Preliminary Design Review Report

Submitted to:
Inst. Dr. Phil Schlosser
GTA Rahel Beyene

Created by:
Team P

Kenny Roback
Sam Stegman
Caleb Woy
Matt Heffinger

Engineering 1182
The Ohio State University
Columbus, OH
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Executive Summary

This week team P focused on creating two potential final concepts of their AEV. This was done in order to test energy usage and compare it to the distance the AEV was able to travel. The two designs used were a double pull and a push/pull system. The team was unable to create code that successfully brought the AEVs to a stop at the gate so the team opted to compare the distance each was able to travel using the same arduino code. The team did it this way because of time restraints. Constructing two AEVs took a lot of time and testing code for each of the on the track would have taken more than the allotted time so the team created their own test. The team will make sure that they have completed code for each AEV in performance test 2.

The AEV is needed to assist the rebel alliance in their war effort against the galactic empire. Currently the rebel alliance is hiding out on remote planets to keep their operations secret from the empire. AEVs will be used to transport R2D2 units, which are being constructed on one side of the planet, to another part of the planet where interceptor aircrafts are being constructed. Since the alliance is hiding out on a remote planet power is very limited. This means that along with being operationally consistent the AEVs will also have to be energy efficient. Essentially the team is trying to decrease the energy/mass ratio as much as possible without compromising its operational consistency. Due to the planet having shifting faults the track may develop variations over time so the final design will not depend on a certain track and that will be taken into account in the code by referencing the AEVs absolute position.

Both AEVs were tested using the same code and propellor type 3030 (as lab week three showed it was more efficient than 2510). In theory both AEVs should have used the same amount of power but their is .39 joules difference between the two runs. The team decided this difference was insignificant when determining which was more efficient because of how small the difference was when compared to the total energy used. The difference in distance traveled was 2.82 meters. This was a significant difference as it showed that the design double pull traveled about 50% farther than push/pull system. With this data the team determined that the double pull design is the more efficient of the two. The team will be focusing their efforts on improving the design of the double pull system and optimizing its code in the coming labs.

The error observed in energy usage between the two designs could be from the battery having less of a charge for the second run, and therefore not outputting at as high of a voltage. The error also could have been caused by a systematic error within the arduino or data recorder. There also may have been a slight error in the recorded distance as the team has experienced problems with the mark counts being off by a few, but this wouldn't cause a 2 meter difference so the team can still reliably use the data to compare the two designs.

In the future the team will be altering the double pull design so that the servo may be used to rotate both motors so that no matter the direction the AEV is traveling in the motors will be in the pull orientation. The team ultimately decided on this future design because they were able to conclude that using a double pull method was the most efficient possible propulsion.

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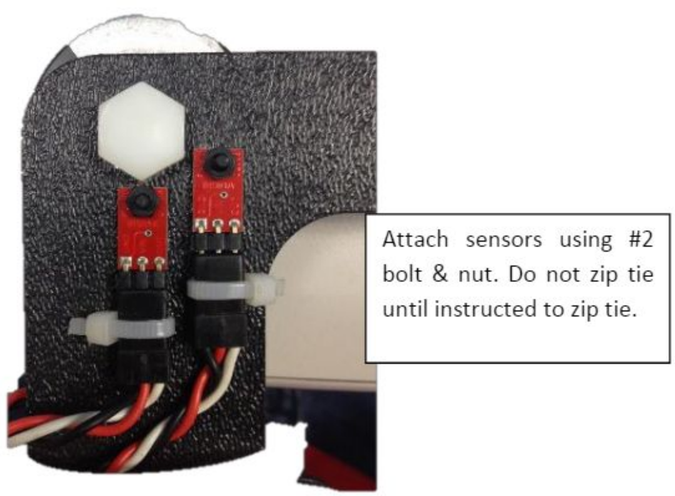
Introduction

With the objective of efficiently transporting the Galactic Empire's droids around the planet's surface efficiently, the team set out to design an AEV to meet these needs. This included their careful planning and testing of multiple designs with a consideration for cost. This report details aspects of the multiple designs considered and the results of testing two possible prototypes. It will also explain what aspects of design the team has emphasized and how they have been executed to create the best possible product.

