NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION

Murray State University
Bryant Harrison

03/29/2019

MURRAY STATE UNIVERSITY

Team Members

Bryant Harrison
Team Advisor
Instructor Murray

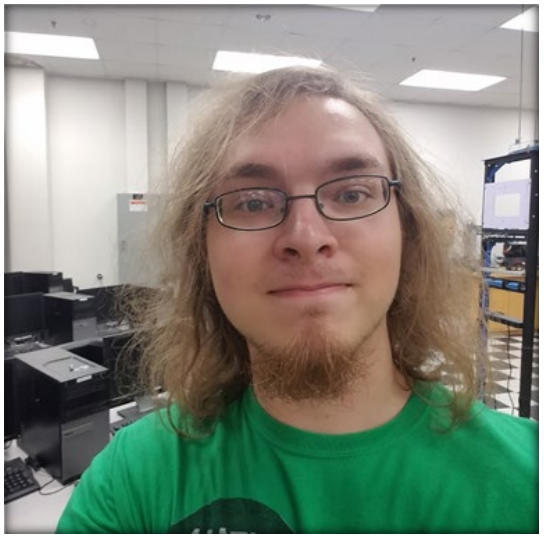
Josh Scarbrough
Sophomore
Electromechanical
Engineering Technology

Team Members

Joe Reed
Senior
Engineering Physics

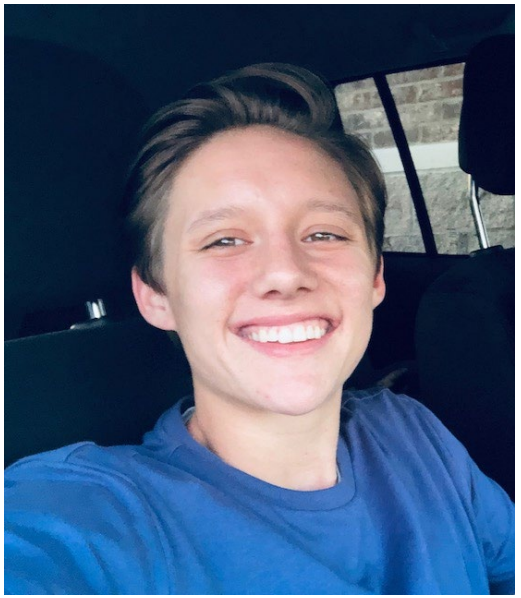
Caleb Cobb
Junior
Electromechanical
Engineering Technology

