NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
University of Utah
Dr. M. Metzger
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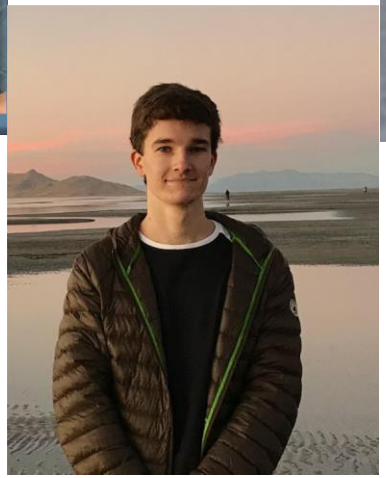
Team Members

Seth Roundy



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Patrick McGann

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Vehicle Design

Recumbent Trike

- Manifold, motor, and accumulator located behind seat
- Pump located next to the pedals
- 20” wheels at the front, 26” at the back
- Frame made of 4030 chromoly steel

Photos of previous vehicle

Design Objectives

- Improve wheel mounting systems to prevent bending of axles
- Enhance hydraulic system to provide the rider with enough torque to start riding from rest
- Incorporate gear shifting system to further help riding from a rest position
- Include electrical system and user interface to display and change modes

Previous Front System

Previous Front Axle Mount

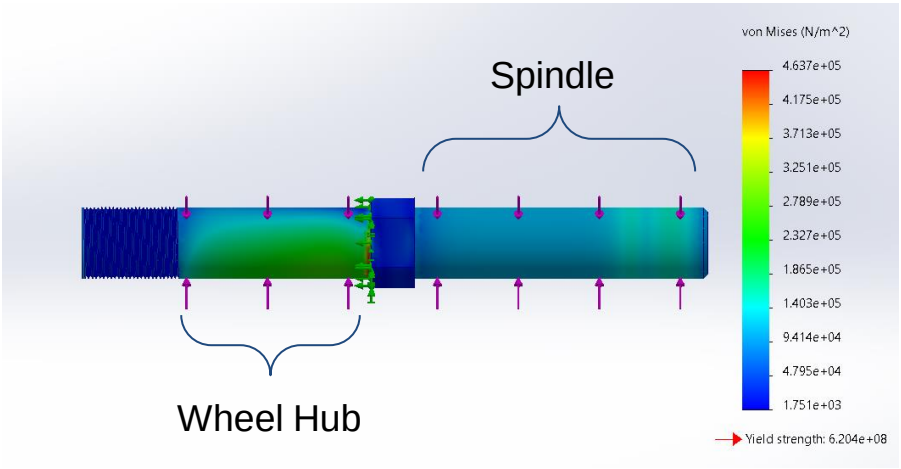
Previous Rear System

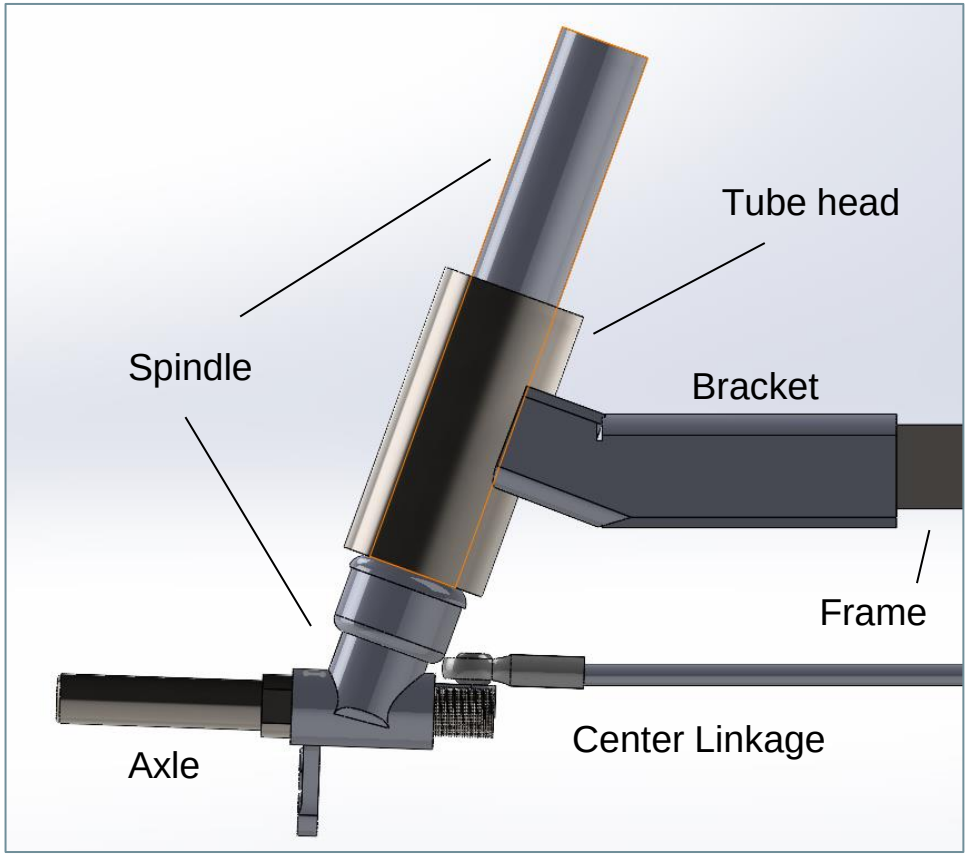
Design

Spindle Concept

Front steering system used to enforce & combine

- Brake mount
- Center Linkage mount
- Axle mount
- Steering unit
- Handlebar mount