Experimental Methodology

In Week 1, the team familiarized themselves with the AEV coding software by reviewing a brief list of functions that would be involved in coding. They then went on to write two simple programs that ran the motors for specific durations at specific speeds that sounded similar to the song March of the Empire.

In Week 2, the team installed the reflectance sensors on the base AEV as show in the picture below and ran the reflectance sensor test. This procedure involved using a provided program that reports the relative and absolute marks, and simply spinning the attached wheel to see that the sensors are recording.



In Week 3, the team tested propulsion efficiency of multiple propellor orientations using the lab's wind tunnels. The propellers tested include the 3030 push/pull and the 2510 push/pull, the numbers in their names referring to the diameter and pitch of the propellers and push/pull being their thrust orientation. A push orientation faces opposite the direction of travel where a pull orientation faces into the direction of travel. The propellers were all placed in identical wind tunnels as shown below, and their thrust per increment of increased voltage was recorded. The team then calculated the propulsion efficiency, advance ratio, and power input using the equations below and the gathered data.

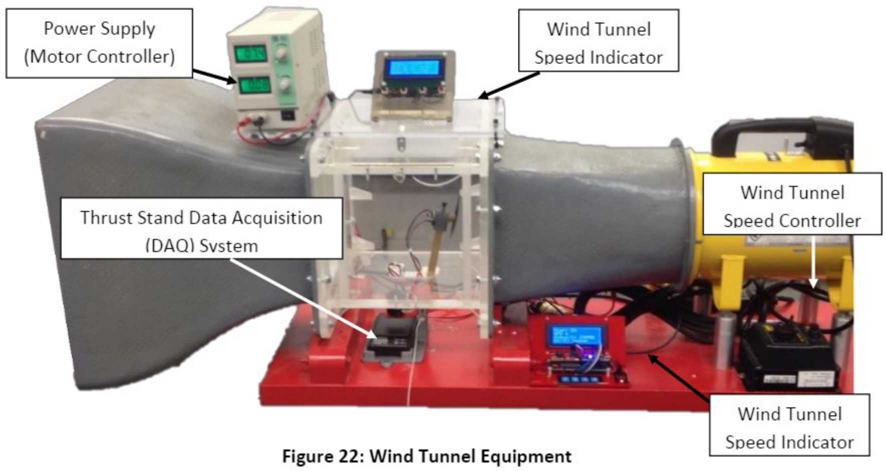


Figure 22: Wind Tunnel Equipment

$$Propulsion\ Efficiency:\ n_{sys} = (P_{out}/P_{in})\ x\ 100\%$$

$$Propeller\ Advance\ Ratio:\ J = v/((RPM/60) * D)$$

$$Power\ Input: P_{in} = V * I * (P_{\%}/100)$$

In Week 4, the team brainstormed ideas for the project and created four separate drawings of individual AEVs. The drawings included orthographic projections, dimensions, and a bill of materials. Three of such drawings are inserted below in the appendix (Figures 6, 7 & 8). The team then went on to create one final drawing combining the best aspects of each individual drawing for their AEV. This eventually lead to the creation of prototype 2.

In Week 5, the team ran comprehensive tests on the base AEV and variations of prototype 2 that included using only either the front or back motor. This included the use of the matLab data recorder data analysis tool to analyze runs down the straight track for each AEV, with the same code. Once the run was completed, graphs for power vs time and power vs distance were created, one of which is provided in figure 4 below. The graphs were then integrated using a matLab script similar to a loop the functions as a riemann sum to calculate the total energy for the run,a and the total energy used during phases of the code. The equation this script was modelled from is produced below.

