NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
KENNESAW STATE UNIVERSITY
DRS. RUHALA
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KENNESAW STATE UNIVERSITY

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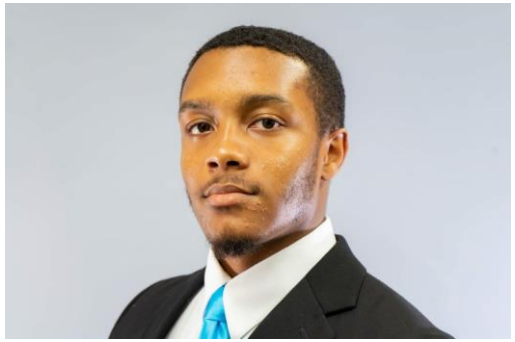
Introduction

- Senior design capstone project team, not an NFPA club.
- We are new to hydraulics, with only the required fluids class as our reference.
- None of our faculty focus on Fluid Power, our advisors have different focuses.
- 2nd KSU team to try this, after the 2018-2019 team.

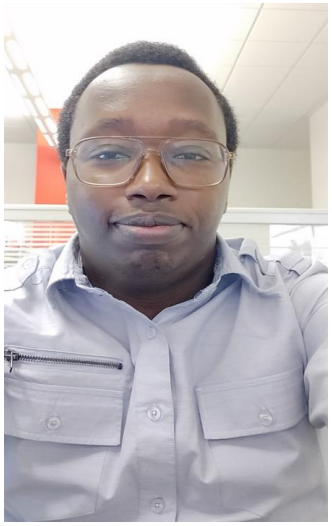
Team Members



Romeo Locke (PM)
Senior – BSME

Will Sanders
Senior – BSME

Sahil Pitre
Senior – BSME



Kevin Wandene
Senior – BSME

Team Advisors

Laura Ruhala Ph.D.
Team Advisor
Associate Professor
Kennesaw State University

Richard Ruhala Ph.D.
Team Advisor
Professor
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Kevin Lingenfelter
Engineering Manager
Danfoss Power Solutions
KSU Mentor

Design Objectives

- Design must meet the constraints of the FPVC
  - Hydraulic and Human Powered
  - Pneumatics and Regenerative Braking Required
- The vehicle must be able to compete in and complete 3 events
  - Sprint, Endurance, and Efficiency challenges.
- Design a safer and more stable vehicle
  - Compared to previous KSU FPVC Team.
- Remain under the assigned FPVC budget
  - Only competition funds are provided.

Design Goals

- **Safety** - of rider, builders and others.
- **Durability** – ability to endure multiple test rides and competition events.
- **Reliability** – no breakdowns or leaks.
- **Stability** – especially for slalom course, and when stopped, increases safety.
- **Weight savings**– light bike, light materials, light rider.
  - 160 lbs. without hydraulic fluid
- **Simplicity** – aiming for simple, efficient & easy to maintain design.

Summary of Midway

Vehicle Frame - Selection

Tricycle

(2 rear wheels)

