Human Powered Vehicle Concept Generation and Selection

Matt Gerlich, Alex Hawley, Phillip Kinsley, Heather Kutz, Kevin Montoya, Erik Nelson October 29, 2013

Overview

- Project Description
- Overall Vehicle Design
- Concept Generation and Selection
 - Frame
 - Steering
 - Drivetrain
 - Ergonomics
 - Fairing
 - Innovătion
- Gantt Chart
- Conclusions
- References

Project Description

- "Design a human powered vehicle that can function as an alternative form of transportation."
- •Objectives
 - High Speed
 - Aerodynamic Drag
 - Maneuverable
- •ASME Human Powered Vehicle Challenge
- Clients Perry Wood & ASME

Overall Vehicle Design

Vehicle Configuration

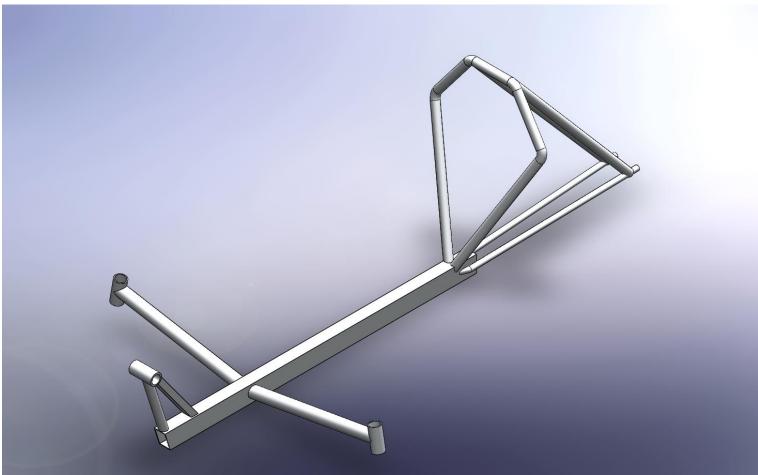
	Score Factor	Recumbent Bicycle	4 Wheeled	Delta Trike	Tadpole Trike	Airplane	Multiple Rider Land Vehicle
Low Speed stability	0.107	2	6	4	5	1	3
Stop & Go Traffic	0.214	2	6	4	5	1	3
Top Speed	0.143	6	3	4	5	1	2
Cargo Capability	0.071	3	6	4	5	1	2
Vehicle Weight/Rider	0.107	6	2	5	5	3	4
Efficiency	0.250	6	2	4	5	1	3
Maintinence	0.036	6	3	5	5	1	4
Durability	0.071	2	6	5	5	1	4