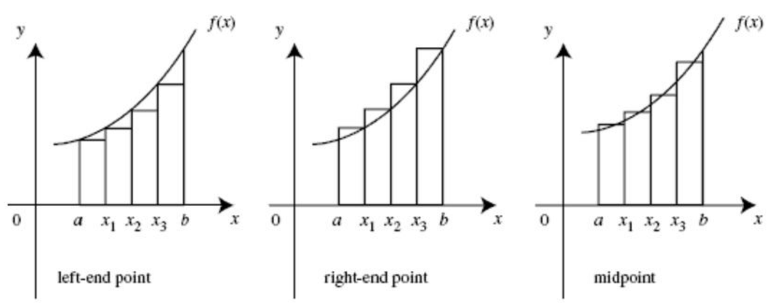


Figure 33: Rectangular Approximate Method

$$Incremental\ Energy: E_j = ((P_j + P_{j+1})/2) * (t_{j+1} - t_j)$$

$$Total\ Energy:\ E = \sum_{N=1}^{N-1} E_N$$

In Week 6, the team created a concept scoring chart, which is used to compare the different designs' strength and flaws to each other, and a screening matrix, which compares each design to the base AEV. It assigns it a score that is then weighted based on what aspects of design are most important to the team using the data from the energy analysis as a reference. Other aspects such as center of gravity, mass, blockage, maintenance, durability, and cost were also taken into account in order to give the team the best general sense of which design was best to continue testing. Examples of the final tables are found in the appendix, Tables 5 & 6.

In Week 7, the team tested using prototype 2 to ensure that the reflectance sensors were functioning properly. To do this they created a standardized code that simple started the motors at 30 percent power and ran them for 4 seconds then compared the recorded marks to a prediction calculated in an excel worksheet. Seeing prototype 2 travel somewhat of a small distance in this test the team decided to change their design to allow for both motors to fit the pull configuration, since this would allow for more force with the same power input, rather than 1 push and 1 pull. This was the genesis of prototype 1.

In Week 8, the team began their independent performance testing routine using prototype 1. This began somewhat delayed due to the team having to troubleshoot their reflectance sensors and ultimately resulted in them having to be replaced after they spontaneously stopped reporting data. Once the new sensors were installed the team began testing. Their plan included slowly accelerating the AEV and coasting as much as possible to get to the first gate of the track. This took the team multiple iterations of coding to achieve; however, the end result was an acceleration in the beginning, coasting to an absolute position and then reversing the motors and applying backward thrust for approximately 1 second. This stopped the AEV at the gate sensor over multiple tests afterwards. The team then went on to estimate the time it took from their small thrust to slow down the AEV to the time the gate would be open. This was found to be approximately 10 seconds and was accounted for in the code. The next step for the team was to get the AEV from the gate to the cargo using as little energy as possible. The team planned on using the same method as before with a slight acceleration and a coast to the cargo however they ran out of time for testing due to the previously mentioned problem with the reflectance sensors. They will be writing code during off time estimating distances and power required to make up for this lost period.

Results

In weeks one and two of lab, Team P didn't collect any data that was all that important to the design process. The lab activities in weeks one and two were focused more on familiarizing the team with the lab equipment and objectives for the future.

The figure below displays data found in Week 3 of lab that Team P used to determine which propeller design/orientation was the most efficient. Based on the results of figure 1, Team P concluded that the EP-3030 propeller in the pull orientation was the most efficient since it created more thrust while at the same amount of power as the rest of the design/orientation combos. The 3030 propeller in the push orientation also produced more thrust than the 2510 propeller in both the push and pull orientation, so the 3030 push was also left on the drawing board to experiment with. In the Appendix on page 13,

Figure 5 depicting the correlation of advance ratio to propulsion efficiency displays more data Team P used to determine which propeller to use moving forward.

