ASME
Human Powered Vehicle

By
Yousef Alanzi, Evan Bunce, Cody Chenoweth, Haley Flenner,
Brent Ives, and Connor Newcomer
Team 14

Concept Generation and Selection
Document

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Department of Mechanical Engineering
Northern Arizona University
Flagstaff, AZ 86011

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1. Introduction

Previously discussed was the project overview including a project overview, quality function deployment, work breakdown structure, and state of the art. Within the project overview it was discussed who the customer is: ASME working through Perry Wood. The problem definition is to create an efficient human powered vehicle that will compete in the annual competition. The design will be scored based on performance as well as from an engineering and technical standpoint. The Quality Function Deployment (QFD) compares the customers' needs to the designs for the vehicle to help give a baseline for the design process. Certain considerations here are things such as efficiency of the vehicle, completely human powered, and it must be able to compete within the competition. The Work breakdown structure (WBS) is a detailed timeline of then each phase of the project is to take place. Finally state of the art (SOTA) was examined to get a better understanding of previous technologies already being implemented. Things that were considered here are issues such as how the rider is positioned in the vehicle, how the rider inputs power, construction materials, and aerodynamics of the vehicle.

There is a need for safe, efficient, and reliable transportation for people in underdeveloped countries. The goal of this project is to reduce transportation costs by designing and building safe, efficient, and reliable human-powered vehicles. Design objectives include weight, cost, speed, acceleration, and size. Constraints include a completely new design as well as only using pure human power when operating the vehicle. Current competition vehicles are made of metal alloys or composites, or even a mixture of both, with a recumbent riding position and minimal aerodynamic effects.

2. Criteria

When deciding on functionalities to have different criteria for, Team 14 divided the human-powered vehicle up into six major groups; frame, steering, material, fairing, power input, and seating position. Within these categories are different criteria that had to be taken into account as seen in the appendix.

3. Analytical Hierarchy Matrix

The analytical hierarchy matrices were determined by taking the six initial criteria and deciding fundamentals for each one. Each criterion has its own fundamentals which aided in determining the weighted factors. Each matrix is displayed in Appendix A.

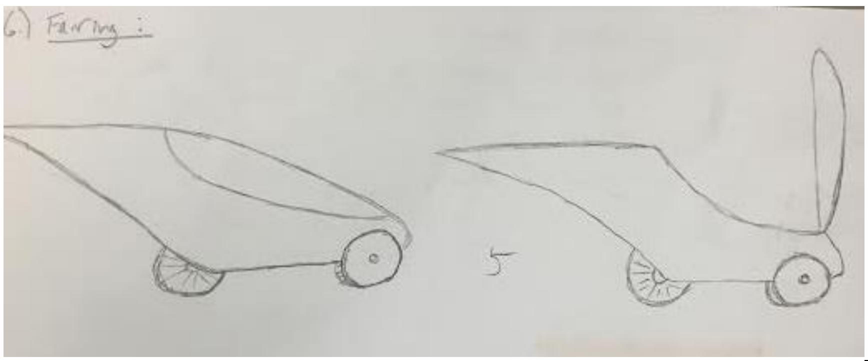
4. Relative Weights of Criteria

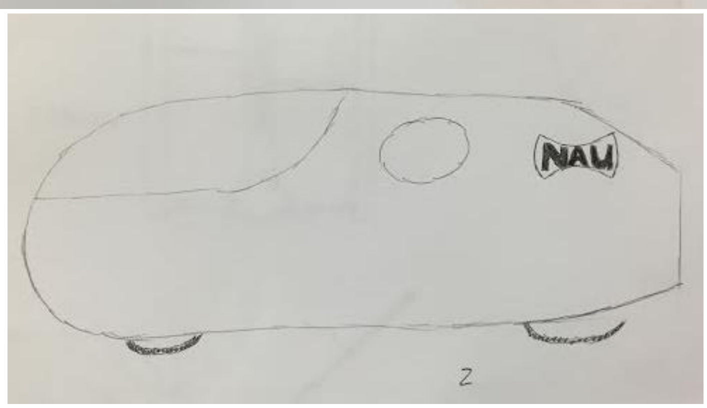
The relative weights of each criteria is shown in Appendix B and was calculated to show which fundamental was most important to the criteria. For example, framing scored highly in weight because in the idea of the frame is to reduce as much weight as possible. The highly scored fundamentals are shown in yellow.

