Human Powered Vehicle
Team 9

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Overview

- Introduction
- Problem Formulation
- Proposed Design
- Prototype Fabrication
- Testing and Results
- Cost Analysis
- Conclusions

Introduction

- ASME Human Powered Vehicle Challenge
- Date: April 25-27
- Location: San Jose, California
- Five Events: Design, Innovation, Endurance, Men and Women sprint
- Clients
  - Perry Wood
  - ASME

Problem Formulation

- Need Statement:
  - There is no current form of transportation that provides the benefits of bicycle commuting, while offering the practicality of automobiles.
- Goal Statement:
  - “Design a human powered vehicle that can function as an alternative form of transportation.”

Problem Formulation

- Operating environment:
  - Extended highway
  - Cone based obstacle course
  - Large parking lot
  - Steel testing fixture

Table 1- Design Objectives

Objective	Measurement Bias	Units
Vehicle can reach high speeds	Top speed on a flat surface	mph
Light weight	Total weight of vehicle	lbs
Highly maneuverable	Turning radius	ft
Contains cargo space	Volume of storage space	ft^3
Support cargo weight	Load storage space can hold	lbs
Large field of view	Total horizontal plane rider can see	degrees
Protects rider from roll over	Force roll bar can sustain	lbs
Low Coefficient of Drag	Drag force on vehicle	lbs
Production run manufacturability	Unit manufacturing cost for production run of 360	dollars
Fits diverse range of operators	Amount of seat adjustability	ft

Table 2- Competition Constraints

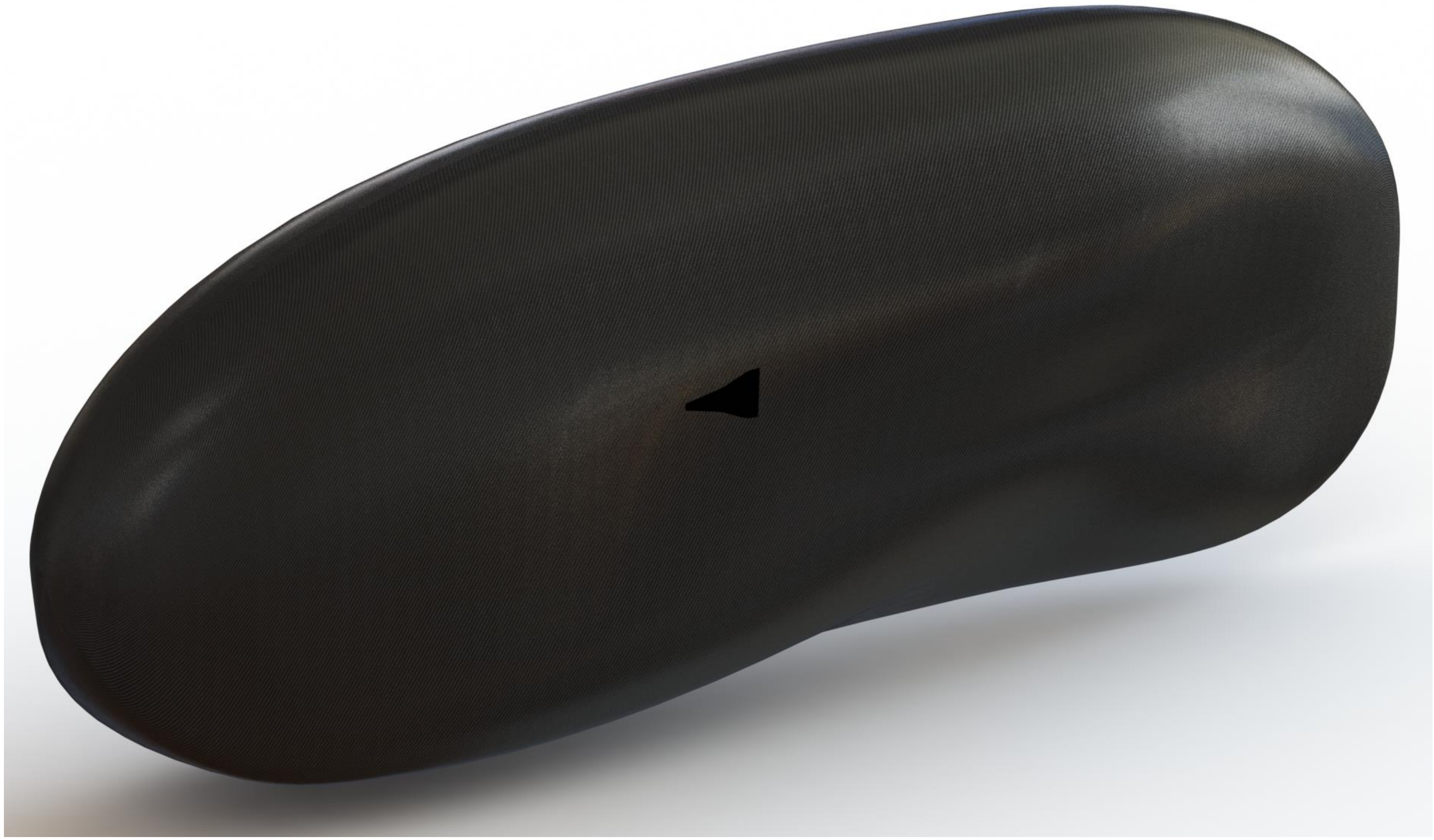
ASME Competition Constraints
Turning radius ≤ 26.25 ft
Roll bar must withstand 600 lbf top with < 2 in deflection
Roll bar withstand 300 lbf side load with < 1.5 in deflection
Must have a seat belt
Field of view must equal or exceed 180°
Carry a 12 lbf parcel of 15 X 13 X 8 in
Stop at a speed of 15.5 mph in a distance ≤ 19.7 ft

