# NFPA Fluid Power Vehicle Challenge

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Final Presentation
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NATIONAL FLUID POWER ASSOCIATION · NFPA ·

SOULenoid CYCLE

# Team Introductions

*Cayla Quinn*

*Jordan Kochavi*

*Kellen Giuliani*

*Martin Reyes*

# Design Objectives

# Design Objectives

*Vehicle Performance* | *Safety* | *Innovation*

- Improve the previous team's hydraulic system
- Manufacture and design a new vehicle frame
- Implement an interactive mechatronics system
- Perform race challenges successfully

# Summary of Midway Revie

# Previous Vehicle Frame

Controller

Manifold

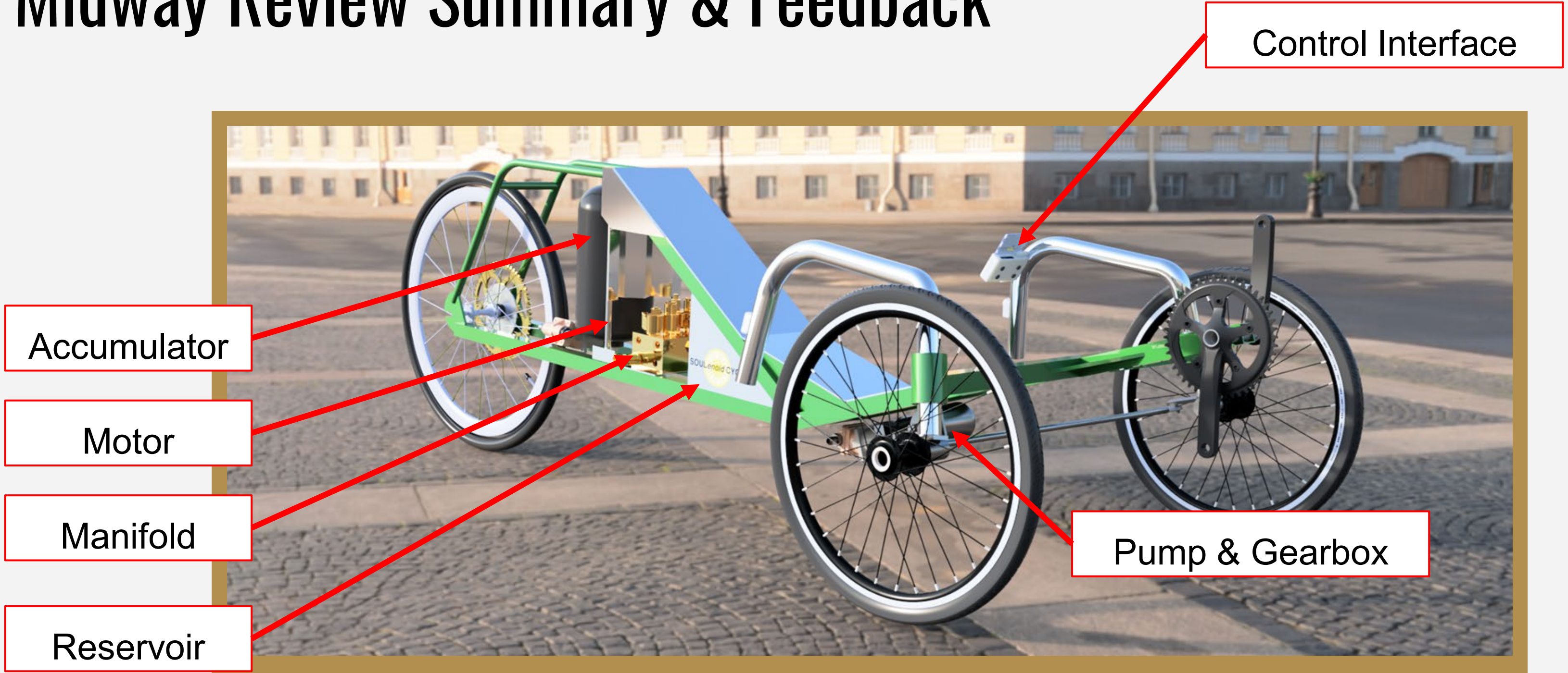
Motor

Reservoir

Pump

Gearbox

# Midway Review Summary & Feedback

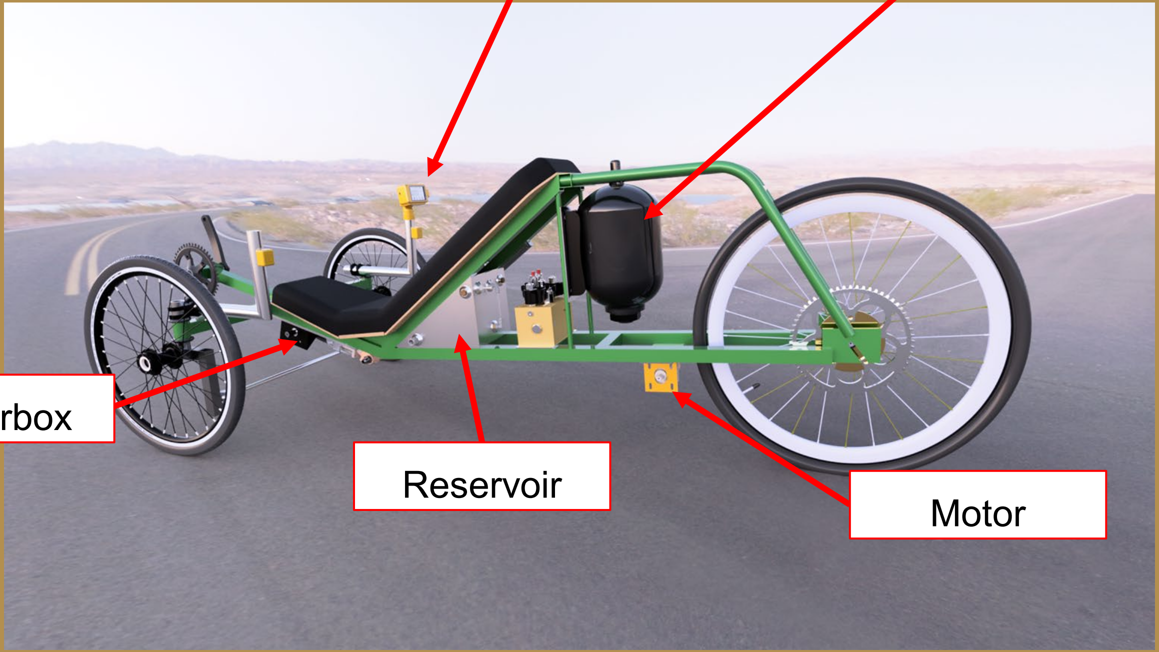



Vehicle Render

- Consider a way to release accumulator pressure to tank without using the motor
- Pneumatic circuit needs work

# Vehicle Frame

# Final Design



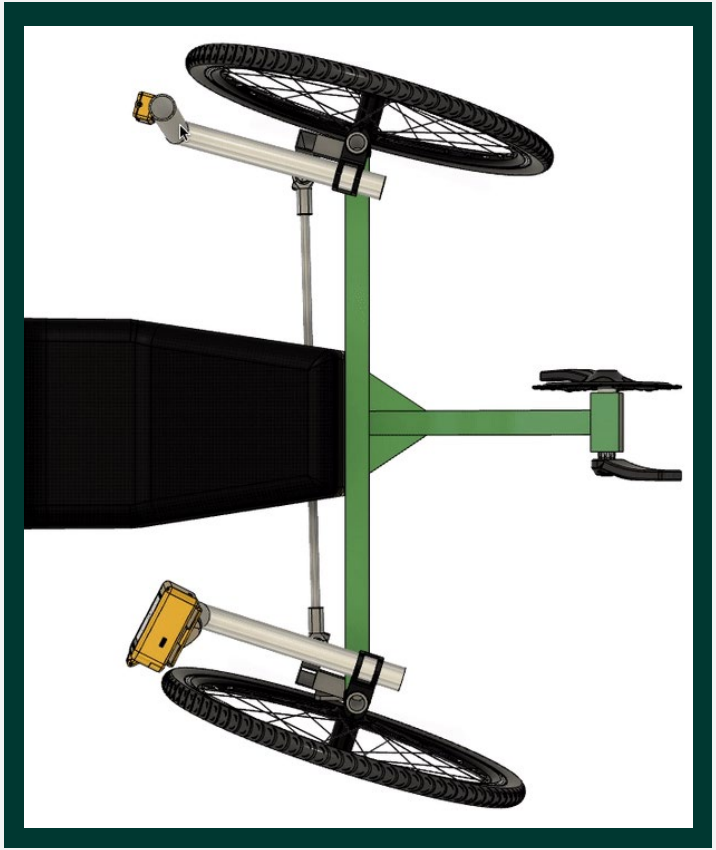

Vehicle Render

# Frame Manufacturing


# Steering Linkage

# Final Steering System Model

- ❑ Intuitive To Steer Despite Being Unconventional
- ❑ Sturdy and Ergonomic with Ample Feedback
- ❑ Implements Ackerman Steering Geometry

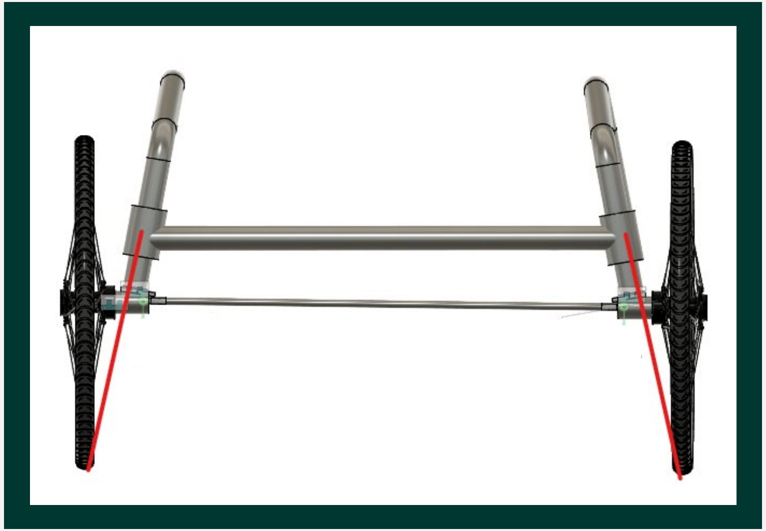


# Sacrifices

## Caster Angle

❑ Canted Wheels Instead

## Centerpoint Steering



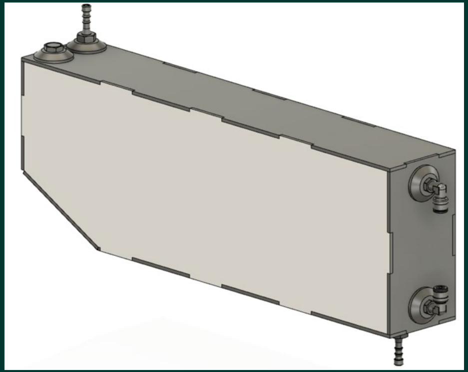
❑ Unnecessary Due to Smooth Driving Surface and Low Speeds

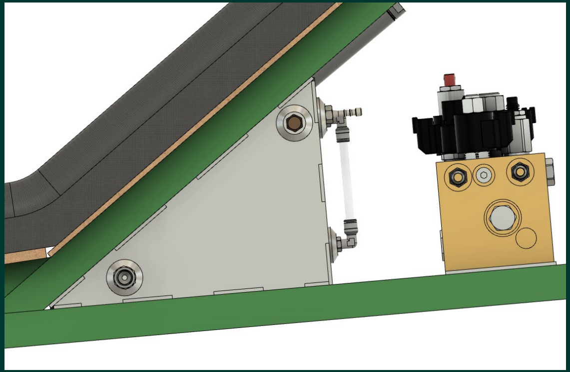
# Linkage Bars

# Hydraulics

# New Vs. Old Reservoir

Previous Reservoir

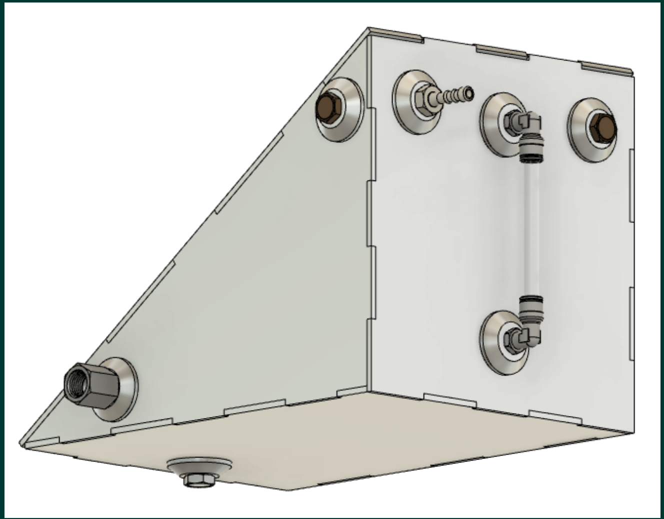




New Reservoir

- ❑ Same capacity of 1.3 gallons
- ❑ 6061-T6 Aluminum
- ❑ New geometry to fit frame

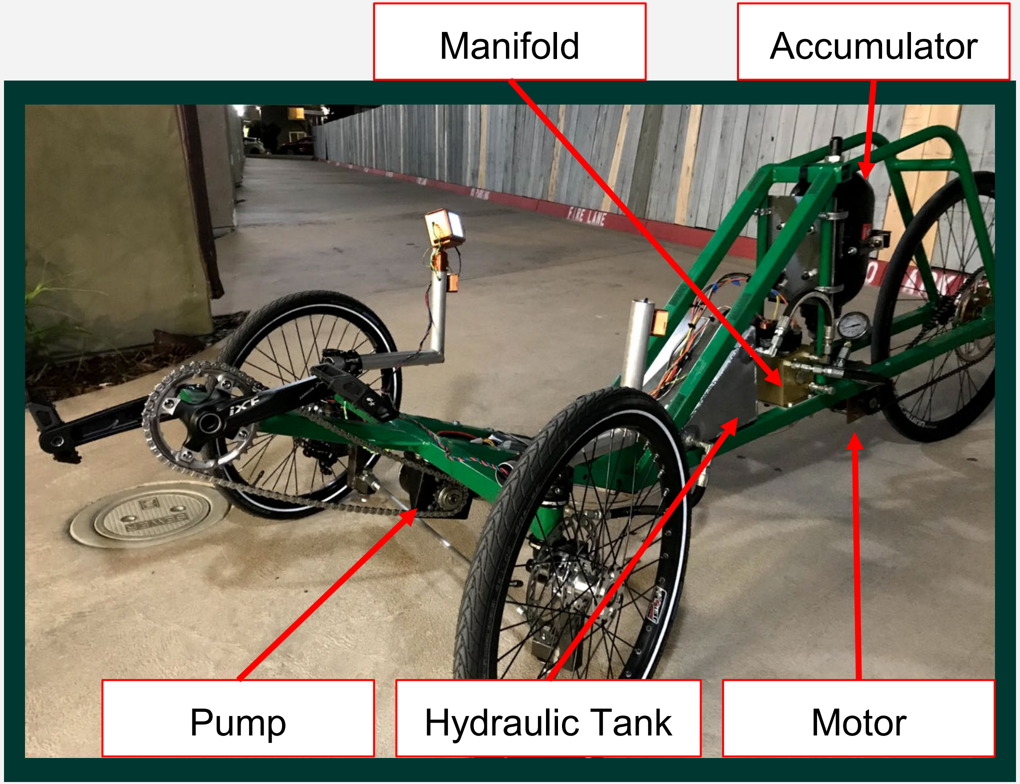
# New Reservoir Manufacturing



- ❑ Used the waterjet to cut the aluminum pieces
- ❑ Another Cal Poly student, Junnior Rodriguez, and the Cal Poly Machine Shop Professor, Eric Pulse, helped us TIG weld the reservoir

