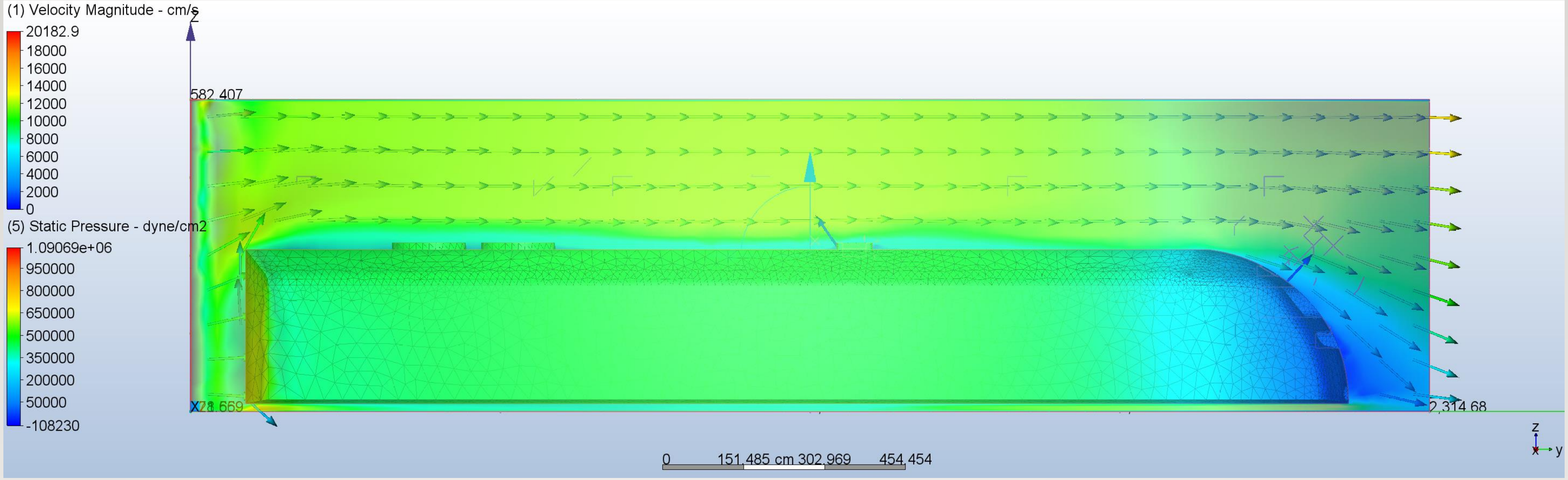
CAD Model



First step of the project is to design a CAD model of the locomotive which could then be used to design the enclosure and conduct CFD analysis

