NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

Final Review
University of Denver
Advisor: Adam York
April 16, 2020

Agenda

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- Midway Summary
  - Project Scope
  - Design Objectives
  - Fluid Power Circuit Design
  - Analysis
  - Selection Hardware
- Vehicle Construction
- Race Simulations
- Safety Features
- Lessons Learned

Introduction

Hayden Dean
Mechanical Lead

Molly Kuettel
Project Lead

Simon Glezer
Financial Lead

Kwabena Asare
Testing Lead

Jeremy Isaac
CAD Lead

Tim O'Meara
Electrical Lead

Project Scope

- The project goal is to design and construct a single-rider vehicle operated using fluid power including energy storage and regeneration technology
- The scope of the project includes:
  - Research
  - Design
  - Analysis
  - Fabrication
  - Competition
- The requirements for the project and the rules of the competition are based on the NFPA and FPVC

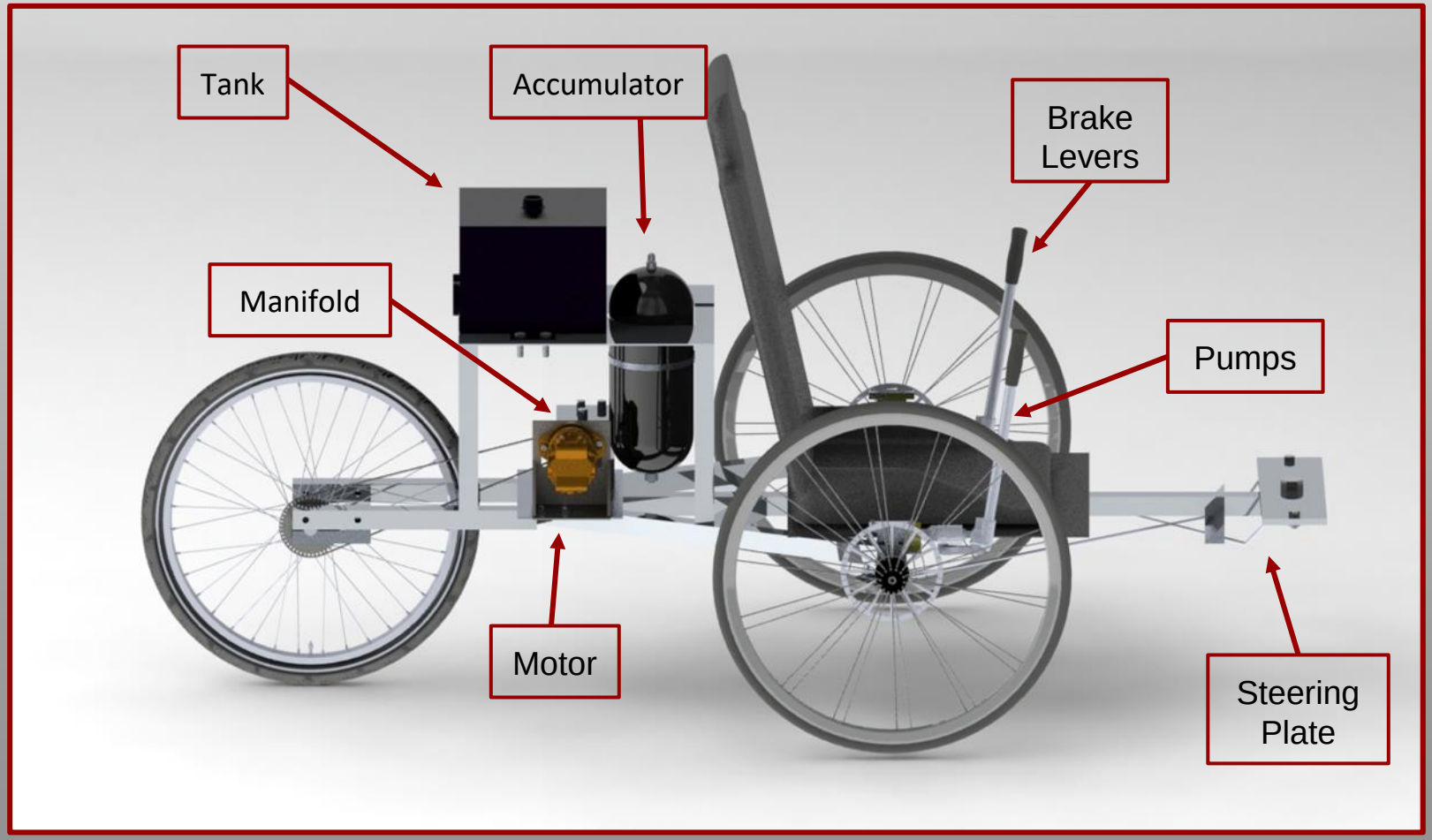
Design Objective

Our team created a stretch goal to design and fabricate a custom frame integrated with the other NFPA requirements.

