NFPA Fluid Power VEHICLE Challenge

NFPA Education and Technology Foundation

Final Review
The University of Alabama at Birmingham
Mentor: Dr. David Littlefield
4/12/24

UAB Hydraulic Bike Team

NFPA Fluid Power Vehicle Challenge

Frame & Hydraulic Circuit Team

Davis Snow

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Hydraulic Pump and Motor Team

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Sunny Patel

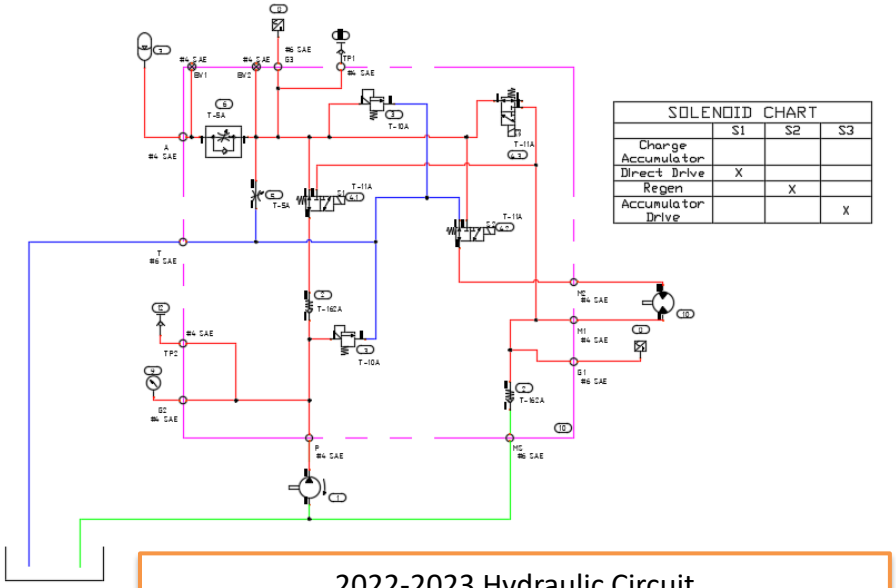
Zack Burnett

2022-2023 Team's Design

2022-2023 Final Tadpole Recumbent Bike

2022-2023 SOLIDWORKS Model

Reservoir & Accumulator



SOLENOID CHART			
	S1	S2	S3
Charge Accumulator			
Direct Drive	X		
Regen		X	
Accumulator Drive			X

