NFPA Fluid Power Vehicle Challenge

NFPA
Education and
Technology
Foundation

FINAL PRESENTATION &
DESIGN REVIEW
Murray State University
Roger Riquelme
5/1/2025

MURRAY STATE
RACERS

Advisor

David Shier
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Danfoss

Meet the MSU Team

Kendall Cloud
Captain/Hydraulics

Kerrigan McManus
Hydraulics

Lydia Blunt

Meet the MSU Team

Angel Santos
Jesse Santillan

Frame

Payton Crick

Transmission

Meet the MSU Team

Asher Cunningham
Controls

Other members:

- Hope Harkins- Controls
- Grace Hanvey- Frame/Hydraulics
- Jonathan Woods- Hydraulics
- Dawson Martin- Controls/Hydraulics

What is Different?

Last years system:

- One pump & two motors
- Bigger hydraulics system
- Basic controls
- Modular frame

What is different?

This year's system:

- One pump & one motor
- Simpler hydraulic layout
- More capable controls
- Modular frame

Hydraulics'

Components

- Two HEM’s 10 pumps/motors
- Rexroth DCV
- Two dump valves and check valves
- Even Lighter Manifold (12lbs)
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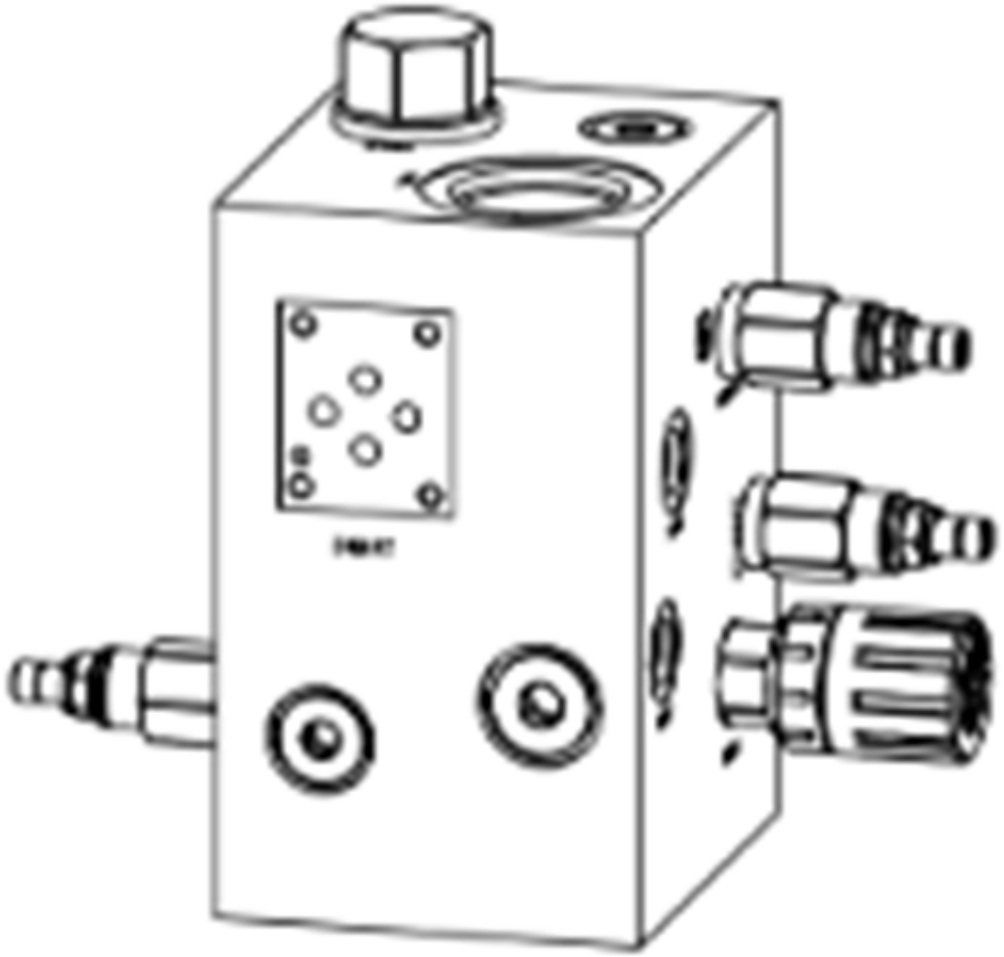
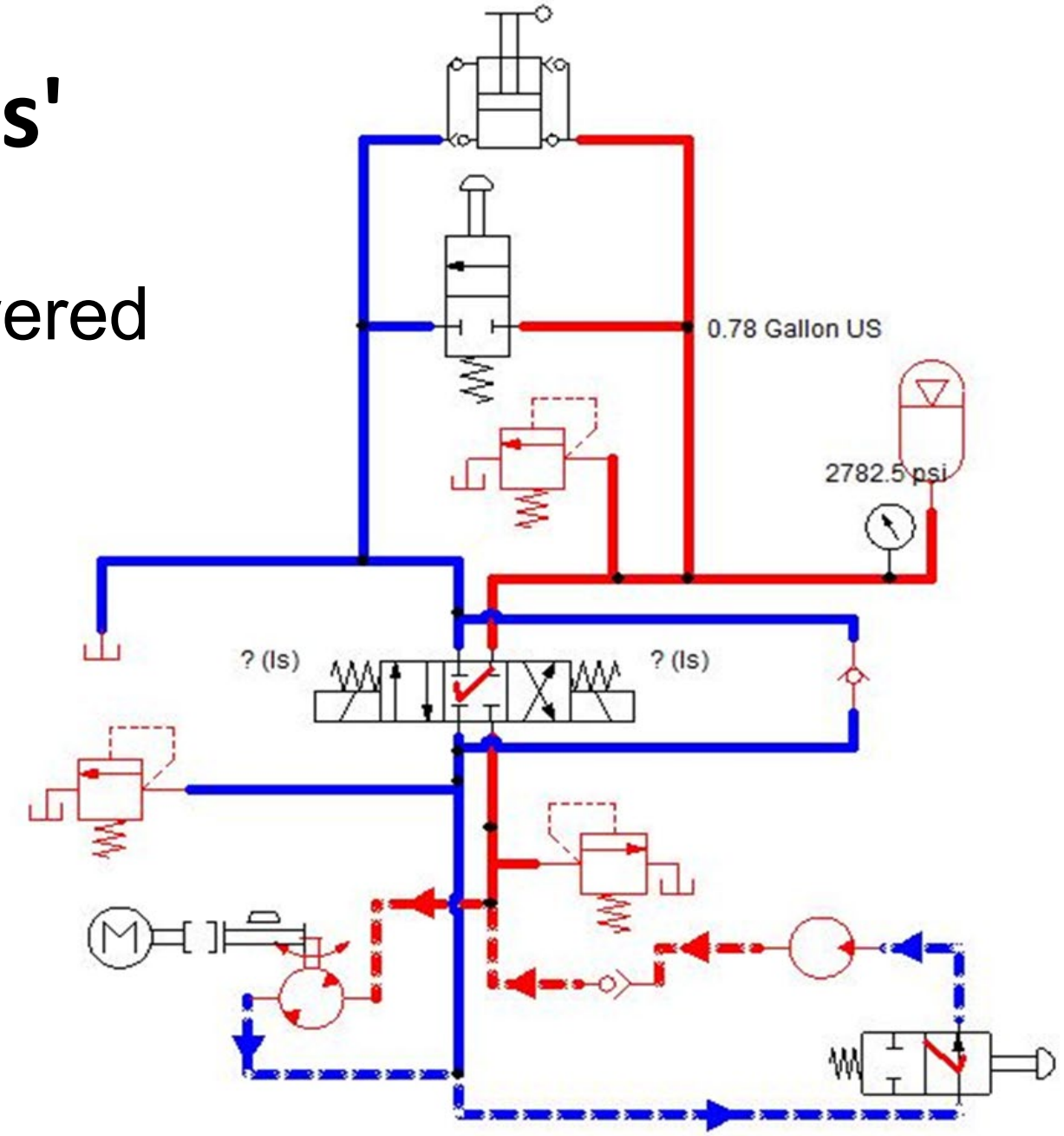


