NFPA

Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

Final Design Review
Arizona State University
Faculty Mentor: Dr. Wenlong Zhang
December 2nd, 2019

Ira A. Fulton Schools of Engineering
Arizona State University

Meet Our Team

- (Pictured left to right): Faculty advisor: Dr. Zhang.
- Team members: Ian Leventhal, Sam Seidel, Pierre Wilson, Robert DeGeorge
- Student Advisors: Jon Bush and Hansol Moon.

Presentation Overview

- Midway Summary: Problem Statement and Objectives
- Midway Summary: Design Objectives
- Midway Summary: Selection of Hardware
- Midway Summary: Vehicle Design
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- Updated Fluid Power Circuit Design
- Updated Motor Mount with Finite Element Analysis
- Electrical Design Components
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- Custom PCB Design
- Vehicle Construction: Layout Prep
- Vehicle Construction: Manifold Preparations
- Vehicle Construction: Reservoir Fabrication
- Vehicle Construction: Sprocket Fabrications
- Vehicle Construction: Component Mounting
- Progress Made Towards Final Vehicle
- Lessons Learned
- Impact of COVID-19
- Next Steps/Conclusion

Midway Summary: Problem Statement and Objectives

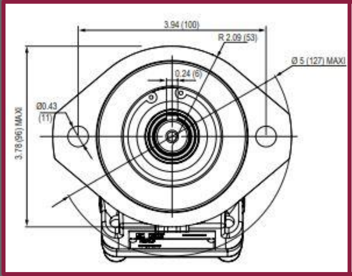
The NFPA has presented us with a competition amongst multiple universities to develop and create a human powered fluid vehicle using hydraulic technology.

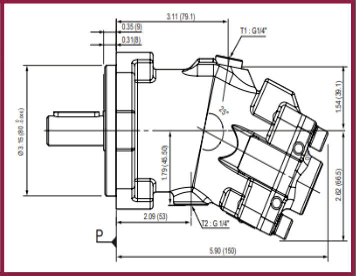
- Endurance challenge is our primary focus.
- A microcontroller will allow for a customizable circuit for different drive modes.
- An integrated hybrid mode allows for a charge process in addition to our regen mode.
- Accumulator(s) must not exceed 1 gallon in total volume.
- Weight of vehicle (excluding rider) must not exceed 210 lbs.
- $5,500 max total budget.
- No active leaks.

Midway Summary: Design Objectives

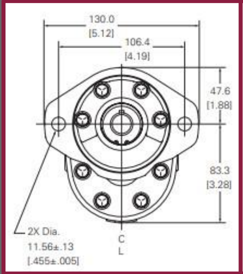
- Pedaling rotates the gears which are connected to the pump.
- The pump pushes liquid from the reservoir into the motor.
- The motor is connected to the back wheels by a gear and chain.
- The accumulators hold a pressurized charge that gets sent to the motor through a hose.
- The manifold has solenoids that can direct the hydraulic fluid flow.
- The direction of fluid flow determines different drive modes such as direct drive or regenerative braking.

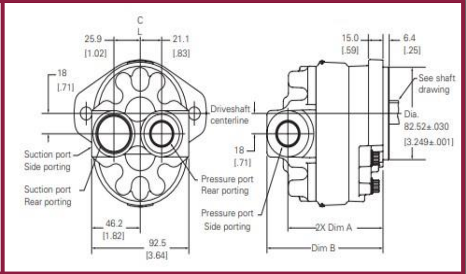
Midway Summary: Selection of Hardware



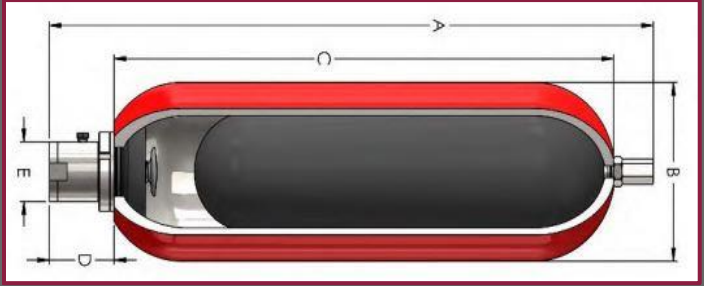


- 5cc Hydro-leduc Piston Motor (0.305 CIR)
- 9.7 lbs
- 0.004 lb-ft/psi
- 18mm diameter keyed shaft