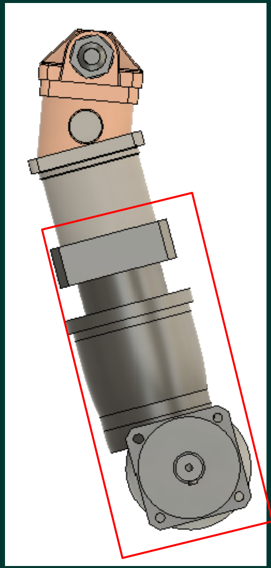
# Relocating Hydraulic Components

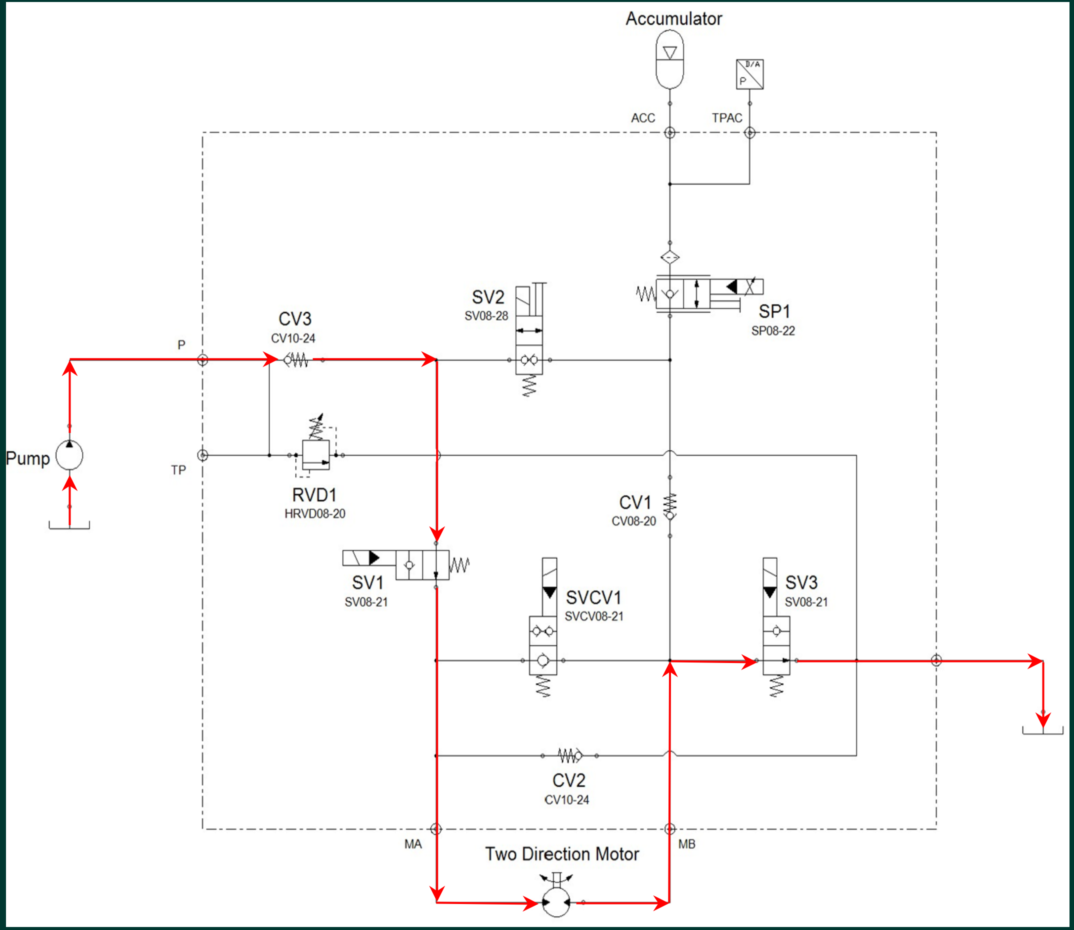
- Relocating components allowed us to use 2ft less of hydraulic
  - Planned to implement hard lines but ran out of time
- Allowed us to mount the accumulator vertically
  - Increased safety & efficiency



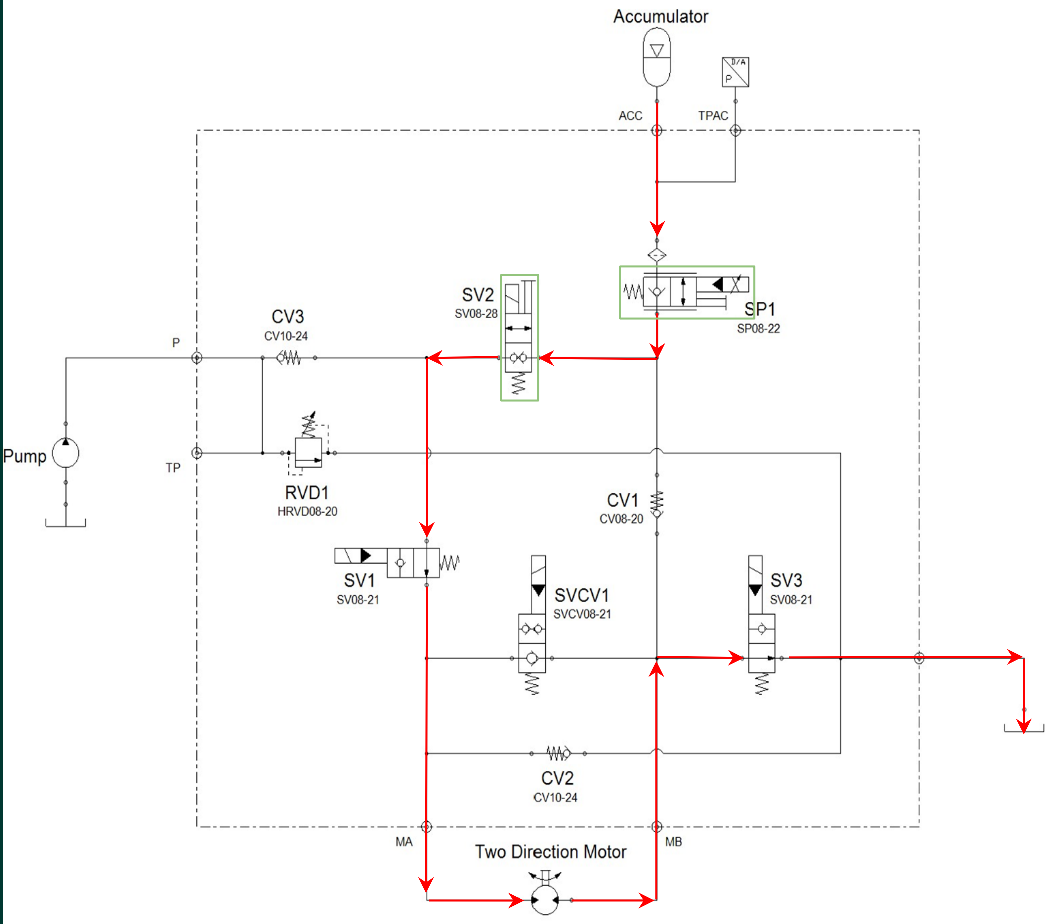
# Components

- ❑ Steelhead Composites Accumulator
  - 1 Gallon Bladder
  - 3000 psi Hydraulic Pressure
  - Light Composite, 10.8 lbs
- ❑ Hydraforce Hydraulic Manifold
- ❑ Bosch 5CC Bent Axis Pump and Motor
  - 5 lbs per unit
- ❑ Apex Dynamic Hypoid Gearbox
  - 4:1 Ratio (10:1 overall from crank to pump)



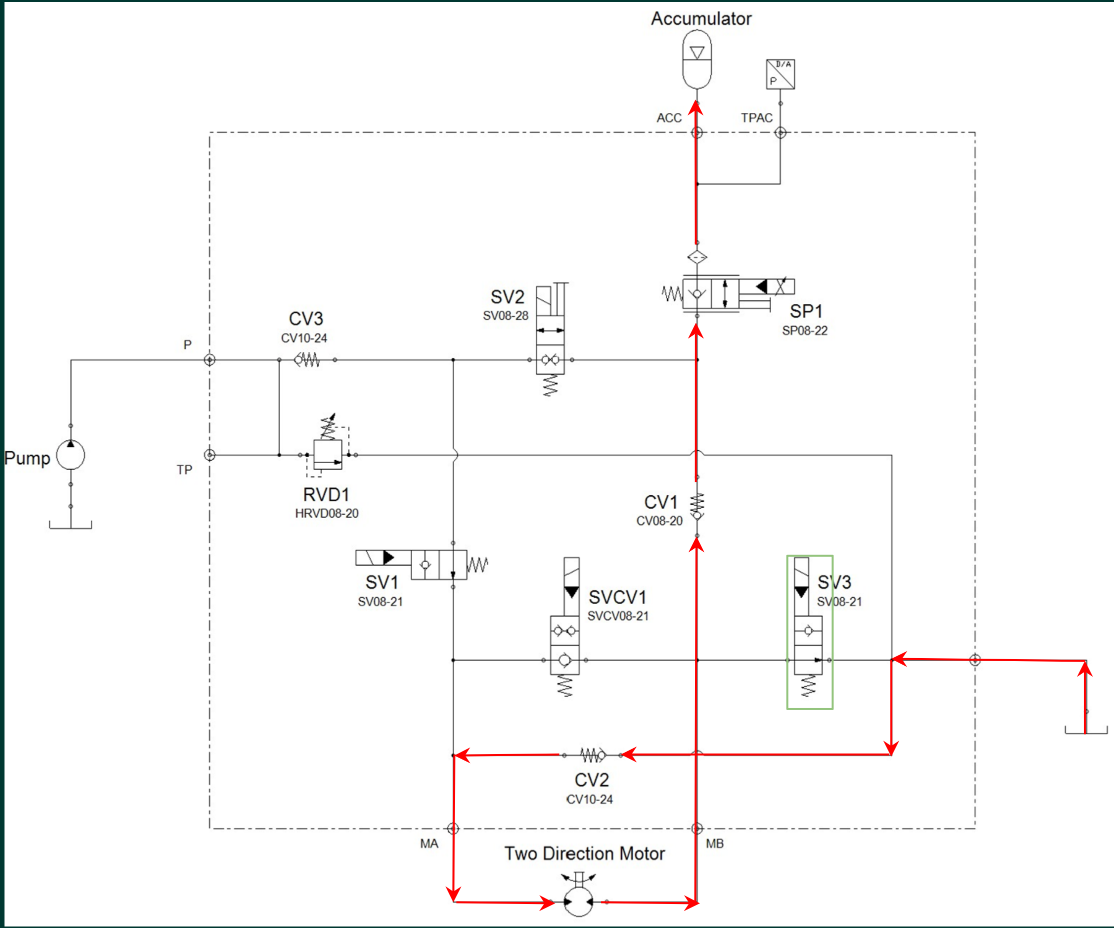



# Direct Drive

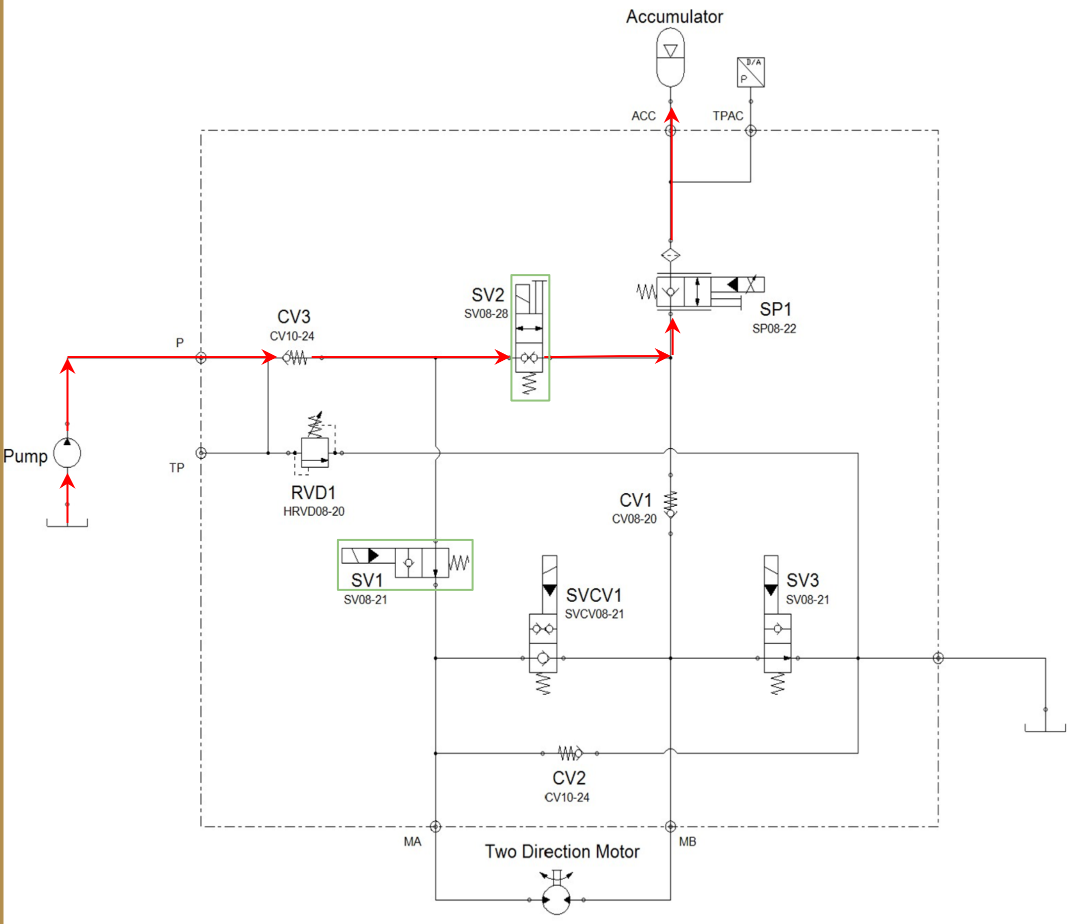


Accumulator
ACC
TPAC
SV2
SV08-28
SP1
SP08-22
CV3
CV10-24
P
Pump
TP
RVD1
HRVD08-20
CV1
CV08-20
SV1
SV08-21
SVCV1
SVCV08-21
SV3
SV08-21
CV2
CV10-24
MA
MB
Two Direction Motor


# Boost




# Regenerative Braking




# Pedal Charge

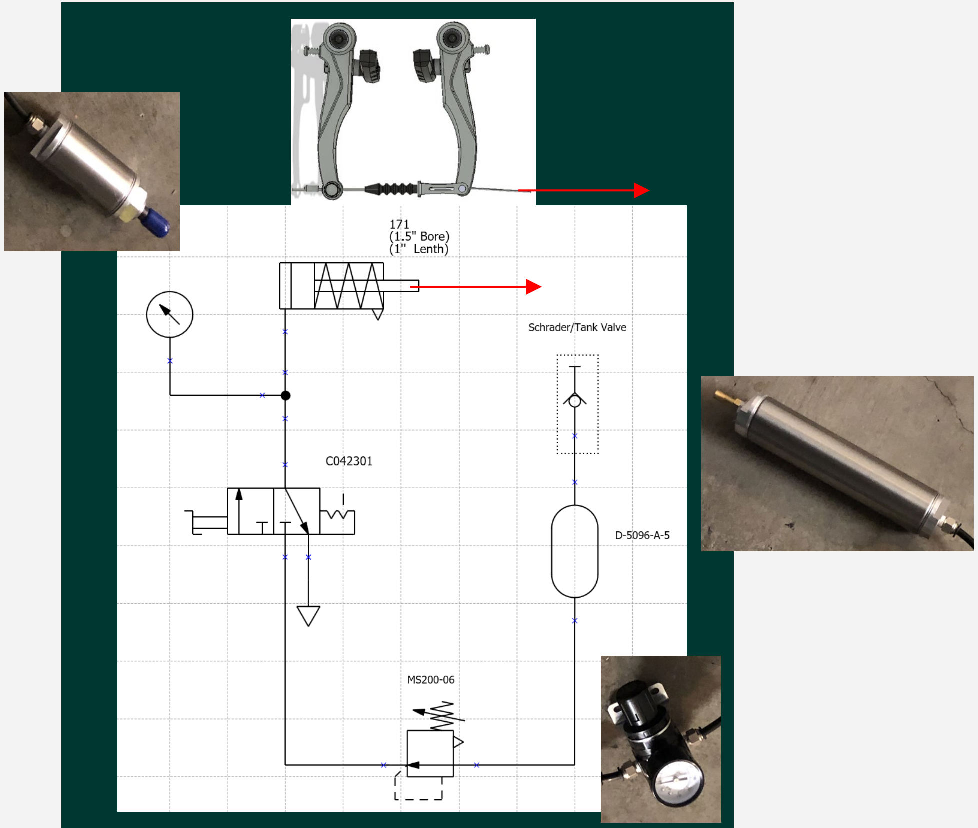
# Pneumatics

# Pneumatic Parking Brake

- ❑ Simple analog design
- ❑ Single-acting air cylinders
- ❑ Rubber pads to contact rim
- ❑ Sufficient braking force to prevent rotation at full accumulator discharge
- ❑ Calculated braking force of 32.31 lbs

