NFPA Fluid Power Vehicle Challenge

NFPA Education and Technology Foundation

FINAL PRESENTATION

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PURDUE UNIVERSITY

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Tim

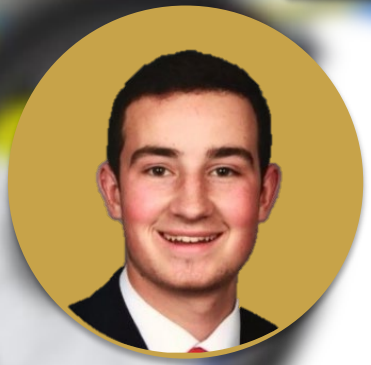

Corey


Shane


Chandler


Adv. Andrea


Dalton


Brad


Evan

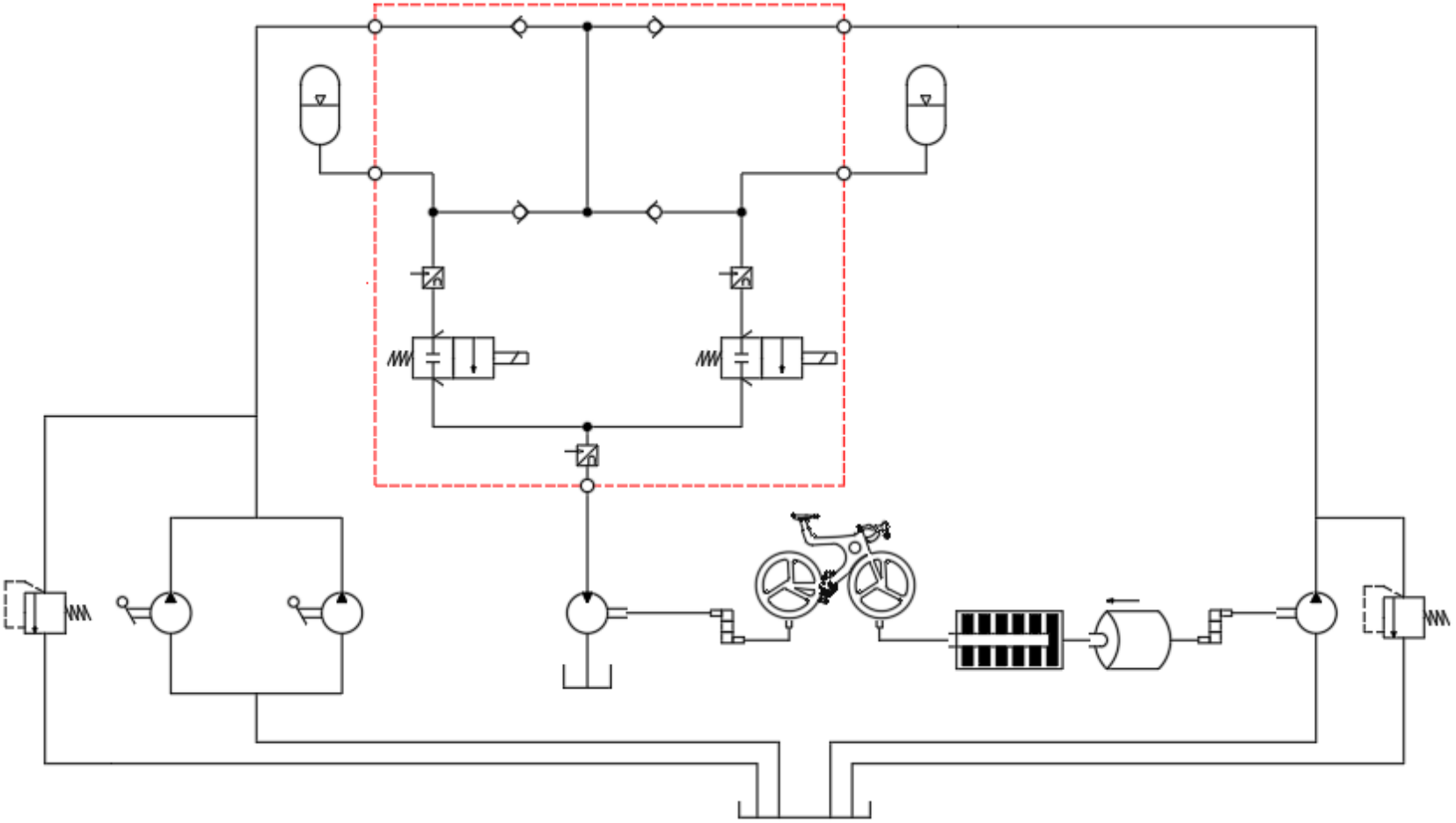

Adv. José

Problem Statement & Design Objectives

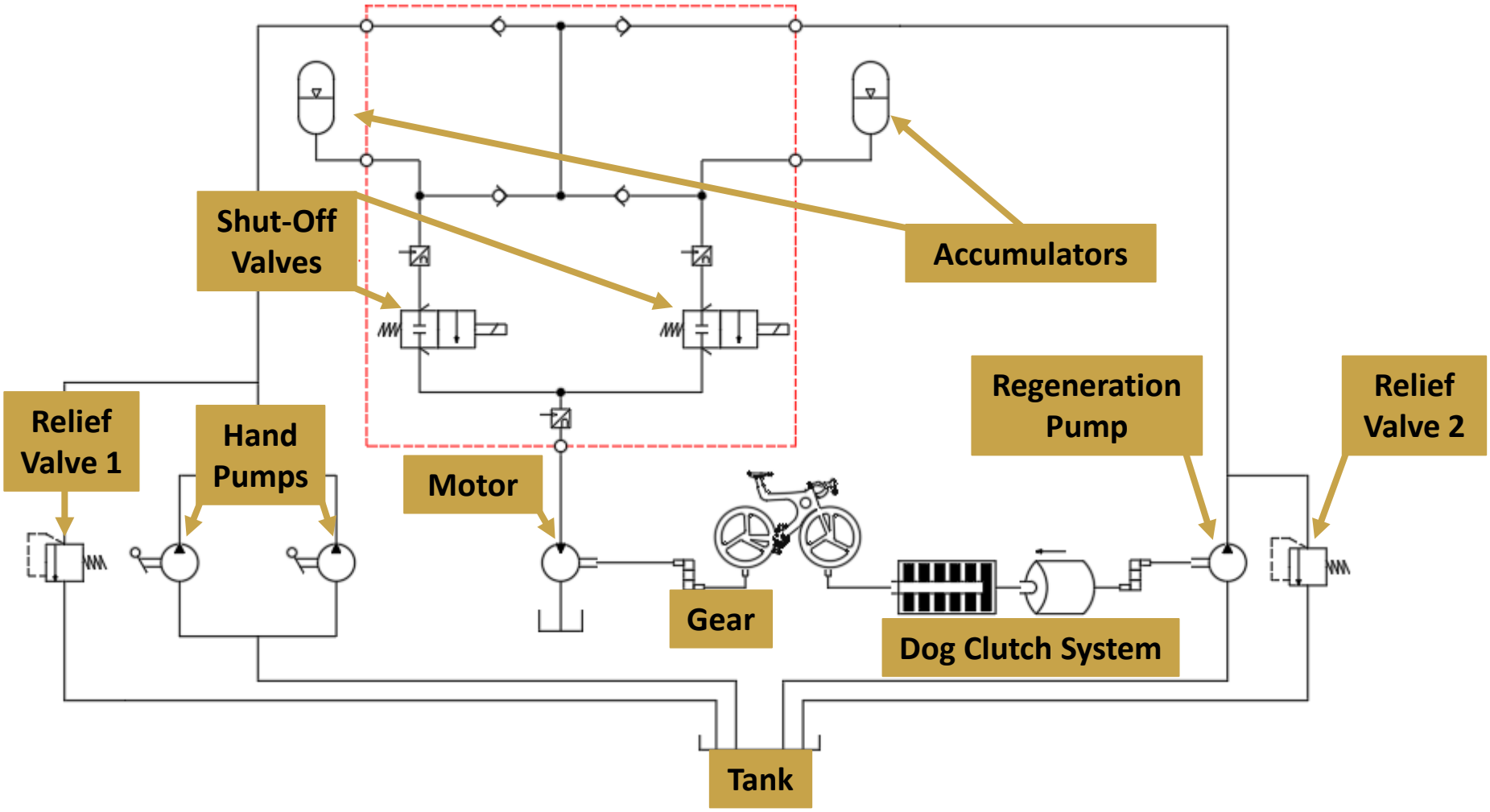
There is a need to design and build a human powered vehicle that uses fluid power to transfer and store energy using novel approaches and innovative technology.

