NFPA Fluid Power Vehicle Challenge

NFPA
Education and
Technology
Foundation

FINAL PRESENTATION
Murray State University
Bryant Harrison
3/1/2018

RACERS

Joe Irby

- Electromechanical Engineering Technology
- Graduating May 2018
- Electrical/Hydraulics/Calculations/Manufacturing

Kevin Mackie

- Electromechanical Engineering Technology
- Graduating December 2019
- Hydraulics/Calculations/Manufacturing

Grant McCuiston

- Manufacturing Engineering Technology
- Graduating December 2018
- Research/Testing/Cost Analysis

Cooper Lindberg

- Electromechanical Engineering Technology
- Graduating May 2019
- Steering/Wiring Systems

Evan Kellems

- Electromechanical Engineering Technology
- Graduating May 2019
- Reservoir Design Process and Construction

Kyle LeBarron

- Electromechanical Engineering Technology
- Graduating May 2018
- Reservoir Design Process and Construction

Joey Caldwell

- Electromechanical Engineering Technology
- Graduating December 2018
- Manufacturing

Problem Statement

We need to create a vehicle that can store hydraulic energy and release on demand while also being able to incorporate regenerative braking.

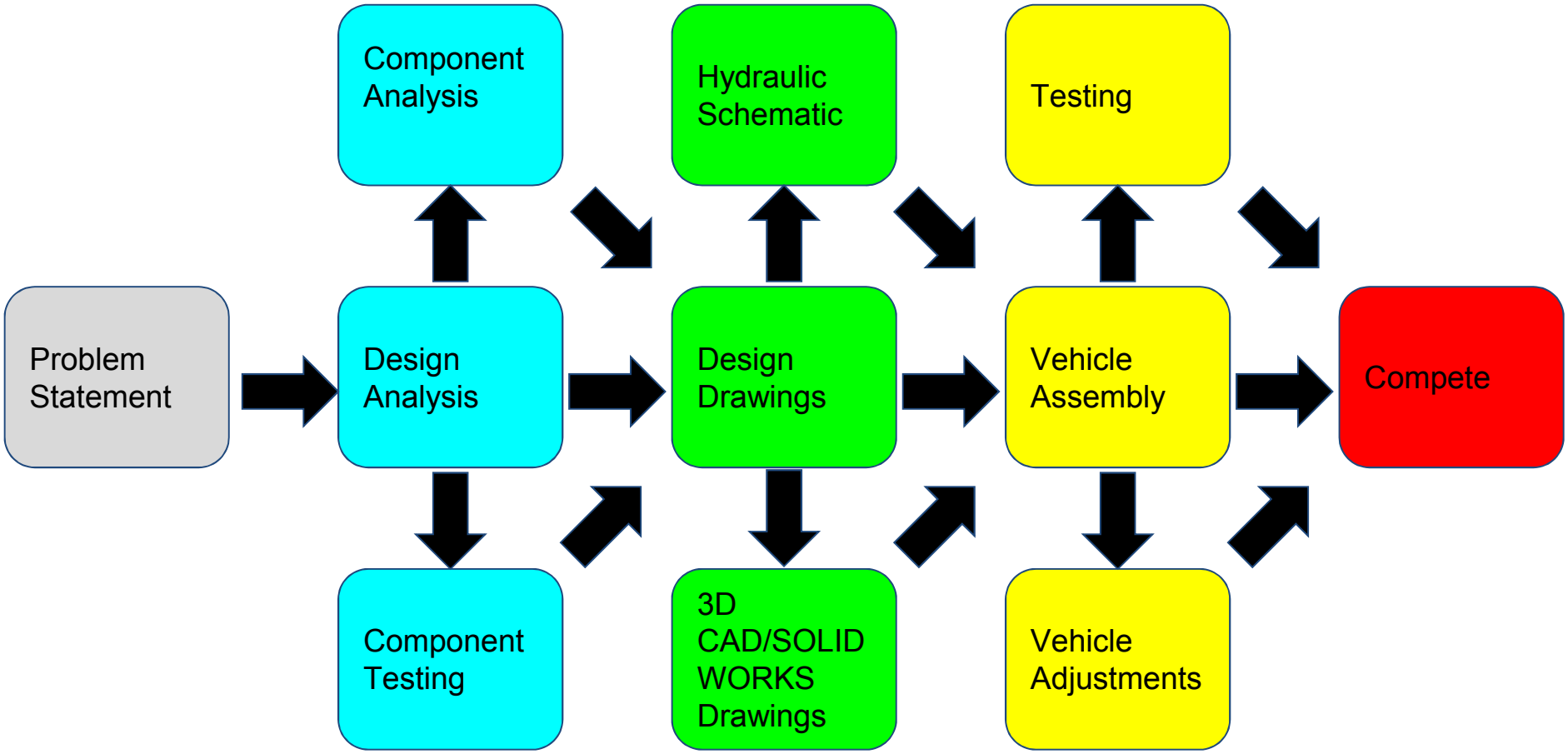
Midway PROTOTYPE

NFPA Fluid Power VEHICLE Challenge

Midway Problems

- Low mechanical advantage for pumping the accumulator to max pressure
- Reservoir needed to be vented
- Streamline connections
- Hydraulic motor created drag while coasting
- Electric clutch too complex to solve in time

Design Process

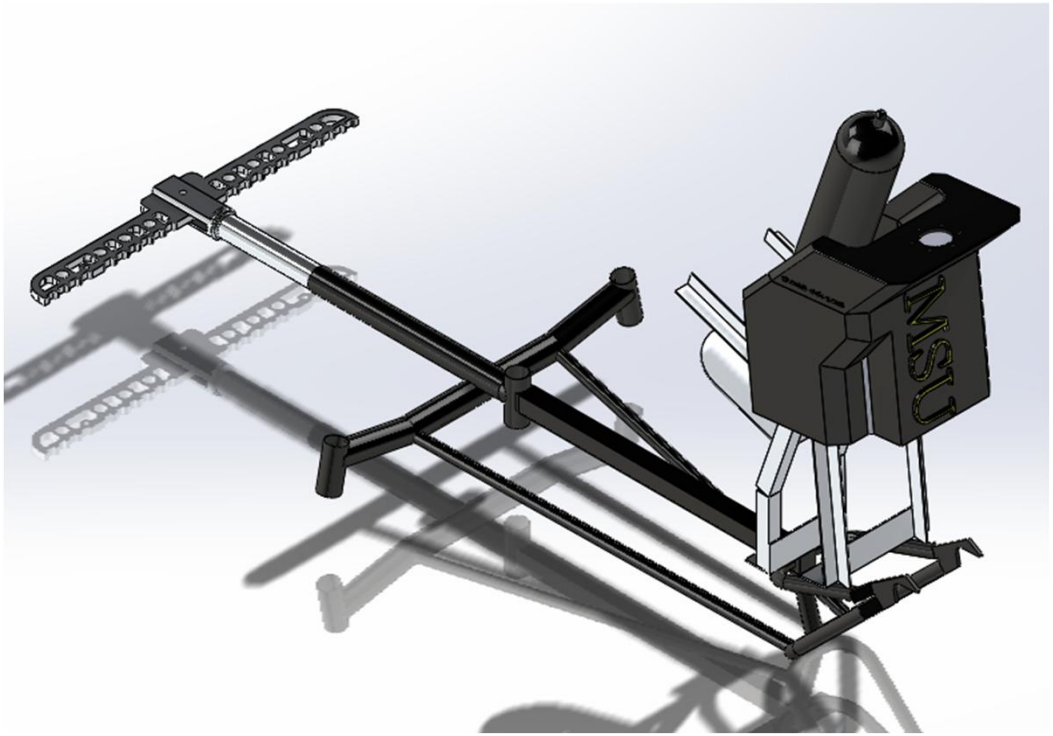


Vehicle Changes Since Midway

- Changed from leg mounted pumps to arm mounted hand pumps
- Steering with our legs
- Back pumps
- New reservoir