2018-2019 Design

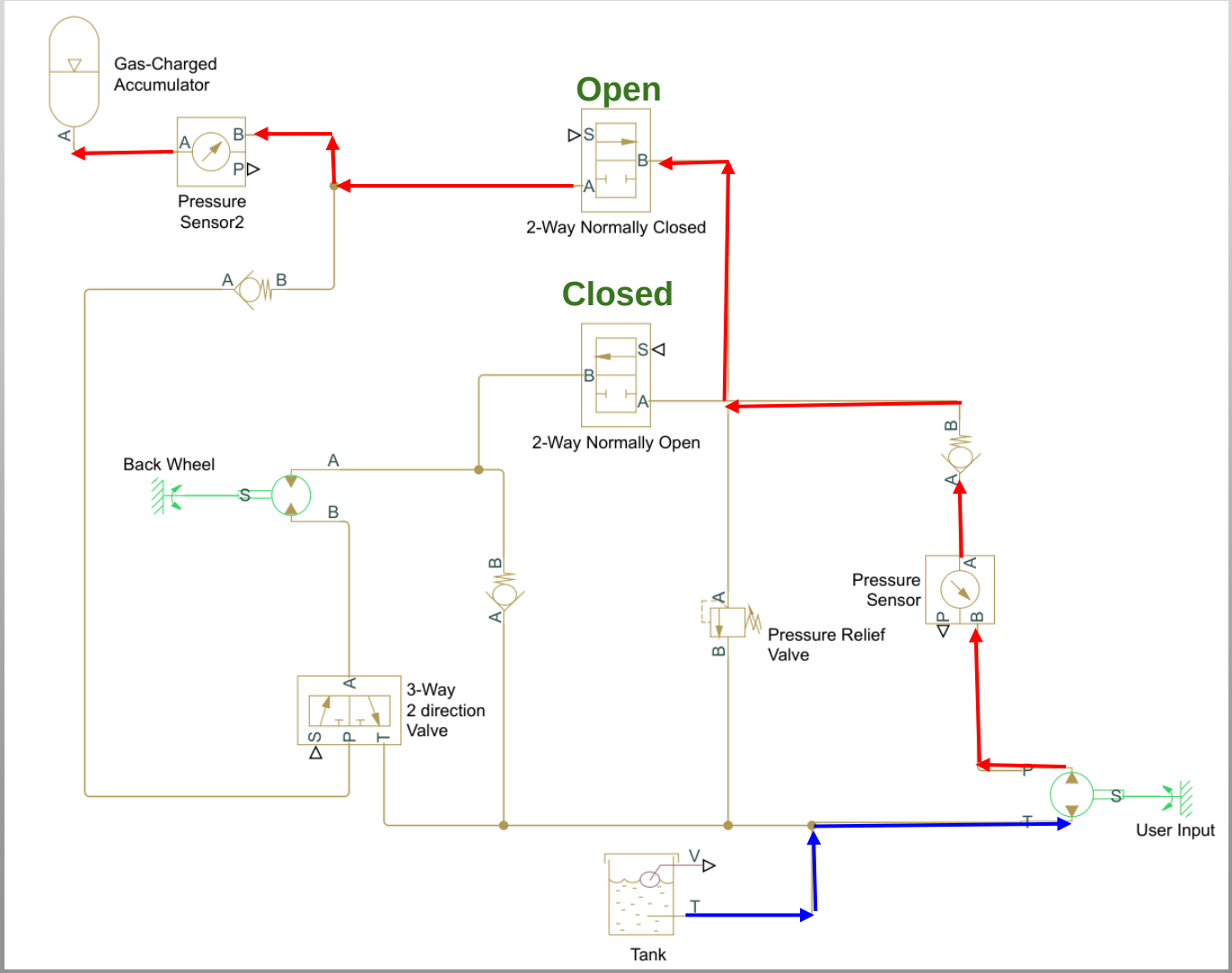
2019-2020 Design

Vehicle Design



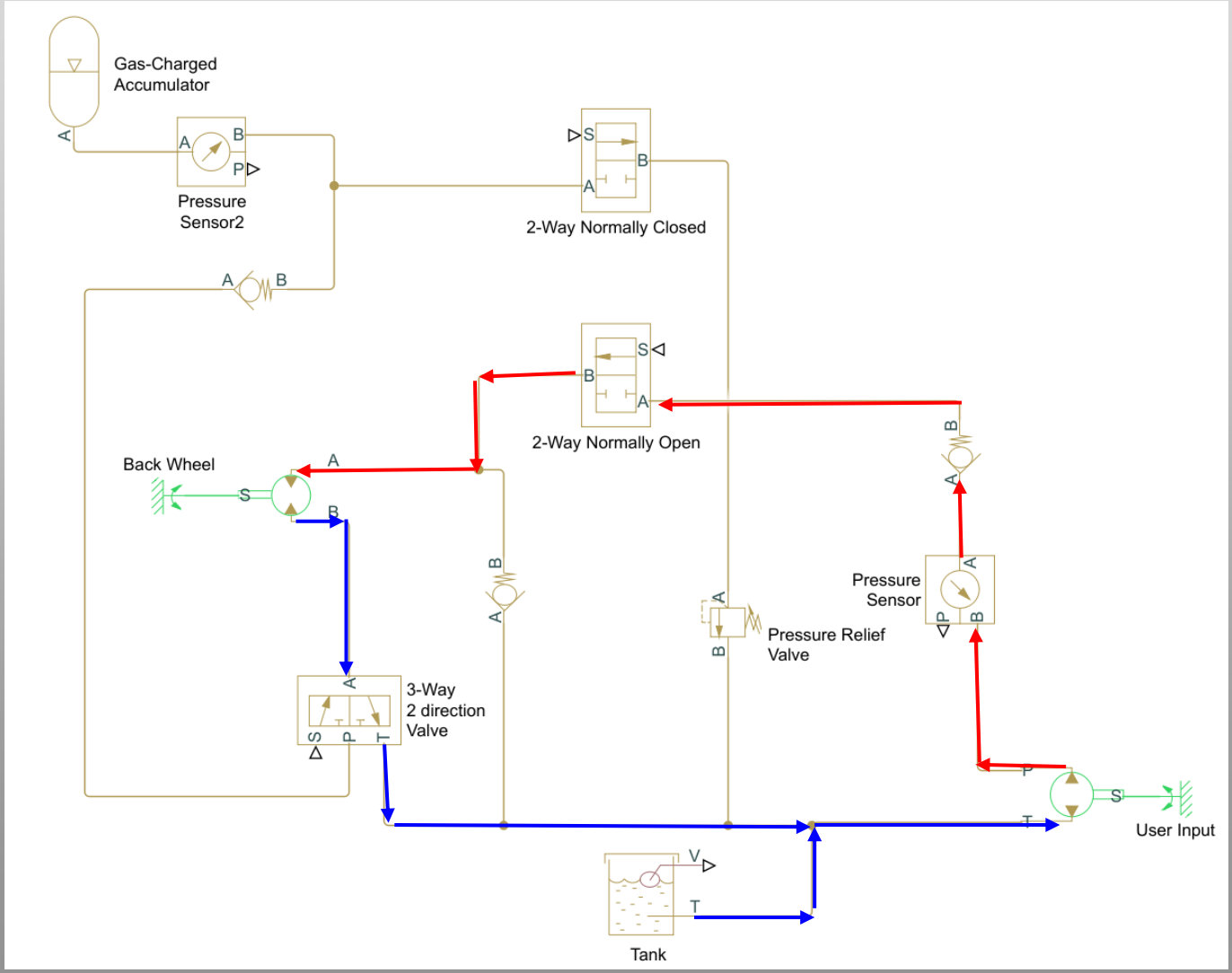
Fluid Power Circuit Design

Precharge Circuit



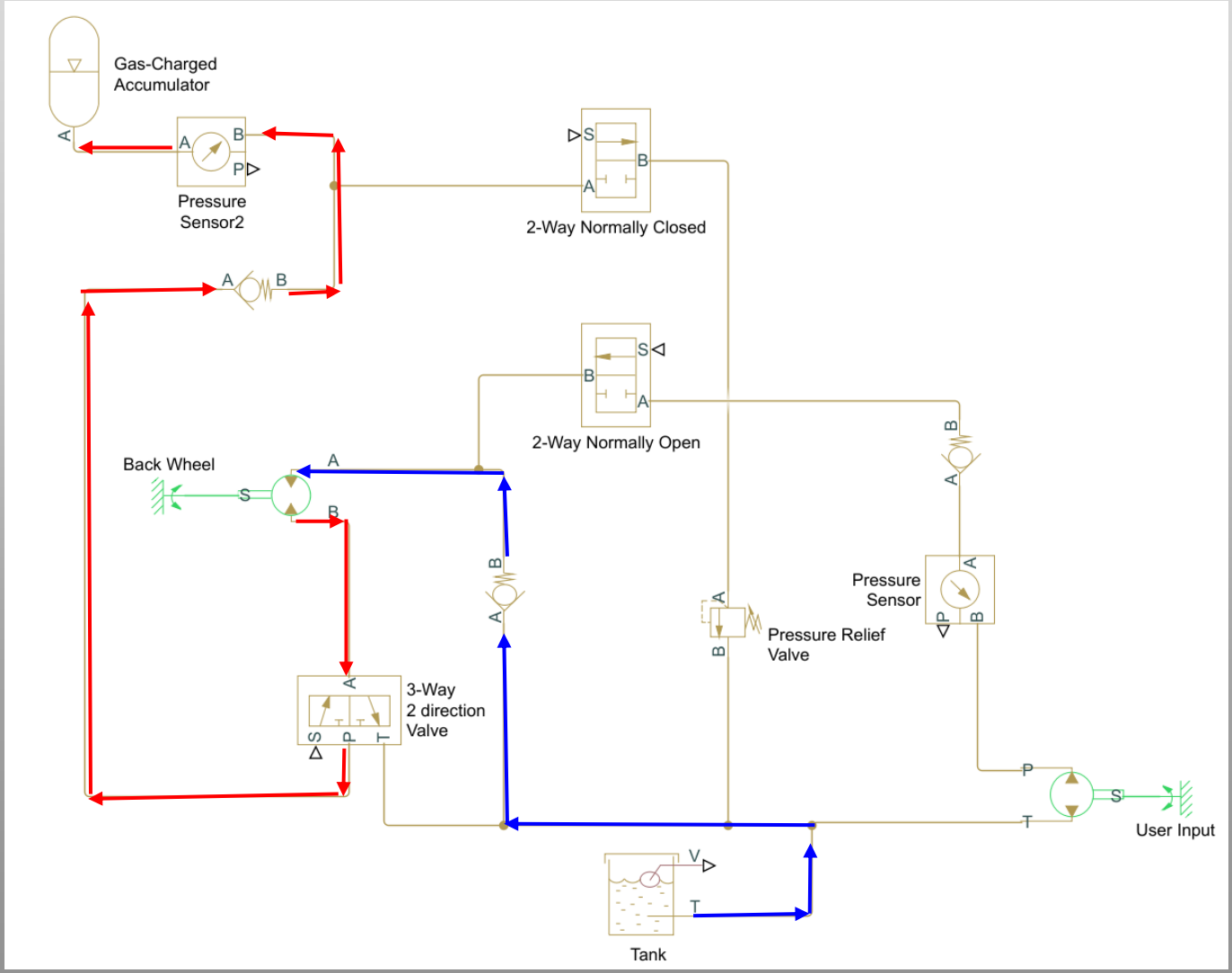
Key	
High Pressure Line	
Low Pressure Line	

