NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
UNIVERSITY OF CINCINNATI
DR. MUTHAR AL-UBAIDI
APRIL 2023

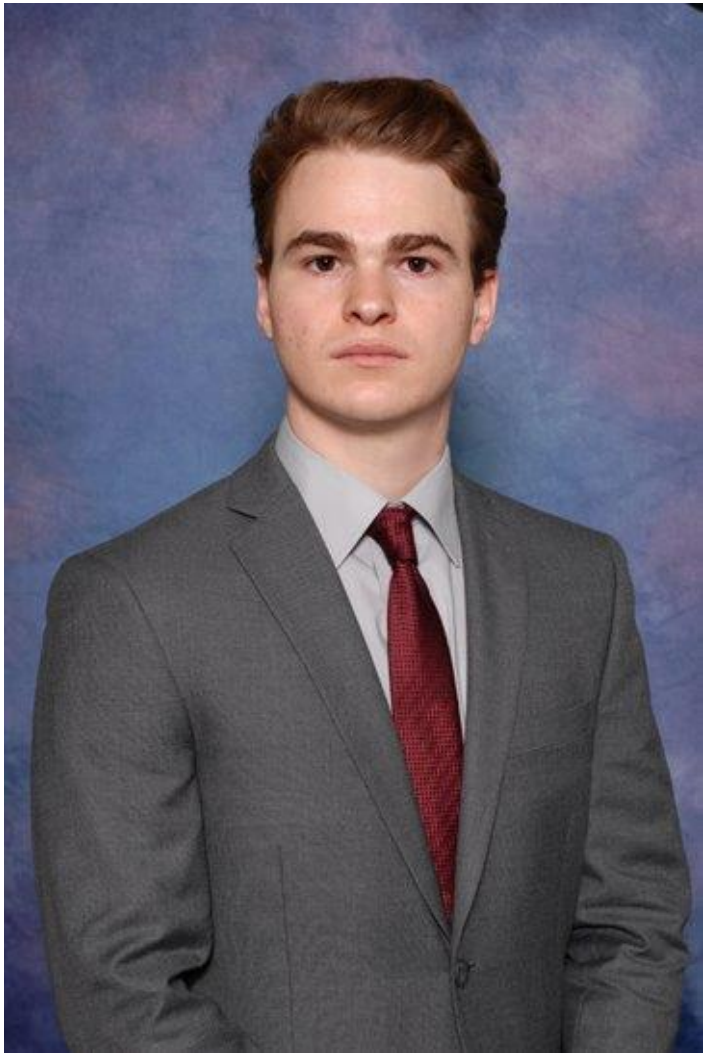
Agenda

- Team Introductions
- Project Goals/Objectives
- Design Recap
- Troubleshooting and Design Modifications
- Results/Analysis
- Lessons Learned
- Questions

Team Introductions

AJ Fisher

- Positions
  - Controls Lead
  - Calculations
  - Fluid Power Club President
- Hometown
  - Marysville, Ohio
- Education & Work Experience
  - 5th year Mechanical Engineering Technology Student at University of Cincinnati
  - Pursuing Master of Engineering in Additive Manufacturing
  - 2 Co-op rotations as Product Design Engineer at Hamilton Caseworks
  - 2 Co-op rotations as Building Systems Engineer at Messer Construction
  - 1 Co-op Rotation as Manufacturing Engineer at Hubbell Inc.
- Interests
  - Golf
  - Manufacturing and machining



Jacob Hasl

- Positions
  - Lead Frame Design and Hydraulic Design
  - Fabrication and Assembly
- Hometown
  - Lancaster, Ohio
- Education & Work Experience
  - 5th year Mechanical Engineering Technology Student
  - Minor in Materials Engineering
  - Certified SolidWorks Expert
  - 2 co-ops as a Manufacturing Engineer
  - 2 co-ops as a Laboratory Testing Technician
  - 1 co-op as a CAD designer
- Interests
  - Research and development of new products
  - Boating
  - Snowboarding

Jack Mikula

- Positions
  - Fabrication and Assembly Lead
  - Frame Design and Machinist
  - Fluid Power Club Treasurer
- Hometown
  - Fort Mitchell, Kentucky
- Education & Work Experience
  - 5th year Mechanical Engineering Technology at University of Cincinnati
  - Minor in Materials Engineering
  - 5 Co-op Rotations at Specialty Manufacturing Solutions
- Interests
  - CNC Machining
  - Figuring out how things work
  - Fishing