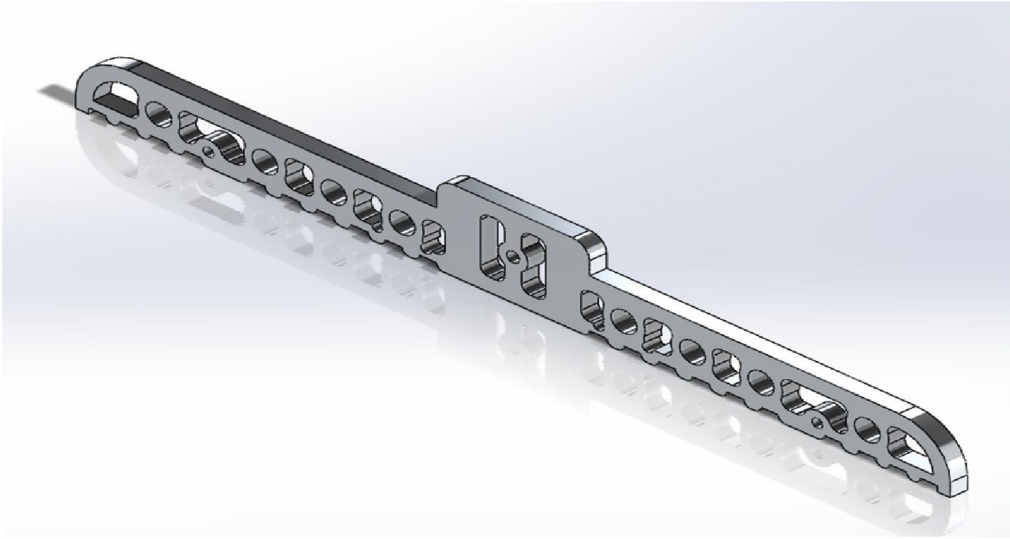
Vehicle Design and Construction

- Topics:
  - Steering System
  - Reservoir
  - Hydraulics
  - Accumulators
  - Hand Pumps



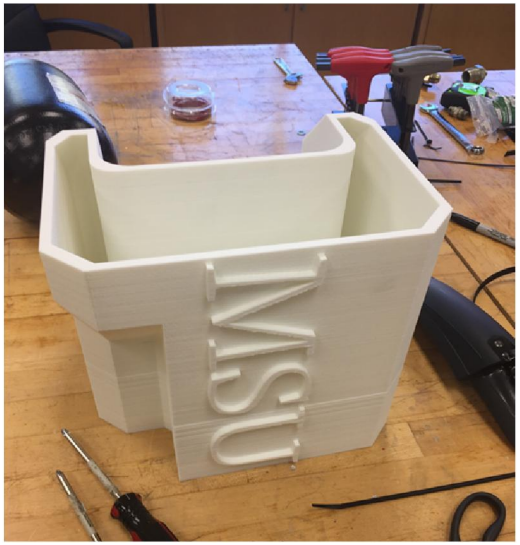
Steering System

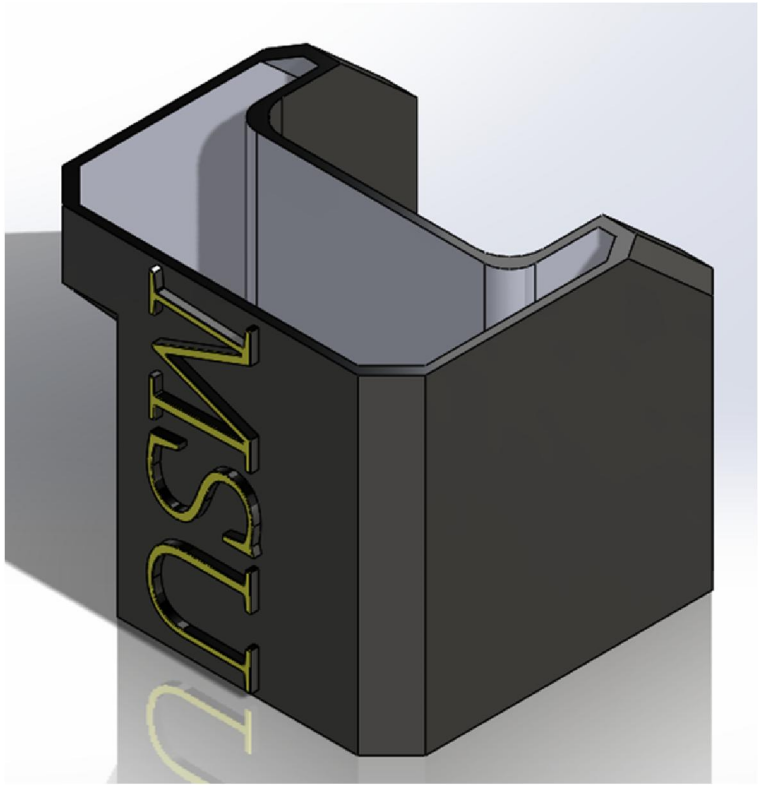
- Removed pumps
- Steering with legs
- Improved turn radius



