NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION
Iowa State University
Dr. Brian Steward
4/14/2021

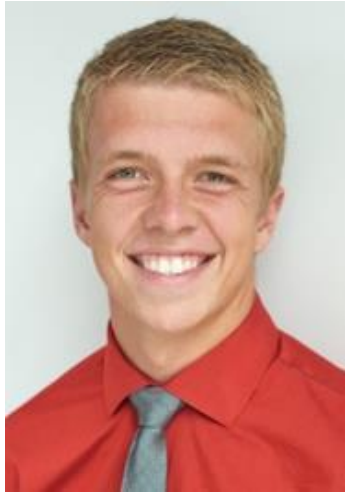
Team Introduction

Tyler Liskow

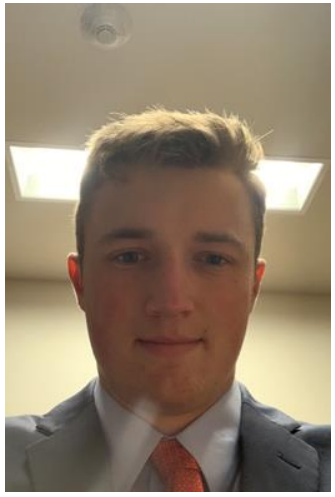
Luke Wille

Isaac Boraas

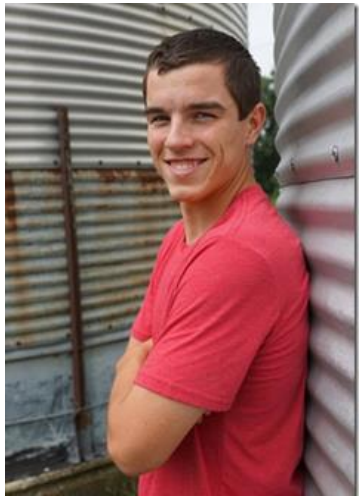
Brent Wesely



Jacob Woodworth



Ben Means



Ben Quade

Dr. Brian Steward

Dr. Saxon Ryan

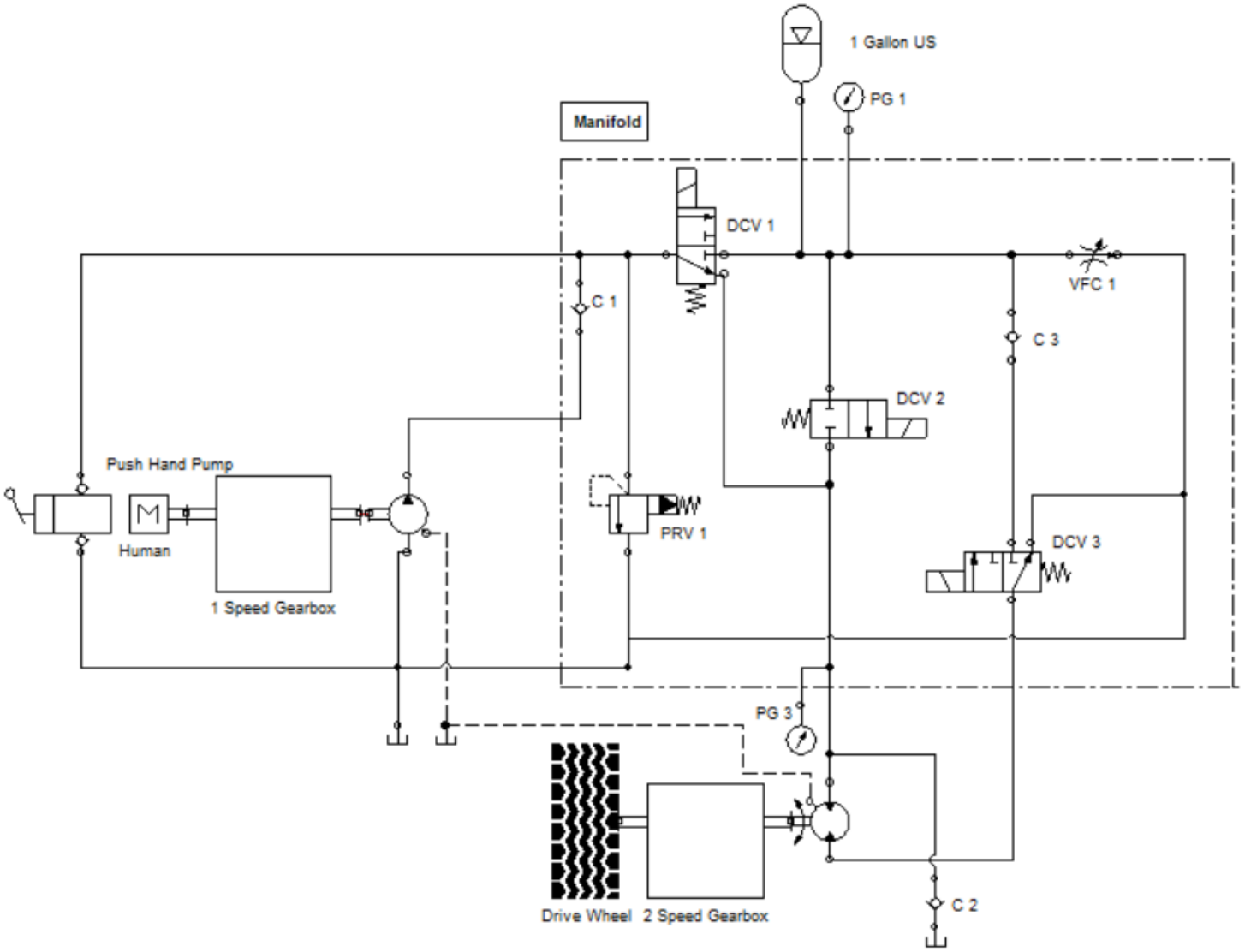
Problem Statement and Objectives

- Refine and improve last year's design
- Design a fluid powered vehicle that:
  - Minimizes losses due to HST's
  - Maximizes top speed
  - Travels 1 mile in at least 30 minutes