$$T_{wheel} = T_{motor} * \frac{wheel\ cog\ size}{motor\ sprocket\ size}$$

$$F_{Brake} = T_{wheel} * R_{rim}$$



# Parking Brake Component Test

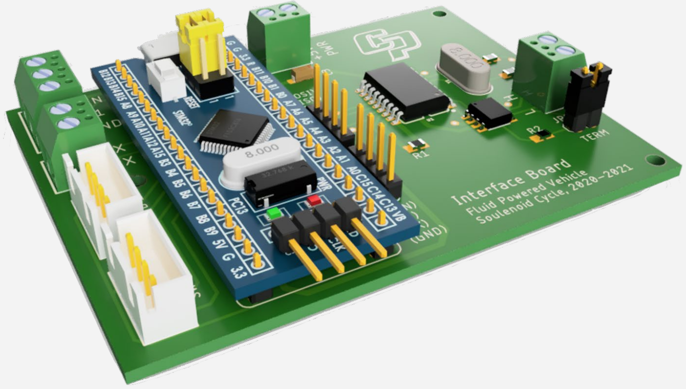
# Mechatronics

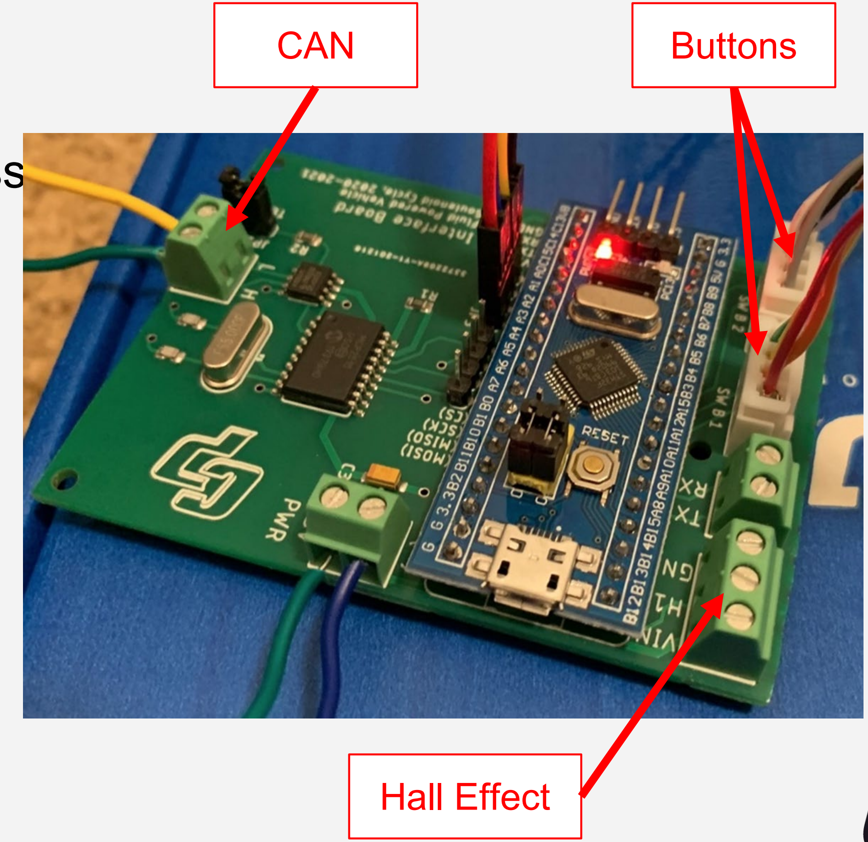
# Subsystem Goals

- ❑ Custom user interface
- ❑ Hydraforce PLC valve driver
- ❑ Data acquisition
- ❑ Network electronics over CAN bus

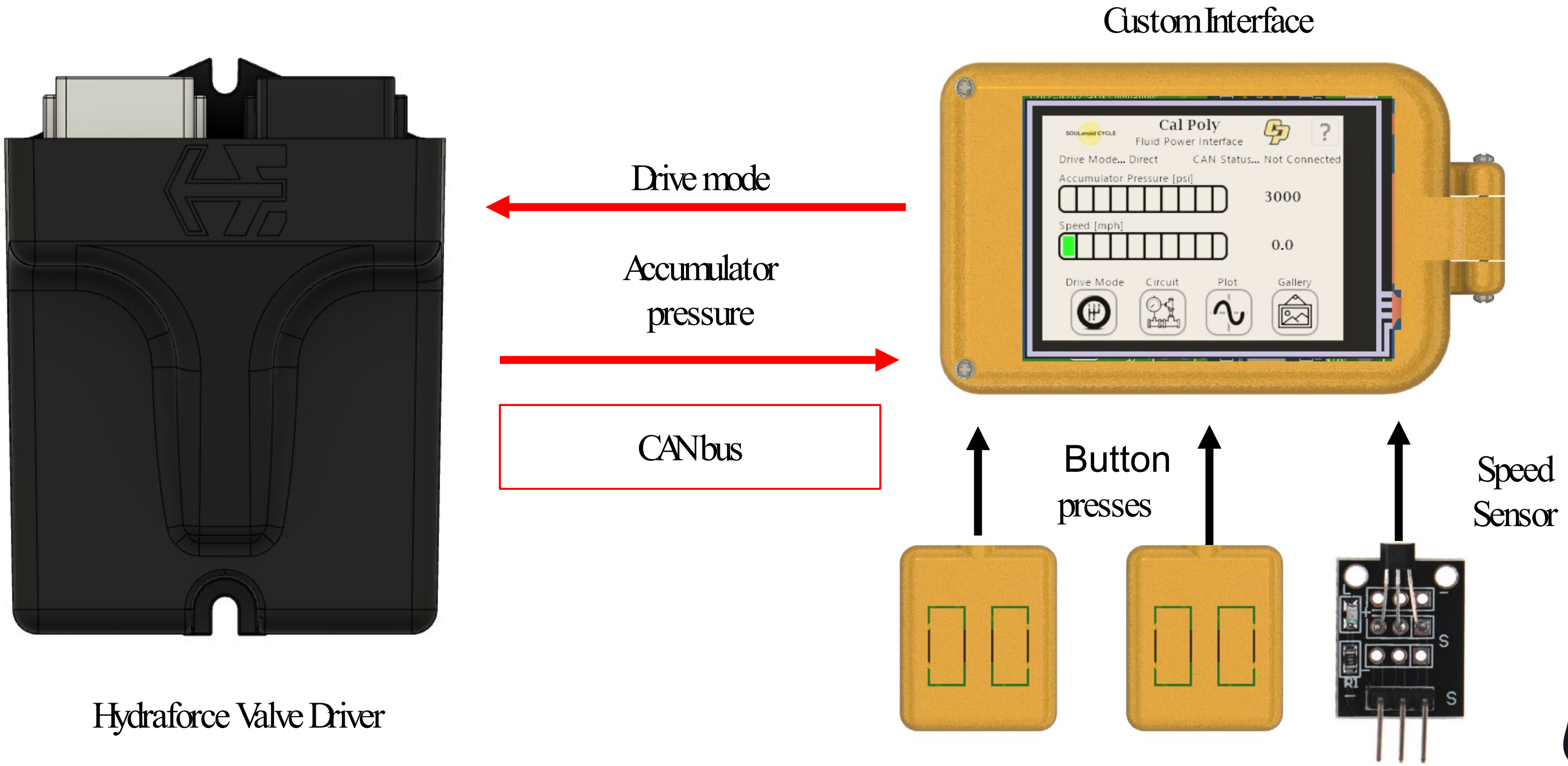
# Custom HMI

- Custom circuit board to access CAN bus
- 72 MHz microcontroller
- 2.8" touch screen



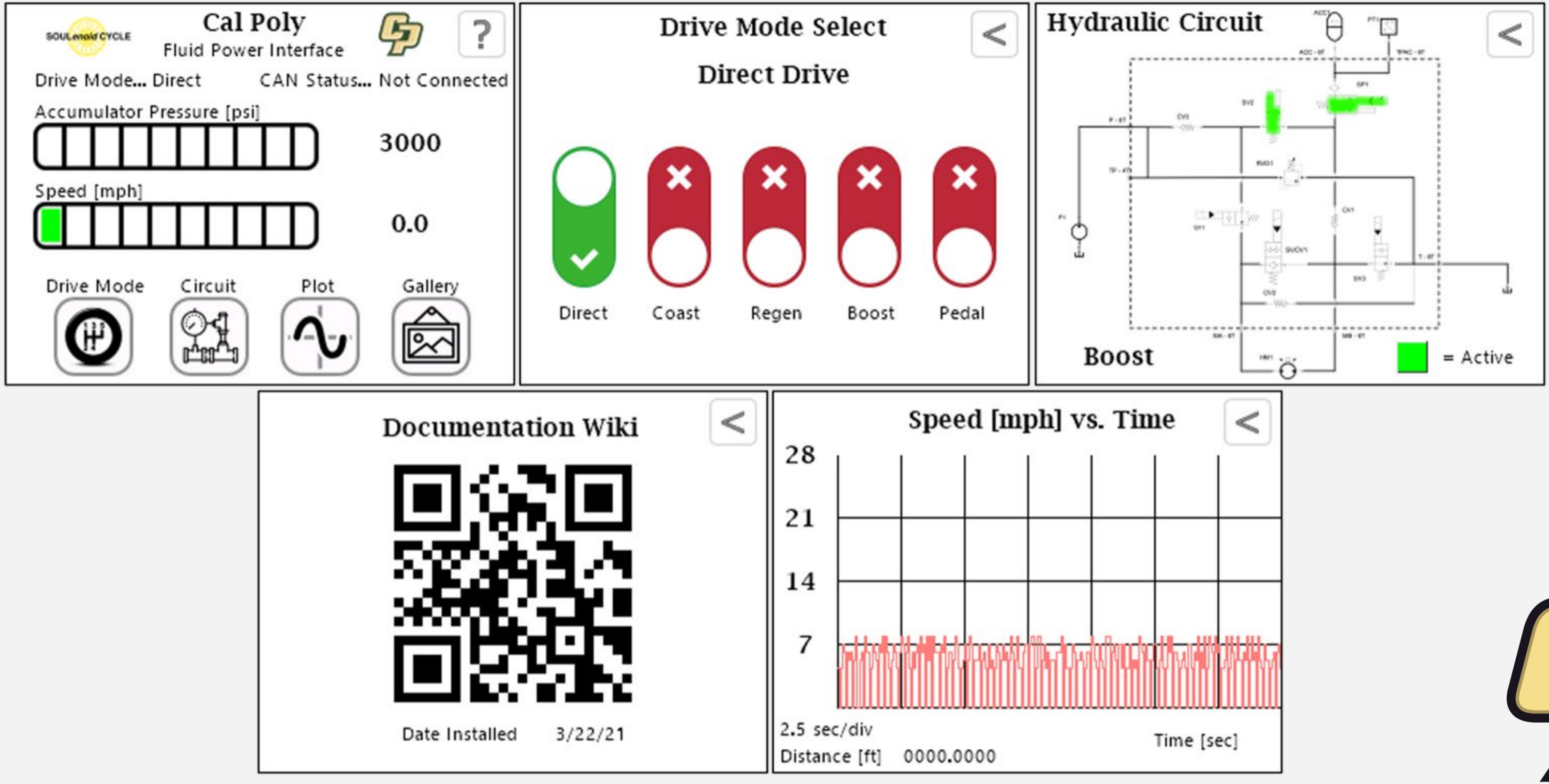
# Controller Area Network



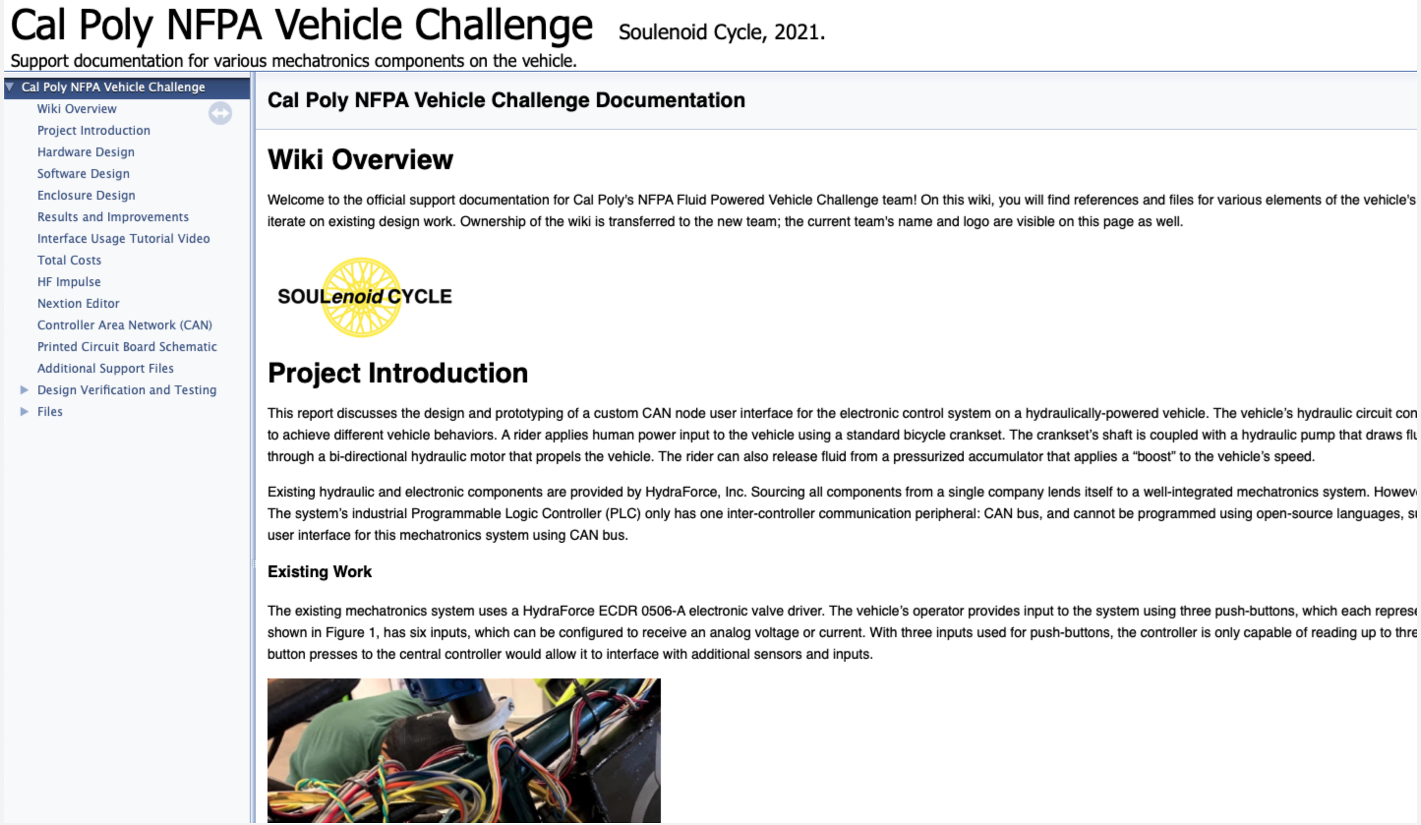
# Controller Area Network

- Multi-purpose service port:
  - Observe CAN bus
  - Program the ECDR 0506-A

# Touch Screen



# Published Documentation



# Cal Poly NFPA Vehicle Challenge Soulenoid Cycle, 2021.

Support documentation for various mechatronics components on the vehicle.



## Cal Poly NFPA Vehicle Challenge Documentation

## Wiki Overview

Welcome to the official support documentation for Cal Poly's NFPA Fluid Powered Vehicle Challenge team! On this wiki, you will find references and files for various elements of the vehicle's
iterate on existing design work. Ownership of the wiki is transferred to the new team; the current team's name and logo are visible on this page as well.

SOULenoid CYCLE

## Project Introduction

This report discusses the design and prototyping of a custom CAN node user interface for the electronic control system on a hydraulically-powered vehicle. The vehicle's hydraulic circuit con
to achieve different vehicle behaviors. A rider applies human power input to the vehicle using a standard bicycle crankset. The crankset's shaft is coupled with a hydraulic pump that draws flu
through a bi-directional hydraulic motor that propels the vehicle. The rider can also release fluid from a pressurized accumulator that applies a "boost" to the vehicle's speed.

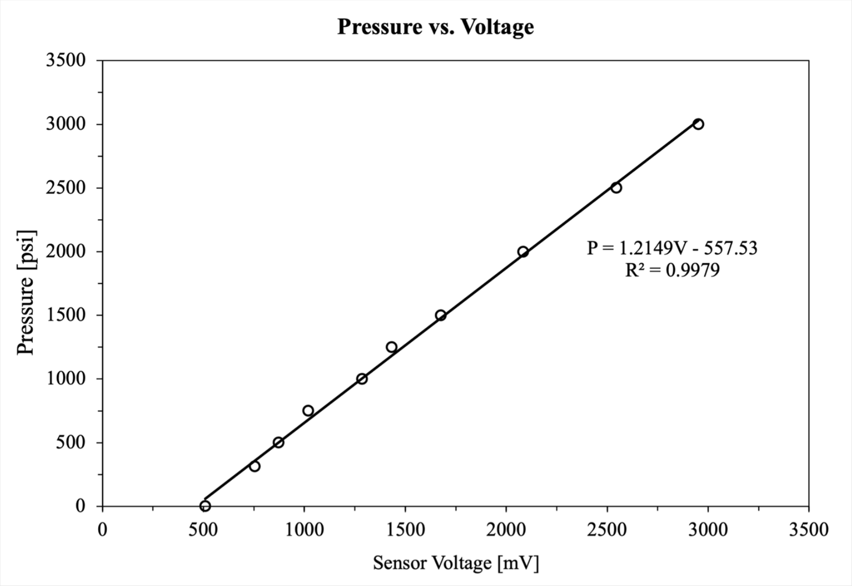
Existing hydraulic and electronic components are provided by HydraForce, Inc. Sourcing all components from a single company lends itself to a well-integrated mechatronics system. Howev
The system's industrial Programmable Logic Controller (PLC) only has one inter-controller communication peripheral: CAN bus, and cannot be programmed using open-source languages, su
user interface for this mechatronics system using CAN bus.