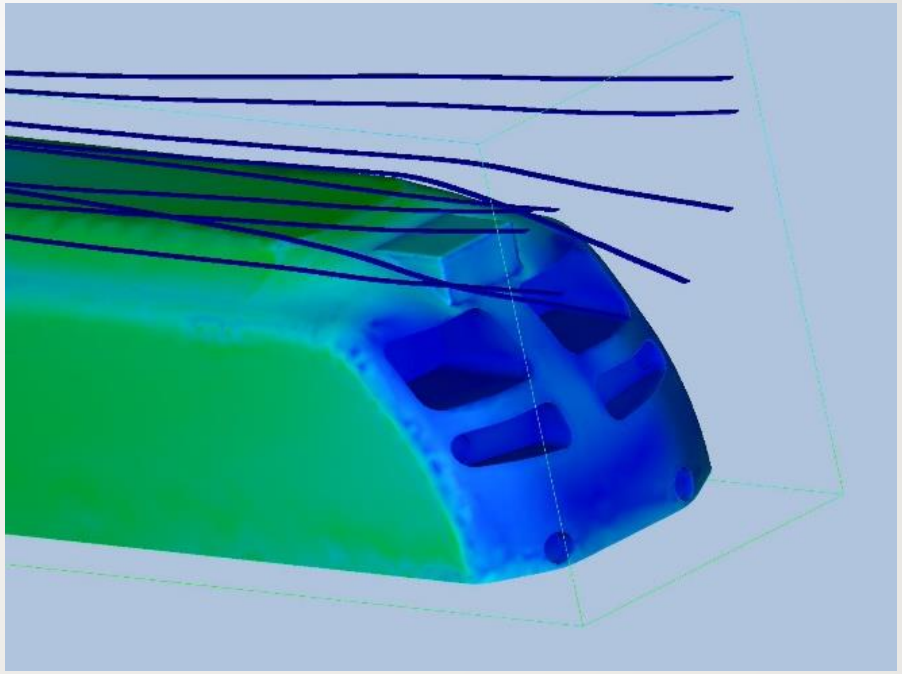
Locomotive dimensions: 71′x10′x15′

CFD Analysis



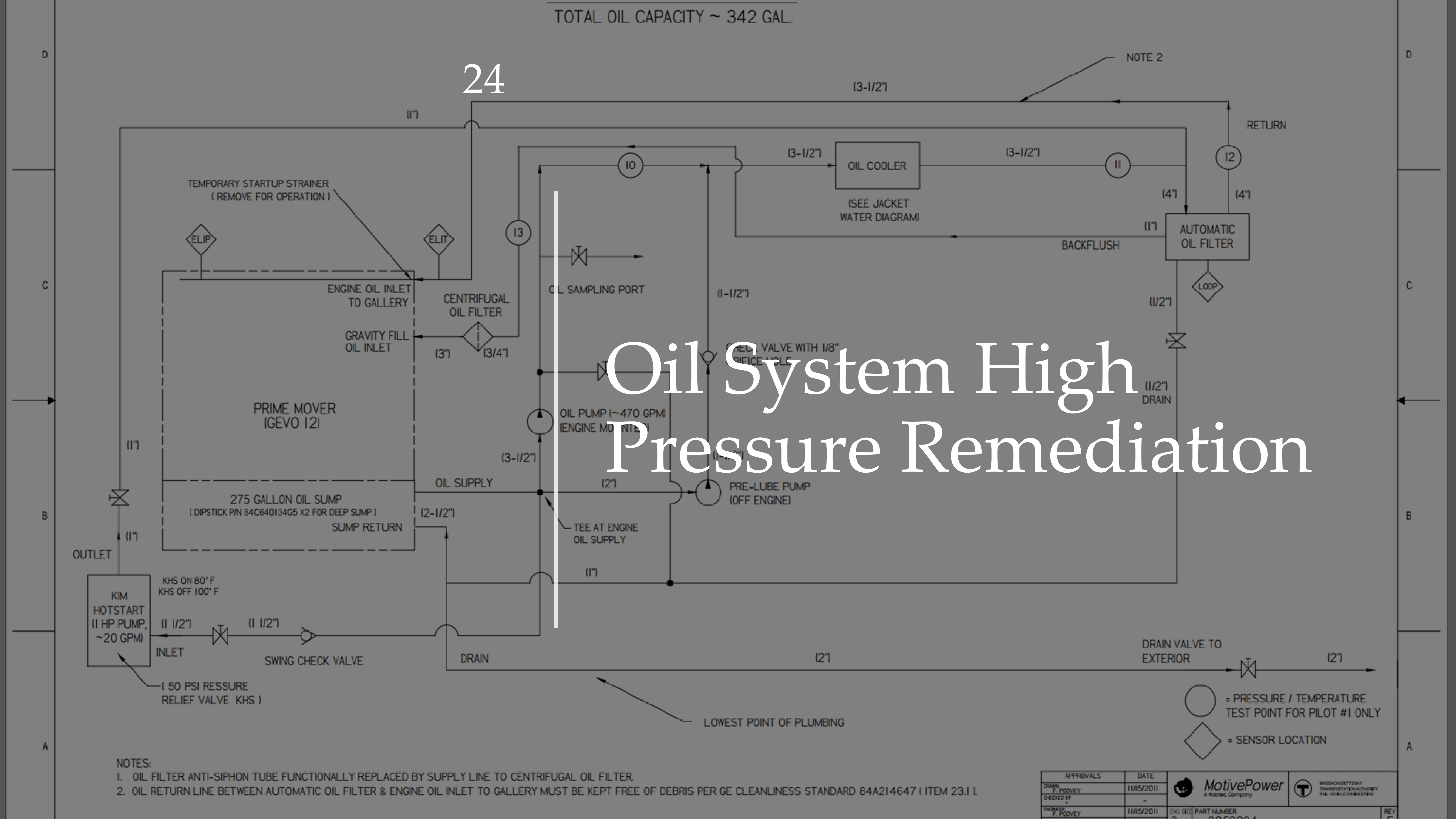
Model simulates locomotive going in reverse at 60mph. Model was verified since air from exhaust flowed at a low velocity over the headlight which suggests soot deposit would be present.