Table 3- Costumer Constraints

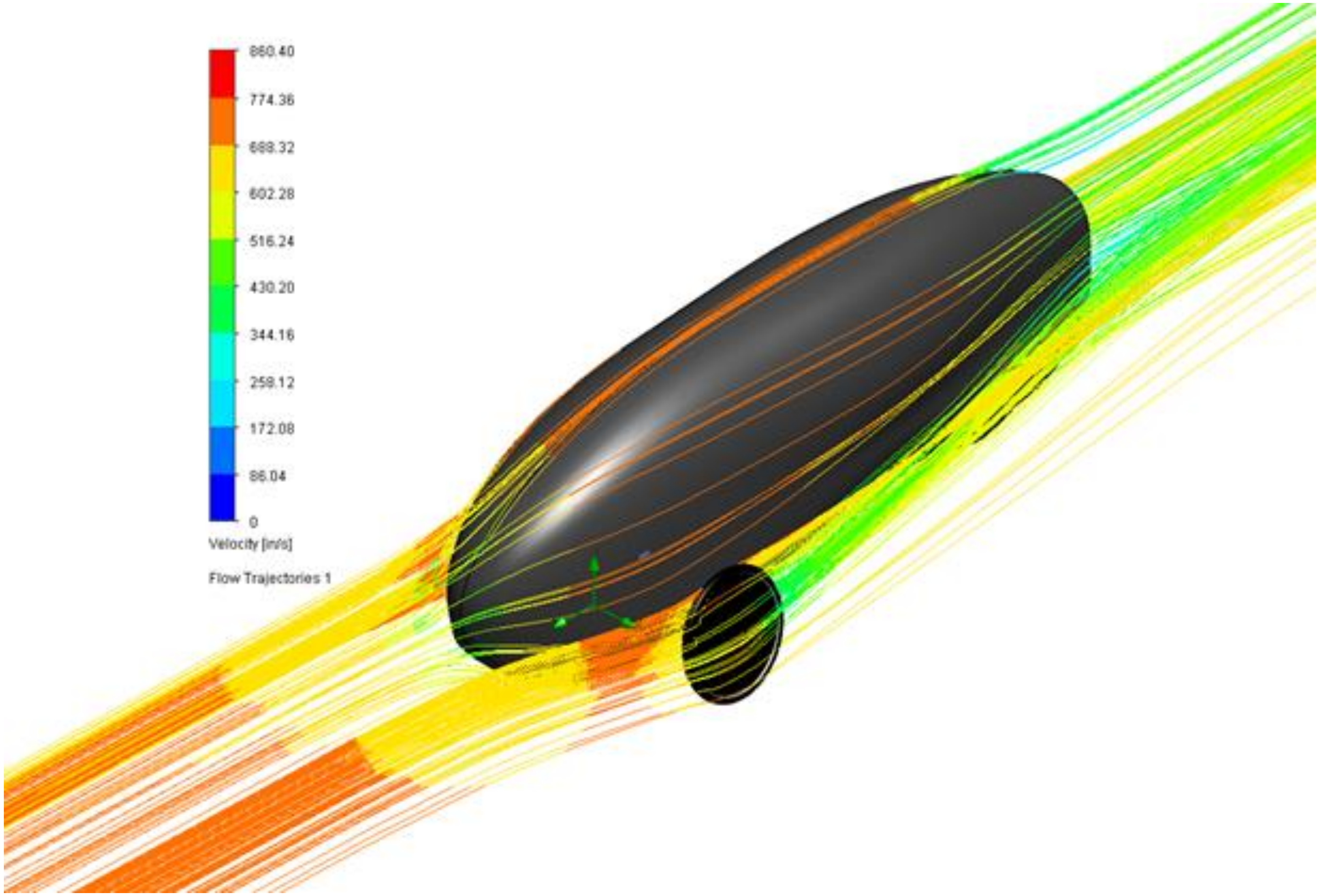
Costumer Constraints
Capable of exceeding 40 mph
Vehicle weight ≤ 80 lbf
Coefficient of drag times the area less than that of a traditional cyclist
Development budget of $6,500.00