2022-2023 Hydraulic Circuit

2023-2024 Team's Design

Design Objectives for New Bike

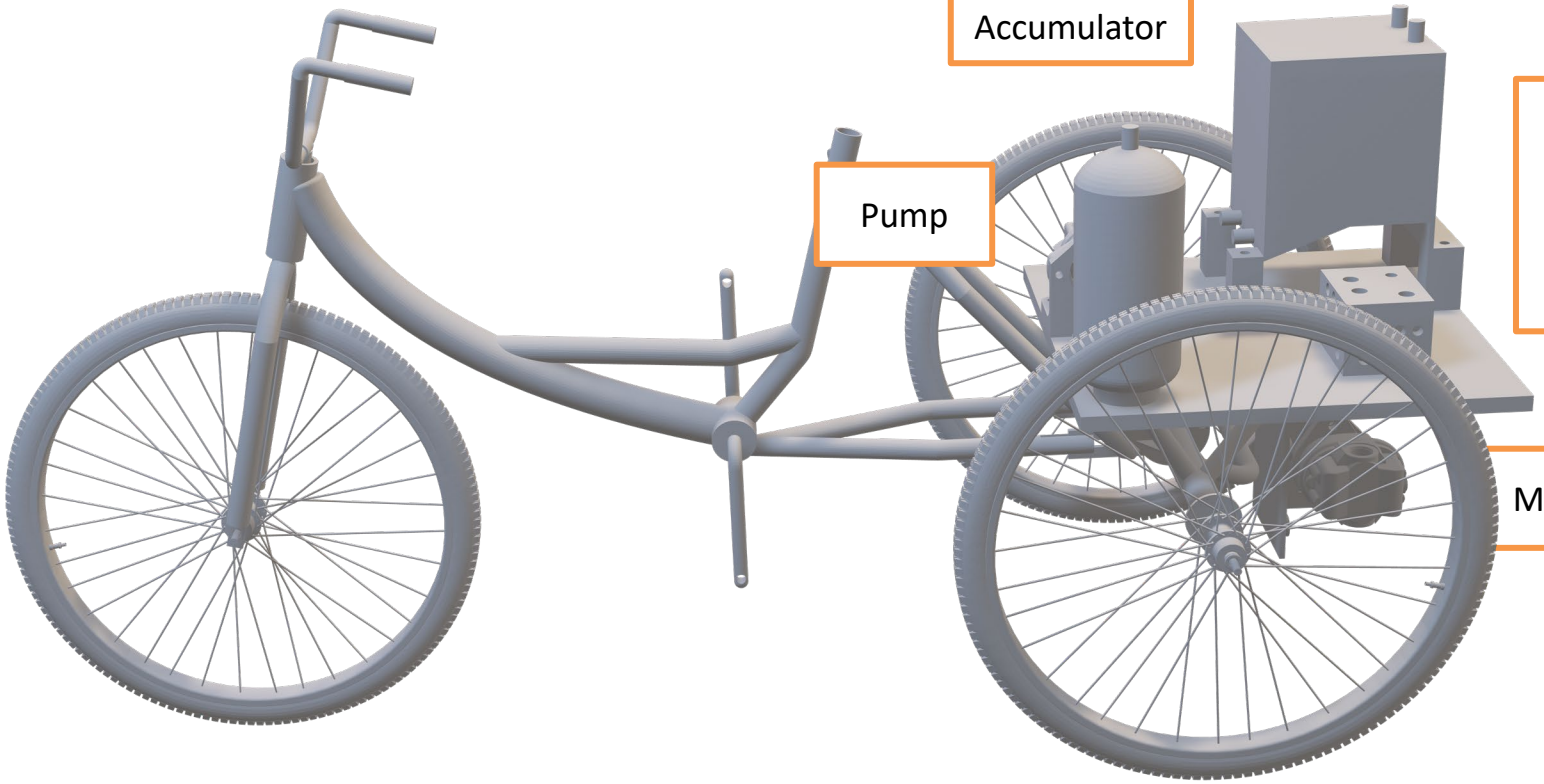
- Approach
  - Started build from scratch rather than adding to past bike, considered recommendations from past team
- Improvements
  - Simplify Frame Design
  - Increase Accessibility to Components on Bike
  - Decrease Hydraulic Circuit Complexity
  - Improve Overall Efficiency
    - Torque, Speed, Bearings, etc.
  - Mitigate Steering Uncertainty
  - Ensure Proper Engagement of Regenerative Braking
  - Eliminate Excess Weight

Midway Review Summary

- Summary
  - Our team received positive feedback and suggestions for improvements
  - Requirements for each portion were met
  - Final design was completed
- Feedback
  - Suggested case drain on hydraulic motor
  - Hoses did not need to be rated so highly
  - Correct motor schematic to depict bidirectional motion
  - Begin building as soon as possible, as it takes longer than expected