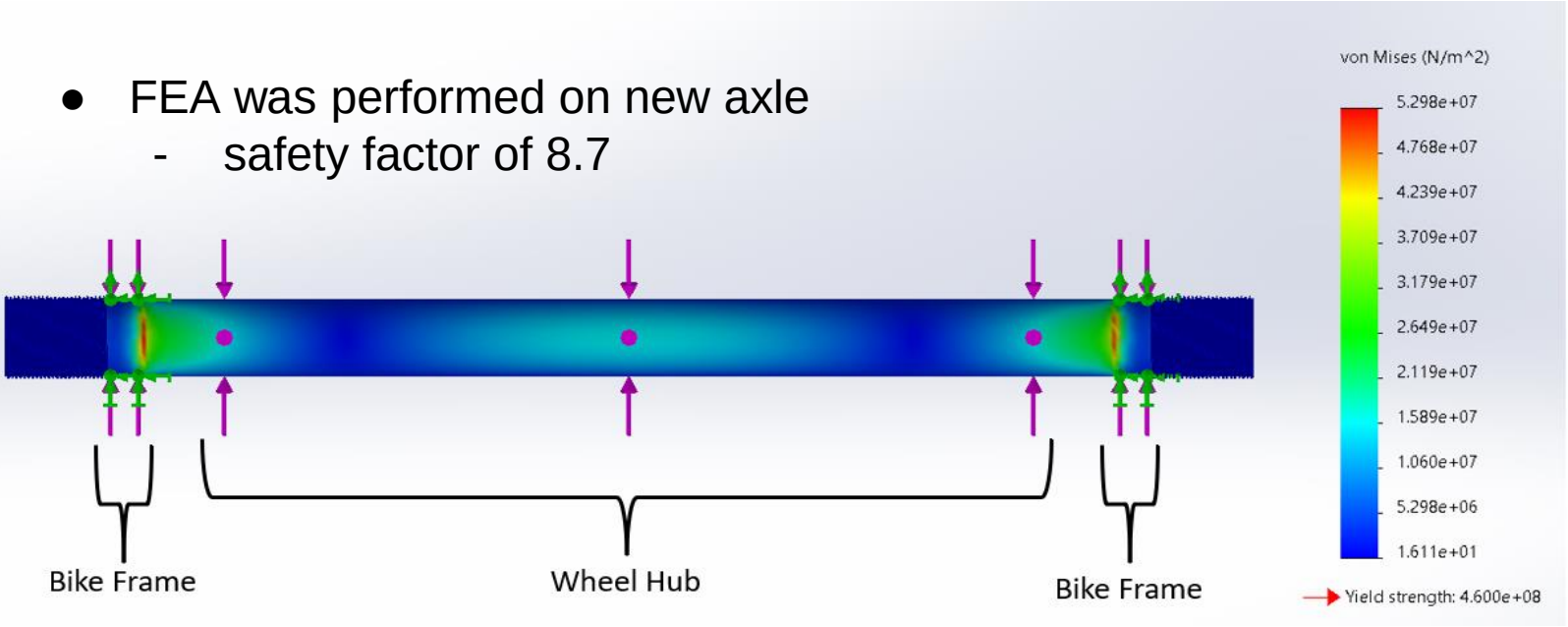
FEA was performed on industry axle

- safety factor of 15

Design

- Previous rear wheel had sprocket mounted onto spokes, and weak hub
- Integrate new Custom Built 26” Enduro Mountain Bike Wheel
  - non-hollow spokes for increased stiffness
  - 12mm through axle, 142mm width hub