Team Members



Max Kephart
Senior
Electromechanical
Engineering Technology

Andrew Kane
Senior
Electromechanical
Engineering Technology



Kaitlyn Isbell
Senior
Electromechanical
Engineering Technology

Team Members

Graduated

Abdulrahman Almarwani
Senior
Manufacturing Engineering Technology

Badr Alghamdi
Senior
Manufacturing Engineering Technology

Team Members

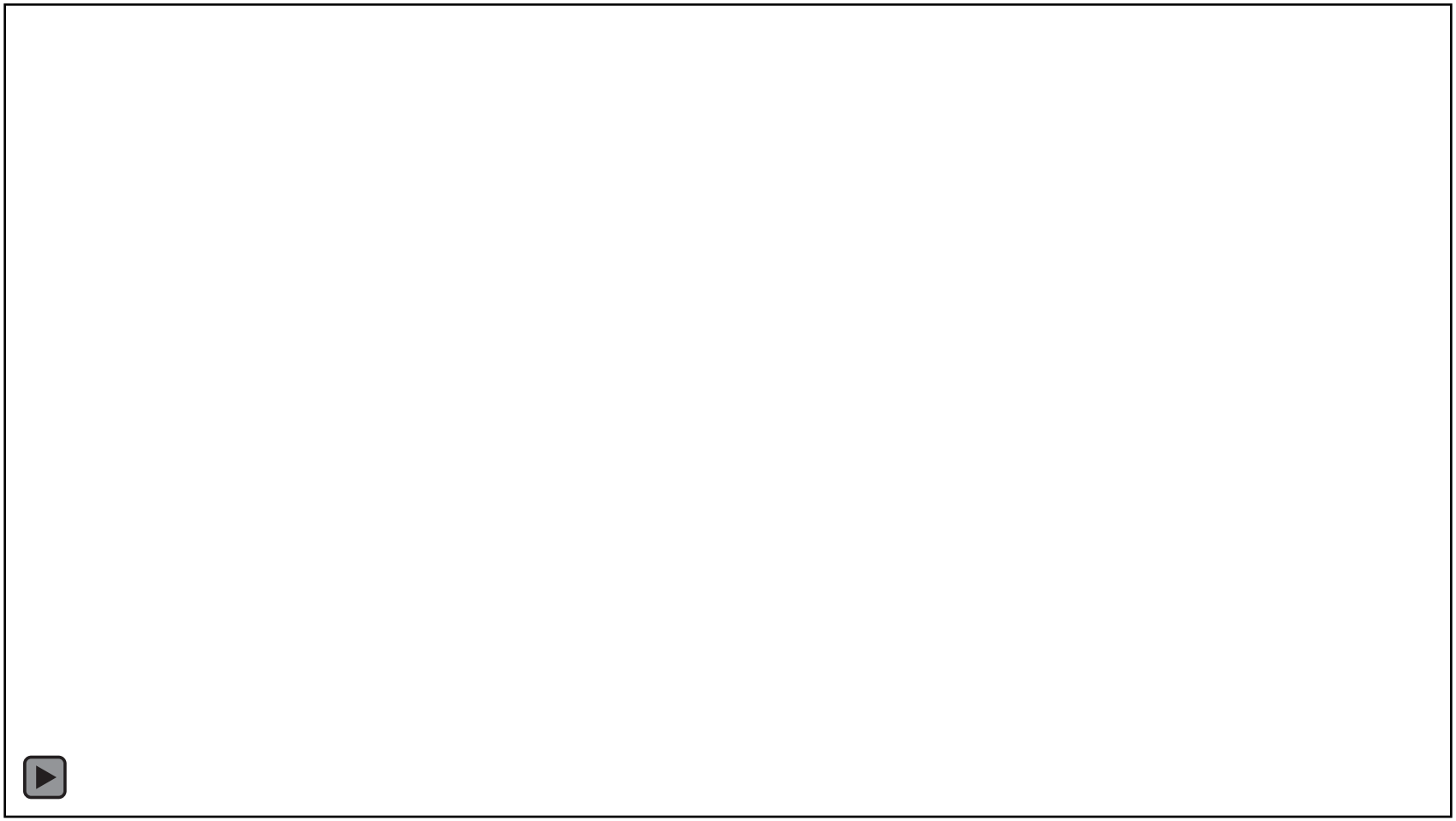
Graduated

Ibrahim Alsharari
Senior