SolidWorks Model

Delta Recumbent Trike with Back Plate storage



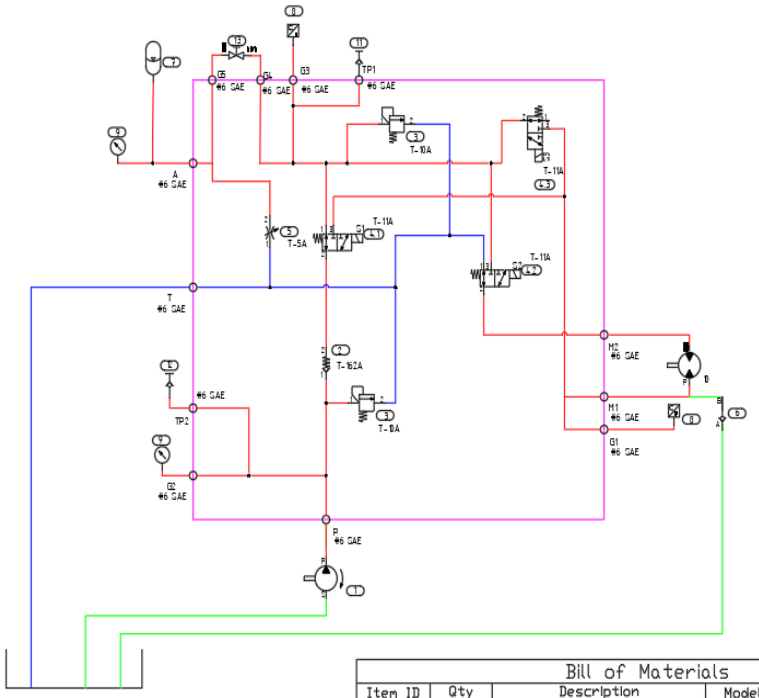
Hydraulic Circuit Design

Hydraulic Design:

- 4-mode design:
  - Charge accumulator
  - Direct drive (S1)
  - Regen (S2)
  - Accumulator drive (S3)
- One-motor system
- Includes pressure gauges/transducers, check, relief, and directional valves as well as a single ball valve

Advantages:

- Manipulate solenoids for boost
- Higher efficiency than initial design



SOLENOID CHART			
	S1	S2	S3
Charge Accumulator			
Direct Drive	X		
Regen		X	
Accumulator Drive			X

Bill of Materials				
Item ID	Qty	Description	Model Code	Part Number
4.1,4.2,4.3	3	Flex Series 3 way directional valve	DMDA-XAN	
3	2	Direct acting relief valve	RDDA-LAN	
2	1	Free flow nose to side check valve	CXBA-XAN	
5	1	Fully adjustable needle valve	NFDC-LAN	

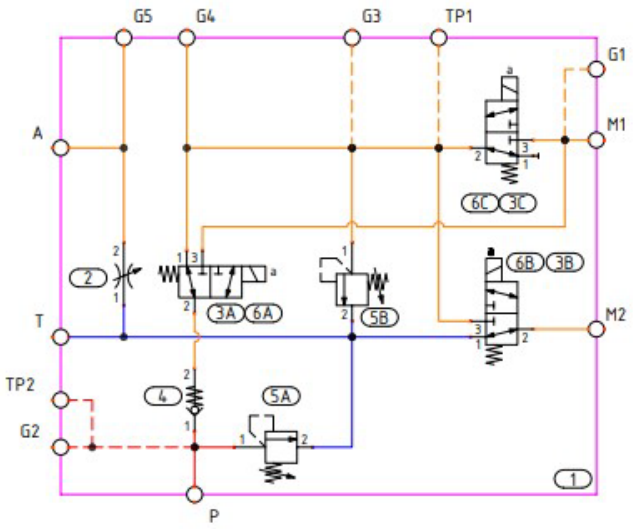
Pink – Manifold

Green – Inlet

Red – Pressure

Blue – Return Line

Hydraulic Circuit Approval



Item	Qty	Model Code	Description	Manufacturer
1	1	FV-14206-M1	Manifold body	Source FP
2	1	NFDC-LAN	Needle Valve	Sun Hydraulics
3	3	DMDAXAN	Direction Control Valve	Sun Hydraulics
4	1	CXBA-XAN	Check Valve	Sun
5	2	RDDA-LAN	Relief Valve, Direct Acting	Sun
6	3	770-224	24VDC Din Coil	Sun

ITEM ID	PORT TYPE	PORT SIZE
A, G1, G2, G3, G4, G5, M1, M2, P, T, TP1, TP2	SAE O-RING	#6 SAE

Notes:
-3000 PSI max
-Team to procure all cartridge valves and coils separately
-Team to ensure relief valves are set correctly