Drive Circuit



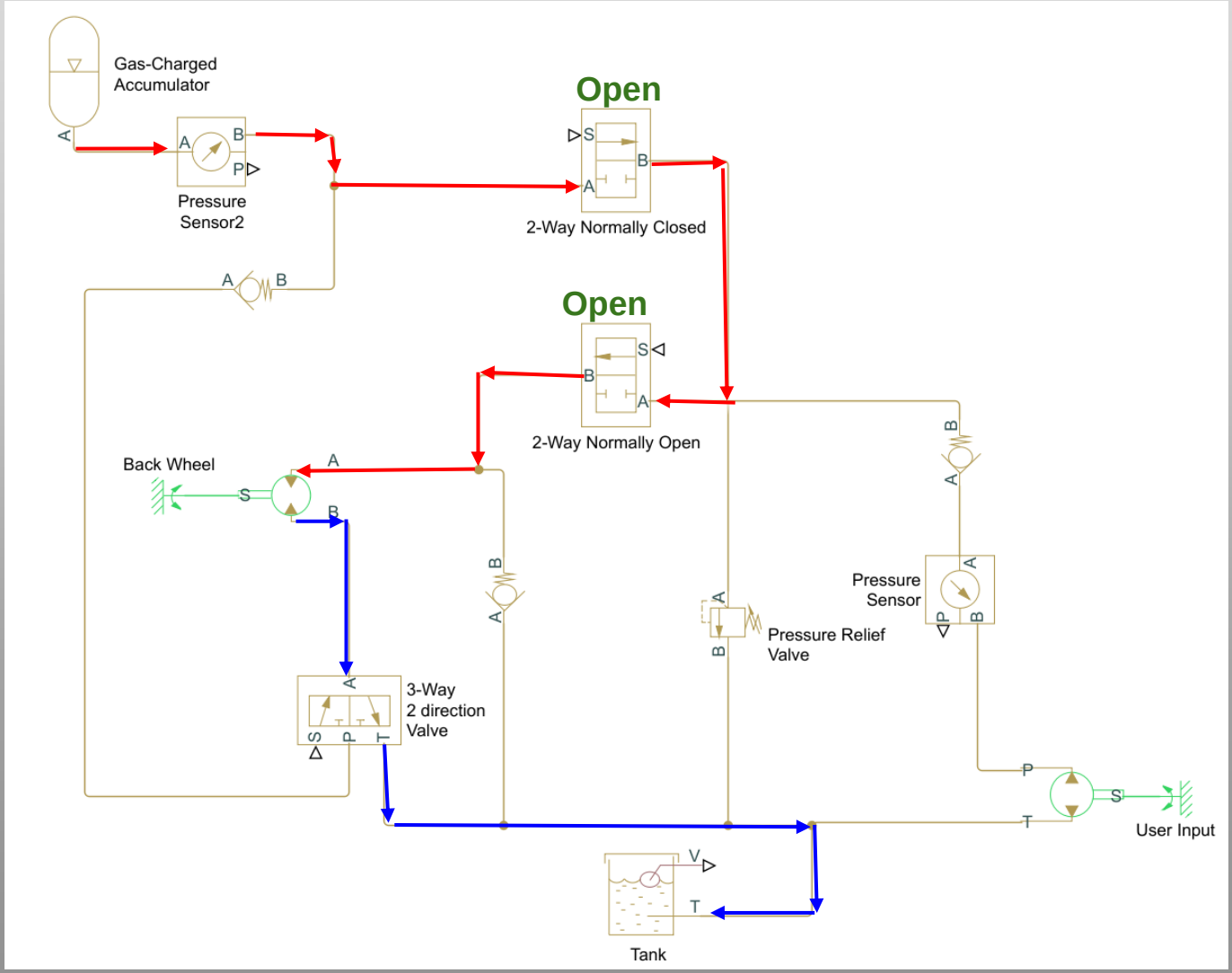
Key	
High Pressure Line	
Low Pressure Line	

Regenerative Circuit



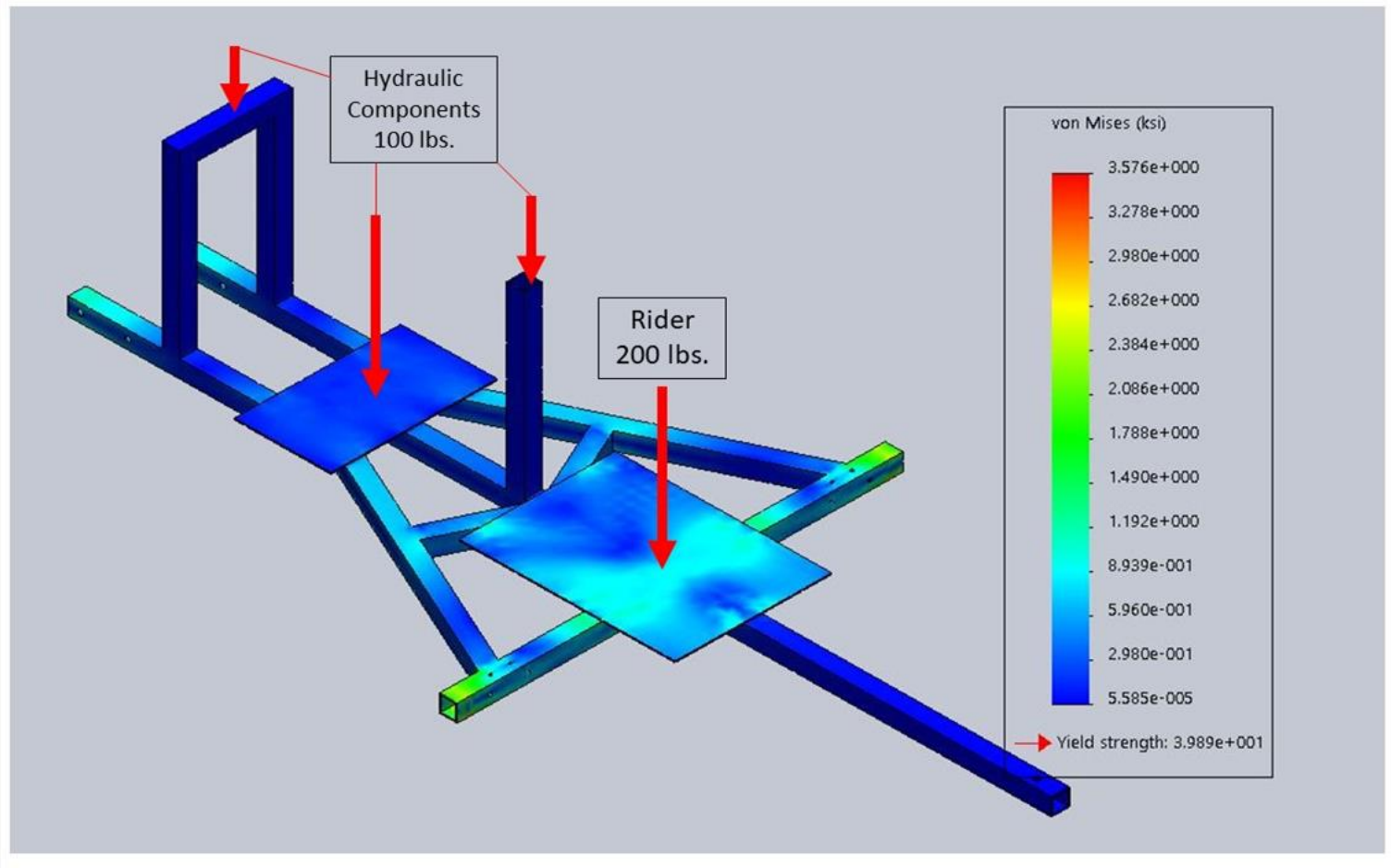
Key	
High Pressure Line	
Low Pressure Line	