Scores	1.00	4.21	4.04	4.21	5.00	1.21	3.00

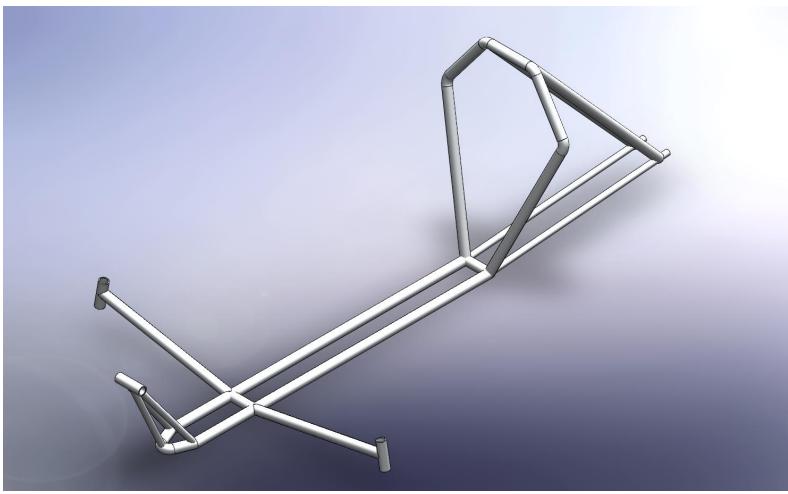
Concept Generation: Frame

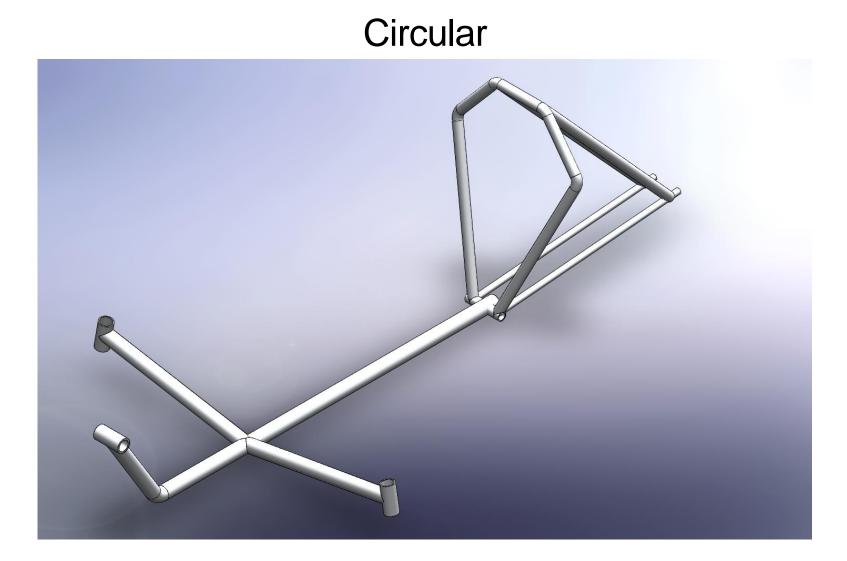
- Design Concepts
 - Rectangular
 - Double Circular
 - Circular

Rectangular



Double Circular







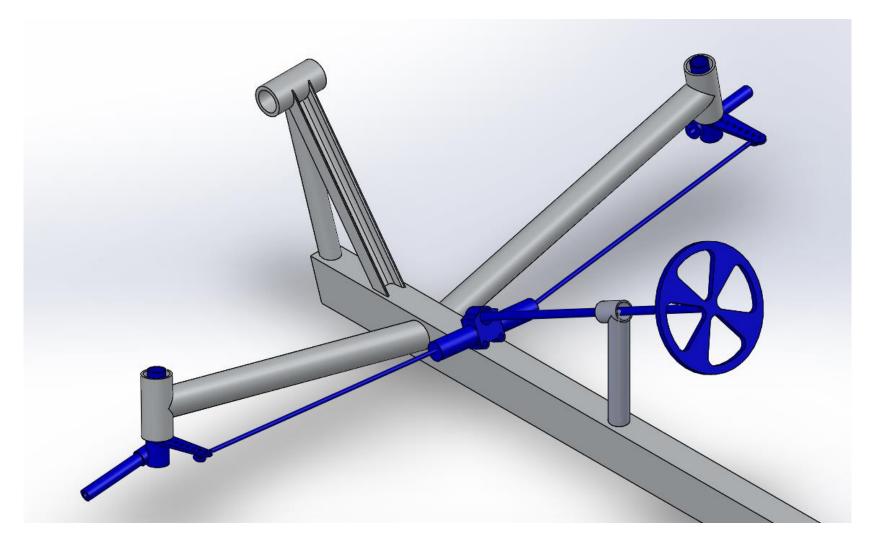
Concept Selection: Frame

	WEIGHT	EASE OF SEAT INTEGRATION	RESISTANCE TO DEFLECTION	FABRICATION TIME	
Weight	1/5	1/5	2/5	1/5	
CIRCULAR	3	1	1	2	Score
Weighted score	3/5	1/5	2/5	2/5	1.6
RECTANGULAR	2	3	3	3	
Weighted score	2/5	3/5	1 1/5	3/5	2.8
DOUBLE CIRCULAR	1	2	2	1	
Weighted score	1/5	2/5	4/5	1/5	1.6