### Existing Work

The existing mechatronics system uses a HydraForce ECDR 0506-A electronic valve driver. The vehicle's operator provides input to the system using three push-buttons, which each represe
shown in Figure 1, has six inputs, which can be configured to receive an analog voltage or current. With three inputs used for push-buttons, the controller is only capable of reading up to thre
button presses to the central controller would allow it to interface with additional sensors and inputs.

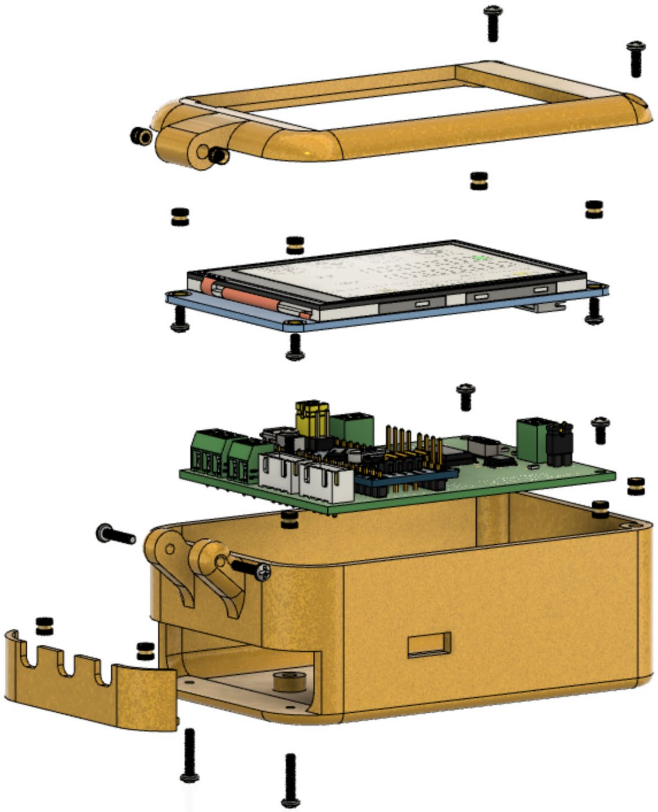
# Real-Time Measurements

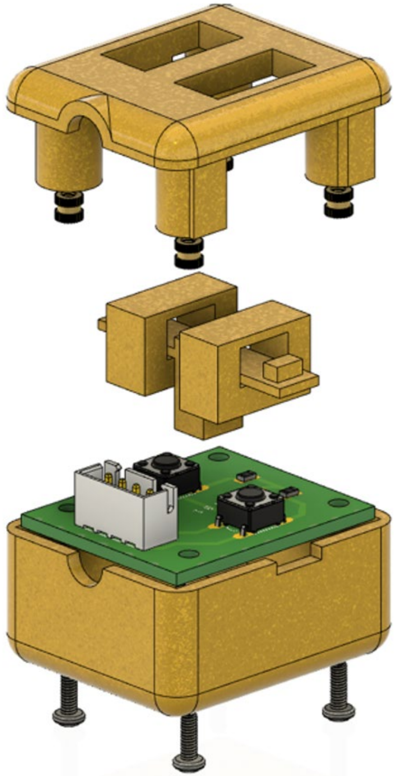
- ❑ Measure accumulator pressure to +/-50psi
- ❑ Measure vehicle speed (mph)
- ❑ Calculate human power input (hp)**
- ❑ Calculate distance traveled (ft)**



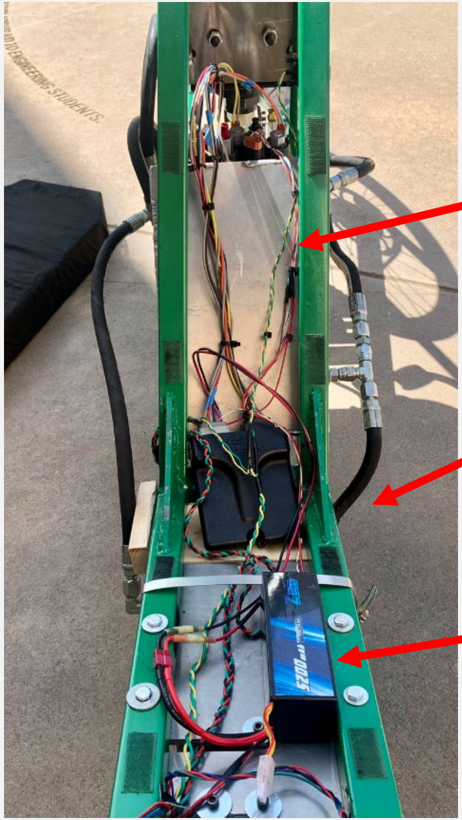

** Experimental

# 3D Printed Enclosures





# Component Placement



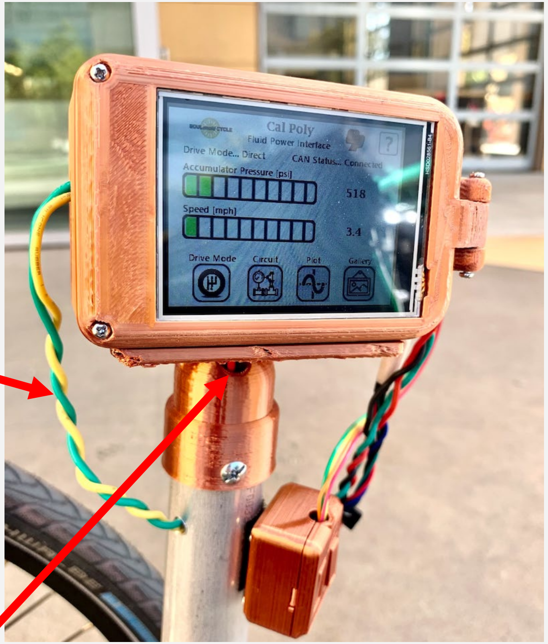
Valve wiring

Valve driver

CAN

Battery

Power lines completely concealed



# Final Vehicle & Race Resu

# Vehicle on Race Day

# Race Results

| Test | Distance (feet) | Result |
|---|---|---|
| Efficiency 1 | 1,200 | 8% |
| Efficiency 2 | 1,300 | 8% |
| Sprint 1 | 500 | 23.46 seconds |
| Sprint 2 | 500 | 22.75 seconds |
| Endurance | - | - |
| Accumulator Charge Time | - | 3:45 |
| | | |

# Lessons Learned

# Final Reflection

- Biggest Challenges
  - COVID Restrictions
  - Manufacturing Time
  - Shipping Times and Lost/Misplaced Packages
- Recommendations for Next Year's Team
  - Implement Pneumatic System
  - Switch to Hard Lines
  - Ease Direct Drive by Changing the Gear Ratio or Switching the Pump
  - Extend Length of Crankset Arm
  - Add Accumulator Dump by replacing CV1
- Lessons Learned
  - Everything Takes Longer than Anticipated
  - Ask for more help

# Questions?

# Reference Slides

# Engineering Specs

| Spec. # | Specification Description | Target Goal | Tolerance | Risk | Compliance |
|---|---|---|---|---|---|
| 1 | External Leakage | None | Max | H | I, T |
| 2 | Bike Weight | 120 lbs | Max | L | A, T, S |
| 3 | Efficiency Score | 18% | ±5% | H | T, S |
| 4 | Sprint Time | 15 sec | ±5 sec | H | T, S |
| 5 | Endurance Time | 5 min | ±1 min | M | T, S |
| 6 | Drive Mode Switch Time | 2 sec | ±1 sec | M | A, T |
| 7 | Internal Leakage | 0.5 psi/s | Max | H | I, T, S |
| 8 | Pneumatics Pressure | 100 psi | Max | M | I, T, S |
| 9 | Pinching Points | 0 | Max | M | I |
| 10 | Drag | TBD | TBD | M | A, T, S |
| 11 | Accumulator Charge Time | 10 Min | Max | H | A, T, S |
| 12 | Presentation Score | 100% | Max | H | T, S |
| 13 | NEMA Rating | Type 4 | Max | M | I, S |
| 14 | Measurement Accuracy | 2% | Min | M | A, T |
| 15 | Durability | TBD | TBD | H | A, I, S |

# FMEA

| System / Function | Potential Failure Mode | Potential Effects of the Failure Mode | Severity | Potential Causes of the Failure Mode | Current Preventative Activities | Occurrence | Current Detection Activities | Detection | RPN |
|---|---|---|---|---|---|---|---|---|---|
| Frame / Stability | Bike, components, or rider tip or fall while riding | a) Injure rider<br><br>b) Break or damage components | 10 | 1) Steering difficulties<br>2) Rider cannot control the drive mode<br>3) Unbalanced weight distribution of rider/components | 1) Iterate on steering angles<br>2) Default coast mode<br>3) Model to confirm overall weight balance | 3 | Testing done by rider | 3 | 90 |
| Hydraulics / Fluid Movement | Fluid losses or internal leakages | a) Safety concerns for rider.<br><br>b) Poor performance in challenges | 5 | 1) Too many fittings<br>2) Broken connections<br>3) Line length or surface roughness too large | 1) Fluid analysis with hand calculations and modeling<br>2) Performance testing<br>3) Safety checks before every ride | 8 | Testing comparison to calculations and models & component checks | 4 | 160 |
| Mechatronics / Fluid Coordination | No response or late response from electronics system | a) Unable to move or control bike<br><br>b) Cannot use fluid power system<br><br>c) Unable to switch drive modes<br><br>d) Increase in racing ti | 5 | 1) Damage to electronic circuit<br>2) Latency issues<br>3) Sensors unresponsive | 1) Electronic components either sheilded beneath seat or in a protective enclosure<br>2) PCB design analysis | 2 | Mechatronics circuit design to be checked and tested | 2 | 20 |

# Additional Frame Info

# Why design a new frame?

# Explored Options

Prone Bike


Velomobile

Elliptical Bike


Upright Standard Bike

Recumbent Vehicle

# Frame Concept Selection Decision Matrix

| Criteria | Weight (1-11) | Frame Concept | | | |
|---|---|---|---|---|---|
| | | Current Frame | New Single Track Frame | Recumbent Frame | Elliptical Frame |
| Safety | 11 | Datum | 0 | 11 | 11 |
| Cost | 1 | | -1 | -1 | -1 |
| Durability | 6 | | 6 | 6 | -6 |
| Weight | 10 | | 10 | -10 | -10 |
| Manufacturability | 9 | | -9 | -9 | -9 |
| Ergonomics | 3 | | 0 | 3 | 3 |
| Human-Power Efficiency | 8 | | 0 | 8 | -8 |
| Size/Shipping Ease | 2 | | 0 | -2 | -2 |
| Steering | 5 | | 0 | -5 | -5 |
| Aerodynamics | 4 | | 0 | 4 | -4 |
| Creative/New Features | 7 | | 0 | 7 | 7 |
| Total | | | 6 | 12 | -24 |

# Frame Selection - Recumbent Design

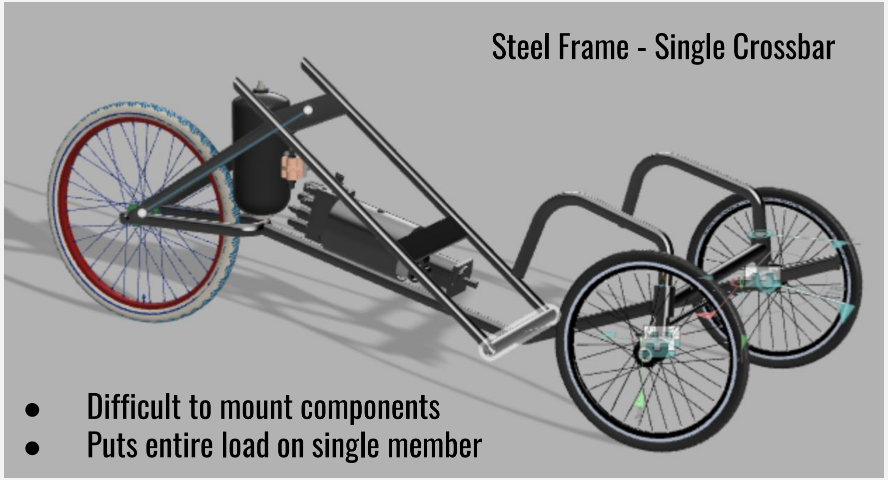
**Delta Trike** (1 front wheel, 2 back wheels)

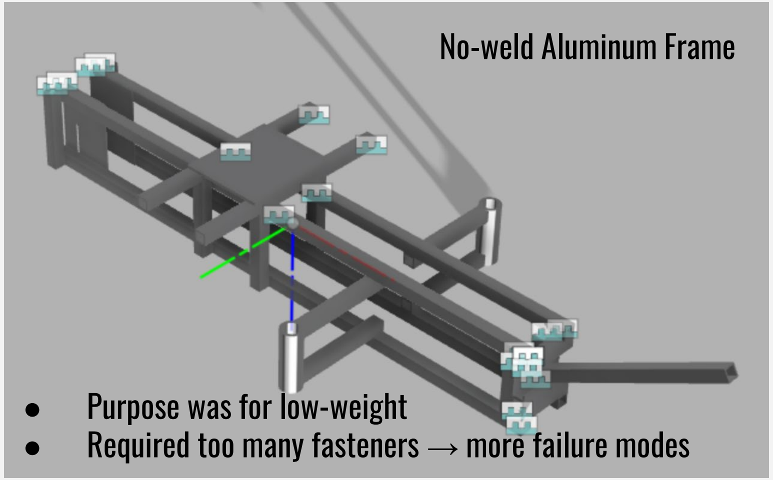
- ❑ Only 1 back wheel is powered - unbalanced torque
- ❑ Over Seat Steering (OSS)
- ❑ Easier to get into & more familiar for the rider
- ❑ More common in the competition

**Tadpole Trike** (2 front wheels, 1 back wheel)

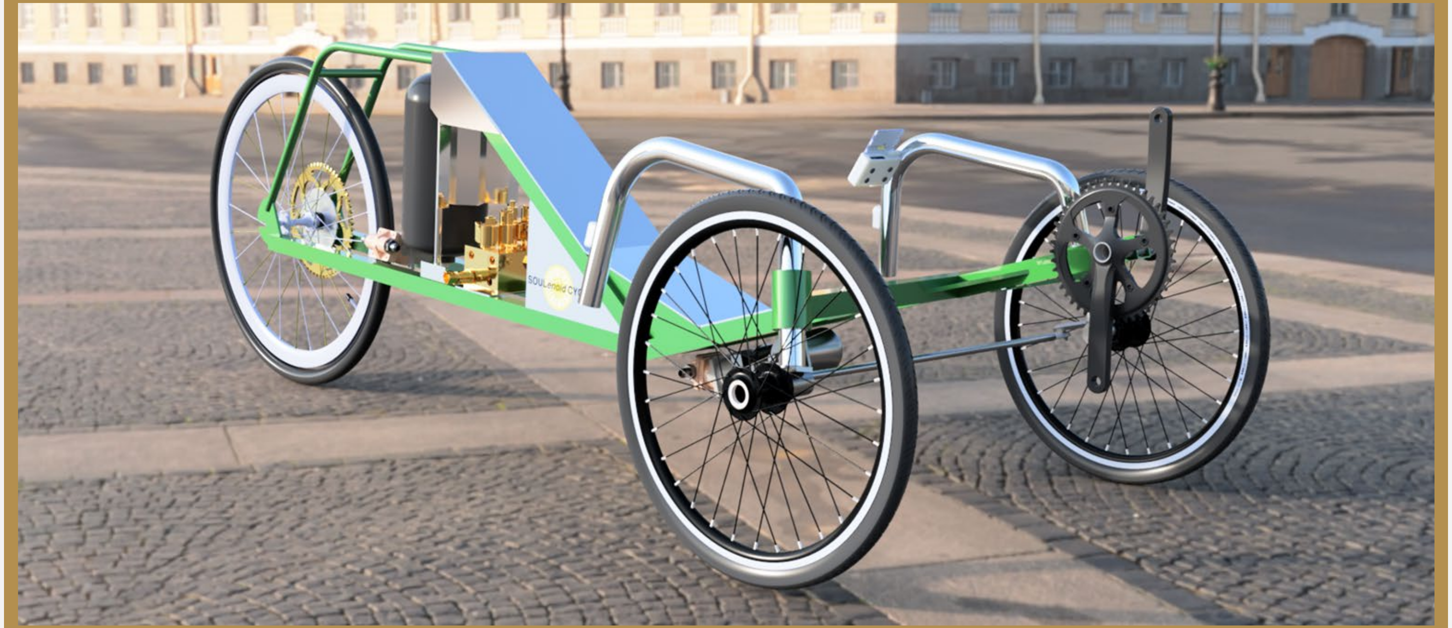
- ❑ The back wheel is powered
- ❑ Front wheels for steering - more complex
- ❑ Typically faster & lighter than delta trikes
- ❑ Hydraulic component placement is easier