Summary of Midway

Vehicle Frame - Assembly

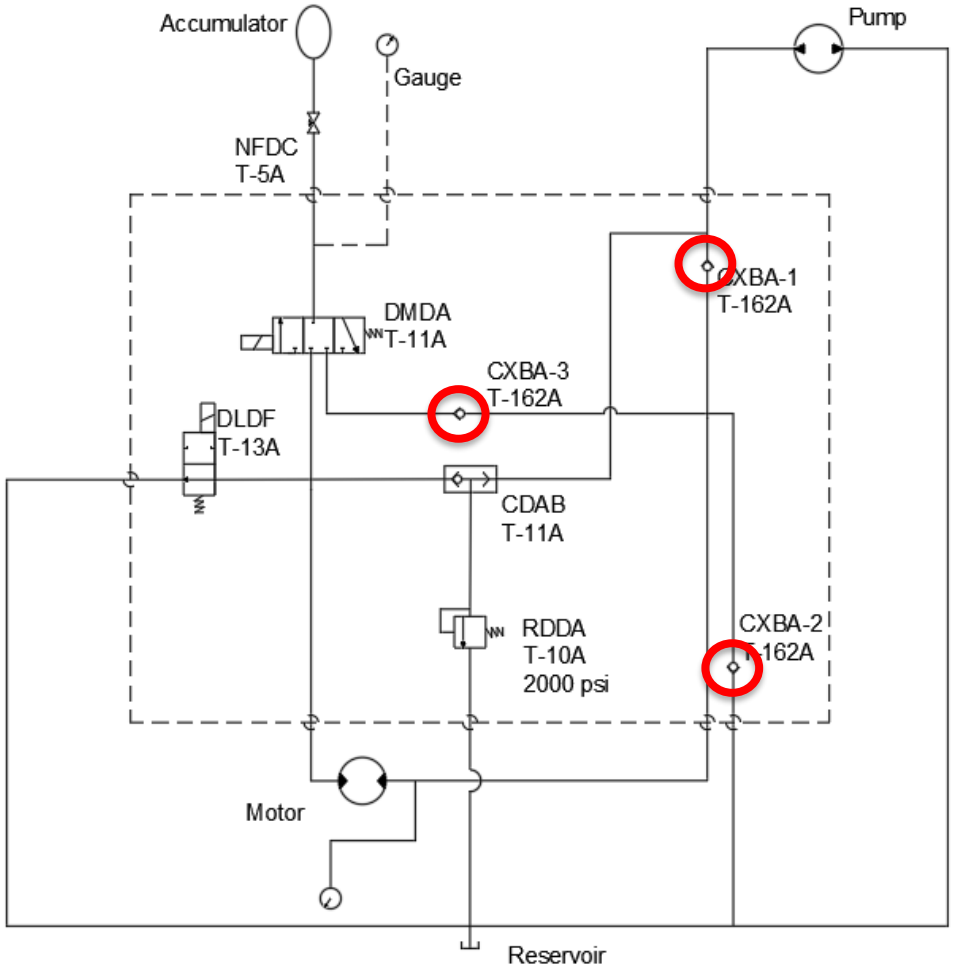
Summary of Midway

Early Analyses Results

- Hydraulics
  - .513 CID pump and .513 CID motor
- Pneumatics
  - We wanted a 7/8 in bore size at 30 psi with a 3/8 in rod diameter.

Summary of Midway

Hydraulic Schematic

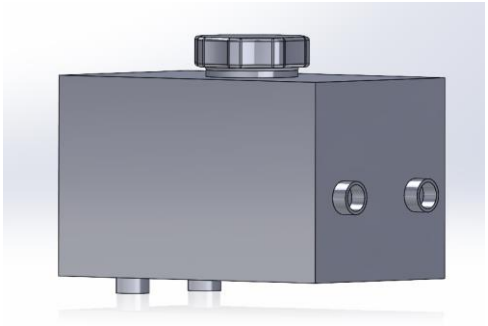


Bill of Materials	
Pressure Relief valve	1
Needle valve	1
3 pos 3-way 24V sol valve	1
2 pos 2-way 24V sol vale	1
Check valve	3
Shuttle valve	1
Pump (.513 CID)	1
Motor (.513 CID)	1
Accumulator (1 gal)	1
Reservoir (Self made)	1

