NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

Trike Retrofit for Fluid Power:

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Advisors: Dr. Rodriguez & Dr. Choudhury

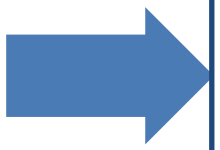
Western Michigan University Team

- Jacob Hermann
  - Engineering Design Technology
- Dane Hoffman
  - Engineering Design Technology
- Hannah St. Clair
  - Engineering Design Technology
- John Hughes
  - Engineering Management
- Sam Sinicki
  - Engineering Design Technology

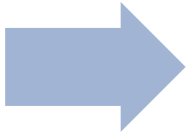
Project Scope:

Design, Build, Test, and Compete with a newly-designed fluid-powered vehicle.

Designed a fluid power drivetrain setup on an existing tricycle frame



Built & Tested the fluid power system for comparison to expected output

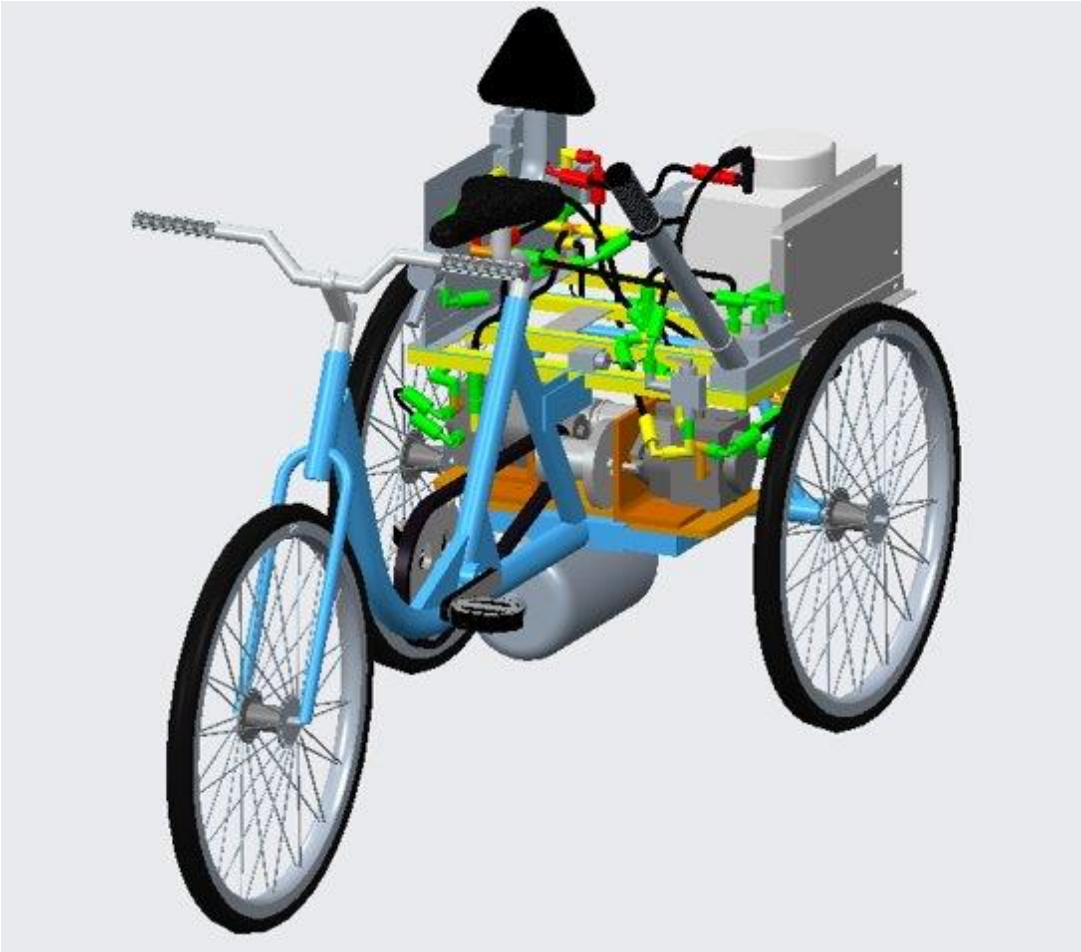


Compete in the Fluid Power Vehicle Challenge

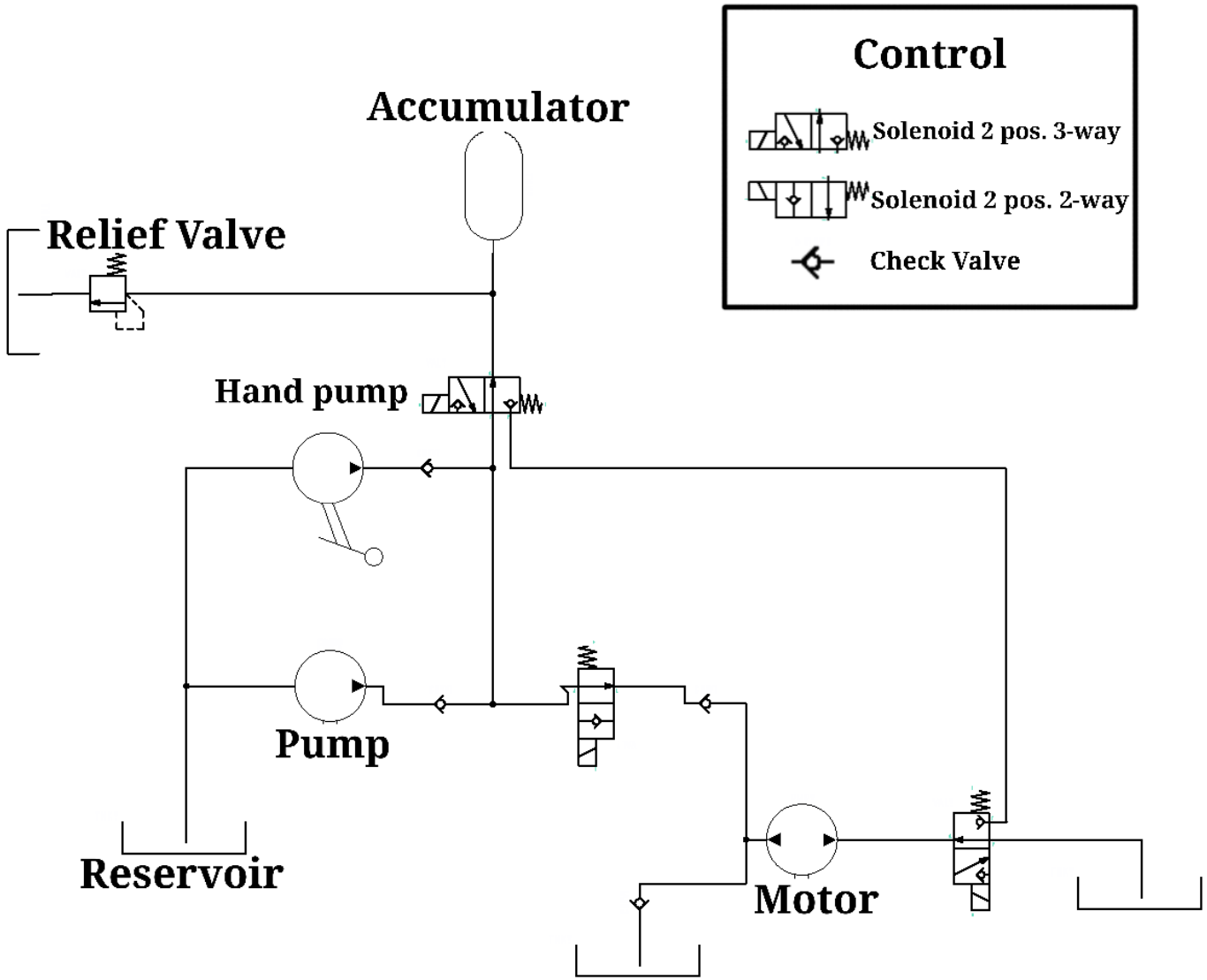
Summary of Midway

Hydraulic Circuit	• Chose the Eaton 26702-DAB Gear Motor • Chose the Eaton 26001-LZJ Gear Motor
Platform	• Looking for a two-platform stack design • Material was not yet selected
Calculations	• Torque created by rider pedaling • Kinematic Speed • Fluid velocity with selected components