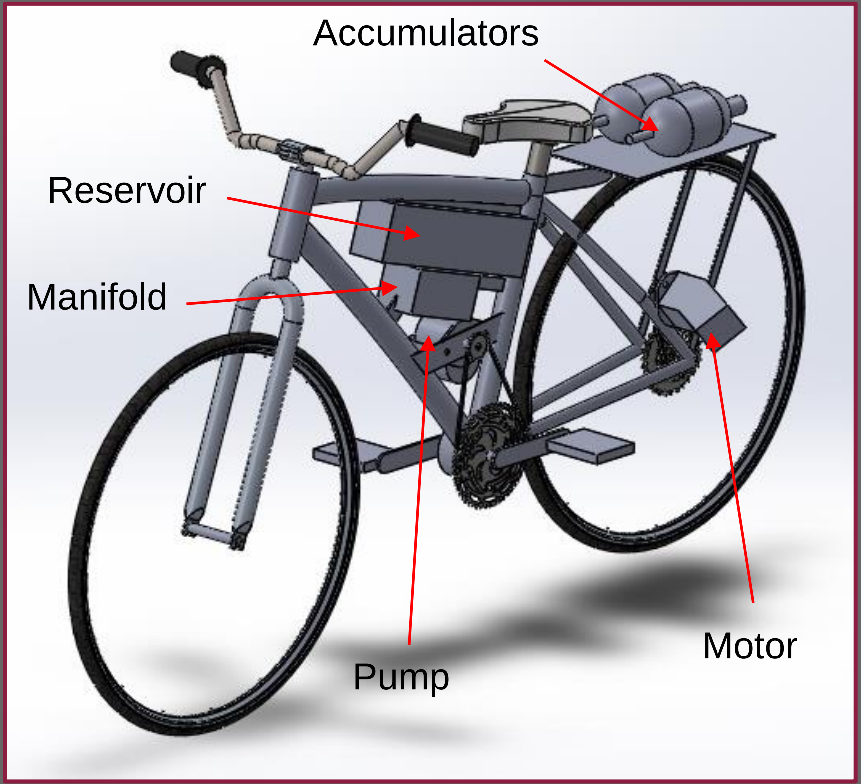


- 0.5 CIR Eaton Gear Pump
- 5/8 9 tooth spline shaft
- 7 lbs
- 7/8-14 UNF-2B pressure port
- 1-1/16-12 UN-2B suction port



- 10 lbs
- 1 quart (x2)
- 3000 psi max
- Pressurized air in bladder induces pressure on hydraulic fluid outside the bladder
- 4-1/4" -8 UN-2 Male SAE fluid port