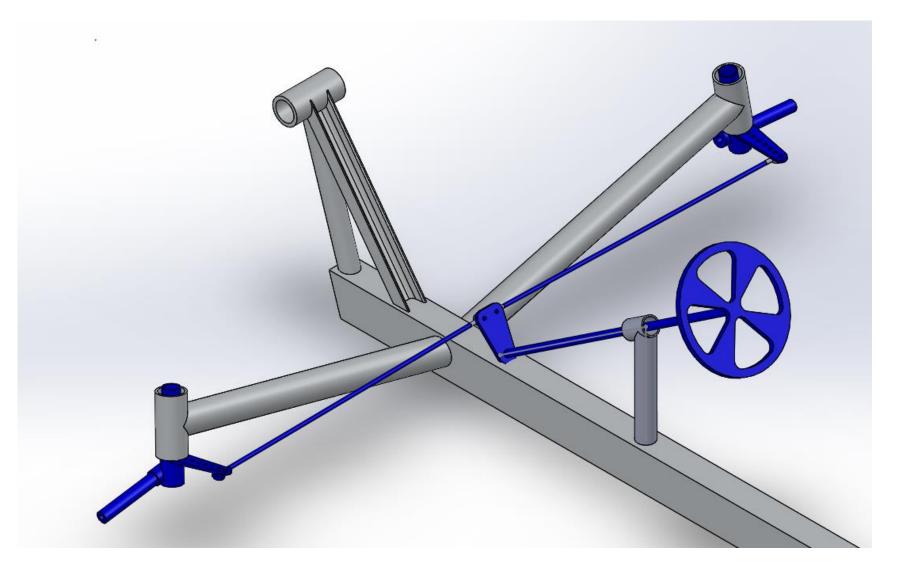
Concept Generation: Steering

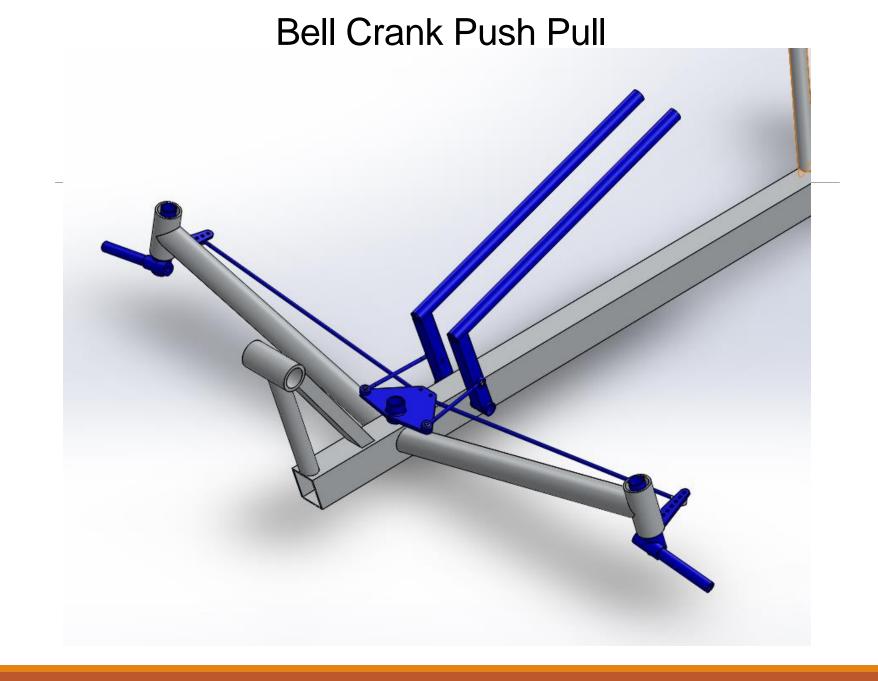
- Design Concepts
 - Rack and Pinion
 - Pittman Arm
 - Bell Crank Push Pull