Hydraulics'

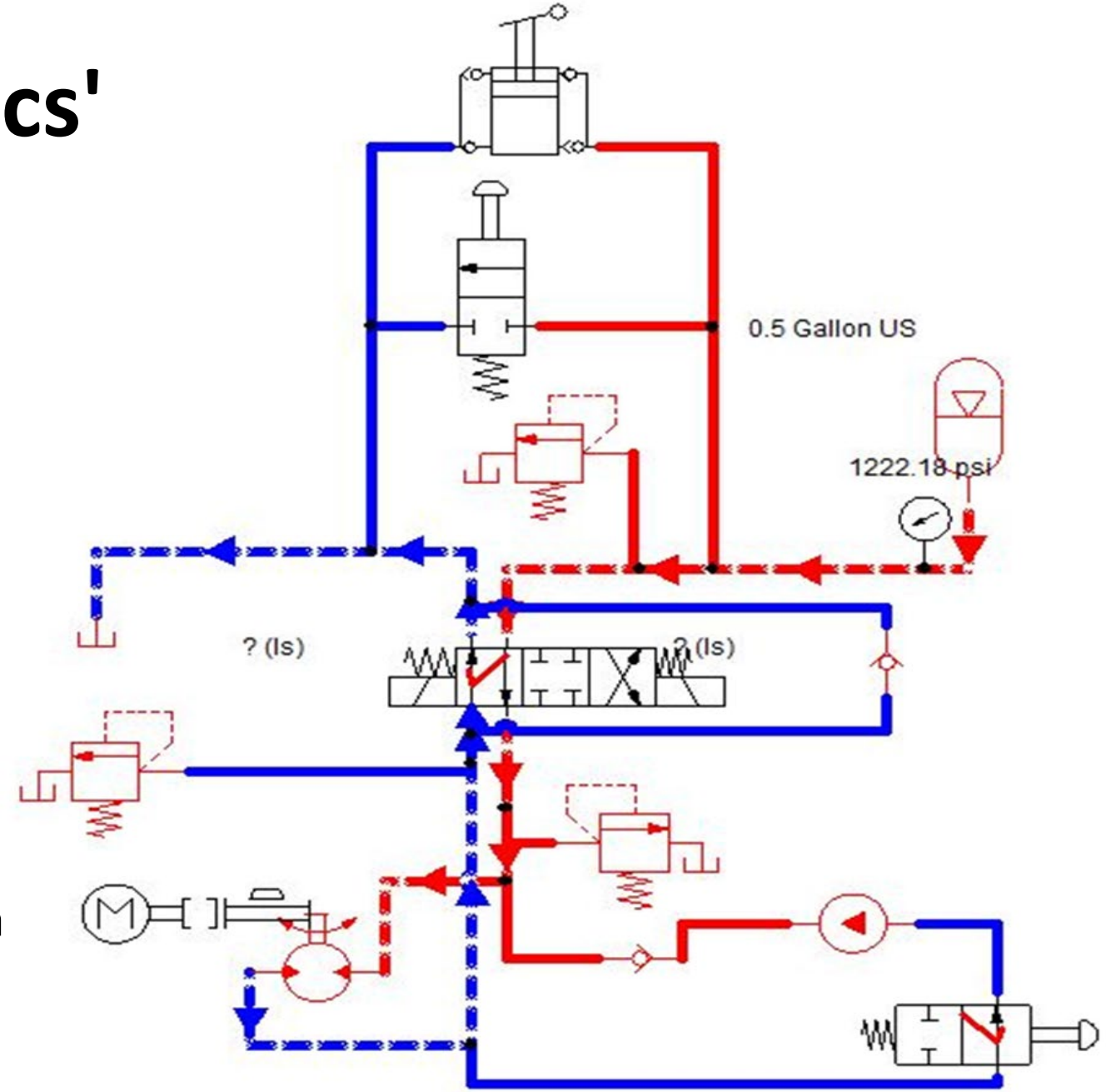
Human Powered



- Fluid is moved from motor to pump via blue line

Hydraulics'