Midway Summary: Vehicle Design

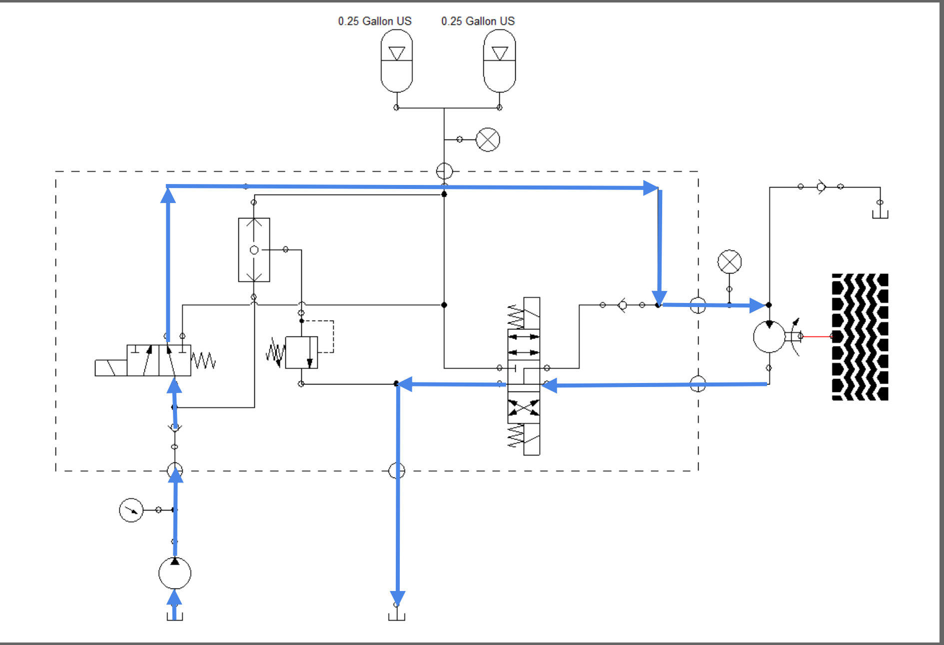


Updated Vehicle Design

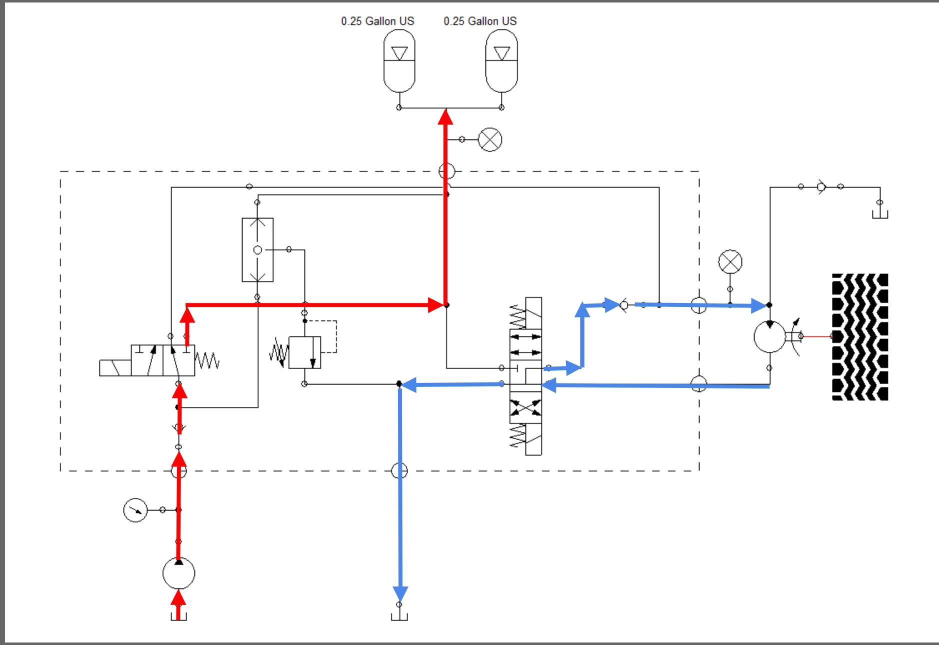
- Reservoir shape redesign and moved above frame
- Pump repositioned to back wheel to account for left hand rotation

Updated Fluid Power Circuit Design

Direct Drive

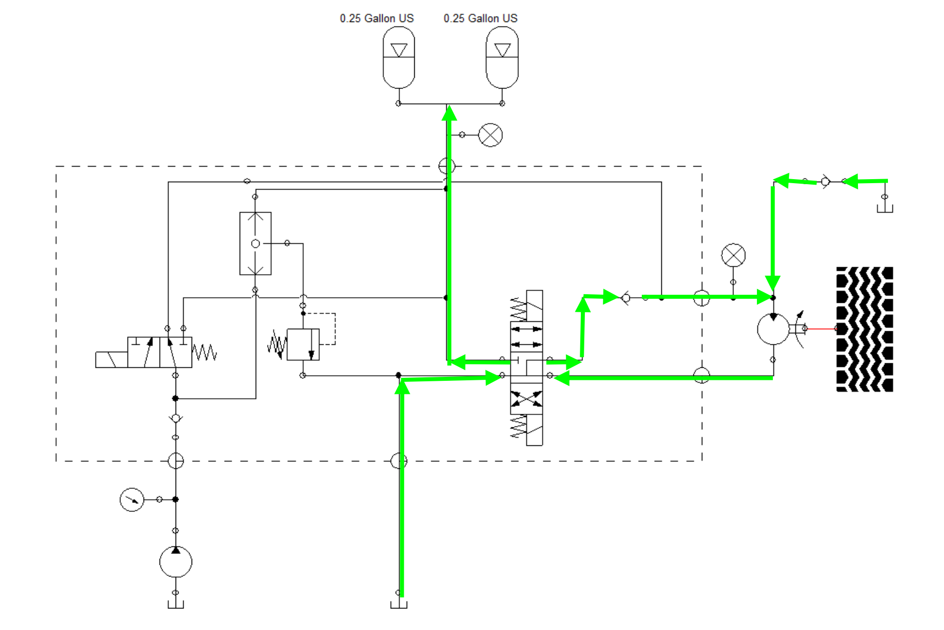


Hybrid Drive (Pre/mid-charge)