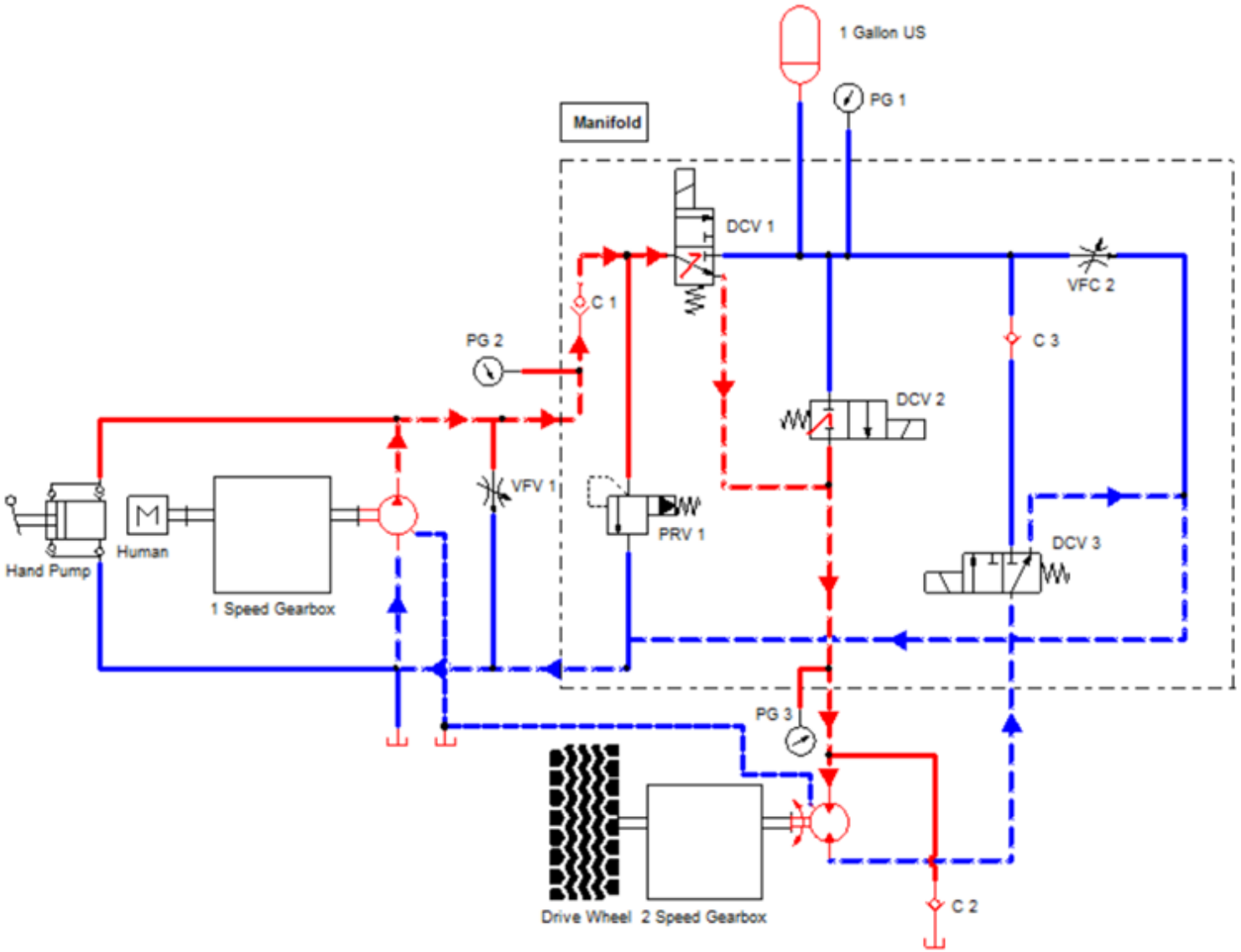
Summary of Midway Presentation

- Design Objective
- Vehicle design
  - Vehicle Design was revised after we tried to assemble the bike from last year's plans. Were able to see what did and did not work from last year.
- Fluid power circuit design
  - See next few pages
- Selection of hardware
  - Assessed hardware selections from last year and determined the additional components we needed.
- Results and incorporation of analyses (e.g., finite element analysis)
  - Frame extension with 6061 T6 Al 1.75 x 1.75 x 1/8 in. square tube.
- Developed a model of a human prime mover
  - Used data from a professional rider and scaled it to 60%
  - Found required tractive effort for the bike
  - Developed a model of the bike
  - Human prime mover model for force on the crank
  - Determined gear ratios for optimal performance

