Human Powered Vehicle Project Proposal

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December 11, 2013

Overview

- Project Description
- Project Goal
- Objectives
- Constraints
- Full Assembly
- Subsections
  - Design Concepts
  - Analysis
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- Conclusion
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Project Description

- ASME Human Powered Vehicle Challenge
- Clients
  - Perry Wood
  - ASME
- There is no current form of transportation that provides the benefits of bicycle commuting, while offering the practicality of automobiles.

Project Goal

- "Design a human powered vehicle that can function as an alternative form of transportation."

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 7.9 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

Figure 1- Full Assembly With Fairing

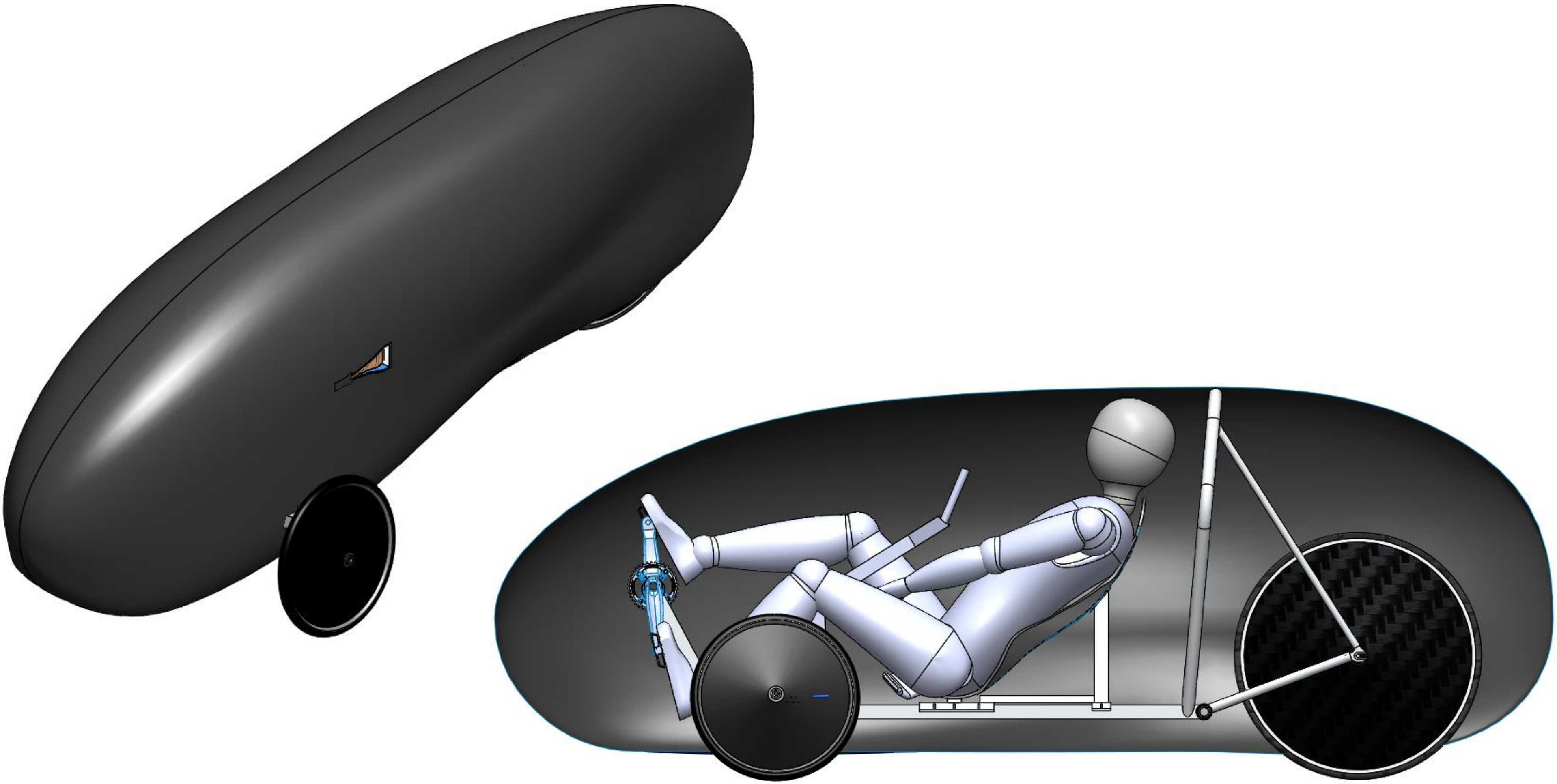


Figure 2- Full Assembly With Model

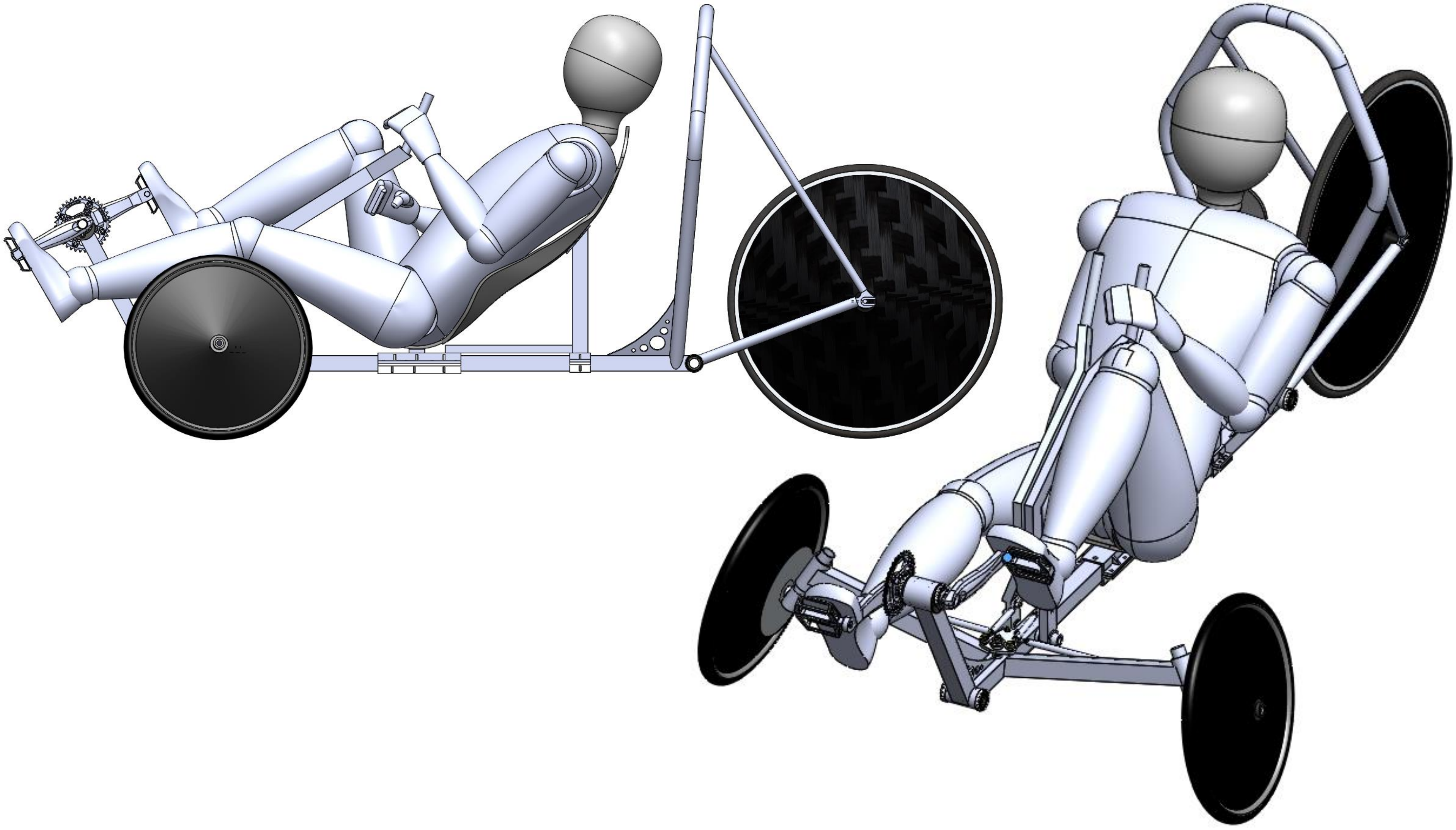


Figure 3- Full Assembly

Table 4- Frame Decision Matrix

	Weight	Ease of Seat Integration	Resistance to Deflection	Fabrication Time	
Score Factor	0.2	0.2	0.4	0.2	**Score**
Circular	3	1	1	2	1.6
Rectangular	2	3	3	3	**2.8**
Double Circular	1	2	2	1	1.6