SUNSOURCE

Creation Date 12/4/2023	Drawn By J. McCarthy	Customer Name University of Alabama at Birmingham
Material Aluminum	Print Checked By Team	Title NFPA-FPVC Manifold
Protective Finish None	Sheet Name Sheet 1 of 1	Part Number FV-14206-V1 Schem
Size B — Dimensions are in inches. Do not scale drawing. Unless otherwise specified, apply standards per FV-1000-Spec1	Third Angle Projection	Rev A

Hardware Selection - Frame

- Husky Bicycles T-124 Industrial Tricycle
  - **Prebuilt frame**: reduce fabrication time, minimize human error
  - **Delta recumbent** configuration: stability, storage space
  - **Custom upgrades** implemented to comply with safety and performance needs

Hardware Selection - Pump

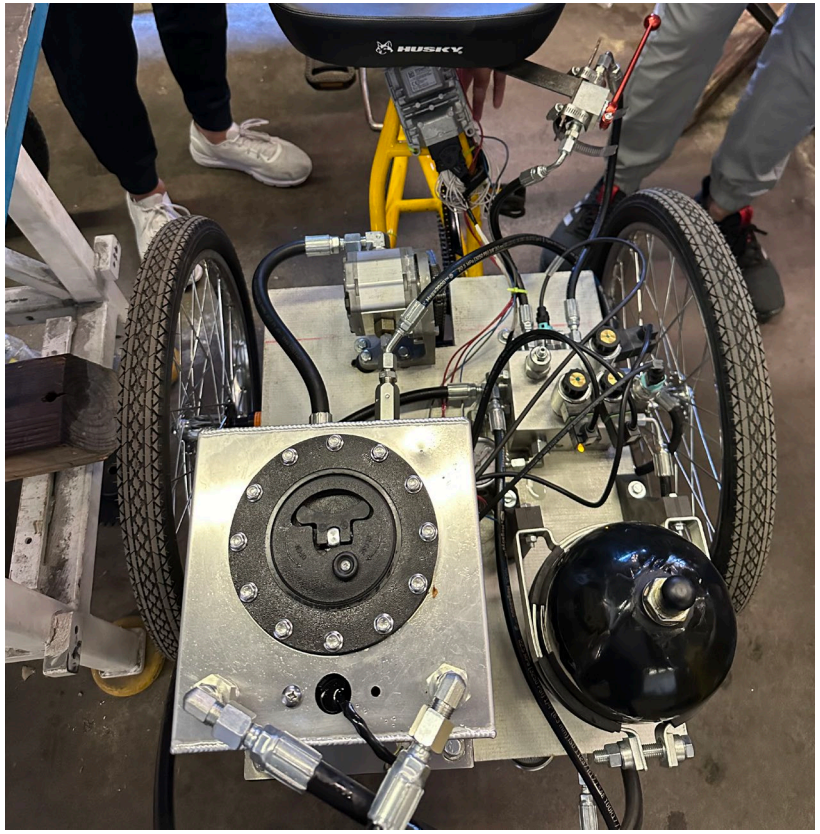
- **Model:** SNP2NN/6,0RN06SAP1E6E5
- **CID:** .37 [in^3/rev]
- **Rotation:** Clockwise
- **Compound Gear Ratio:** 6.38 [Increase RPM]
- **RPM:** 415
- **Weight:** 5.3 [lb]
- **Mount:** 2 bolt SAE A Flange
- **Flow Rate:** .66 [GPM]

Hardware Selection - Motor

- **Model:** SNM2NN/011BN06GAM6E6E5
- **CID:** 0.66 [in^3 /rev]
- **Rotation:** Bi-directional
- **Gear Ratio:** 1.2 [Increase Torque]
- **RPM:** 194
- **Torque with Gear Ratio:** 332.4 [lb-in]
- **Weight:** 5.5 [lb]
- **Mount:** 2 bolt SAE A Flange