- Minimize overall weight
- Properly size components
- Maximize human comfort
- Implement necessary safety features
- Charge accumulators and use pump to maintain pressure

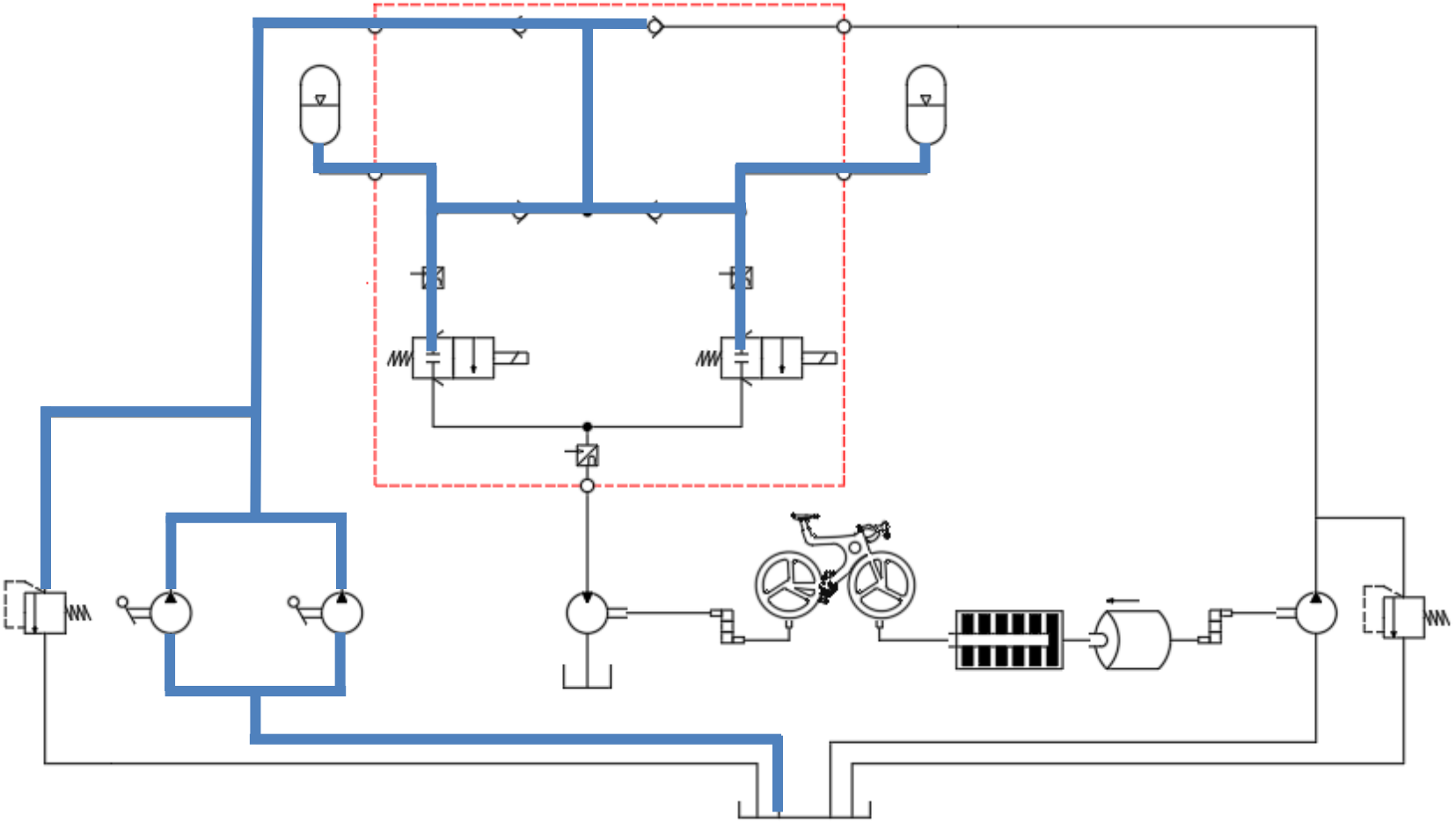
Hydraulic Circuit Overview



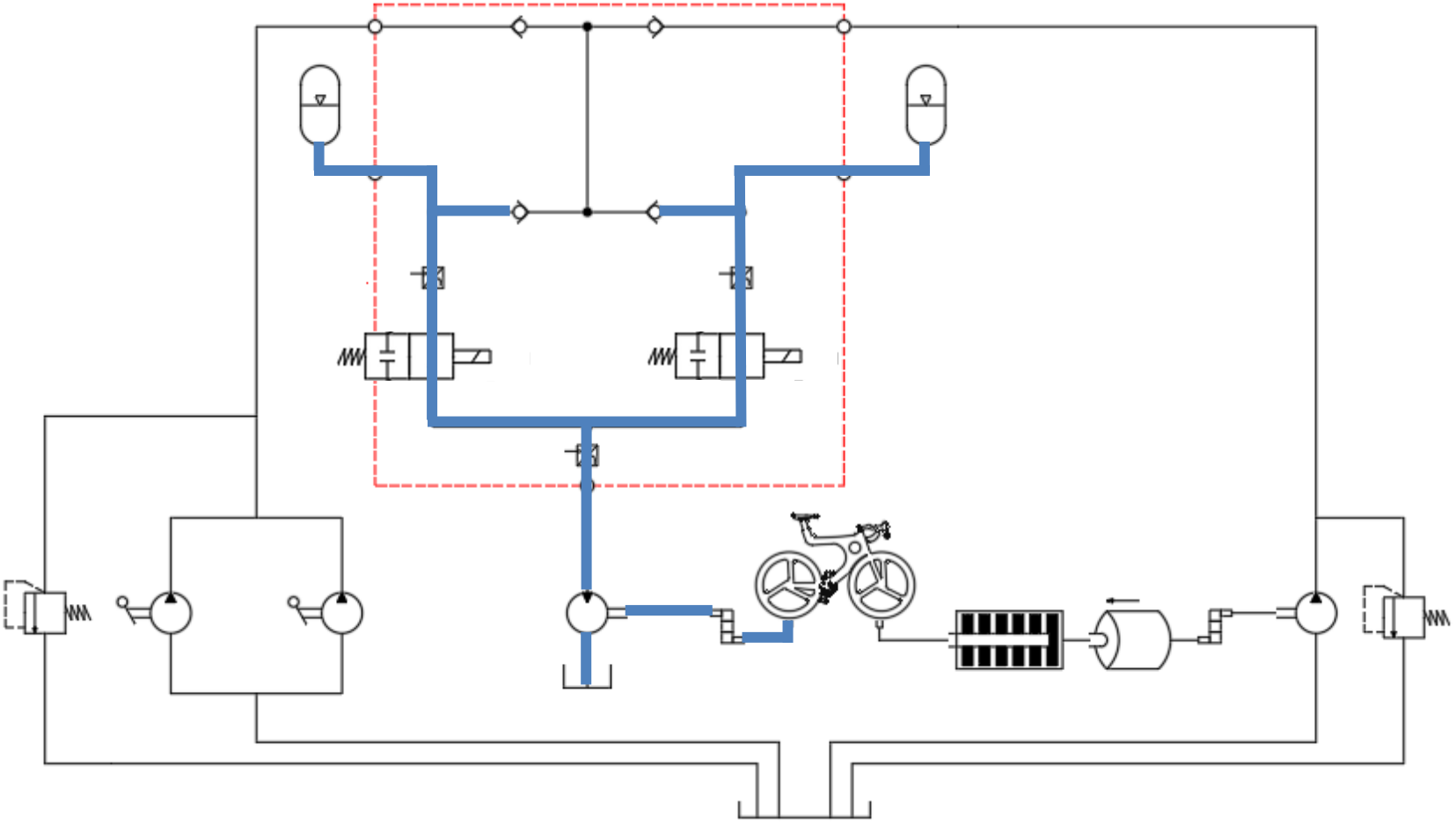
HC: Component Layout