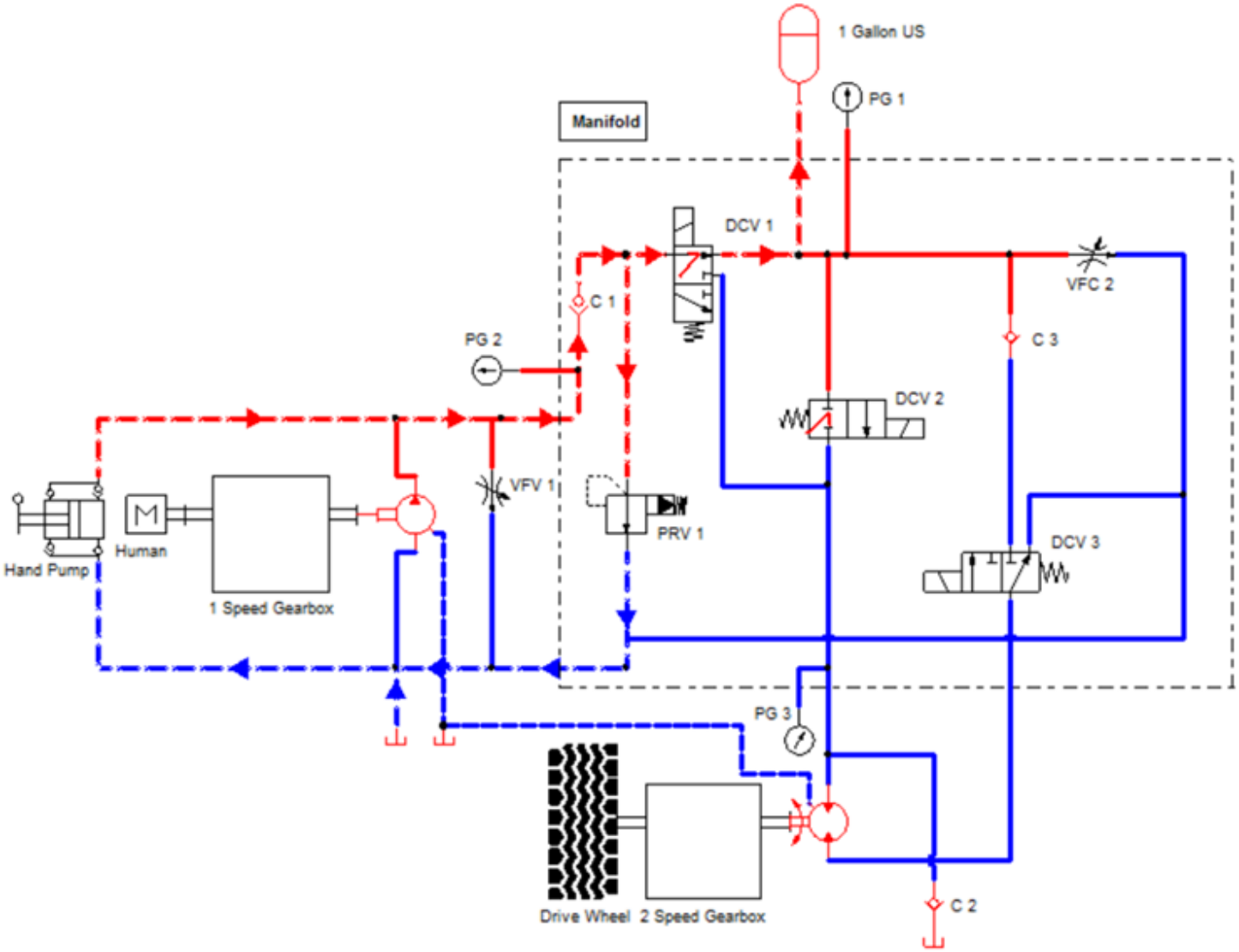
Hydraulic Circuit Design



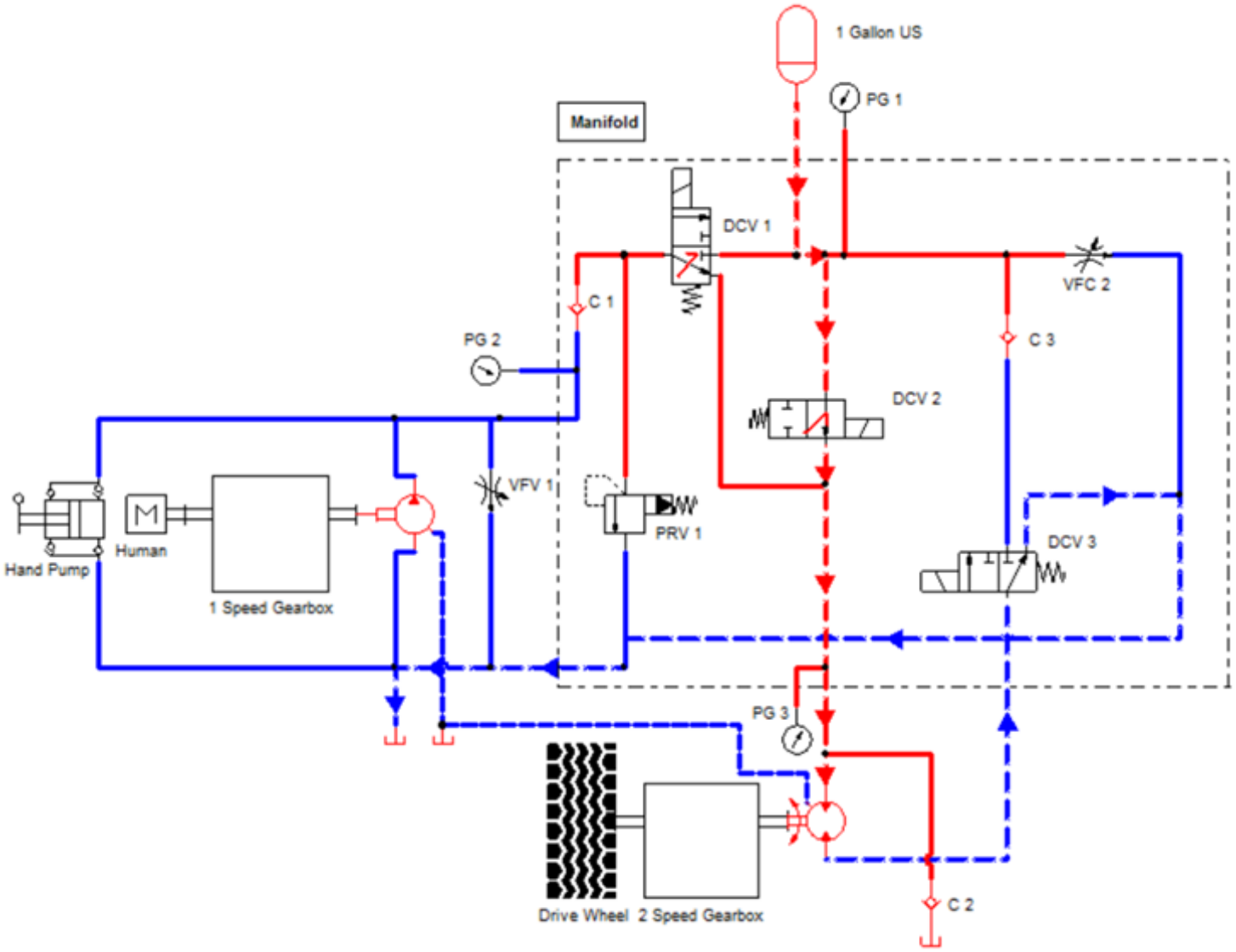
Normal Drive Mode