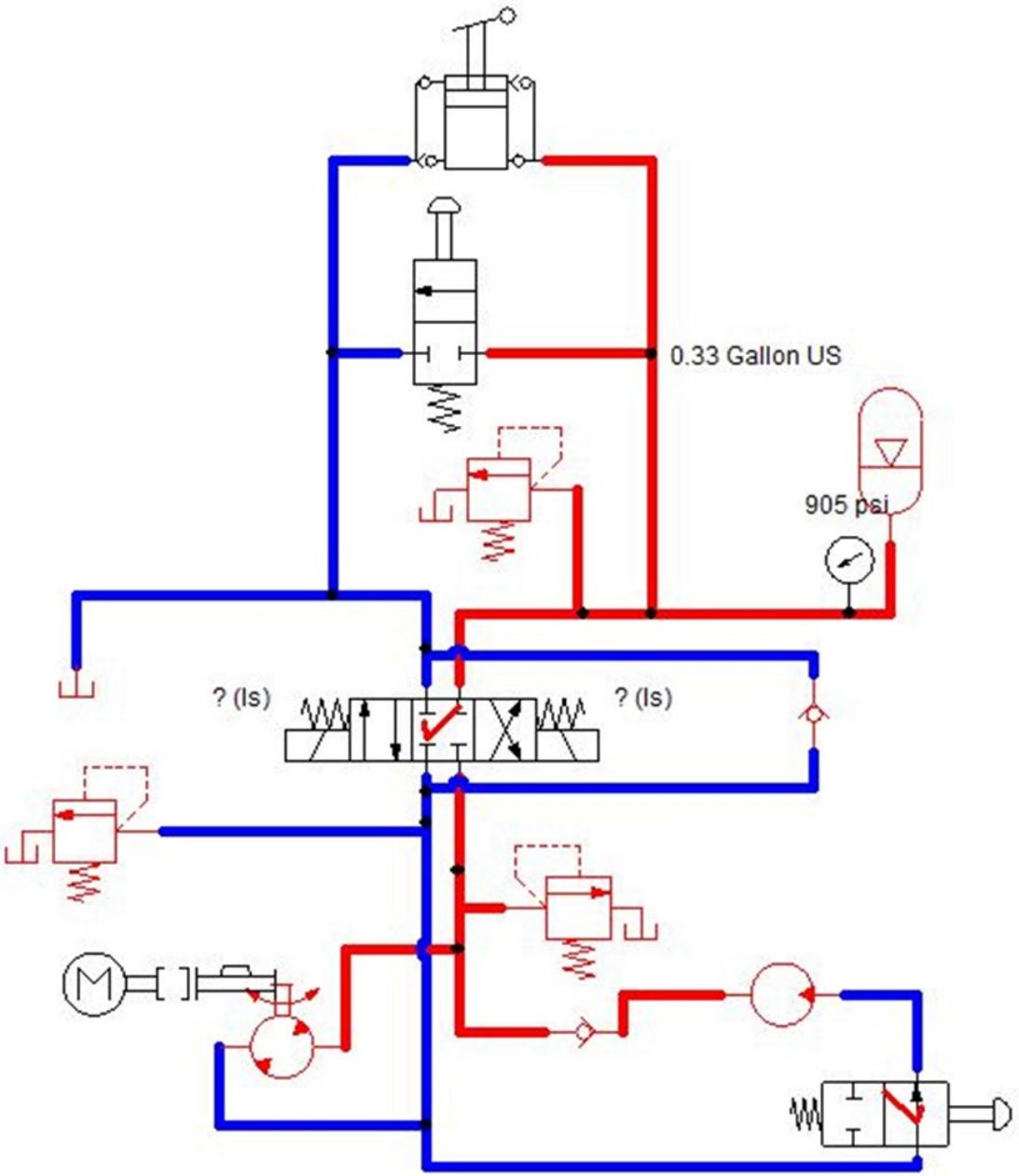
Discharge



- Fluid is pulled from the accumulator to the motor into the tire

Hydraulics

Hand Pump

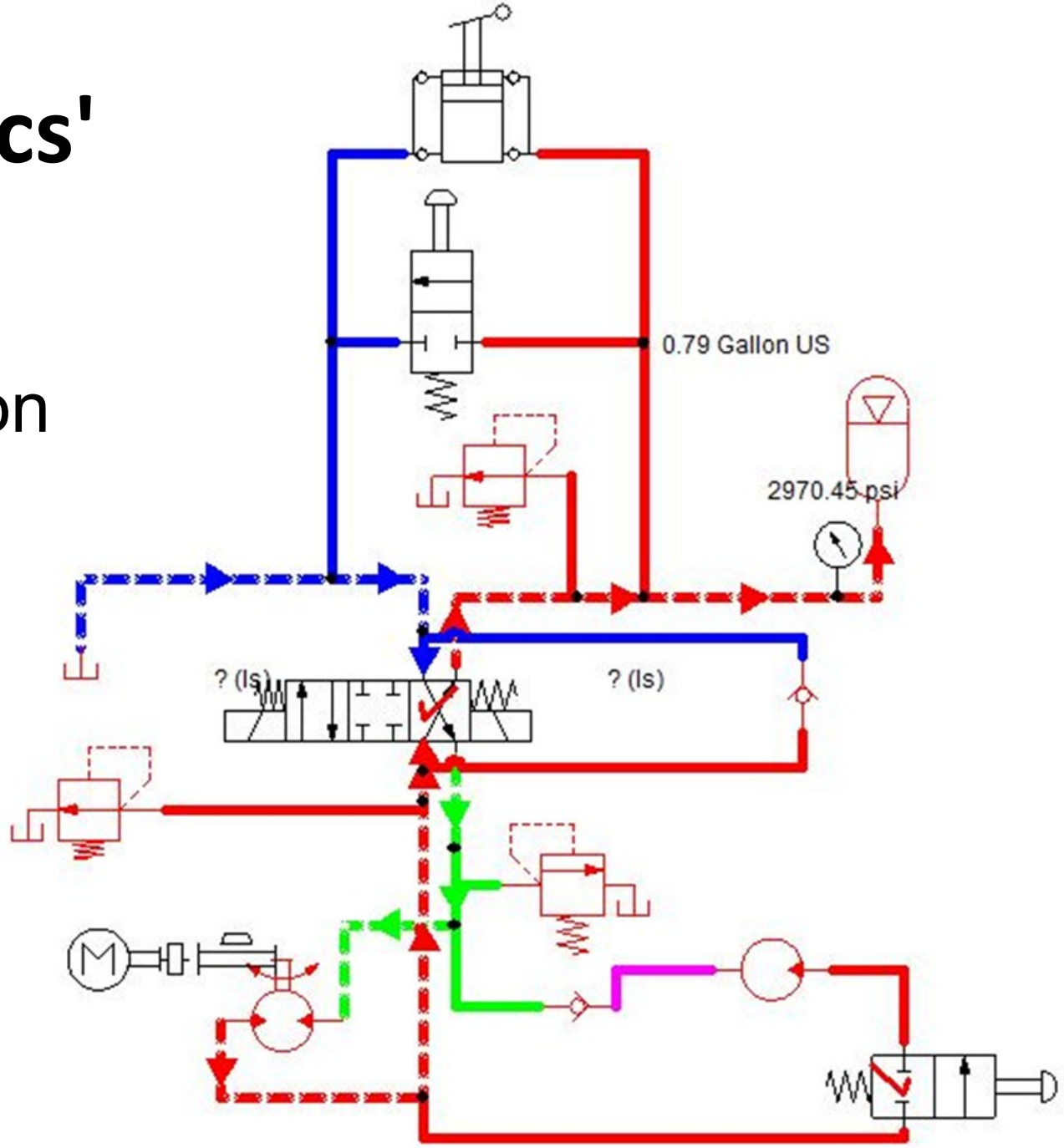


- Fluid is pulled from the tank by the hand pump into the accumulator

Hydraulics'