Will Pascol

- Positions
  - Controls/Electrical
  - Fabrication and Assembly
  - Fluid Power Club Secretary
- Hometown
  - Columbus, Ohio
- Education & Work Experience
  - 5th year
    Mechanical Engineering Technology at University of Cincinnati
  - 3 Co-op rotations at Makino CNC as a Field Service Engineer
- Interests
  - CNC Machining
  - Rollercoaster engineering

Evan Wise

- Positions
  - Project Manager
  - Fabrication and Assembly
  - Fluid Power Club Vice President
- Hometown
  - Dayton, Ohio
- Education & Work Experience
  - 5th year Mechanical Engineering Technology at University of Cincinnati
  - Minor in Materials Engineering
  - 2 Co-op Rotations at ADVICS Manufacturing Ohio, Inc
  - 3 Co-op Rotations at Valco-Melton
- Interests
  - Watching football and hockey
  - 3D-Printing
  - Dungeons and Dragons

Muthar Al-Ubaidi, PhD

- **Professor and Director Mechanical Engineering Technology Program**
- **Education**
  - B.S. Mechanical Engineering, University of Baghdad
  - Masters Nuclear Engineering, University of London
  - PhD Nuclear Engineering, University of Cincinnati
- **Hometown**
  - Baghdad, Iraq
  - Came to Cincinnati, USA in 1978
- **Project Team**
  - Faculty Advisor

Industry Mentor

Assigned Mentor

- Dan Turner of GPM Controls
  - Hydraulic expert
  - Reviewed calculations
  - Offered opinions and input
  - Assisted with concept creation

GPM Controls

Don't just go with the flow... Control it!

Goals/Objectives

Vehicle Objectives

Project Measurables

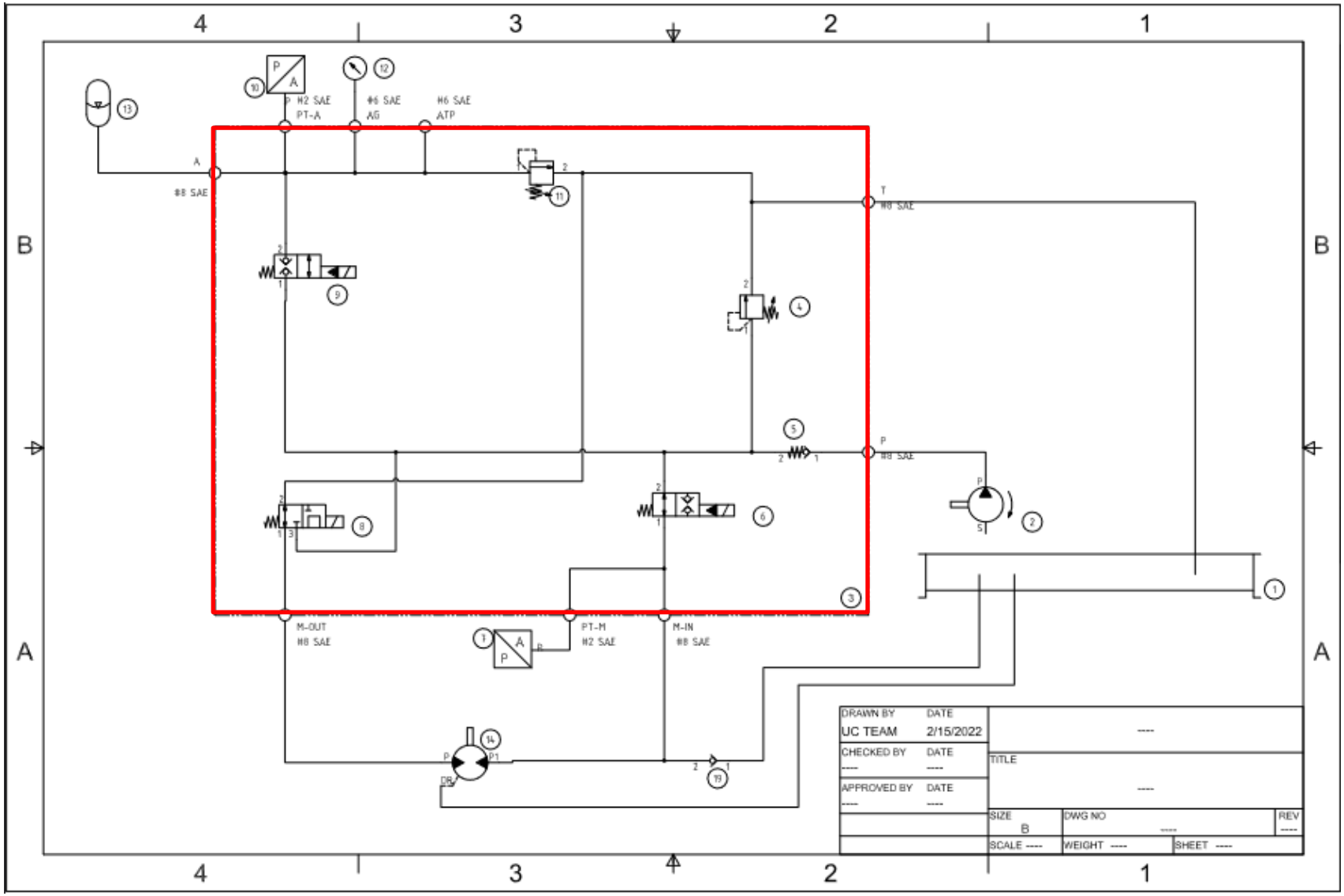
- Obtain a top speed of between 15-20 MPH
- Maximize accumulator efficiency
- Design a proper regenerative braking system