Midway CAD Model



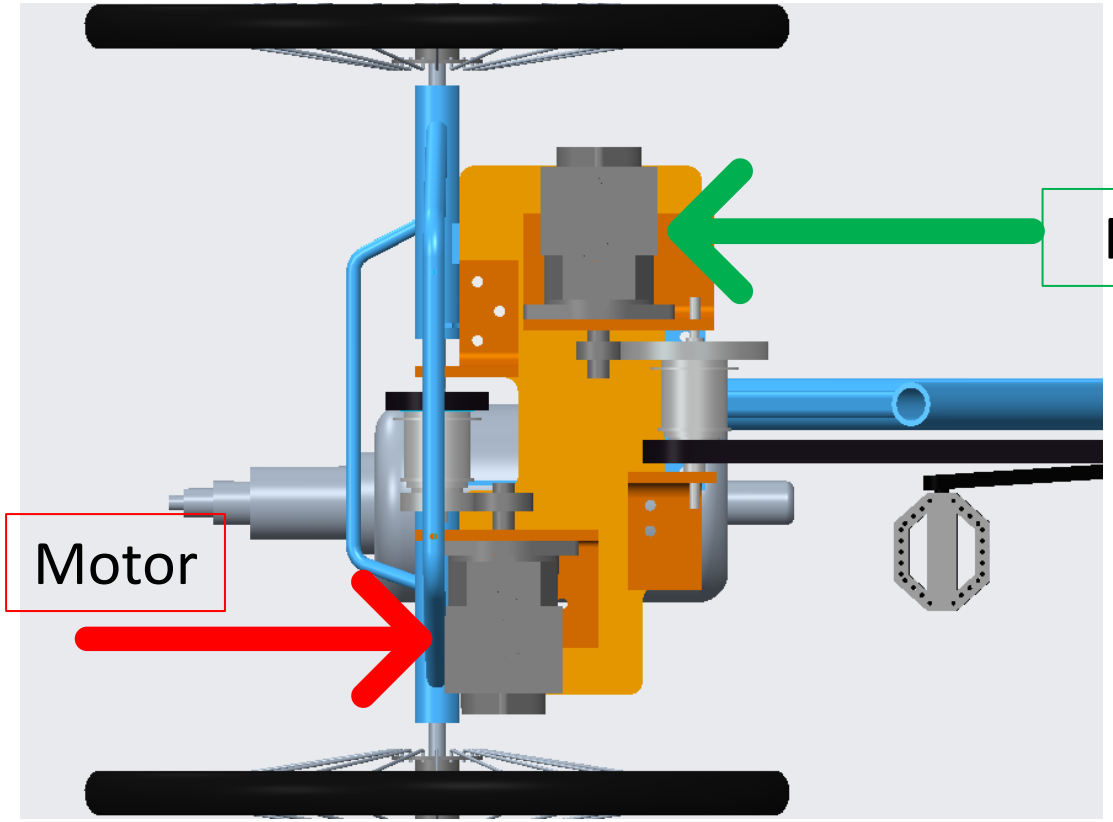
Hydraulic Circuit



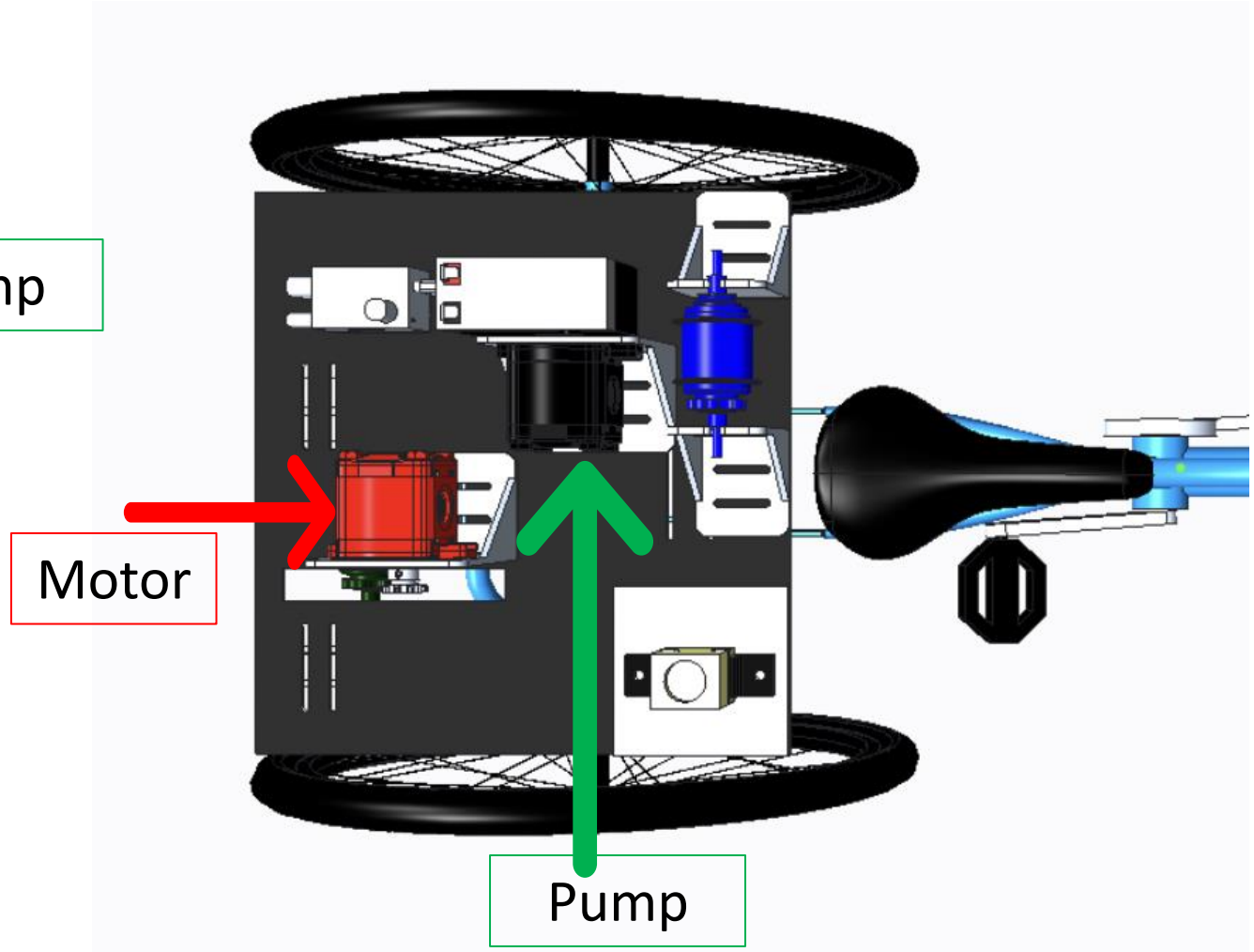
Changes from Original Design

- Made platform smaller for more pedal clearance
- Redesigned mount for reservoir and accumulator
- Changed mounting points for front hub
- Rotated pump to adjust to new system
- Added manifold