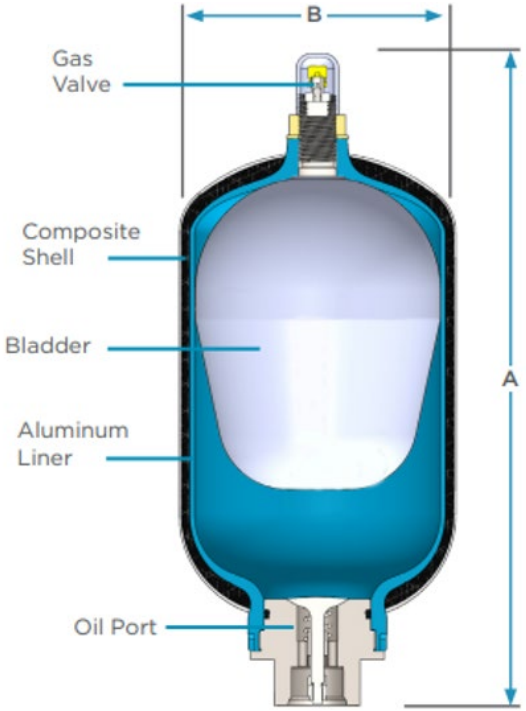
Hardware Selected - Hosing

Route	Hosing Size
Reservoir to Pump	8M3K
Pump to Manifold	4M3K
Manifold to Motor	6M3K
Motor to Manifold	4M3K
Reservoir to Motor	6M3K
Case Drain to Reservoir	6M3K
Manifold Return Line	6M3K
Manifold to Ball Valve to Manifold	4M3K
Accumulator to Manifold	6M3K



Hardware Selection - Accumulator

- Steelhead Composites – AB30CN010G0N
- Style – Bladder
- Maximum Pressure – 3000 psi
- Pre-Charge – 700 psi
- Weight – 10 lbs

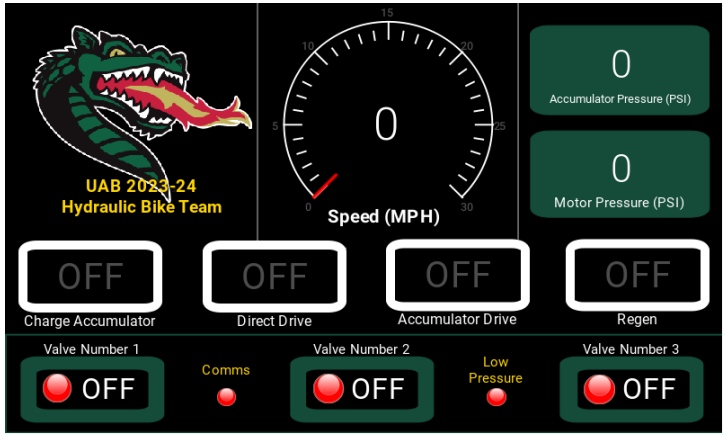


Hardware Selection - Brakes and Rotor

- Origin 8 Vise Hydraulic Disc Brakes
- Braking Force Capability: 8880 N
- 160 mm rear rotor
- 180 mm front rotor
- 2 calipers, 1 short and 1 long hydraulic brake line

Hardware Selection - Electronic Components

- **HMI Screen:** Exor ex705
- **Controller:** HY-TTC 32 Micro-Controller
- Display and controller will require a 24V DC battery
- **Advantages**
  - Customizable
  - Pressure Displays
  - Speed Reading
  - Previous Team Assistance