- FEA was performed on new axle
  - safety factor of 8.7



Construction

All welding was done by the team

Incorporation of spindles

Construction

Front System

New radial piston pump

Incorporated a 12 speed Pinion Gearbox

Rear System

New back wheel, axle, and sprocket

Electrical Design

Electrical System

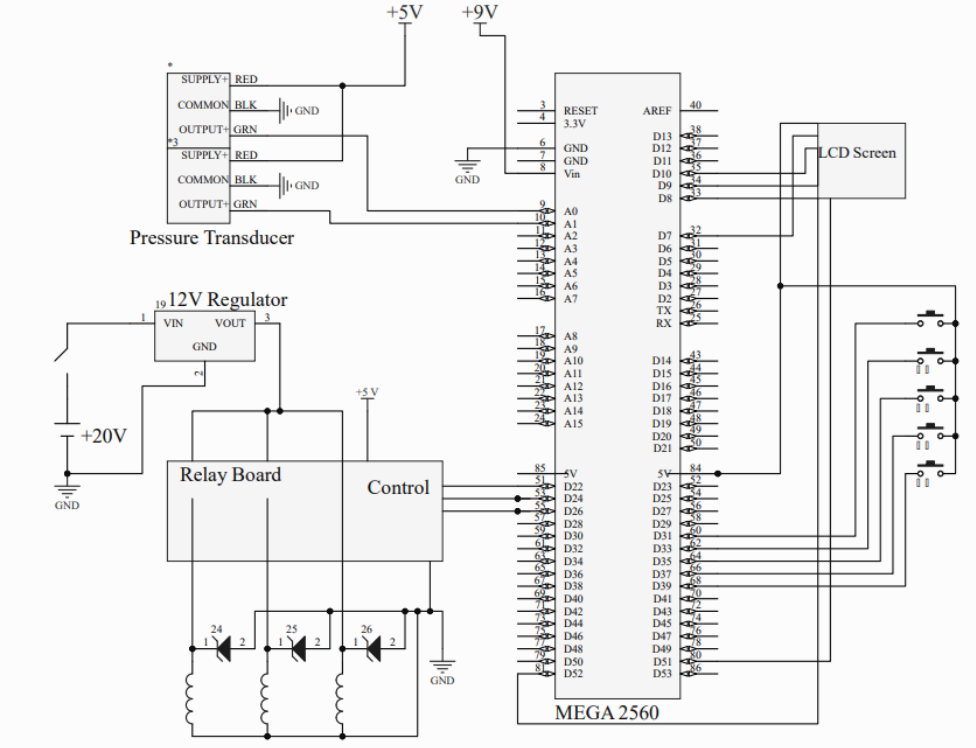
Location: Front of vehicle

