Design Concept Report

To: Chris Yocom
From: Group 10, Matthew Alighchi, Eddie Martinez, Ethan Viator, Gerardo Ledezma-Barrios
Date:December 1, 2017
Subject: ENGR 100 Hovercraft Design Concept

Overview and Details:

Our design process began by brainstorming and looking for materials and checking the equations to see if they would work. Once we were getting our design approved we realized some of the materials would not work so we had to go back and calculate everything to make sure it would function properly.We then completed Checkpoint 1 and once approved we started getting all of our materials and ordering so we could have everything we needed as soon as possible. Once we bought the rental kit we soldered onto our circuit. After this we added the clips to our battery so it could connect to the batteries. Then we had a meeting to make sure everything was in place and that everyone knew what had to be done for Checkpoint 2. We then began designing our prototype so that it would meet the requirements needed for Checkpoint 3.For Checkpoint 4 we made sure the weight was balanced so that it could move forward with stabilizers and prototyped the propulsion system, and by Checkpoint five, we further did weight distribution and made sure the propulsion was fully functional. The Final Competition required further weight distribution and propulsion testing to make sure it was consistent. Our hovercraft as shown in figure 1 will be in the shape of a circle and will be 24 inches in diameter and should weigh about 4.75 pounds once we add everything to the hovercraft. For our deck we are using wood curls that is a very light substance that will work with our project. For our plenum chamber we plan on using circular styrofoam that will be placed below the deck and ail the way around. For our lifting fans we are using two axial fans that will be powered by the nickel metal hydride battery, and a ramp for the propulsion. The stabilizers are wooden circles on a fixed axle. We plan on putting two holes in the wood to place the fans in. The batteries will be used on each side to distribute the weight of the fan equally. The pressure we need is .291 in H2O to get it to hover off the ground as well as a 176.1 cfm flow rate. From table 1, this all costed 226 dollars. The propulsion system we plan on using is a weight distribution system using gears to move our motors to propel the hovercraft backwards and forwards. The motor will stay in one point to unbalance the hovercraft moving it forward and once the sensor detects a different light the fuel cell will turn on motor. Once this happens the motor will turn on and move other way causing it to go back in the other direction.Out power system will consist of one Nickel Metal hydride battery package that will be powering both of our fans. The batteries are 1.2 Volts and are combined in series and are 12 volts, they have a capacity of 2 Ah and will be able to power the fans for 61 minutes. The batteries and fans will be connected in parallel as seen in figure 2. The control system is a ramp with two golf balls behind a sliding door that is attached to a string with a motor that will tug it and release the golf balls, with a light sensor on the side. The program as seen in figure 3, initially moves forward and waits five seconds before detecting light, so by the time it reaches the end zone, the motor pulls the door and the golfballs release, thus shifting the weight backwards. Then it waits 10 seconds to detect light and when it comes back to the start zone it turns off.

Results:

Since Checkpoint 3, the lift has been fully functional. The only design change we made was from having the fans be supported by duct tape to a wooden chamber for the final competition. The propulsion, however, had a few difficulties. The original design was a door that lifted upwards, which worked for Checkpoint 4 but failed for Checkpoint 5, because the weight was too heavy and the motor wasn't strong enough for that system. Furthermore, we needed the addition of stabilizers to help it stay straight, which we settled on wooden wheels on a fixed axle held on the hovercraft using legos. Thus, for the final competition we used a door that gets pulled outward by the jerk of the string instead and it worked consistently. The design, overall, was not very good. The circular base made it much harder to balance, and it needed to hit the back wall to gain momentum. We were not able to complete the final competition, only getting a little over half of the track. If given another chance, we would've switched to a square base, put more emphasis on the weight distribution, and not rush so much for the final competition.

Global Engineering:

While in this course the hovercrafts are used for a competition, full scale, autonomous hovercrafts provide great benefits inside United States. The greatest benefit, however, is providing a much safer means for search and rescue teams. In regions that have heavy snowfall in which people can be trapped, autonomous hovercrafts provide a safe way for rescue team can search for missing people. In regions that are flooded, autonomous hovercrafts can can help bring people to mainland, and like snowfallen areas, lure rescuers to their location. Before autonomous hovercrafts, rescue teams ran at a great risk of being trapped themselves or not being able to rescue people in time, but now, autonomous hovercrafts provide an efficient and safe means to save people's lives. However, autonomous hovercrafts are not just beneficial in the United States, but to the entire world. While rescue is still vital outside the United States, a larger impact is transportation. Now, many developing countries have a much safer way of transporting people, goods, and other vital cargo. It also reinforces the transportation of ambulance retrieval in wars. The military built an autonomous hovercraft called the "Air Mule" which retrieves and delivers soldiers in need [1]. Since United States manufactured, autonomous hovercrafts have reached the rest of the world, transportation has never been better.