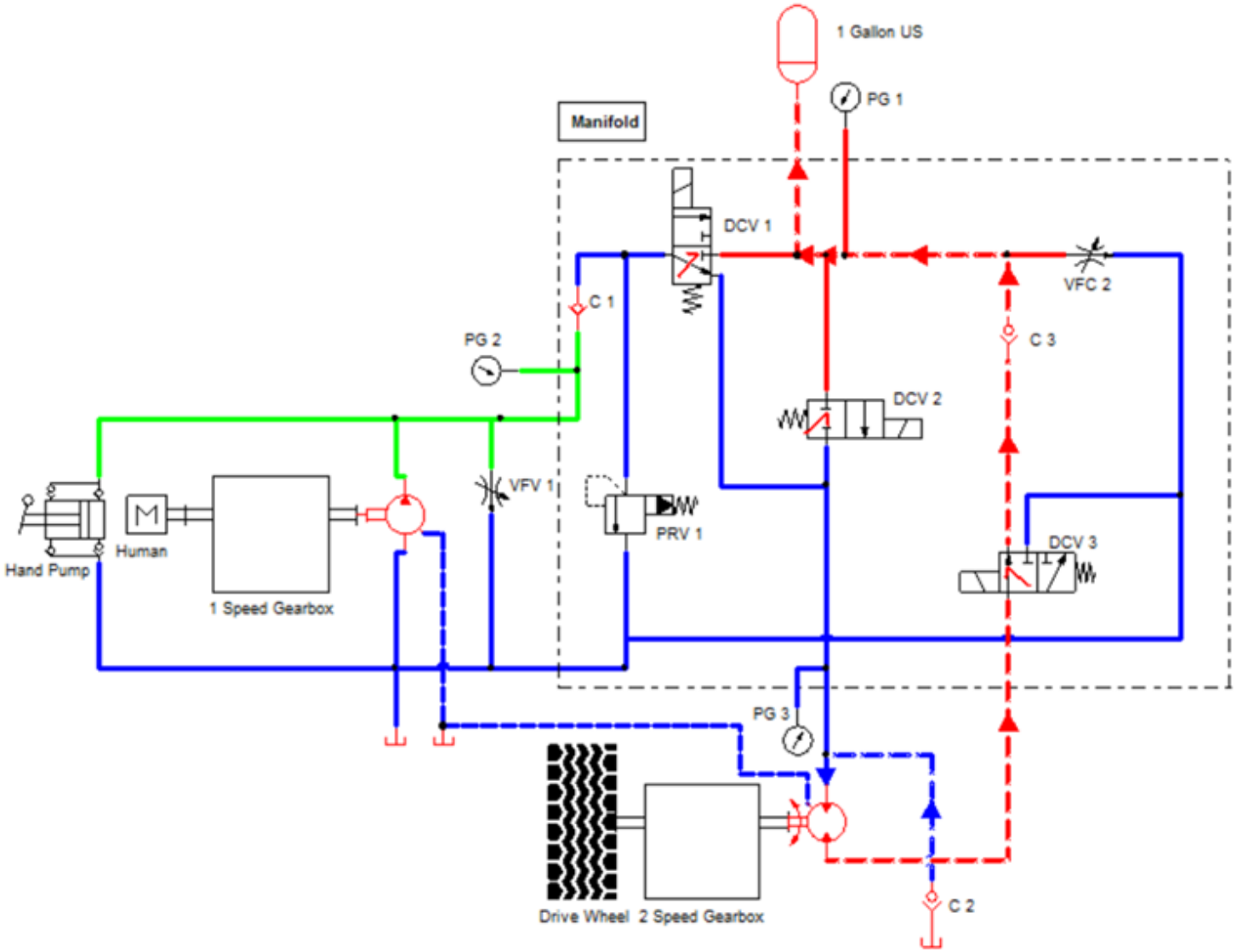
Accumulator Pressurization Mode



Accumulator Power Mode



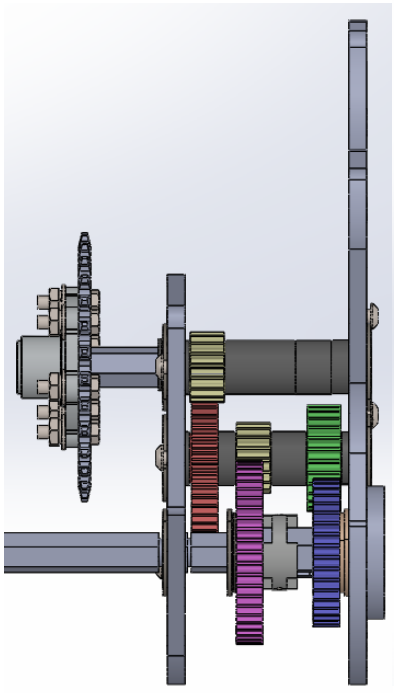