5. Concept Generation and Decision Matrices

5.1 <u>Fairing</u>

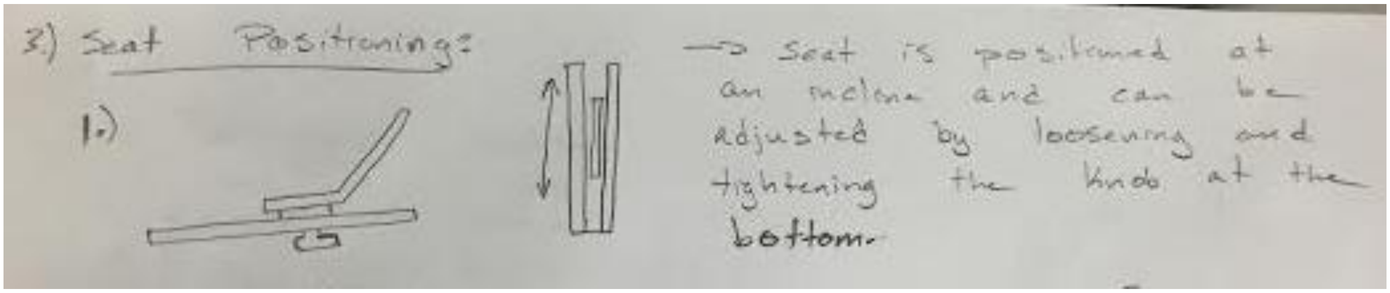
The fairing was chosen to be teardrop shaped to minimize drag as well as improve the overall aerodynamic efficiency of the vehicle. It will be constructed of carbon fiber to reduce the overall weight of the vehicle.





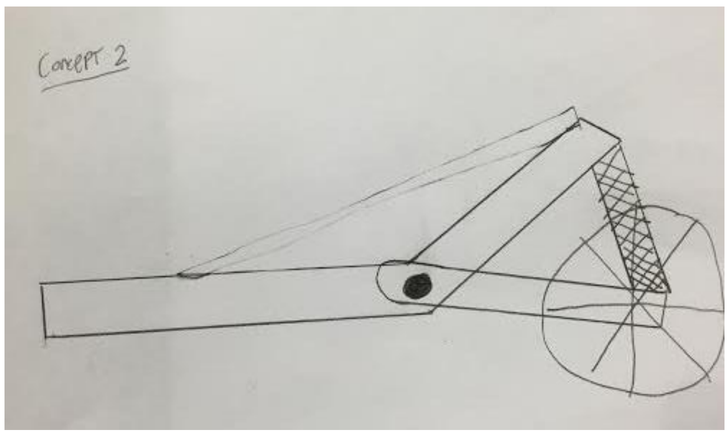
5.2 <u>Seating</u>

The seat will be a stand alone rigid body that is designed so that it contours to spine of the rider. Putting them in a natural and comfortable position that prevents the rider being slumped over and expands the riders lung capacity providing more stamina and endurance.



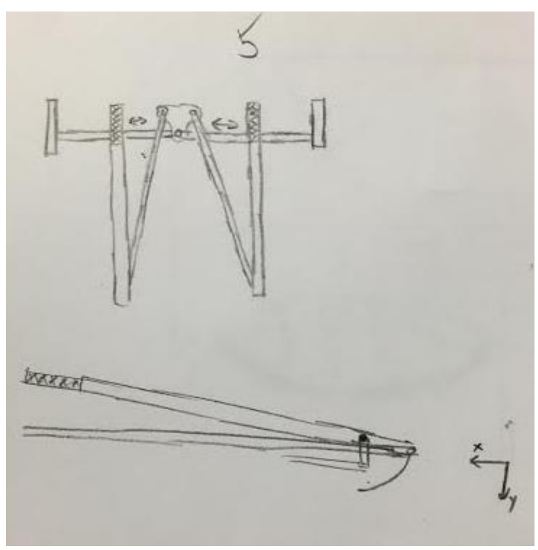
5.3 Framing

The frame will be short to try to maximize the top speed of the vehicle. The rear triangle is heavily braced to increase the frame's strength and durability. The triangular shape is there so the rider can have enough room for his head when he is riding.



5.4 Steering

The steering will be controlled by levers located in a natural position off to the side of the rider. It will take the vertical inputs from the the rider and translate those vertical motion into lateral motions that will be used to control the steering of the front wheels. A sketch of this design can be seen below.



5.5 Material

Aluminum was chosen to construct the frame due to its strength to weight ratio. It is comparable in strength to steel but at a fraction of the weight. Aluminum is also a lot easier to manufacture than carbon fiber, and is a lot stronger than wood or fiberglass.