Targeted Areas for Improvement

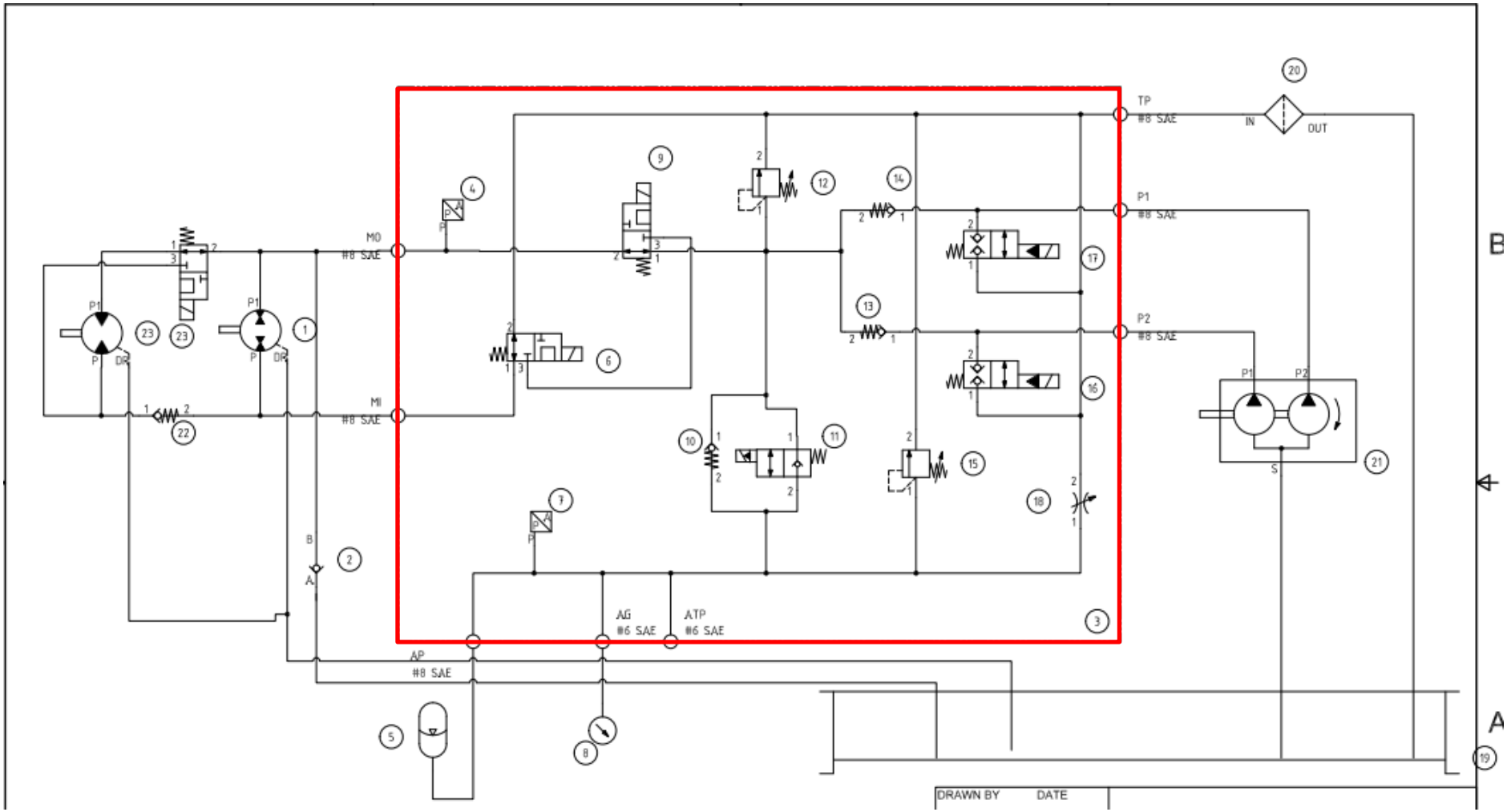
- Easier pedaling and increased pump RPM through improved gear ratio
- Simplified electrical and hydraulic system
- Improved organization of components, wiring, and tubing