Figure 4- Frame

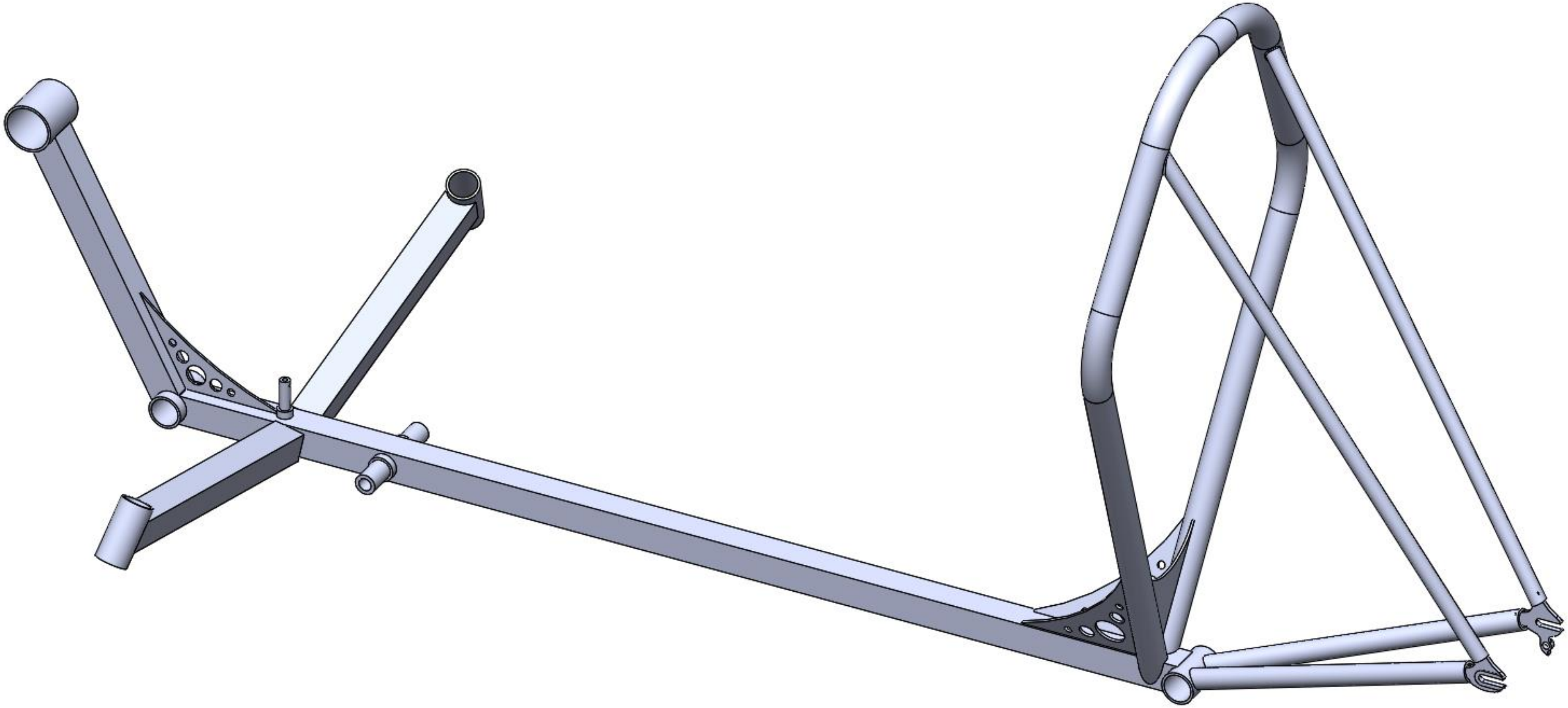


Figure 5- Square Outrigger Stress

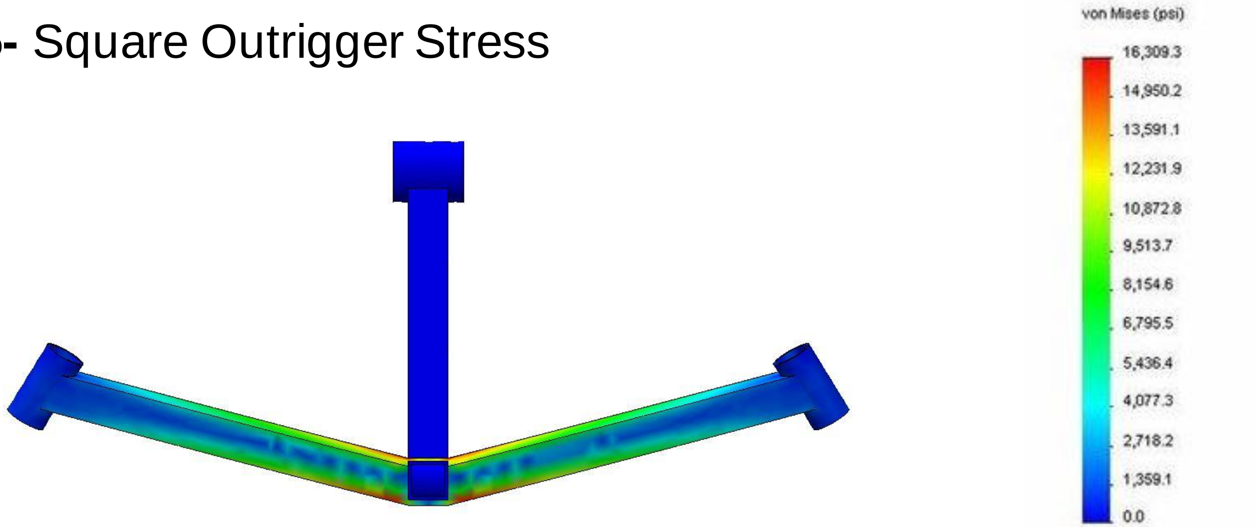


Figure 6- Square Outrigger Deflection

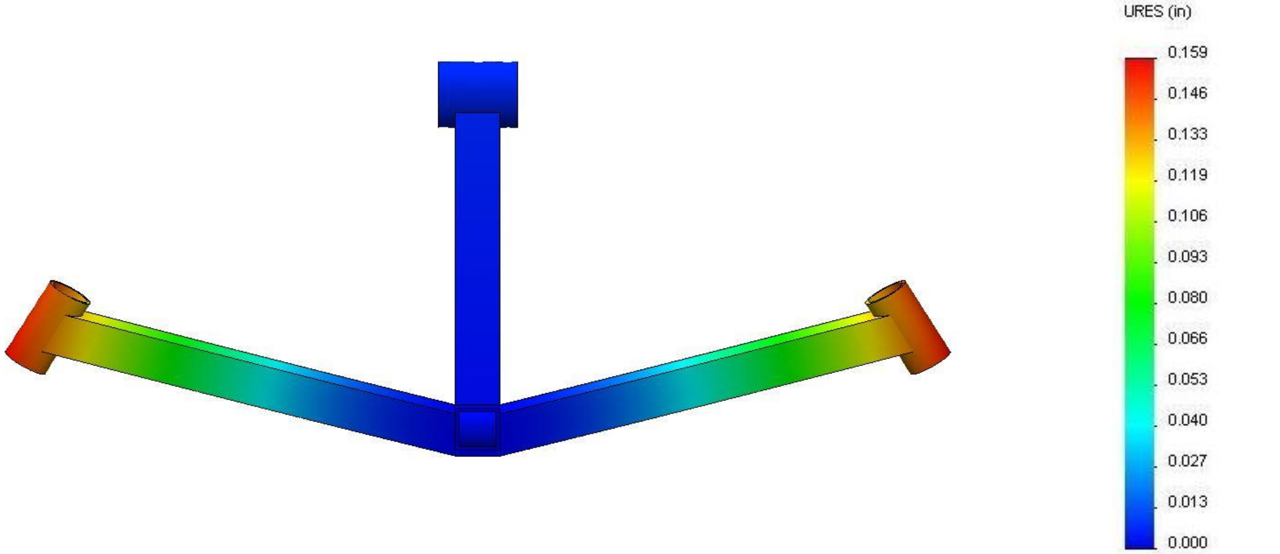


Table 5- Stress and Deflection Calculations

Part	Deflection (in)	Part	Stress (psi)
Main Tube Deflection	0.342	**Outrigger Stress Nominal**	14593
Outrigger Deflection	0.159	**Outrigger Stress Max**	22473
FEA Deflection	0.159	**FEA Stress**	16309
Main Tube Lateral Deflection	0.171		
Outrigger Lateral Deflection	0.060		