Proposed Design

Proposed Design
Fairing



Proposed Design
Fairing

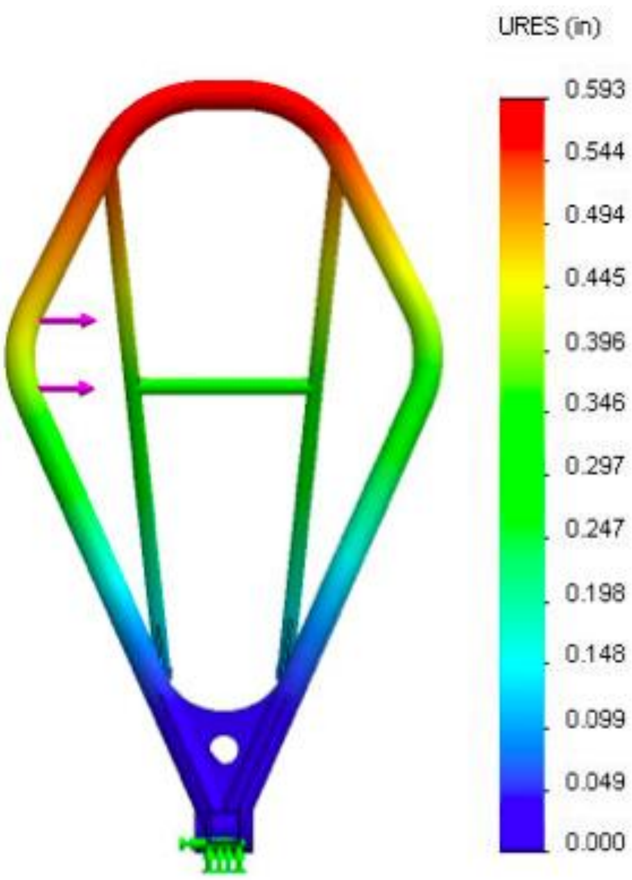


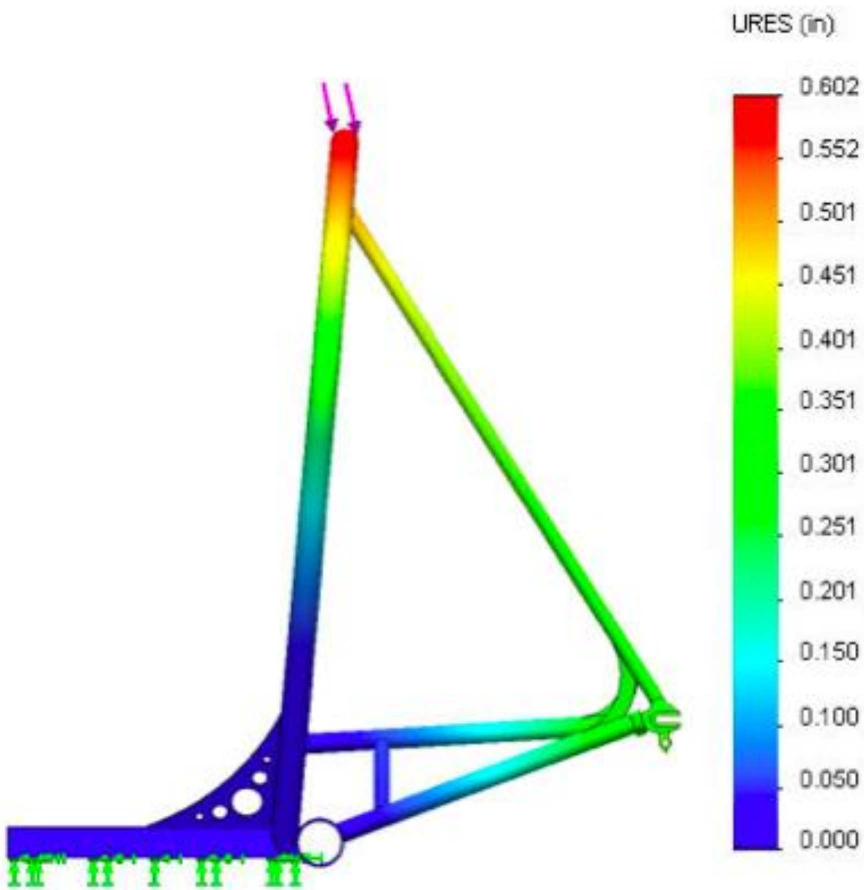
Proposed Design
Fairing

- Coefficient of drag (C_d) = 0.09
- $C_dA = 90.2\ in^2$
- 333.5 Watts to reach 40 mph
- h = 37 in, w = 24 in, L = 114 in
- 2 x 2 twill Carbon Fiber 3k with epoxy resin