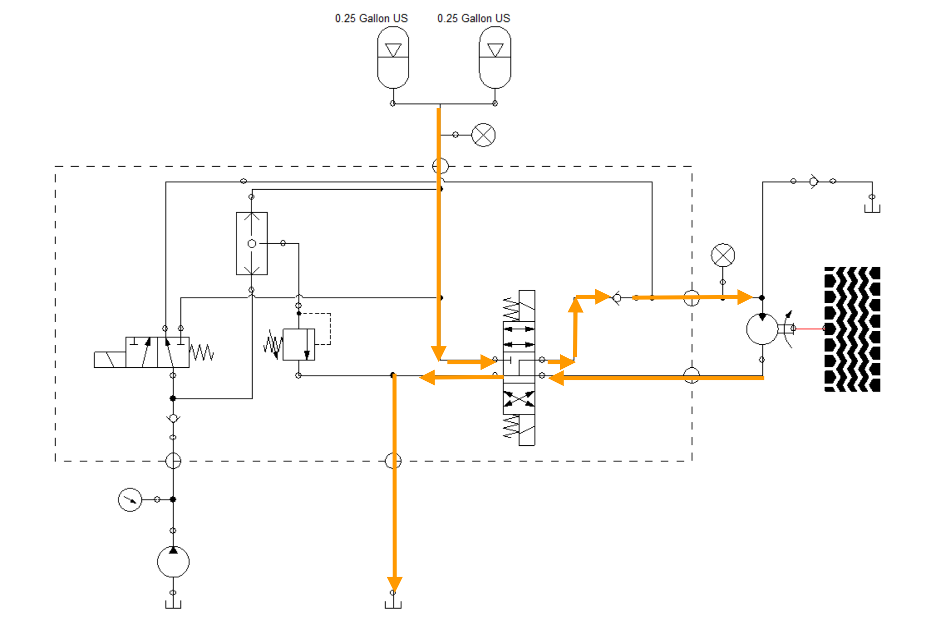


Updated Fluid Power Circuit Design

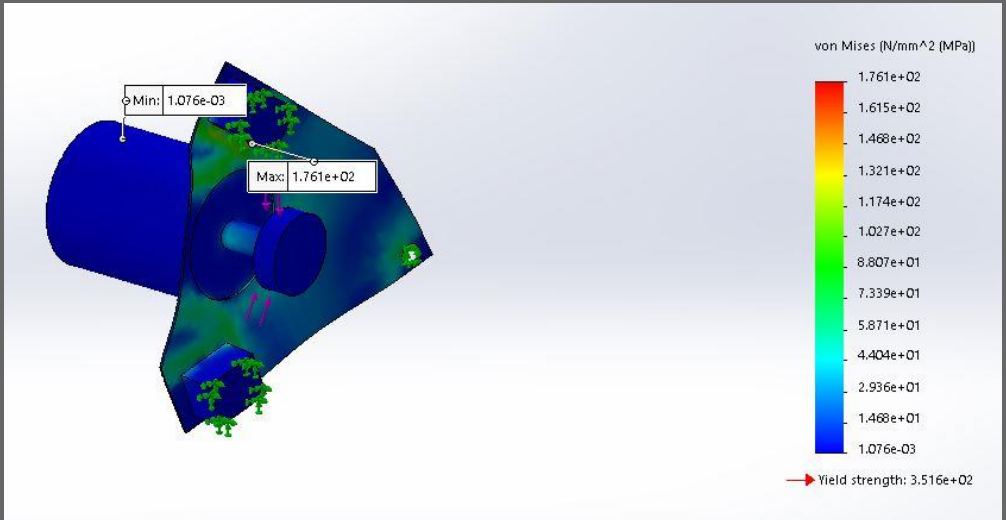
Regenerative Drive



Discharge Drive

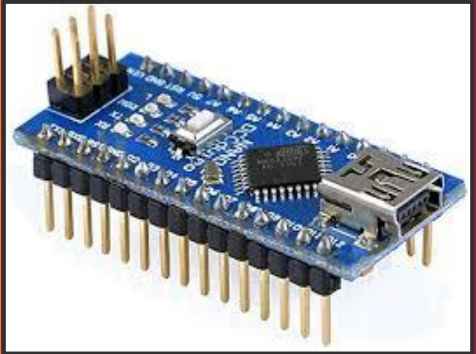


Updated Motor Mount with Finite Element Analysis



Electrical Design Components

Arduino Nano
The logical processor of the electrical circuit.