Summary of Midway

Component Selection- Hydraulics

1 Gallon



Reservoir

Manifold

Danfoss Gear Pump

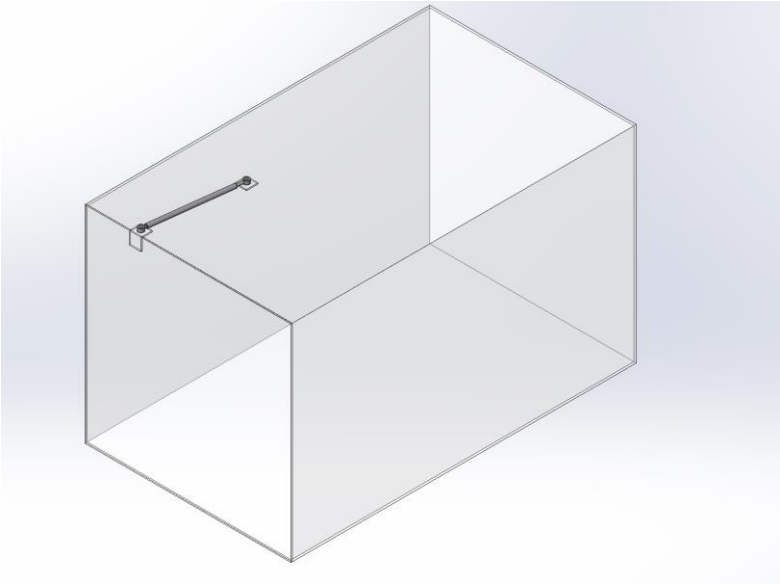
Traditional Trike

Danfoss Gear Motor

Summary of Midway

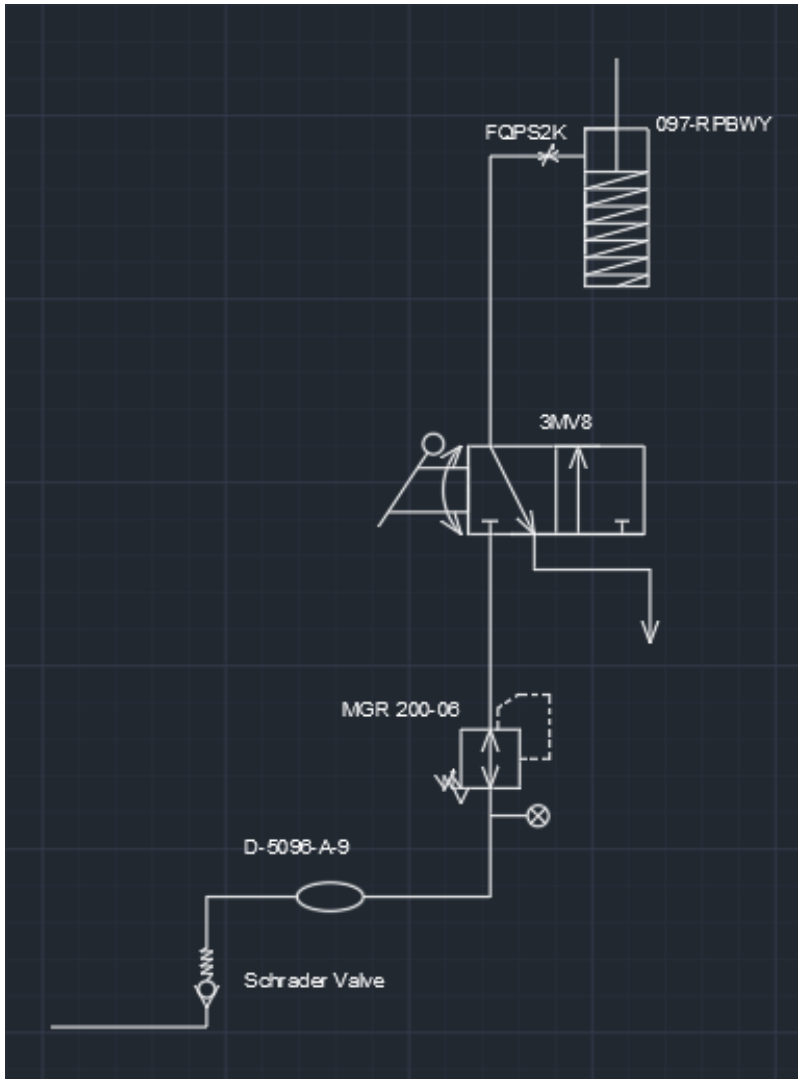
Pneumatic Objective

- Objective
  - Keep a door closed using pneumatic pressure and have spring open door when necessary.