CAD Rendering

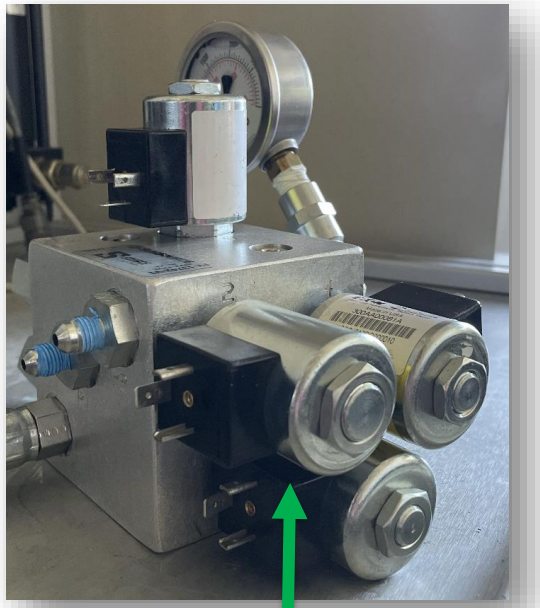


Original Pump and Motor Set Up



New Pump and Motor Set Up

Manifold



Solenoid

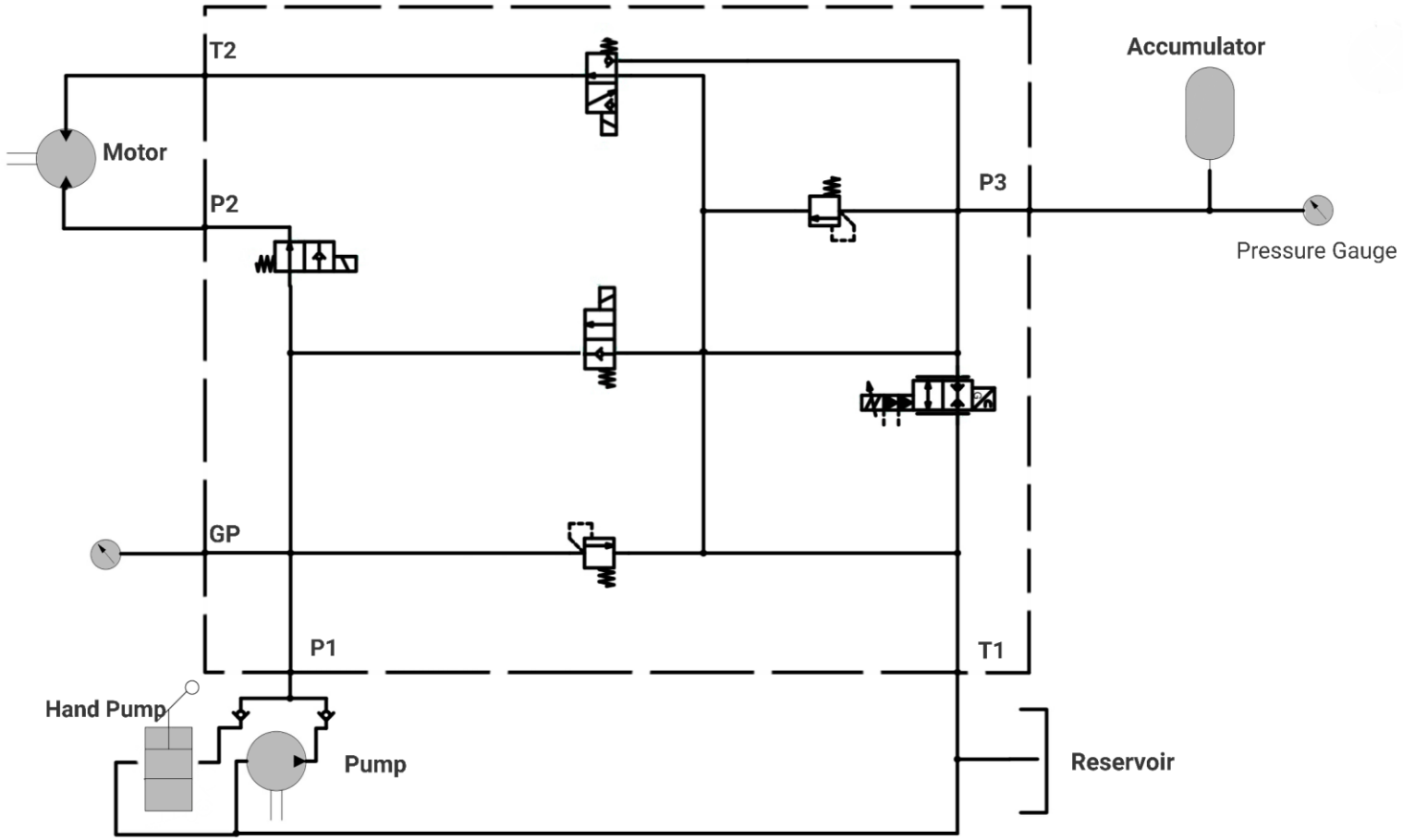
Manifold

- Use to avoid mechanical controls
- More compact and simplified

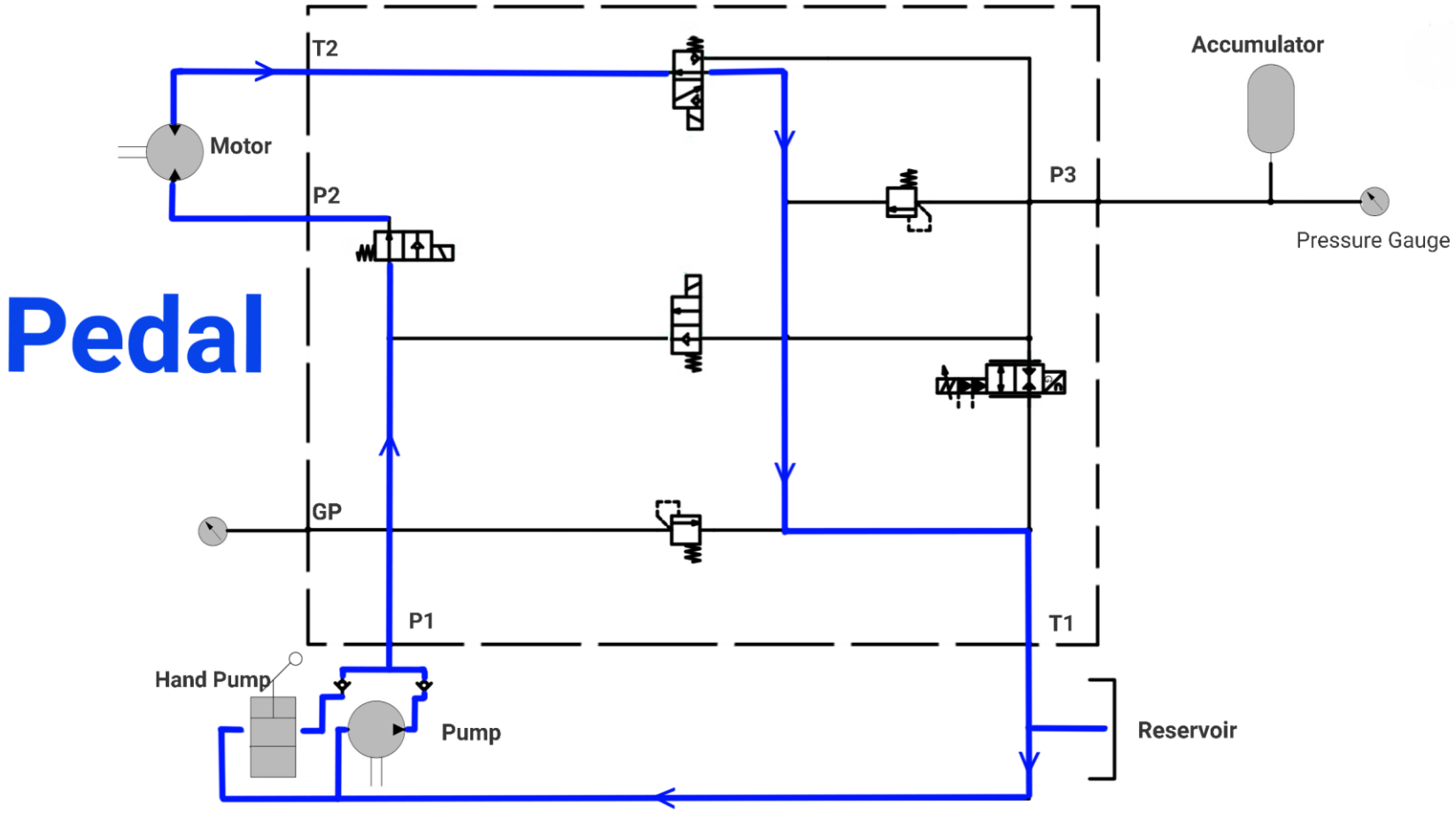