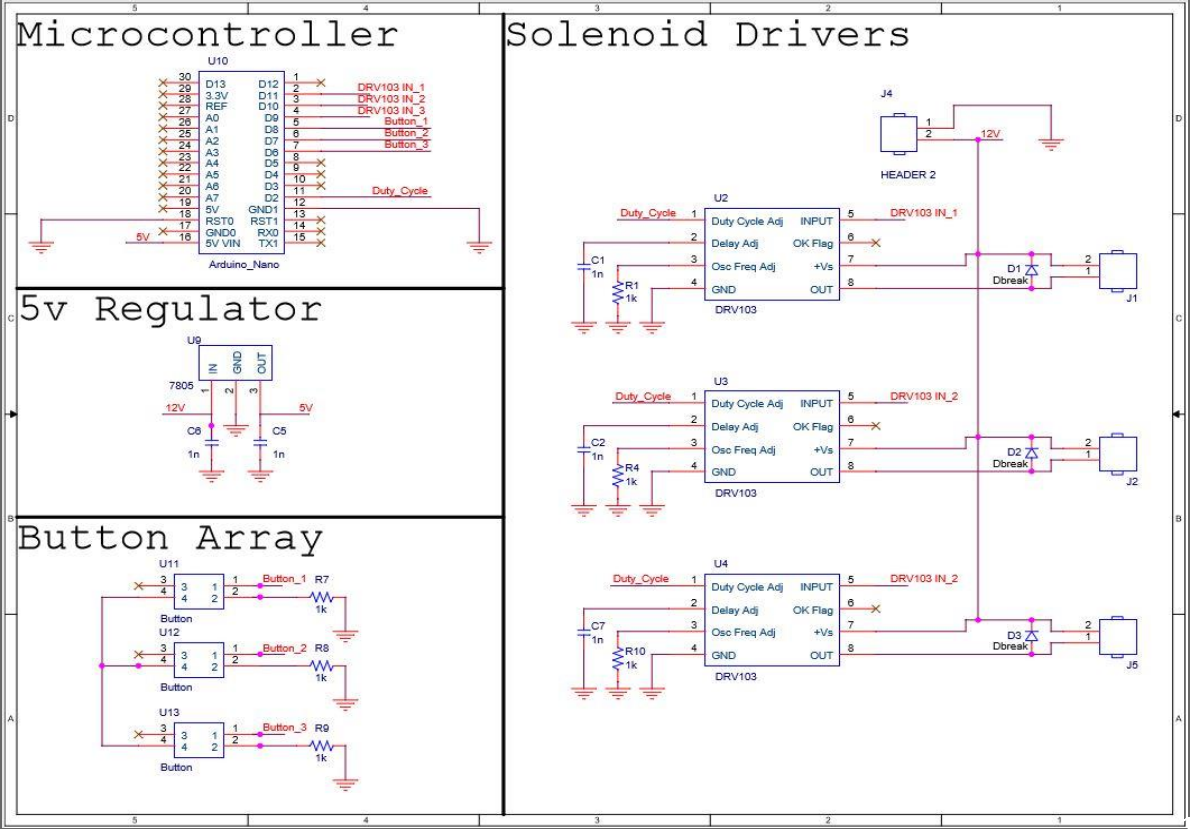
DRV103-H
Solenoid driver designed to drive electromechanical devices such as solenoids.

Push Button
Will be used as main input devices to change drive modes on the fly.

Hydraulic Solenoids
Used in the manifold to designate the path of fluid flow and dictated drive modes.