Regenerative Braking



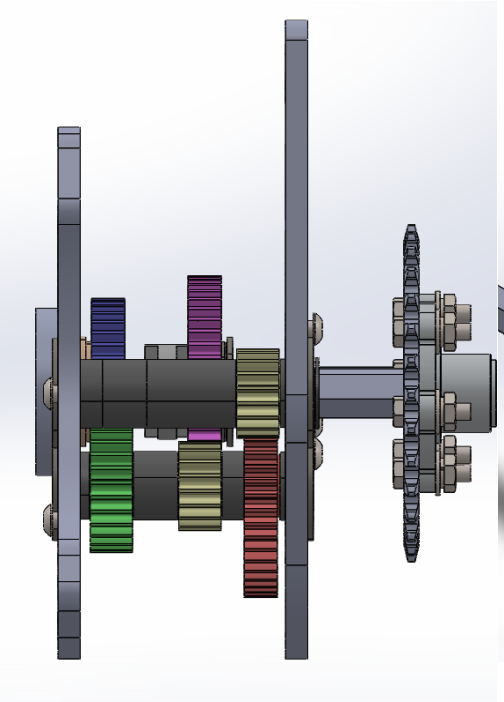
Gear Box Design

- **Gearbox Only**
- First Gear 9.1:1
- Second Gear 4.7 : 1