Electronic controls

- Quicker for rider
- Easier to access

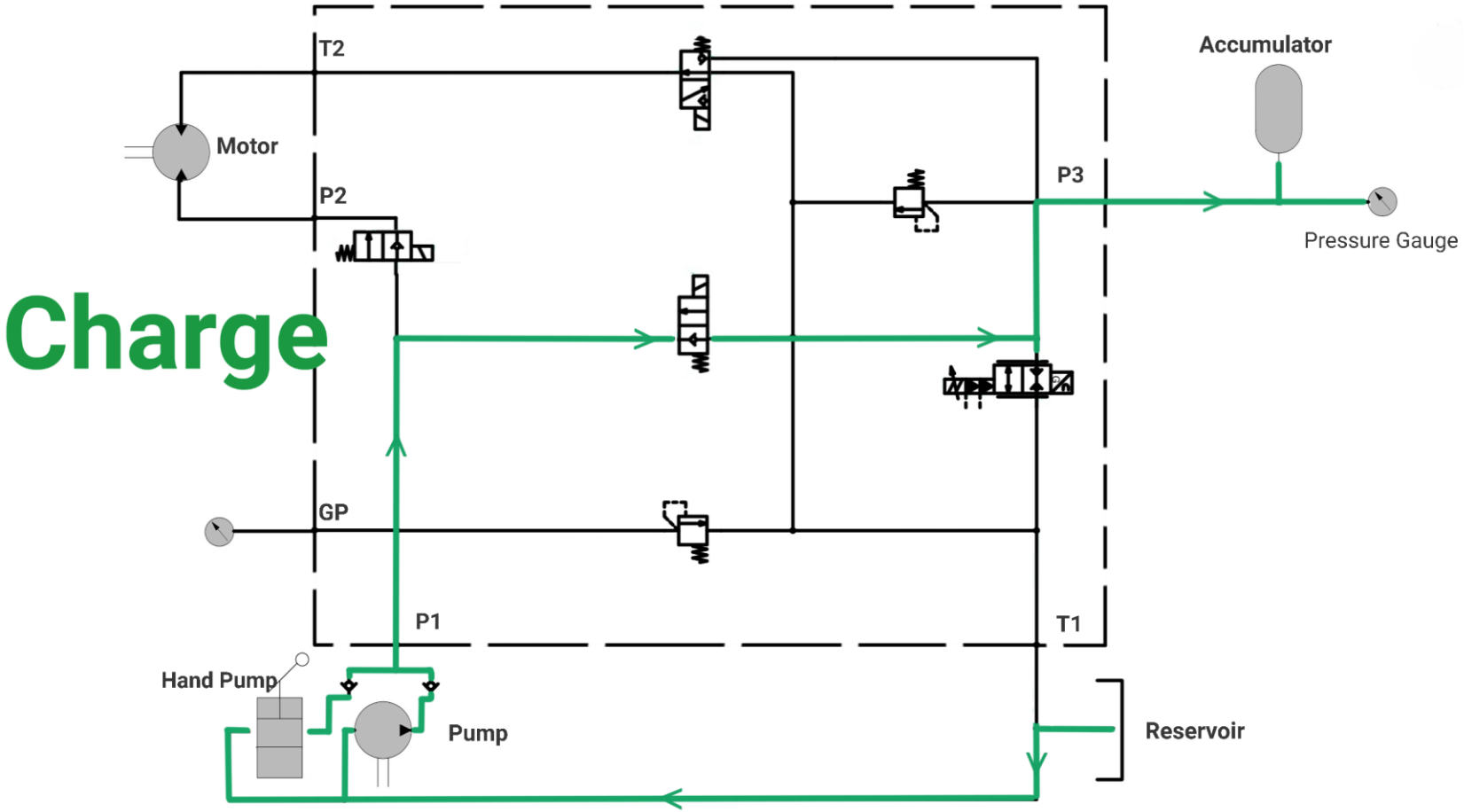
Improved Hydraulic Circuit



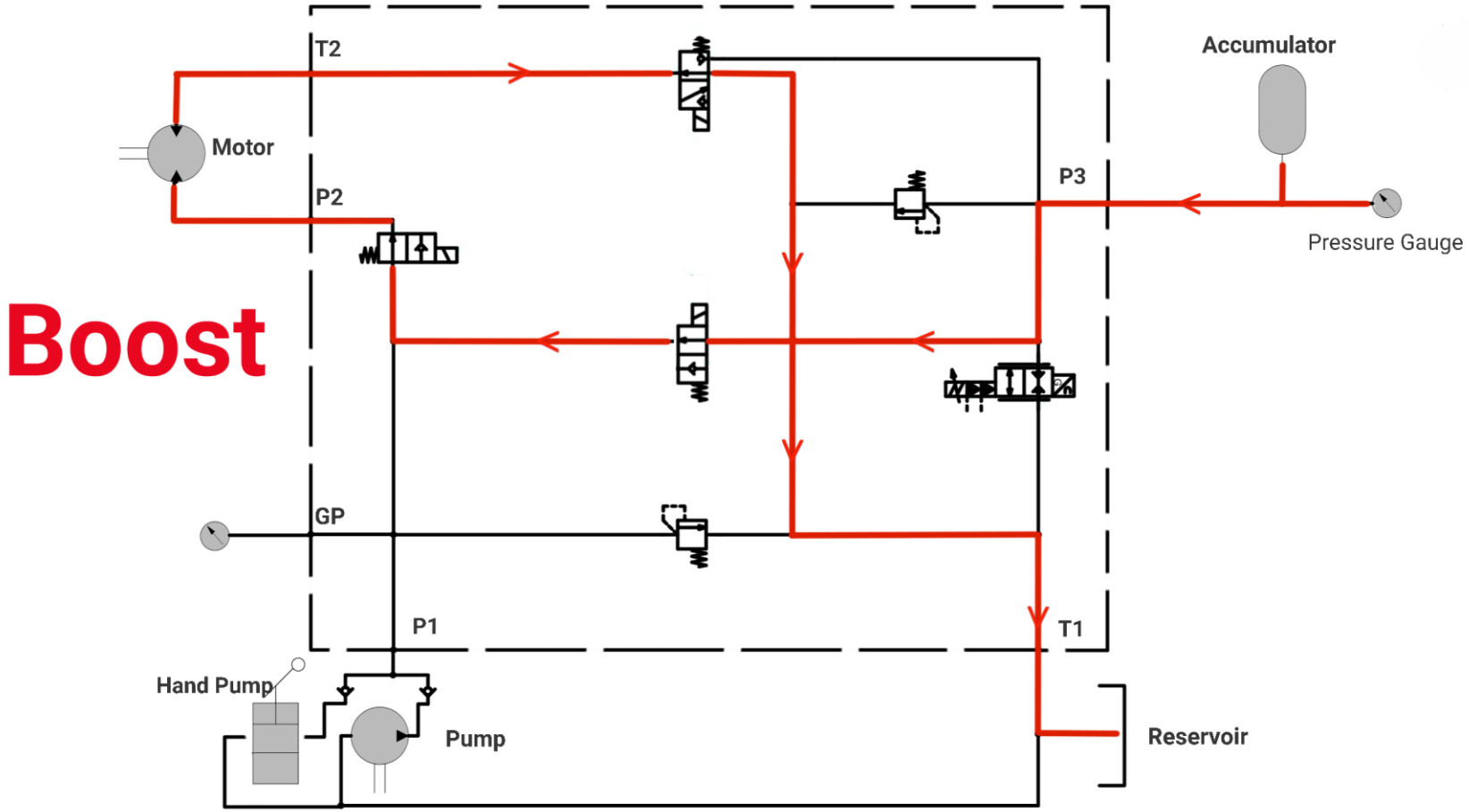
Mode 1


T2
Motor
P2
Pedal
GP
P1
Hand Pump
Pump
T1
P3
Accumulator
Pressure Gauge
Reservoir