Electromechanical
Engineering Technology

Hussain Alnabhani
Senior
Manufacturing Engineering
Technology

Photo of Vehicle

Dude……



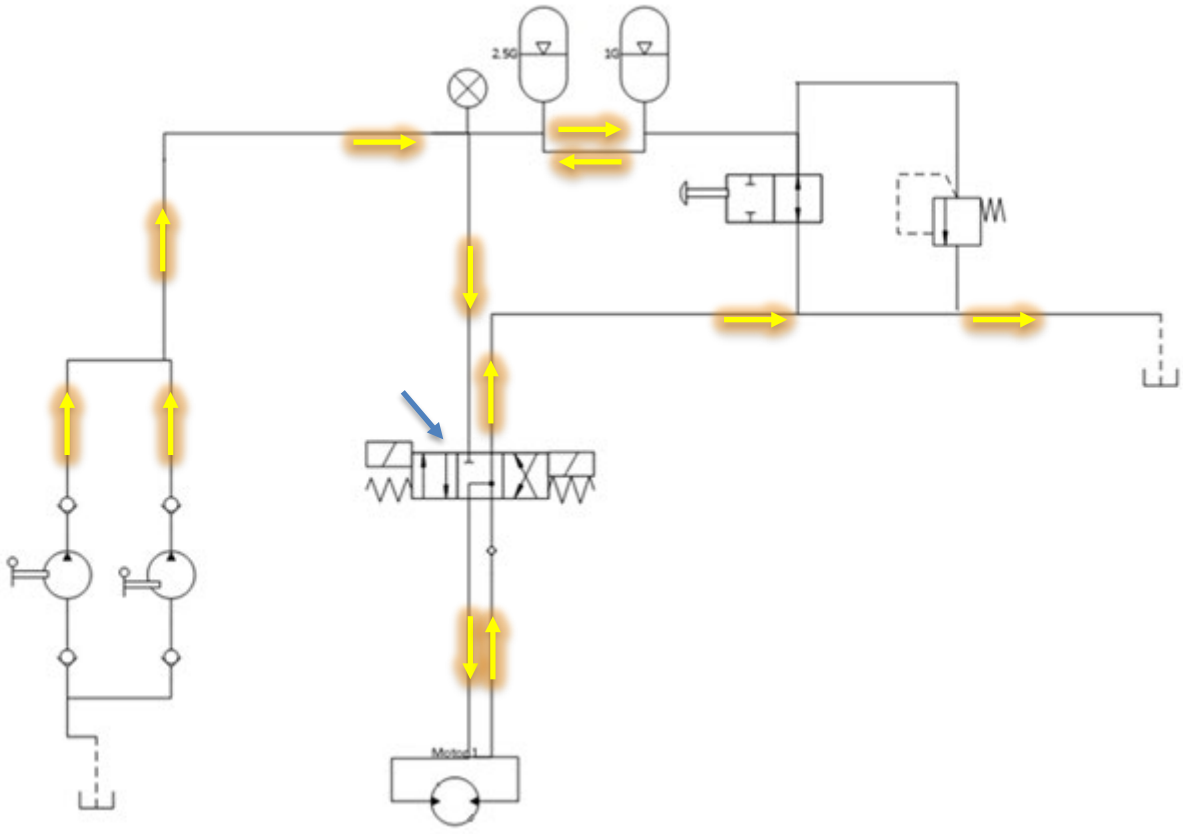
Problem Statement

To design and deploy a vehicle that can store energy in a hydraulic circuit, release that energy on demand, while also maintaining the ability to regenerate energy from momentum. This design needs to be safe and have a high degree of manufacturability.