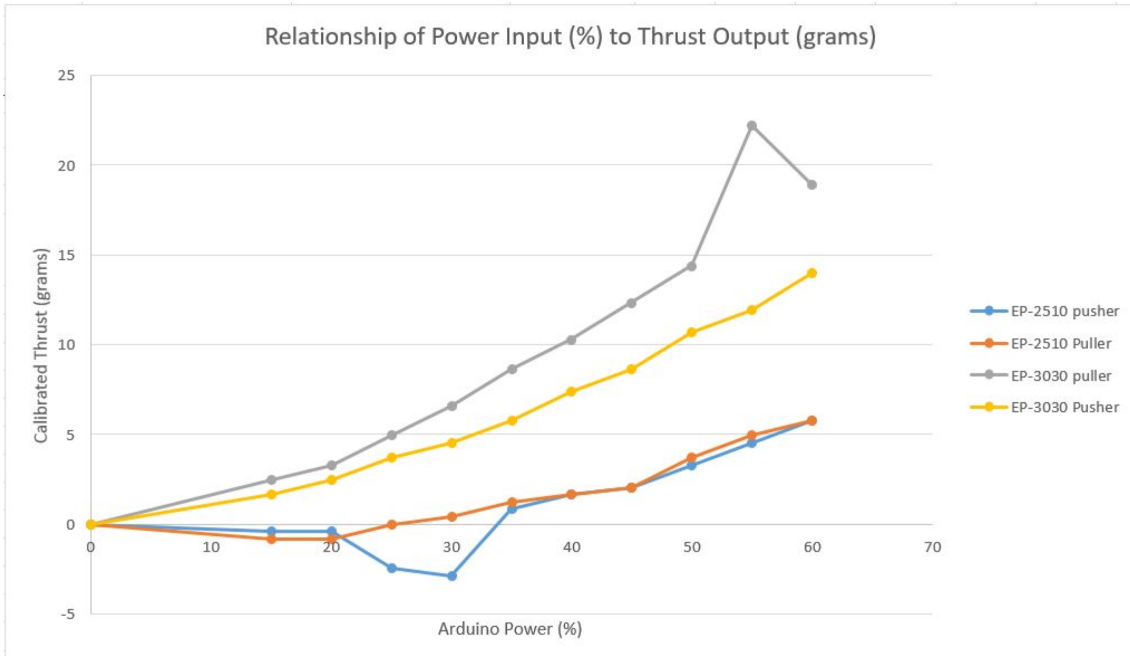


Figure 1:Power Input vs. Thrust Output

In week 4 of lab, Team P create four designs to potentially use in the final test which can be seen in Figures 6 & 7 of the Appendix below. These designs were then experimented with and changed a bit into two prototypes used in lab 8's performance test. Seen below in figures two and three are the two prototype concepts used in lab 8. Figure two below shows the double push or pull system and figure three depicts the push/pull combo system. Orthographic views with more details about each of the prototype designs can be found in the Appendix below (Figures 9 & 10).