Rack and Pinion



Pittman Arm





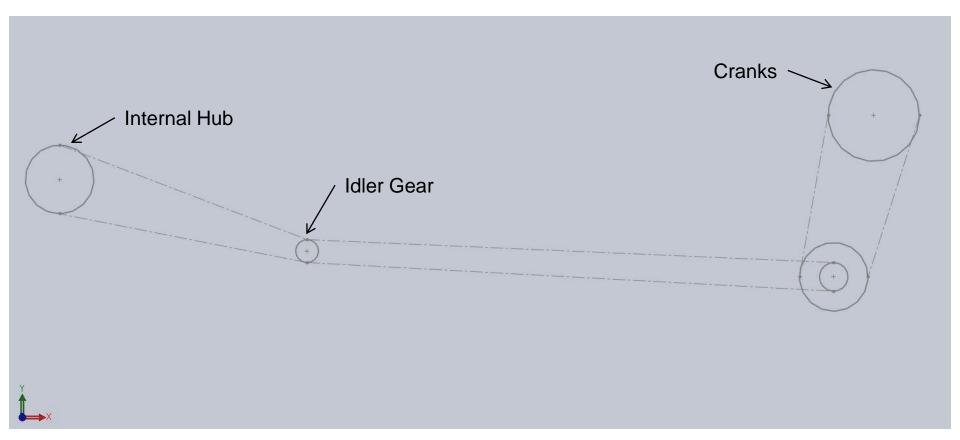
Concept Selection: Steering

	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	21/58	1/5	77/94	13/35	12/35	16/35	21/38	3.1048
PITMAN ARM	8	3	3	2	7	3	8	
WEIGHTED SCORE	1 17/38	3/10	43/70	13/35	4/15	16/35	1 2/19	4.5619
BELL CRANK PUSH PULL	6	8	7	8	3	6	3	
WEIGHTED SCORE	1 3/35	4/5	1 13/30	1 17/35	4/35	32/35	29/70	6.2476

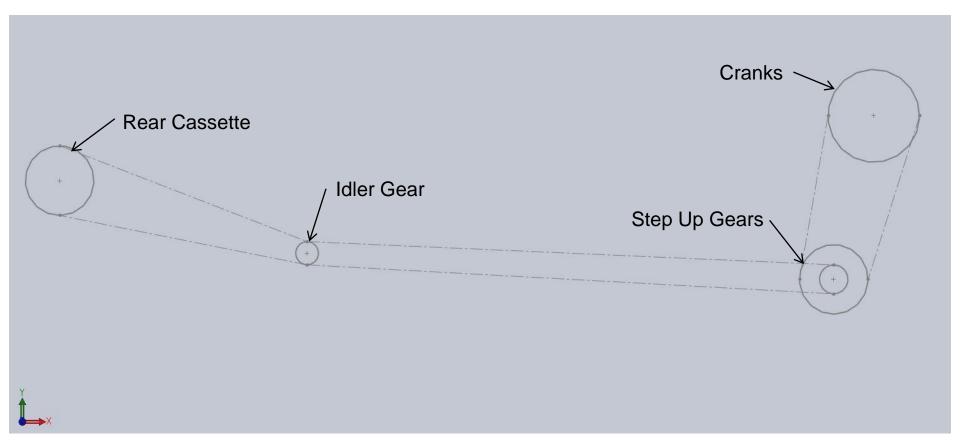
Concept Generation: Drivetrain

- Design Concepts
 - Internally geared hub
 - Step up gear
 - Step up gear with reverse