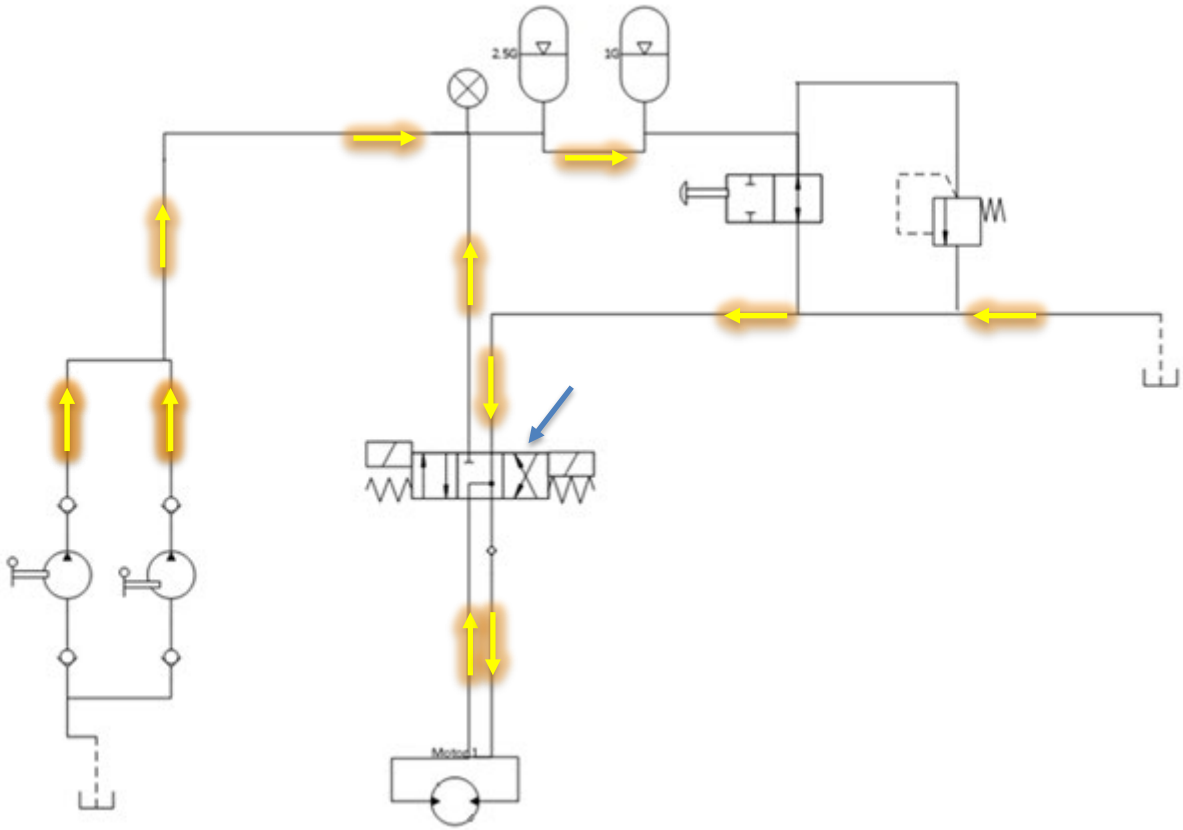
Goals

- Move Steering to Hands
- Move Power-In System to Legs
- Add manifold
- Add electric clutch
- Redesign reservoir