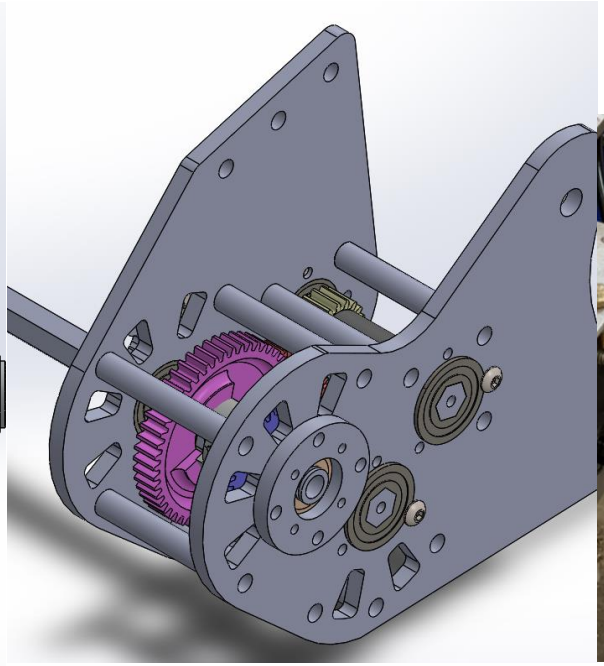
- **Full Output Transmission**
- First 17:1
- Second 8.6: 1 Then Changed to 6.1:1