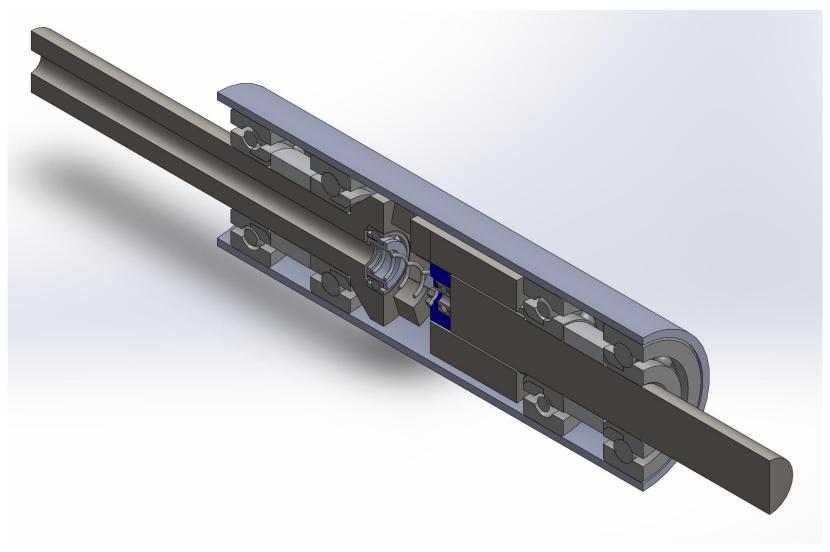
Internally Geared Hub



Step Up Gear



Reverse Gear



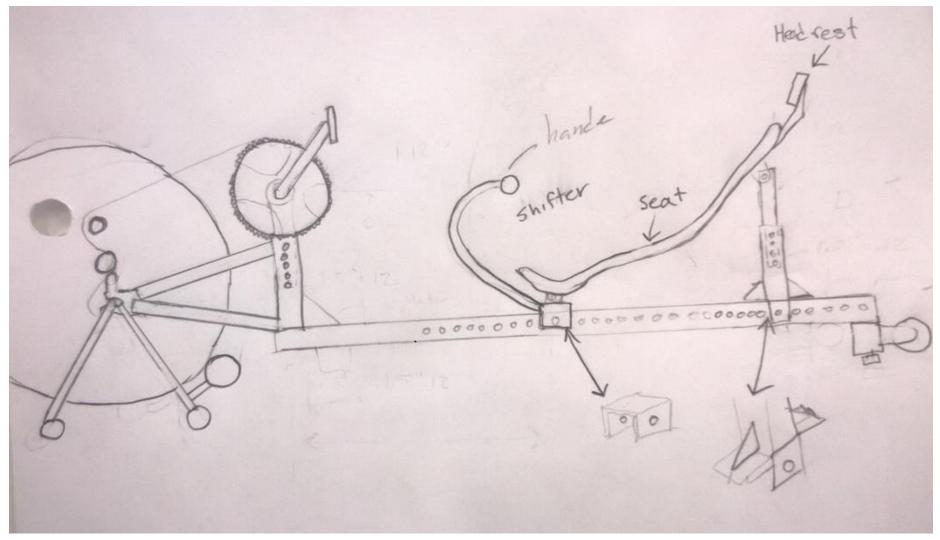
Concept Selection: Drivetrain

- Step Up Gear With Reverse Gear
 - Advantages
 - Large gear range
 - Efficiency
 - Ability to go in reverse