Figure 7- Top Load Roll Bar Deflection

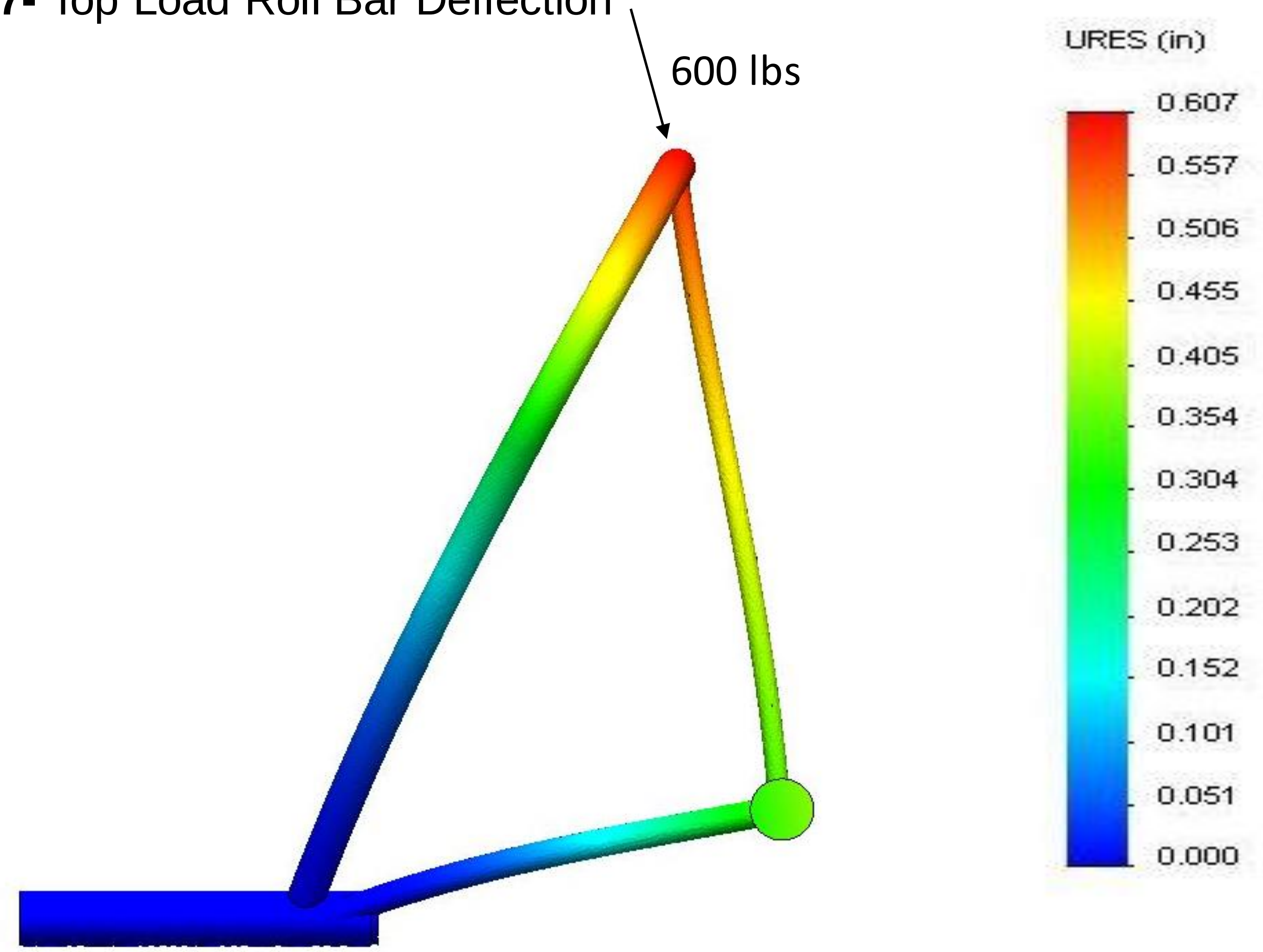


Figure 8- Side Load Roll Bar Deflection

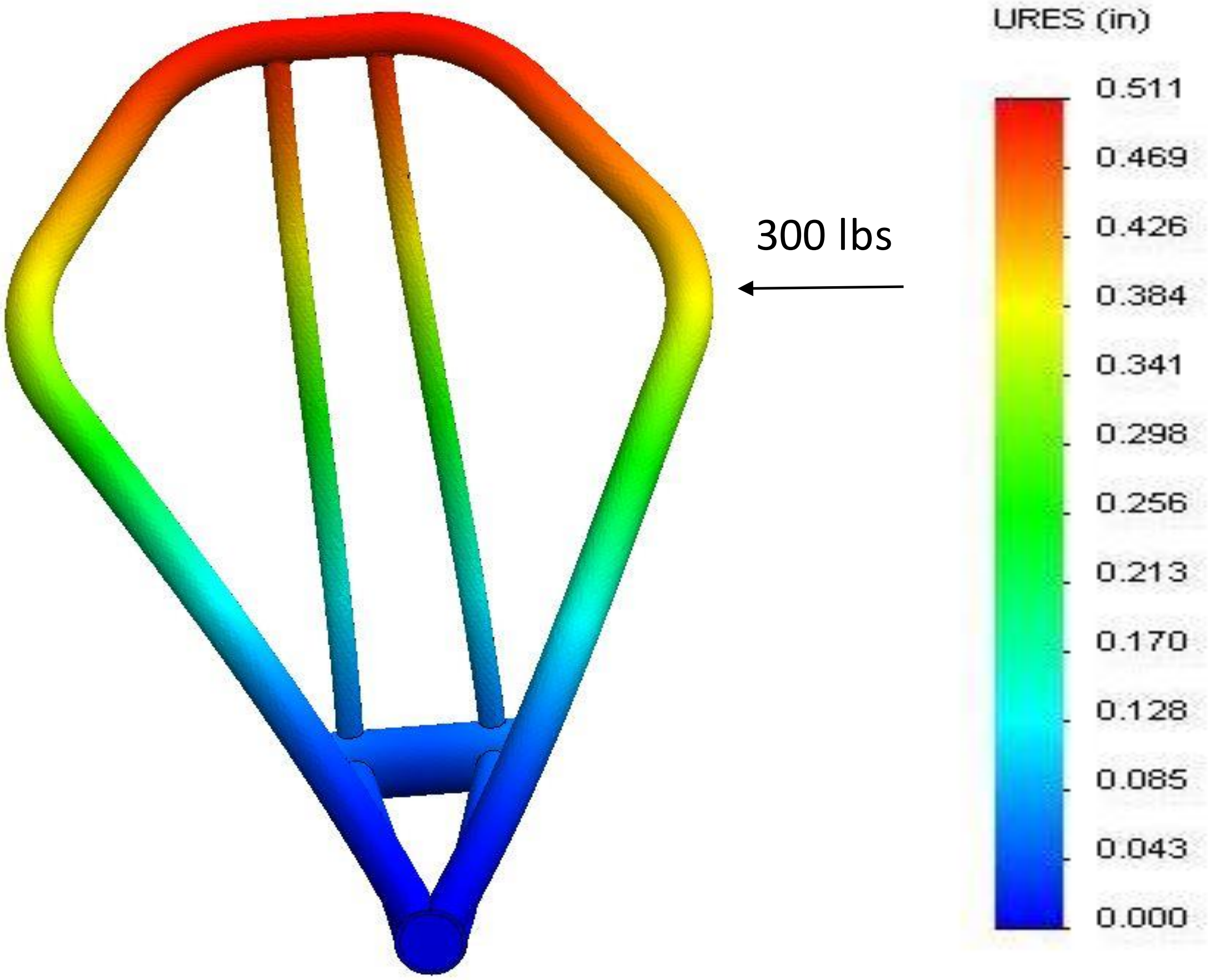


Figure 9- Rack and Pinion

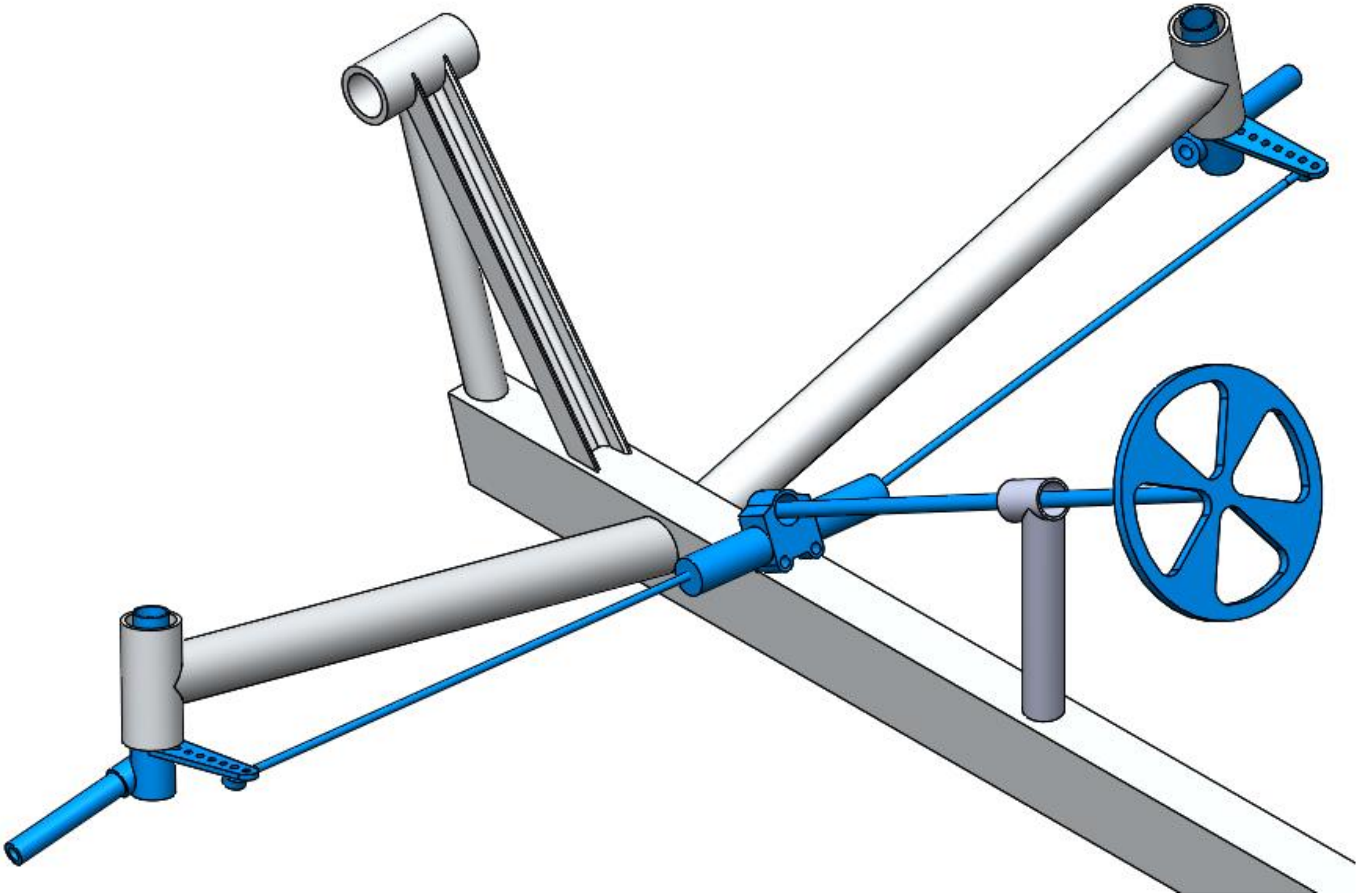


Figure 10- Pittman Arm

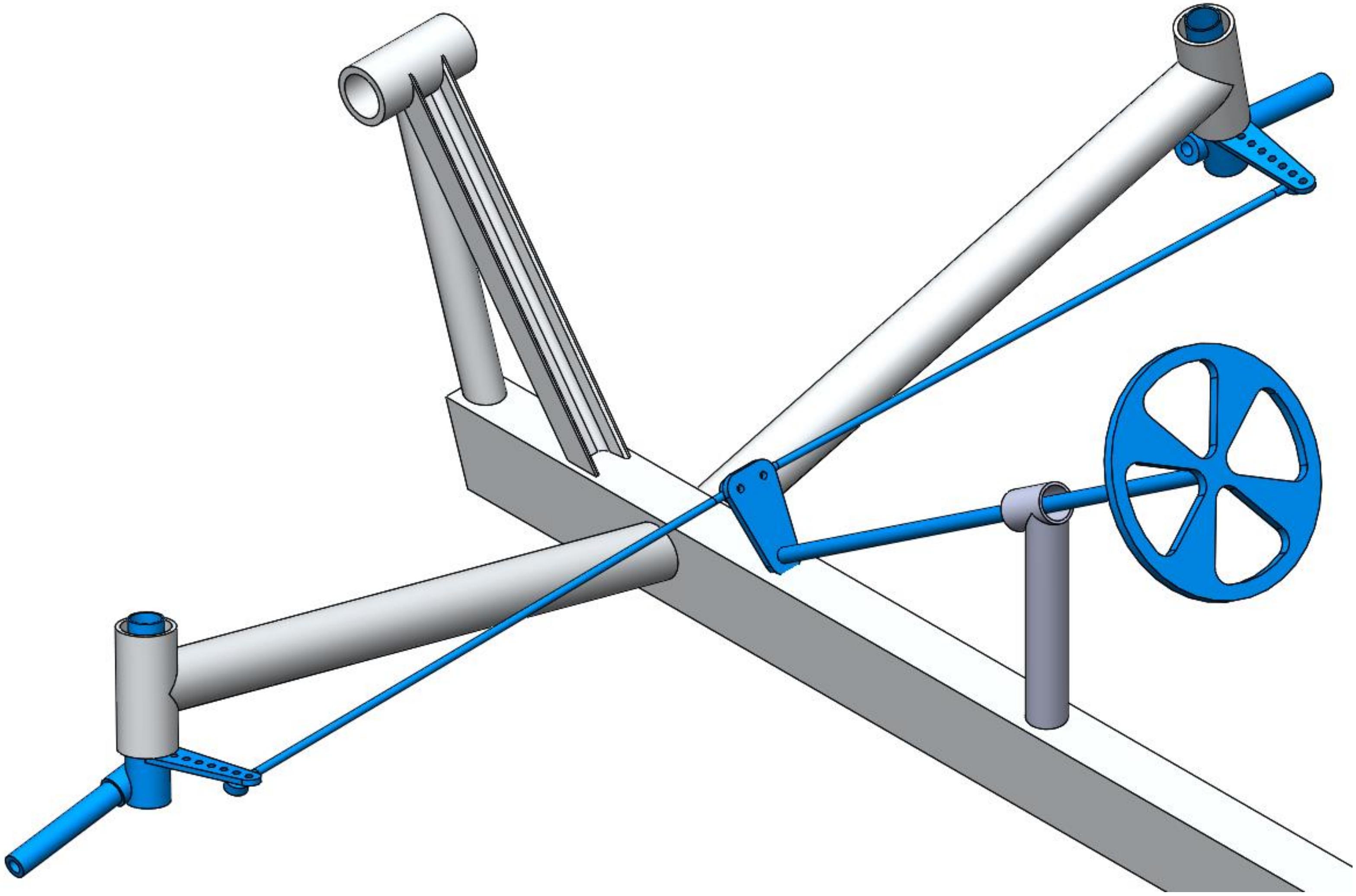


Figure 11- Bell Crank Push Pull

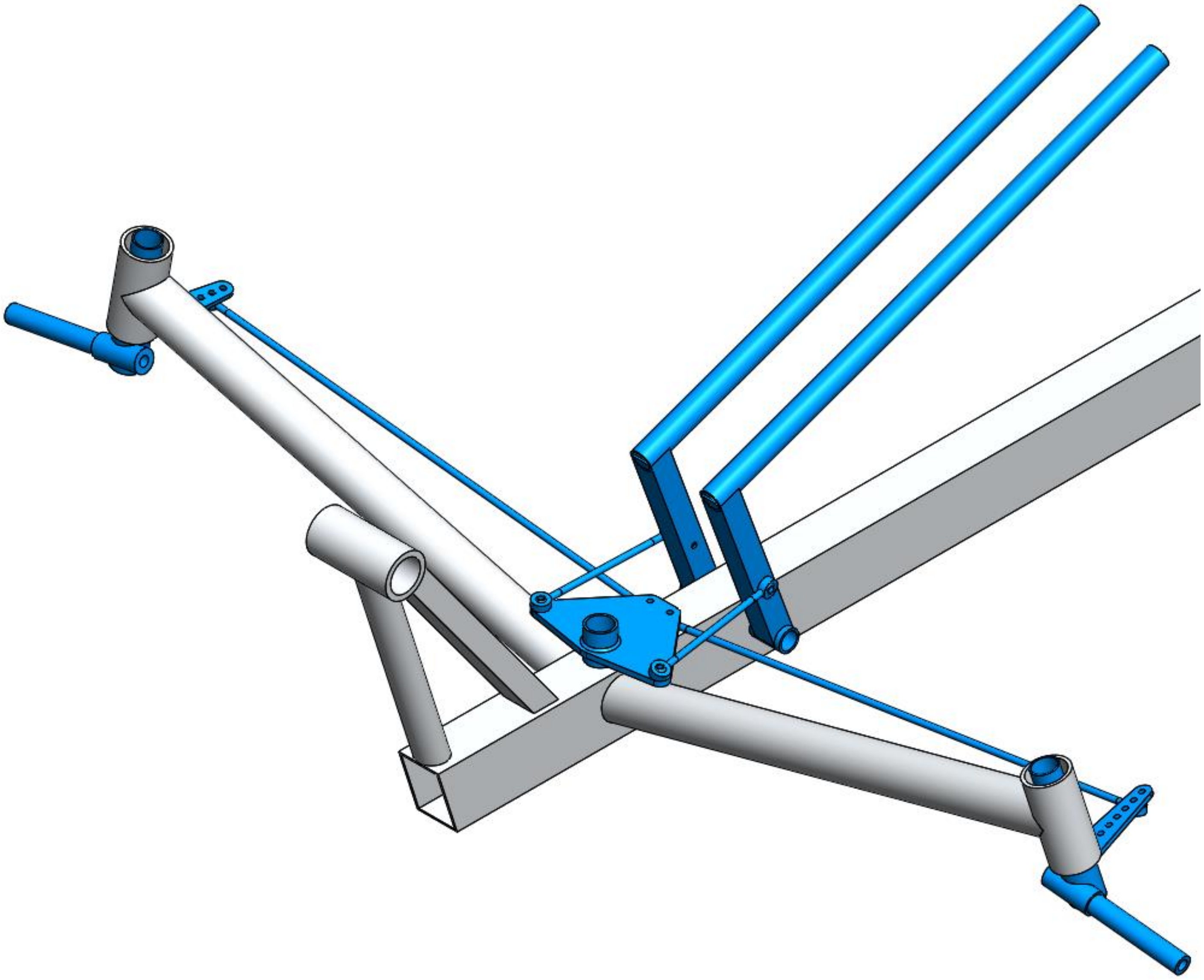


Table 6- Steering Decision Matrix

	Weight	Cost	Ease Of Use	Ease Of Exiting Vehicle	Fabrication Time	Adjustability	Play	
Rack & Pinion	2	2	4	2	9	3	4	**Score**
Weighted Score	0.36	0.2	0.82	0.37	0.34	0.46	0.55	3.1
Pitman Arm	8	3	3	2	7	3	8	
Weighted Score	1.45	0.3	0.61	0.37	0.27	0.46	1.12	4.56
Bell Crank Push Pull	6	8	7	8	3	6	3	
Weighted Score	1.09	0.8	1.43	1.49	0.11	0.91	0.41	**6.25**