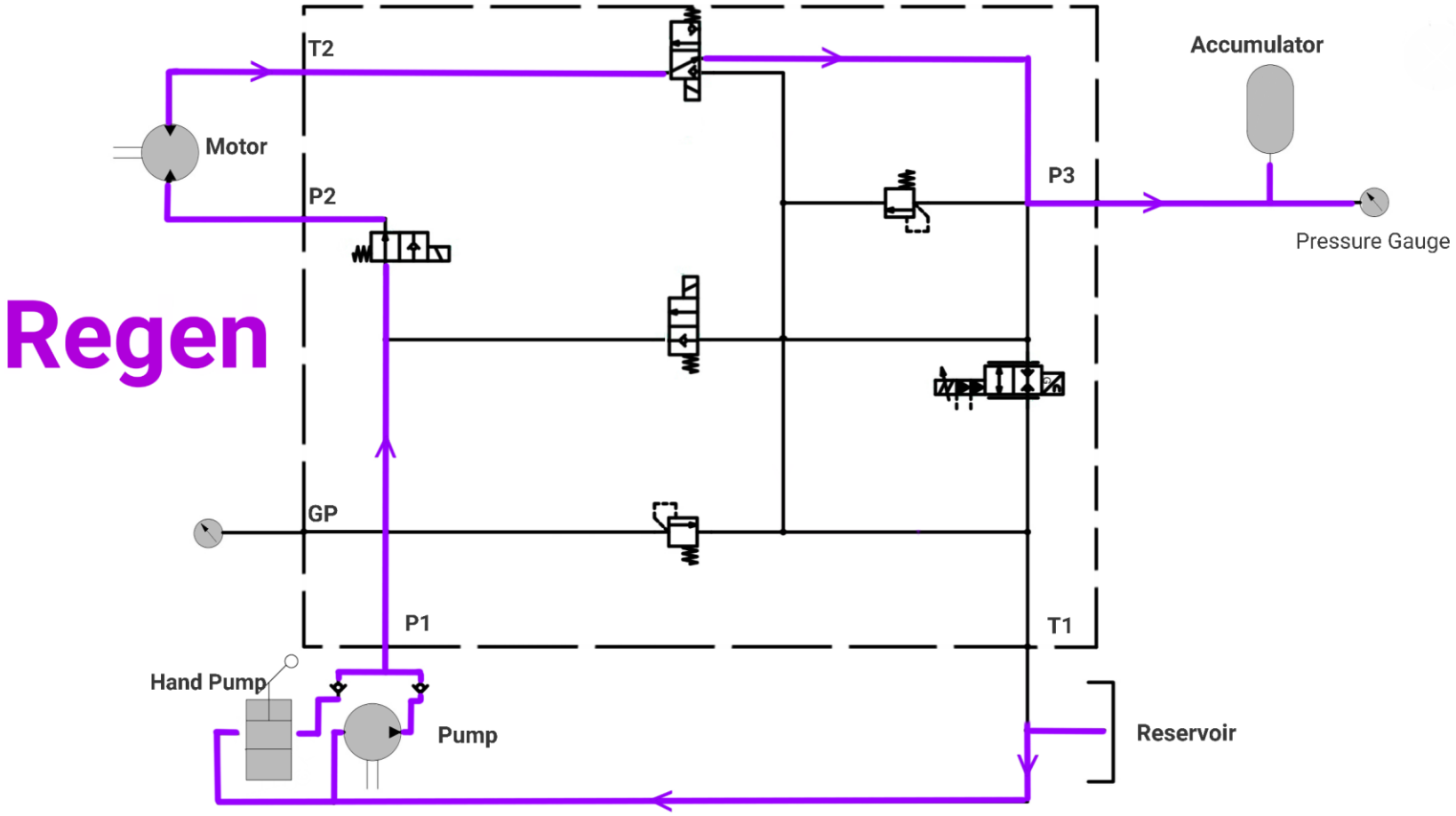
Mode 2


Charge
T2
Motor
P2
GP
P1
Hand Pump
Pump
P3
Accumulator
Pressure Gauge
T1
Reservoir

Mode 3


Boost
T2
Motor
P2
GP
P1
Hand Pump
Pump
P3
Accumulator
Pressure Gauge
T1
Reservoir

Mode 4


Regen
T2
Motor
P2
GP
P1
Hand Pump
Pump
P3
Accumulator
Pressure Gauge
T1
Reservoir

Selected Hydraulic Components

PUMP

COMPANY: Eaton
TYPE: Gear
PART#: 26001-LZG
WEIGHT: 6 lbs
DISPLACEMENT : 6.6 cm^3/rev

MOTOR

COMPANY: Eaton
TYPE: Gear
PART#: 26702-DAB
WEIGHT: 6 lbs
DISPLACEMENT : 8.8 cm^3/rev

Selected Hydraulic Components

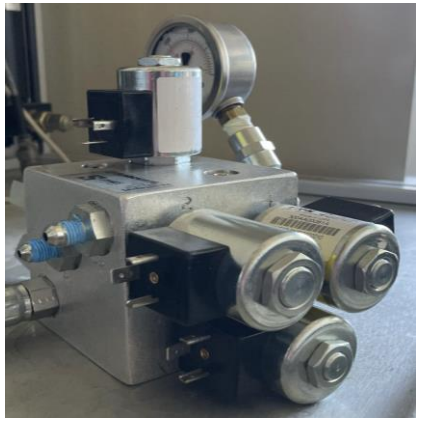
HAND PUMP

COMPANY: Doering
TYPE: Single Acting
PART#: 241872 - S
FLOW: .601 in^3/Pump

ACCUMULATOR

SIZE: 1 Gallon
TYPE: CARBON FIBER
WEIGHT: 6.81 lbs empty
RATING: 3000 psi

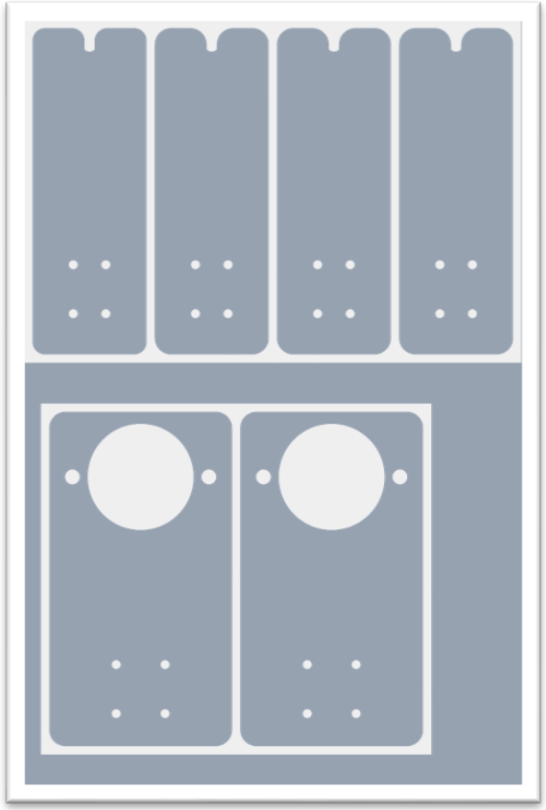
MANIFOLD



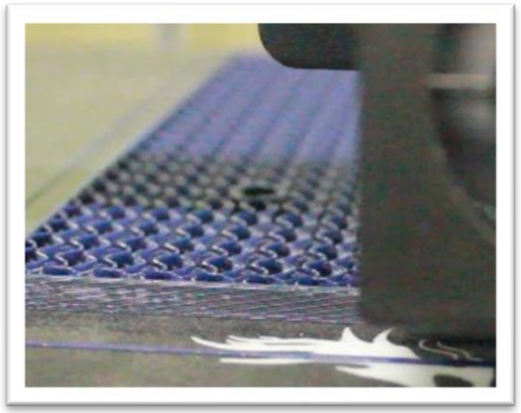
COMPANY: Sun-Source
TYPE: Block
PART#: FV-13742-V1
MATERIAL: Aluminum
RATING: 3000 psi