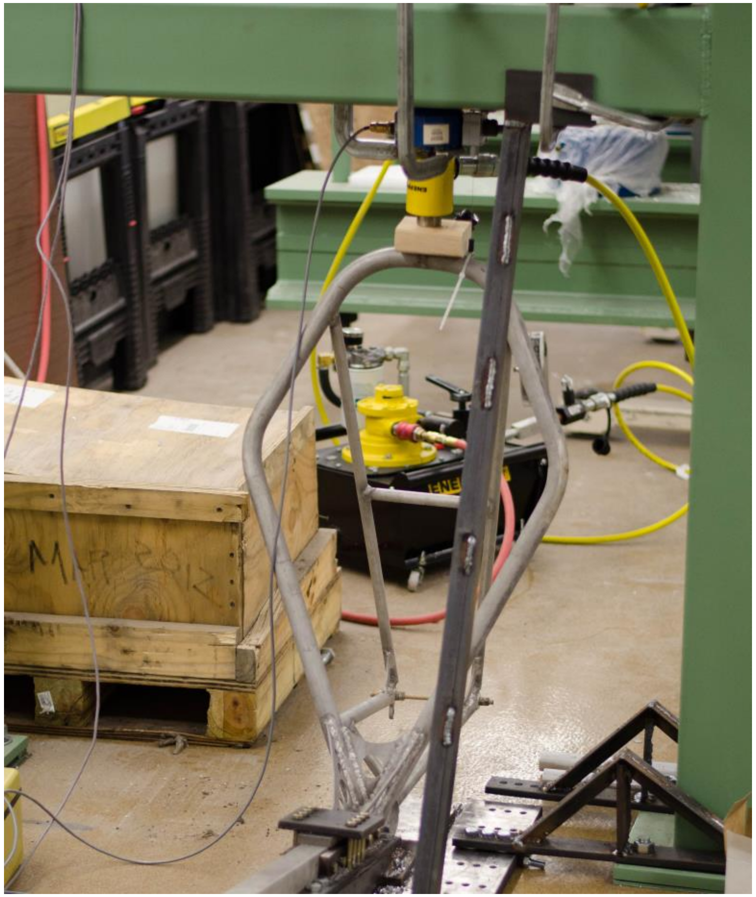
Proposed Design
Frame

Proposed Design
Frame





Proposed Design
Frame



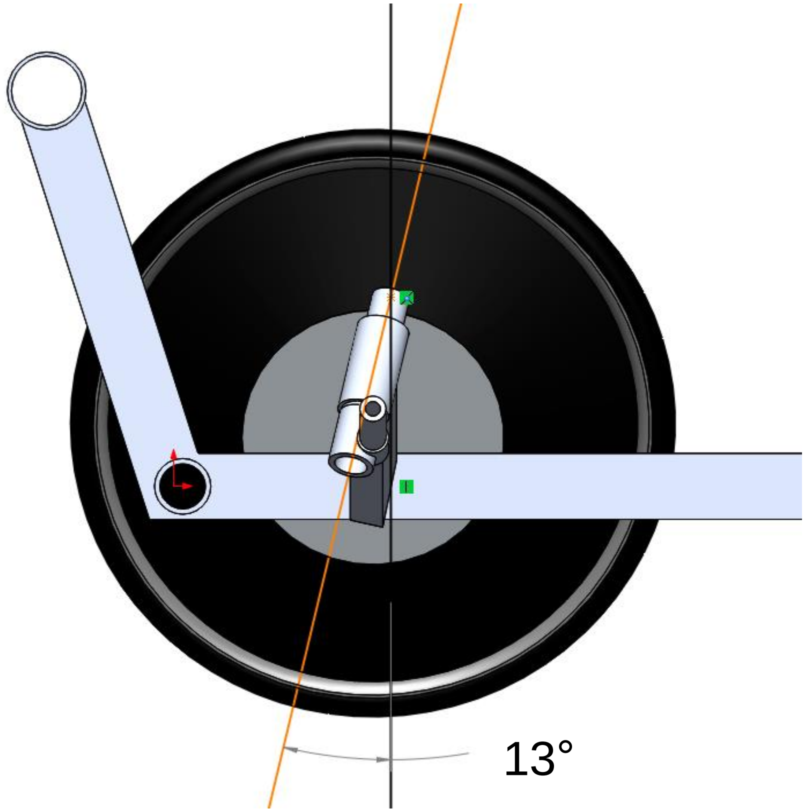
Proposed Design Frame

Table 4- Frame Test Results

Load	FEA Max Deflection	Physical Max Deflection	Maximum Allowable Deflection
Top 607 lbf (2700 N)	0.602 in (1.53 cm)	0.378 in (0.96 cm)	2 in (5.1 cm)
Side 301 lbf (1339 N)	0.593 in (1.51 cm)	1.382 in (3.51 cm)	1.5 in (3.8 cm)