Summary of Midway

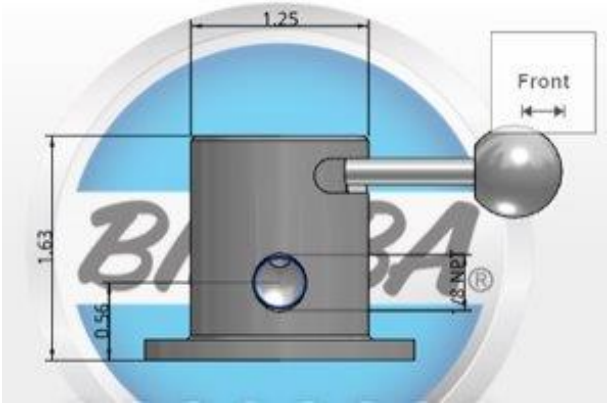
Pneumatic Schematic



Summary of Midway

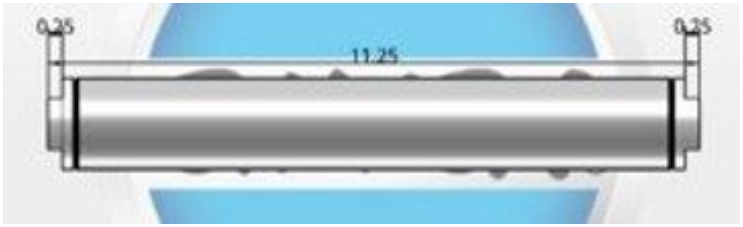
Component Selection – Pneumatics

Air Cylinder



Valves

Shrader Valve



Air reservoir

Summary of Midway

Component Selection – Pneumatics

Regulator

Flow Control

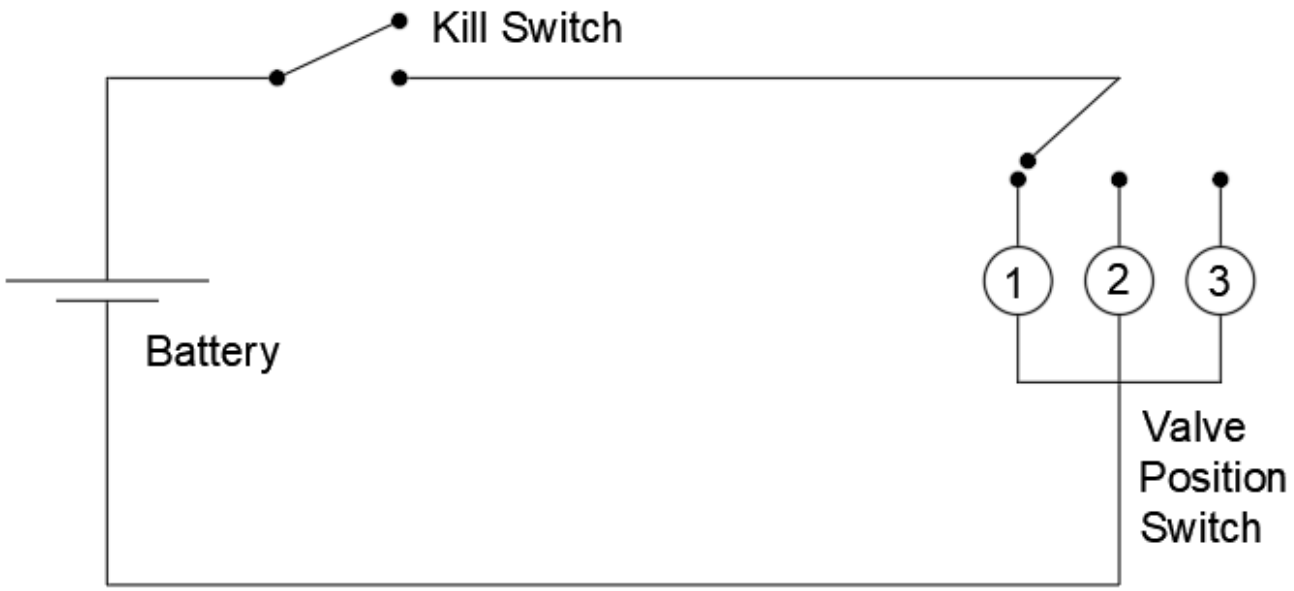
Cylinder mounting

Rod Mounting

Pnuematic Changes

- Actuator
  - Before: 7/8 in bore size and 3/8 in diameter rod @ 30 psi
  - After: Power factor of 09 & 7 inch stroke @ 20 psi
- Reservoir
  - Before: Was not measured.
  - After: 9 inch and 1.5 inch diameter