Figure 12- Caster Angle

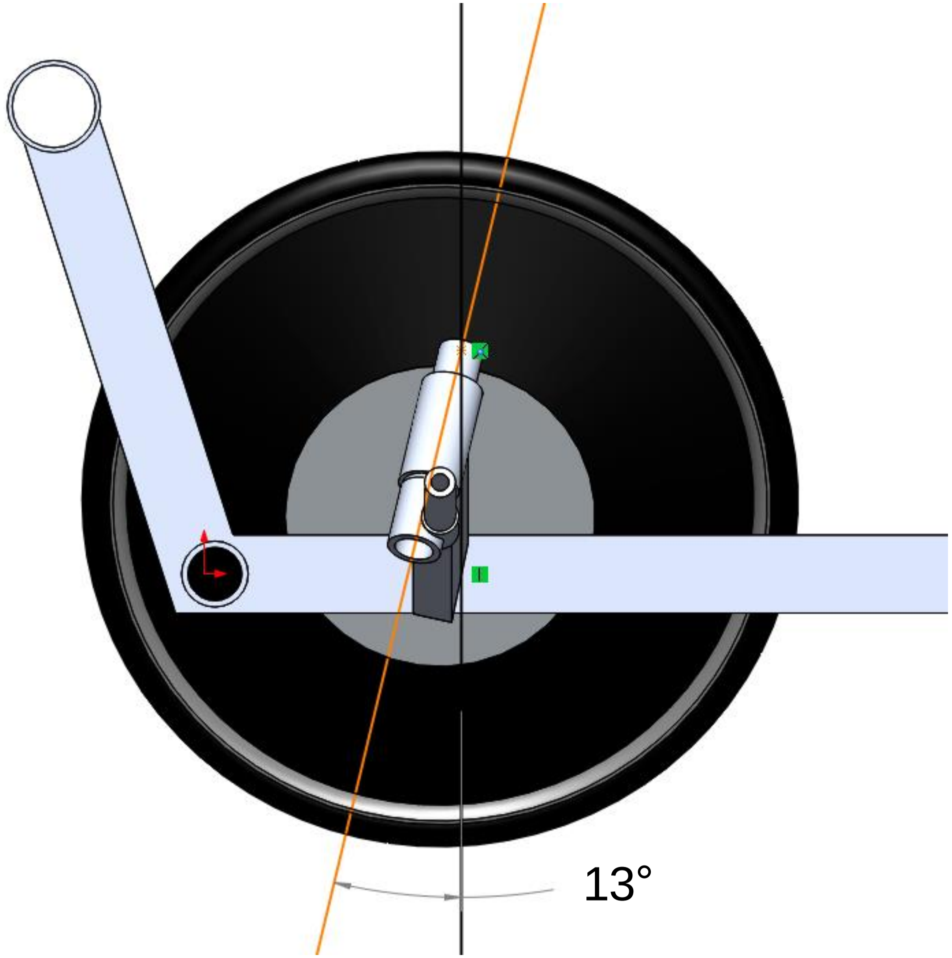


Figure 13- Camber Angle

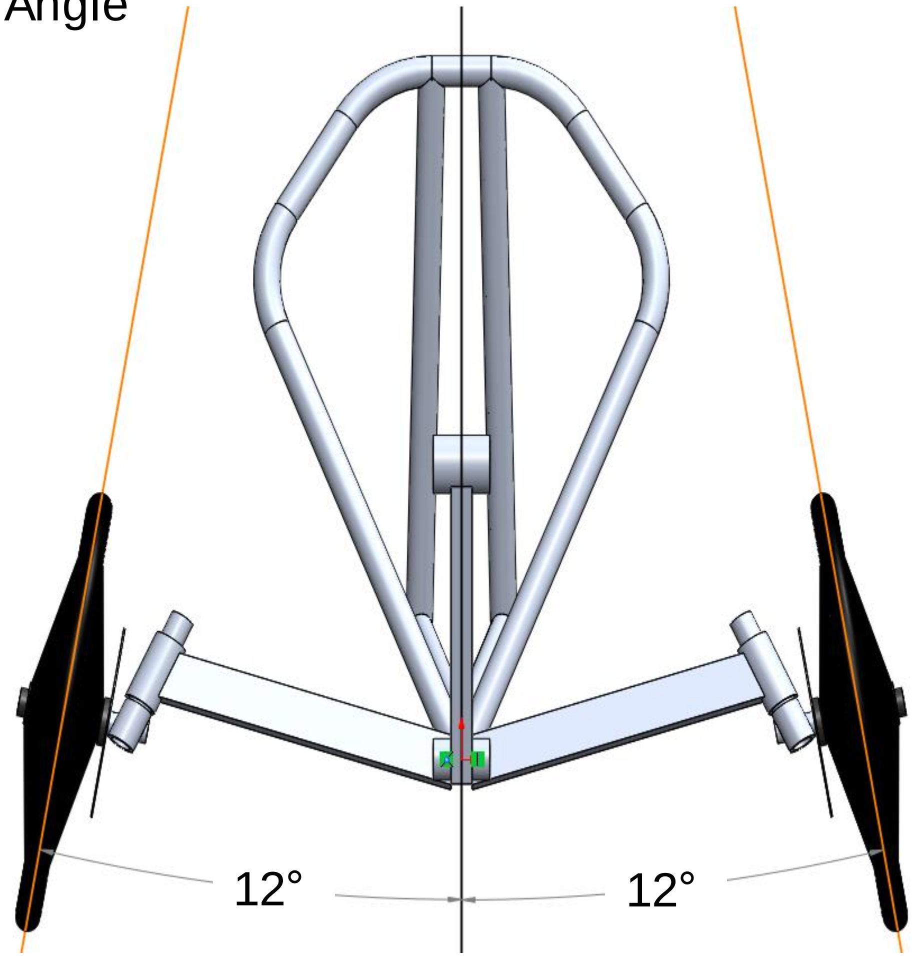


Figure 14- Kingpin Angle

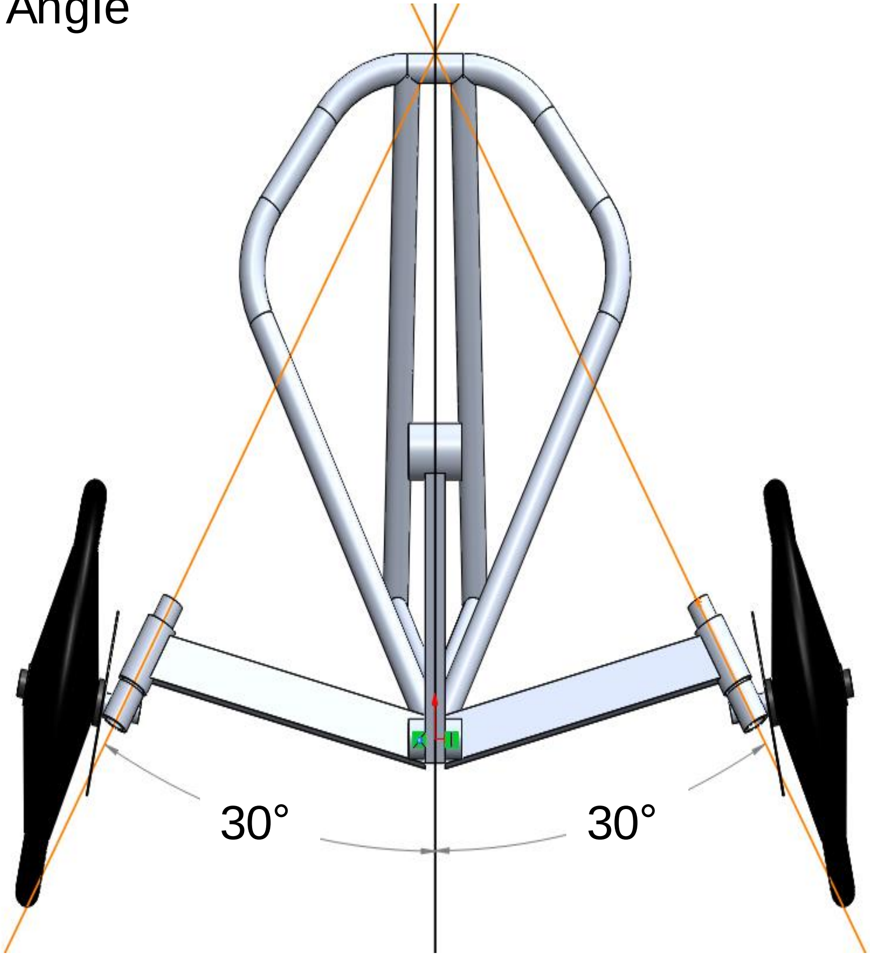


Figure 15- Steering

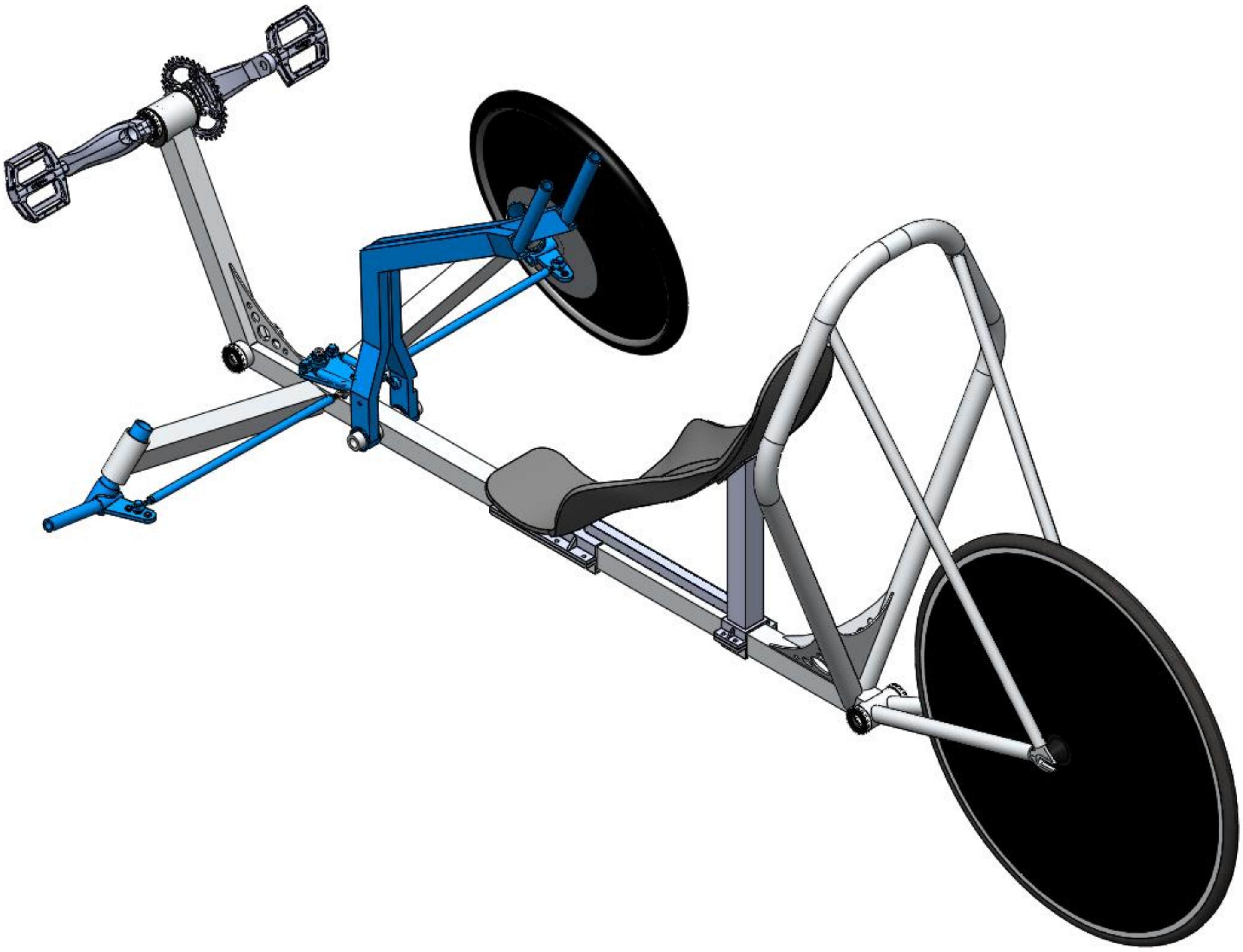


Figure 16- Steering Knuckle FEA

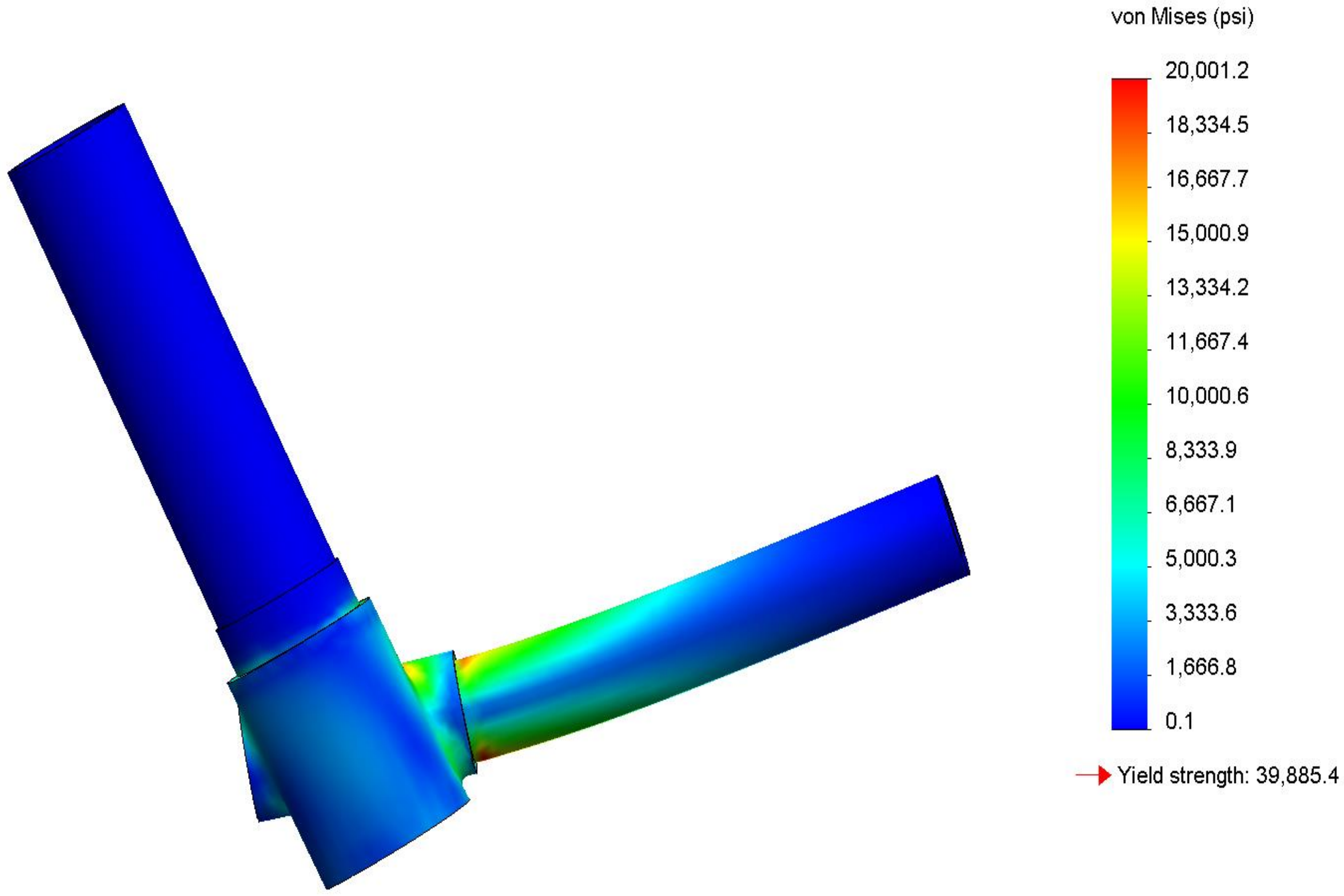


Figure 17- Bracket Concept

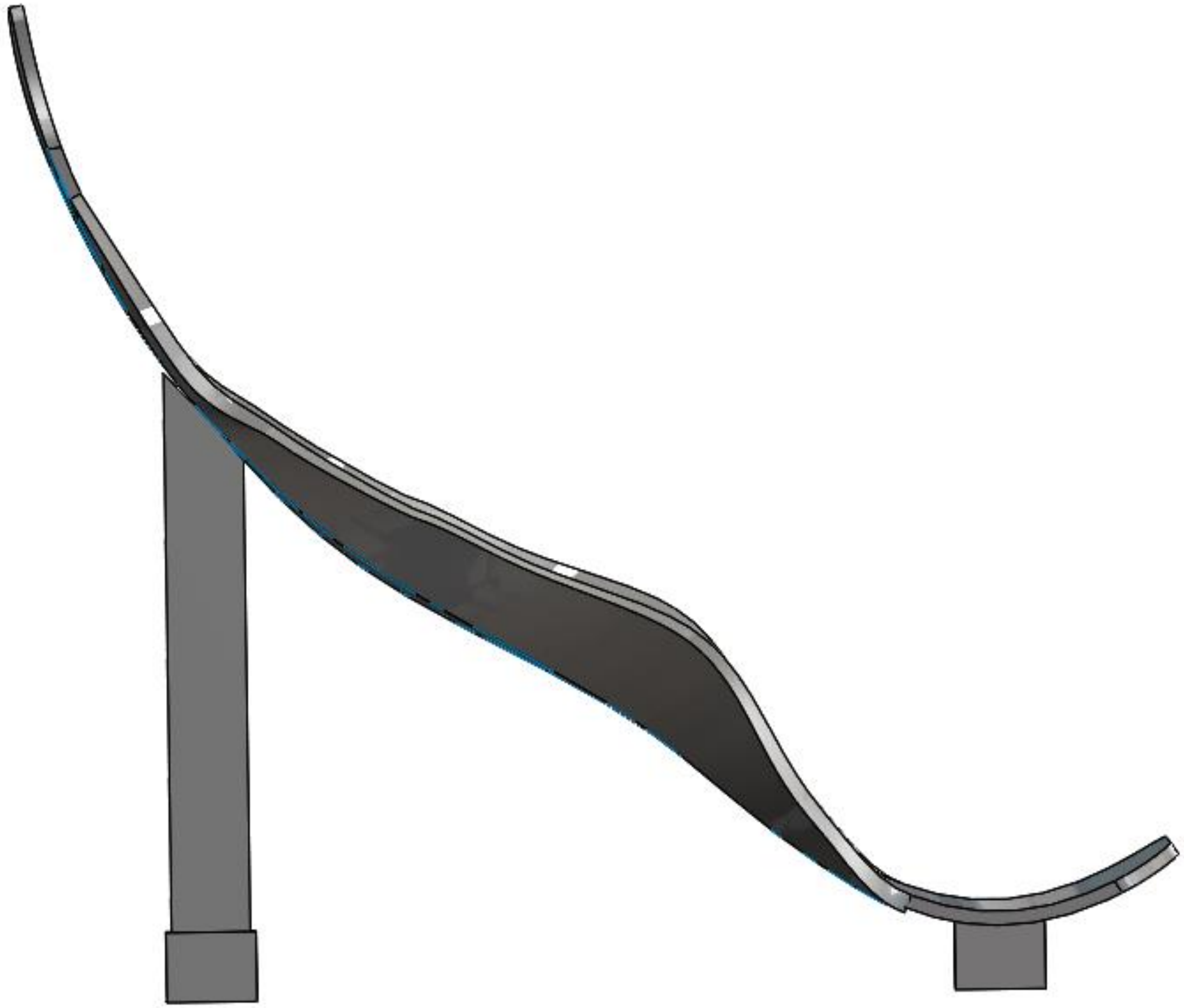


Figure 18- Rider Position Angle