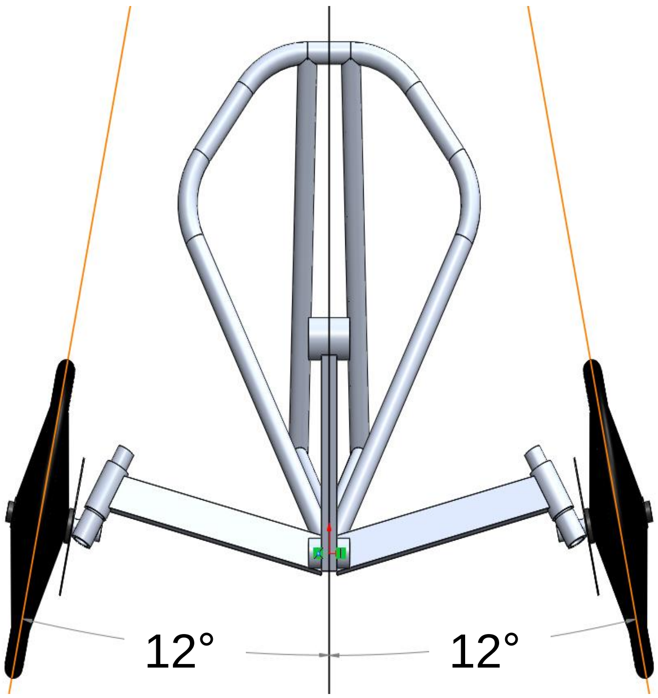
Proposed Design
Steering

Proposed Design
Steering



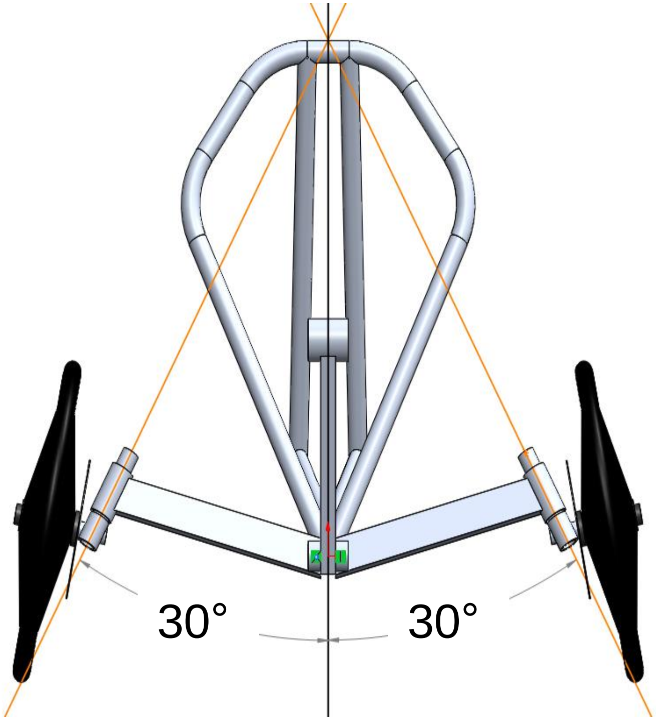
Caster Angle

Proposed Design
Steering



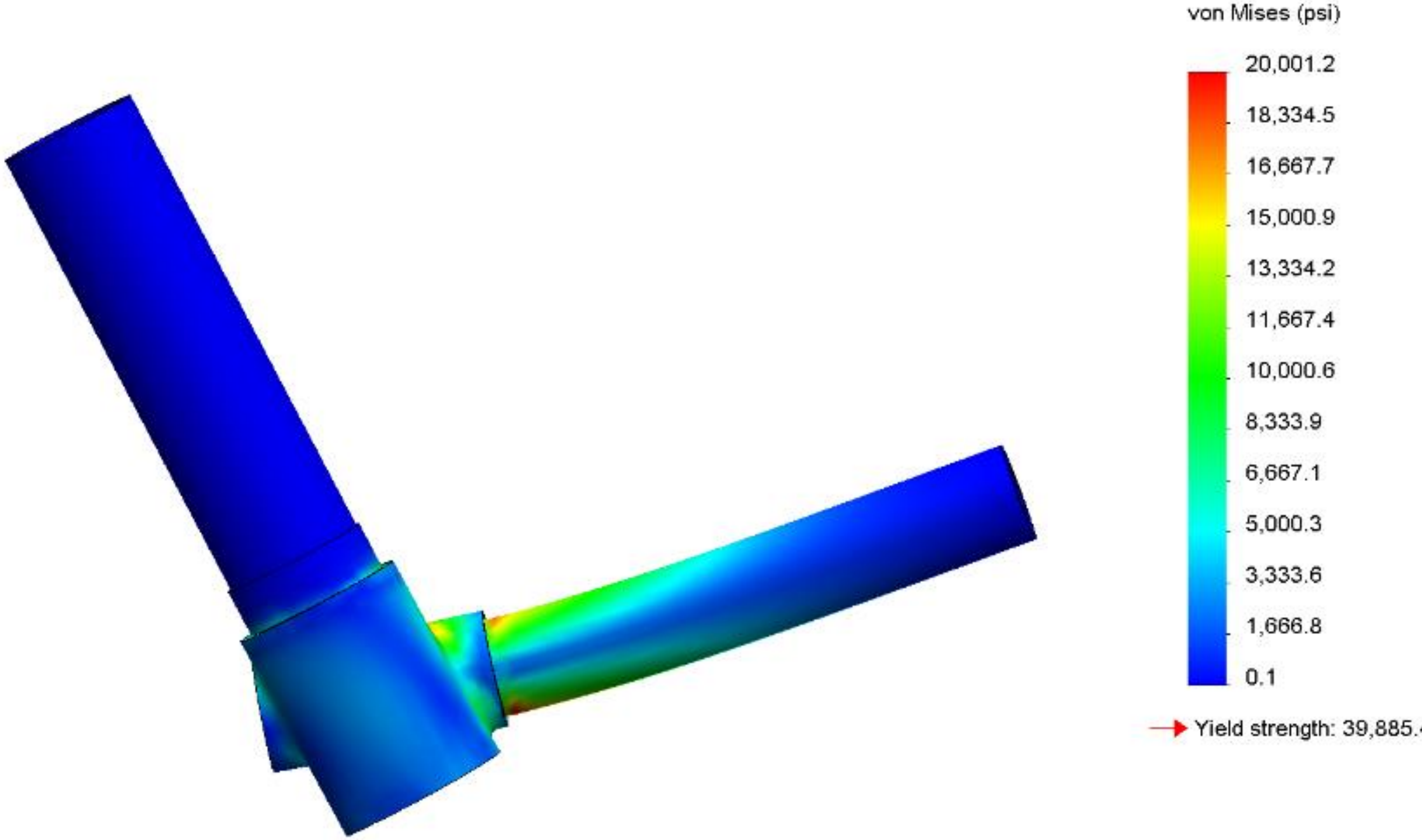
Camber Angle

Proposed Design
Steering

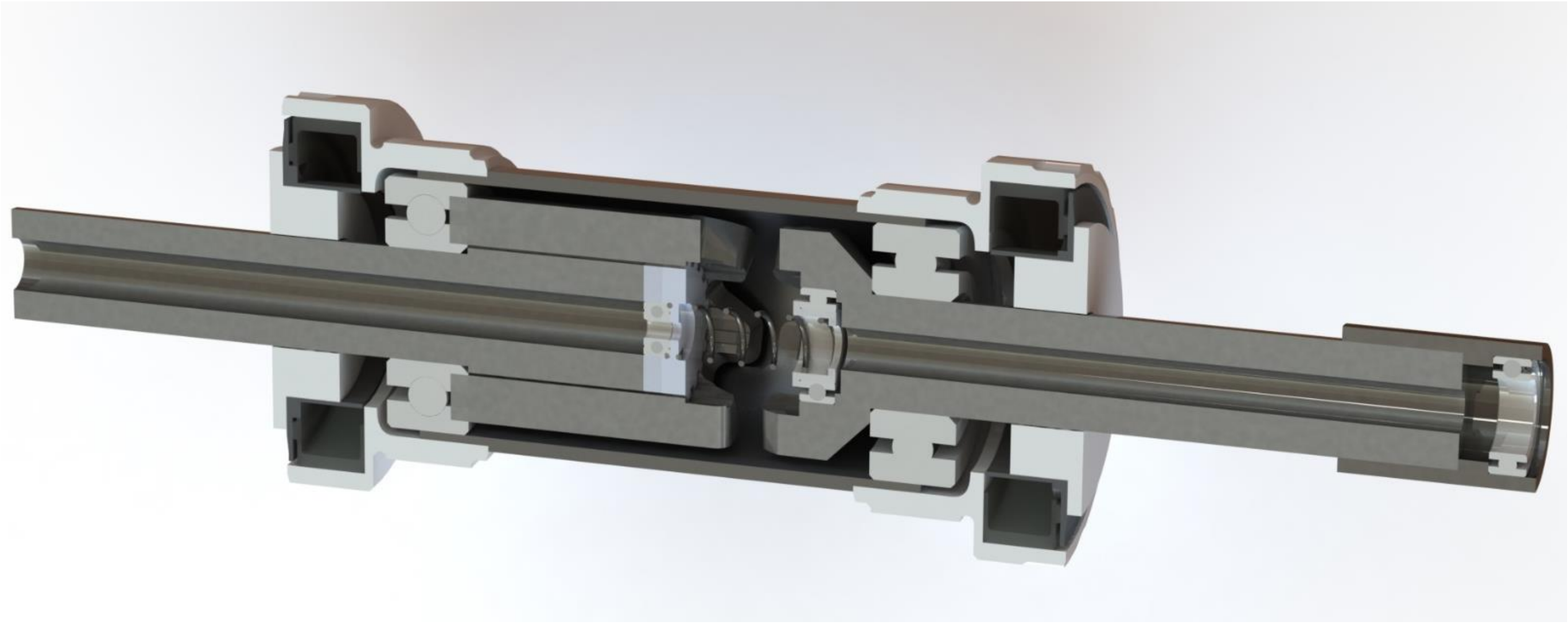


Kingpin Angle

Proposed Design
Steering



Proposed Design
Drivetrain

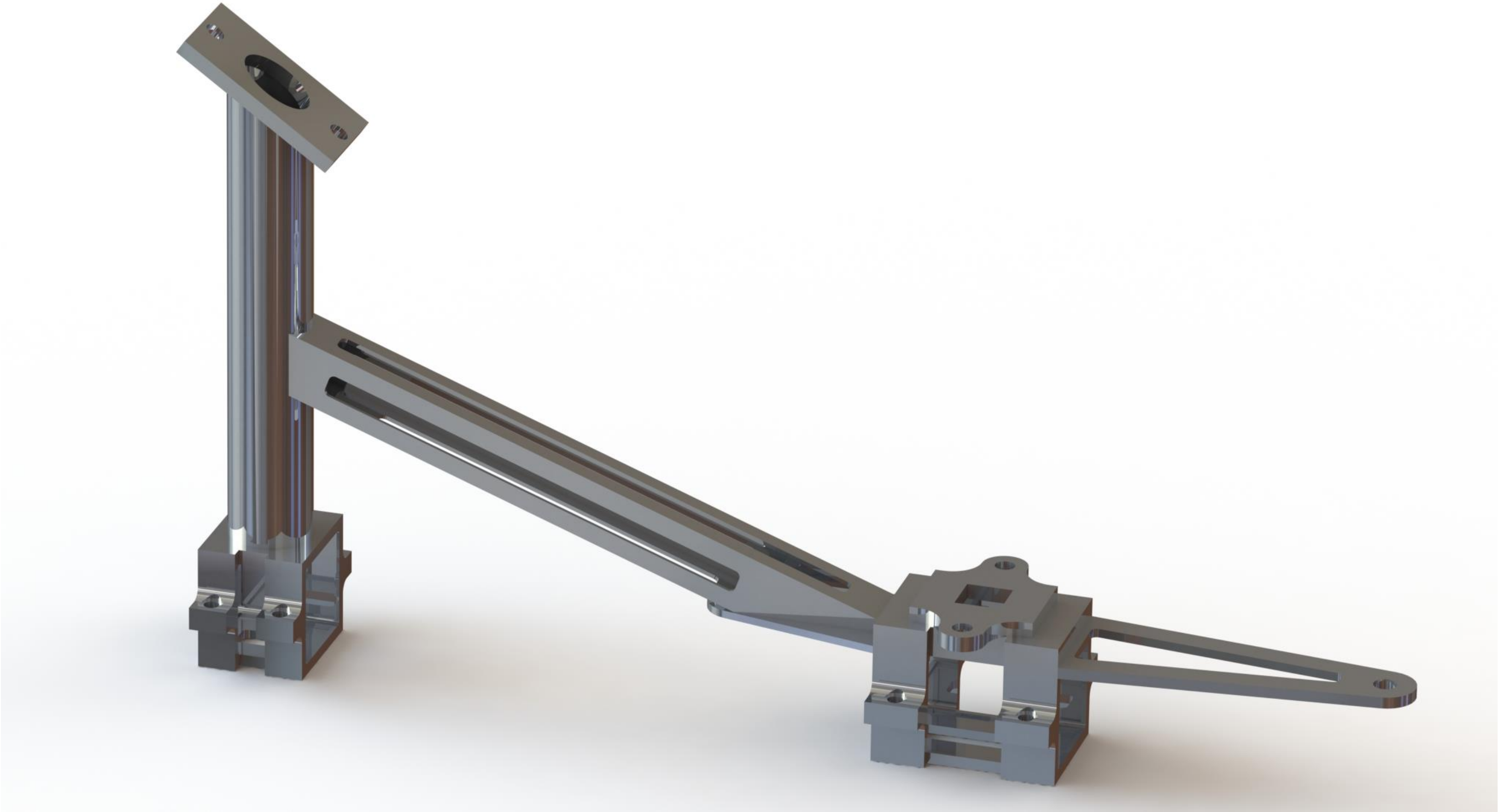