Electronic Circuit Schematic



1 = Valve 1 Activated
2 = No Valves Activated
3 = Valve 2 Activated

Electronic Selection

2-way switch

3-way switch ON-OFF-ON

Spade connectors

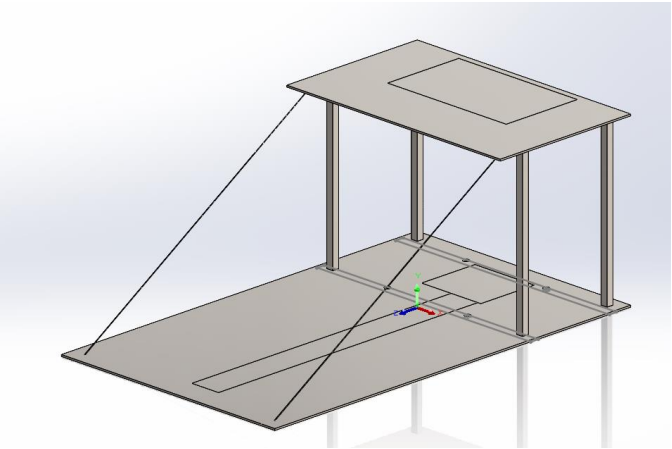
Battery

18 AWG wire

Analyses

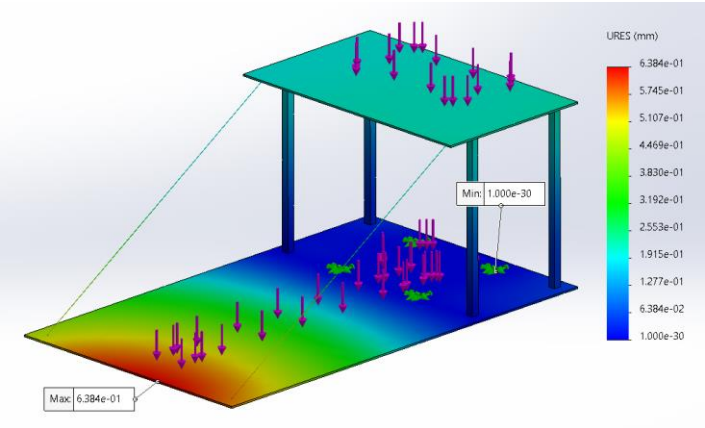
Sub - Assembly	Component	Hand Calculations	CAE (Computer Aided Engineering)	Completed Analysis
Fluid power schematic	Fluid power Schematic		Hopsan	✓
Hydraulic Components	Motor	Sizing calculations		✓
	Pump	Sizing calculations		✓
Pneumatic Components	Air Cylinder & Reservoir	Sizing Calculations		✓
Vehicle	Vehicle with components		CFD	X
	Gear train	Gear Ratios		✓
	Frame		FEA	X
	Mounts		FEA	✓
Fluid power schematic & Vehicle	Both Subassemblies		Simscape™	X

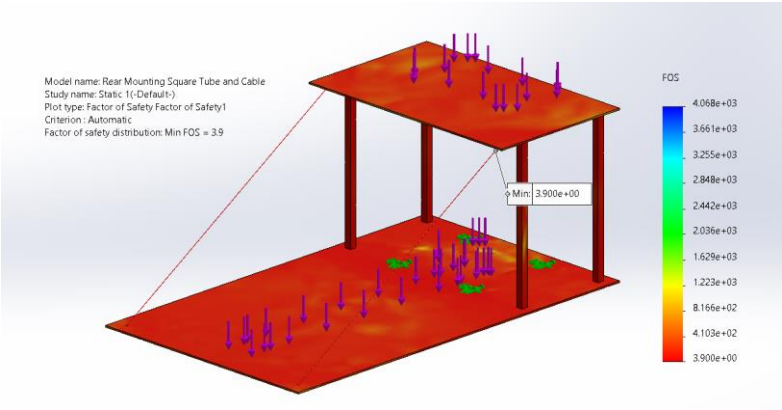
Analyses -
Mounting Manifold



We were originally going to use ¼” steel plate.