Headlight Enclosure Model



Modelled headlight cover and conducted CFD analysis to check if stresses are minimized when travelling at 60mph in reverse and forward direction. Verified that engine soot avoids light beams path and rain isn’t forced into headlight

Oil System High Pressure Remediation



Background

- The Locomotive Oil System has an anomalous high pressure (130+ PSI) somewhere which caused pumps in the system to fail (Max safe pressure: 50PSI)
- My goal is to identify the root cause of this high pressure and implement a method to stop pumps from failing
- This would be done by:
  - Installing pressure gauges through various points of oil system and conducting tests on the locomotive.
  - Writing a test report on the results of these tests and methodically finding a solution to the issue
  - Testing different methods of remedying the issue and implementing a robust solution

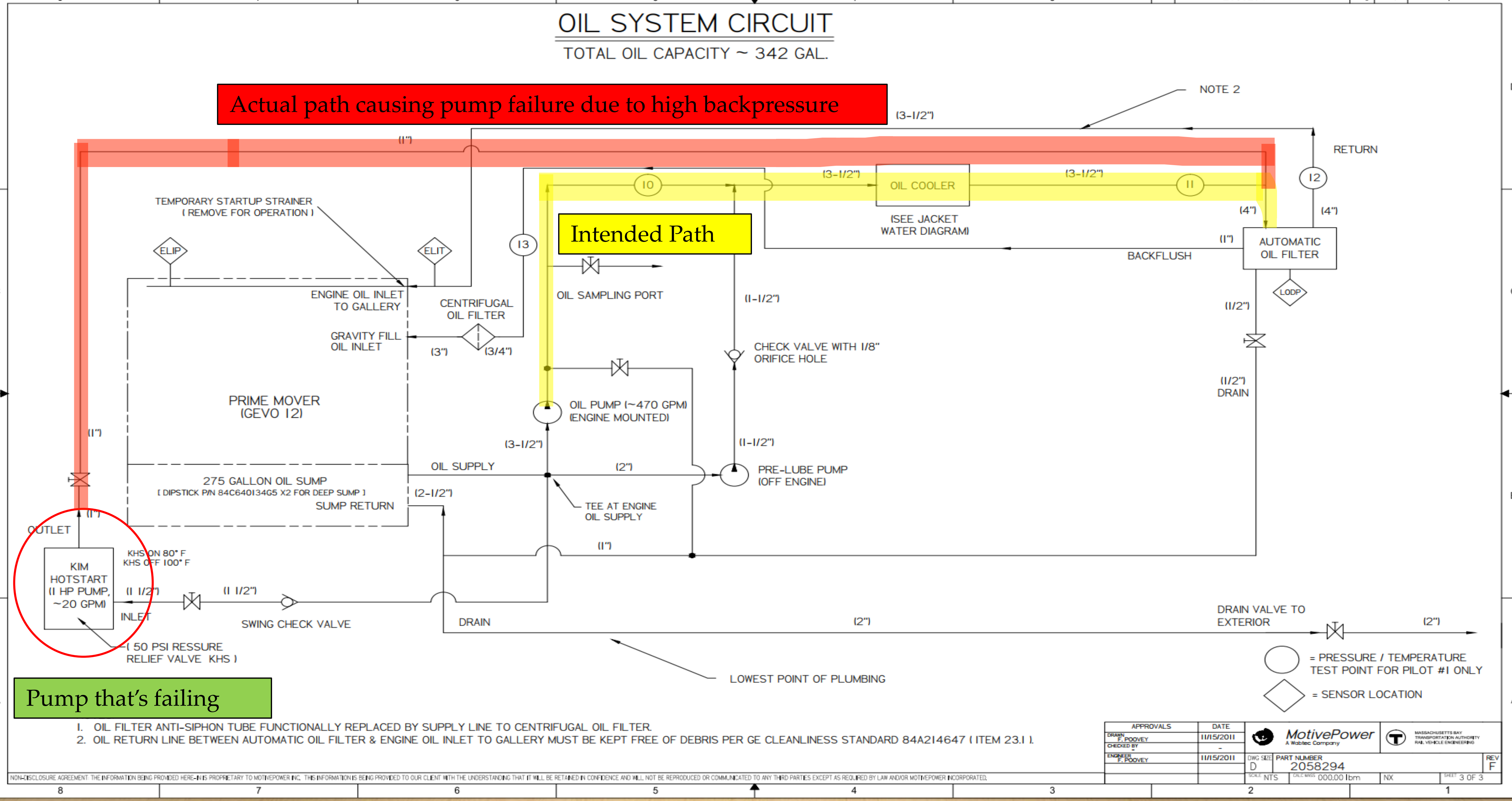


Diagram of Oil Circuit

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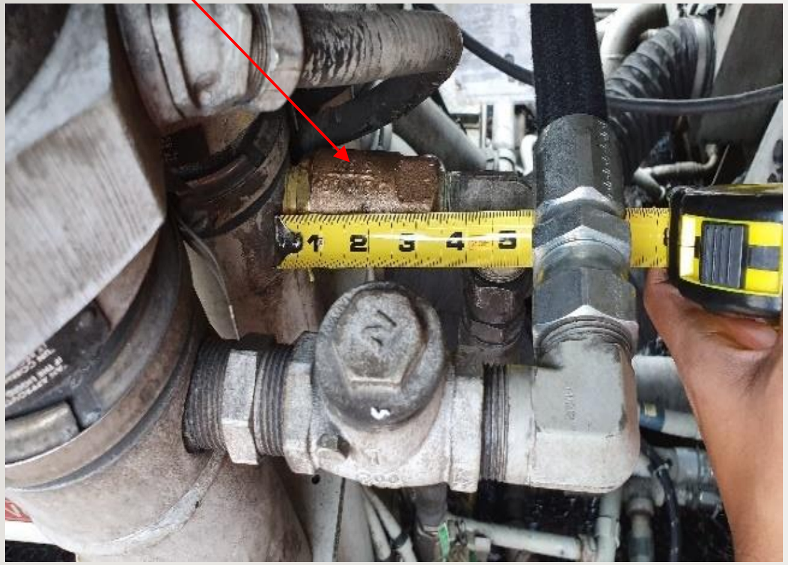
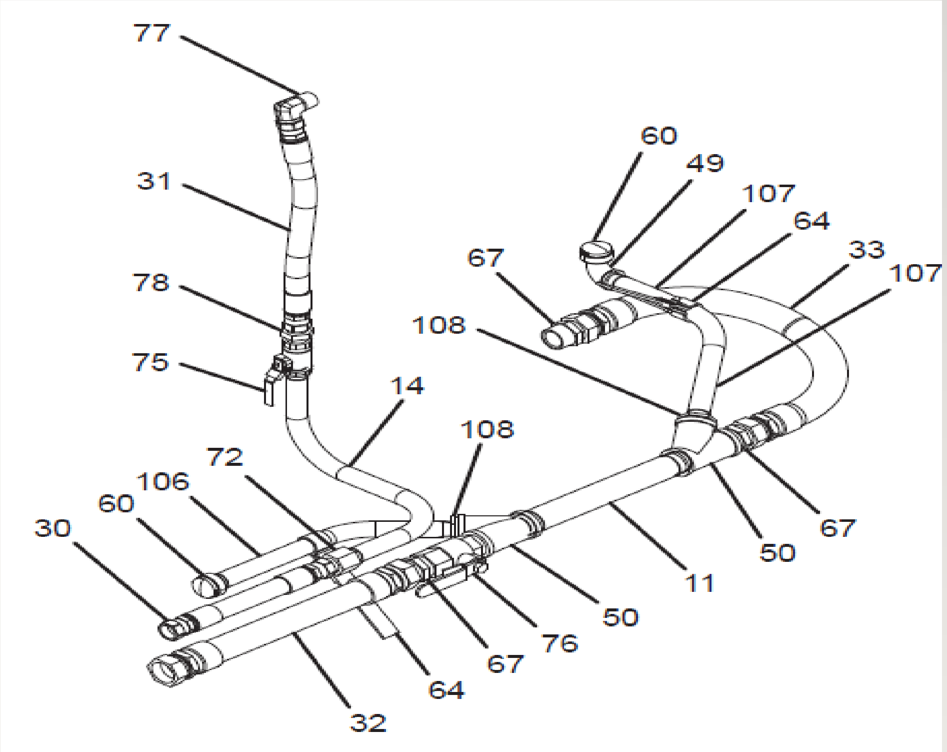
After high pressure root cause was identified, check valve was installed since pump failure was caused by a high back pressure

Check valve



Link to test report:
https://drive.google.com/file/d/1C3XPQ9D4zT72x_KkbFJrbwF7PvbFfBRI/view?usp=sharing