# Recumbent Frame Design



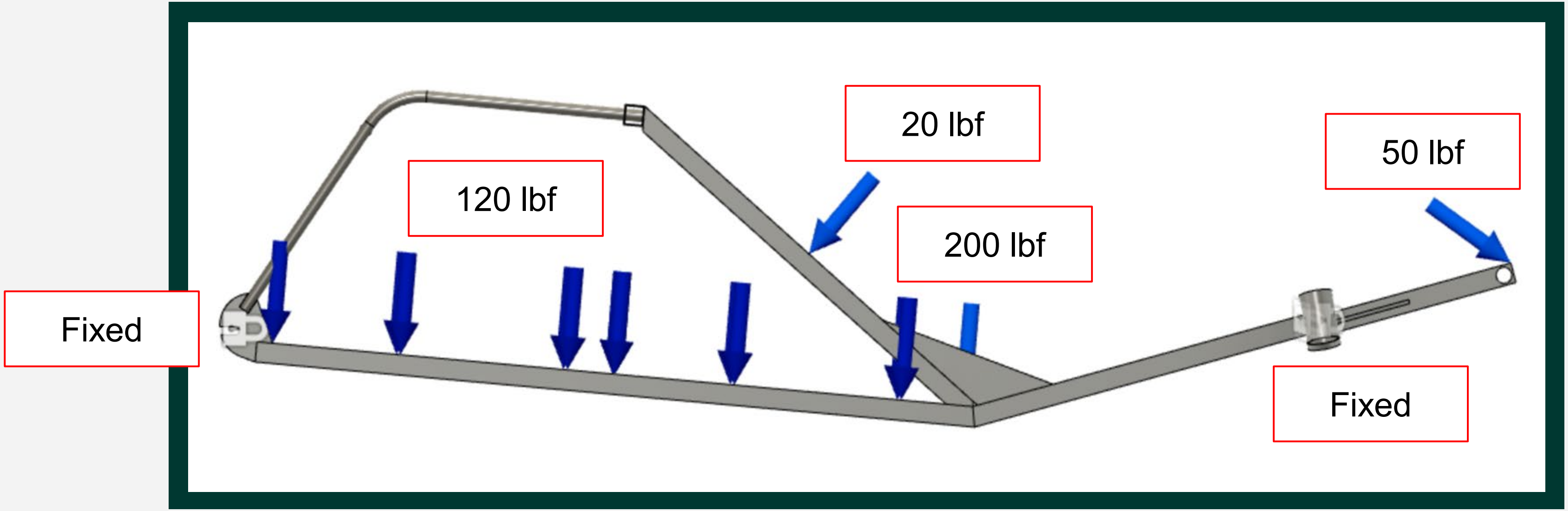




# Recumbent Tadpole Tricycle Design



Vehicle Render

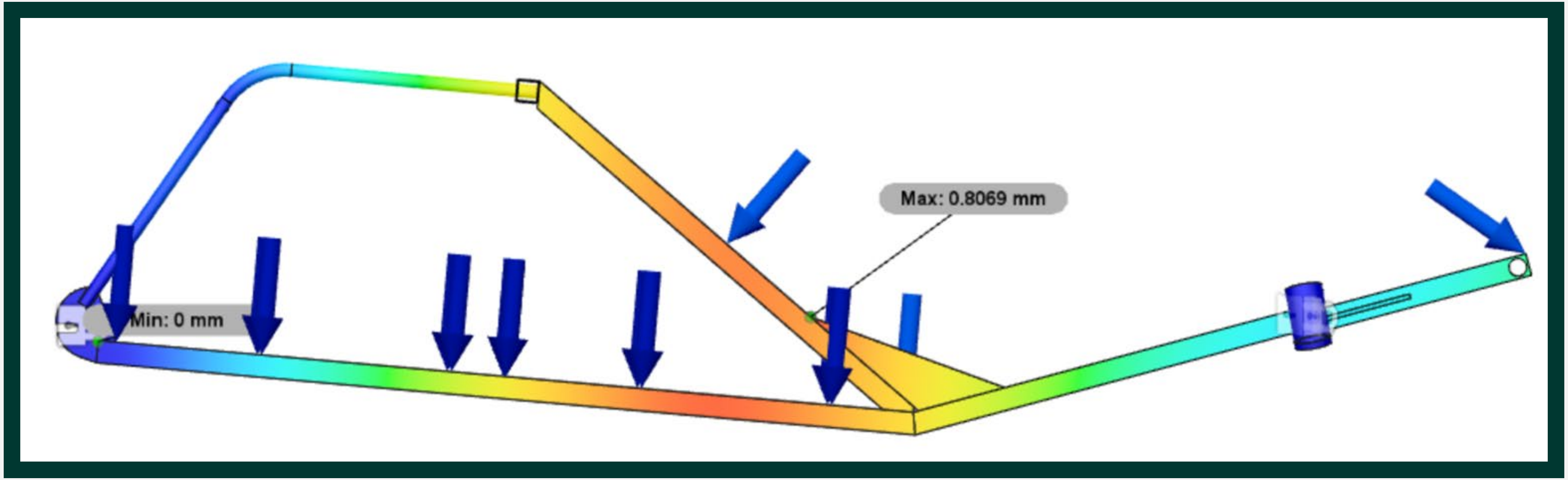
# Structural Loading




Applied loads inspired by University of Denver, Cleveland State University, and Purdue University

# Structural Loading

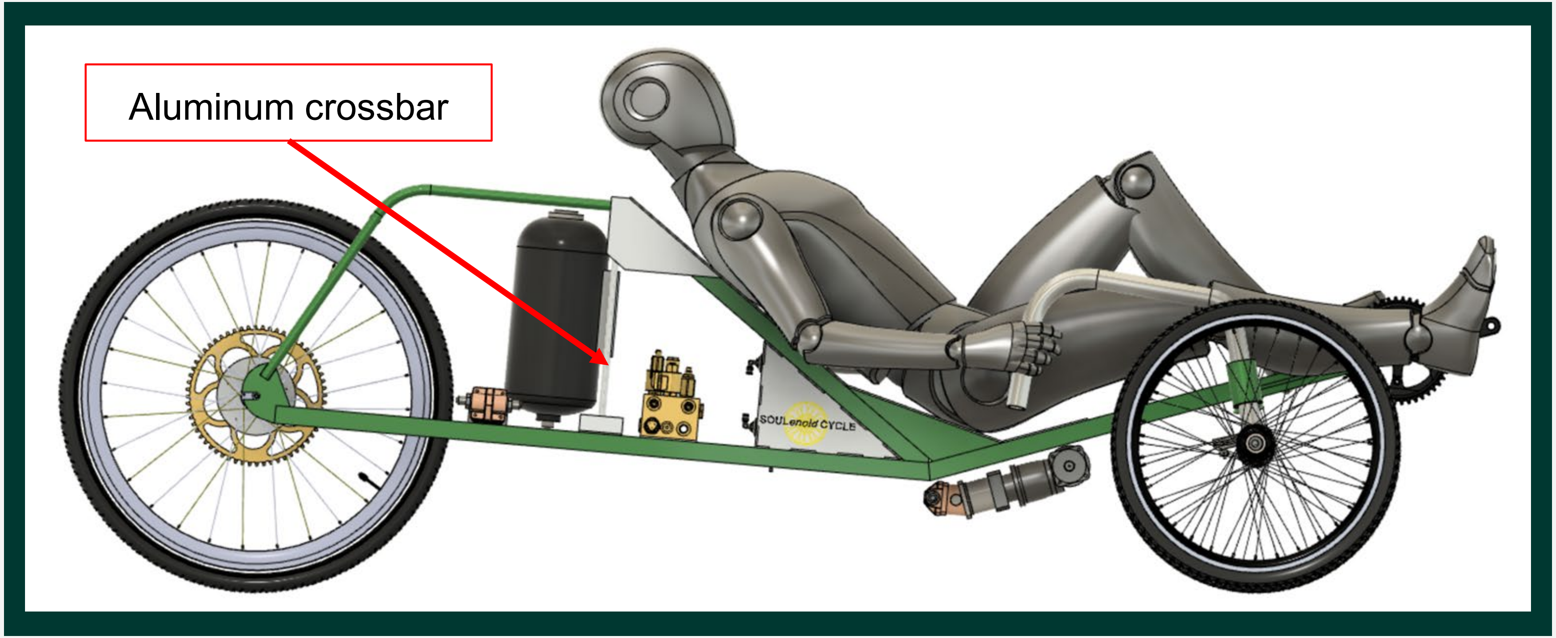
- Static FOS of 3.0




Static loading FEA results, displaying displacement.

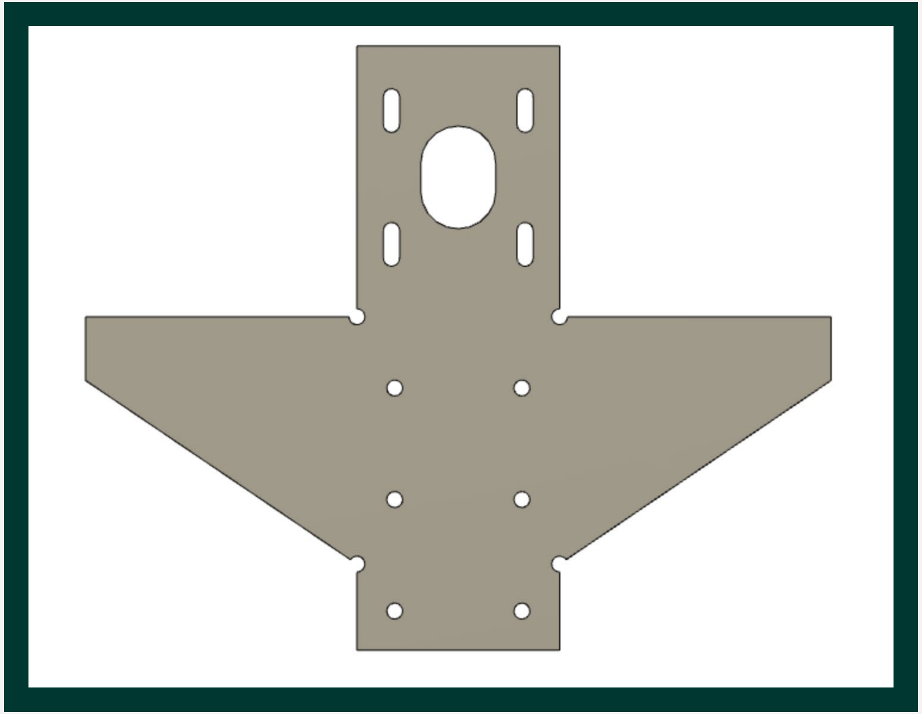
# Structural Loading

The reservoir, and the aluminum mountings for the accumulator provide additional frame support



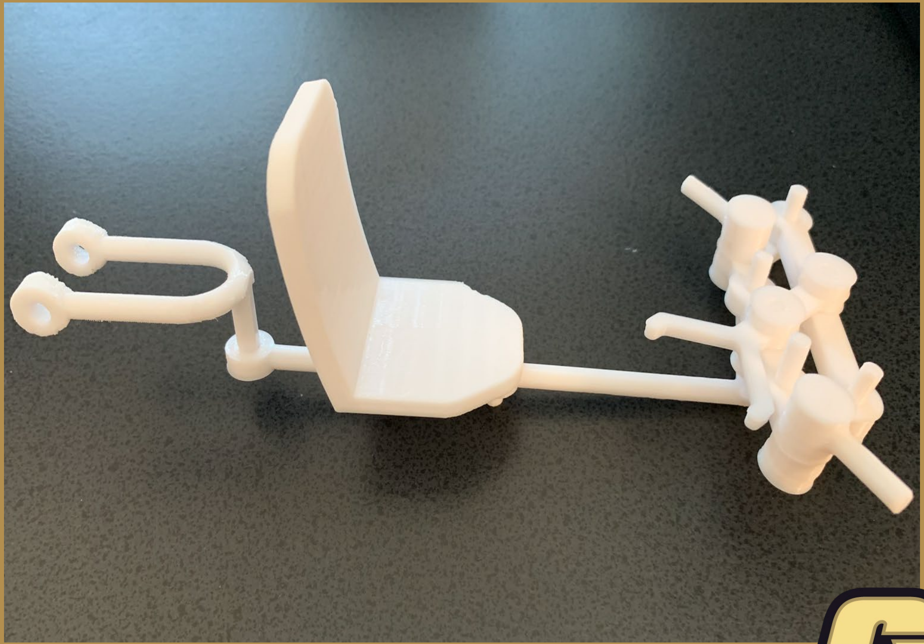
# Motor Mount

- Sheet metal Aluminum 6061
- 0.08” thickness
- Corner relief



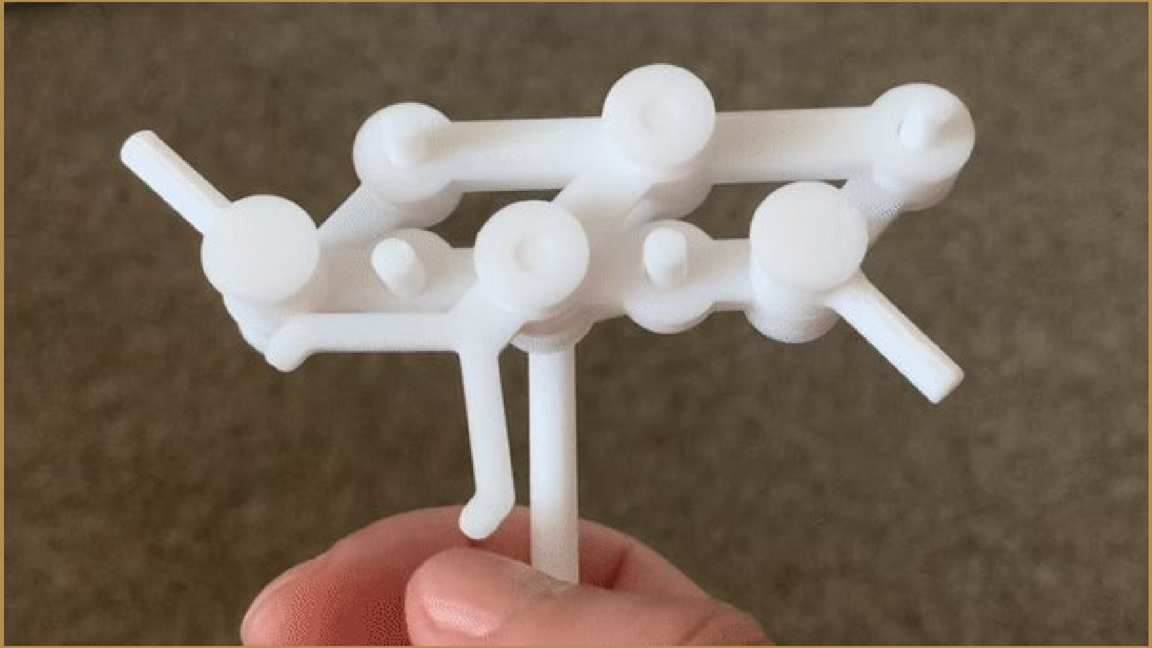
# Frame Prototyping

Delta Trike Prototype



Tadpole Trike Prototype

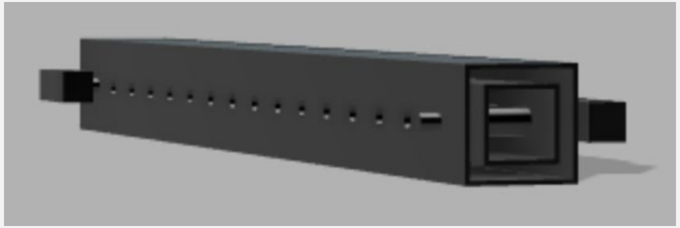
# Tadpole Steering Mechanism Prototype

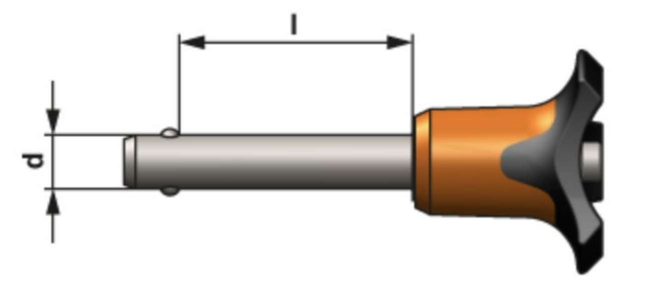


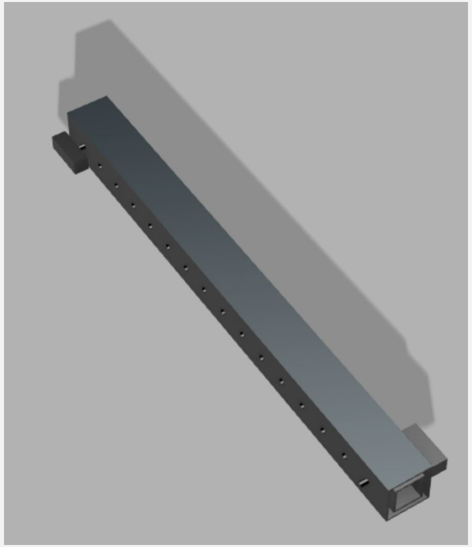
Steering Linkage

# Adjustable Pedal Distance

- Bike is adaptable for people between the heights of 4.5ft and 6.5ft
- Seat is stationary → pedal distance should be alterable by 1ft
- A lot of force is put on the pedals → extension must be strong with minimal deflection
- Nested tubes with self-locking pins