6. Updated Project Plan

The project plan has been revised to reflect the current state of the project. The concept generation and selection phase saw the heaviest change as the original plan did not account for the deliverables required. The original plan called for concept generation in the beginning followed by evaluations and refinement of those concepts, whereas the new plan demonstrates the the majority of that four-week block was spent evaluating criteria for the decision matrices. Outside of that section, the deadlines for various tasks have been adjusted slightly, but there have been no major changes.

	Task	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10	Week 11	Week 12	Week 13
Product Specification and Project Plan	Meet with client	■												
	Problem definition	■												
	SOTA research	■	■	■	■	■	■	■	■	■				
	Establish objectives/constraints/requirements	■												
Concept Generation and Selection	Criteria selection		■											
	Analytical hierarchy matrix		■	■										
	Concept generation			■	■									
	Decision matrices					■								
	Concept selection					■								
Engineering Analysis	Concept simulation				■	■	■	■	■					
	Initial analysis/simulated testing						■	■	■					
	Design/model refinement								■	■				
	Design review									■				
Project Proposal	Model synthesis										■	■		
	Design review											■	■	
	Presentation/report finalization											■	■	■

7. Conclusions

The project is now at a stage where the real design work can begin. The team must remain conscious of the criteria that shape the project, especially strength, weight, and ease of manufacturing. The team has also chosen the general outline of the design: a teardrop-shaped fairing, foot pedals, a one-piece adjustable seat, a laterally braced, aluminum backbone frame, and twin-stick steering. It should also be noted that the project remains on schedule, although there remains much work to be done in a short amount of time.

8. References

[1] American Society of Mechanical Engineers . n.d. <https://www.asme.org/about-asme>

[2] Dieter, George. Engineering Design: A Materials and Processing Approach. New York: McGraw-Hill, 1983

8. Appendix A:

a.) Material

	Strength	Weight	Ease of Manufacturing	Aesthetics	Cost	Durability
Strength	1.000	1.000	9.000	5.000	0.143	1.000
Weight	1.000	1.000	7.000	7.000	0.250	7.000
Ease of Manufacturing	0.111	0.143	1.000	7.000	0.111	5.000
Aesthetics	0.200	0.143	0.143	1.000	0.111	3.000
Cost	6.998	4.000	9.001	9.001	1.000	7.000
Durability	1.000	0.143	0.200	0.333	0.143	1.000
Totals:	10.309	6.429	26.344	29.334	1.143	24.000

b.) Framing

	Strength	Weight	Ease of Manufacturing	Aesthetics	Cost	Durability
Strength	1.000	0.200	1.000	9.000	4.000	2.000
Weight	5.000	1.000	9.000	8.000	9.000	3.000
Ease of Manufacturing	1.000	0.111	1.000	9.000	1.000	4.000
Aesthetics	0.111	0.125	0.111	1.000	0.125	0.125
Cost	0.250	0.111	1.000	8.000	1.000	1.000
Durability	0.500	0.333	0.250	8.000	1.000	1.000
Totals:	7.861	1.881	12.361	43.000	16.125	11.125

c.) Steering

	Ease of Use	Cost	Ease of Manufacturing	Power Input
Ease of Use	1.000	8.000	4.000	4.000
Cost	0.125	1.000	0.200	0.200
Ease of Man	0.250	5.000	1.000	1.000
Power Input	0.250	5.000	1.000	1.000

Totals:	**1.625**	**19.000**	**6.200**	**6.200**

d.) Fairing

	Weight	Efficiency	Ease of Manufacturing	Cost	Durability
Weight	**1.000**	**0.250**	**4.000**	**4.000**	**4.000**
Efficiency	**4.000**	**1.000**	**7.000**	**6.000**	**3.000**
Ease of Man	**0.250**	**0.143**	**1.000**	**2.000**	**5.000**
Cost	**0.250**	**0.167**	**0.500**	**1.000**	**2.000**
Durability	**0.250**	**0.333**	**0.200**	**0.500**	**1.000**
Totals:	**5.750**	**1.893**	**12.700**	**13.500**	**15.000**

e.) Power Input

	Speed	Maneuverability	Safety	Cost
Speed	**1.000**	**7.000**	**3.000**	**7.000**
Maneuverability	**0.143**	**1.000**	**4.000**	**1.000**
Safety	**0.333**	**0.250**	**1.000**	**1.000**
Cost	**0.143**	**1.000**	**1.000**	**1.000**
Totals:	**1.619**	**9.250**	**9.000**	**10.000**

f.) Seating

	Ease of Use	Cost	Ease of Manufacturing	Comfort
Ease of Use	**1.000**	**8.000**	**4.000**	**4.000**
Cost	**0.125**	**1.000**	**0.200**	**0.200**
Ease of Man	**0.250**	**5.000**	**1.000**	**1.000**
Comfort	**0.250**	**5.000**	**1.000**	**1.000**
Totals:	**1.625**	**19.000**	**6.200**	**6.200**