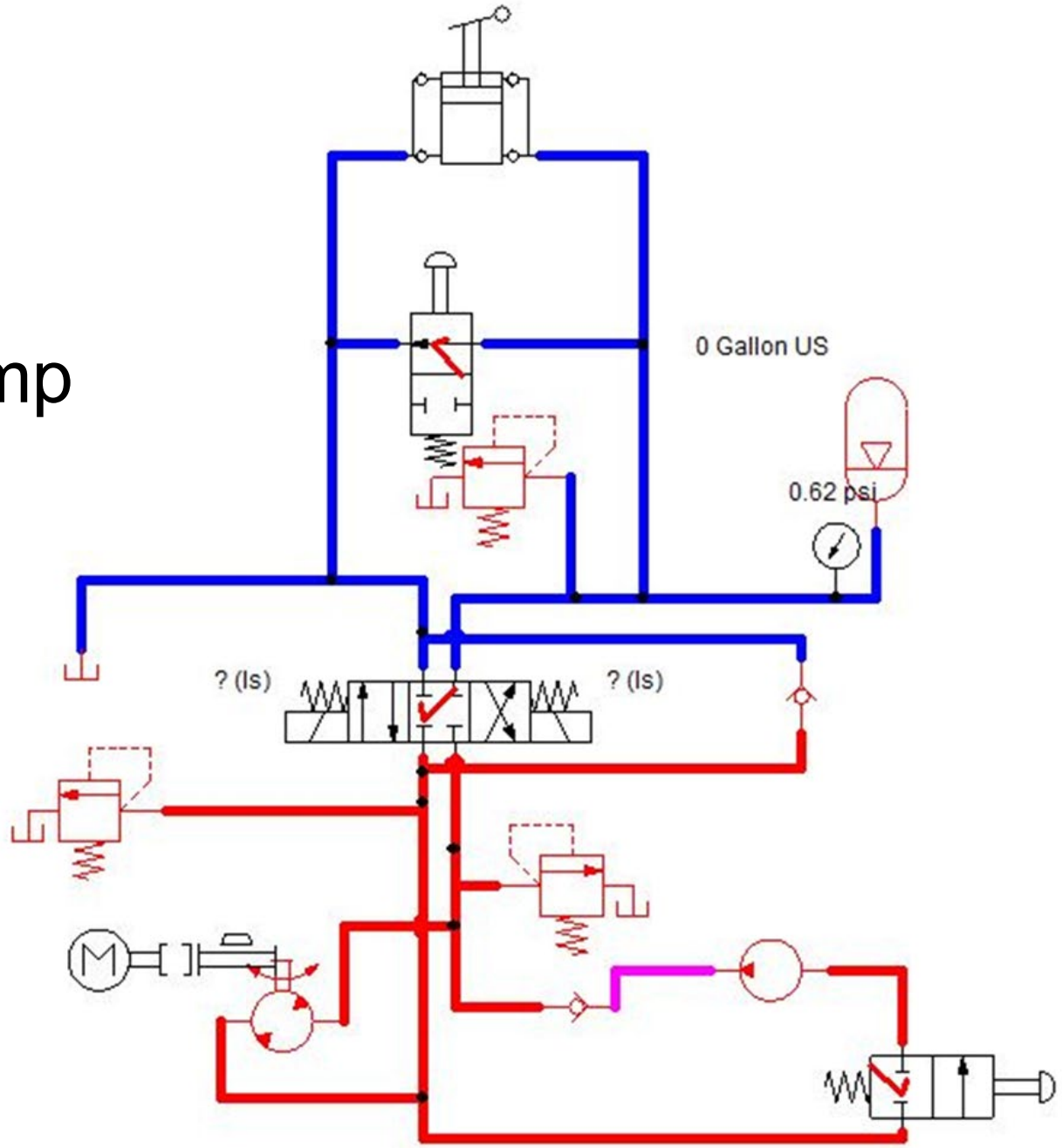
Regeneration

- Fluid is pulled from the tank by pedaling and deposited into the accumulator to create pressure



Hydraulics'

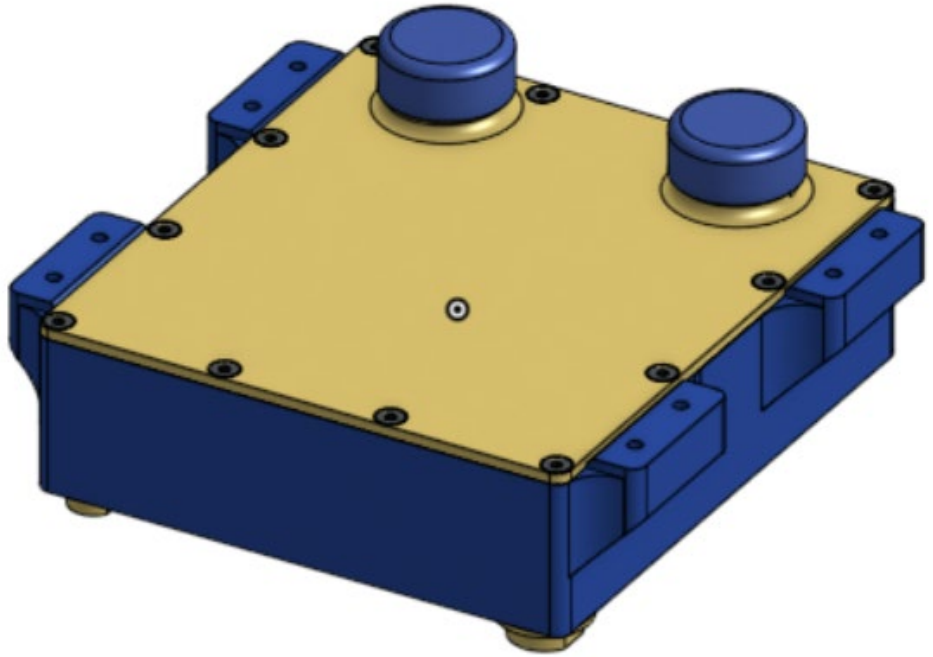
Emergency Dump

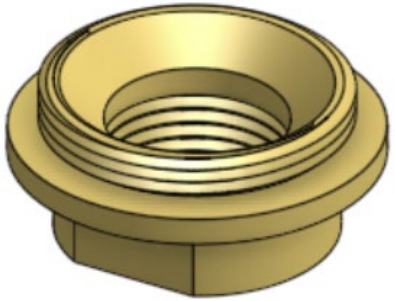


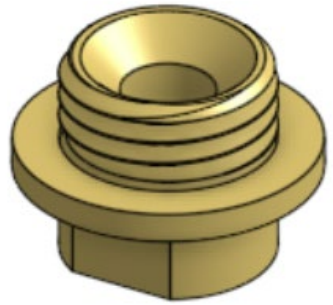
- When the ED is twisted, it dumps all the pressure and fluid back to tank

Reservoir

- 3D-Printed Reservoir
  - Custom-made to fit within modular frame using PLA Filament
  - Custom Threaded Fitting Mounts
    - Made with Arbitrary Threads for Adaptability
  - Angled Inside to Direct Fluid towards Manifold Fitting
  - Epoxy used to seal inside/make fluid-tight
  - Custom Rubber Gasket to seal inside/make fluid-tight
  - Threaded Inserts
  - Venting and Fill Caps