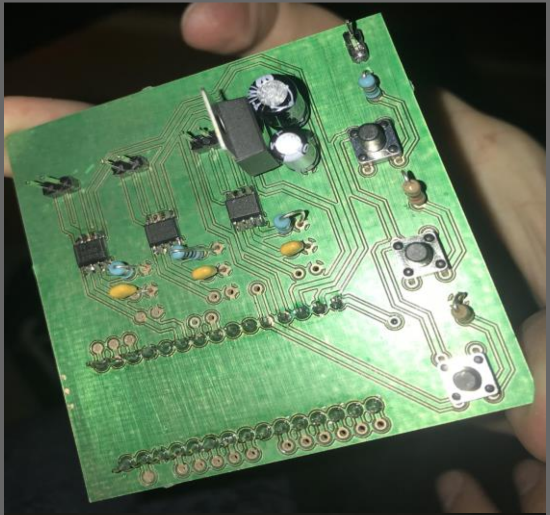
Electrical Design Schematic

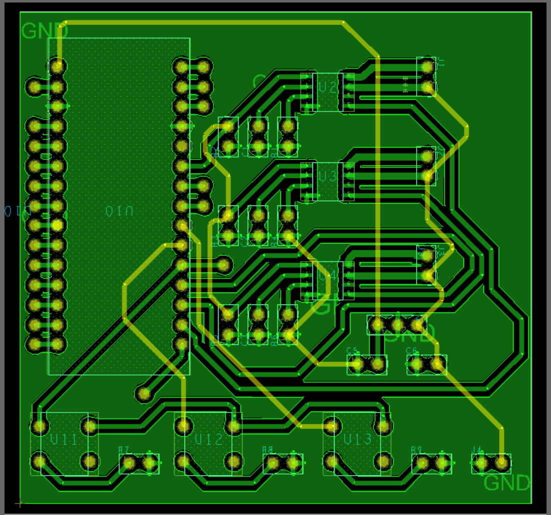
- Designed using Cadence
- Easy to follow subsystems
- Controlled with an Arduino Nano

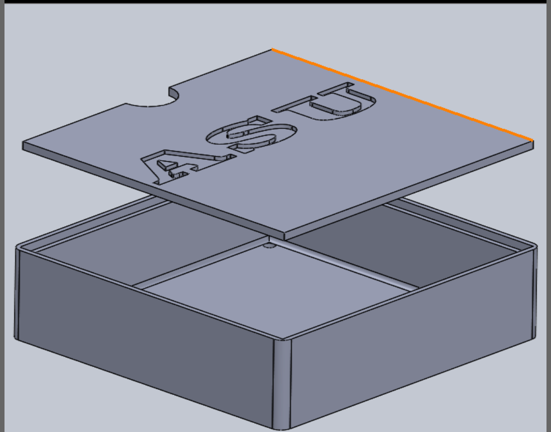


Custom PCB Design

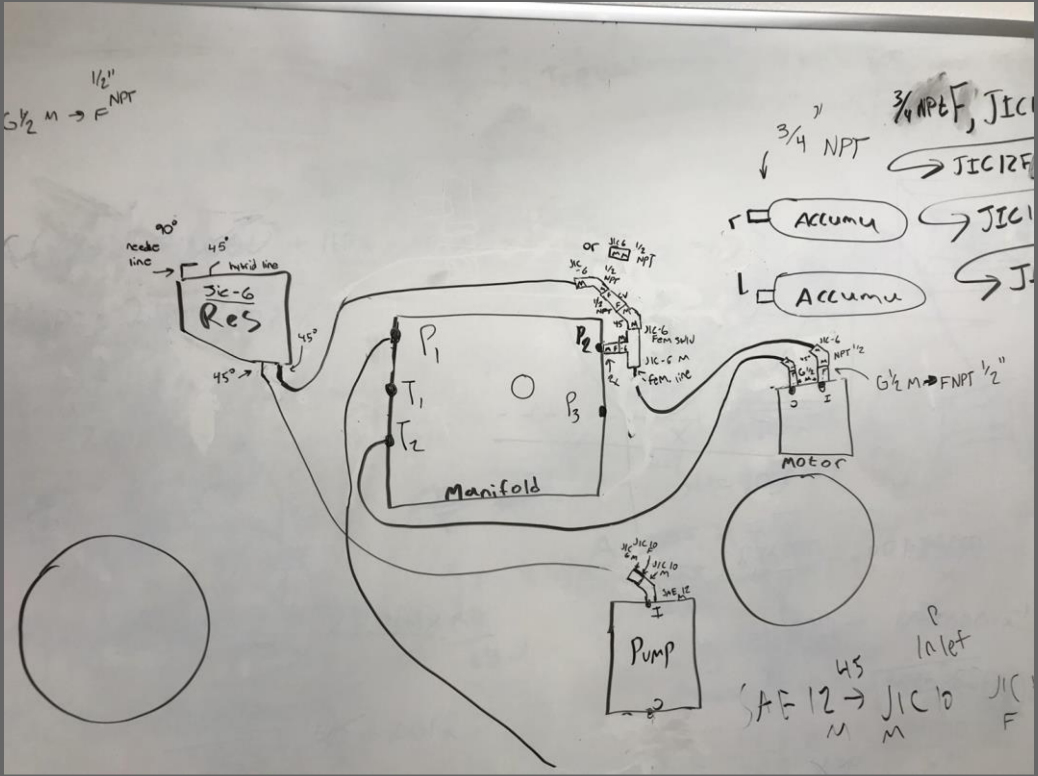
- Custom 3D printed housing
- Small form factor
- Fabricated at ASU