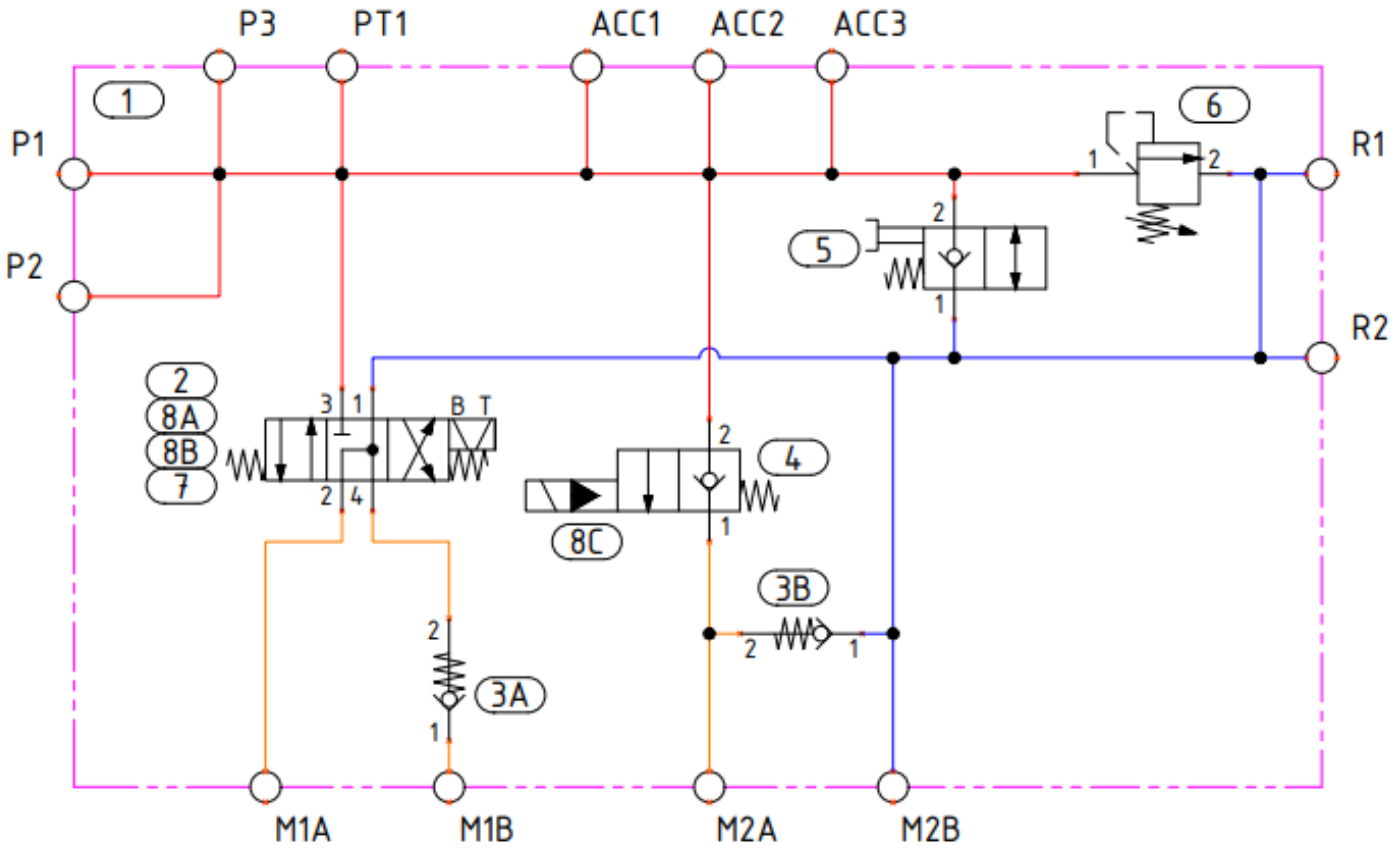
Bike Circuit Energized



Bike Circuit Power Regen



Manifold Circuit



Manifold

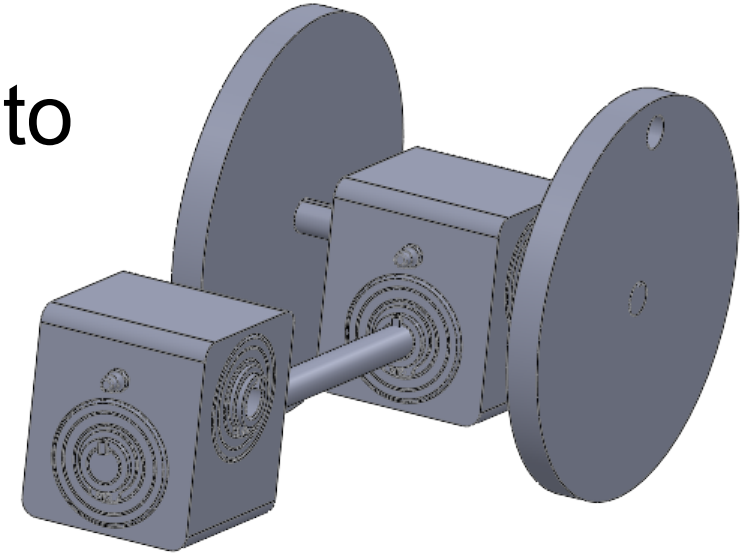
- Designed to be expandable for future teams.
- Was priority to create a more space efficient circuit and reduce the number of connections

Steering

- Created a steering system that would allow the rider to steer using their arms.
- Resulted in larger turning radius.