Figure 19- Average Power at Various Angles

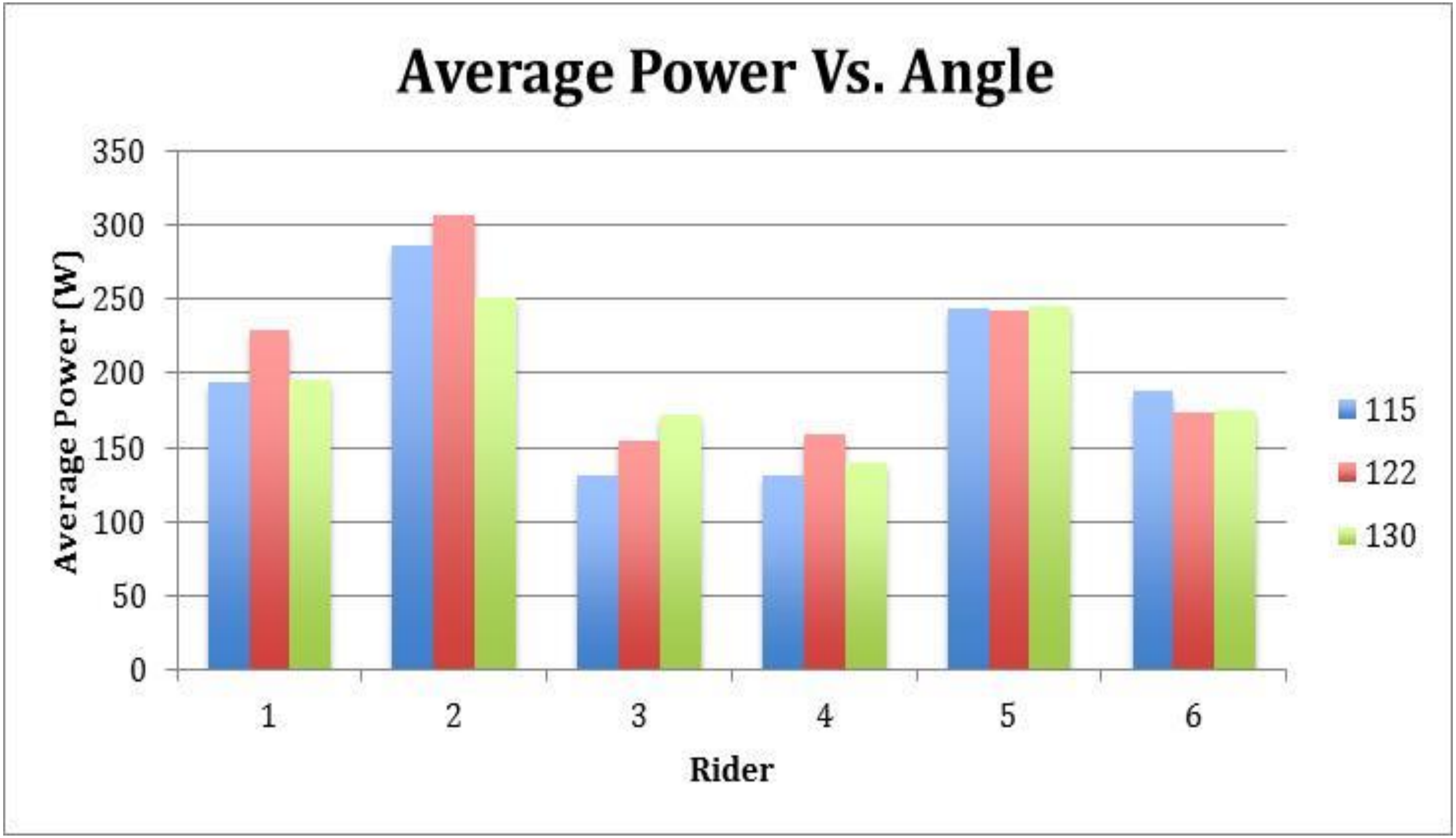


Figure 20- Ergonomics Assembly

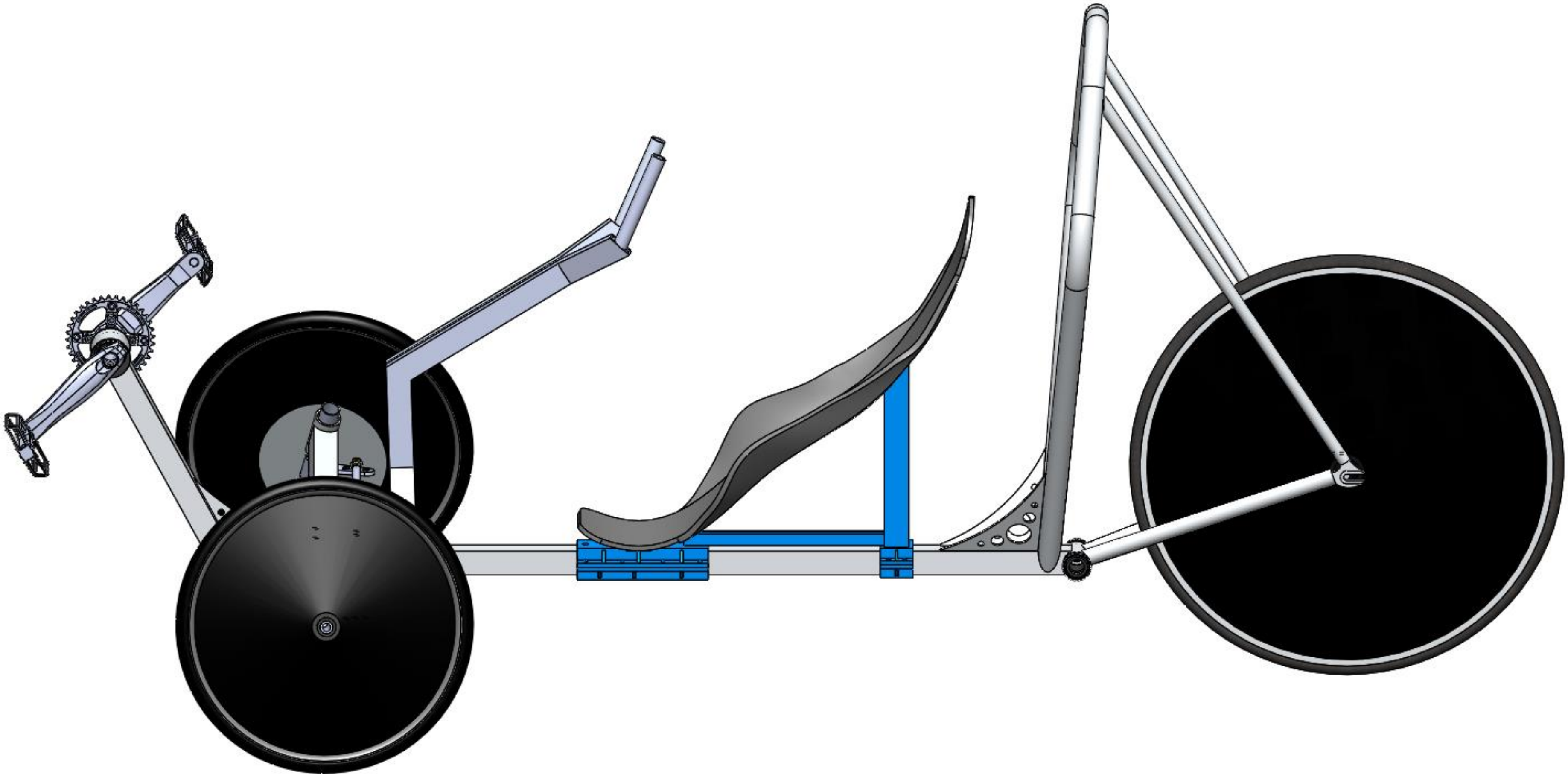


Figure 21- Seat Bracket

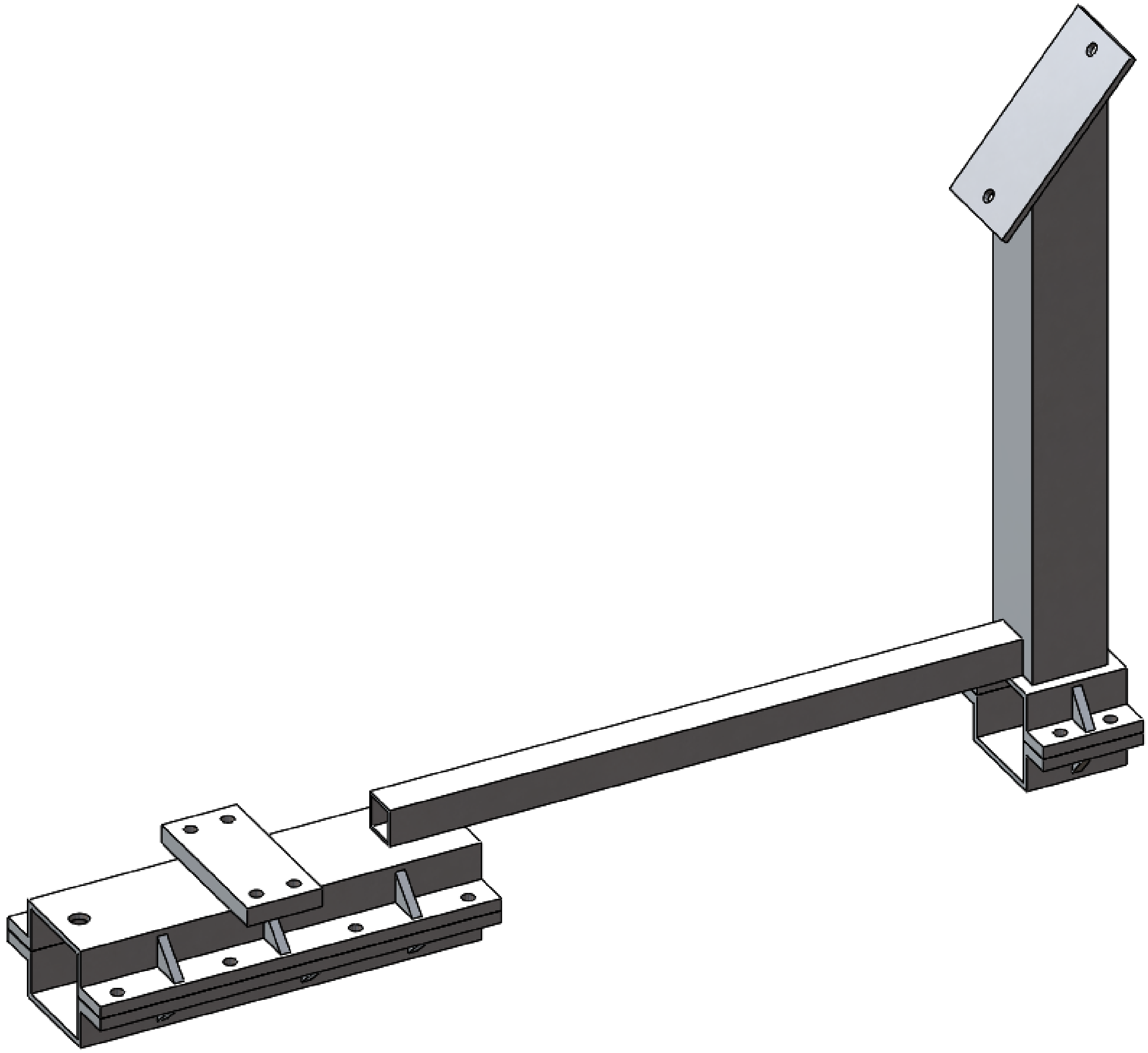


Figure 22- Gear Design Concepts

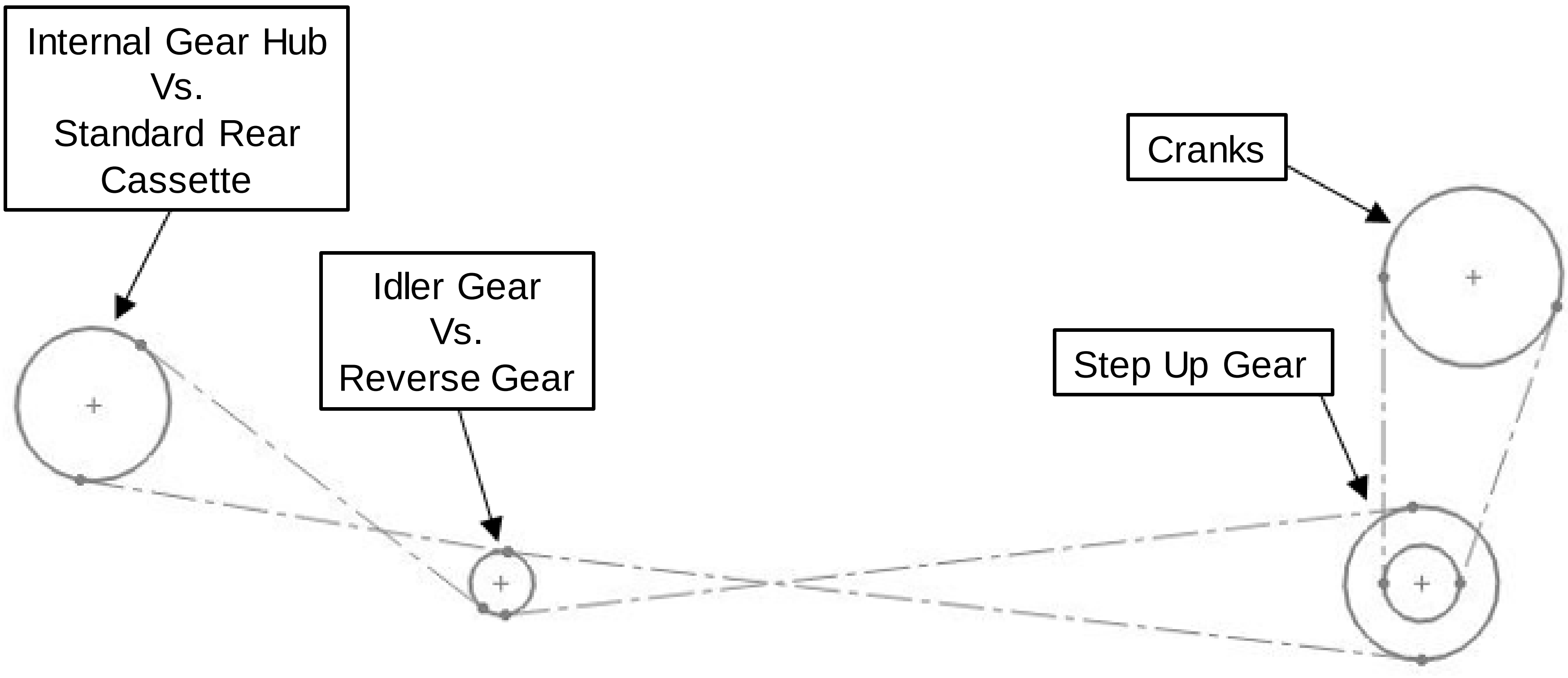


Figure 23- Reverse Gear Concept

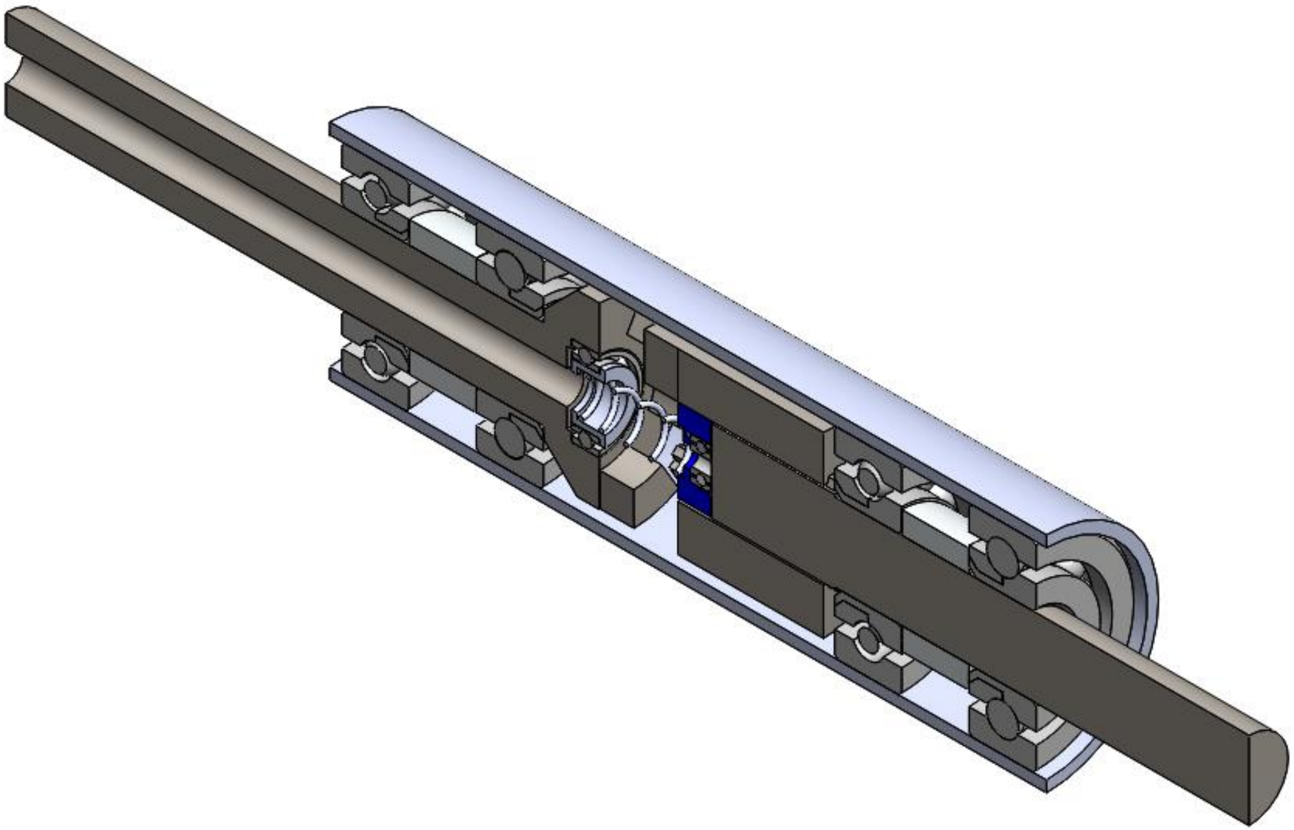


Table 7- Gear Ratios and Speeds

Gear Ratio	Speed at 90 RPM (MPH)	Speed at 110 RPM (MPH)