Manufacturing

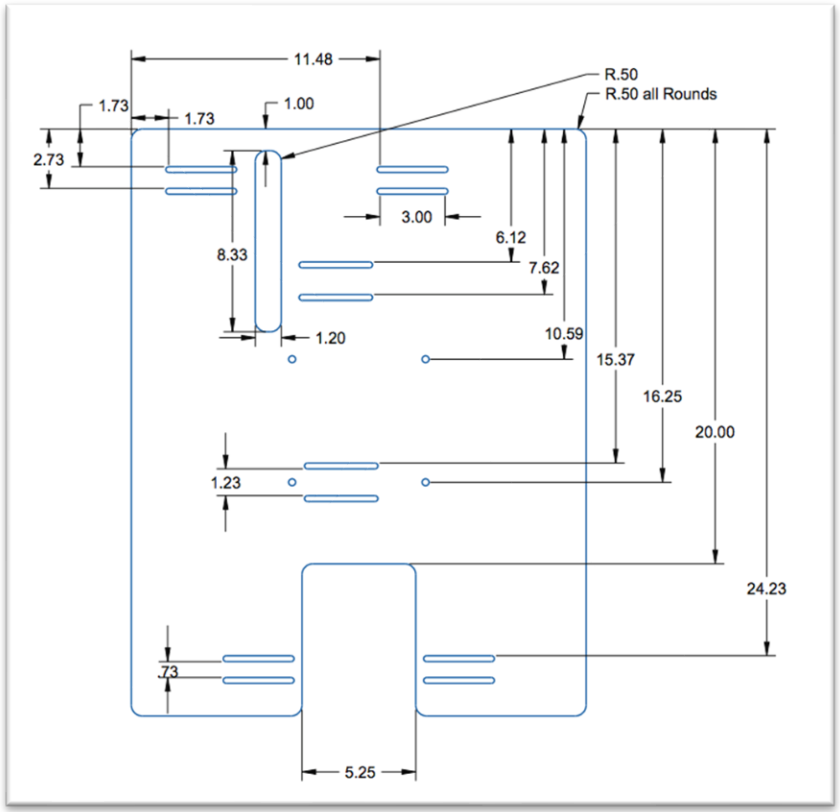
Brackets



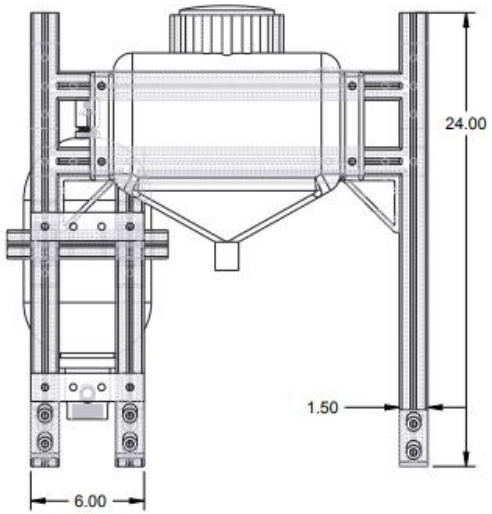
Prototype Prints

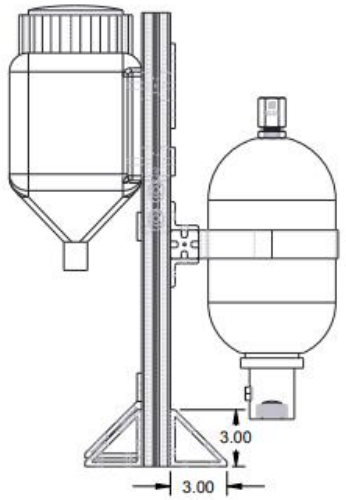


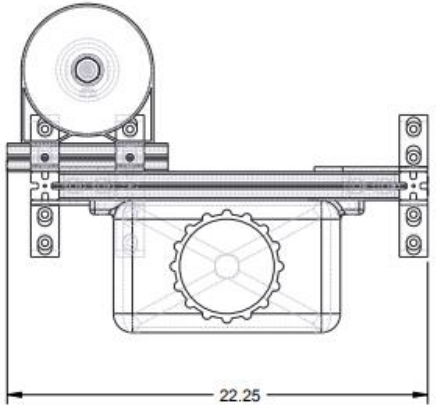
Platform



Manufacturing



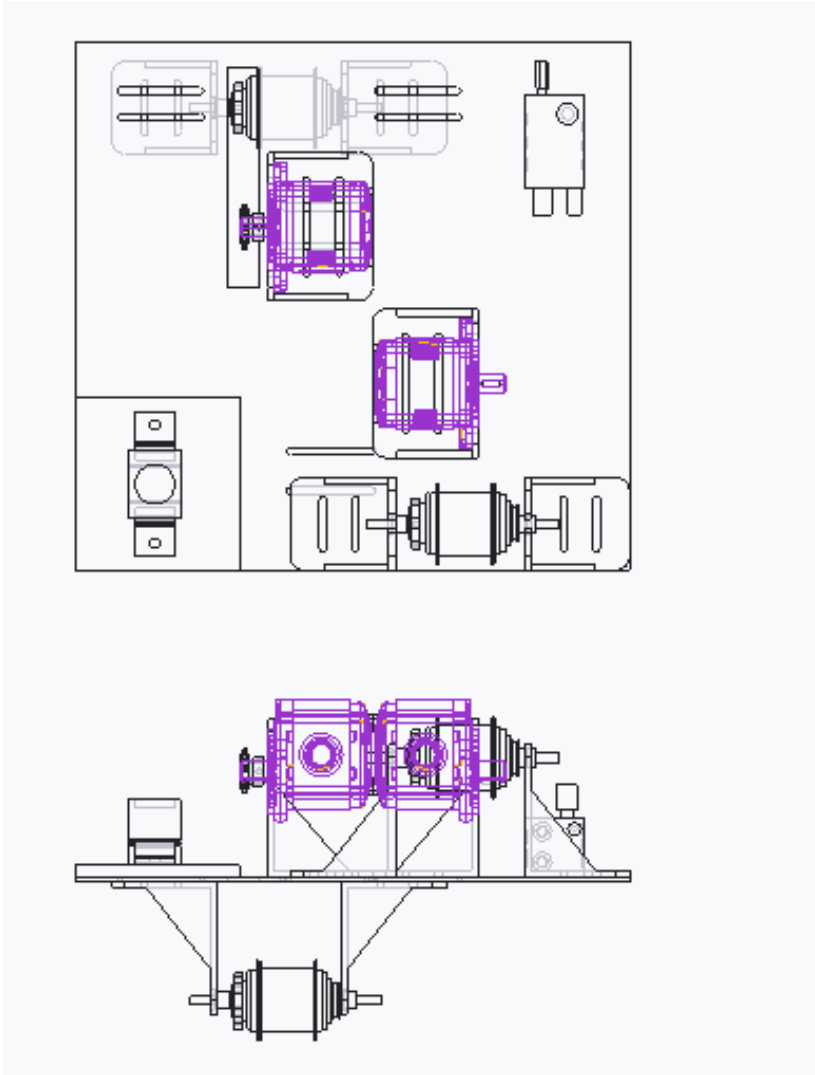




Modified Platform Design

- First iteration of Accumulator and reservoir stand
- Slots for adjustability
- Holes for mounting point
- First iteration of base platform

Manufacturing



Speed Control: 2x Internally Geared Hubs

- Compact setup with 3 gear ratios
- Controlling RPM to pump and to rear axle
- Increased torque during start
- Increased RPM at steady state
- Normally equipped inside wheel assemblies on traditional bikes

		Front HUB			gal/min	ft/s	PSI		Rear HUB			MPH
	RPM Pedal	HUB In	HUB Out	RPM PUMP	Flow Rate Pump	Fluid Velocity	Delta. P	Rpm Motor	HUB In	HUB Out	Rear Axle	Speed
Front 0.75:1 - Rear 0.75:1	60	151	113	404	0.70	4.60	974.0	381	190	143	71	5.5
Front 1:1 - Rear 1:1	60	151	151	538	0.94	6.13	730.5	508	254	254	127	9.8
Front 1.33:1 - Rear 1.33:1	60	151	201	716	1.25	8.16	549.3	675	337	449	224	17.4