First Reservoir

- Completely 3D printed
- Inside lined with resin
- Holds 2.25 gallons
- Hard to seal



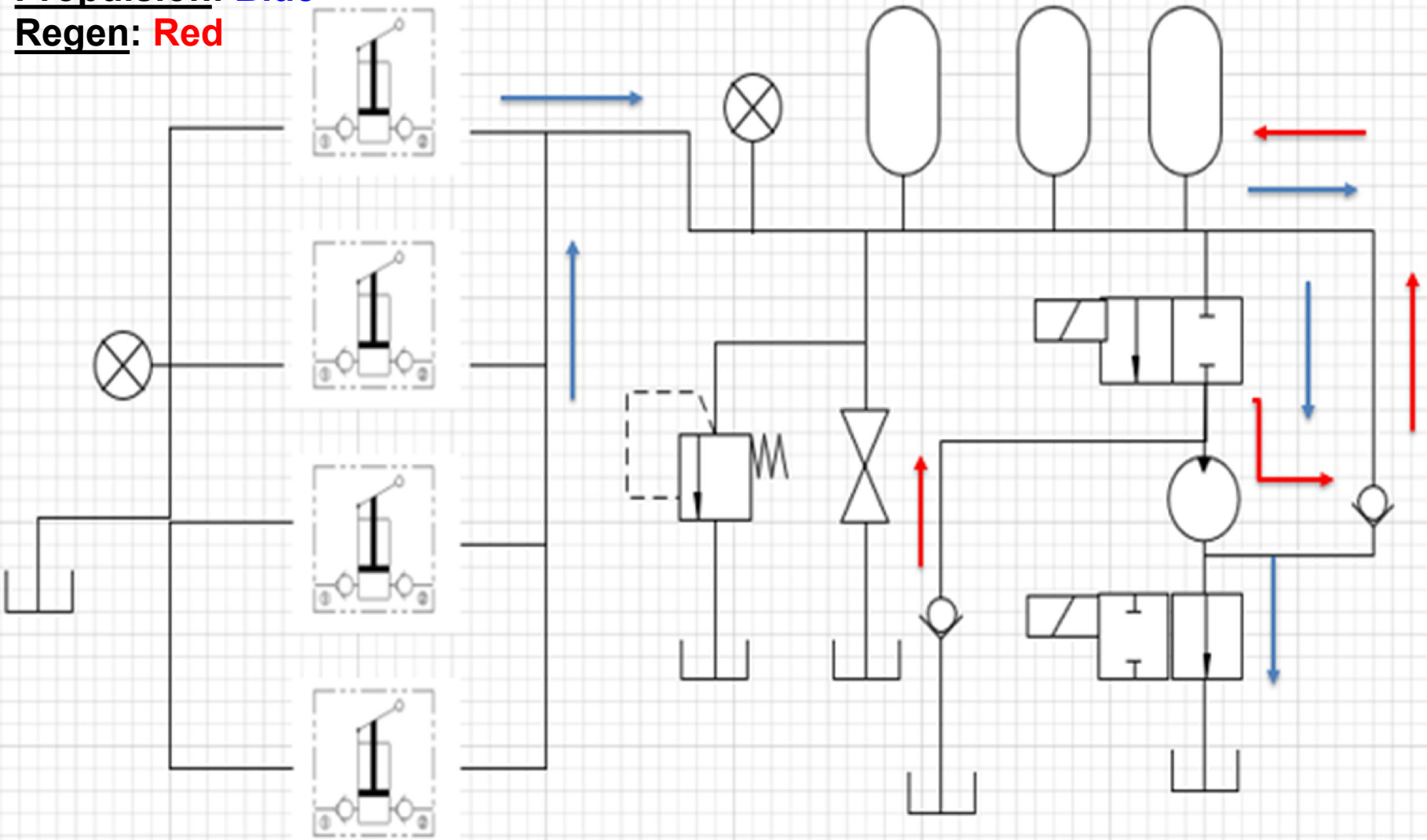


Final Reservoir

- Constructed out of PVC piping
- Holds 3.67 gallons of fluid
- Used a two tank system