Use: Control and display system states and information

Control Panel

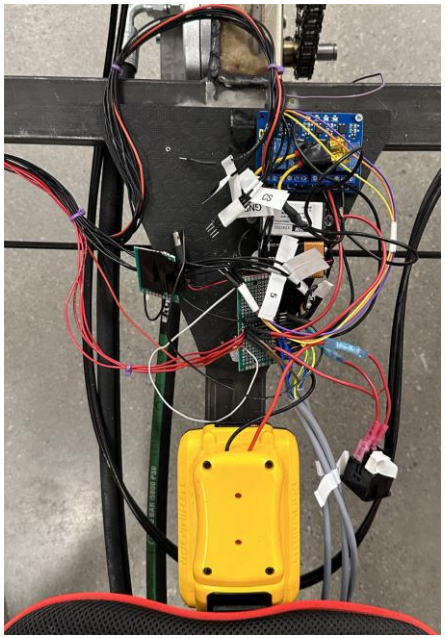
Location: Top of left handlebar

Use: Provide information and human interface with system



Conceptual Circuit Design

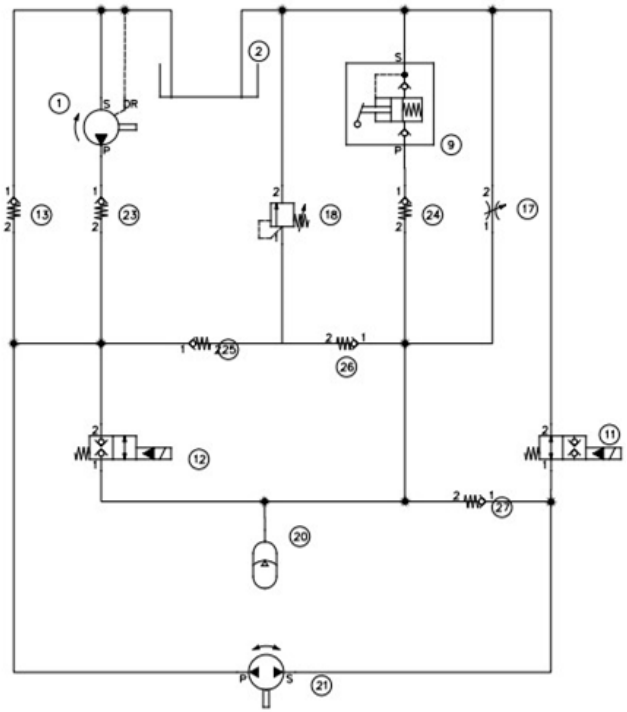
User Interface Panel



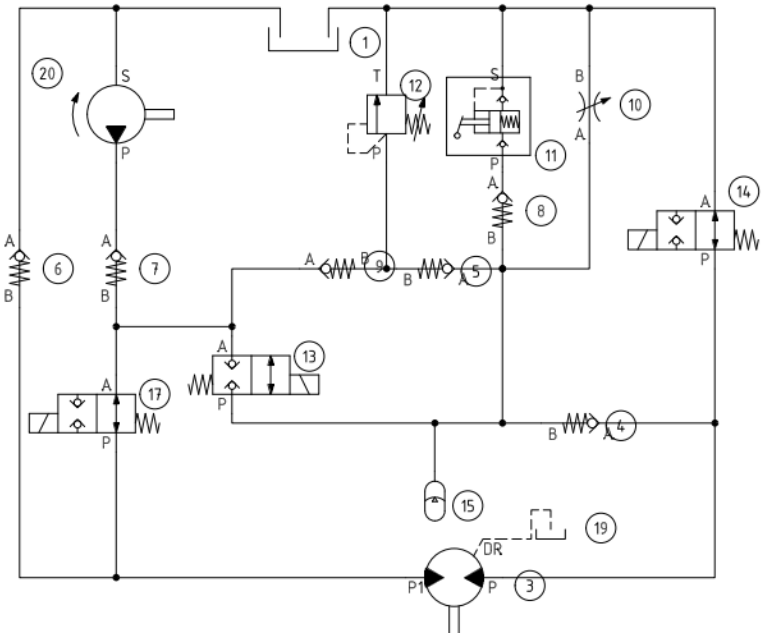
Wiring Under the Box

Hydraulic Circuit