1.50	10.56	12.91
1.69	11.88	14.52
1.93	13.58	16.60
2.25	15.84	19.36
2.57	18.11	22.13
3.00	21.13	25.82
3.38	23.77	29.05
3.86	27.16	33.20
4.50	31.69	38.73
4.91	34.57	**42.25**

Figure 24- Drivetrain

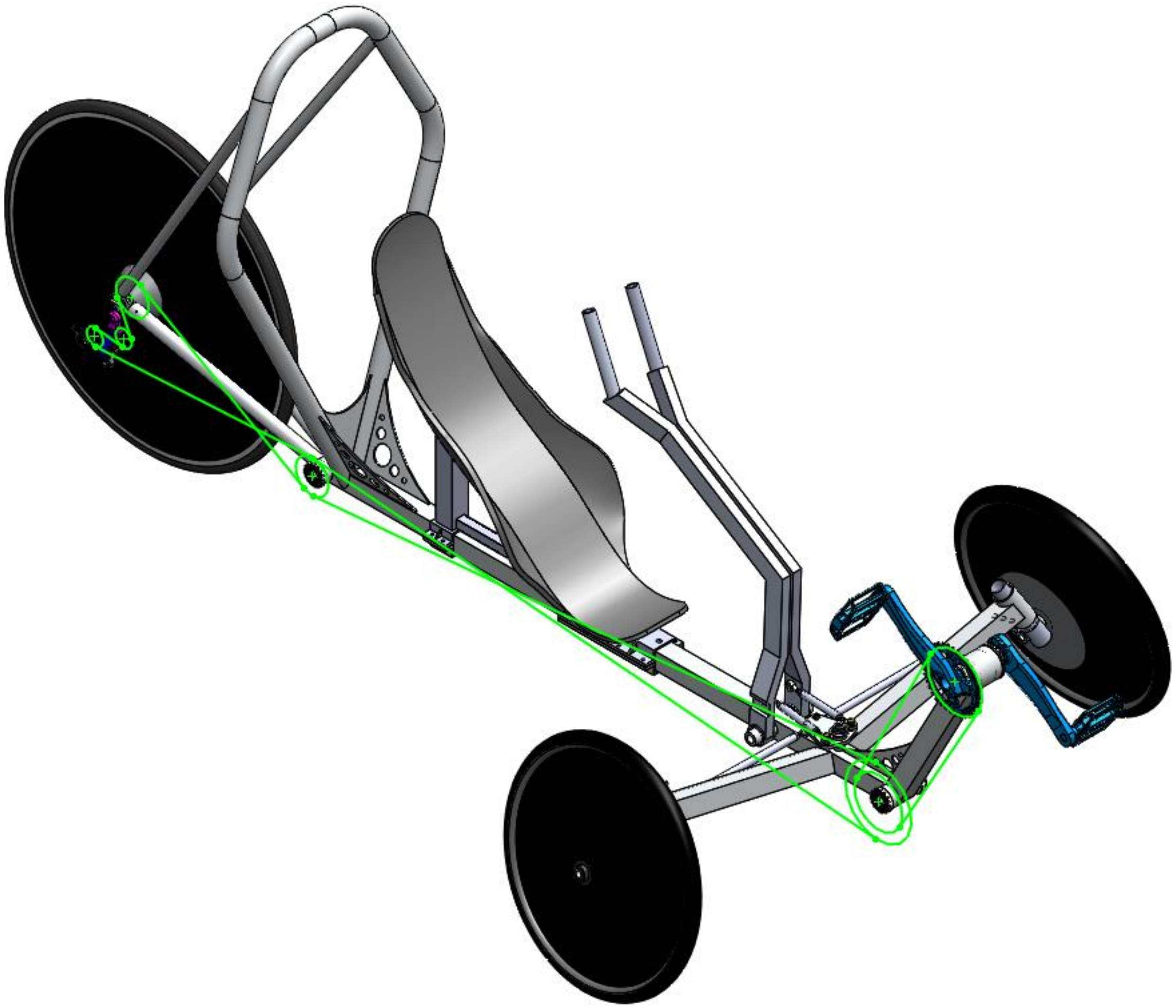


Figure 25- Front Fairing

Figure 26- Rear Fairing

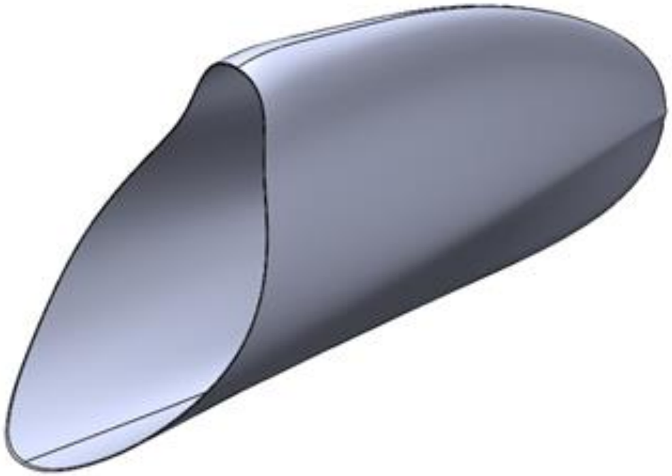


Figure 27- Full Fairing

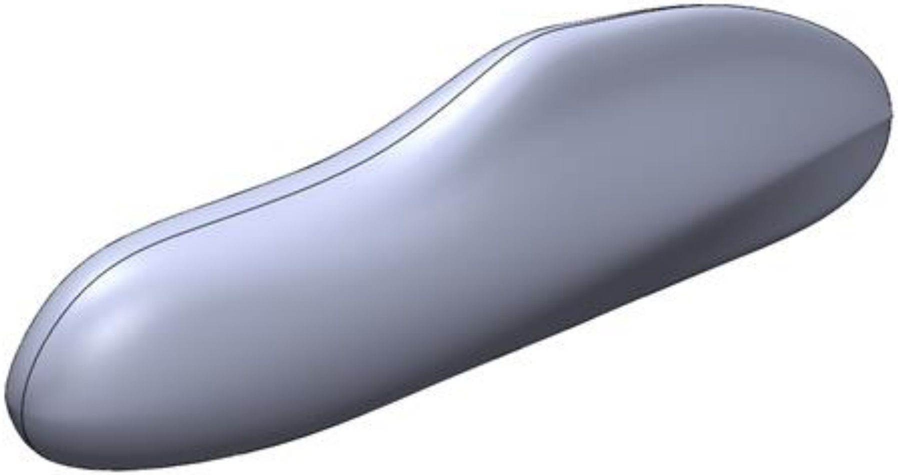
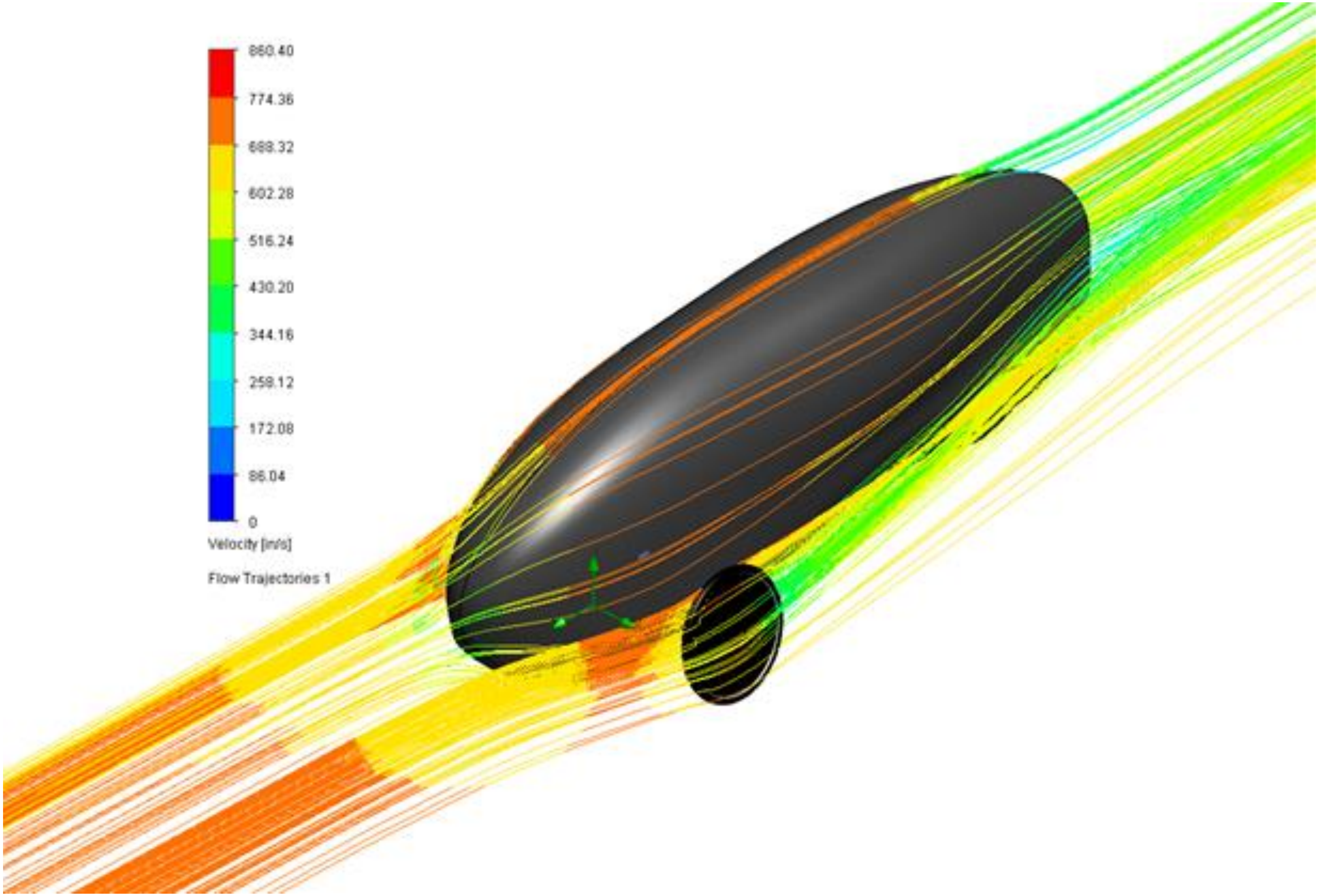