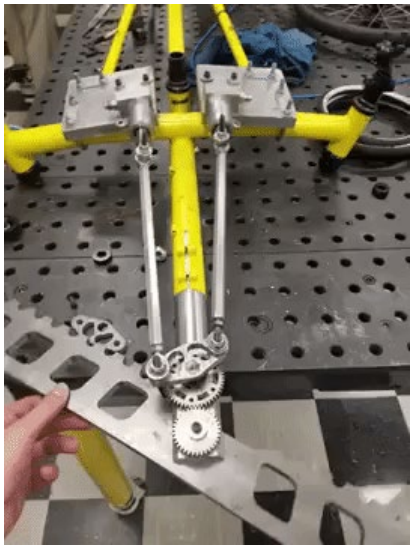
Power-In

- Radial Piston Pump
- Flywheel with linkages to hand pump cylinders
- Foot lever with linkages to hand pump cylinders



Power-In

- ½ inch 7065-T6 Aluminum Gears
- Failed at roughly 1600 PSI system pressure
- 117lb_f required by the rider to pressurize to 3000 PSI



Power-In

The final build

- No Gears
- Force of 1352 lb_f on connecting rods at 3000 PSI
- 165 lb_f required to pressurize to 3000 PSI

Power-In

Other Problems

- The mounting of the cylinders
- Different heights of riders
- Foot slipping on the bar

Accumulators

- Using two accumulators, both carbon fiber bladder type from Steelhead Composites' Minimax line
- 3,000 PSI Maximum
- 2.5 Gallon – 14 lbs / 1 Gallon – 8 lbs
- Alternative was using two 3 litre steel piston type with each weighting 40 pounds empty

Motive Force

Minimum System Pressure	Motive Force (Pounds Force)
800 PSI (2.5G) (Sprint)	67
1500 PSI (1G) (Sprint)	125
100 PSI (Both) (Efficiency)	8
500 PSI (Both) (Endurance)	67

$$\left(\frac{System\ Pressure * Motor\ Displacement}{2\pi}\right) * (Gear\ Ratio) = Torque\ @\ Wheel\ Hub$$

$$\frac{Torque\ @\ Wheel\ Hub}{Wheel\ Radius} = Motive\ Force$$

Rear Wheel

- Previous wheel a possible failure mode
- ~24 lb of torque being applied to hub
- Should the hub fail it would be catastrophic to entire bike
- Replaced with much more rigid wheel and tire
- Increased safety of the bike

Clutch

- The need for a new wheel became greater than the need to add the clutch.
- All of the designed system for the clutch was done around the previous wheel.
- Clutch, gear and new wheel did not all fit within the space between forks.
- Would have to make major changes to bike frame and not enough time to test