Boost Circuit



Key	
High Pressure Line	
Low Pressure Line	

Static Frame Analysis



Total Distributed Applied Force: **300 lbs**
Maximum Stress: **3.57 ksi**
6061-T6 Yield Strength: **39.89 ksi**

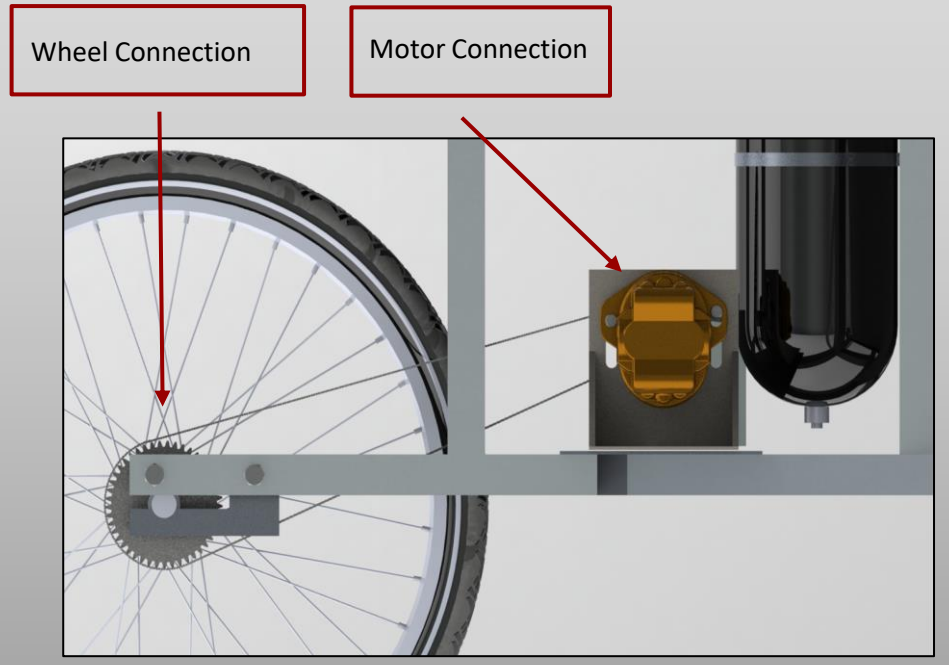
Component Selection

- **Eaton Bi-Directional Motor**
  - Displacement: 0.62 CID
  - Mating: Keyed
  - Output Rotation: Bi-Directional

- **SteelHead Composites 1 Gallon Carbon Fiber Accumulator**
  - Pressure: 3000 psi
  - Weight: 11.12 lbs

- **Doering Lever-Operated Push to Pump**
  - Displacement: 0.601 CID
  - Max psi: 5000

Motor Connection

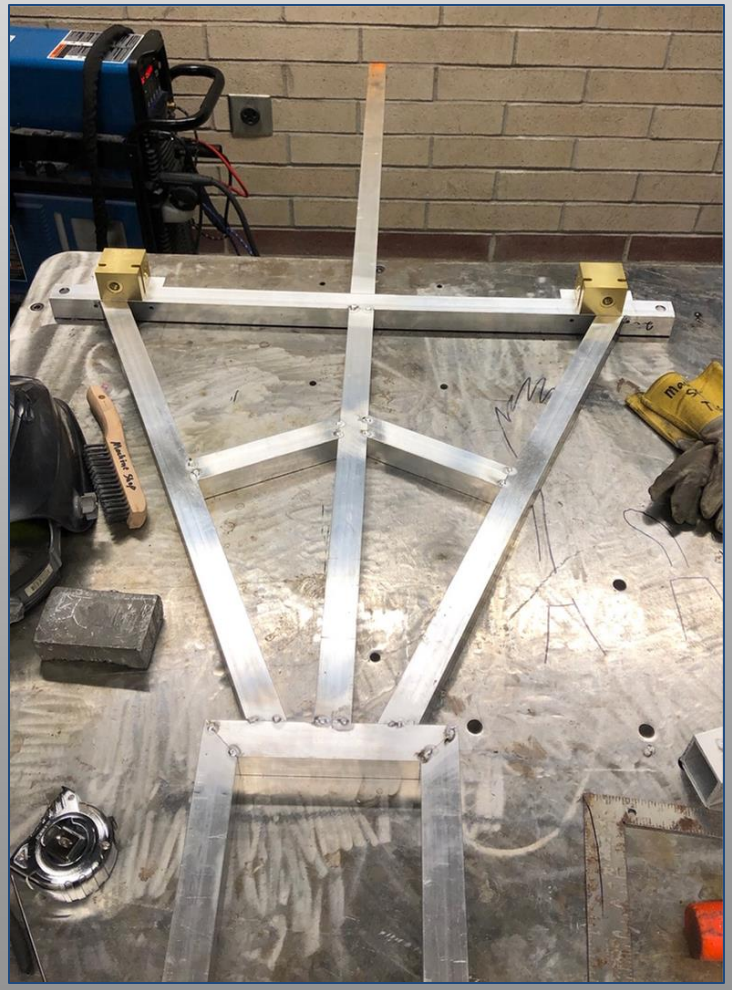


Motor Gear Teeth: 12
Motor Gear Safety Factor: 1.54
Wheel Gear Teeth: 48
Wheel Gear Safety Factor: 1.60
Gear Ratio: 4.0