UAB Team's HMI Screen Display

Micro-Controller HY-TTC 32

Vehicle Construction

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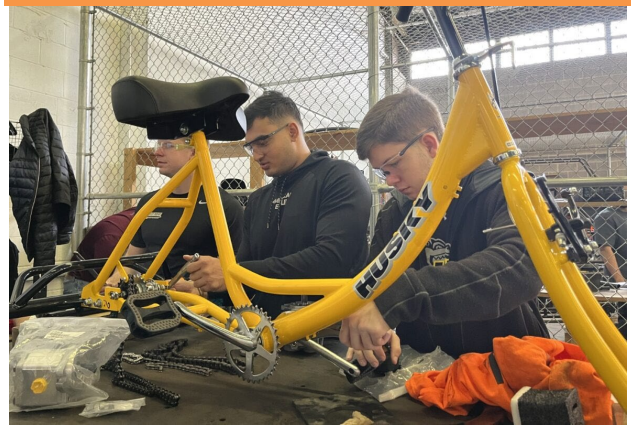
Frame Construction



Rear Plate Construction

Rear Brake Installation

Rear Plate Prototype

Differential Bracket Installation

Rear Plate Mounting

Vehicle Construction

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Fitting/Production of Hosing

Installation of Hosing, Valves, Transducers, & Gauges

Installation of HMI and Wiring

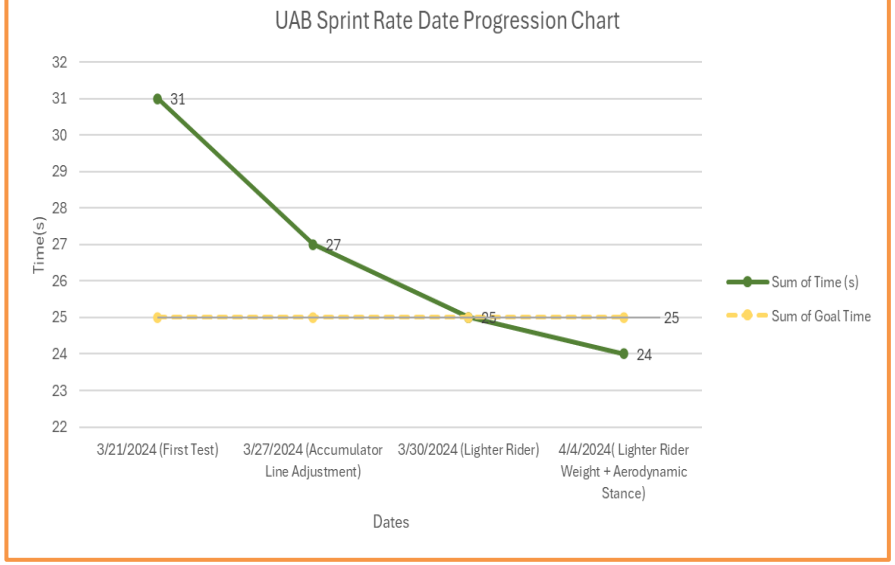
Vehicle Testing and Improvements

- Removed differential with two shafts and replaced with thru shaft
  - Differential would cause axle to free spin when activating regenerative braking
- Added a rear brake to support full accumulator charge
- Used a composite plate instead of steel plate
  - Around 70% lighter while sustaining necessary strength
- Reconfigured components upon realizing rotation constraints
- Replaced hosing for accumulator from 4m3k to 6m3k
- Added additional line from reservoir to motor with check valve to allow for regenerative capabilities

Testing Results

- **Test Run # 1 – 3/21**
  - Demonstrated functionality of ¾ modes
  - Regen mode nonfunctional, fix found
- **Test Run # 2 – 3/27**
  - Demonstrated functionality of all modes
- **Test Run # 3 – 3/30**
  - Rider preparation and demonstration of bike reliability
- **Test Run # 4 – 4/4**
  - Testing different racers and stances

Sprint Race Results



Final Vehicle

Total Weight approximately 160 lbs

Lessons Learned

Technical Lessons

- Spline shaft problem
- JB Weld
- Diff with Regen/braking
- Hosing sizing
- Technological issues take up time
- Hydraulics

Overall Lessons

- Communication
- Teamwork
- Critical Thinking
- Seeking help/advice
- Time Management
- Presentation Skills

Acknowledgements

- NFPA
- Hubbell
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Thank you!
Questions?