- Check valve dimension were checked with oil system parts catalog
- To install check valve, neighboring pipe dimensions were changed to account for valve installation
- Test report was written up to be submitted once issue was mitigated



Location of pump on oil system parts catalog

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Automated Plant Watering System

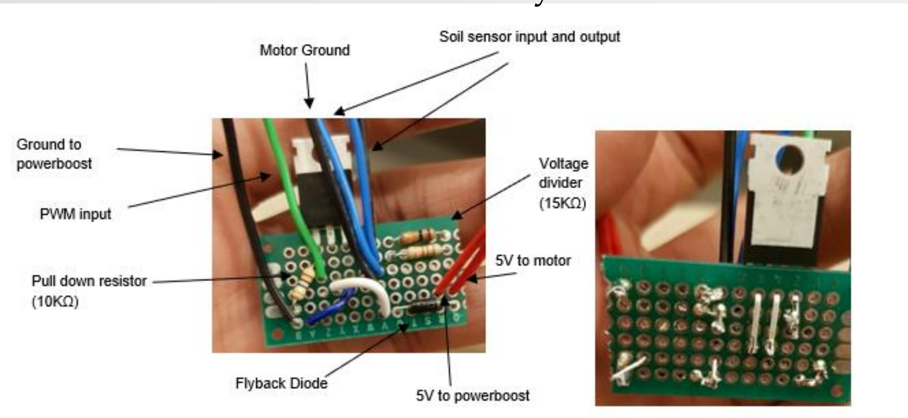
Background

- GenOne Technologies has an Engineering Development Program which contains an accelerated introduction to most rapid prototyping tools such as 3D printing, CAD, electronics and programming
- I and another student worked on building an automated plant watering system
- I mainly worked on the hardware design and some coding of the system and my coworker worked on implementing the code
- Link to project write up: https://docs.google.com/document/d/1r28xjfTWbs7BHfZeK0E40Bb3MW9BOwAyVgBZuEpPLMc/edit?usp=sharing

Final Product

Product pumps water from the tank into the plant when it detects soil moisture is low. Product only activates outside of working hours.