Hovercraft Design:

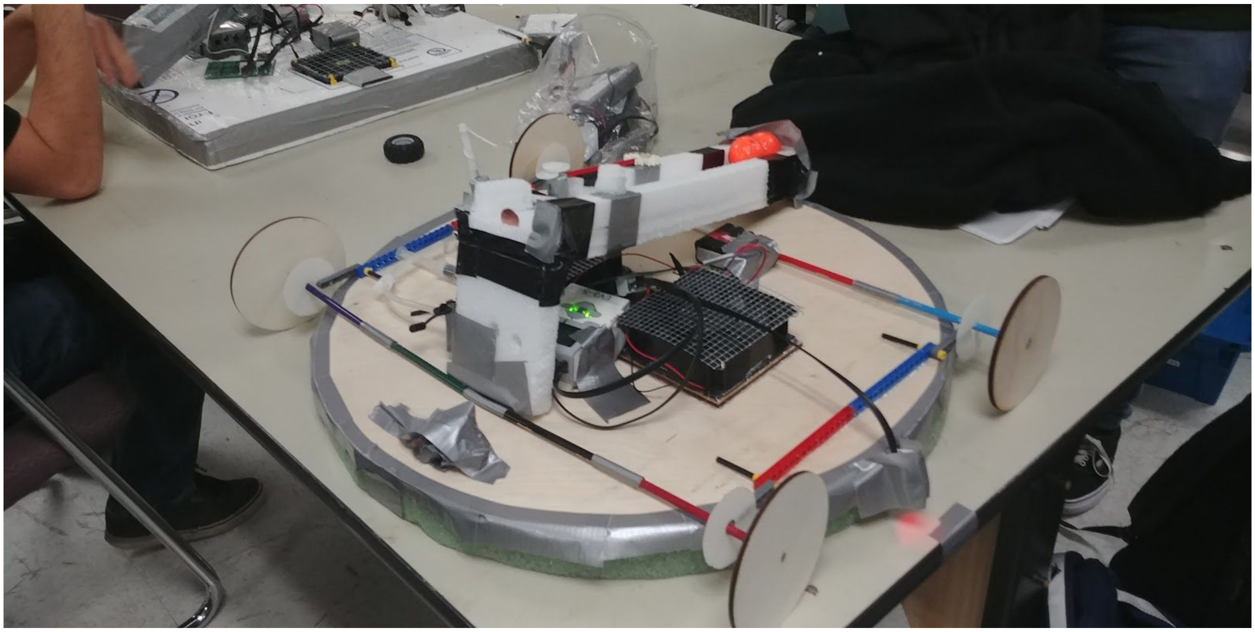

Figure 1: Hovercraft layout showing an angled view. The base and plenum chamber are circular, made out of wood and styrofoam respectively, and the fans are glued onto the base in the center. The ramp provides the propulsion by releasing golf balls, and the stabilizers are 4 wooden wheels on 2 axles held by lego pieces. The EV3, battery pack, and circuit board are under the ramp, with a weight outside for support, and a light sensor on the side.

Table 1: Hovercraft Budget for Team Athletic Snow Dune Racers.

Item	Vendor	Weight (lbs)	Cost ($)
2 PMD2412PMB1-A.(2).GN	Future Electronics	1.425	40
12v battery packs	Amazon	.6	25
Rental kit (Lego NXT, Circuit board, Distance sensor, relays)	Engr 100 Kit	1	80
Pipe Insulation	Home Depot	Not used	8
Uxcell DC Motor	Amazon	.045	5
Fuel Cell	Engr 100 Kit	.05	0
24" Wooden Circle Woodpeckers	Amazon	1.4	20
Lucksender 75 Type Plastic Crown Gear Single Double Reduction Gear Worm Gear	Amazon	.01	6
Paxcoo 4 Pieces Breadboards Kit with 120 Pieces Jumper Wires for Arduino Proto Shield Circboard Prototyping	Amazon	Not used	12
styrofoam	Walmart	.22	30
	Totals:	**4.75**	**226**

Lift Calculations:

Diameter:

$d =$ 24 in = 2 ft

Radius:

r = 12 in = 1 ft

Weight

$W =$ 4.75 lb

1. Gap Height:

$h_{GAP} =$ 4mm=.157 in

2. Deck Area:

$Eqn\ (1): \ A = \pi(r)^2 = \pi(12)^2 = 452.4\ in^2$

3. Pressure Required (psi):

$Eqn\ (2): \ P_{req} = \frac{W}{A} = \frac{4.75}{452.4} = .0105\ psi$

4. Pressure Required (inH$_2$O):

$Eqn\ (3): \ P_{req} = (\frac{W}{A})27.68 = (.00105)27.68 = .291\ inH2O$

5. Gap Area:

$Eqn\ (4): \ A_{GAP} = \ (Perimeter)(Gap\ Height) = (2\pi(12))(.157) = 11.84\ in^2$

6. Leakage Velocity:

$Eqn\ (5): \ v_L = 4.182 * 10^3\sqrt{Preq} = \ 4.182 * 10^3\sqrt{.0105} = 428.4348\frac{in}{s}$

7. Flow Rate (in^3/s):

$Eqn\ (6): \ Q_{req} = (VL)(Agap) = (393.1587)(11.84) = 5072\frac{in^3}{s}$

8. Flow Rate (CFM):

$Eqn\ (7): \ Q_{req} = \frac{Qreq}{28.8} = \frac{4654}{28.8} = 176.1\ CFM$

Battery Details:

1. Chemistry: NiMh
2. Number of cells: 20
3. Cell Voltage: 1.2 V
4. Capacity: 2000(1) = 2000 mAh
5. Configuration (describe how cells are connected in series and parallel): all cells will be in in series.

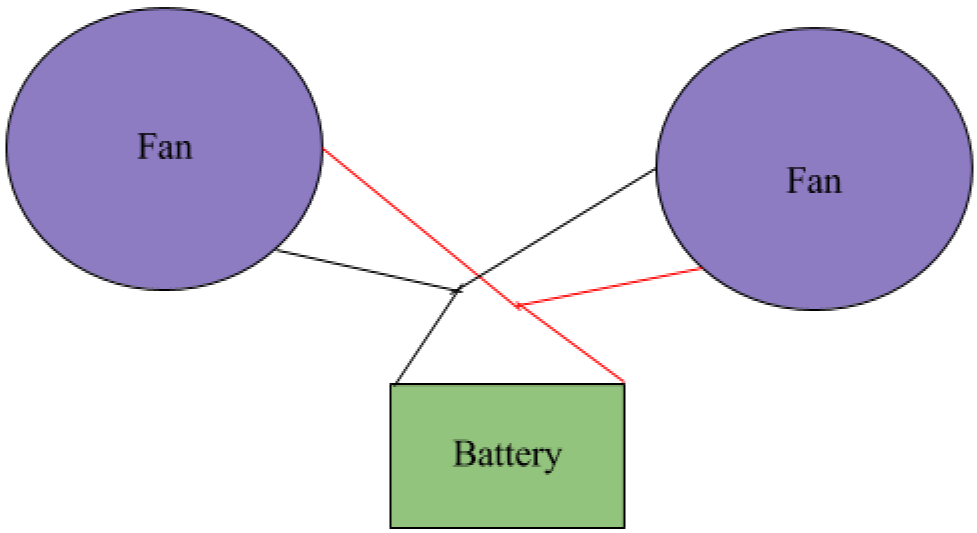

Figure 2: The battery schematic. A singular battery pack and two fans connected parallel.

Control System:

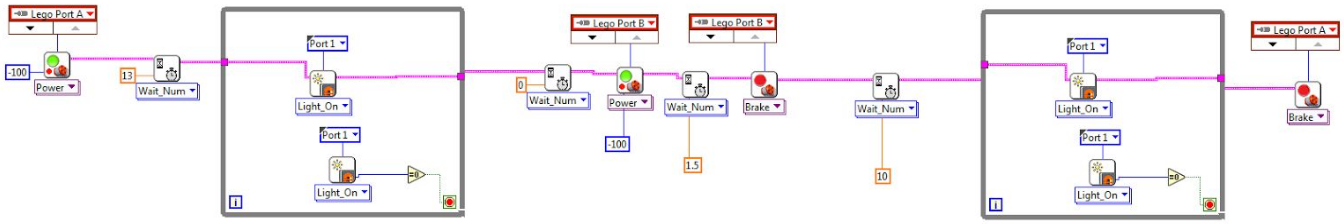

Figure 3: The Labview program of the hovercraft. It starts the lift fans then waits 13 seconds, then it waits to detect black from the floor, once it does it starts the propulsion for 1.5 seconds then turn the propulsion off, then it waits ten seconds to detect black again, which is the start zone. Once it does it turns off the fans and stops in the start zone.

References:

1. Atherton, Kelsey D. “Air Mule Hovercraft Ambulance Flies Autonomously.” Popular Science, 11 Jan. 2016, www.popsci.com/air-mule-robot-ambulance-flies-autonomously.