After CAE, found that 1/8” steel plate would still work, while providing weight savings of **26.4 lbs.**





Vehicle Construction & Assembly

- Polycarbonate shielding and reservoir

Vehicle Construction & Assembly

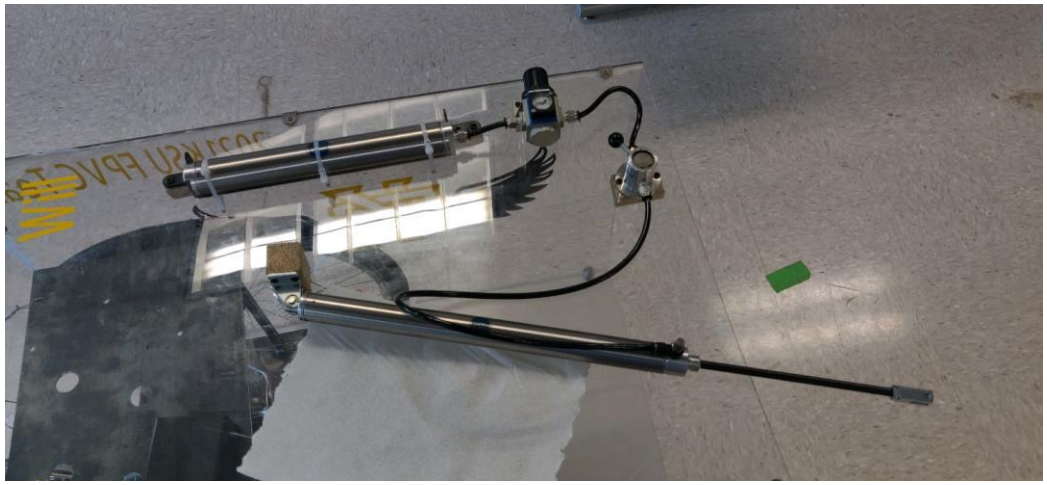
- Hose routing

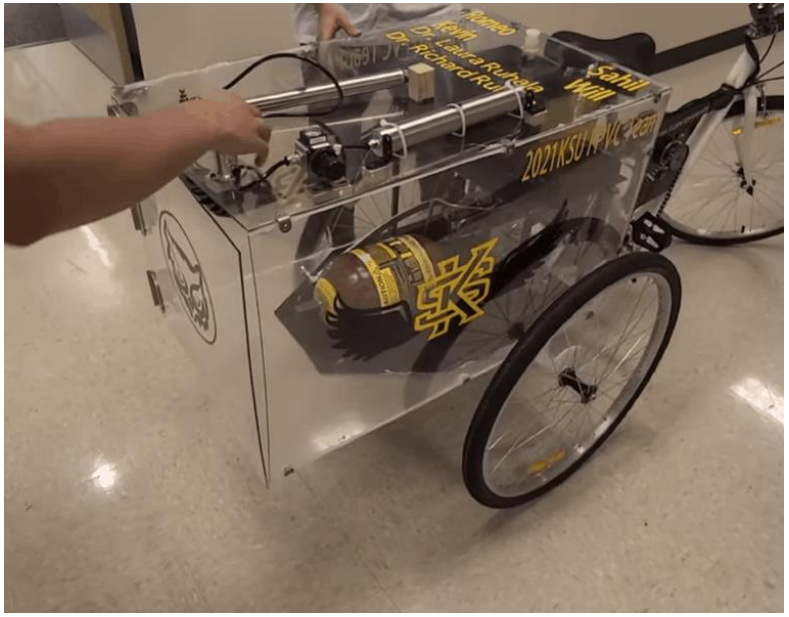
Vehicle Construction & Assembly

- Sheet metal

Vehicle Construction & Assembly

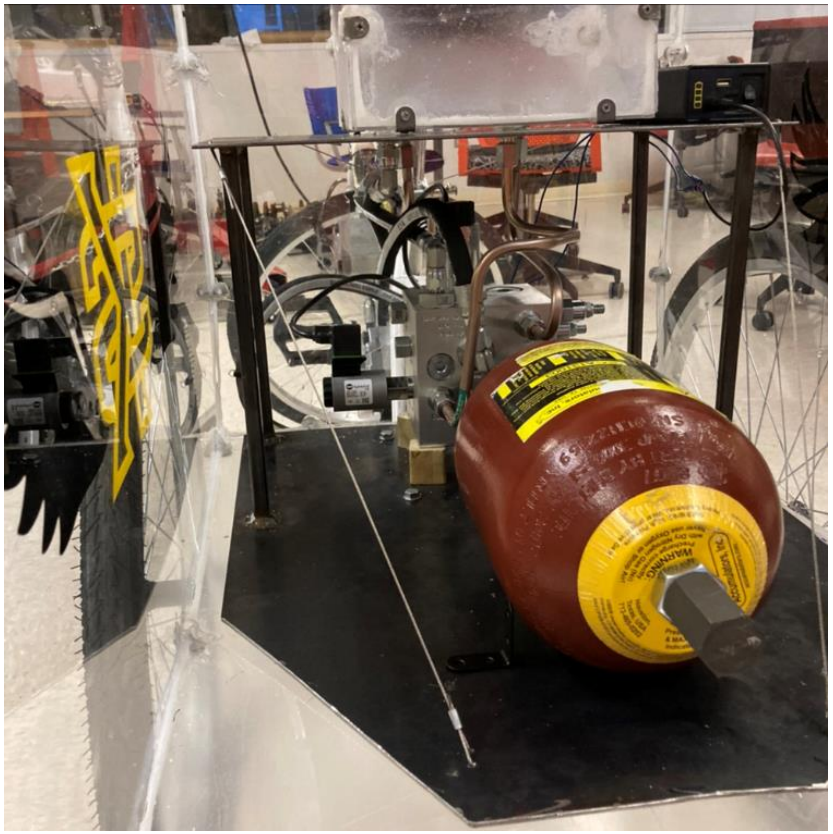
- Pneumatics





Vehicle Construction & Assembly

- Putting it all together!



Vehicle Construction & Assembly

- Putting it all together! (cont.)