Gear Hubs

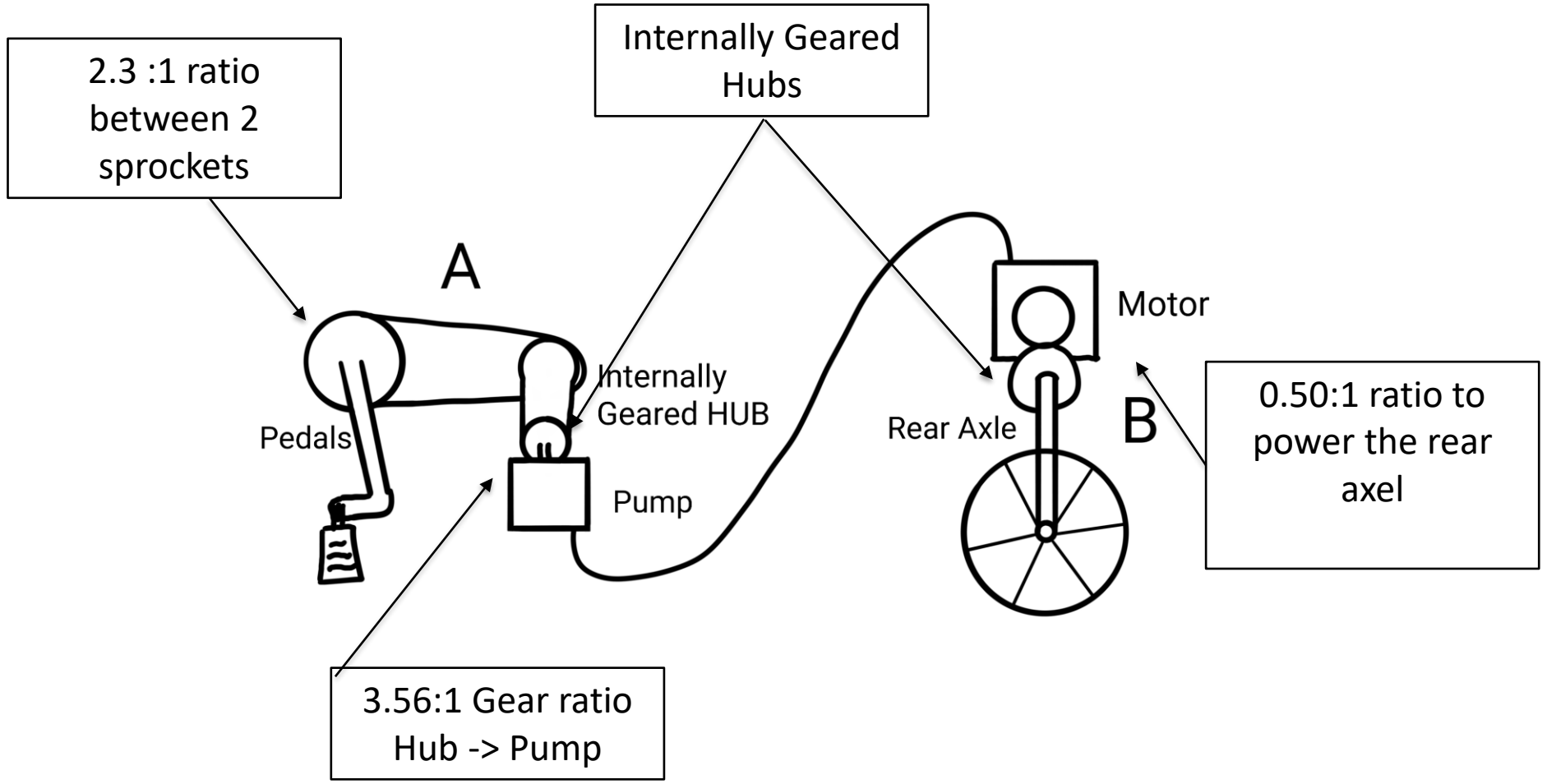
GEAR HUB #1

COMPANY: NEXUS
TYPE: 3 - Speed
PART#: SG-3R40
WEIGHT: 1.95 lbs
RATIOS:
1) 0.733
2) 1.000
3) 1.364

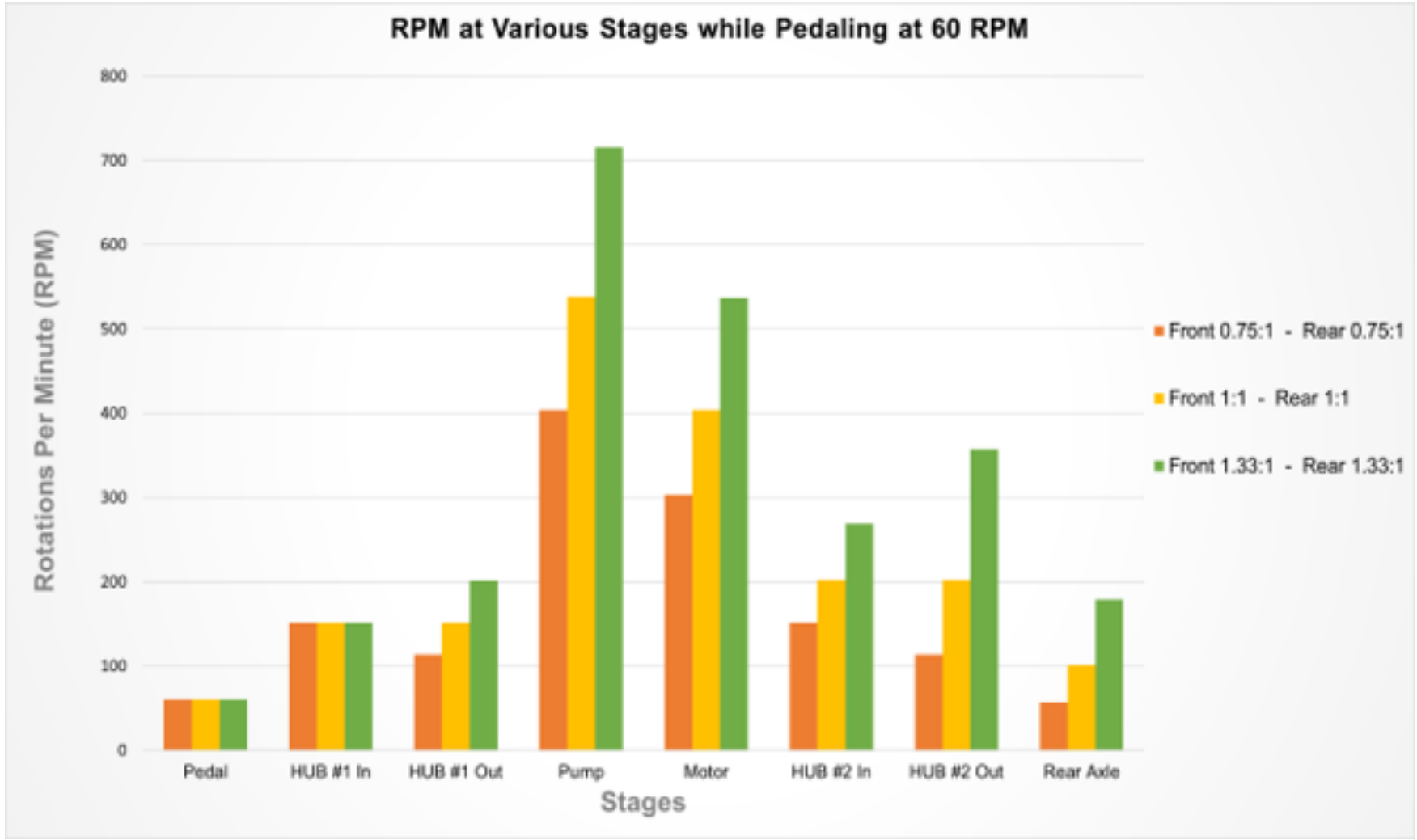
GEAR HUB #2

COMPANY: STURMEY ARCHER
TYPE: 3 - Speed
PART#: S-RC3
WEIGHT: 2.84 lbs
RATIOS:
1) 0.733
2) 1.000
3) 1.364

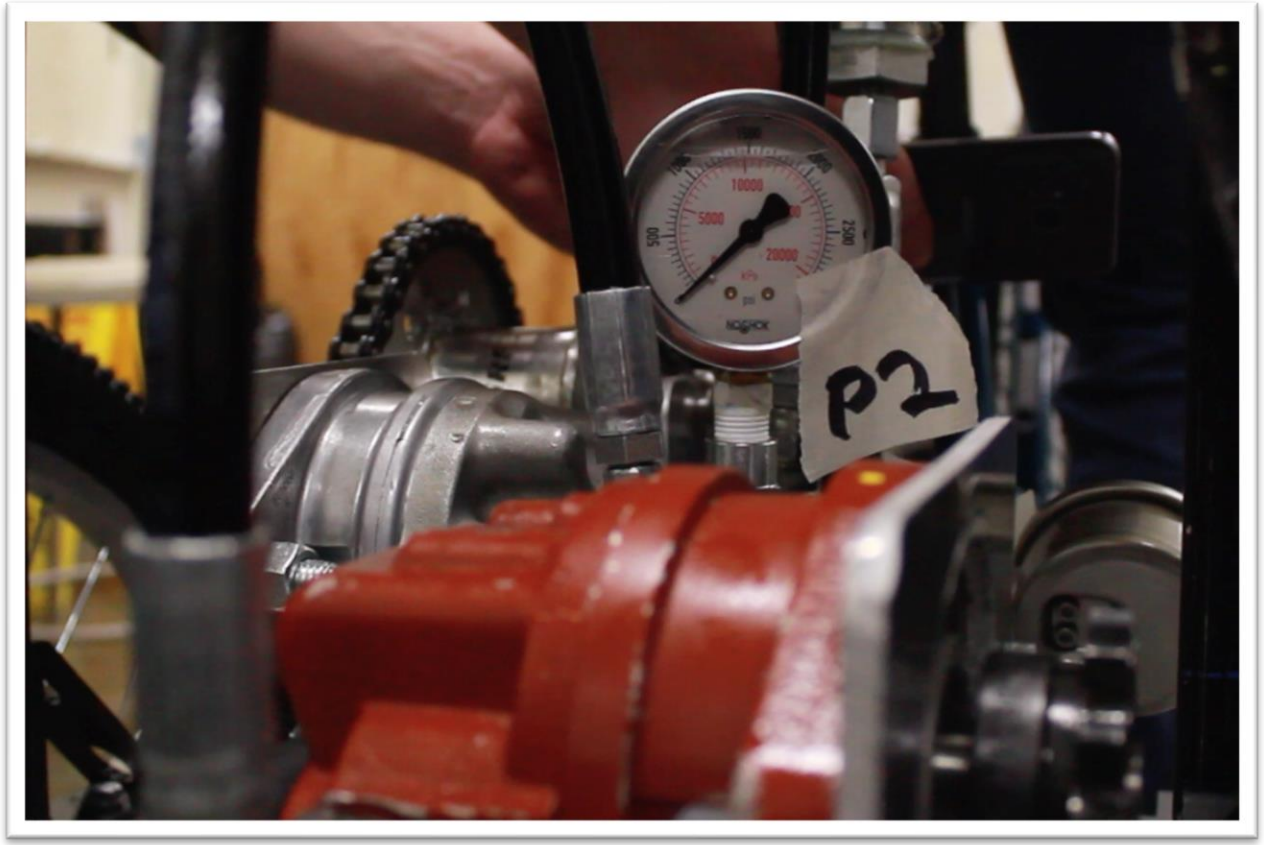
Simple System Schematic



Kinematic Speed Calculations



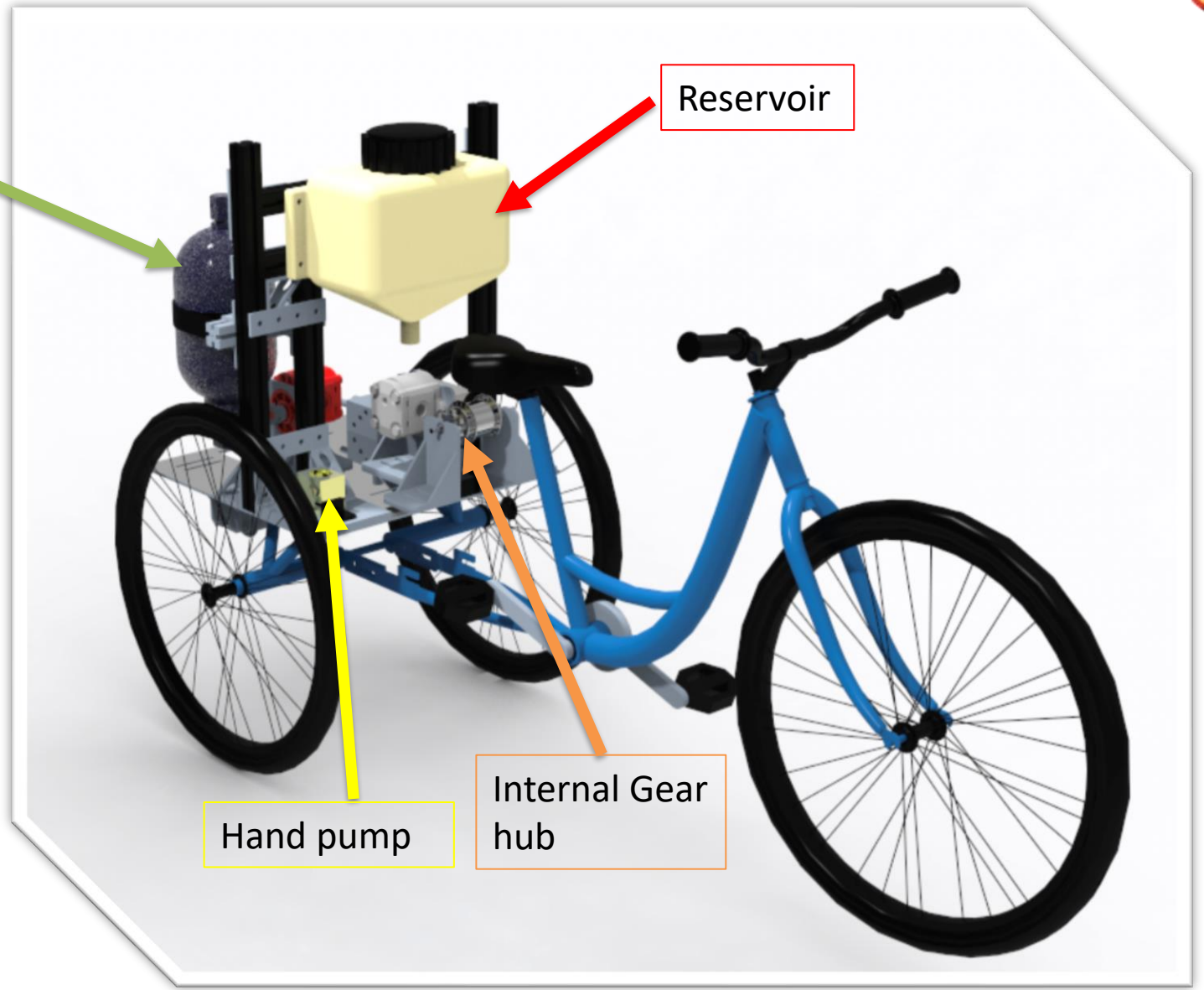
Testing



Verified Operation of:

- Pump
- Hand Pump
- Motor
- Accumulator
- Front Drive Train
- Rear Drive Train
- Manifold
  - Pedal
  - Charge
  - Boost
  - Regen

Final CAD Rendering



Problems We Encountered

- Chain Tension
  - All chains needed length and tension adjustments
- Sprocket Alignment
  - Chain frequently popped off due to runout and alignment issues that were not coplanar.
- Pedal assembly
  - Original pedal assembly was difficult and near-impossible to replace

Lessons Learned

- Importance of communication
- Designing process
- Importance of the testing week
- What can be imagined cannot always be manufactured
- Design to deadlines

Conclusions

- Trike was selected for vehicle frame
- Hydraulic circuit was created
- System schematic created for trike
- Calculated optimized drive train
- Build & Test

Thank you

WMU Advisors
- Dr. Alamgir Choudhury
- Dr. Jorge Rodriguez

WMU Faculty
- Andrew Wyman
- Mike Konkel

Industry Technical Advisor
- Jay Dalal

NFPA Program Manager
- Stephanie Scaccianoce

Questions?