Appendix B:

a.) Material

	Strength	Weight	Ease of Manufacturing	Aesthetics	Cost	Durability	Overall
Strength	0.097	0.156	0.342	0.170	0.125	0.042	0.155
Weight	0.097	0.156	0.266	0.239	0.219	0.292	0.211
Ease of Manufacturing	0.011	0.022	0.038	0.239	0.097	0.208	0.103
Aesthetics	0.019	0.022	0.005	0.034	0.097	0.125	0.051
Cost	0.679	0.622	0.342	0.307	0.875	0.292	0.519
Durability	0.097	0.022	0.008	0.011	0.125	0.042	0.051

b.) Framing

	Strength	Weight	Ease of Manufacturing	Aesthetics	Cost	Durability	Overall
Strength	0.127	0.106	0.081	0.209	0.248	0.180	0.159
Weight	0.636	0.532	0.728	0.186	0.558	0.270	0.485
Ease of Manufacturing	0.127	0.059	0.081	0.209	0.062	0.360	0.150
Aesthetics	0.014	0.066	0.009	0.023	0.008	0.011	0.022
Cost	0.032	0.059	0.081	0.186	0.062	0.090	0.085
Durability	0.064	0.177	0.020	0.186	0.062	0.090	0.100

c.)Steering

	Ease of Use	Cost	Ease of Manufacturing	Power Input	Overall
Ease of Use	0.615	0.421	0.645	0.645	0.582
Cost	0.077	0.053	0.032	0.032	0.049
Ease of Man	0.154	0.263	0.161	0.161	0.185
Power Input	0.154	0.263	0.161	0.161	0.185

d.) Fairing

	Weight	Efficiency	Ease of Manufacturing	Cost	Durability	Overall
Weight	0.174	0.132	0.315	0.296	0.267	0.237
Efficiency	0.696	0.528	0.551	0.444	0.200	0.484
Ease of Man	0.043	0.075	0.079	0.148	0.333	0.136
Cost	0.043	0.088	0.039	0.074	0.133	0.076
Durability	0.043	0.176	0.016	0.037	0.067	0.068

e.) Power Input

	Speed	Maneuverability	Safety	Cost	Overall
Speed	0.618	0.757	0.333	0.700	0.602
Maneuverability	0.088	0.108	0.444	0.100	0.185
Safety	0.206	0.027	0.111	0.100	0.111
Cost	0.088	0.108	0.111	0.100	0.102

f.) Seating

	Ease of Use	Cost	Ease of Manufacturing	Comfort	Overall
Ease of Use	0.615	0.421	0.645	0.645	0.582
Cost	0.077	0.053	0.032	0.032	0.049
Ease of Man	0.154	0.263	0.161	0.161	0.185
Comfort	0.154	0.263	0.161	0.161	0.185

Appendix C:

a.) Fairing

Fairing	Weight	Efficiency	Ease of Manufacturing	Cost	Durability	**Overall**

Concept 1	4	3	3	2	3	3.164
Concept 2	4	5	3	2	3	4.132
Concept 3	4	1	3	2	3	2.196
Concept 4	4	2	3	2	3	2.680
Concept 5	4	5	3	2	4	4.200

b.) Seating

Power Input	Speed	Ease of manufacturing	Safety	Cost	**Overall**
Concept 1	3	2	3	3	2.815
Concept 2	5	5	5	5	5.000
Concept 3	2	2	2	4	1.834

Concept 4	3	2	4	2	2.454

c.) Frame

Power Input	Speed	Ease of manufacturing	Safety	Cost	**Overall**
Concept 1	3	2	3	3	2.815
Concept 2	5	5	5	5	5.000
Concept 3	2	2	2	4	1.834
Concept 4	3	2	4	2	2.454

d.) Steering

Steering	Ease of use	Cost	Ease of manufacturing	Power input	**Overall**
Concept 1	3	1	1	5	2.905

Concept 2	5	3	3	1	3.797
Concept 3	5	4	4	1	4.031
Concept 4	5	4	4	1	4.031
Concept 5	5	4	5	1	4.216

e.) Material

Material	Strength	Weight	Ease of Manufacturing	Aesthetics	Cost	Durability	**Overall**
Steel	5	1	4	1	3	5	3.261
Aluminum	3	3	3	4	3	4	3.372
Carbon fiber	4	5	2	5	1	4	2.859
Fiberglass	2	4	2	2	3	2	3.121

Wood	1	2	5	3	3	1	2.853