Design Recap

Fluid Circuit 2023 Design

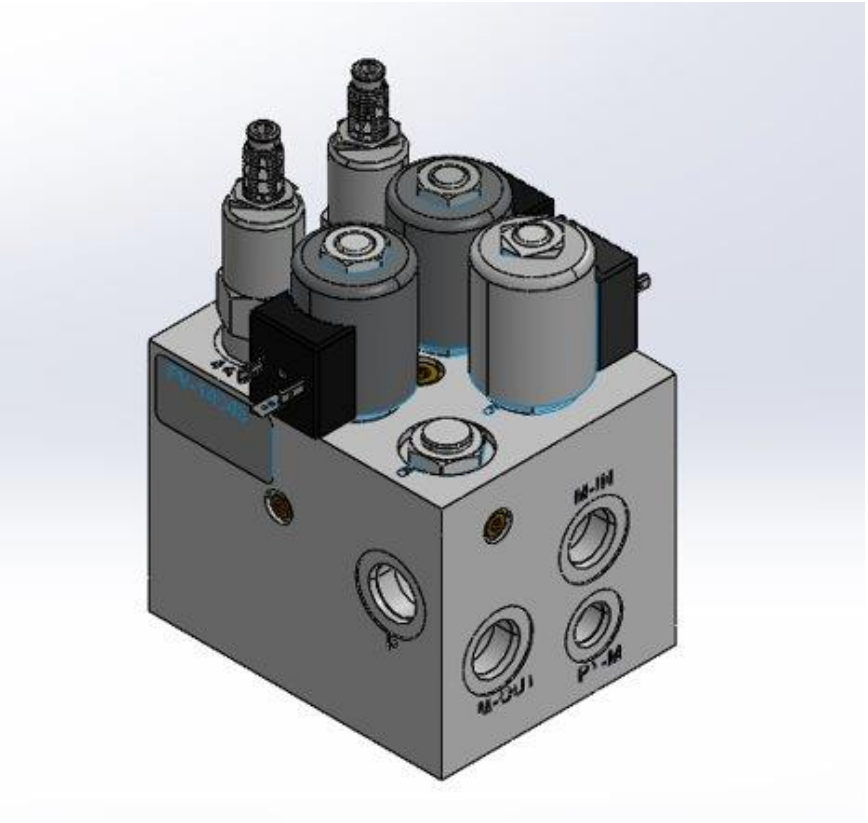


Fluid Circuit 2022 Design



Manifold

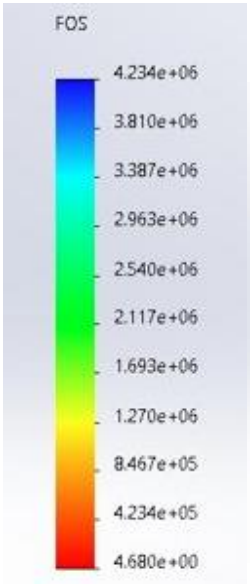
- Manifold designed by Sunsource with help from Jeff McCarthy, Dan Turner, and Ernie Parker