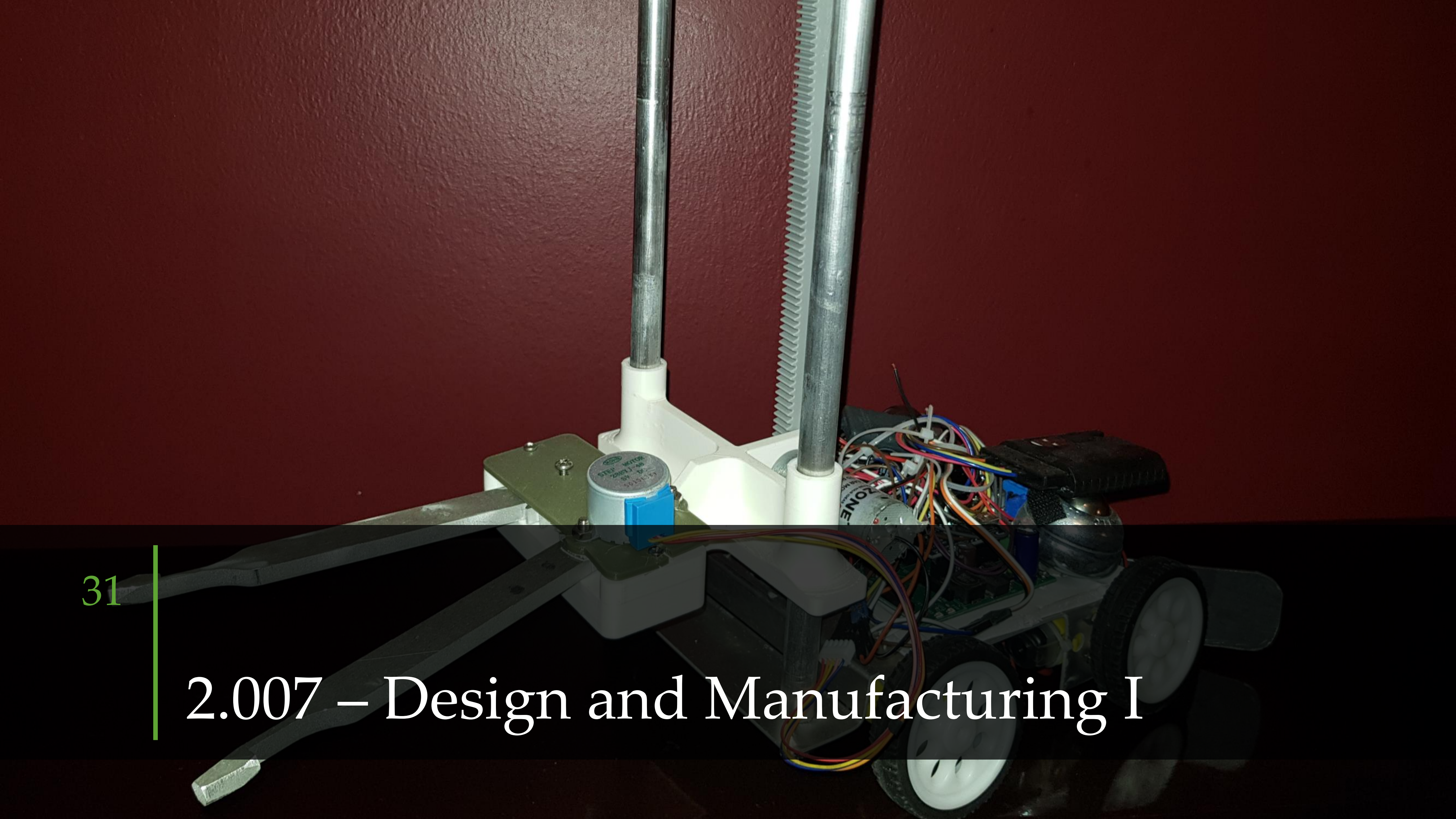
Electronics to control the system



Housing for electronics and peristaltic motor

Soil Sensor

Custom designed float switch mount



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2.007 – Design and Manufacturing I

Background

- This class requires students to come up with their own robot to participate in a competition that requires the robot to complete certain tasks on a game board
- Every design implemented on the robot needs to be backed by equations and analysis stating its value
- Robot needs to be through all the design stages, from ideation and prototype design to programming.

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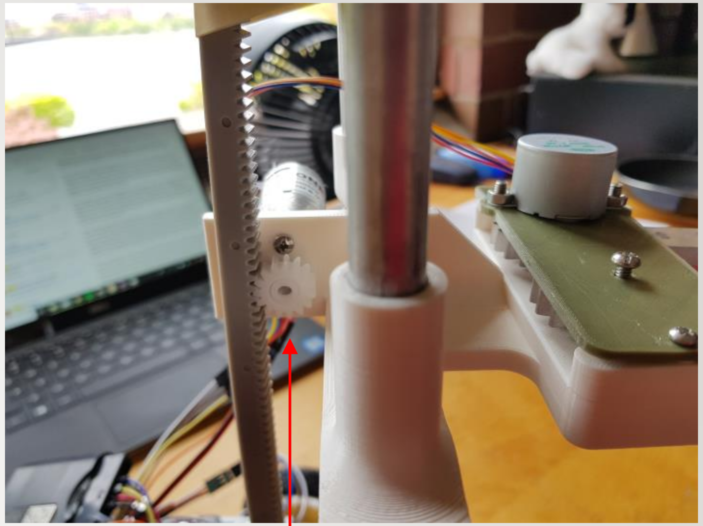
Final Robot

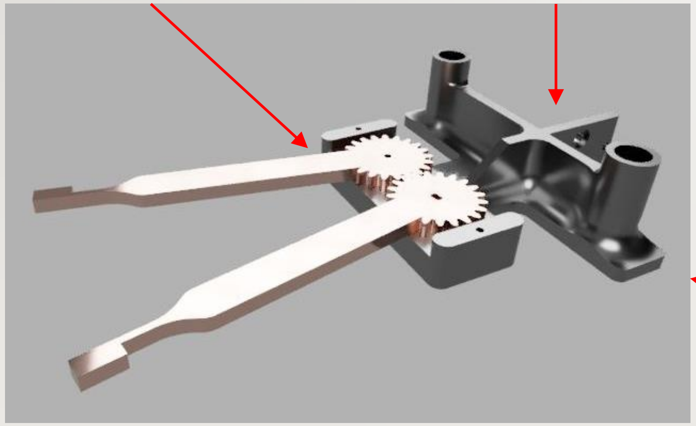
Robot has an autonomous mode which drives, grabs and pulls a device on the game board with a push of a button