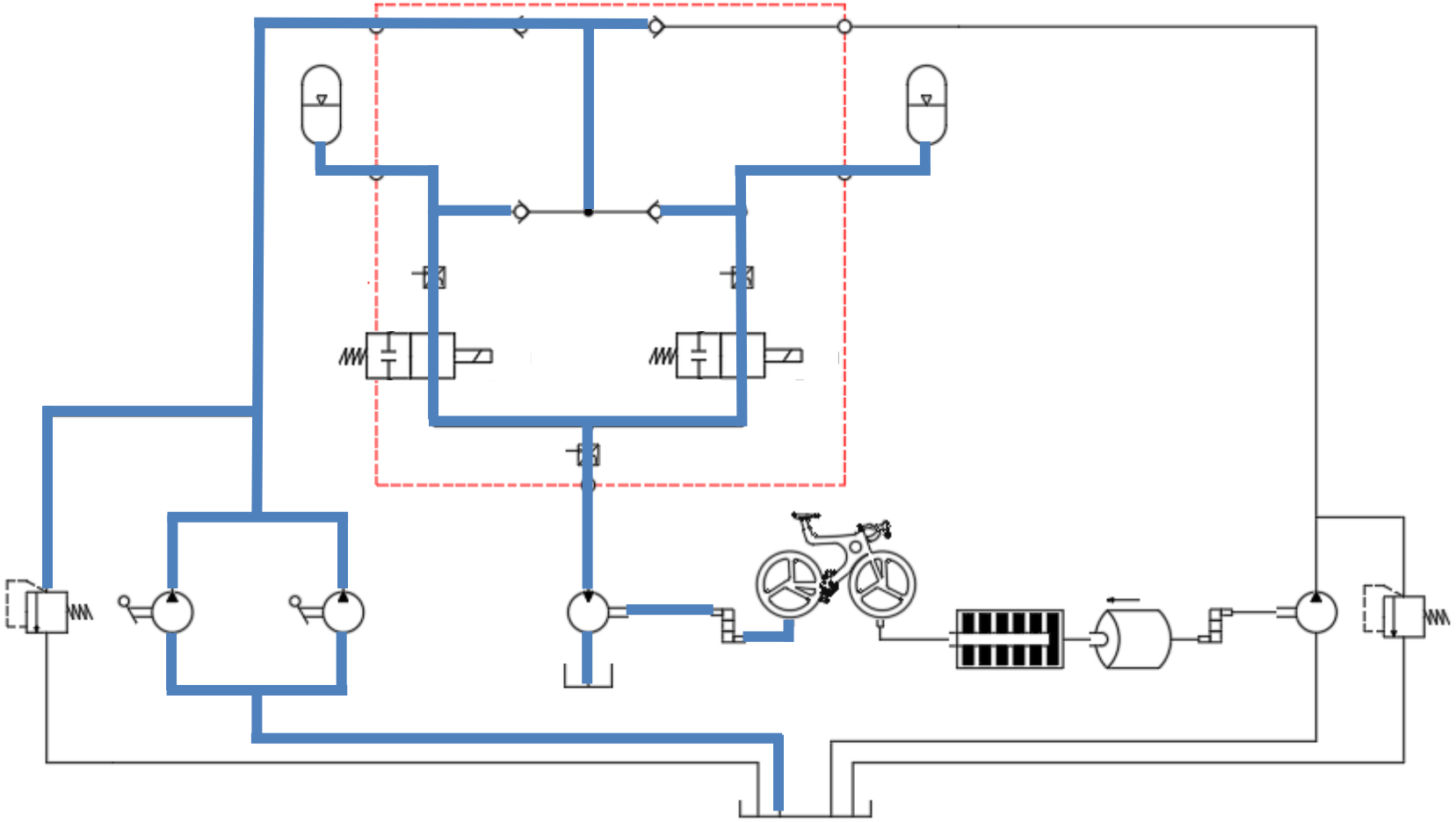
HC: *Charging* Mode



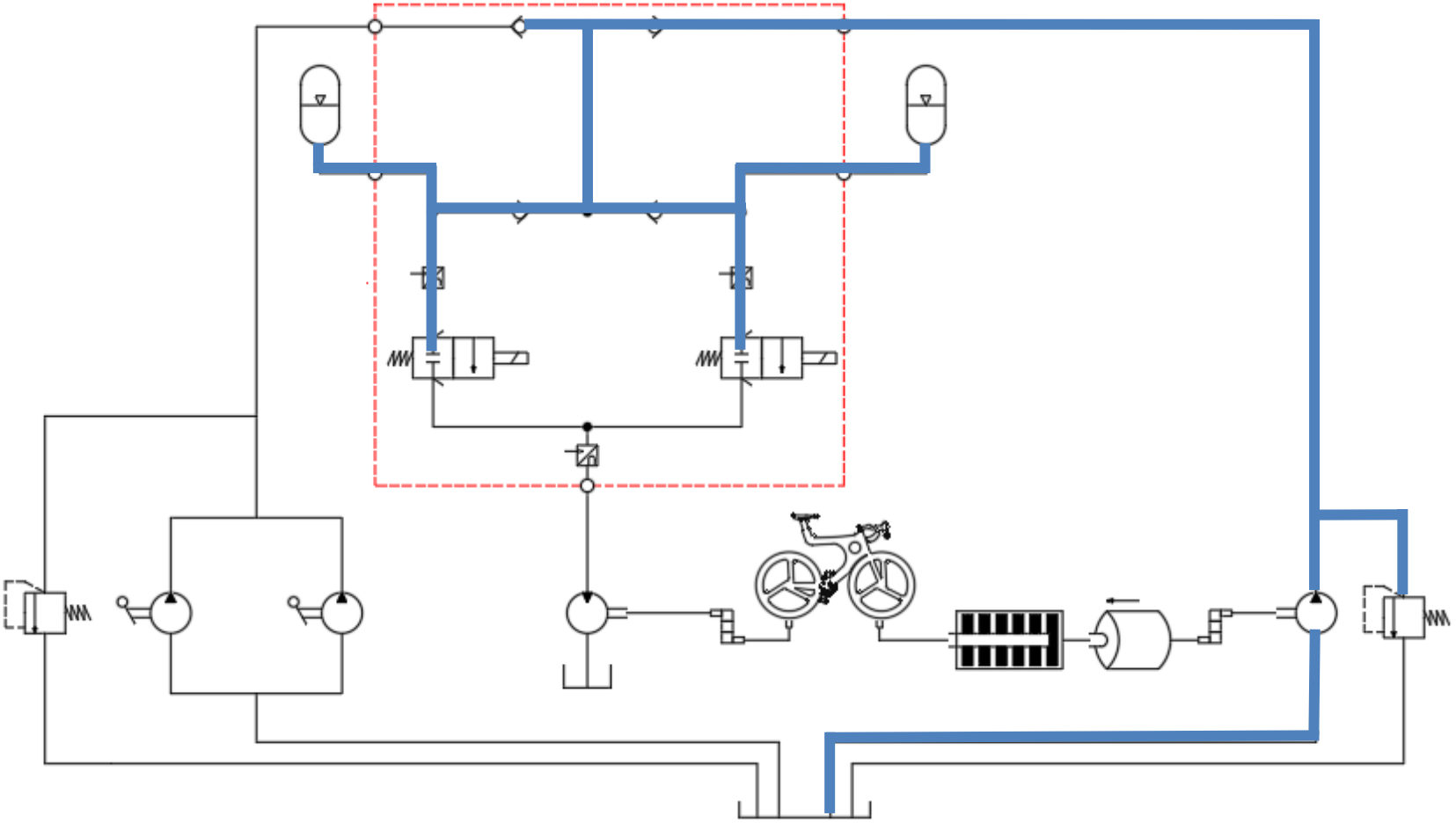
HC: *Boost* Mode



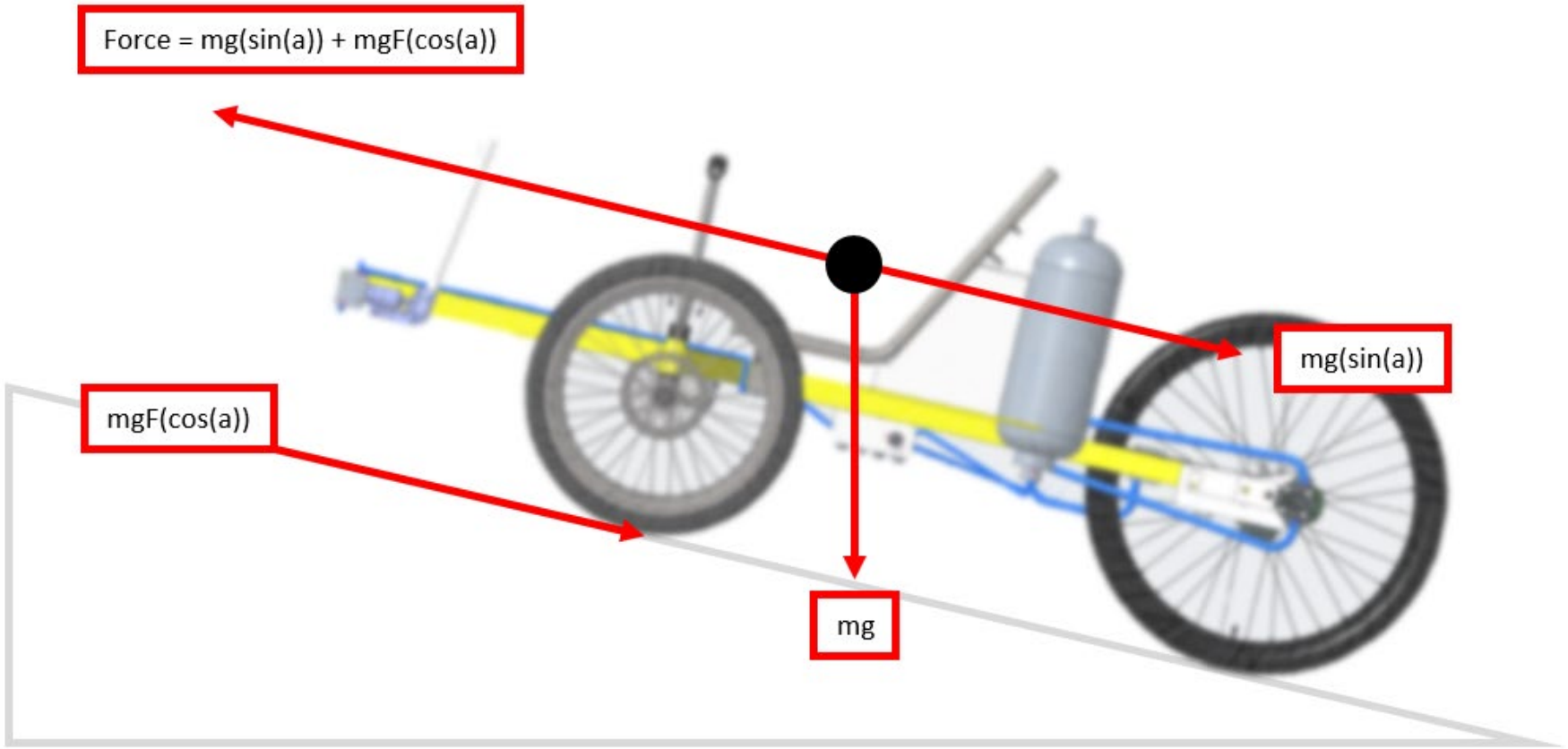
HC: *Pump* Mode



HC: *Regen* Mode



Sizing the Circuit



Hydraulic Input

Design Matrix

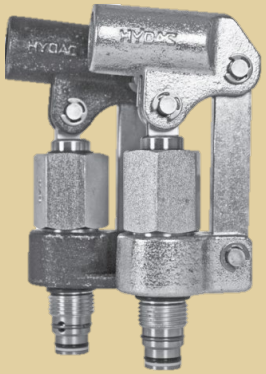
Selection Criteria			Datum	Rowing	Leg Press
	Performance	Stability	S	-	S
		Versatility	S	-	S
		Power	S	+	+
	Efficiency	Weight	S	-	+
		Aerodynamics	S	S	S
		Smoothness	S	-	-
	Manufacturing	Component Routing	S	-	+
		Component Space	S	-	+
		Complexity	S	-	+
	Miscellaneous	Aesthetics	S	+	-
		Ergonomics	S	S	-
		SCORE		2	5

