



N F P A

***Fluid Power***

**=VEHICLE**

***Challenge***



NFPA  
Education and  
Technology  
Foundation

**FINAL PRESENTATION & DESIGN  
REVIEW  
SOUTH DAKOTA STATE UNIVERSITY  
TEAM ADVISOR: DOUG PRAIRIE  
DATE: 4/16/2026**



# Team Members



Jake Druley



Jacob Hinders



Gabe Nelson



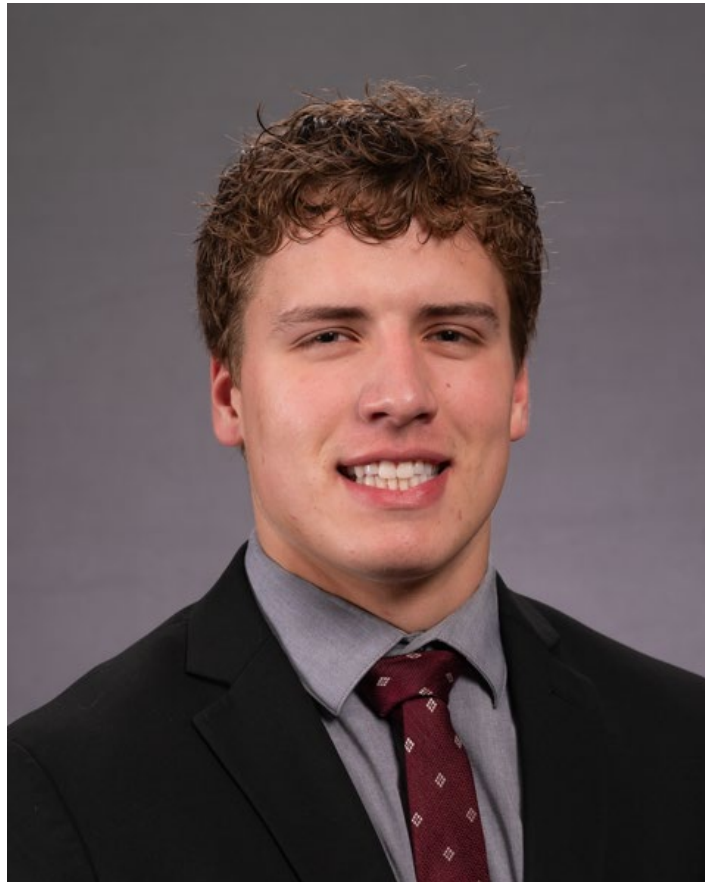
# Team Members



Carson Gunnerson



Michael Mackenthun



Anders Olsen



# Team Members



Cole Bisbee



Jake Heinrichs





# Design Objectives

- Optimized Hydraulic System
  - New, smaller displacement pump and motor
  - Less cluttered tubing
  - Resized Reservoir
- Cleaned up Electrical Circuit
  - Trimmed wires
  - Used better connectors
  - Rewired entire circuit
- Implementation of Pneumatic Circuit
  - 100 psi clutch
- Other Changes
  - Modified rear mounting panel to reduce weight and improve efficiency
  - Changed to more efficient gear ratios