Proposed Design Drivetrain

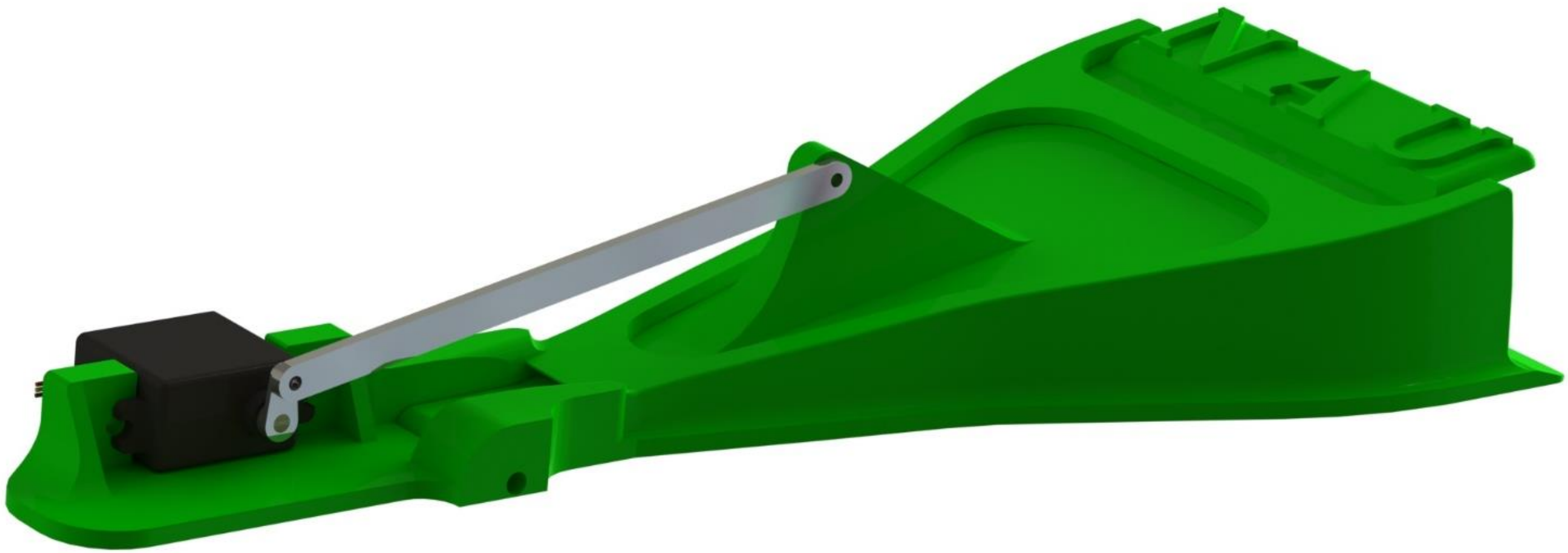
Table 5- Drivetrain Gear Ratios

Gear Ratio	Speed at 90 RPM (MPH)	Speed at 110 RPM (MPH)
1.63	11.44	13.99
1.83	12.87	15.73
2.09	14.71	17.98
2.44	17.16	20.98
2.79	19.62	23.98
3.25	22.89	27.97
3.66	25.75	31.47
4.18	29.42	35.96
4.88	34.33	41.96
5.32	37.45	45.77

Design Details
Ergonomics