Hydraulic Pumping

Design Matrix

Selection Criteria			Datum	Dual Foot Pump	Rotary Pump	Piston Pump	Pneumatic Pump
	Performance	Stability	S	+	S	S	+
		Weight	S	+	+	+	+
	Efficiency	Rideability	S	+	+	+	S
		Component Routing	S	S	S	S	+
	Manufacturing	Component Space	S	S	S	+	+
		Cost of Modifications	S	+	+	+	S
		Modification Time	S	+	+	S	S
	Miscellaneous	Aesthetics	S	+	+	+	S
		Innovative	S	+	-	+	S
		SCORE		7	5	6	4

Overall Hydraulic
Bill of Material (BOM)

Accumulators	Hand Pump	Motor	Regeneration Pump
			
2 x 1.3 USG	7.5 cc/stroke	3.12 cc/rev	7.54 cc/rev
MAX Pressure: 3000 psi		MAX Pressure: 3600 psi	

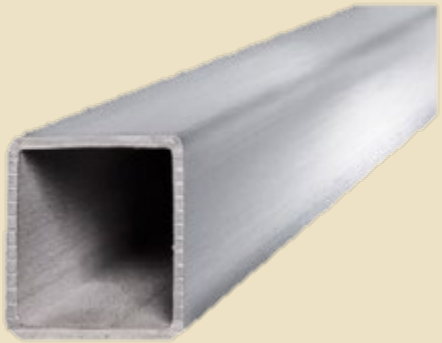
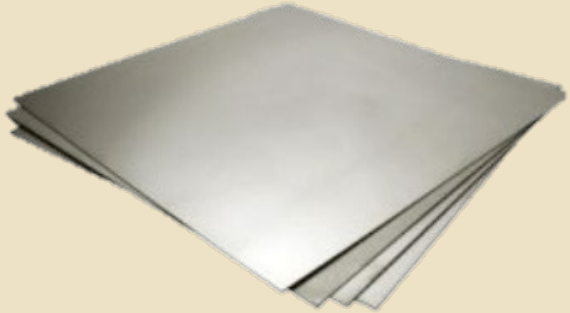
Frame

Design Matrix

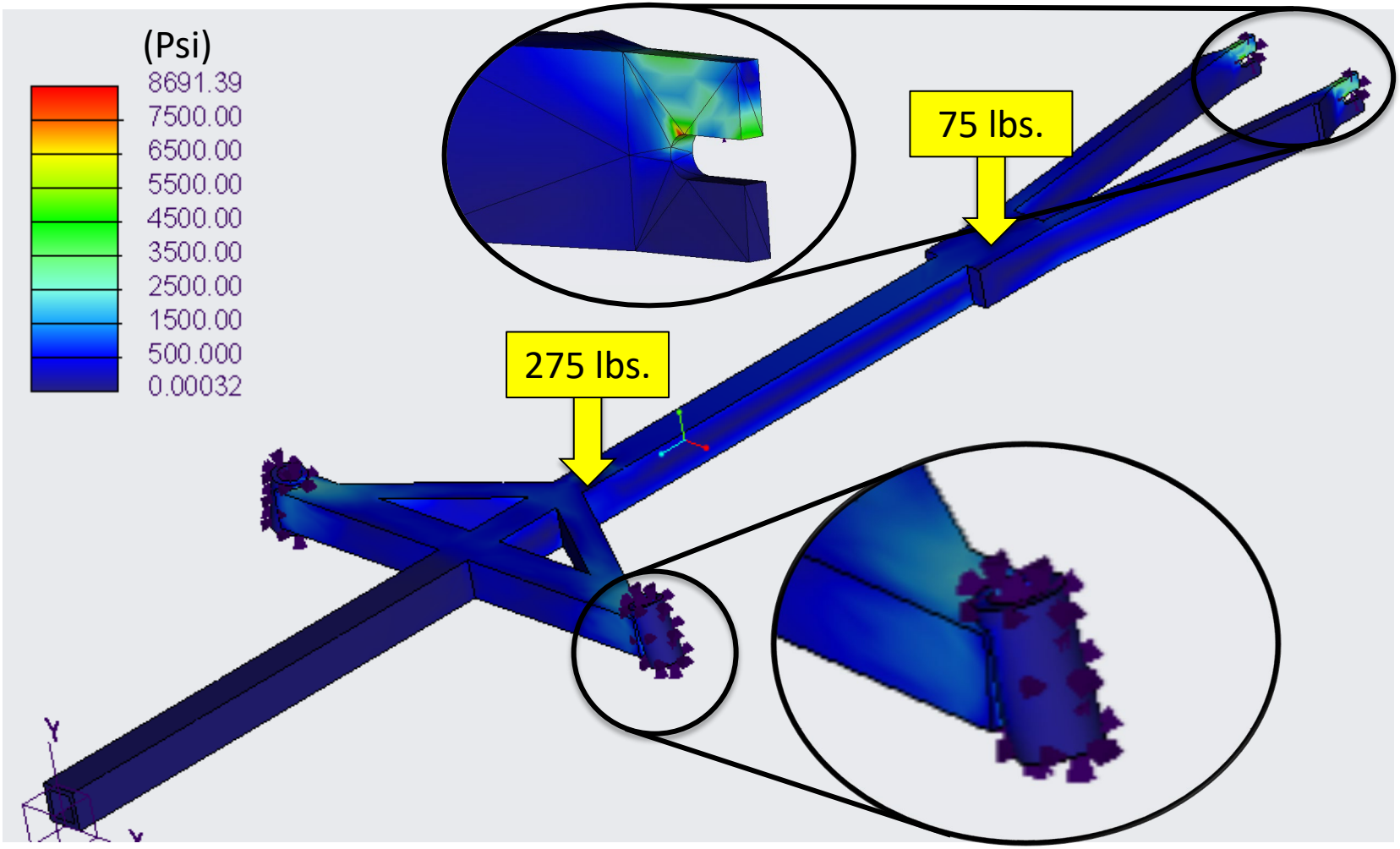
Selection Criteria			Datum	Trike	Mountain Bike	Road Bike	Monowheel
	Performance	Stability	S	+	S	S	-
		Versatility	S	S	+	+	-
		Weight	S	-	+	+	+
	Efficiency	Rideability	S	+	S	+	S
		Rolling Resistance	S	S	+	+	+
		Component Routing	S	+	+	+	-
		Aerodynamics	S	+	S	+	-
	Manufacturing	Component Space	S	+	+	+	S
		Cost of Modifications	S	-	S	S	+
		Modification Time	S	S	S	S	-
		Weldability	S	+	S	+	-
	Miscellaneous	Aesthetics	S	S	+	+	+
		Ergonomics	S	+	+	+	+
		SCORE		7	7	10	5