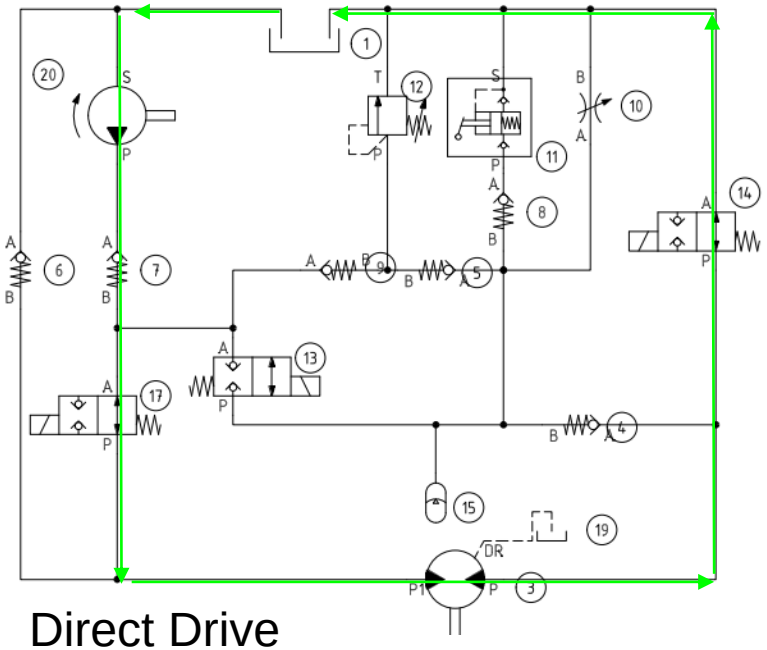
Previous



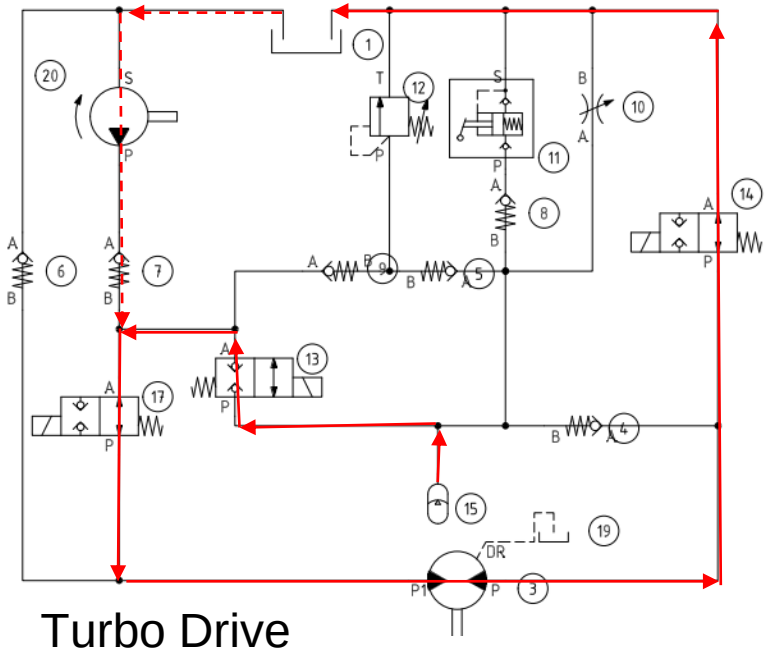
New



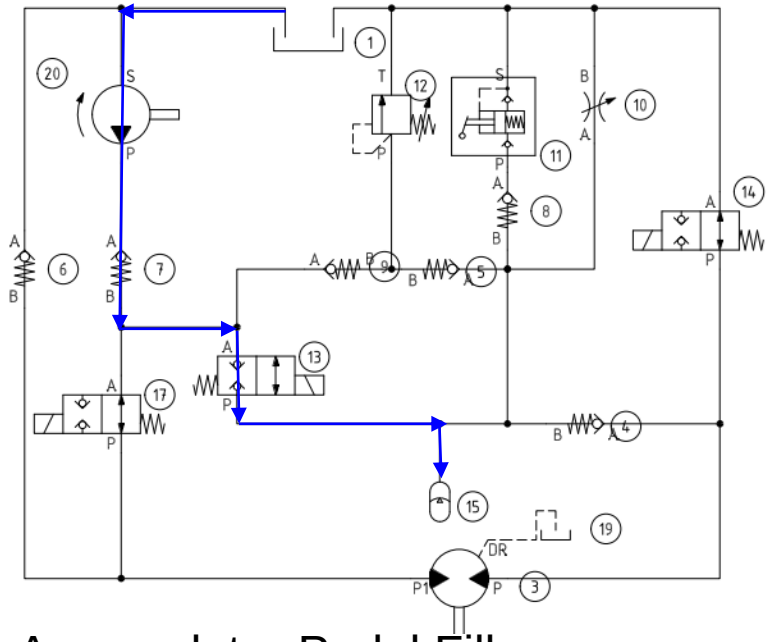
- 5cc/rev bent axis piston motor - 0.34cc/rev micro-piston pump
- Extra valve allows additional modes of operation
- Added needle valve from midway review comments
- Pump lower height than reservoir to ensure reliable inlet flow