Vehicle Testing

Hydraulics

- Regenerative Braking
  - Bike free wheel does not allow regenerative braking by coasting, as was intended.
  - Left circuit unchanged because regenerative braking was achievable by pedaling pump.
- Hose Lengths
  - Most of the hoses were too short by a hair.
  - 90° Fittings were bought.

Vehicle Testing

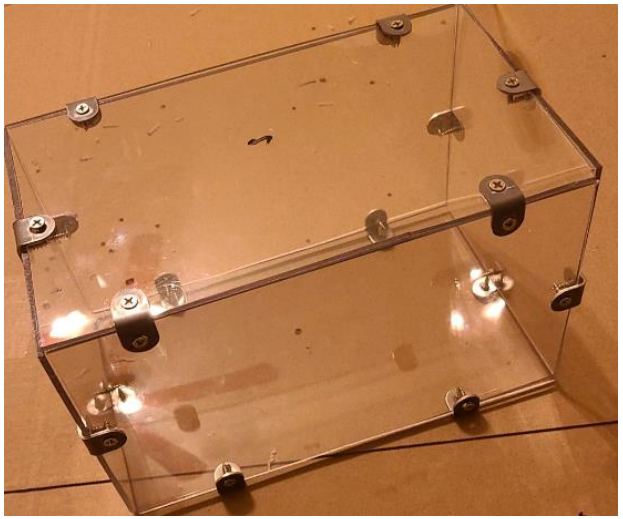
Hydraulics

- Direct Drive
  - Pressure in motor exceeded pressure relief valve minimum, redirecting fluid to reservoir
  - Tuned pressure relief valve to maximum (2000 psi) to allow motor to turn