Frame

BOM

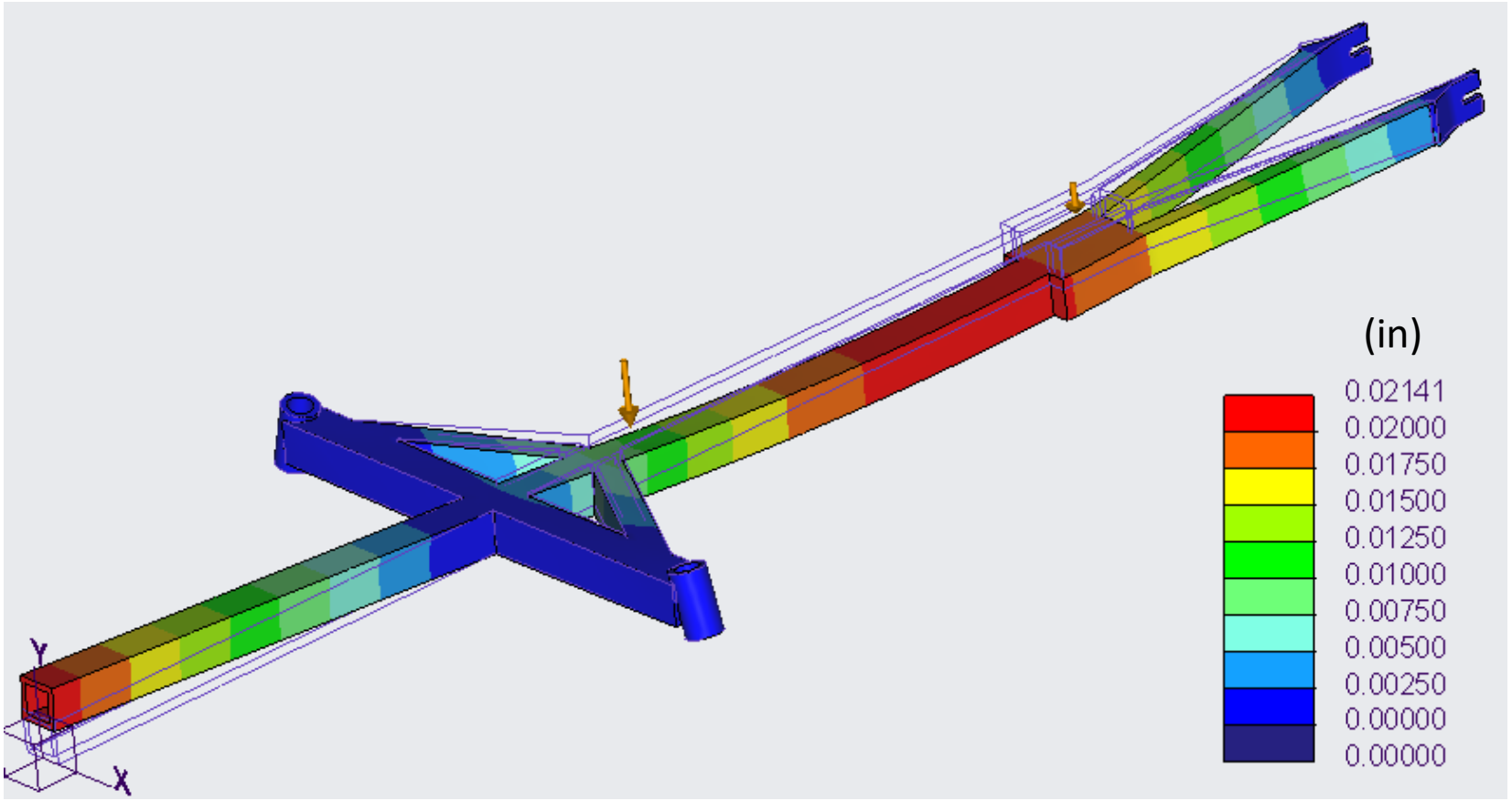
Square 6061 Aluminum Tubing	Aluminum Plates
	
~ 10 feet	10 $feet^2$

Finite Element Analysis (FEA)



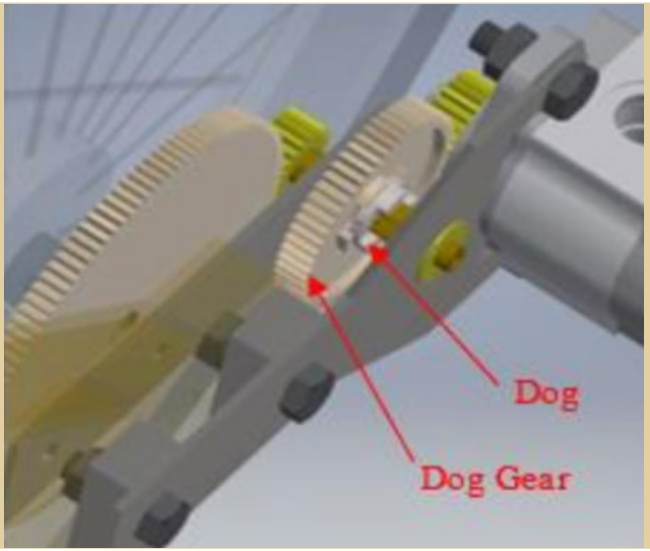
Frame

Deformation



Mechanical Components

BOM

Motor Gearbox	Regeneration System
	
Gear Pair: 55/16	First Stage: 120/20 Second Stage: 56/20
Gear Ratio: 3.45:1	*Total* Gear Ratio: 16.8:1

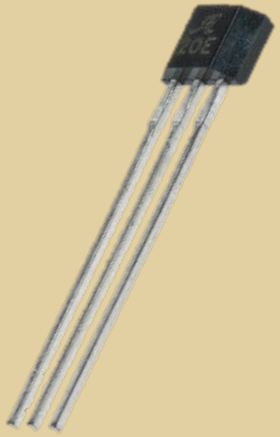
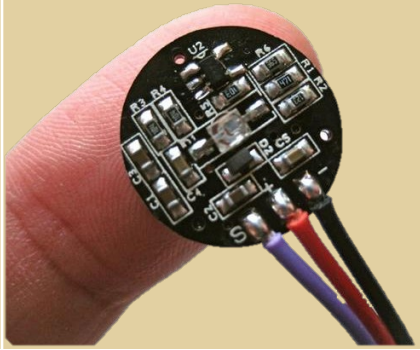
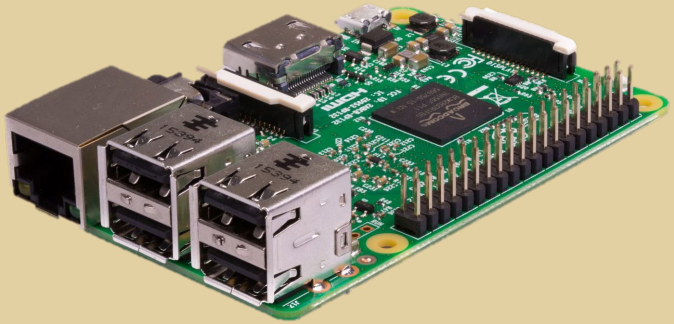
Electronics