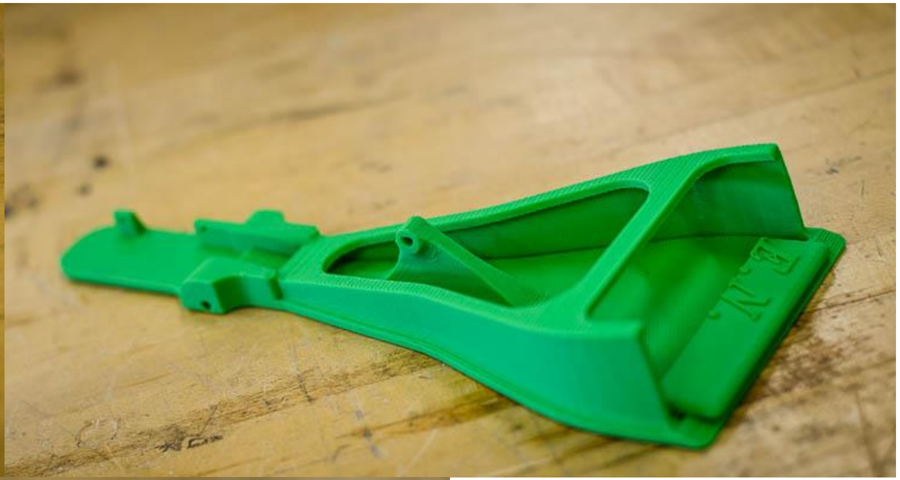
Proposed Design
Vents



Proposed Design
Analysis

- Tipping Analysis
- Vent Geometry CFD
- Wheel Fairing CFD
- Steering Arm FEA
- Bell Crank FEA
- Outrigger FEA
- Frame Tubing Optimization
- Carbon Fiber 3-Point Bending
- Accelerometer Data Collection

Prototype Fabrication



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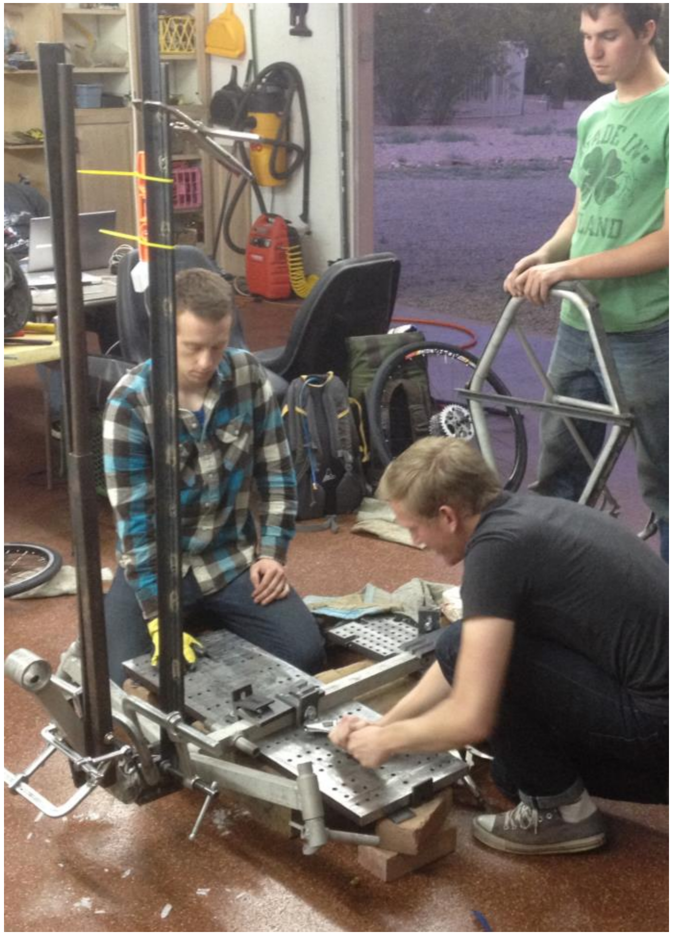