Vehicle Testing

Hydraulics

- Plastic reservoir
  - Sealant sprung a leak
  - Replaced with steel reservoir



Polycarbonate Reservoir

Steel Reservoir

Vehicle Testing

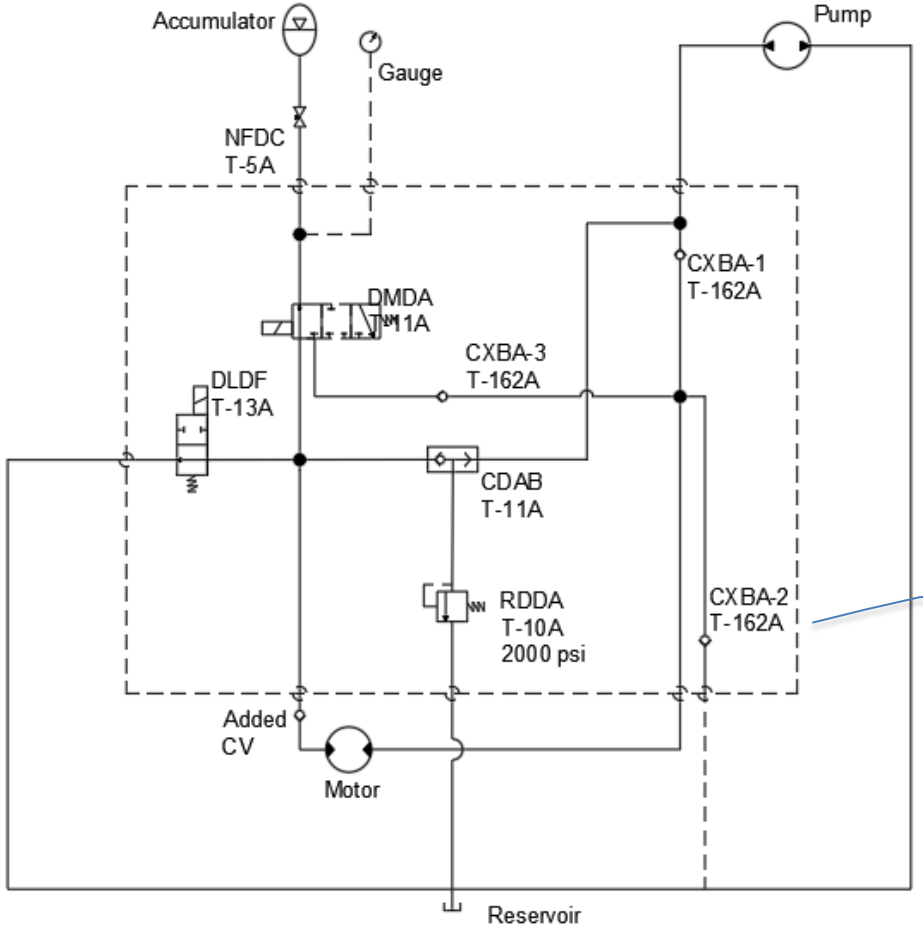
Hydraulics

- Back pressure on the motor
  - Prevent any back pressure that would spin the motor backwards as we drained the accumulator in boost mode.
  - Added check valve to prevent this.

Revised Hydraulic Schematic

Boost

- Check valve was allowing fluid to go to the reservoir before going through motor
- Line was capped off because theoretical regen erative braking was unachievable



Possible failed check valve

Removed tubing between this valve and reservoir, blocked off lines

Vehicle Testing

Pneumatics

- Goal
  - Controlled door opening.
  - Door maintains closed over long period of time.
- Tuning
  - Reservoir: > 60 psi
  - Regulator: 25 psi
  - Flow control: nearly closed.
- Results
  - Door Opening: 3 seconds.
  - Door Closed: > 30 minutes.

Vehicle Testing

Mechanical

- Wheel Problem

Vehicle Testing

Mechanical

- Chain tensioning

Final Vehicle

Lessons Learned

- Start manufacturing early. This is very important.
- Test complete bike as early as possible to find possible issues or improvements.
- Plan out everything ahead of time e.g., knowing where to pre-charge if you do not have the equipment for it.

Conclusion

- Very good learning experience.
  - From very little hydraulic knowledge to working bike in ~ 7 months.
- Value of teamwork & goal-setting.
- Gained pneumatic, electrical, hydraulic, tool, and simulation experience.
- Met goals of both class and competition, simultaneously.

Acknowledgements

- Phillip Sanders
- Ernie Parker
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- Josh Scarbrough
- Kent Sowatzke

QUESTIONS?