Mechanical Advantage: 2.03

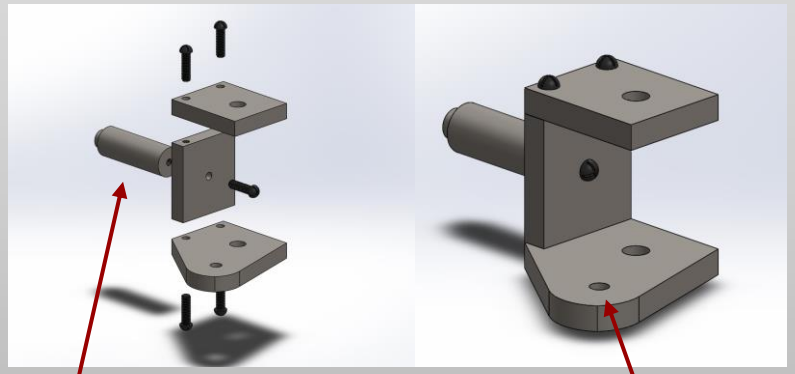
Construction

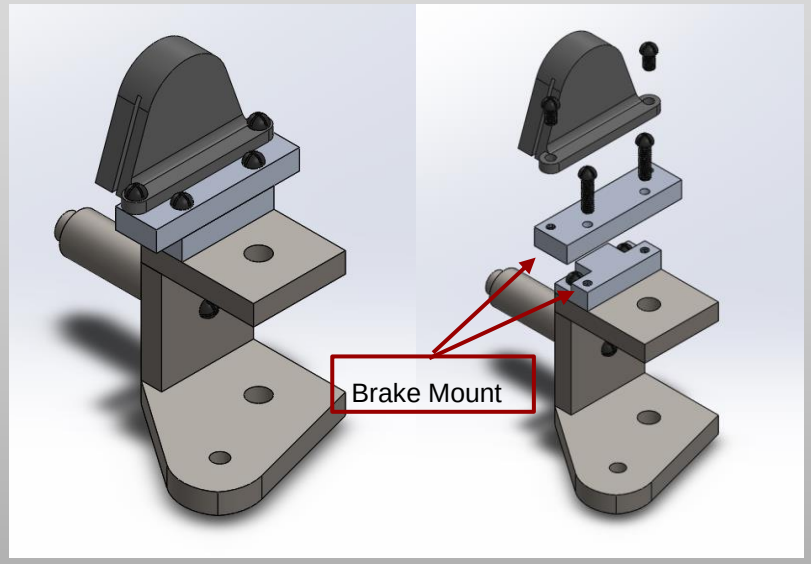
Construction

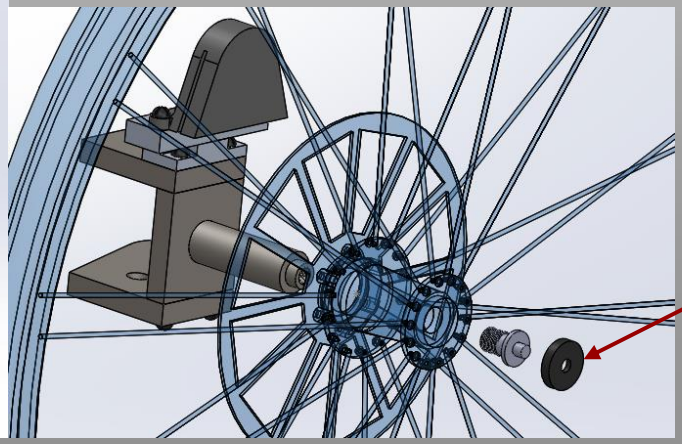


- Custom frame
  - 6061 Aluminum
  - 1.5 inch square tubing
  - 5000 series filler rod
- Cutouts milled into members to allow for more secure welds

Front Wheel Assembly

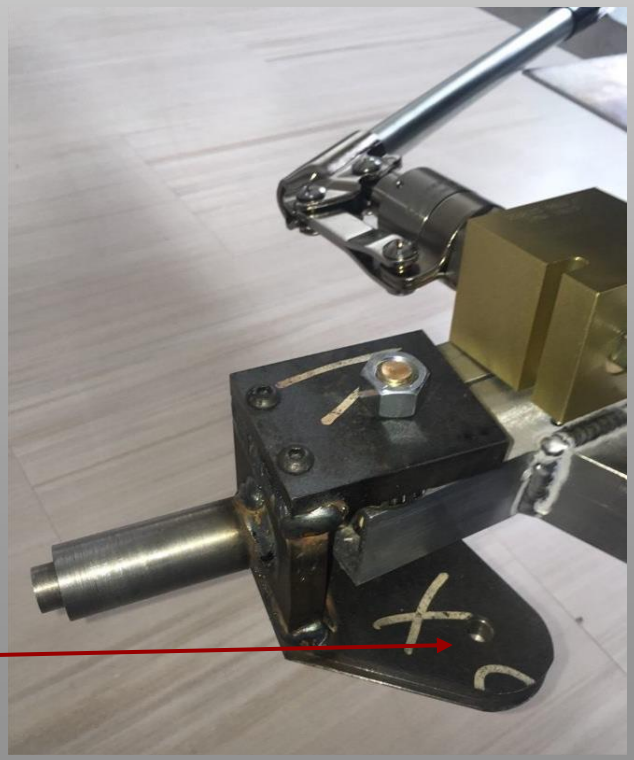






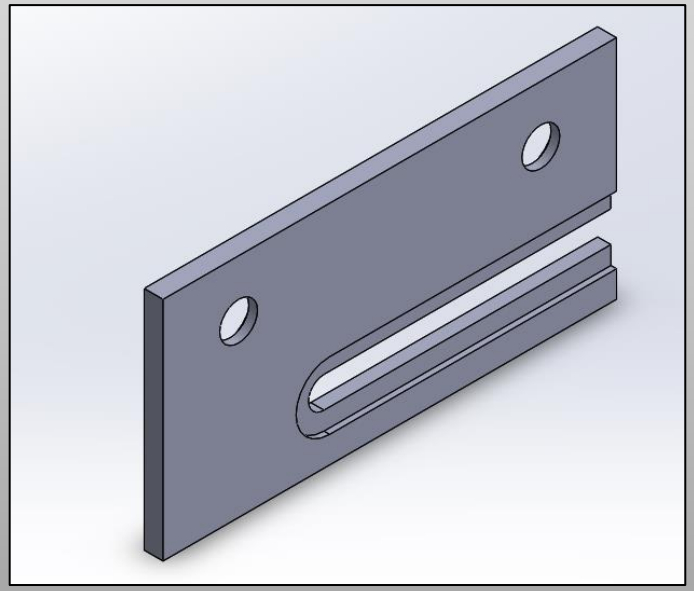
Construction

- Designed & Machined
  - Back wheel dropouts
  - Front wheel hubs
  - Ackermann steering

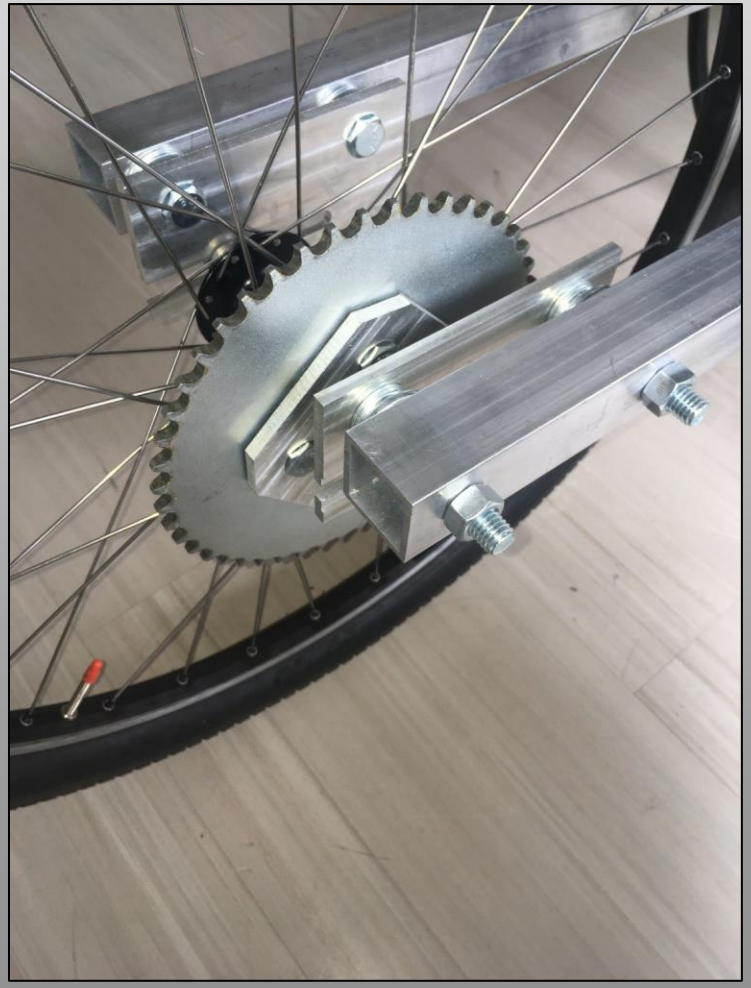


Ackerman Steering Holes

Rear Dropout



Chain Tensioner

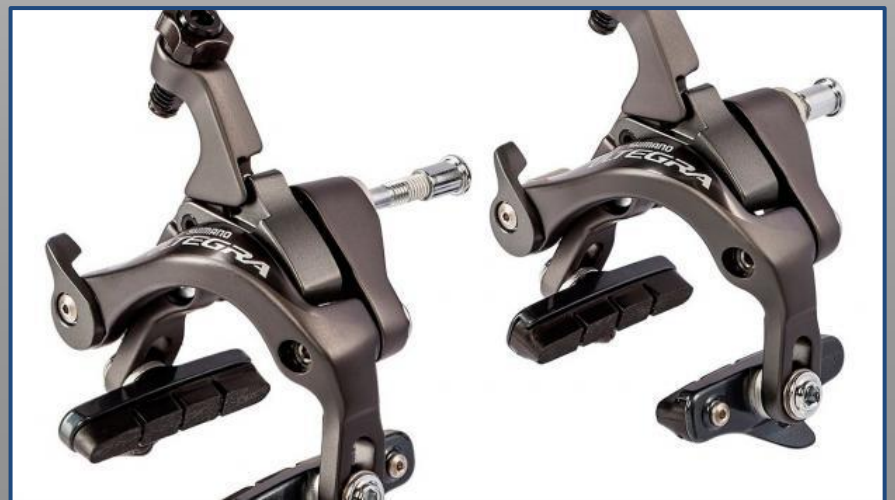


Construction

Components	Status
Frame	Complete
Custom Specced Wheels	Complete
Axles	Complete
Hubs	Complete
Pump Mounts	Complete
Hydraulic Circuit Mount Plate	Complete
Rear Dropouts	Complete
Seat Mounted	Complete
Hydraulics Hoses	In Progress
Tank Mount	In Progress
Steering Assembly	In Progress