Ergonomics

- Rider Position
- Test using trainer
 - Angles
 - Maximum Power Output

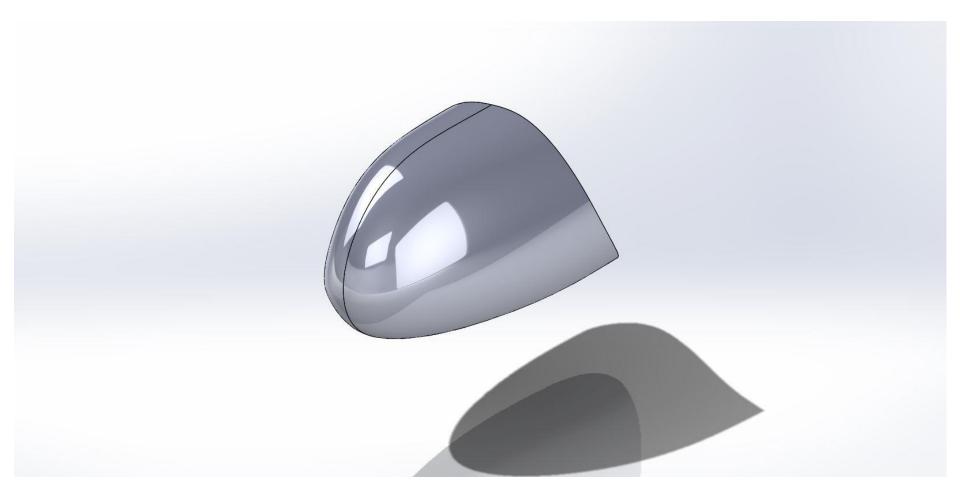
Rider Position Test Fixture



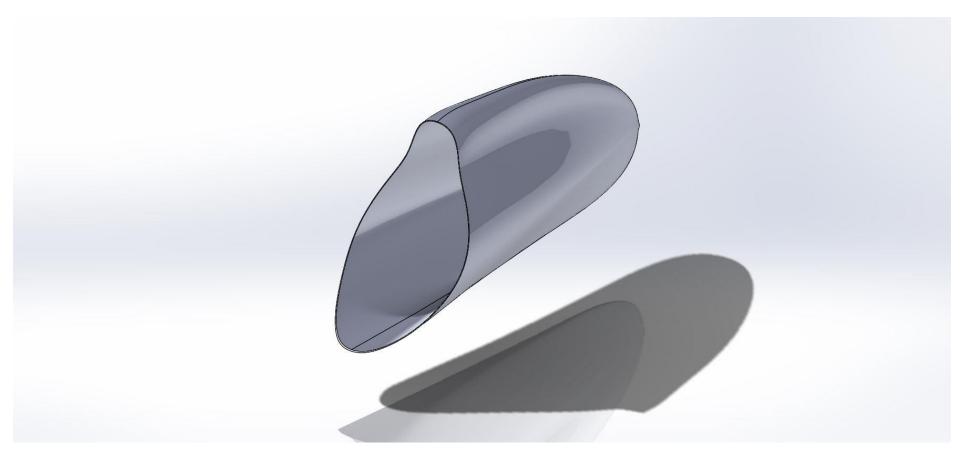
Concept Generation: Fairing

- Design Concepts
 - Front fairing
 - Tail fairing
 - Full fairing

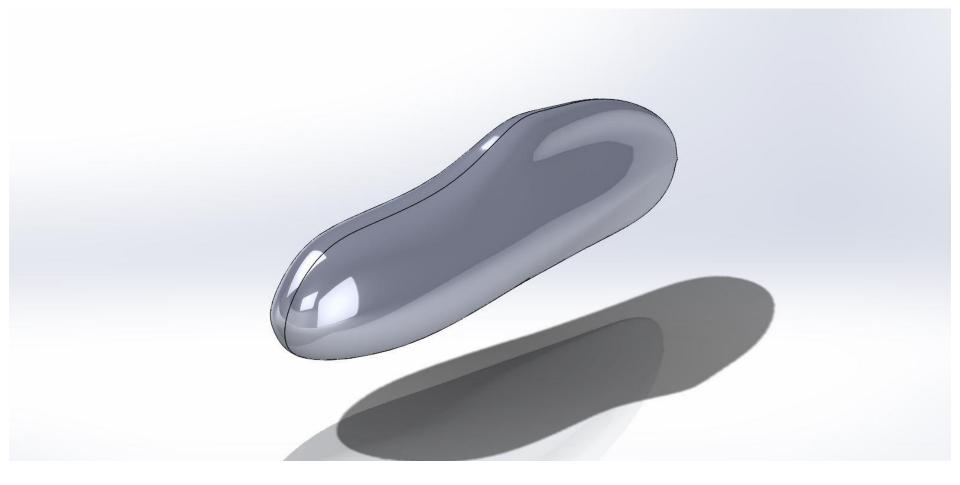
Front Fairing



Tail Fairing



Full Fairing



Concept Selection: Fairing

- Full Fairing
 - Lower C_d
 - Weather protection
 - Higher speeds
 - Rider protection
 - Security