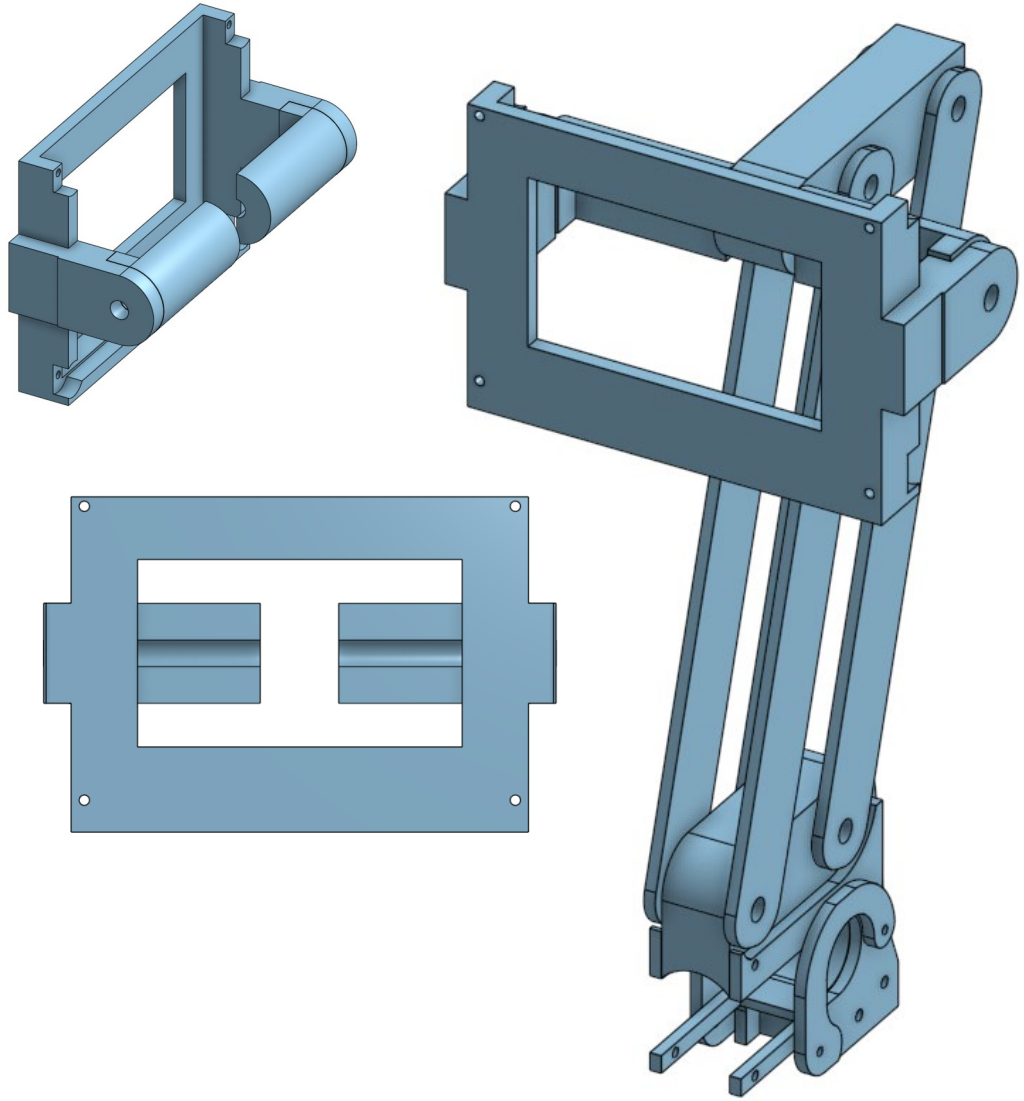




Frame

HMI Mount

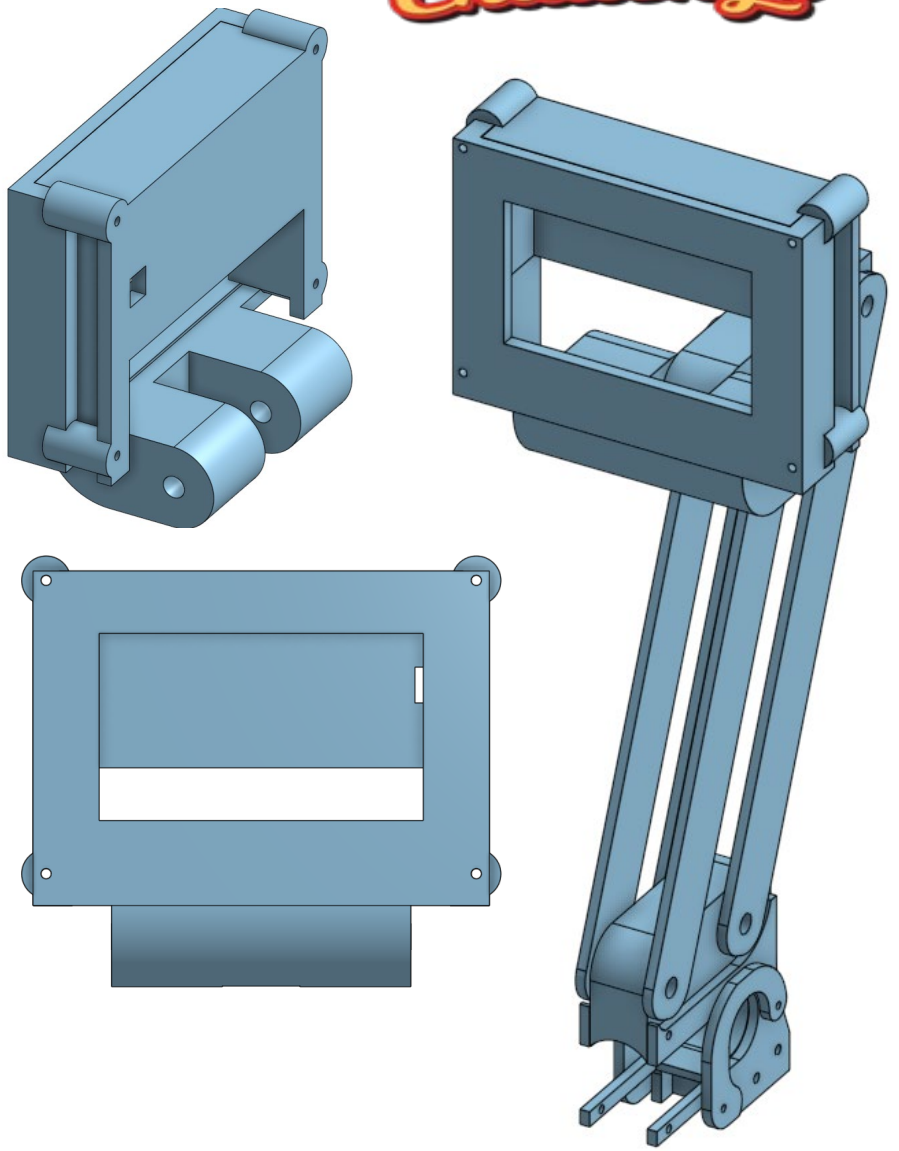
- The old mount showed promising but lack stability.
- Riders were more likely to hit their knees on the mount
- Design style was also not ideal for compatibility.



Frame

HMI Mount

- New design provides full encasement.
- The HMI is located at a higher elevation.
- Rider has enough clearance to comfortably pedal.



Frame

Lessons Learned from Previous Season:

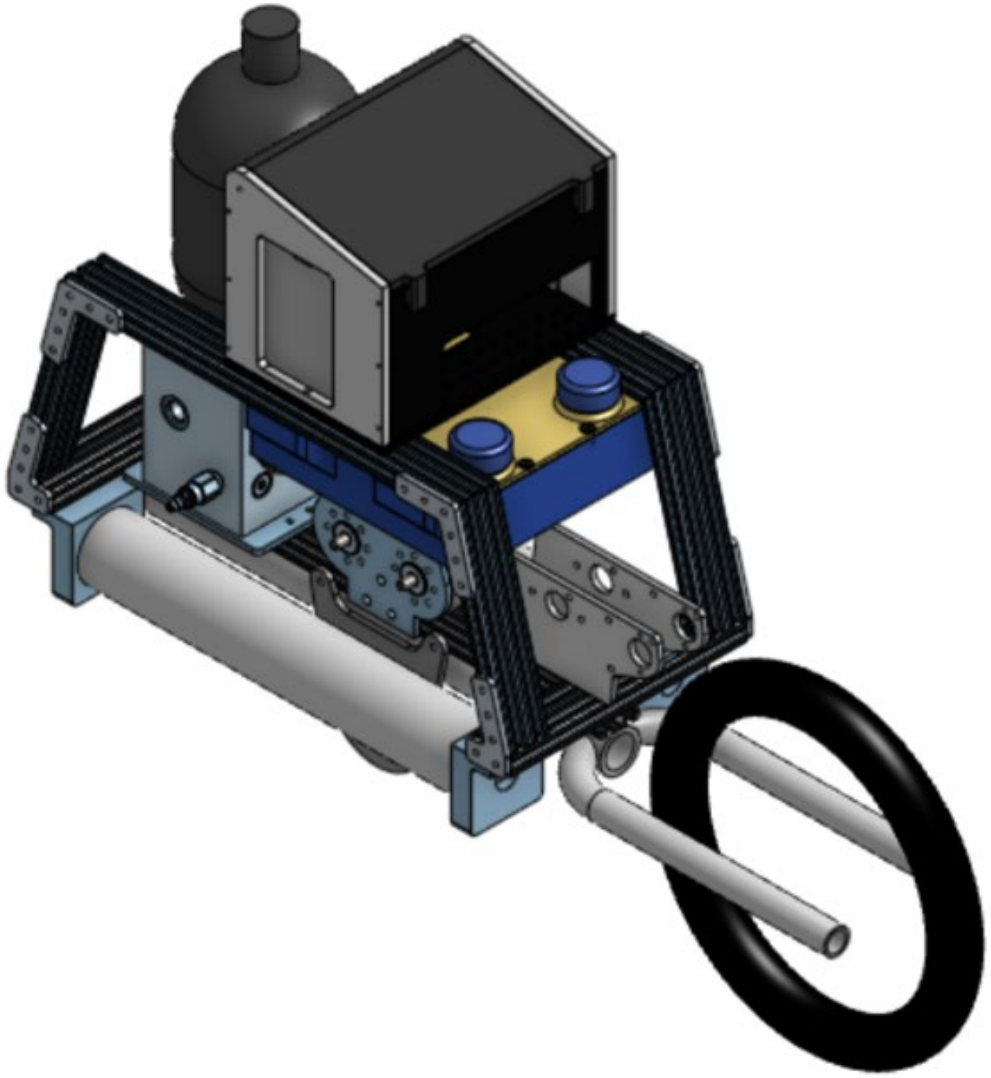
- Poor Adaptability
- Fixed Seat
- Limited Mounting Points
- Poor Center of Mass
- Value Aesthetics