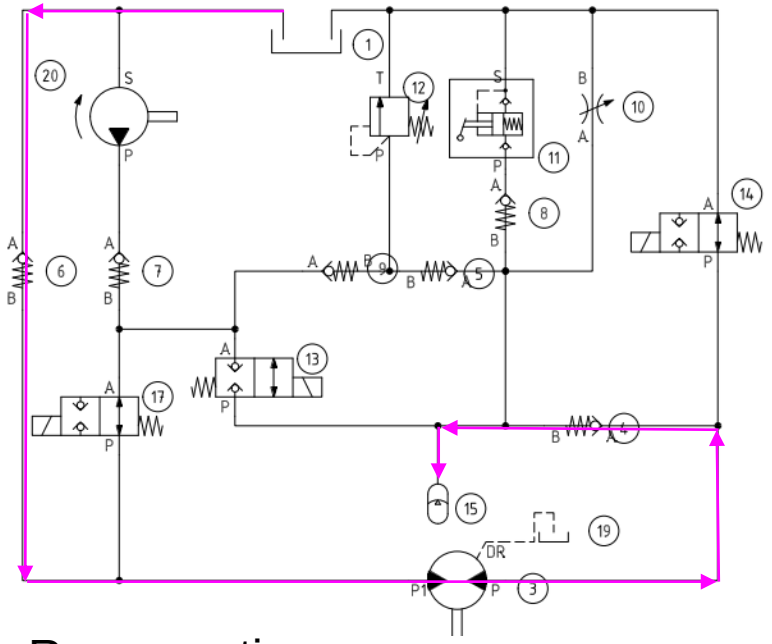
Direct Drive



Turbo Drive



Accumulator Pedal Fill



Regeneration

Full Vehicle Photos

New vehicle

Previous vehicle

Testing/Performance

- All axles are well supported and show no sign of fatigue
- From the new pump and gearbox, the vehicle moves from rest with less effort by the rider
- Stopping performance has increased by the optimization of two front mechanical disc/rotor brakes
- The programmed user interface allows the rider to change operation modes, while taking in real time data via the sensors on the bike
- Hydraulic lines and fittings have been upgraded from previous years to withstand higher pressures
- 0.13 GPM achieved flow rate
- Minimum pressure ~2000 psi
- Turning radius is 8 ft
- Maximum speed is 7 mph

Lessons Learned

- Choose components friendlier to typical industry components
  - Optimized gear ratios around a selected pump and desired operating pressure
  - Attempted to achieve a gear ratio unrealistic for available parts
  - Desired GR: (48:1) ; Achieved GR: (21.6:1)
- Bike weight plays a crucial role for effective operation
  - A lighter bike reduces necessary pressure for movement
- Standardize hydraulic fittings as best as possible
  - Hydraulic system currently has 4 different thread types
- Work around lead times on parts
  - Focus attention on other areas when waiting on other parts
- Testing and optimization consumes ample time
  - Testing did not happen until last week, resulting in additional

Recommendations for Subsequent Teams

- Modify a pre-existing frame, or use of a lighter material to reduce required torque
- Streamline hydraulic routing and reduce use of fittings and orifices
- Make greater use of industry mentor resources
- Start early, set a clear schedule far ahead of time and plan for delays
- Make full use of your power input - distribution of flow rate and pressure
    - Achieved pressure can easily trigger pressure relief valve, reducing total system efficiency
- Consider how much accumulator volume you'll realistically use in a race for multiple precharges and desired flow rate

Questions?