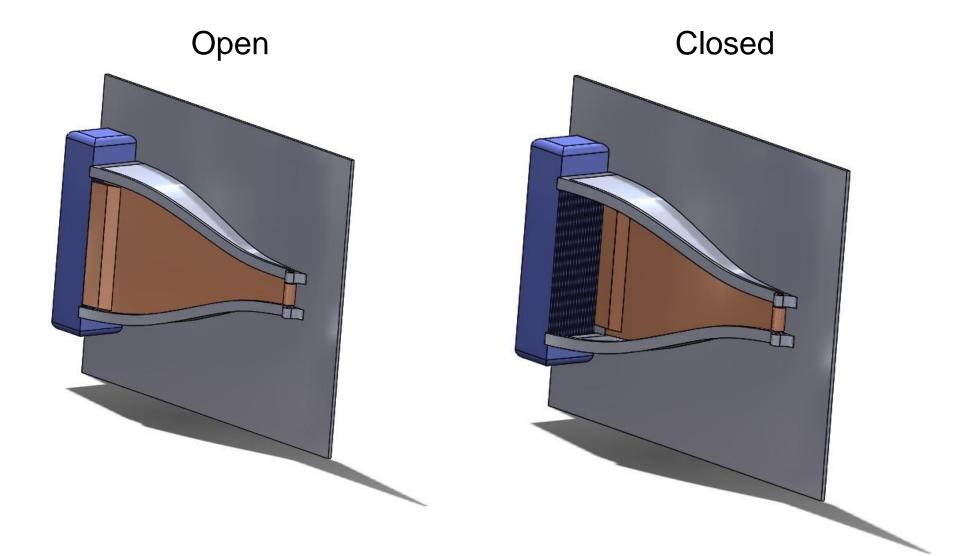
Innovation

- Weather proofing
- Safety
- Sustainable manufacturing

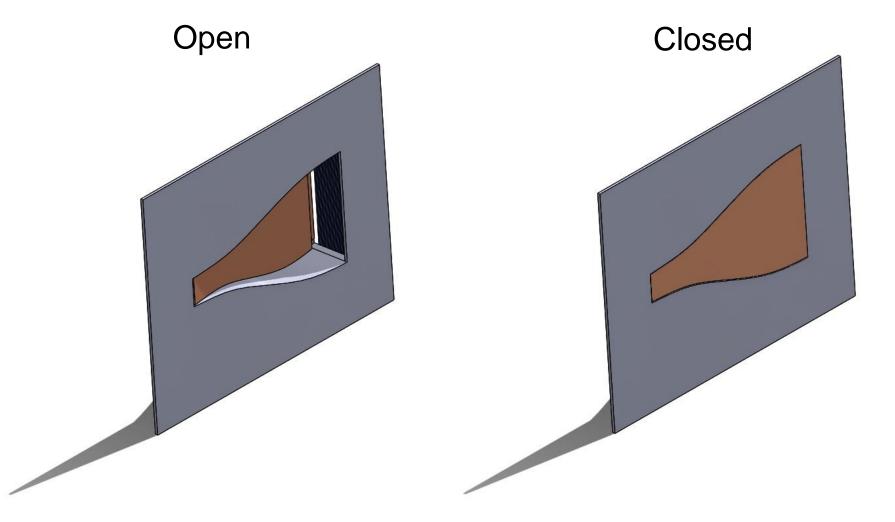
Weather Proofing

- Rider volume is sealed off from exterior
- Coated wind shield
- Anti fog ducting
- Interior climate control

Interior View



Exterior View



Safety

Fully functional light system

- Headlight, tail lights, turn signals
- Foldable side view mirrors

Sustainable Manufacturing

- Low waste production
- Recycling
 - Scrap carbon fiber
 - Plastic remolding
 - Aluminum chip plastic composite testing
 - Melted chip castings