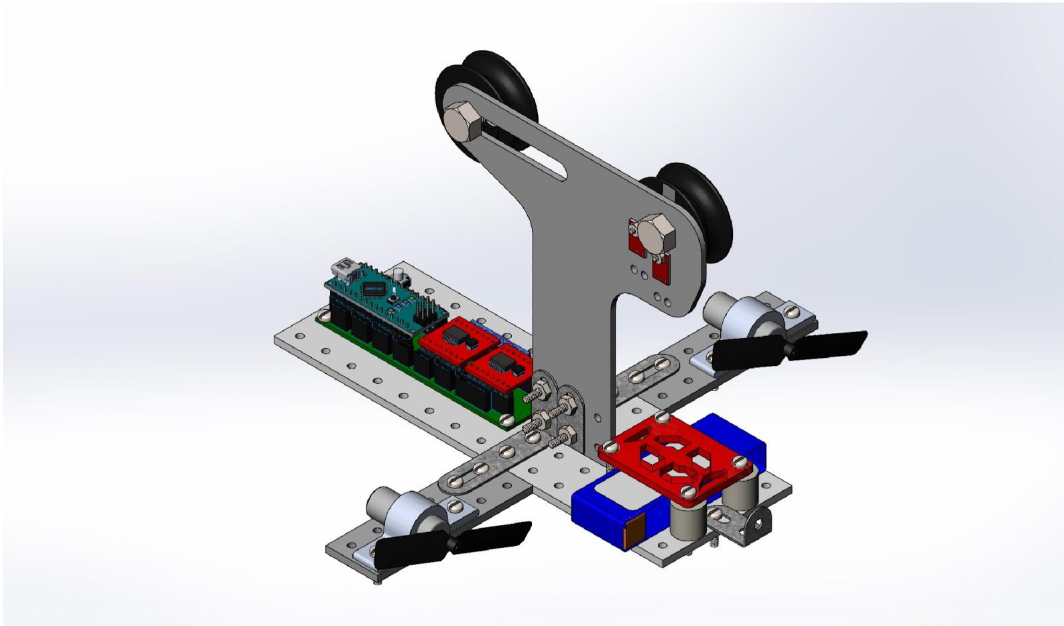


Figure 2: AEV Prototype 1

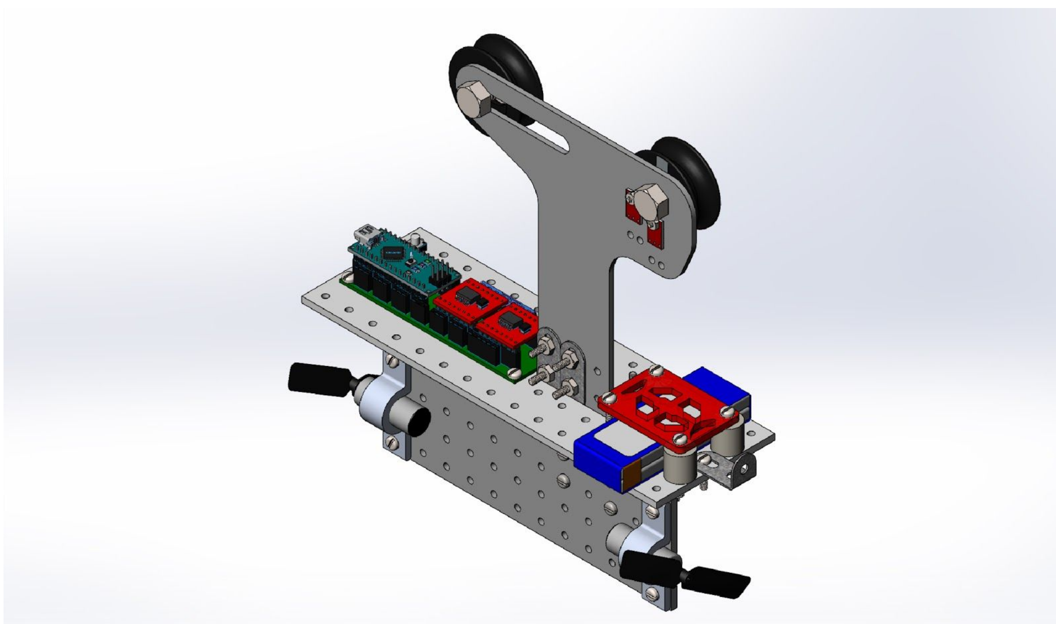


Figure 3: AEV Prototype 2

In Week 6 of lab, Team P created a screening score sheet and scoring matrix to compare different possible designs. The results from week 6 can be seen in tables 5 & 6 in the Appendix below. In lab 8 a new screening scoresheet and scoring matrix was created based on the prototypes from lab 8. They can be seen below as tables 1 and 2. The score sheet and scoring matrix in Week 6 favored the push/pull combo system compared to the other designs from then. From lab 8, the results of the new score sheet and scoring matrix below show the double push or pull system out scoring the push/pull combo system in both scenarios. On the scoresheet the double push or pull system received a net score of 6 compared to the push/pull combo system which totaled a 2. The scoring matrix showed the double push or pull scoring a 2.8 compared to the push/pull combo at a 2.1 and the reference AEV at a 2.3. Some of the improvements of Prototype 1 compared to Prototype 2 include less blockage of the motors with the double push or pull, and the design is cheaper than the push/pull combo.

Table 1: Concept screening Prototypes 1 & 2

Success criteria	Reference	Prototype 1	Prototype 2
Balanced in turns	0	+	+
Minimal blockage	0	+	-
Center-of-gravity	0	+	+
Maintinance	0	0	0
Durability	0	+	+
Cost	0	+	-
Environmental	0	+	+
Sum +'s	0	6	4
Sum 0's	7	1	1
Sum -'s	0	0	2
Net Score	0	6	2
Continue?	no	yes	no