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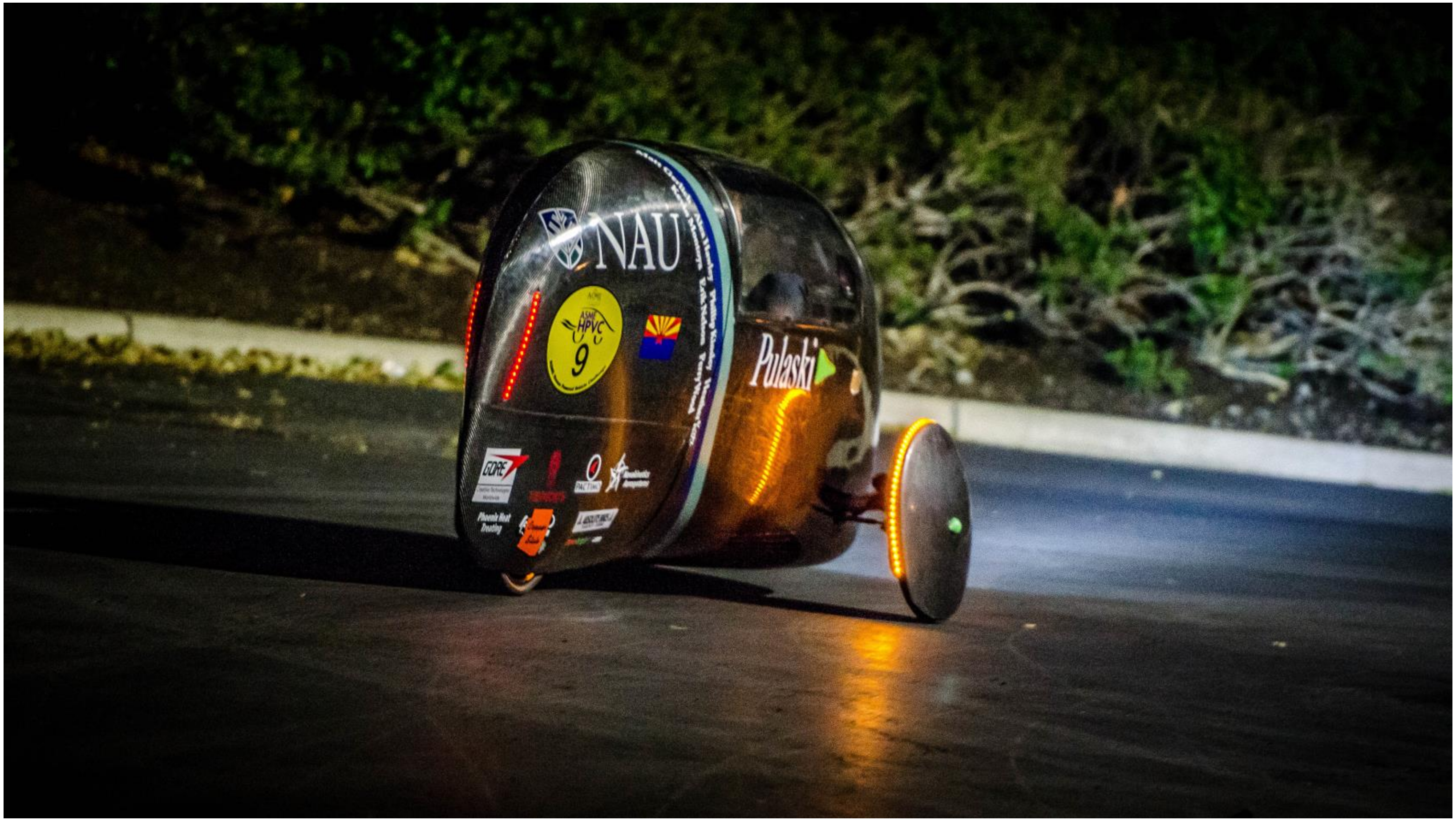

Testing and Results
Performance

Table 6- Performance Testing

Physical Test	Method	Results
Rider Position	Measure power output for simulated race at different angles	Angle of 122°
Turn Radius	The turn radius will be measured for a complete a 180° turn.	Turning radius of 8.4 feet
Braking Distance	Measured stopping distance from 15.5 mph.	Complete stop in 12 feet.
Top Speed Test	Measured with a 600 meter run up and 200 meter speed trap.	44.8 mph was reached

Testing and Results
Competition

- 2nd place overall
- 1st place in women's sprint
- 2nd place in design
- 2nd place in innovation
- 3rd place in endurance

Cost Analysis

Table 7- Total Vehicle Costs

Subsection	**Projected Total**
Frame	$424.21
Fairing	$2,926.34
Steering	$802.36
Drivetrain	$1,349.04
Ergonomics	$278.73
Innovation	$192.10
Vehicle Total	**$5,972.78**

Conclusions

- Pulaski successfully met all the constraints and objectives set forth by ASME and team advisor through numerical and physical testing.
- The vehicle reached a top speed of 44.8 mph, achieved a turning radius of 8.4 feet, and completed a stop within 12 feet starting at 15.5 mph.
- The team utilized CNC machines, manual mills, 3D printer, and composite manufacturing processes.
- Pulaski was fabricated over four months and cost approximately $6,000.
- The team placed 2nd overall and received 5 total trophies at the ASME HPVC West in San Jose, CA.

Special Thanks To!

- Perry Wood
- George Sedillo
- Dr. Tuchscherer
- Jim Corning
- Dr. Kosaraju

Sponsors

- W.L. Gore
- Kenworth
- Absolute Bikes
- Nova Kinetics
- SuperBrightLEDS.com
- Copperstate
- Phoenix Heat Treat
- Power On Cycling
- Pactimo

Questions?