Project Plan Gantt Chart

GARTT, Project	⇒		2013	en en				~						
Name	Begin date	End date	Week 38	Week 39 9/22/13	Week 40 9/29/13	Week 41	Week 42 10/13/13	Week 43 10/20/13	Week 44	Week 45	Week 46	Week 47 11/17/13	Week 48	Week 49
476C Requiements	10/8/13	12/2/13		1998/1999		,					and the second			
Innovation Design	9/27/13	12/5/13			-									
Innovation Concept Generation	9/27/13	10/11/13			-									
Innovation Prototyping	10/12/13	11/6/13								h				
Innovation Analysis	11/7/13	11/29/13								È.				
Material Order date	12/5/13	12/5/13	01											
Frame Design	9/27/13	12/5/13			,									
Old Frame Test Date	10/10/13	10/10/13				4	() () () () () () () () () ()							
Frame Concept Generation	9/27/13	10/17/13		1	8			0.						
Analysis of Chosen Concept	10/18/13	11/23/13												
Specific Geometry Declared	11/24/13	11/24/13												
 Material Order date 	12/5/13	12/5/13												
e Ergo Design	9/27/13	12/5/13					-							
Rider Position Study	9/27/13	11/20/13	1									h		
Rider/Pedal Position Decleration	11/21/13	11/21/13												
Concept Generation	9/27/13	11/1/13							-	h				
Analysis of chosen Concept	11/2/13	12/4/13					10			122			100	
Material Order date	12/5/13	12/5/13												•
Drivetrain Design	9/27/13	12/5/13		5	-		10							
 Cost Analysis 	9/27/13	10/11/13			-		h							
Component Declaration	10/12/13	10/12/13											لے	
Reverse Gear Concept Generation	9/27/13	10/27/13												
DriveTrain Analysis	10/28/13	12/4/13							-	-1				
Material Order date	12/5/13	12/5/13												٠
 Fairing Design 	9/27/13	12/5/13			-		201							
Concept Generation	9/27/13	10/27/13			-			14 M	h					
Analysis of concepts	10/28/13	11/13/13									- h			
Proto Printing	11/14/13	11/16/13										h		
Windtunnel Test	11/17/13	11/17/13					11					• 1		
Analysis of results	11/18/13	12/3/13										4		
Retest with final geometry	11/25/13	11/30/13											4	
Material Order date	12/5/13	12/5/13												
Steering/Braking Design	9/27/13	12/5/13		5			111						_	
Concept Generation	9/27/13	10/22/13						h						
 Analysis of concept 	10/23/13	11/29/13						-						
Clearance Confirmation	12/3/13	12/3/13					10							
Material Order date	12/5/13	12/5/13												*
Previous vehicle testing	10/2/13	10/23/13	1		-			-						

Conclusion

- •The vehicle will be fully faired with a rectangular center tube frame.
- •The steering will use a bell crank push pull system.
- •The drivetrain will contain step up gear configuration with an integrated reverse gear.
- Rider position will be evaluated through use of a test rig.
- •The vehicle will have innovative aspects in weather proofing, safety, and sustainable manufacturing.

References

- R. G. Budynas and J. K. Nisbett, *Shigley's Mechanical* Engineering Design, New York, McGraw-Hill, 2011
- T. A. Philpot, Mechanics of Materials, New Jersey, Wiley, 2011
- American Society of Mechanical Engineers, Rules for the 2014 Human Powered Vehicle Challenge (2014) [Online]. Available: https://community.asme.org/hpvc/m/default.aspx
- Zeke Smith, Advanced Composite Techniques, Napa, CA: Aeronaut Press, 2005.
- C. R. Kyle, Ph.D. and Frank Berto, "The mechanical efficiency of bicycle derailleur and hub-gear transmissions," Technical Journal of the IHPVA, vol. 52, pp. 3-11, 2001
- Philip J. Pritchard and John C. Leylegian, *Introduction to Fluid Mechanics*, Manhattan College: John Wiley & Sons, Inc., 2011.

Questions?