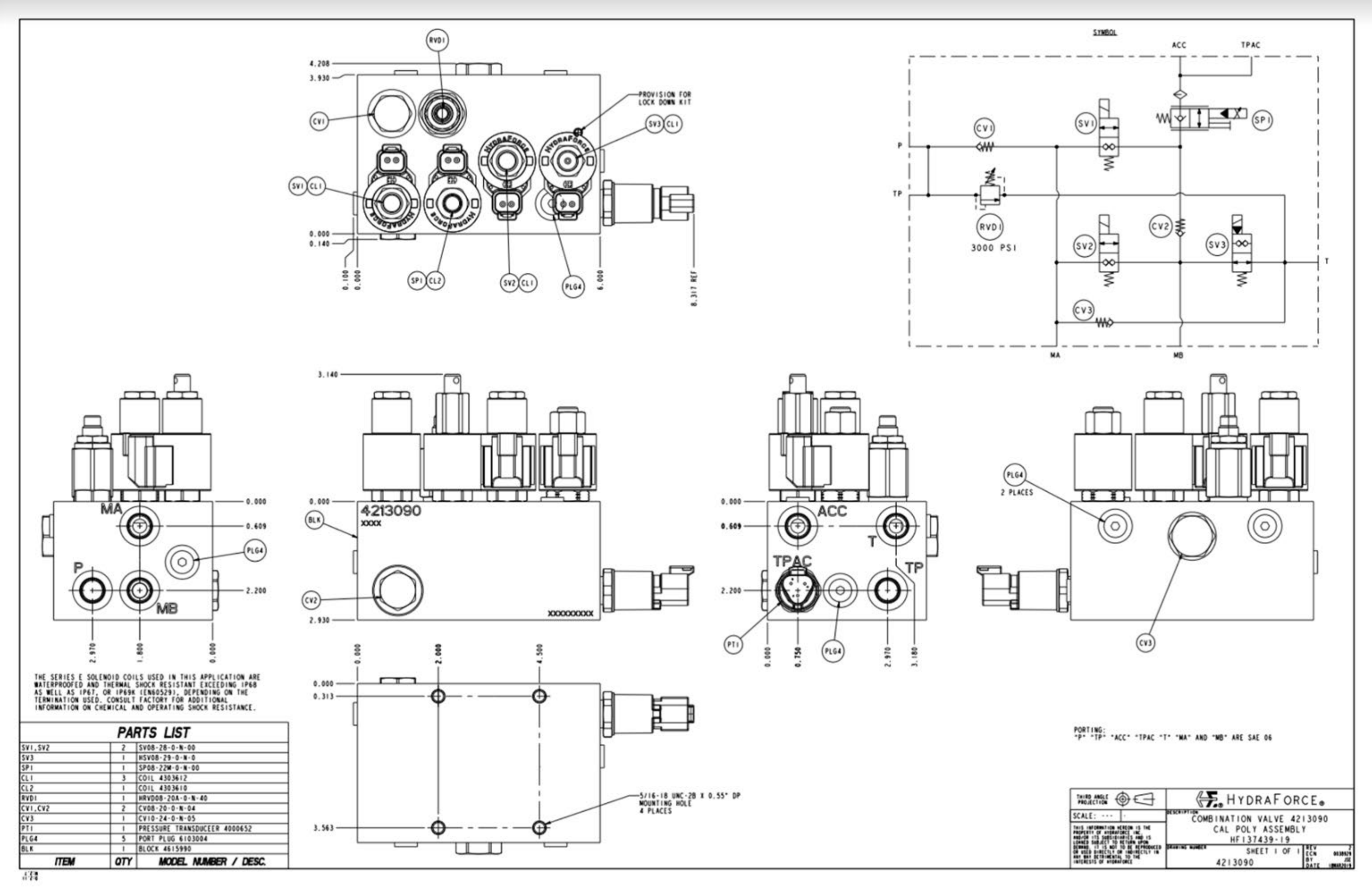
# Ergonomics

- Height of 4.5’ -> Leg Height of 2.25’ -> Lower Leg Height of 1.125’
  - At a bend angle of 30, cos(30) = distance/lower leg height(1.125) -> distance ~ 1’
  - Minimum Distance from seat to pedals of 2’
- Height of 6.5’ -> Leg Height of 3.25’ -> Lower Leg Height of 1.625’
  - At a bend angle of 30, cos(30) = distance/lower leg height(1.625) -> distance ~ 1.4’
  - Maximum Distance from seat to pedals of 2.8’
- 2.8’-2’ = 0.8’ of adjustable movement ~10 inches

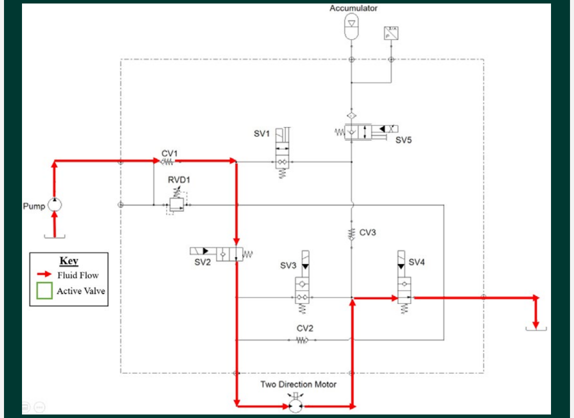
# Additional Hydraulics And

# Pneumatics Info

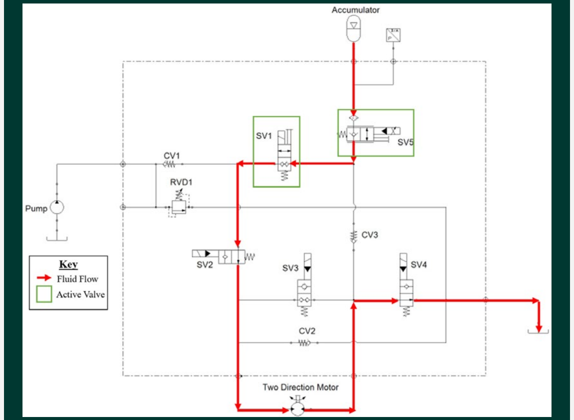
# Manifold Drawing



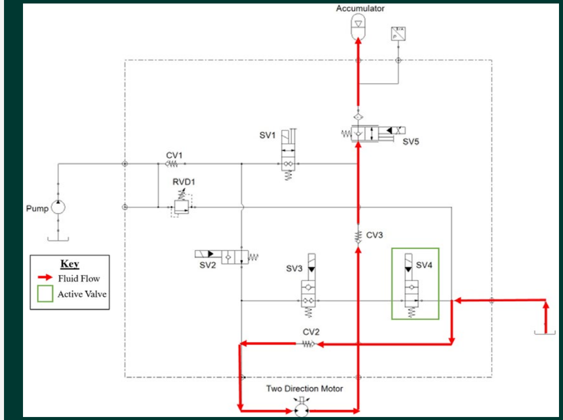
# Required Drive Modes




Direct Drive

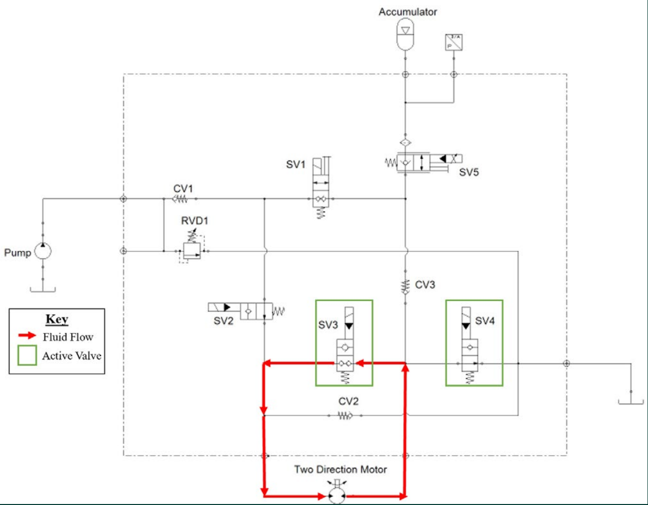



Boost

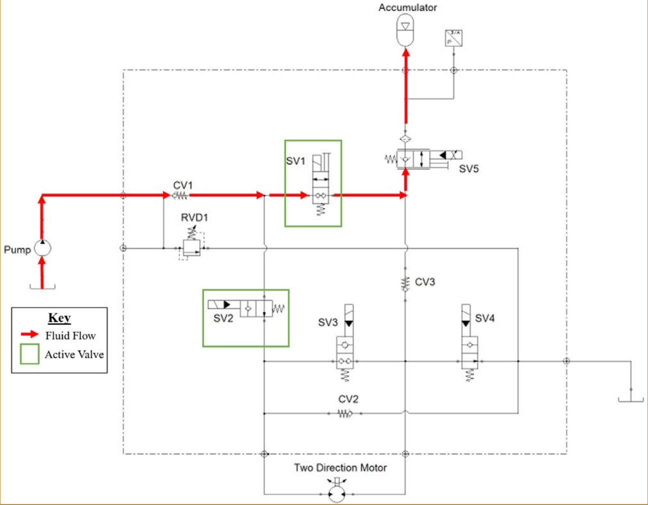



Regenerative Braking

# Additional Drive Modes



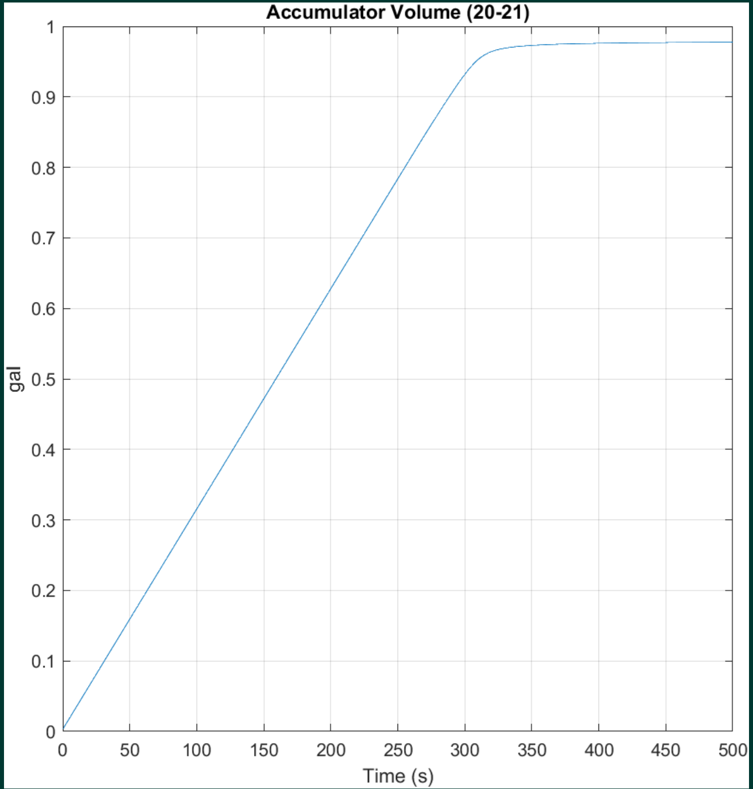

Coast




Pedal Charge

# Accumulator Recharge

- ❑ Accumulator Recharge Model
- ❑ Model: 5.2 minutes

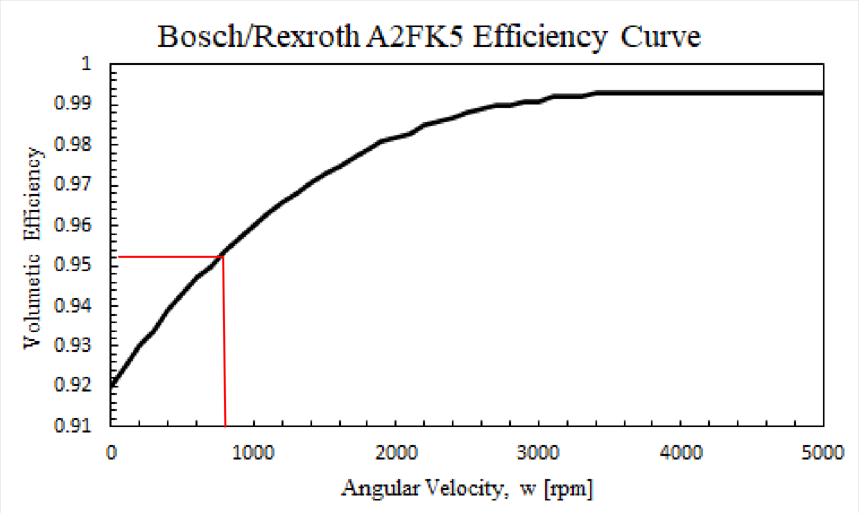


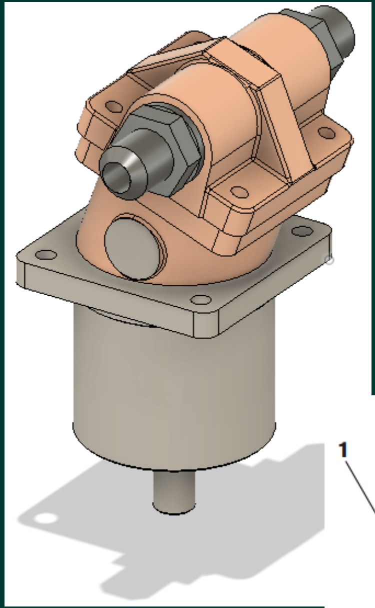
# Accumulator

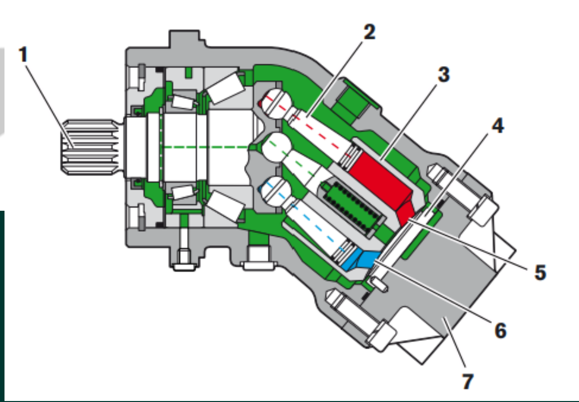
- ❑ Steelhead Composites Accumulator
  - 1 Gallon Bladder
  - 3000 psi Hydraulic Pressure
  - 500 psi pre-charge Gas Pressure
  - Light Composite, 10.8 lbs

# Pump & Motor

- Bosch/Rexroth A2FK5 Bent Axis
  - 5 CC Fixed Displacement
  - 5 pounds Aluminum Body

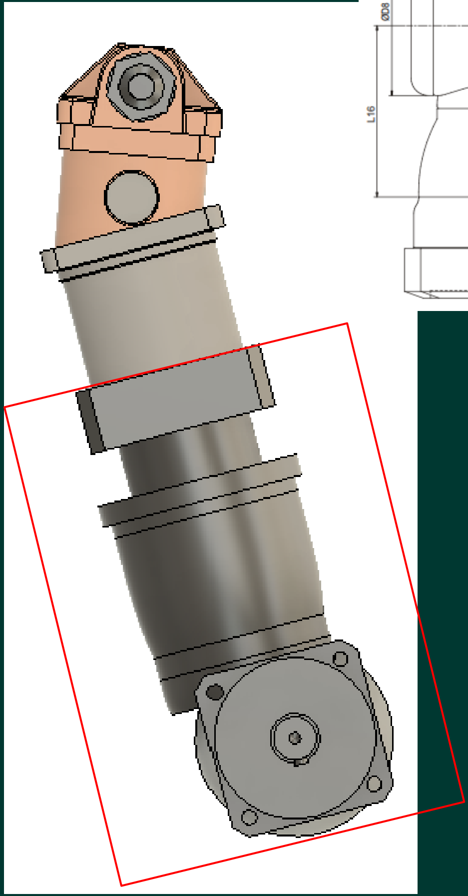


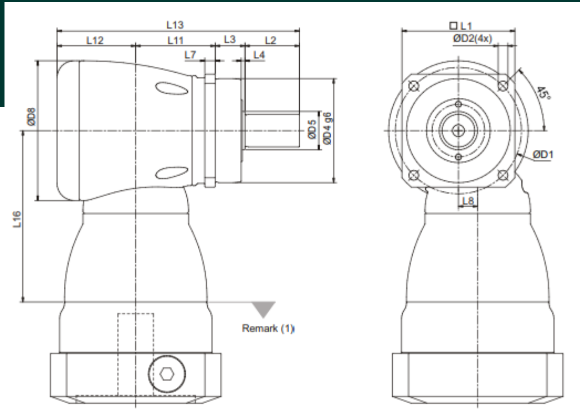





# Front Gearbox

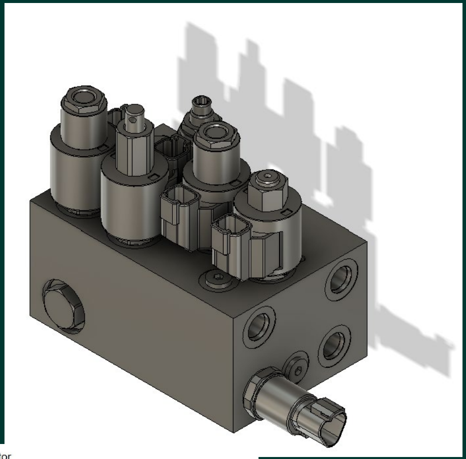
- Apex Dynamics KF Series
- 4:1 Gearbox attached to Pump
- Total front ratio from crank to pump at 10:1
- Needed to better meet operating range for pump (~800 RPM)

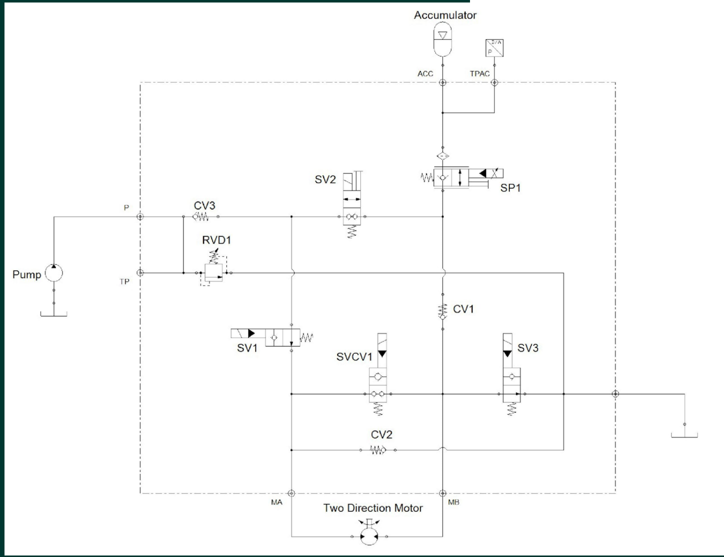




# Manifold

- ❑ Hydraforce Custom Manifold
    - Controls hydraulic fluid flow
    - Reduces number and lengths of hydraulic lines
    - Pressure Losses through valves are flow dependent.