For the Future:

- CAD is a useful tool
- Communication with other groups
- Planning and time management

Reusing

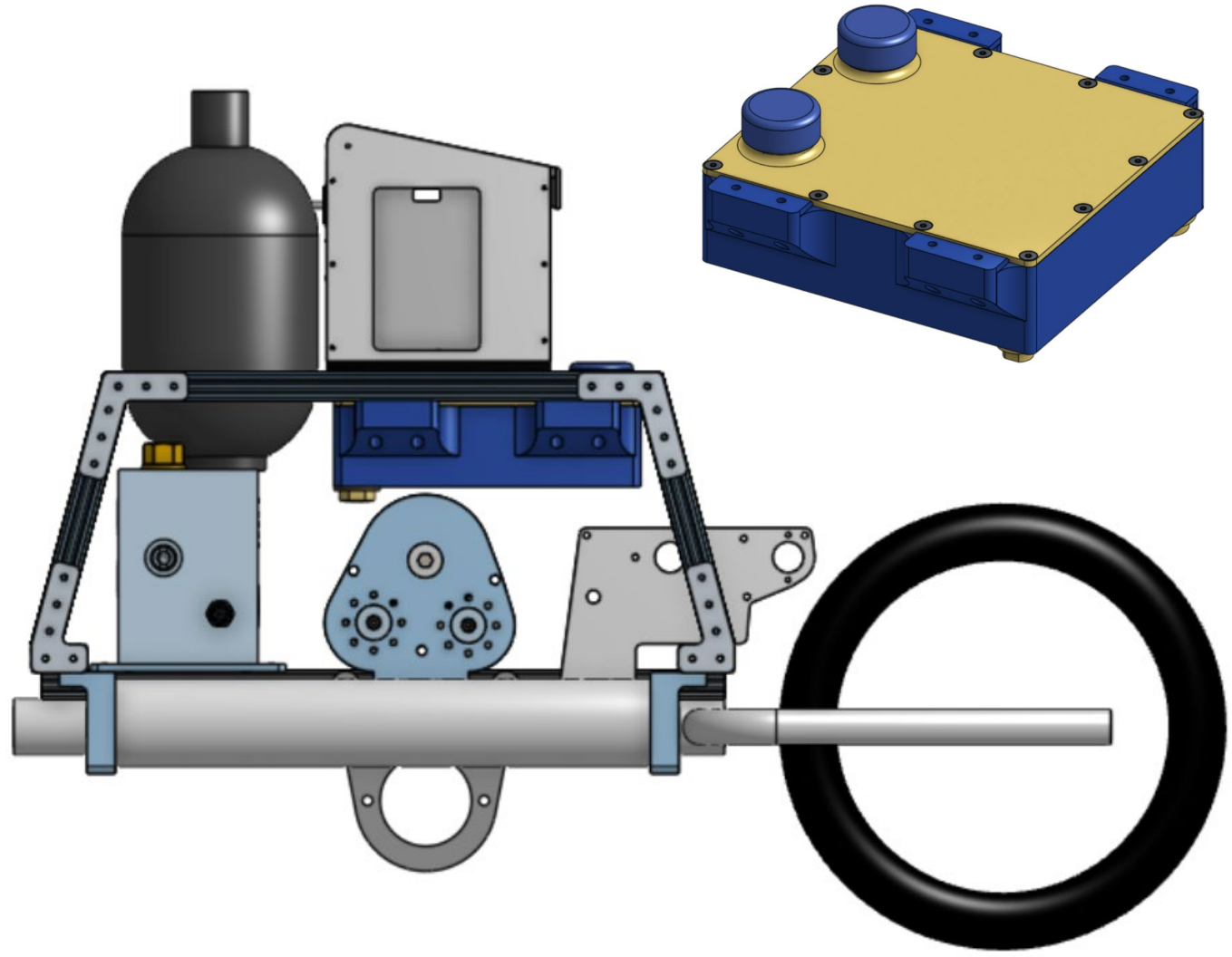
- 6061 Welded Aluminum Frame
  - Shortened Length
  - Reduced Weight



Frame

Frame Modifications

- Construction of Modular Frame
  - 8020 aluminum extrusion
  - Improves mounting issues
  - Improves adaptability
  - Improves poor center of mass
- Adjustable Seat Design
  - Improves adaptability
  - Improves seat adaptability
  - Ensures comfortability for rider
- Mounts
  - Water Jetted Aluminum Brackets
  - Custom 3D-Printed Mounts
  - Custom 3D-Printed Reservoir