Top view

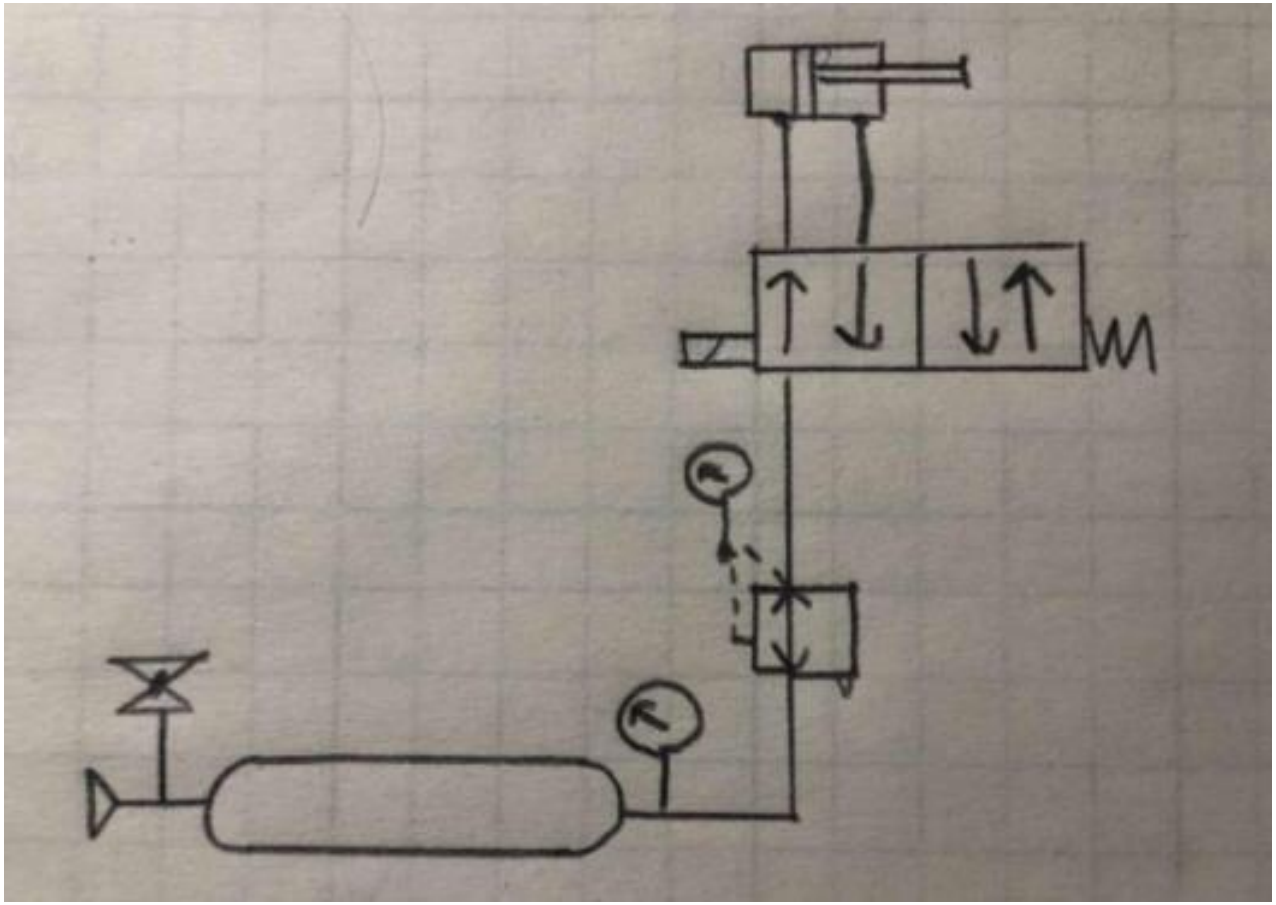


Front view



Rear Isometric view

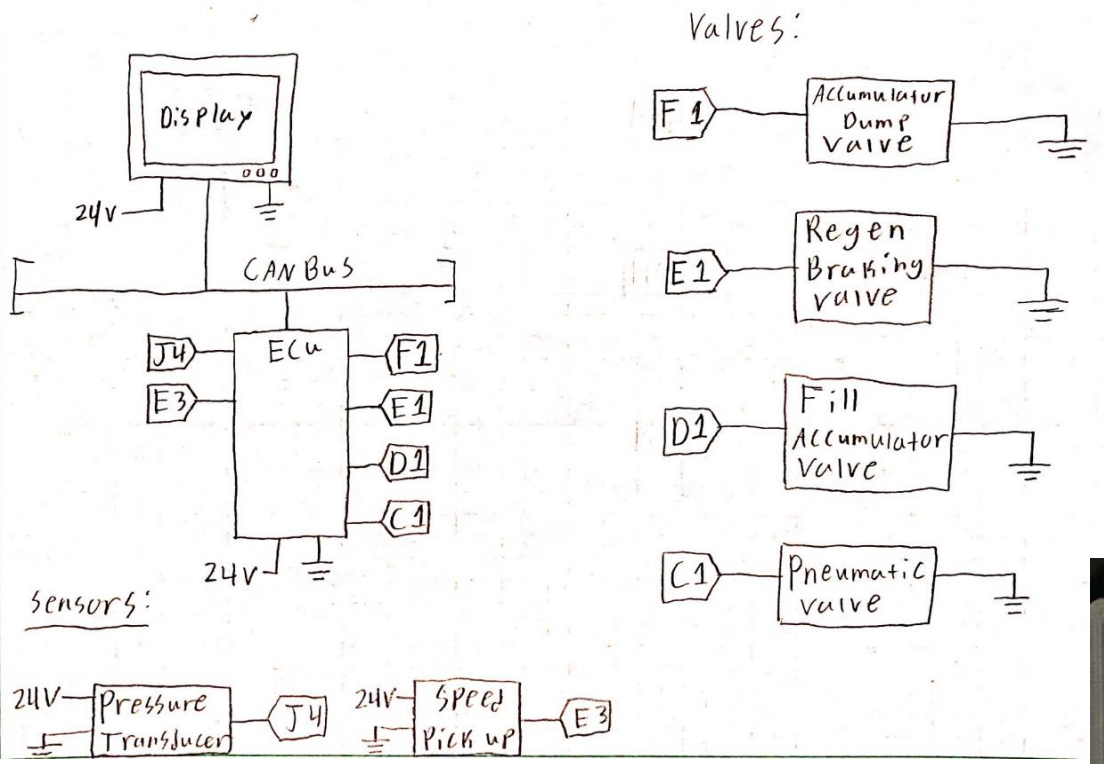
Pneumatic circuit design

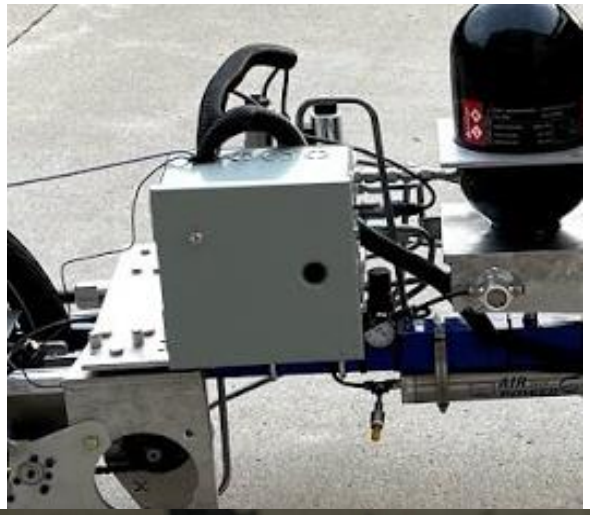


Pneumatic Circuit Schematic for Drive Gearbox

- Double acting actuator was used to ensure enough force was applied to move the dog gear both directions, instead of relying on a spring.

Electrical Circuit





- EX705 Multitouch Control Kit
  - –Control all valves through the display
  - –Using inductive sensors on rear wheel to monitor bike speeds
  - –Monitoring real time pump pressure through pressure transducer on the manifold

Vehicle Construction

- Construction was completed by the original proof of working design date
- Most components were designed and fabricated by the team
  - Reservoir (red circle) was a new design; we had the lab at ISU weld it
  - Frame extension and mounting of pedals was all done by the team
  - Assembled all our own hydraulic tubing
  - Designed and assembled the entire gear box
  - Motor and pump mounts were used from last year's design
  - Wired the whole bike ourselves, even with the little knowledge we had on electronics

Rough prototype of last year's design

Wiring and initial chain routing

Initial tests using hydraulic lines, to ensure circuit works

Vehicle Testing

- Vehicle tests began April 5th
  - Problems we ran into right away
    - Chain derailment
    - Output shaft to our wheel was flexing far too much
    - Hydraulic fittings not tight
    - Random bolts not tightened down
  - How we overcame these
    - Adjusting chain paths and adding tensioners and guides.
    - Securely constrained the output shaft with roller bearings on each side.
    - Rechecked all nuts, bolts, and fittings.
- Fine tuning