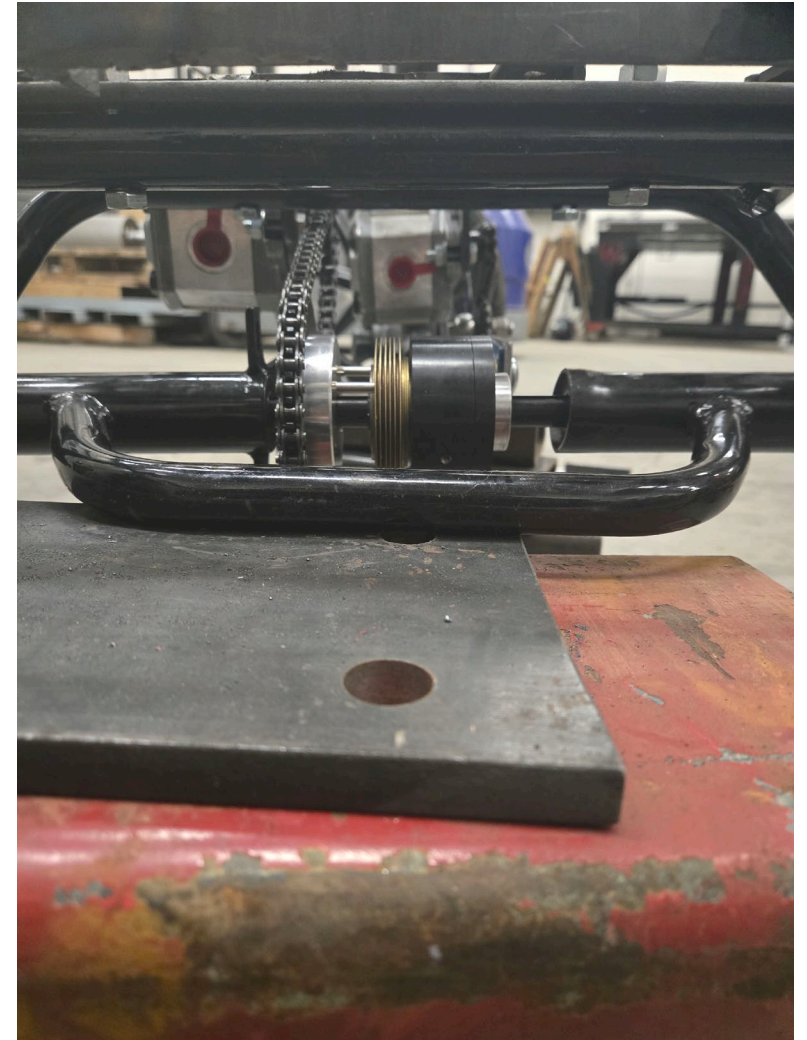


# Vehicle Construction



# Vehicle Testing

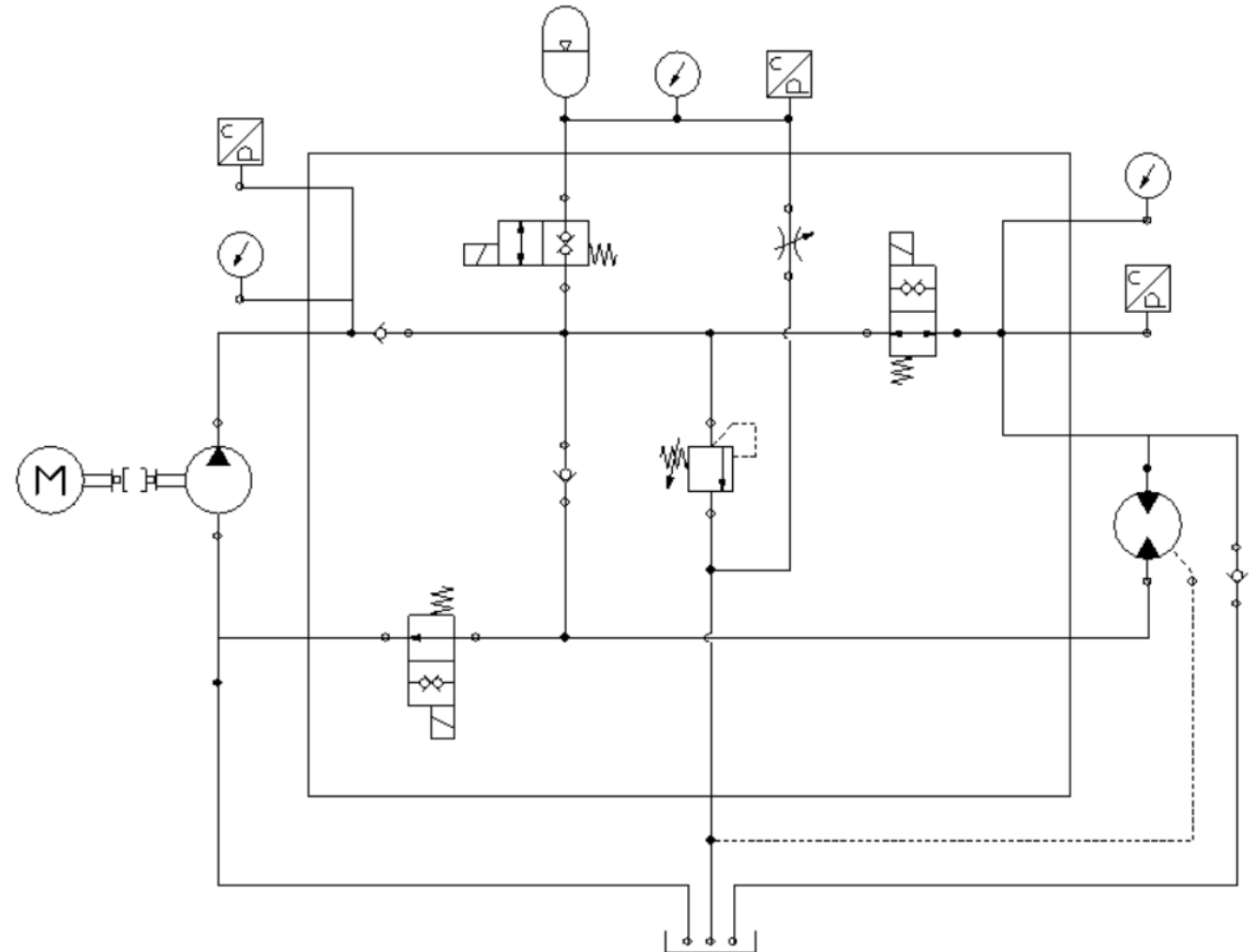
- Precharge - 800 psi
- Tested different gear ratios between pedal to pump and motor to rear axle
- Pneumatics / clutch testing
- Electrical testing





# Circuit and Manifold: New

- Planned to downsize ports and switch from spool valves to poppet valves
- Planned for a pressure-loss optimization year
- Optimized line sizing
- Removed needle valve for reverse in favor of pneumatically actuated clutch
- Still allows for regenerative braking