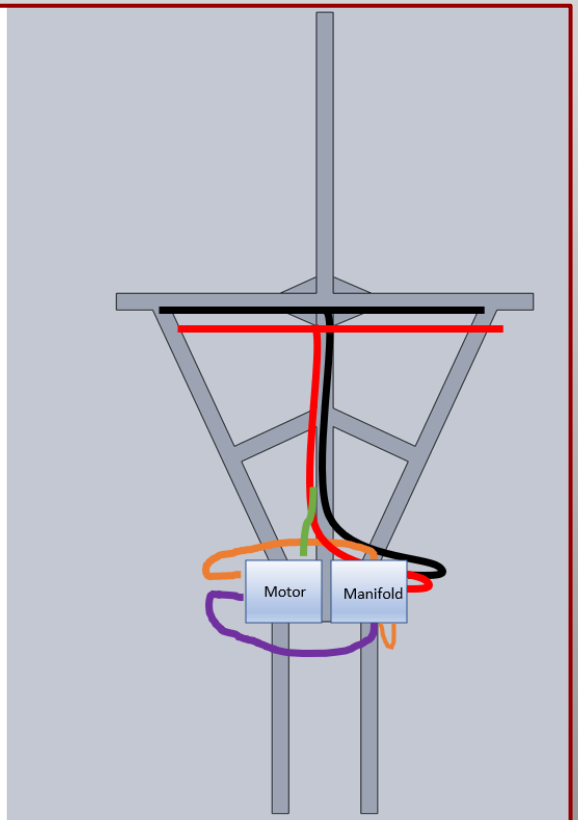
Safety Features

- Chain guard
- Pressure gauge
- Independent brakes on all wheels
- Rider Safety:
  - Helmet
  - Seat belt



Hydraulic Construction

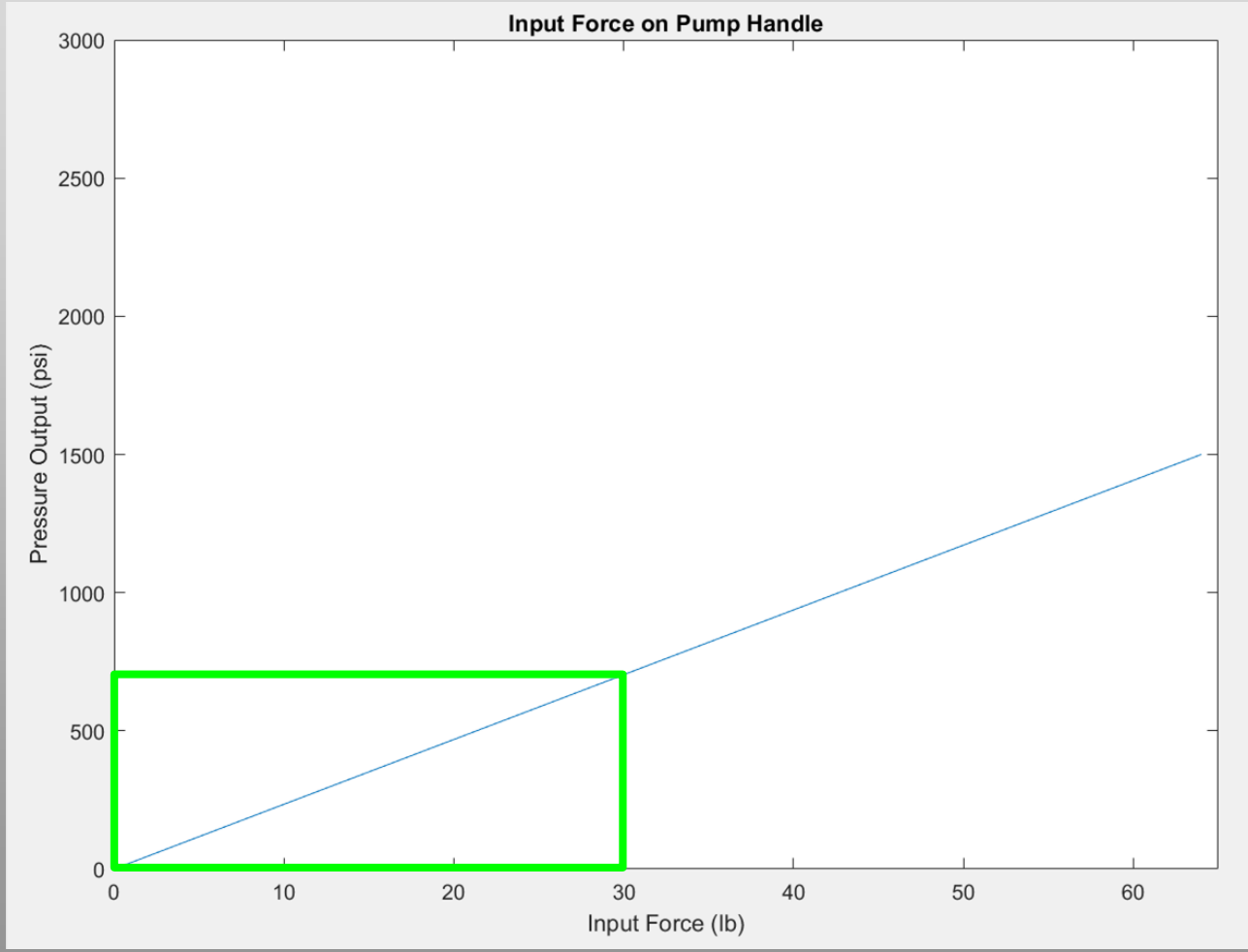
Approximate Hose Length	
Pump	~65”
Pump Return	~65”
Accumulator	~8”
Tank	~22”
Motor	~24”
Motor Return	~24”

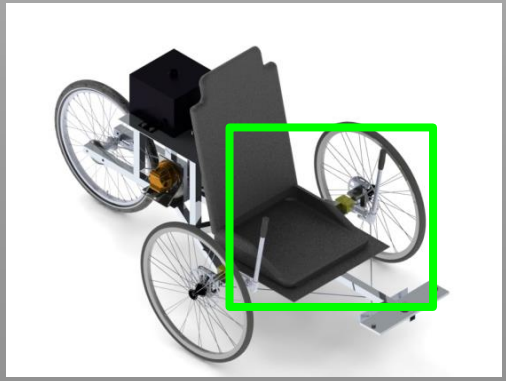


- **Goal**: Limit potential losses
  - Limit bends, 90 degree turns, and T-joints
  - Elevated tank location
  - Accumulator connected to manifold via straight hose
  - Limit lengths of hoses