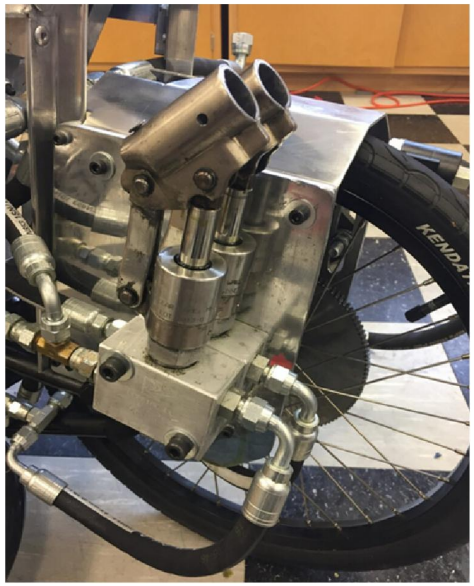
Hydraulics

Propulsion: Blue
Regen: Red



Hand Pumps

- Why hand pumps?
- What are the advantages?
- Placement of the pumps



Accumulators

- 3 Accumulators
  - Main Accumulator
    - 2.5-gallon
    - Carbon fiber
    - Weighs 14-lbs
    - Varying precharge
  - Extra Accumulators
    - Two .251-gallon
    - Weighs 10-lbs per accumulator
    - Fixed precharge

Vehicle Testing

Total Fluid (3 Accumulators)

Accumulator Type	Precharge (PSI)	Gallons (U.S.)	Max PSI	Divide by Max PSI	Nitrogen Level	Fluid per accumulator (Gallons)
Large Accumulator	900x	2.5	3,000	2,250/3,000	.75	2.5-.75= **1.75**
Small Accumulator	1,625x	.251	3,000	407.875/ 3,000	.136	.251-.136= **.115**
Small Accumulator	1,550x	.251	3,000	3389.50/ 3,000	.130	.251-.130= **.121**

Total Fluid Amount: 1.75+.115+.121= **2.21 Gallons**

Vehicle Testing

Total Volume (2 Reservoirs)

*Formula: PI(r^2)*Height = Volume in^3*

PI(3^2)*15” = 424 in^3 per reservoir

424 in^3*2 = 848 in^3

Convert the inches cubed into U.S. gallons..

848 in^3 * .0043290 = **3.67 gallons**

Efficiency and Lap Race Test Run Results

Determined our course lap was 0.13 mile.

Kyle's Efficiency Race Results: **Without pumping during test run**

Run 1: Precharge(900 PSI) = 4.25 laps in 3 mins 15 secs

Run 2: Precharge(525 PSI) = 4.5 laps in 3 minutes

Joe's Efficiency Race Results: **Without pumping during test run**

Run 1: Precharge(900 PSI)= 3.75 laps in 3 mins 30 secs

Run 2: Precharge(525 PSI)= 4.25 laps in 3 mins 22 secs

Sprint Race Test Run Results

Determined our course was 0.09 mile.

Drivers held button during race.

Kyle's Sprint Race Results: 165 lbs

➔ Run 1: Precharge(1,000 PSI) = 11.1 seconds

Joe's Sprint Race Results: 310 lbs

➔ Run 1: Precharge(1,000 PSI) = 11.5 seconds

Joey's Sprint Race Results: 240 lbs

➔ Run 1: Precharge(1,000 PSI) = 10.4 seconds

Cost Analysis

- HP 16-21 Hand Pump (x4) : $200.00 = **$600.00**
- MicroMax Bladder Accumulator: **$900.00**
- Parker VOAC Bent-Axis Hydraulic Motor: **$2,223.00**
- 2-Way, Spool Directional Control Valve: **$150.00**
- Parker Hydraulic Accumulator (x2): $240.30 = **$480.60**
- 50 ft of Parker Hydraulic Hose and Fittings: **$284.00**
- Bike Frame: **$250.00**
- 3D Printer Material: **$20.00**
- Misc. Expenses: **$200.00**

Total Material Cost: $5,107.60

Lessons Learned

1. More component testing should be completed before assembly process.

1. Incorporate electric clutch for free spinning without spinning the motor.

1. For more mechanical advantage we need longer lever arms to allow for easier pumping.

1. The center of mass is located too far back.

1. 3D printed material can lead to potential issues such as leaking.

Final Vehicle

Q&A

Questions?