# Calculations



## Pump Calculations

| Torque required to run NEW pump |               | OLD pump    |        |
|---------------------------------|---------------|-------------|--------|
| displacement                    | 0.0854 in/rev |             | in/rev |
|                                 | 1.40 cc       | 2.8 cc      |        |
| pressure differential           | 800 psi       | 800 psi     |        |
|                                 | 55.17 bar     | 55.17 bar   |        |
| pump eff                        | 0.85          | 0.85        |        |
| input torque                    | 1.38 Nm       | 2.76 Nm     |        |
|                                 | 1.02 ft lbf   | 2.04 ft lbf |        |
| pump input ratio                | 6.4           | 4           |        |
| Pump input torque               | 6.52 ft lbf   | 8.15 ft lbf |        |

## Gear Ratios

|            |         |
|------------|---------|
| Crank Gear | 64      |
| Pump Gear  | 10      |
| Ratio      | 1 : 6.4 |

|            |          |
|------------|----------|
| Motor Gear | 14       |
| Axle Gear  | 36       |
| Ratio      | 2.57 : 1 |

## Resizing Reservoir

| Enter Pipe Diameter and Length   |                  |
|----------------------------------|------------------|
| Pipe Diameter (in)               | Pipe Length (ft) |
| 3/8                              | 20               |
| 0.375                            | 240              |
| Pipe Capacity                    |                  |
| Cubic inches                     | 26.51            |
| US Gal                           | 0.11             |
| Max Oil Capacity for Accumulator |                  |
| US Gal                           | 0.61             |
| Max Oil Capacity for Manifold    |                  |
| US Gal                           | 0.0625           |
| Max Oil Capacity for Pump        |                  |
| US Gal                           | 0.02             |
| Max Oil Capacity for Motor       |                  |
| US Gal                           | 0.02             |
| Total Max Oil Capacity           |                  |
| US Gal                           | 0.83             |
| Reservoir Size                   |                  |
| US Gal                           | 0.99             |
| Cubic inches                     | 229.58           |
| with 20% free space              | 275.50           |
| Dimension Options                |                  |
| 8in x 8in x                      | 4.30             |
| 6in x 6in x                      | 7.65             |
| Cube                             | 6.51             |

## Pneumatic Clutch Calculations

|                   |         |        |
|-------------------|---------|--------|
| Max output torque | 18.7567 | ft-lbf |
|                   | 225.081 | in-lbf |
| Max RPM at axle   | 256.303 | rpm    |

# Transmission Calculations

## 2024-2025



Gearbox Output Speed \* (Input Gear/Output Gear)= Output Gear RPM

| P1.6 | Gearbox Ratio | gearbox output speed RPM | Pump Rpm | motor rpm | rear axle rpm | ground speed ft/min | rider input rpm | mph   |
|------|---------------|--------------------------|----------|-----------|---------------|---------------------|-----------------|-------|
| 1    | 1.05          | 84                       | 336      | 152.41    | 57.15         | 388.64              | 80.00           | 4.42  |
| 2    | 1.32          | 105.6                    | 422.4    | 191.60    | 71.85         | 488.58              | 80.00           | 5.55  |
| 3    | 1.61          | 128.8                    | 515.2    | 233.69    | 87.64         | 595.92              | 80.00           | 6.77  |
| 4    | 2.04          | 163.2                    | 652.8    | 296.11    | 111.04        | 755.08              | 80.00           | 8.58  |
| 5    | 2.5           | 200                      | 800      | 362.88    | 136.08        | 925.34              | 80.00           | 10.52 |
| 6    | 3.13          | 250.4                    | 1001.6   | 454.33    | 170.37        | 1158.53             | 80.00           | 13.17 |

## 2025-2026

Gearbox Output Speed \* (Input Gear/Output Gear)= Output Gear RPM

| P1.6 | Gearbox Ratio | gearbox output speed RPM | Pump Rpm | motor rpm | rear axle rpm | ground speed ft/min | rider input rpm | mph   |
|------|---------------|--------------------------|----------|-----------|---------------|---------------------|-----------------|-------|
| 1    | 1.05          | 78.75                    | 504      | 204.12    | 79.38         | 539.78              | 75.00           | 6.13  |
| 2    | 1.32          | 99                       | 633.6    | 256.61    | 99.79         | 678.59              | 75.00           | 7.71  |
| 3    | 1.61          | 120.75                   | 772.8    | 312.98    | 121.72        | 827.67              | 75.00           | 9.41  |
| 4    | 2.04          | 153                      | 979.2    | 396.58    | 154.22        | 1048.72             | 75.00           | 11.92 |
| 5    | 2.5           | 187.5                    | 1200     | 486.00    | 189.00        | 1285.20             | 75.00           | 14.60 |
| 6    | 3.13          | 234.75                   | 1502.4   | 608.47    | 236.63        | 1609.07             | 75.00           | 18.28 |



# Lessons Learned

- Pneumatics
  - None of us have worked with pneumatics before
- Electrical circuit / wiring
- Dealing with lead times
- Pressure loss effects
- New rims / tires / axle

Questions?