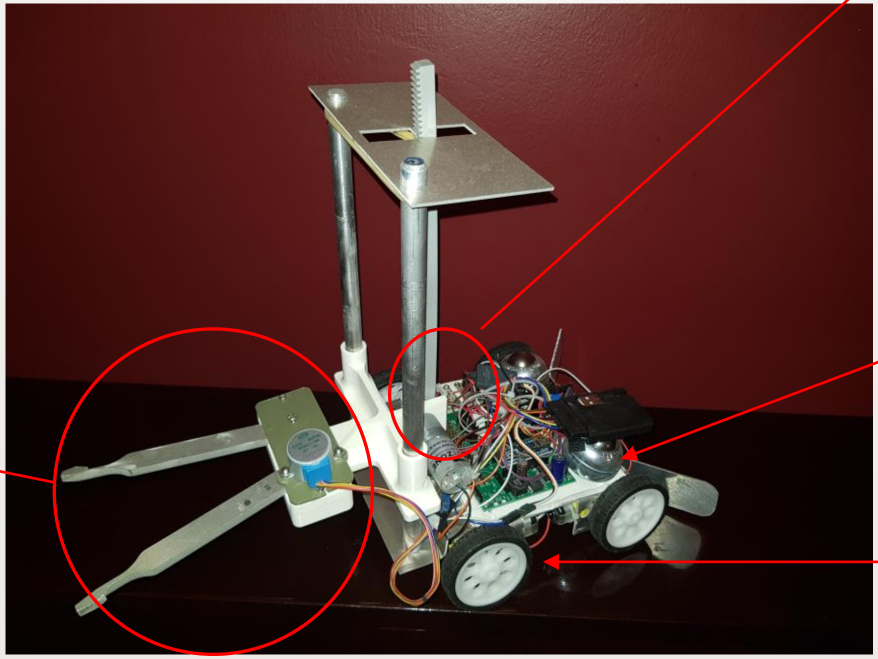


Rack and Pinion lifting mechanism with steel columns for robustness

Waterjet gears and prongs interfaced with a stepper motor to allow for precise opening of mechanism

3D printed holder which interfaces opening mechanism with lifting mechanism





Counterweights to keep center of mass low and stable

4 wheel drive for high torque and precise control of the robot

Sheet metal chassis with drilled holes for mounting of electronics

2.670 – Mechanical Engineering Tools

Background

- This class introduces students to using machine shop tools
- Students are given blueprints of making a flashlight and are required to make it using shop tools from metal stock
- Shop tools used are taps, lathes and mills (learned how to CAM on CNC mill)

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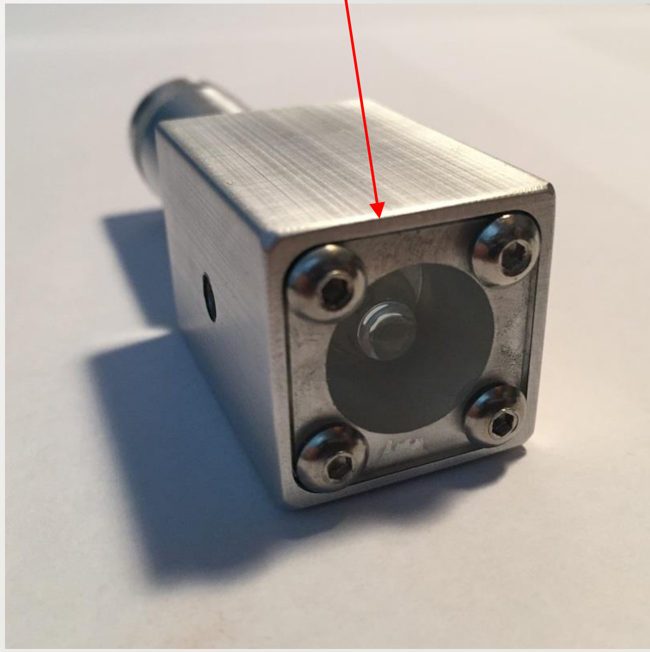
Flashlight