Table 2: Concept scoring matrix Prototypes 1 & 2

		reference		Prototype 1		Prototype 2	
Success criteria	weight	rating	weighted score	rating	weighted score	rating	weighted score
balanced	5%	3	0.15	3	0.15	2	0.1
minimal blockage	15%	3	0.45	3	0.45	2	0.3
center of gravity location	10%	2	0.2	3	0.3	3	0.3
maintinance	5%	3	0.15	3	0.15	3	0.15
durability	15%	3	0.45	3	0.45	3	0.45
cost	20%	3	0.6	2	0.4	1	0.2
environmental	30%	1	0.3	3	0.9	2	0.6
total score			2.3		2.8		2.1
continue?			no		yes		no

The results of the data collected in Week 8 by the EEPROM during the Performance Test can be seen below in Figure 4. It can be observed from the figure that the double push or pull system was more efficient than the Push/Pull combo. The two designs used about the same amount of power (about 7.5 W), but the double push or pull system traveled to around 3.2 meters while the motors were running which was almost a whole meter farther than the push/pull combo system in the same amount of time.

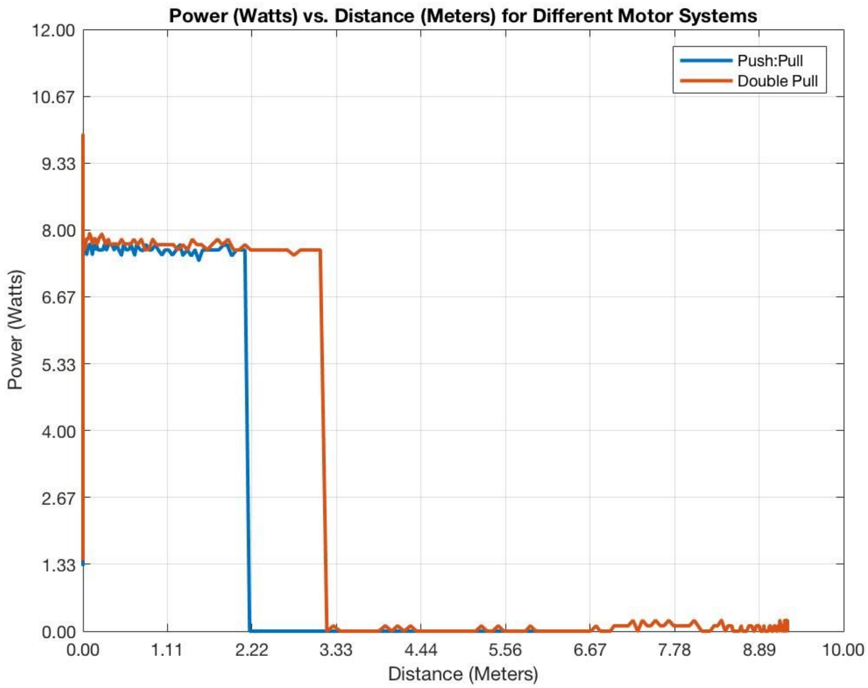


Figure 4: Power (Watts) vs. Distance (Meters) for Different Motor Systems

Tables 3 and 4 below show a breakdown of how much energy was used during each line of code for the Performance Test. It can be observed from the tables below that the double push or pull system required less energy to start the motors; however, the push/pull combo system required less overall energy. The double push or pull system did however travel a total distance of 7.97 meters which is much further than the push/pull combo system which only traveled 5.15 meters.

Table 3: Energy Breakdown Data for Double Push or Pull System

Arduino Code	Total Energy (Joules)	Distance (m)
motorspeed(4,30)	1.84	0
goFor(4)	29.38	3.29
brake(4)	0	4.68
Totals	31.22	7.97

Table 4: Energy Breakdown Data for Push/Pull Combo System

Arduino Code	Total Energy (Joules)	Distance (m)
motorspeed(4,30)	2.25	0
goFor(4)	28.58	2.25
brake(4)	0	2.9
Totals	30.83	5.15

Discussion

The choice in propeller use was a very important part of the lab as a whole, because of how much more efficient the one is over the other. It was very important that good class data was taken during the lab in Week 3, and based on the results it was very easy to see that the 3030 propeller was more efficient all around. Team P had suspected that prior to the lab, and was already using the 3030 propeller in the very first runs. Another very important observation from Week 3 was determining whether using the propellers in a push or pull orientation was more efficient. Based on the results, Team P determined the pull orientation to be more efficient, and decided to focus on testing pull systems as much as possible.