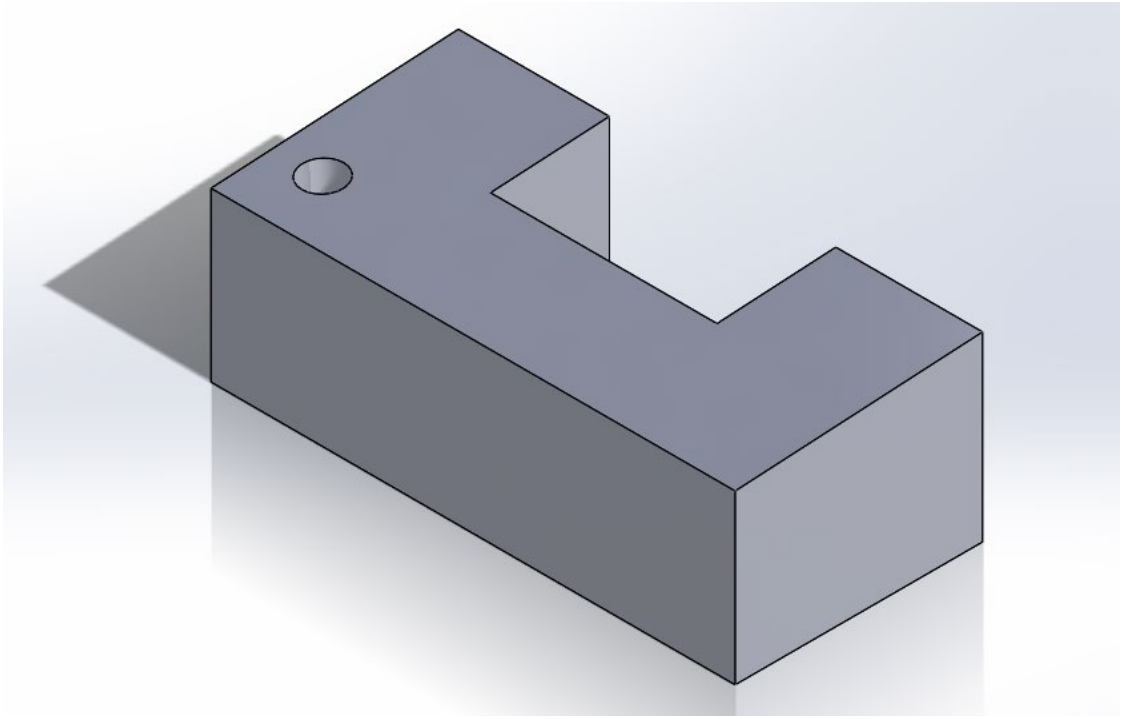
Fluid Calculation

Volume (Gal)	Precharge (PSI)	Gas Volume (Gal)	Fluid Volume (Gal)
3.5 (Efficiency)	100	.12	3.38
3.5 (Endurance)	500	.58	2.91
1 (Sprint)	1500	.5	.5
2.5 (Sprint)	800	.67	2.33

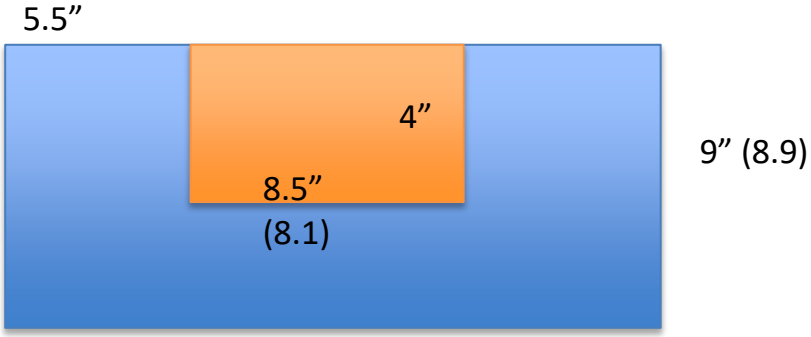
$$\frac{Accumulator\ Volume\ * Gas\ Pressure\ (Precharge)}{Maximum\ System\ Pressure} = Gas\ Volume\ (Pressurized)$$