Design Matrix

				Datum	Raspberry Pi	Intel Joule 570x	nVidia Jetson TK1	Dragon Board	BeagleBone Black
Selection Criteria	Performance	Clock Speed	S	S	+	+	+	-
		Cores	S	+	+	+	+	-
	Efficiency	GPIO	S	+	S	S	-	+
		GPIO Voltage	S	+	-	-	-	+
		Power	S	-	-	-	S	-
	Connectivity	Bluetooth	S	+	S	-	S	-
		Wifi	S	S	+	-	S	-
	Miscellaneous	Memory	S	+	+	+	+	S
		Onboard Storage	S	-	S	S	S	+
		SCORE		5	4	3	3	3

Electronics

BOM

Speed	User	Central Unit	Supply
			
Hall Sensor	Heartrate Sensor	Raspberry Pi & Miscellaneous Items	Power

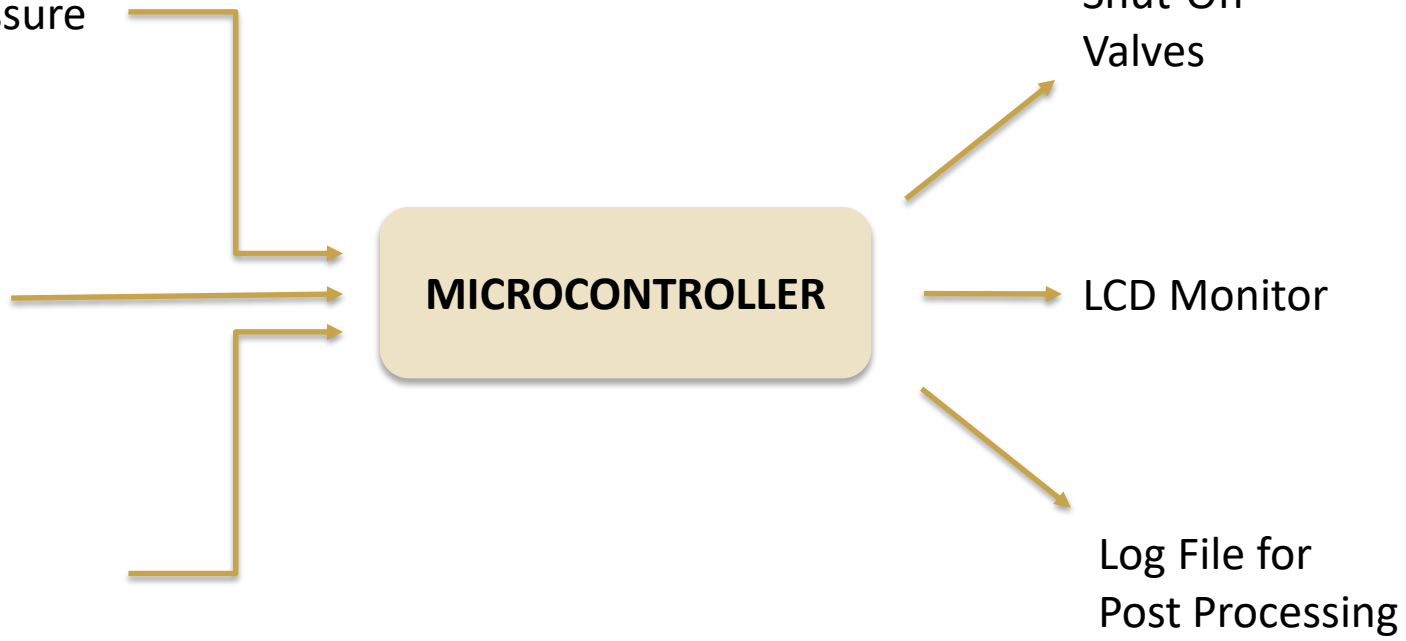
Electronics

Layout

HYDRAULIC SYSTEM
- Accumulators Pressure
- Mainline Pressure

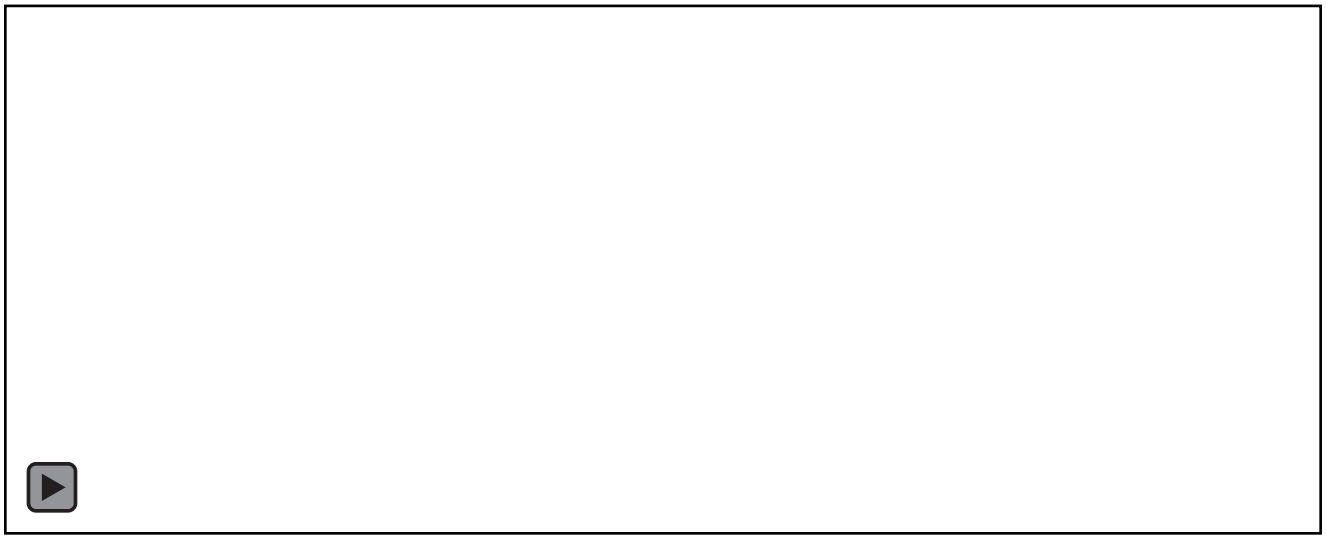
BIKE SYSTEM
- Distance
- Speed
- Acceleration
- Wheel RPM