Over the course of the lab, the design of Team P's AEV has been fairly similar to the two designs that Team P initially brainstormed in lab 4. The two designs developed in lab 4 can be seen in figures 6 and 7 below in the Appendix. Figure 6 displays the double push or pull system, and figure 7 displays the push/pull combo system. Other than these features that Team P has kept constant, the overall look of the designs from lab 4 have changed. Since lab 4, the double push or pull system (Figure 6 in the Appendix) was transformed into prototype 1 by moving the motors from the back of the vehicle more towards the front in order to create a more stable balanced design. There is also not a nose piece in the front which would increase the aerodynamics of the design, because the team has not received their 3D printed parts yet. Prototype 2 did not change much from the design in figure 7 of the Appendix. The team did however determine that it would be too hard to construct using a tube as a wind tunnel, so Team P decided to just use a platform already supplied to them to create the configuration.

In week 6 of lab, Team P was able to conclude that two motors needed to be used. The score sheet and scoring matrix really helped with the decision. The designs with one motor did not receive a high enough score to really be considered anymore. After that, the push/pull combo system looked to be the favorite for the final design. In week 8 when the team decided to try a double pull for the performance test, it was a big turning point.

Based on test results from lab 8, Team P has decided to focus more on the double push or pull system. When comparing the prototypes in the new scoresheet and scoring matrix the double push or pull outscores the push/pull combo. Based on observations of the data from lab 8, Team P is happy with the way the double push or pull system performed in the pull orientation. With the same code, the double pull traveled almost three meters further. However, the double pull system did use about 0.5 more joules of energy. Although, Team P is not too worried about that. The team believes that it has to do with a systematic error within the arduino or data recorder. In theory they should have used the same amount of energy, because they were ran with the same code and each had two motors. Based on lab 8, Team P's design process was affected, because with the completion of the lab the team was able to move closer to choosing one final design. By observing how much further the vehicle was able to go in a double pull system specifically over the push/pull combo system, the team is now able to focus more of improving the double push or pull system.

The team has hopes of receiving some 3D printed parts soon so that the double push or pull prototype can be further improved. A wing could be added in order to increase aerodynamics which was a part of another design in lab 4 located in the Appendix below as Figure 8. The nose piece from the design in Figure 6 of the Appendix could also be added for increased aerodynamics. Another 3D printed part, which would allow the servo to be implemented into the code, could drastically improve the efficiency of the double push or pull system by allowing the motors to spin halfway through the run. This would turn the double push or pull system into a double pull system only. This is the team's ultimate goal. Team P hopes to receive their parts soon so that they are able to create the most efficient design possible.

Conclusion

With the completion of lab 8, Team P has decided to use the double pull system utilized in Prototype 1, because it was more efficient than the push/pull system found in Prototype 2. Prototype 1 scored higher in both the Concept Screening Matrix in Table 1 and Concept Scoring Matrix in Table 2 than Prototype 2. The team decided that the 0.39 additional Joules consumed during the test run of Prototype 1 over Prototype 2 was negligible compared to the 2.82 meter difference in performance, and that the difference in Joules was possibly caused by testing error. Using the data in Table 1, it can be seen that the double pull system consumes 3.92 J for every meter traveled while the alternating push/pull system consumes 5.99 J per meter traveled while running the same Arduino code, a difference of 2.07 J per meter. Because the double pull system is more efficient, the group plans to implement it into its final design and have submitted parts to be 3D printed to the staff. Until the 3D printed parts are available, Team P will use a makeshift design made of available materials that embodies similar design principles. The makeshift design utilizes a double pull system with an added servo that can rotate the motors so that the AEV can be slowed down and reversed while still maintaining the more efficient pull orientation.