# Implementation of Hard Lines, Sizing

- Hardlines are measured by O.D.
- Fluid Speed should not exceed:
  - Pump Inlet/Suction: 4 ft/s
  - Main Line: 20 ft/s
  - Return: 10 ft/s
- Used previous estimates of pump flow rate at 800 rpm:
  - 1.5 gpm

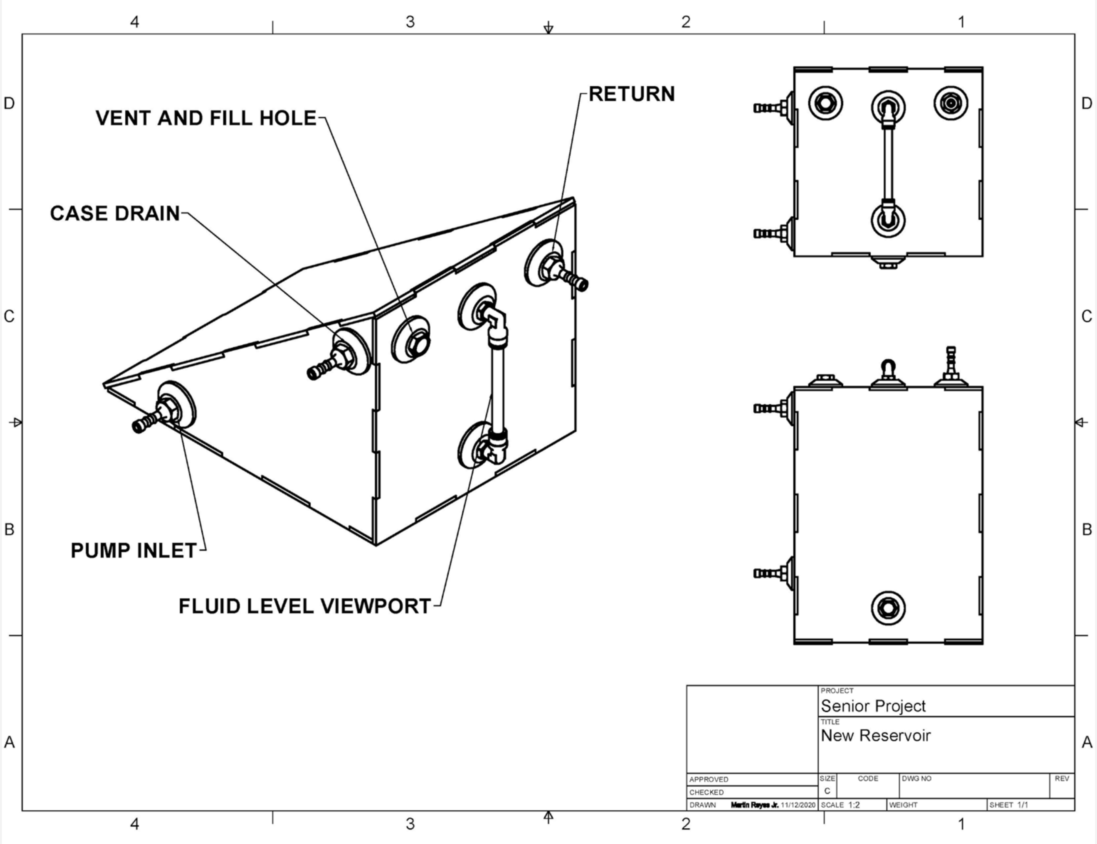
$$D = 0.64\sqrt{\frac{Q\,[gpm]}{V\,[\frac{ft}{s}]}}$$

| INPUT | |
|---|---|
| Q [GPM] | 1.5 |
| V [ft/s] | 4.0 |
| | |
| I.D. TUBE SIZE | |
| D [in] | 0.39 |
| | 1/2 |
| FOS | 1.28 |

| INPUT | |
|---|---|
| Q [GPM] | 1.5 |
| V [ft/s] | 20.0 |
| | |
| I.D. TUBE SIZE | |
| D [in] | 0.18 |
| | 1/4 |
| FOS | 1.43 |

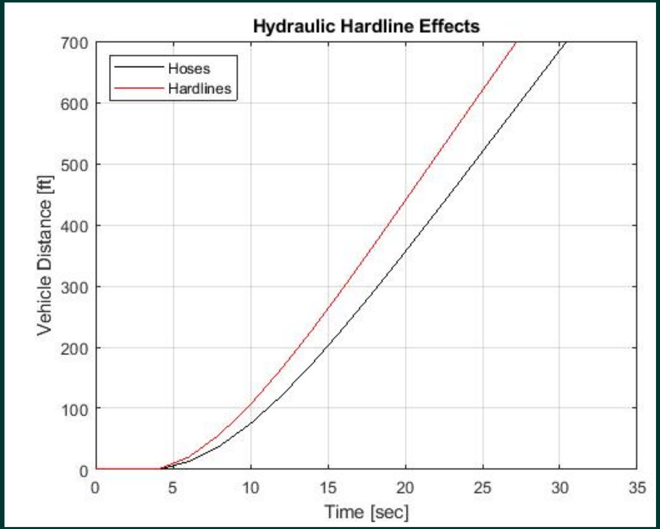
| INPUT | |
|---|---|
| Q [GPM] | 1.5 |
| V [ft/s] | 10.0 |
| | |
| I.D. TUBE SIZE | |
| D [in] | 0.25 |
| | 1/4 |
| FOS | 1.01 |

# Reservoir Drawing



# Hydraulic Lines

- Planned implementation of hardlines
  - Less Weight, Minimize bends and line length, No cross section line expansion, Require more planning and manufacturing
  - Model Prediction of +11% in sprint time
- With the relocation of components, we reduced the length of hydraulic hoses by 2 feet
  - Recommended improvement for next year's team



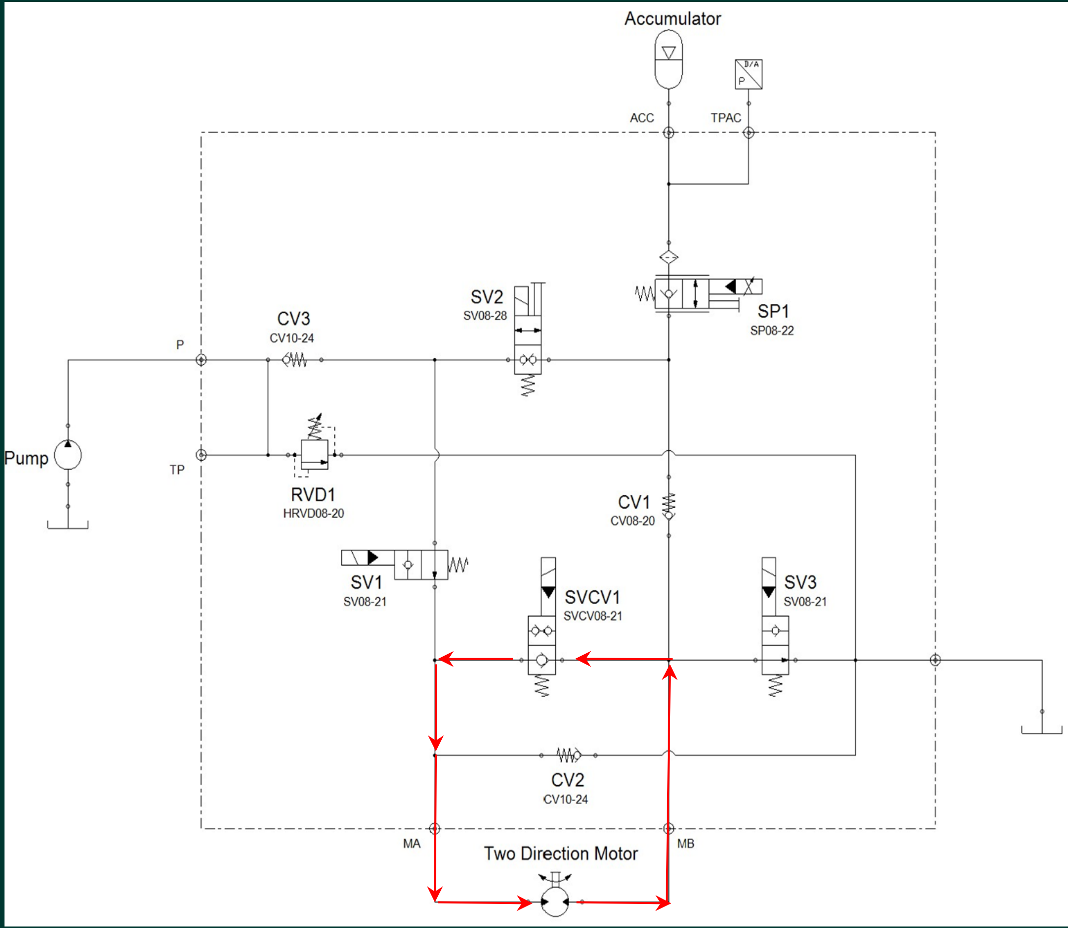

# Horsepower Calculation

$$q_v = \frac{V_g \bullet n \bullet \eta_v}{1000} \quad [\text{L/min}]$$

$$P = \frac{2\pi \bullet T \bullet n}{60000} = \frac{q_v \bullet \Delta p}{600 \bullet \eta_t} \quad [\text{kW}]$$

$V_g$ = Displacement per revolution in $cm^3$
$\Delta p$ = Differential pressure in bar
$n$ = Speed in rpm
$\eta_v$ = Volumetric efficiency
$\eta_{mh}$ = Mechanical-hydraulic efficiency
$\eta_t$ = Total efficiency ($\eta_t = \eta_v \bullet \eta_{mh}$)

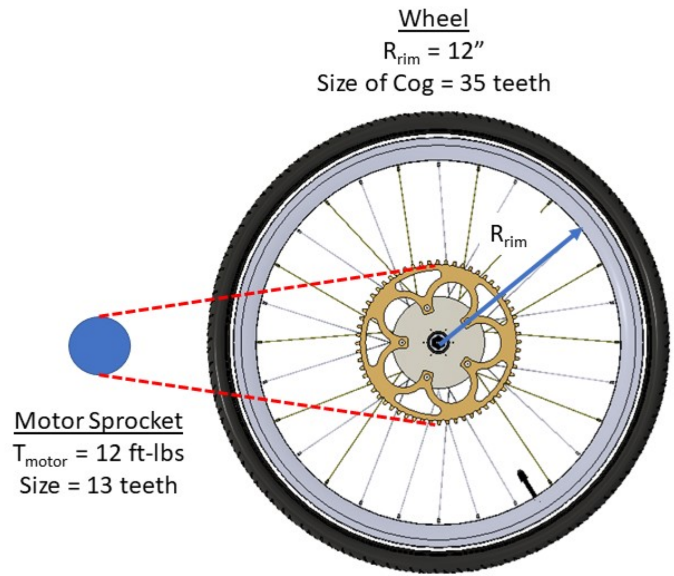
- Function of Flowrate and Pressure.
- Used vehicle speed to get motor speed through tire and cog ratios.



Accumulator
ACC
TPAC
SV2
SV08-28
SP1
SP08-22
CV3
CV10-24
P
Pump
TP
RVD1
HRVD08-20
CV1
CV08-20
SV1
SV08-21
SVCV1
SVCV08-21
SV3
SV08-21
CV2
CV10-24
MA
MB
Two Direction Motor


# Coast

# Braking Force Required




$$T_{wheel} = T_{motor} * \frac{wheel\ cog\ size}{motor\ sprocket\ size}$$

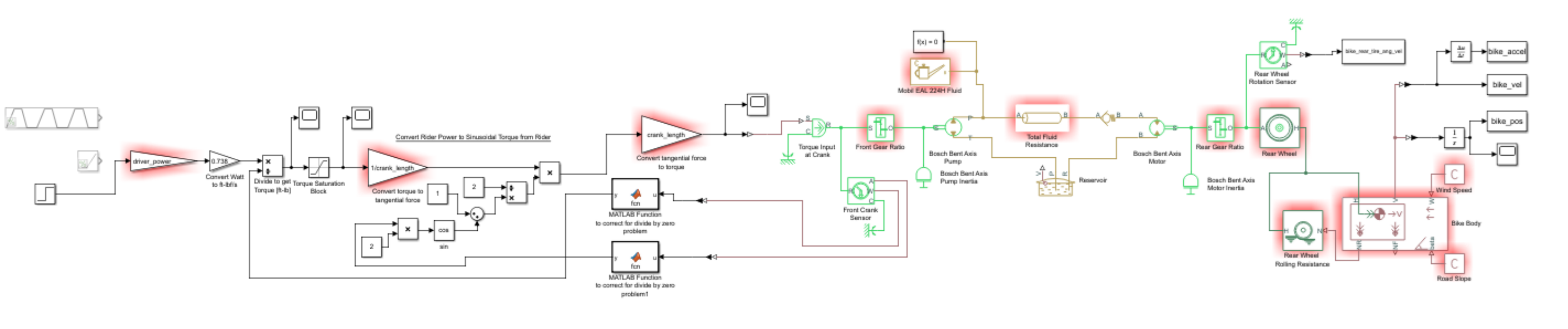
$$T_{wheel} = 12\ ft - lb * \frac{35}{13}$$

$$T_{wheel} = 32.31\ ft - lb$$

$$F_{Brake} = T_{wheel} * R_{rim}$$

$$F_{Brake} = (32.31\ ft - lb)\left(\frac{12}{12}\right) ft$$

$$\boxed{\boldsymbol{F_{Brake} = 32.31\ lb}}$$



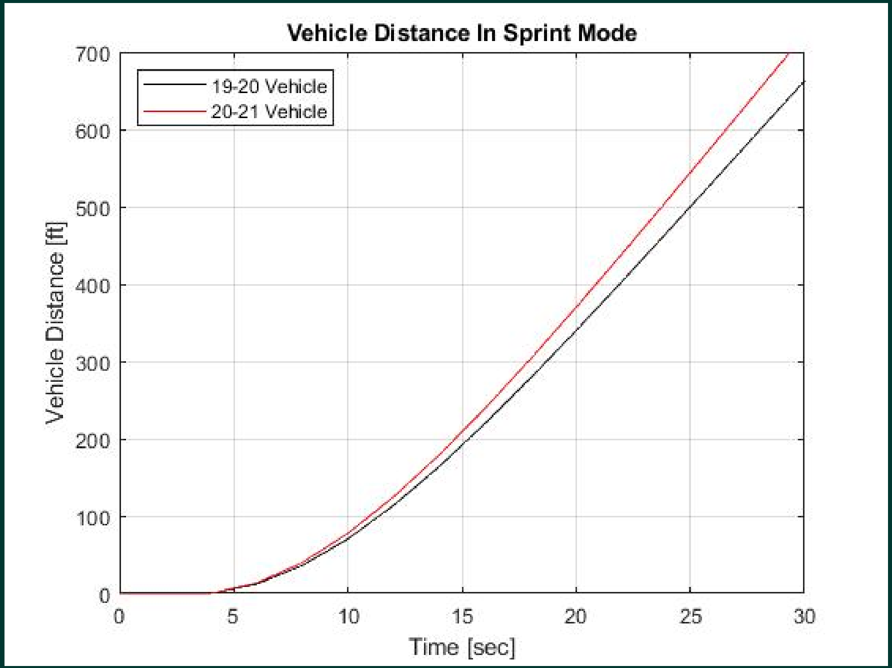

# Performance Models

# Modeling Parameters

| Parameter | Vehicle | | |
|---|---|---|---|
| | 19-20 | 20-21 | % Change |
| Tube ineternal Diameter [in] | 0.37 | 0.60 | 62.2% |
| Tube Length [in] | 120 | 70.0 | -41.7% |
| Tube Roughness [ft] | 3.0E-05 | 5E-06 | -83.3% |
| Bike Weight [lbf] | 103 | 100 | -2.9% |
| CG Height [in] | 33.0 | 14.7 | -55.5% |
| Rolling Resistance Coefficient | 0.004 | 0.005 | 25.0% |