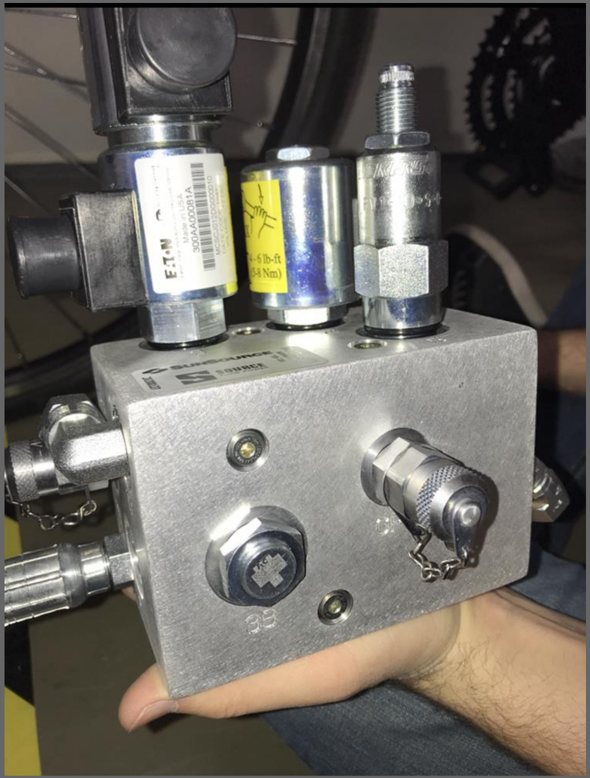




Vehicle Construction: Layout Prep



Vehicle Construction: Manifold Preparations

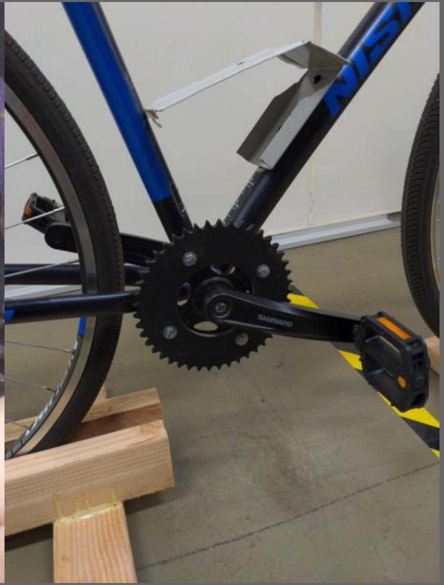


Vehicle Construction: Reservoir Fabrication

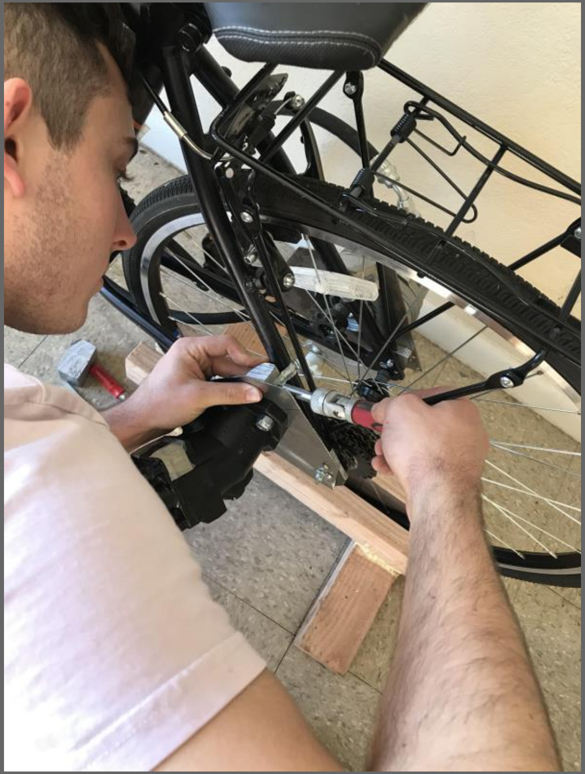
Vehicle Construction: Reservoir Fabrication

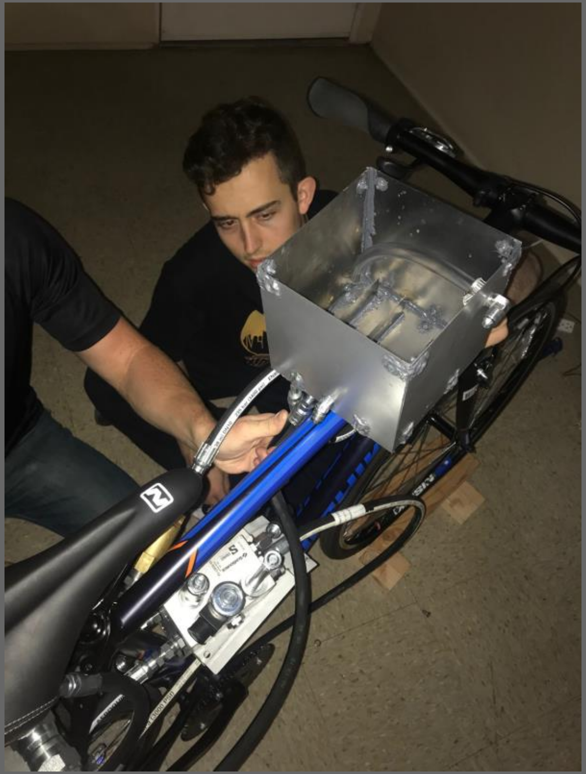


Vehicle Construction: Sprocket Fabrications



Vehicle Construction: Component Mounting





Progress Made Towards Final Vehicle

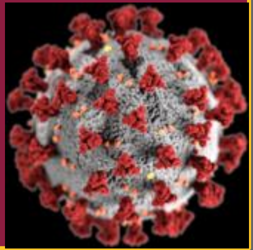
- Pump mount fabrication
- Motor mount fabrication
- Manifold Mount fabrication
- Accumulator mount fabrication
- Sprocket coupling fabrication
- Reservoir fabrication
- Hose assembly
- Gear mounting
- PCB fabrication

Lessons Learned

- Plan further ahead for hydraulic fitting requirements
- Compile orders to one batch rather than multiple forms
- Volumetric efficiency is different than mechanical efficiency
- Order the correct components
- Use thicker sheet metal if planning to weld
- Plan ahead faster for the unexpected (COVID-19)
- Beginning power plant fabrication simultaneously as opposed to consecutive

Impact of COVID-19

- Campus closed
  - Lab closure
  - Central prototype meeting hub removed
  - Access to heavy duty machinery removed
- Shipping times greatly delayed
- Difficult to meet up and work on project together
- Bicycle had to be moved to Sam's house, then relocated to Robert’s home
- Resourcefulness of prototype component implementation
- Working against a mandatory quarantine



Next Steps/Conclusion

- Test ECU/manifold functionality
- Reroute hydraulic hoses to be more ergonomic
- Implement improved manifold mount
- Implement intended reservoir/ECU mount
- Write a professional engineering report for capstone
- Prepare for our class “innovation showcase”
- Compile resources necessary for the following ASU team to succeed

Questions?