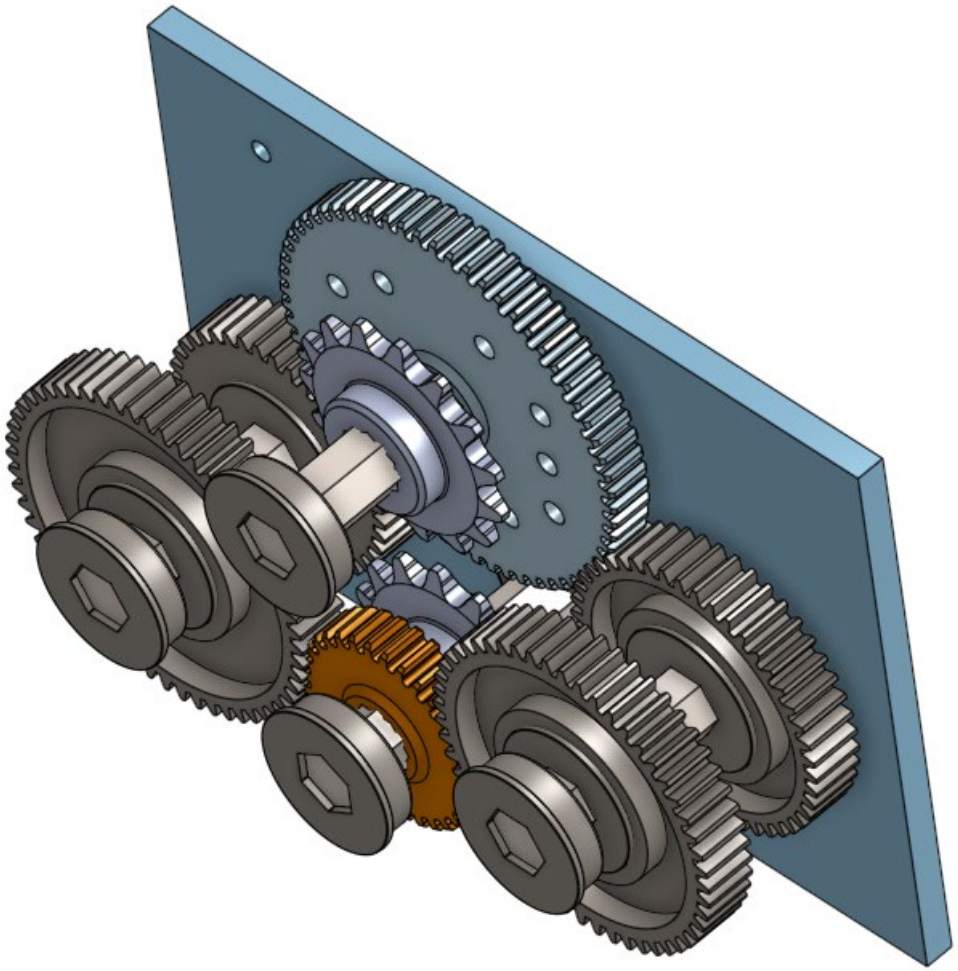
Transmission

Old Design

- Previously we used a 4 speed manual transmission
- This design was optimized for the different competition events
- Open design, no protection from outside elements

Objective

- Allowing optimal usage for our motor in all races and to reduce rider fatigue with minimal losses.

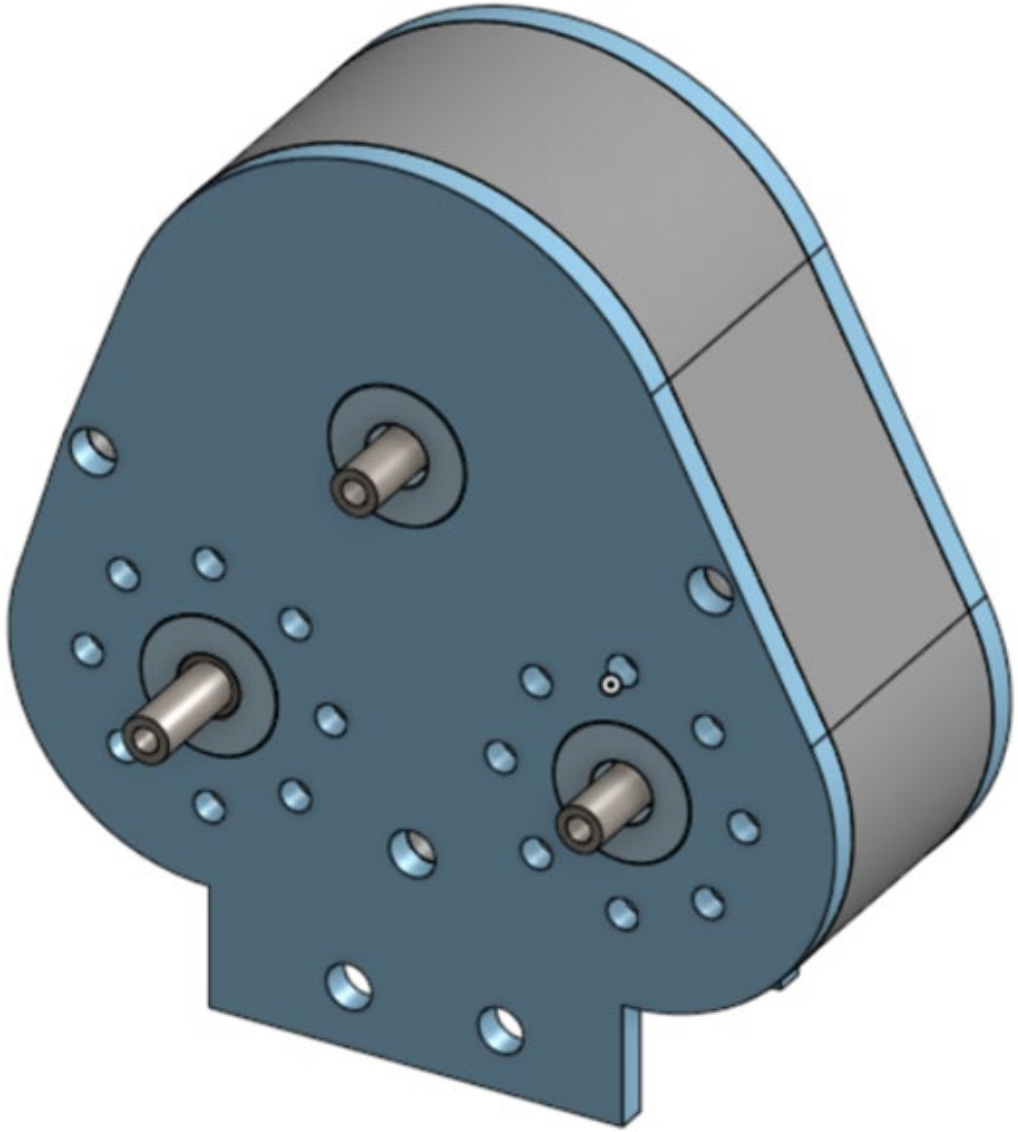


Transmission

- We are sticking to a 4 speed manual transmission
- This year we are enclosing the transmission
- With the changing of the competition events, we have changed the gear ratio to be a better fit

Objective

- With this years model being enclosed we are wanting to make it a wet transmission