# Sprint Race

- ❑ Sprint Model
- ❑ Fastest Time to 600 ft
- ❑ Model: 26.5 seconds
    - ~5% faster than last year's model

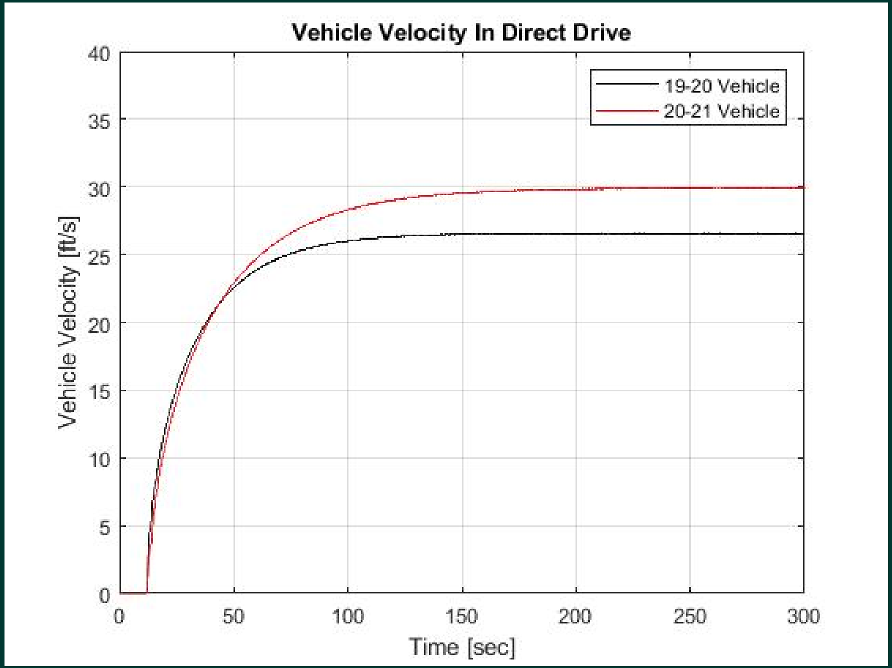


# Efficiency Score

- ❑ Efficiency Model + Judging Excel Rubric
- ❑ How efficiently can the vehicle move
  - Function of Accumulator stored energy, vehicle and rider weight, distance traveled
- ❑ Model: 5,500 ft
  - From excel rubric, 42%

# Endurance Race

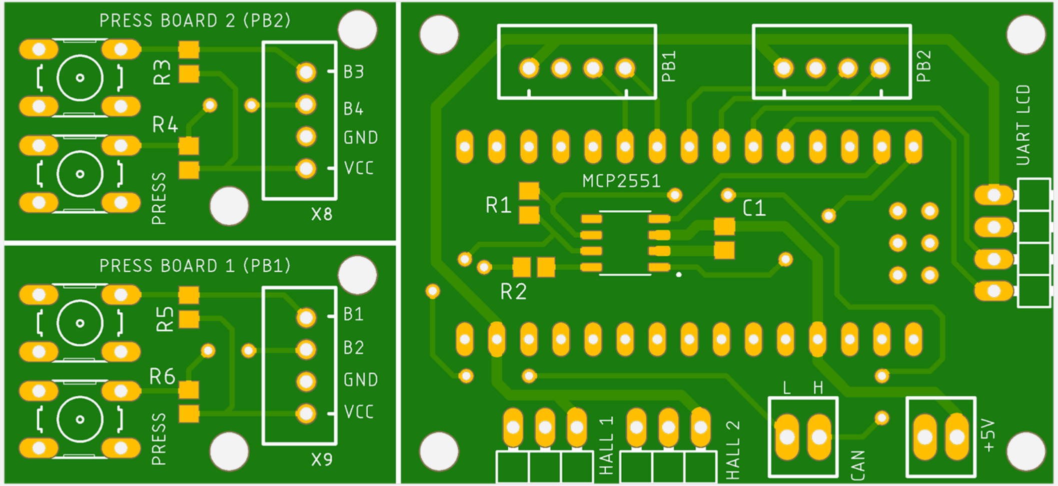
- ❑ Direct Drive Model
- ❑ Fastest time to complete 1 mile course.
- ❑ Model Estimate: 2.9 minutes
    - Average velocity 15% faster than last year's model



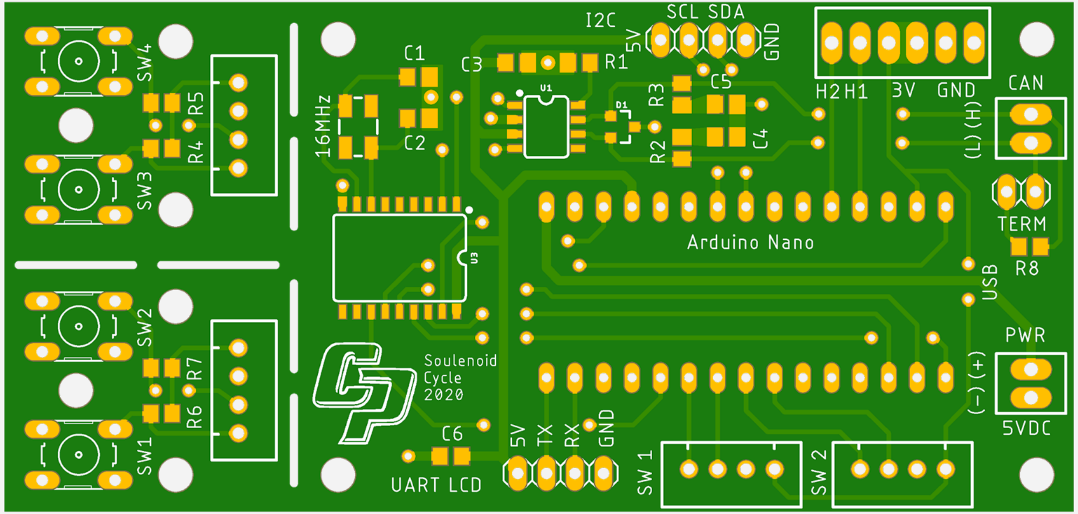
# Manufacturing & Current B

# Current Bike Pictures

# PCB Design 1

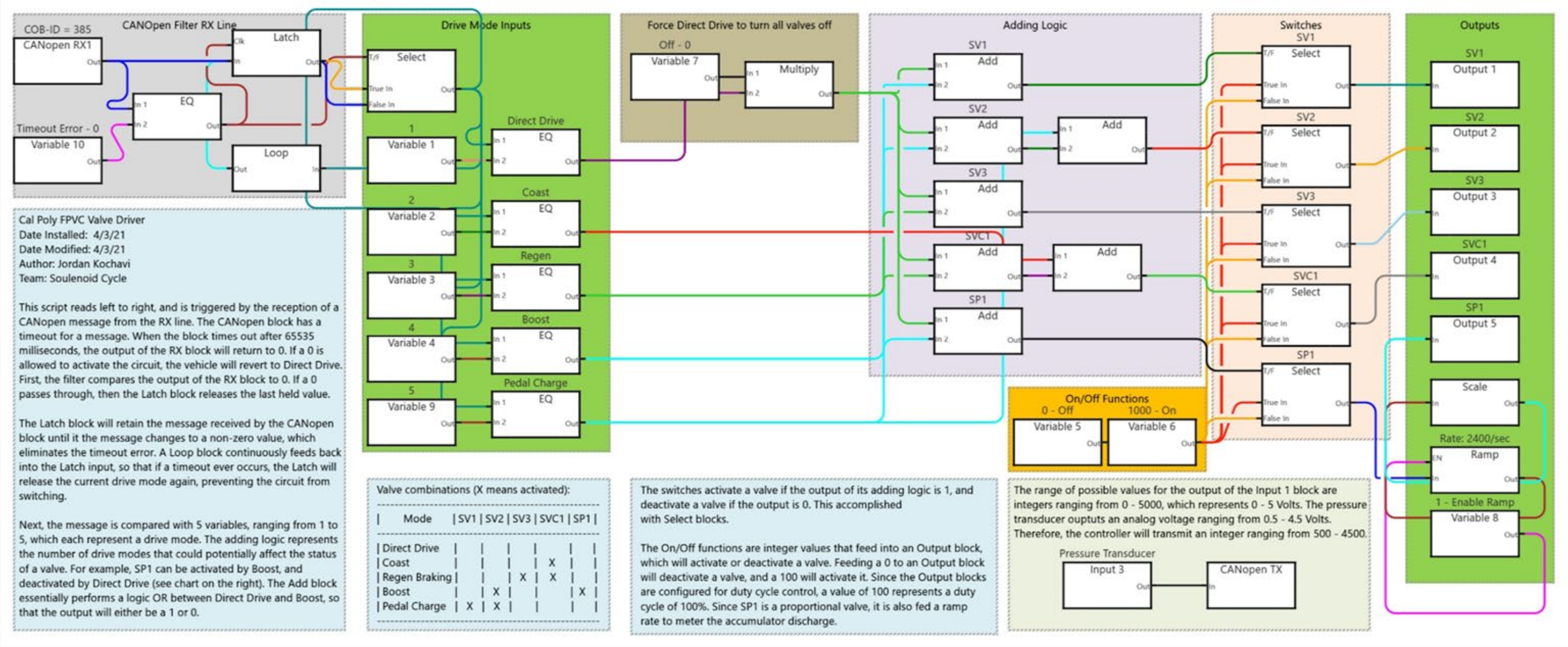

PRESS BOARD 2 (PB2)
R3
R4
B3
B4
GND
VCC
PRESS
X8
PRESS BOARD 1 (PB1)
R5
R6
B1
B2
GND
VCC
PRESS
X9
PB1
PB2
UART LCD
MCP2551
R1
C1
R2
HALL 1
HALL 2
L H
CAN
+5V

# PCB Design 2

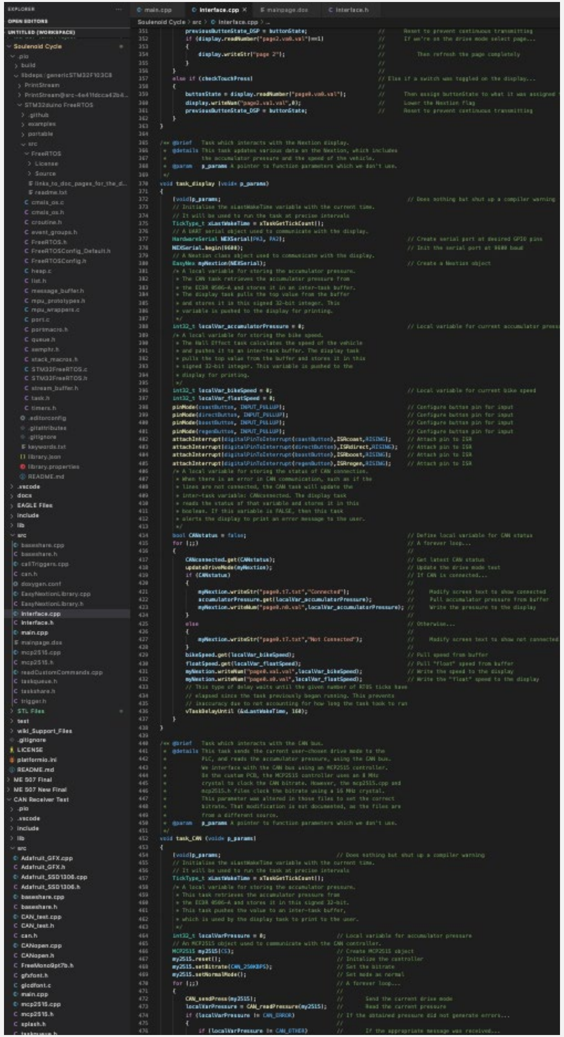


SW4
SW3
SW2
SW1
R5
R4
R7
R6
16MHz
C1
C2
C3
R1
I2C
SCL SDA
5V
GND
H2 H1
3V
GND
CAN
(L) (H)
R3
R2
C5
C4
TERM
R8
Arduino Nano
USB
PWR
(−) (+)
5VDC
Soulenoid
Cycle
2020
C6
5V
TX
RX
GND
UART LCD
SW 1
SW 2

# HF Impulse Programming



# Line Code



# “Ergonomic Testing”

# Shop Updates

**11/4/2020**

- First day working on the bike
- Replaced back tire because it had a leak
- Plugged screw hole in hydraulic reservoir

**11/10/2020**

- Tested the recharge, coast, and direct drive modes
- Fixed chain tension
- Tightened loose fittings on hydraulic lines

**11/17/2020**

- Tested regenerative braking and boost modes
- Regenerative braking took 4 minutes and 35 seconds for 3 people to walk the bike to an accumulator pressure of 2800psi
- Took about 23 seconds for a 150lb rider to travel 600ft in boost mode
- Accumulator took approximately 1,000ft to discharge completely for a 150lb rider (approx 35 seconds)

# DVP - Frame

- ❑ Build welding jig - Concept validation
- ❑ Bend some round steel tubing - Concept validation
- ❑ Laser cut to-scale steering linkage - Concept validation
- ❑ Weigh hydraulic components - Design verification

# DVP - Hydraulics

- ❑ Measure losses through manifold - Design verification
- ❑ Measure losses through entire hydraulic circuit - Design verification

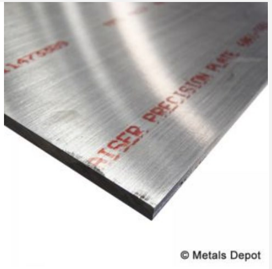
# DVP - Mechatronics

- ❑ Check controller baud rate compatibility - Design Verification
- ❑ Test bench-top CAN transceiver circuit - Design Verification

# Purchases & Budgeting

# Frame Purchases To-Date

| Material | Supplier | Cost |
|---|---|---|
| 1-1/4 X 1-1/4 X 16GA (.065 wall) A513 Square Steel Tube - **8ft stock** | Metals Depot | $131.60 |
| 1 X 1 X 16GA (.065 wall) A513 Square Steel Tube - **2ft stock** | Metals Depot | $5.48 |
| 1-1/2 X 1-1/2 X 16GA (.065 wall) A513 Square Steel Tube - **2ft stock** | Metals Depot | $6.94 |
| 3/4 OD x 16 GA (.065 wall) A513 HREW Round Steel Tube - **8ft stock** | Metals Depot | $32.48 |
| 1 OD x 16 GA (.065 wall) A513 HREW Round Steel Tube - **8ft stock** | Metals Depot | $35.20 |
| .125 (1/8)" thick 6061-T6 Aluminum Sheet - **2 x 4ft stock** | Metals Depot | $131.96 |
| Total | | $343.66 |



# Steering Purchases To-Date

| Material | Supplier | Cost |
|---|---|---|
| ICE 20" Front Wheel with Disc Hubs (Pair) | Recumbent Trike Store | $305.00 |
| ICE Standard Steel Front Axles Disc (Pair) | Recumbent Trike Store | $52.00 |
| FSA The Pig Headset | Amazon | $23.59 |
| 31.8 Stem 45mm Bike Stem Wake Mountain Bike Stem | Amazon | $9.97 |
| RUJOI Bike Disc Brake Kit | Amazon | $33.99 |
| SCHWALBE Marathon Racer HS 429 Tires | Amazon | $85.98 |
| Total | | $510.53 |




# Mechatronics Purchases To-Date

| Material | Supplier | Cost |
|---|---|---|
| Nextion 2.8” LCD | Amazon | $32.99 |
| STM32 Blue Pill | Amazon | $18.99 |
| Buck Voltage Regulator | Amazon | $13.99 |
| 3D Print Threaded Inserts | Amazon | $7.49 |
| ST-Link Programmer | Amazon | $6.99 |
| TJA1050 CAN Transceiver | Amazon | $6.39 |
| Total | | $86.84 |