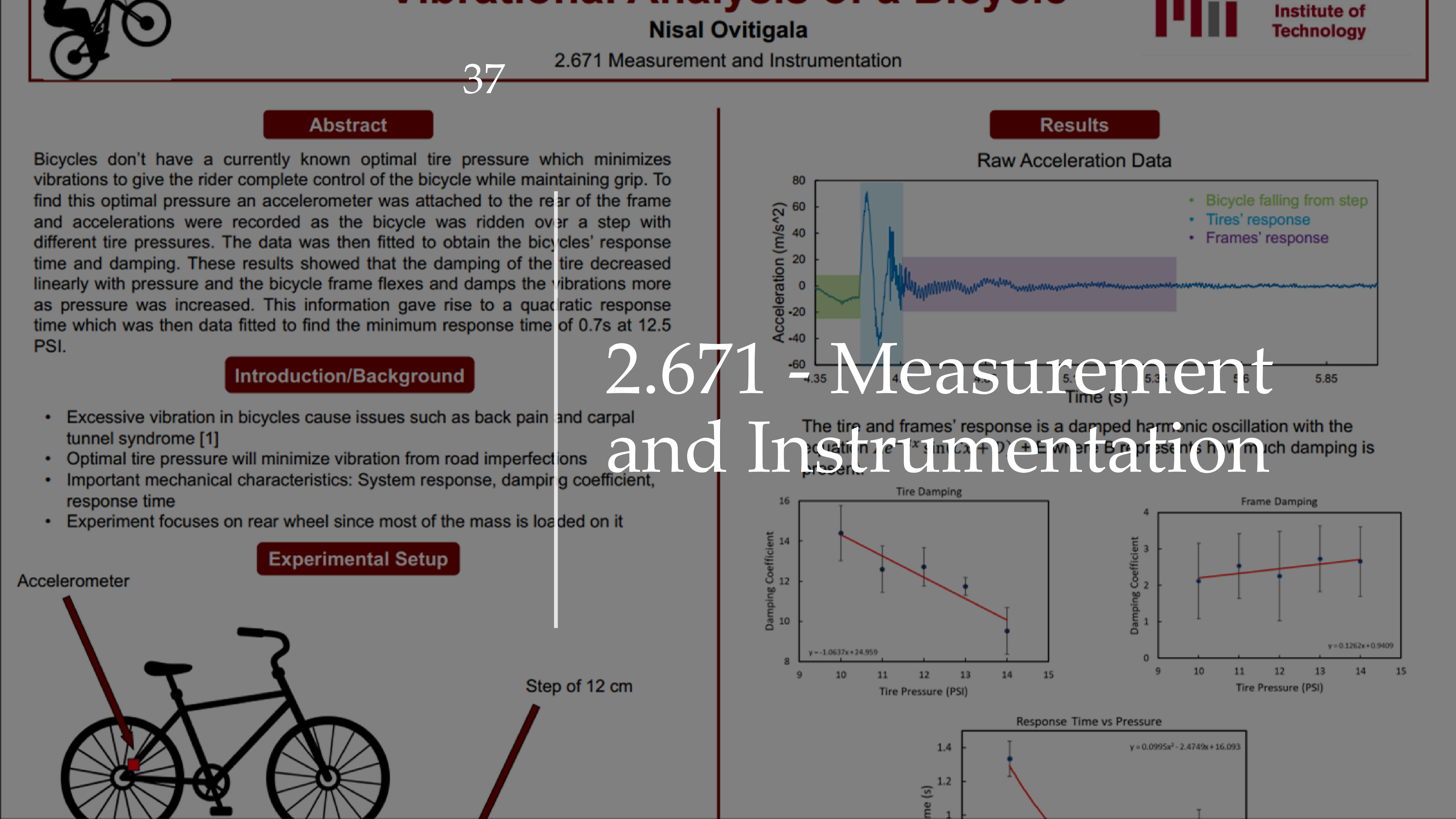
Knurled base for grip

Machined flashlight body with a lathe

Machined flashlight head with a mill



2.671 - Measurement and Instrumentation



Background

- This class teaches students about various details of conducting experiments such as calibration, uncertainty analysis, system identification and precision measurement
- This class also requires the student to conduct research into a personal project which requires the student to apply knowledge learnt in class and write a research paper on their study

Research Paper and Skills

- Wrote a research paper on finding the optimal tire pressure for a bicycle to minimize transmitted vibrations to the rider
  - Link to paper https://drive.google.com/file/d/1UVSDc55OLHpcO9sdQLBfIbl7BKmdurgK/view?usp=sharing
- Conducted measurements of nanometer scale distances using laser interferometry
- Experimentally determined frequency response transfer function of a vibration isolation setup using system identification tools