$$Accumulator\ Volume - Gas\ Volume = Fluid\ Volume$$

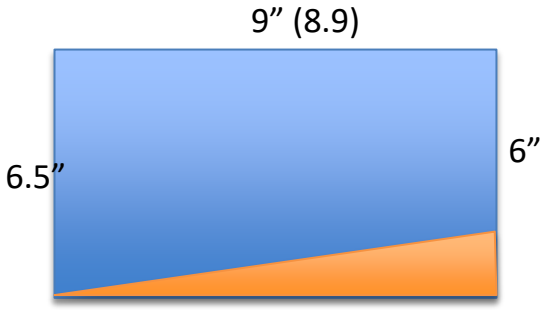
Reservoir



Reservoir

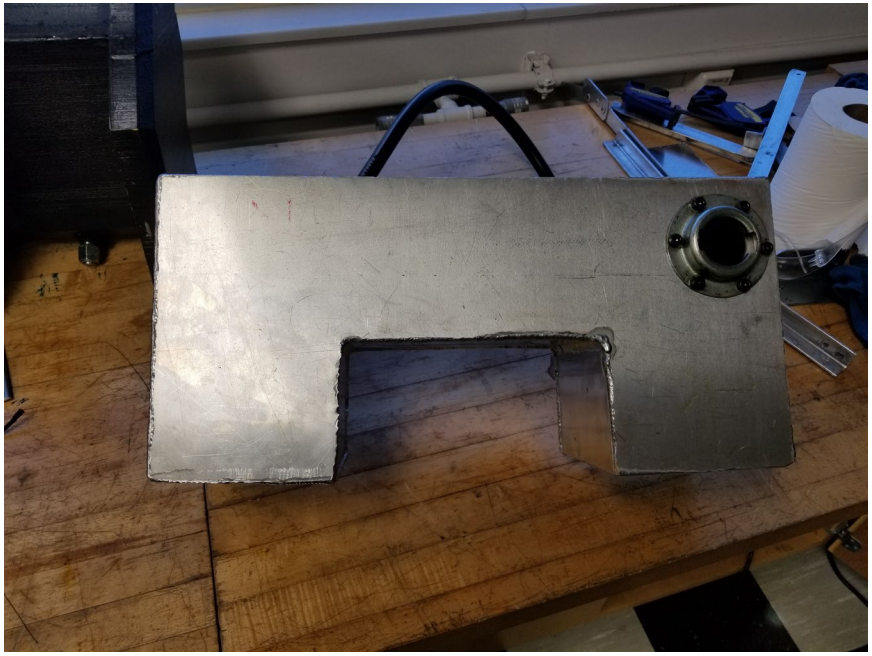


TOP



RIGHT

Completed Reservoir

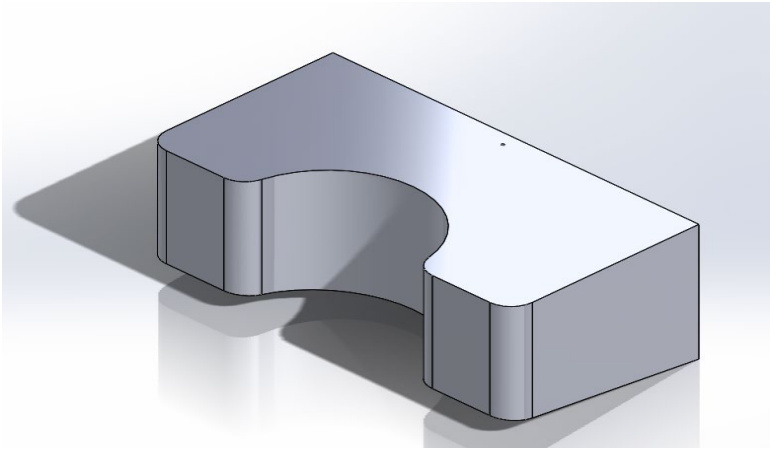


Reservoir Mounting

- Originally designed to mount around and protect the accumulator.
- Moved to the current location for the following reasons:
  - –Clearance for other components
  - –Lower center of gravity

Reservoir

- Metlflow would not quote a one off working prototype
- Aerosprot prototyping was able to make a one off prototype but the price was outside of what we could afford with our budget



Bill of Materials

Item (*Previous Inventory)	Cost	Total
(2) HF 16-21 Hand Pump*	$200	$400
Parker VOAC Bent-Axis Hydraulic Motor*	$2,230	$2,230
SteelHead MicroMax 1G	$600	$600
SteelHead MicroMax 2.5G*	$900	$900
Hosing and fittings	$705	$705
Rear Wheel	$130	$130
Bike Frame*	$250	$250
Misc	$1500	$1500
Cartridge Valves	Donation	Donation
Manifold	Donation	Donation
	Grand Total	**$6,715**

Ideas for Next Design

- Dynamic lever ratio using actuator to automatically adjust based on system pressure.
- Adding second motor to be used when a lower displacement would be called for, like efficiency race and even parts of the endurance race.
- Designing a clutch and new wheel

Lessons Learned

- If it works on paper it does not mean it works in reality. Math is only an indicator as to the real world.
- Testing is the most important part of design. Each step should be tested rather than waiting to test several things at once.
- Flexibility in design for failures. Nothing should be required to move forward.
- Never say “Oh, that will be easy”. It is a curse.

Thank You

- Nation Fluid Power Association
- Bimba (IMI)
- Jim Kaas, Industry Mentor
- Jeff McCarthy, Sunsource
- Ernie Parker
- Event Sponsors
- Bryant Harrison, Advisor
- The MSU Bike Team for getting us here