Table 8- Coefficient of Drag Comparison

Length (in)	Width (in)	Height (in)	Speed (in/s)	Force (lbf)	Area (in^2)	Cd
96	18	37	704	0.59	681.5	0.038
96	20	37	704	0.51	716.5	0.031
96	22	37	704	0.54	760.0	0.031
96	24	37	704	0.61	803.7	0.033
102	18	37	704	0.41	670.3	0.026
102	20	37	704	0.49	702.1	0.030
102	22	37	704	0.56	753.5	0.032
102	24	37	704	0.51	790.6	0.028
108	18	37	704	0.54	670.5	0.035
108	20	37	704	0.48	701.4	0.030
108	**22**	**37**	**704**	**0.43**	**740.0**	**0.025**
108	24	37	704	0.57	788.4	0.032

Figure 28- Vehicle CFD



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 Carbon Fiber 3k

Figure 29- Fairing

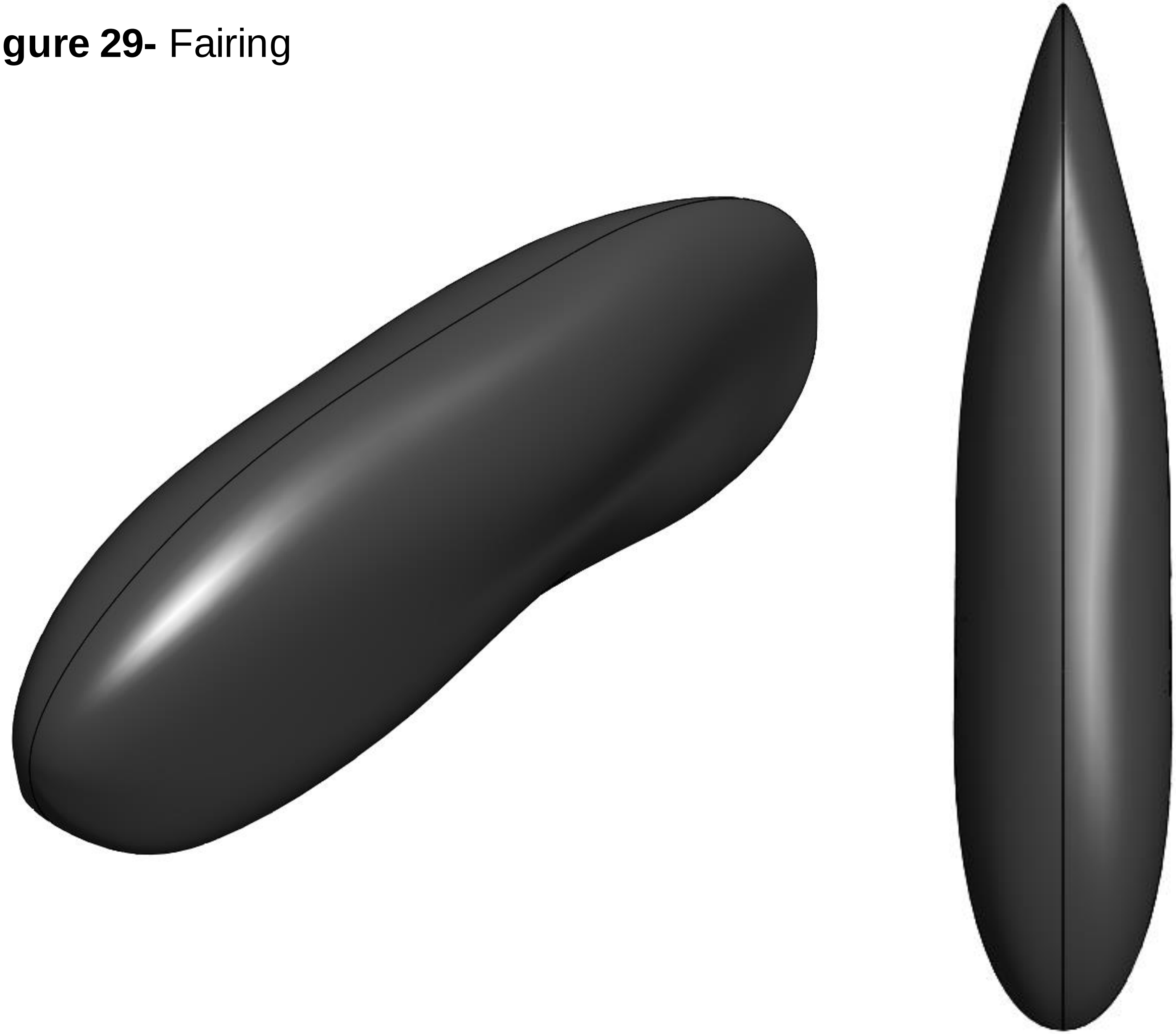


Figure 30- Interior View (Open)

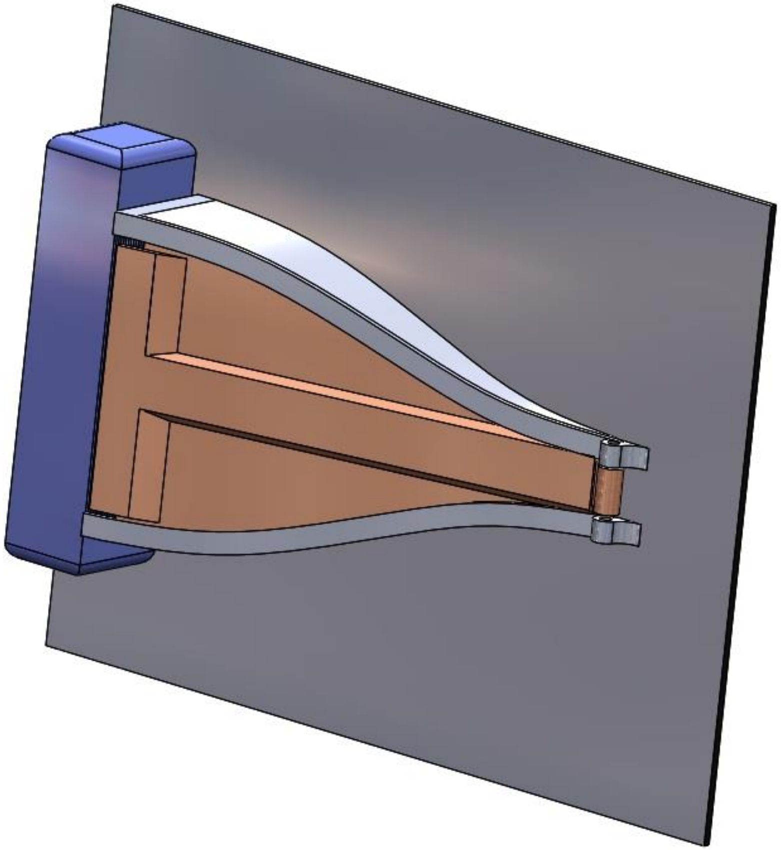


Figure 31- Interior View (Closed)

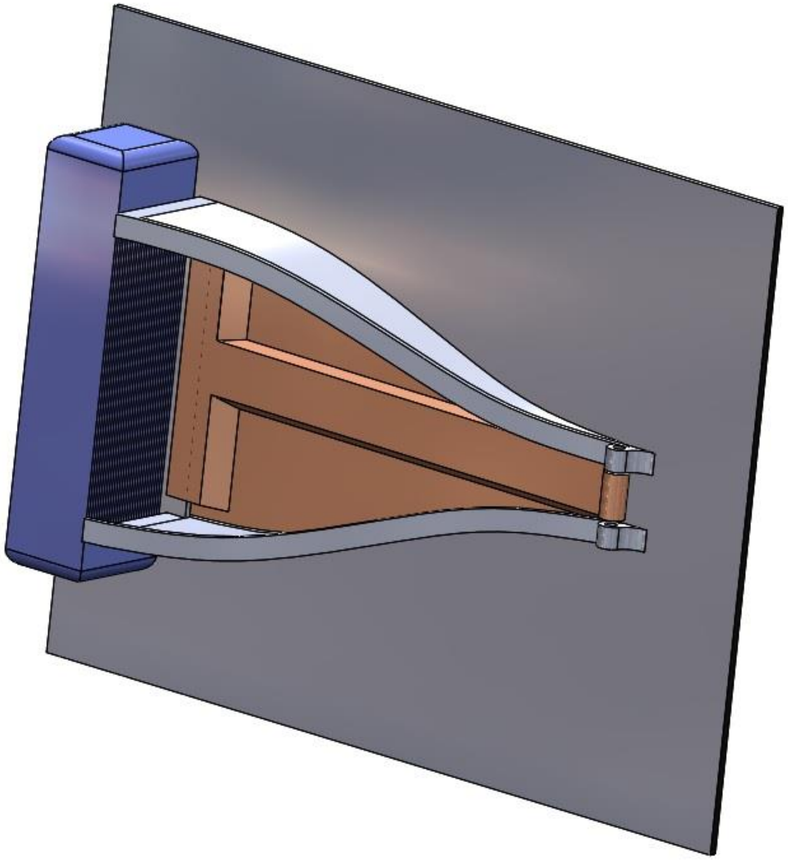


Figure 32- Exterior View (Open)

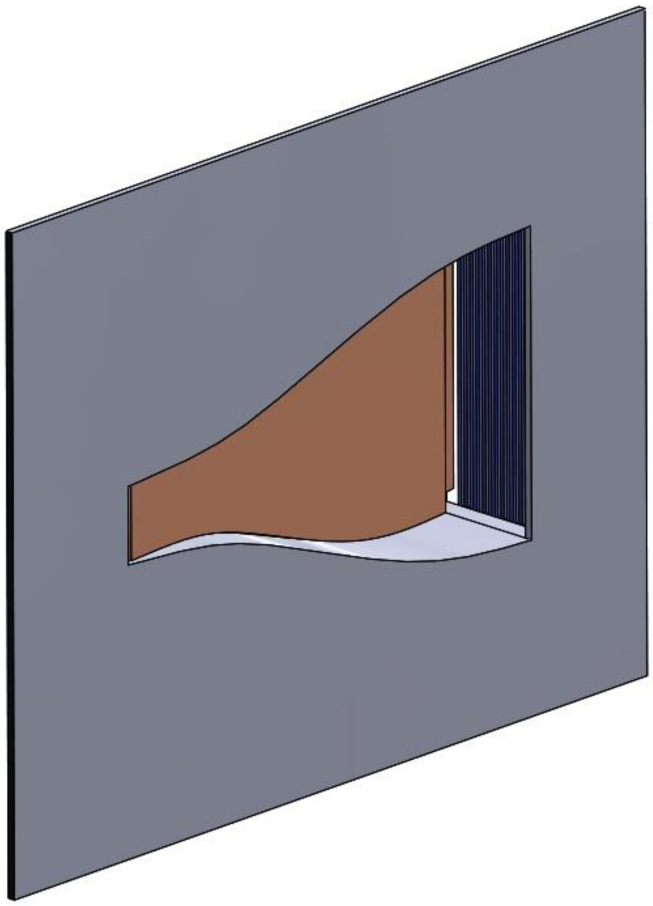


Figure 33- Exterior View (Closed)

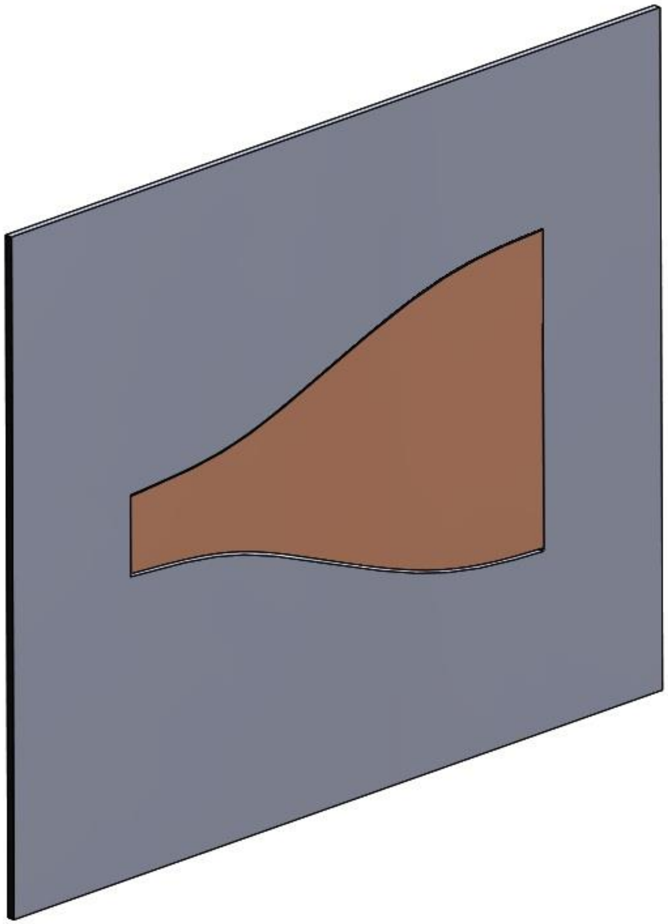


Figure 34- Interior View (Open)