HUMAN USER
- Heart-Rate

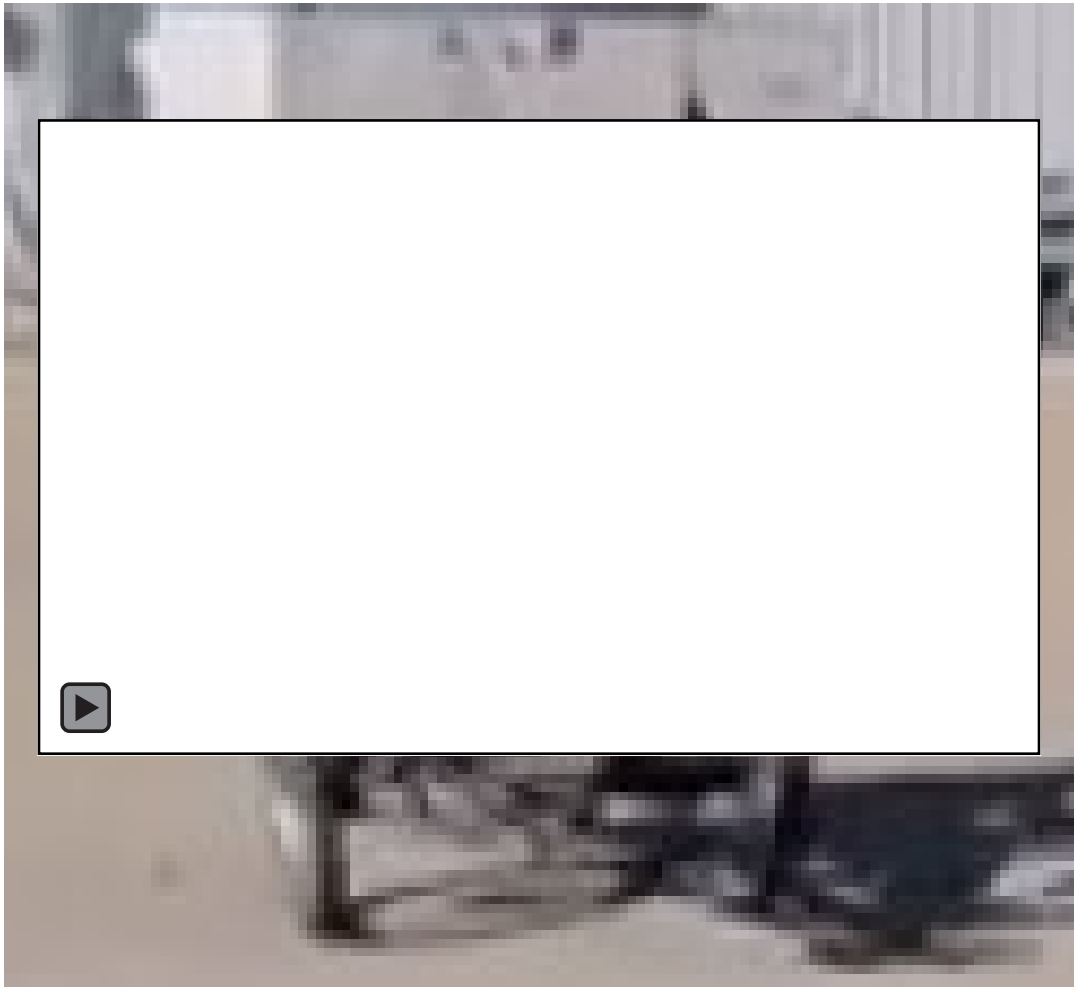


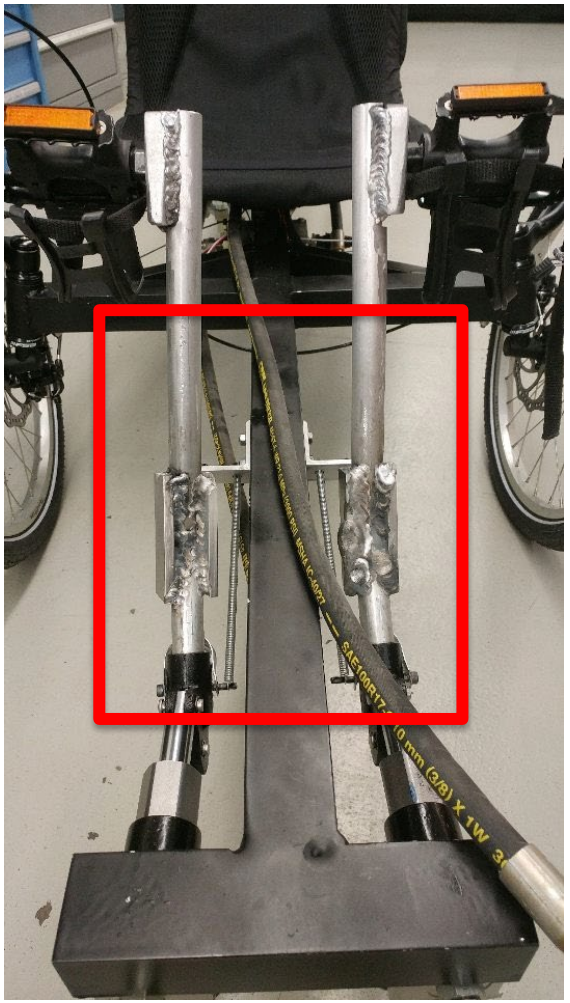
Vehicle Design Summary

Criteria	Constraints
Lightweight	Less than 210 lbs.
Strong	Support a human rider with all components
Stable	3 wheels
Compact	Enough room for all components



Testing & Changes Made





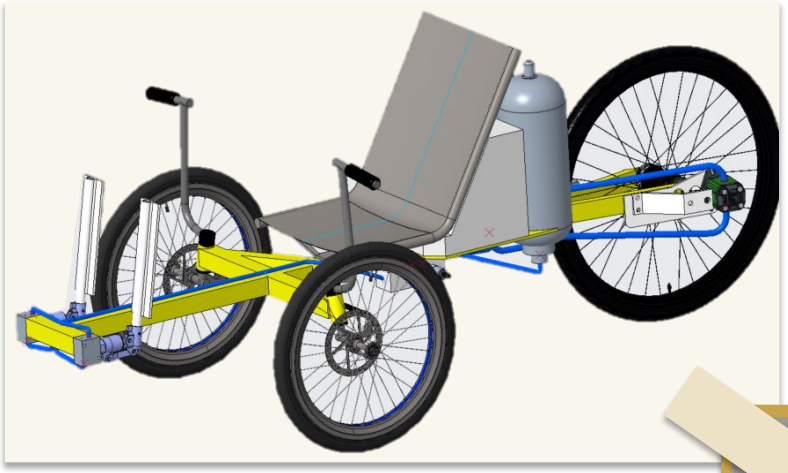
Conclusion

- Power
  - Foot pumps
  - 2 x 1.3 gal. accumulators
- Gearboxes:
  - Motor: 55/16 pair (3.45:1 ratio)
  - Regeneration: 120/20 pair (first stage), 56/20 pair (second stage) [16.8:1 Total ratio]
- Electronic Controls
  - Increase versatility, improve functionality
  - Easy transition between modes
  - Real-time feedback

Lessons Learned

- Supply Chain
  - Make sure parts are easily obtainable and ordered well in advance
- Hydraulic Nuances
  - Talk to professionals and don't be afraid to ask questions
  - Never "fake it till you make it"
- Time Management
  - Leave room in the project timeline for mistakes and problems
- Scope Creep
  - There's no such thing as scope creep – only scope gallop
  - Focus on the need and *look into* the "nice to haves" later

Thoughts?



FLUID FOLKS
CHAINS NOT INCLUDED