  - Finally, we were able to get to the fun part and make the bike function smoothly.
  - We found shifting our gearbox into high gear and using a smaller gear on our bike wheel helped the jerkiness of it.
  - We are thinking this is due to being able to keep constant pressure on the motor, resulting in smoother pedaling.
  - Output shaft also sheared in half on the day we were going to record race footage, but we were fortunate enough that Dr. Ryan was able to machine us a new one very quickly.

Final Vehicle

- Functional design that is very comfortable for the rider
  - All metal tubing
  - Wiring is all covered and secured

Experience with Final Races

- Endurance
  - Lot harder than expected
- Efficiency
  - Farther than expected
- Sprint
  - Could tell our bike was very heavy

Lessons Learned

- Lead times are longer than expected
  - Fabrication
  - Shipping
  - Assembly
- Complex fabrication is better to be outsourced
  - Our reservoir leaked at first, but we were able to work with the ISU lab to ensure leaking was stopped.
  - May be better to contract with a professional fabrication shop in future
- Weight of components truly matters
  - Had weight concerns, but met the requirement
  - Vehicle should be considered as a design constraint earlier in the process
- Hydraulic and pneumatic fitting knowledge is very valuable
  - Several components had fitting which were not in stock
  - Next year we will take extra care looking at all the fitting sizes on our components, so we do not run into the same problem.
- A positive attitude is key
  - We had a few nights where we thought we would never get this bike to work, but we made sure to keep our spirits up and came into the shop the next day with a brand-new attitude.
  - In the end we were able to put it all together and the feeling of accomplishment was amazing.

Thank You