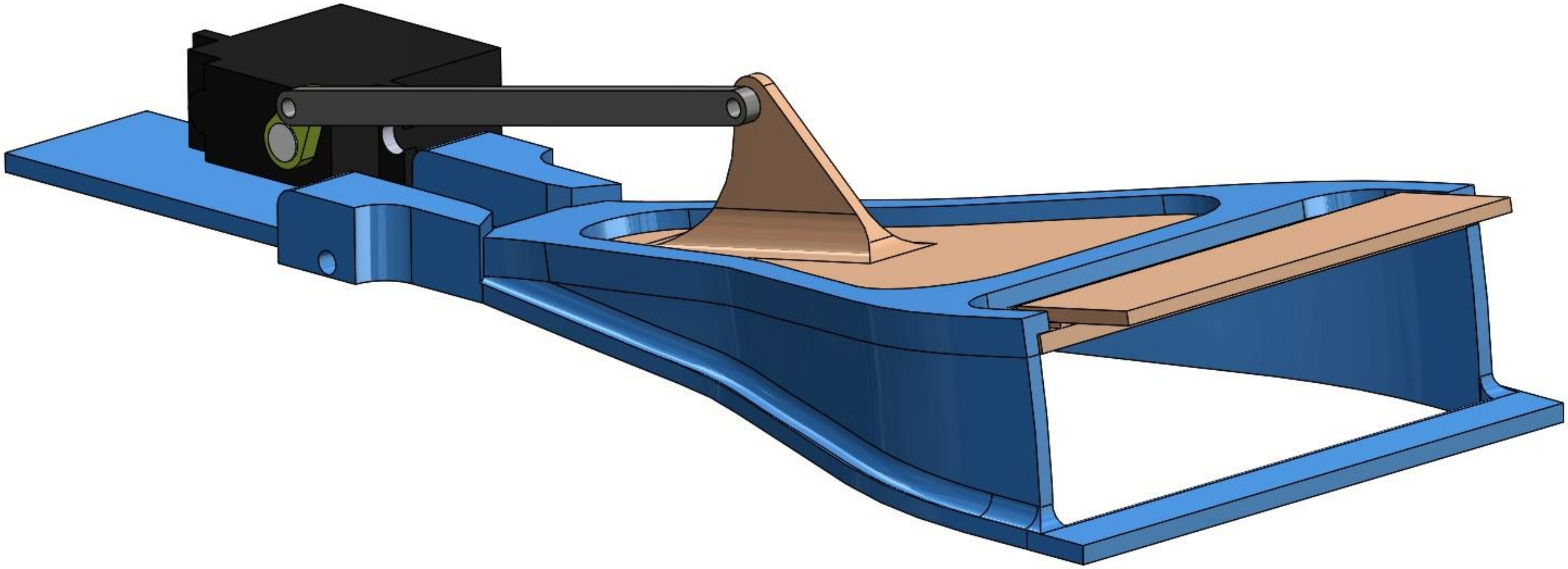


Figure 35- Interior View (Closed)

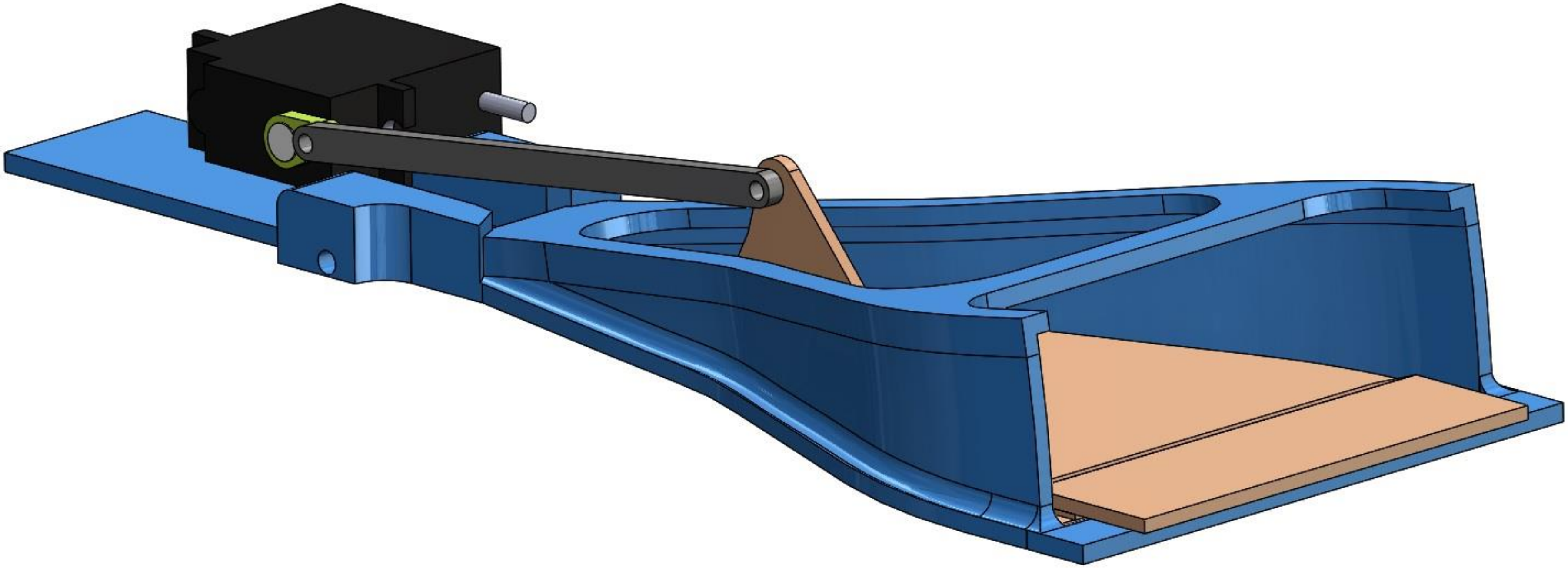


Figure 36- Fairing with Vents

Figure 37- Top View of Lights

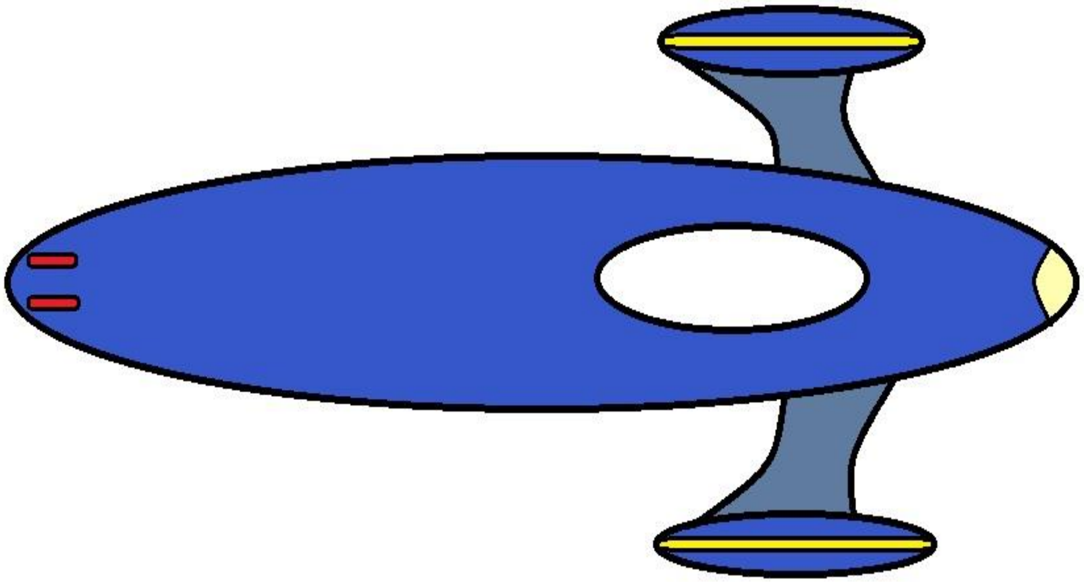
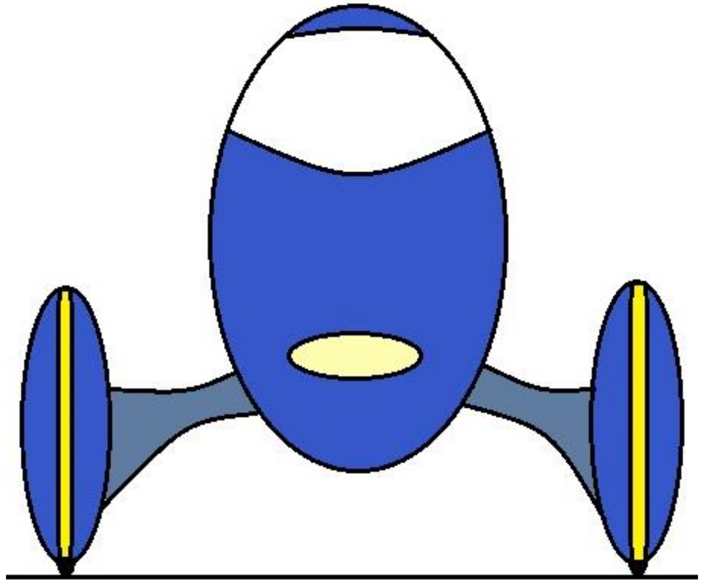


Figure 38- Front View of Lights



Cost Analysis

Table 9- 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**

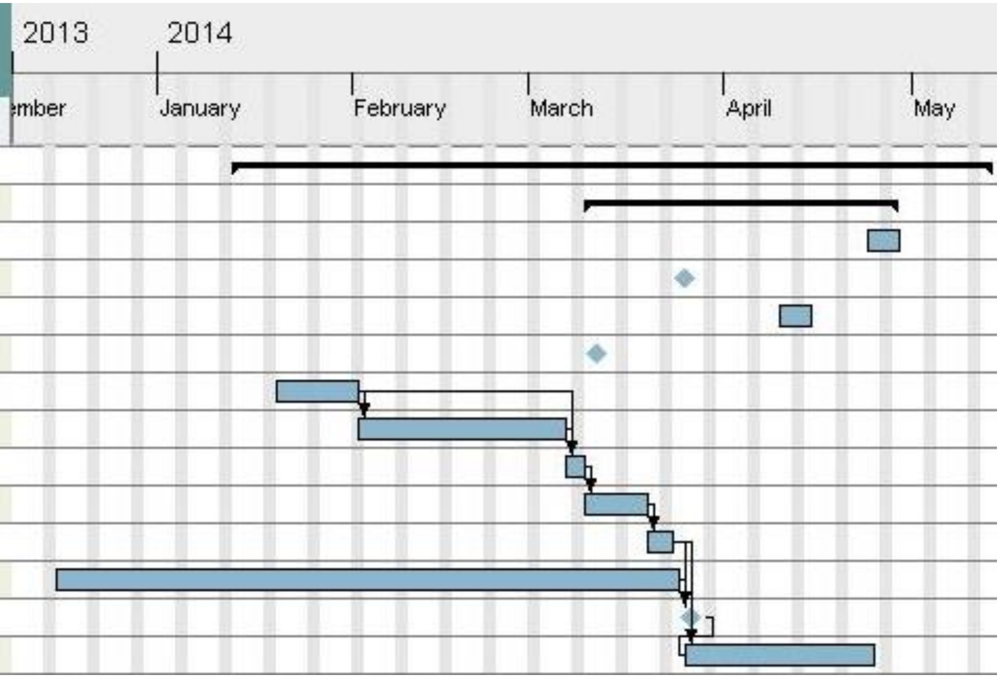
Cost Analysis

Table 10- Production Run Costs

Costs	**Total**
Capital	$189,800.00
Labor	$907,200.00
Overhead	$54,000.00
Materials	$2,154,600.00
Total	$3,305,600.00

Figure 39- Spring Semester Project Plan

Name	Begin d...	End date
486C Requirments	1/13/14	5/13/14
Competition Dates	3/10/14	4/28/14
California	4/24/14	4/28/14
Design Report Due - West	3/24/14	3/24/14
Florida	4/10/14	4/14/14
Design Report Due - East	3/10/14	3/10/14
Machining of all Heat Treated components	1/20/14	2/1/14
Machining of all non HT parts	2/2/14	3/6/14
Pre-HT mock build	3/7/14	3/9/14
Heat Treat	3/10/14	3/19/14
Vehicle Assembly	3/20/14	3/23/14
Fairing Construction	12/16/13	3/24/14
Official Vehicle Testing Date	3/25/14	3/25/14
Testing and Revisions	3/26/14	4/24/14



Conclusion

- “Design a human powered vehicle that can function as an alternative form of transportation.”
- Client is Instructor Perry Wood and ASME Human Powered Vehicle Challenge.
- Main objectives for the vehicle include high speeds, low coefficient of drag, and maneuverability.
- The frame will use 1.5 in x 1.5 in aluminum square center tubing and outriggers to minimize weight and deflections.
- A bell crank push pull system will be uses for steering.
- The steering knuckle will be made out of aluminum to reduce weight while maintaining a factor of safety of 2.

Conclusion

- The rider position will be at an angle of 122 degrees for visibility and efficiency.
- A quick-release pin and Delrin plastic will be used to adjust the seat with ease.
- The drivetrain will contain a step up gear configuration with an integrated reverse gear.
- The drivetrain will minimize the gear ratio while achieving a max speed of over 40 mph.
- The fairing has a coefficient of drag of 0.09 and C_dA = 90.2 in^2.
- Vents will be incorporated into the fairing to provide comfort in a variety of climates.

References

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Questions?