Controls

- Utilizes a series of toggle switches to manipulate solenoid valve positioning
- Diagram on cover displays which switches should be activated for each drive mode

Frame


FOS
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3.810e+06
3.387e+06
2.963e+06
2.540e+06
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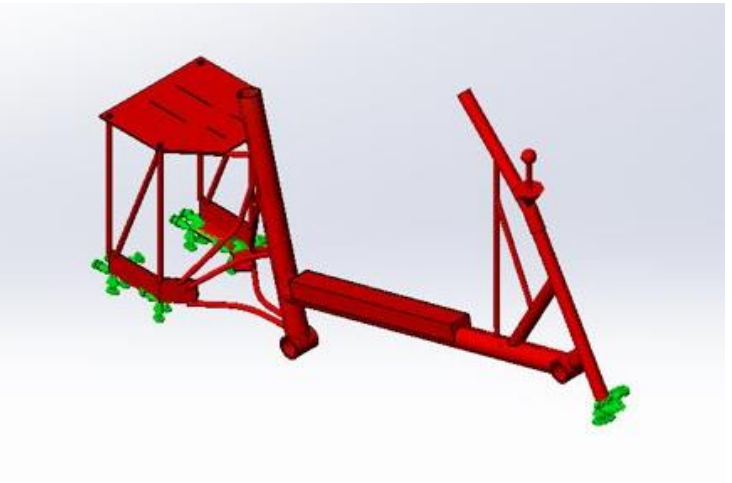


Results and Analysis

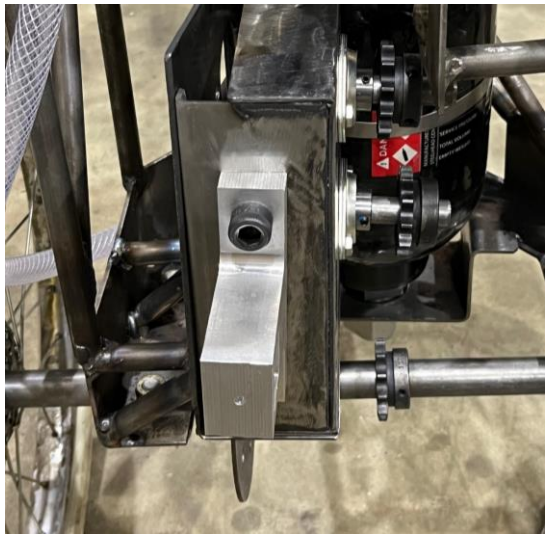
2022 vs 2023 Testing Data

Testing Data				
Team	Top Direct Drive Speed (MPH)	Top Direct Drive Speed (FPS)	Time to Top Direct Drive Speed (s)	Time to Max Accumulator Charge
2022	9.67	14.18	38.7	3:38
2023	5.66	8.31	19.5	1:47

Troubleshooting and Design Modifications

Major Hurdles

- U-Joint
  - The U-Joint was failing to grab on to the steering column and was causing slipping on the shaft making the steering not work correctly.
- Derailer/Gearbox
  - Alignment with the chain and different gears caused our original shifting idea not to work. Also, due to the chain we used, the derailer did not have enough force to move the chain.
  - Original plan was to use shifter cable to move a gear in and out but the cable kept snapping. To solve this issue, we wired in a linear actuator to move the gear. The linear actuator proved to be unreliable.



Major Hurdles

- Main Sprocket
  - Chain was not gripping correctly on the waterjet sprocket we had made. In addition, there was too much torque needed to rotate the sprocket.

- Controls
  - Original plan was to use CoDeSys controller
  - After troubleshooting multiple issues, it was decided to use toggle switch system for competition

Lessons Learned

Key Learnings

Learning: Having a large gear ratio to the pump causes the torque requirement to be too high.

Solution: Decrease the gear ratio from pedal to pump, raise ratio from motor to driveshaft.

Learning: Set screws are an ineffective fastener in high torque applications

Solution: Utilize torsion pins and keyways for securing moving components such as sprockets.

Learning: It is desirable to have a pump with a displacement greater than or equal to your motor

Solution: Use a smaller motor or larger pump if the system is too inefficient.

Thanks, Questions?

NFPA Fluid Power Vehicle Challenge