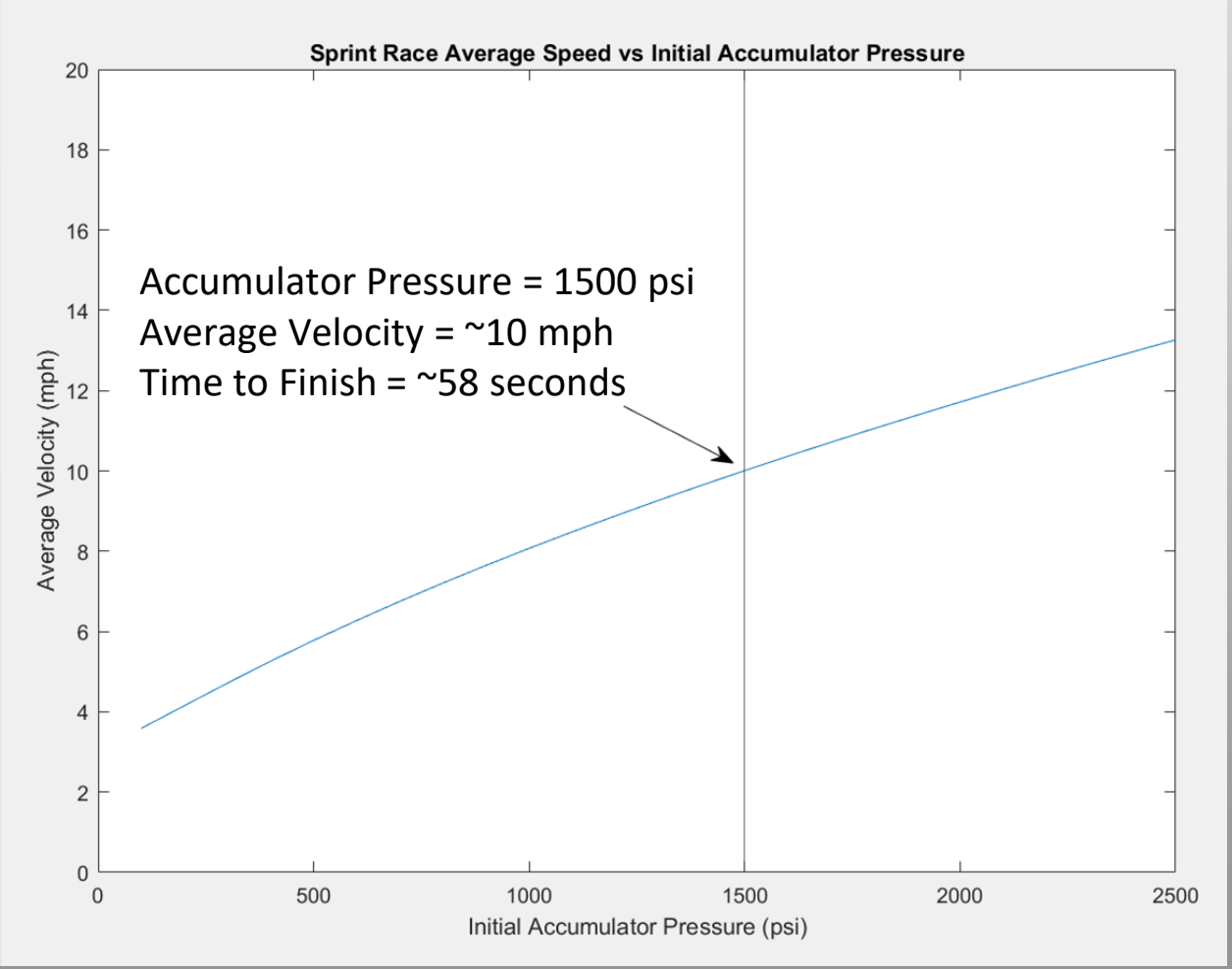
Race Simulation

Human Power Input

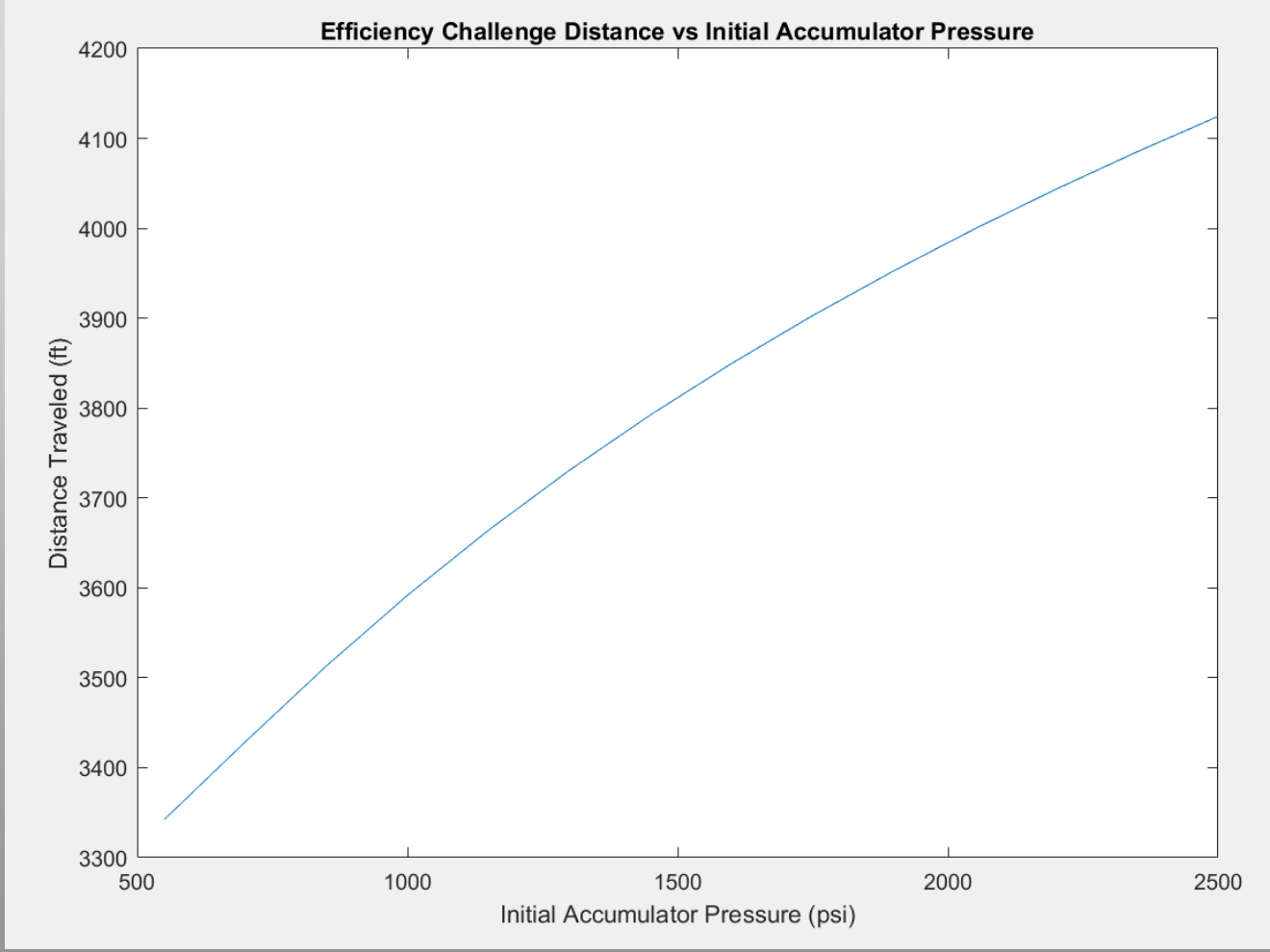




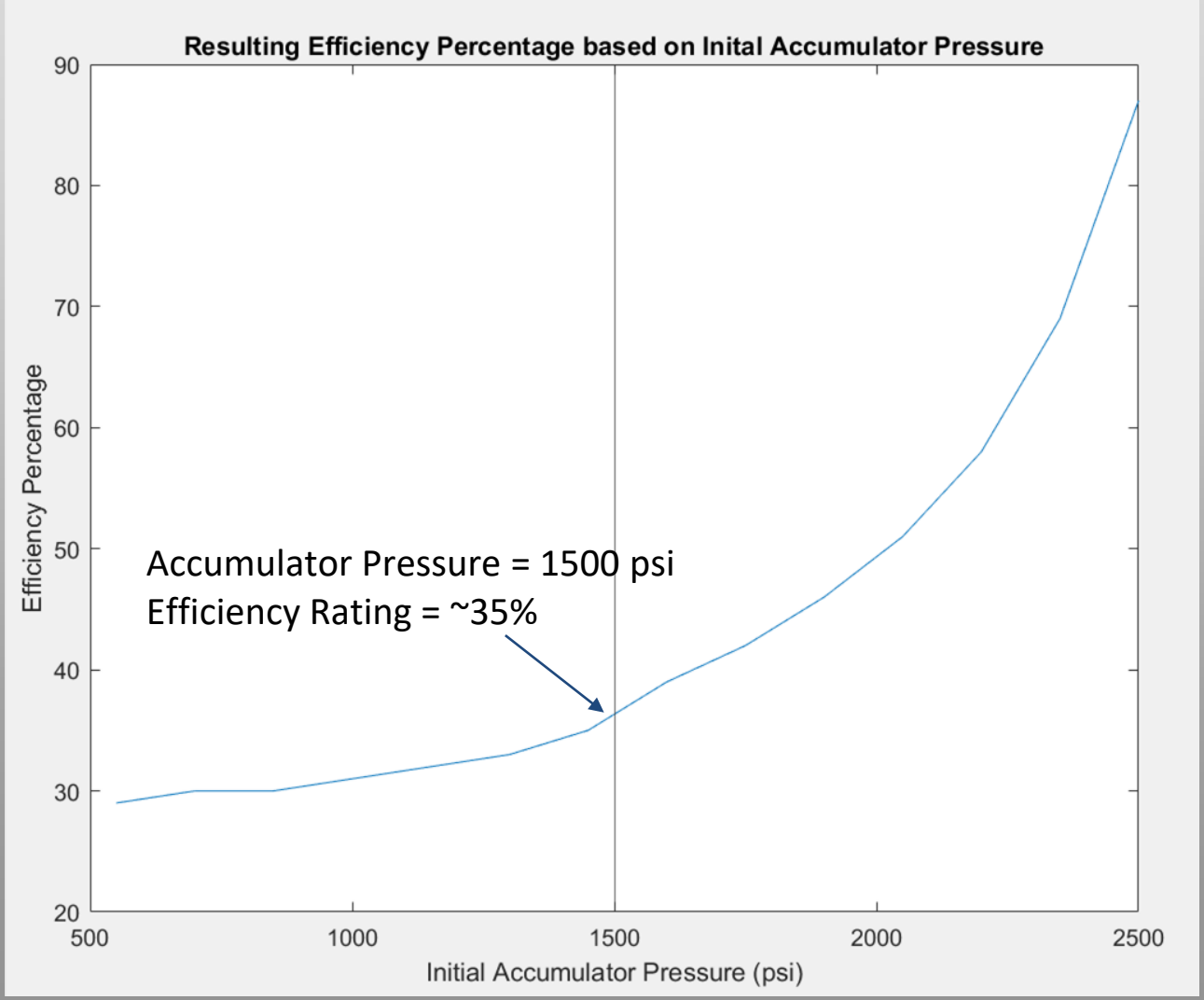
Sprint Race Simulation



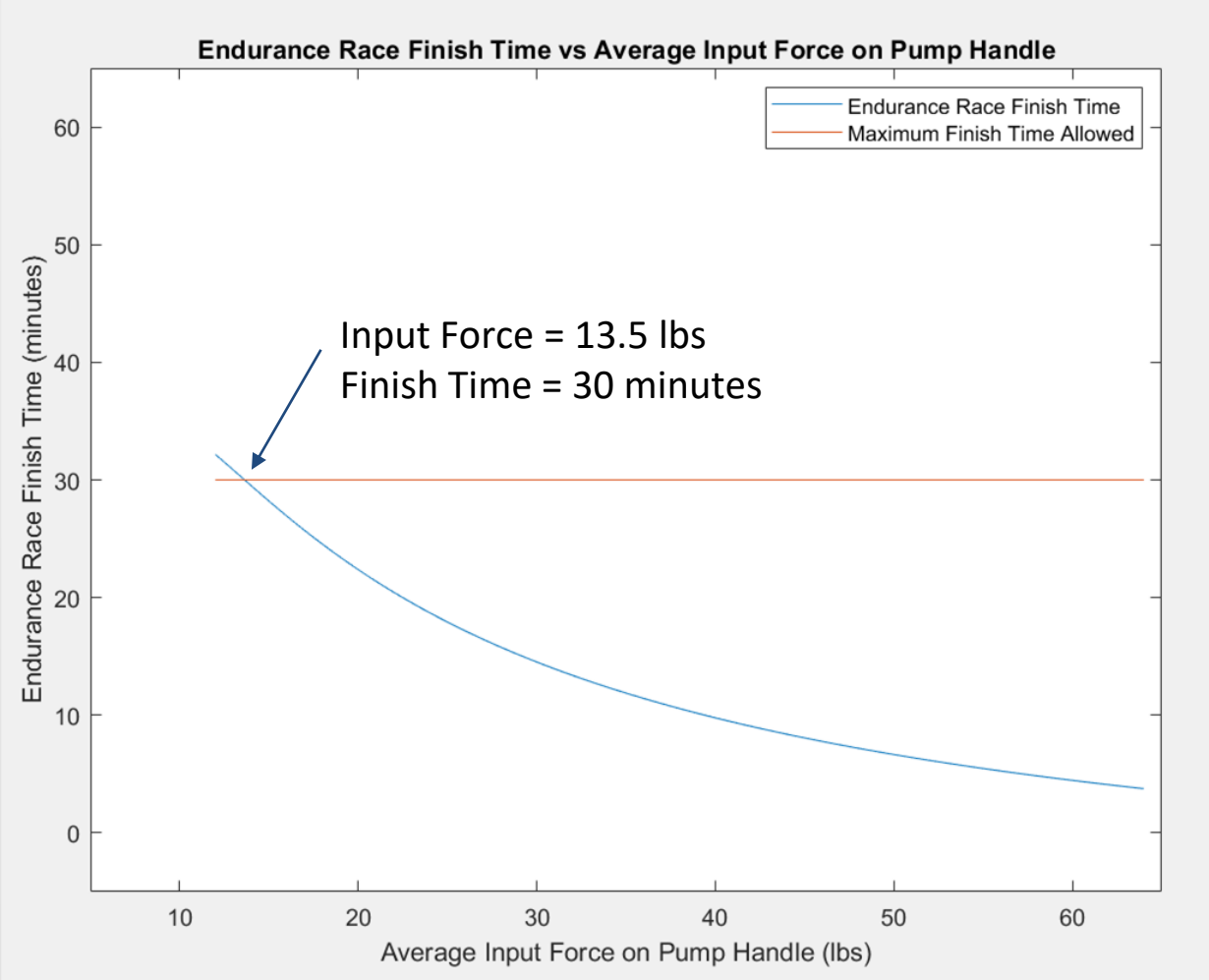
Efficiency Challenge Simulation



Efficiency Challenge Simulation



Endurance Race Simulation



- Simulation Considers:
  - Switching Riders
  - Regenerative braking demonstration

Lessons Learned

- Improvements
  - T-joints
  - Use legs for power
  - Learn more hydraulics upfront
- Takeaways:
  - Custom frame
  - Matlab simulation code for future optimization
  - Project interest for following years
  - Increased knowledge of hydraulic power

Thank You

- NFPA Competition Advisors
  - Stephanie Scaccianoce
  - Darrell Leighton
  - Ernie Parker
- University Advisors
  - Adam York
  - Justin Huff
  - Christopher Sturt