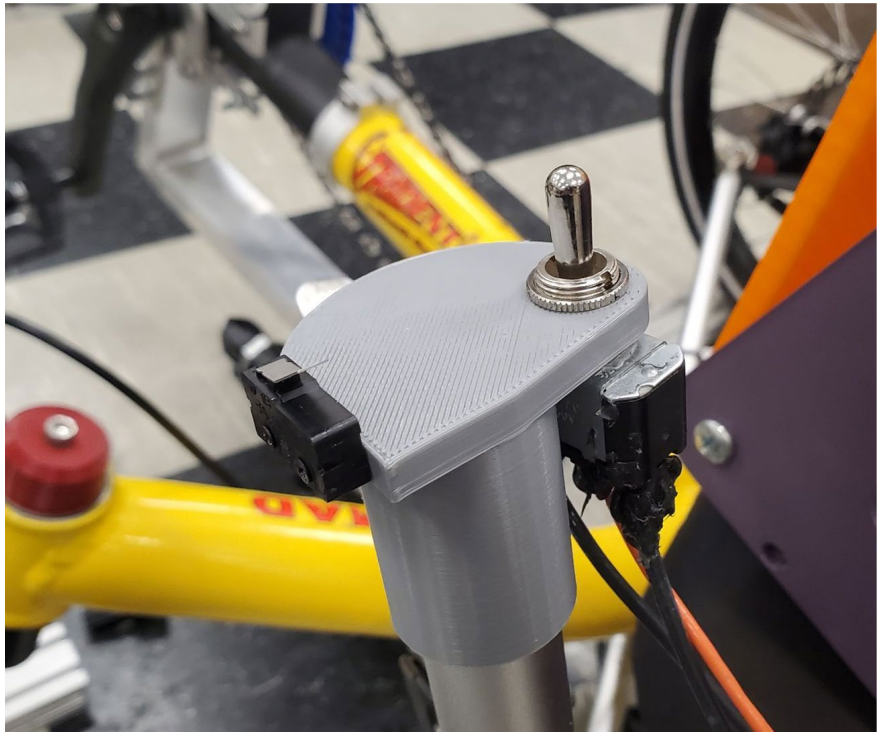


Transmission

H	I	J	K	L	M	N
Ratio 2						
Wheel size(in)	16	0.000793331		Ratios 1:x	x OutPut	
S1 G1 tooth count A*	56			GR1	0.928571429	
S1 G2 tooth count B	36			GR2	1.925925926	
S2 G1 tooth count A**	60			GR3	0.888888889	
S2 G2 tooth count B*	80			GR4	0.428571429	
S3 G1 tooth count A	52			NAS1 + NAS2 = NBS1 +NBS2		
S3 G2 tooth count B**	32			NAS2 + NAS3 = NBS2 +NBS3		
Motor-trans Ratio 1:x	2			NAS1 + NAS2	116	OK
Trans-wheel Ratio 1:x	3			NBS1 +NBS2	116	
				NAS2 + NAS3	112	OK
				NBS2 +NBS3	112	
Wheel Ratio						
GR1	2.785714286					
GR2	5.777777778					
GR3	2.666666667					
GR4	1.285714286					

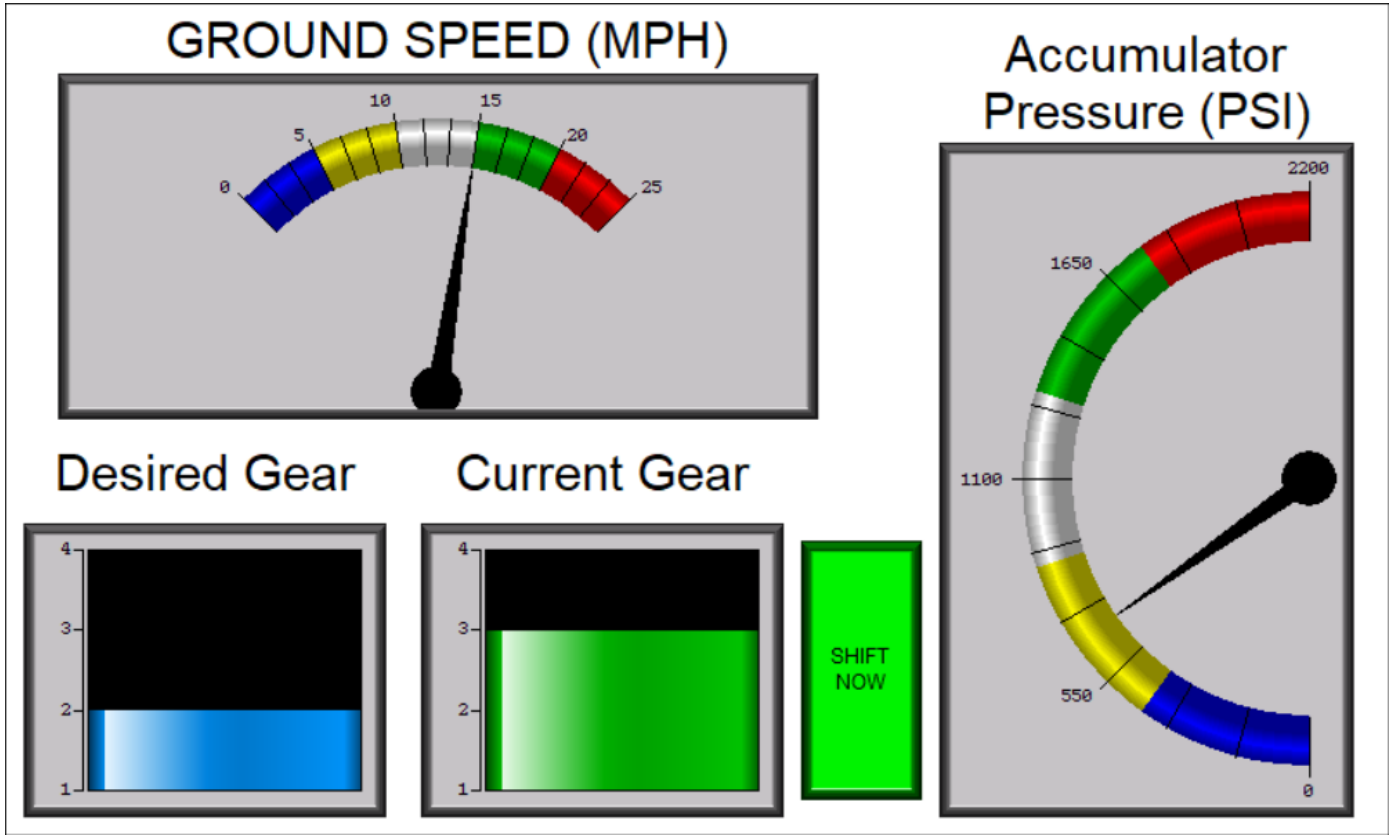
Controls: Shifting

- Dual-throw switch for gear selection
- Push-button switch to prevent air waste



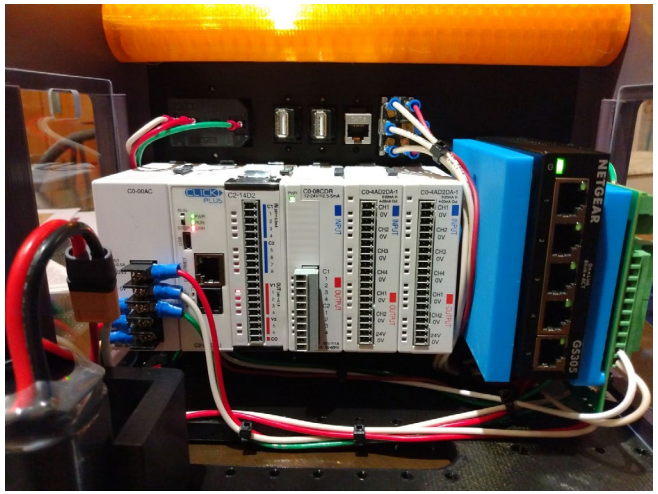
Controls: HMI

- Speedometer
- Accumulator Pressure
- Current / Desired Gear
- Shift Suggestion



Controls: Flexibility

- Everything connected to unmanaged Ethernet switch
  - Simplicity for debugging
  - No latency between HMI/PLC
- Box allows easy access
  - Lid flips up
  - Side panels slide off
- Can run off AC or DC power



Lessons Learned

- Complete plans for frame and hydraulics earlier
- Having better time management
- Leader having more communication with team
- Working in tandem

Questions?