Appendix

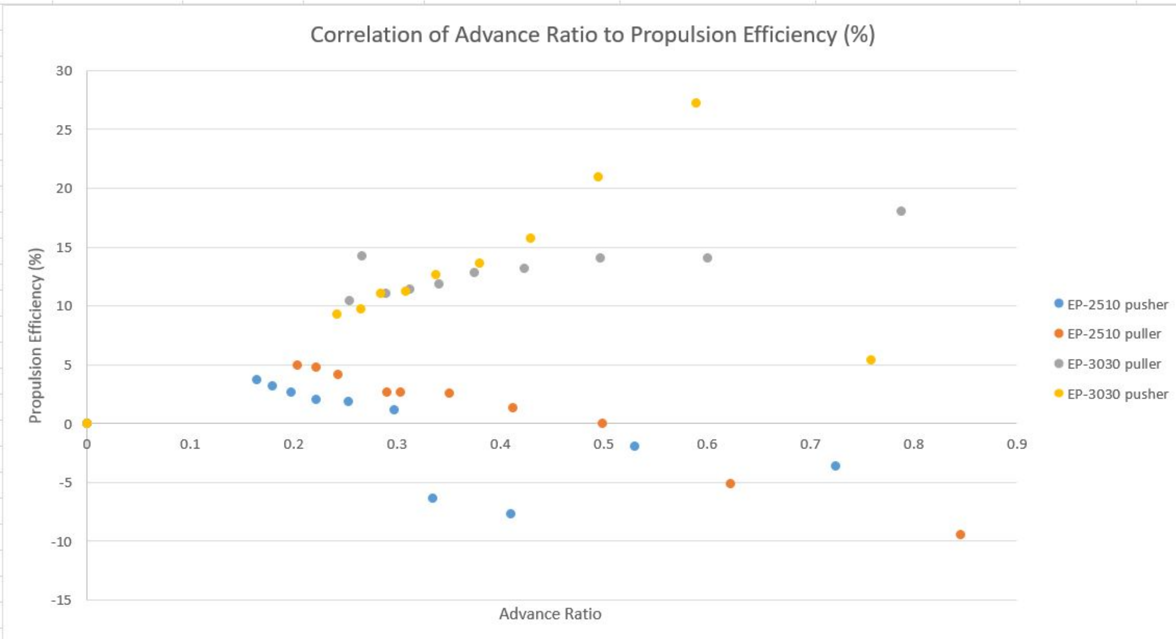


Figure 5:Correlation of Advance Ratio to Propulsion Efficiency

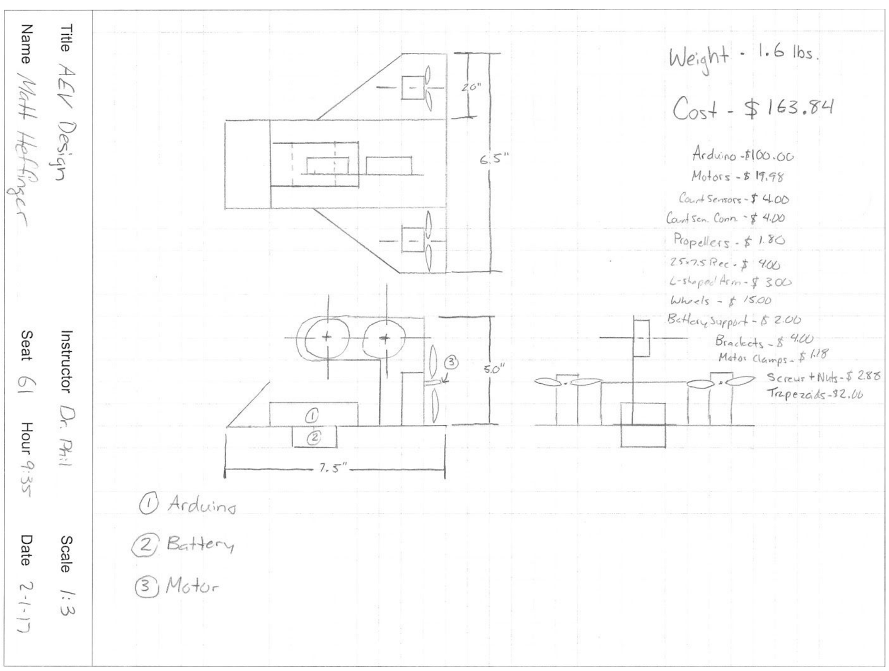


Figure 6: Double Push or Pull System

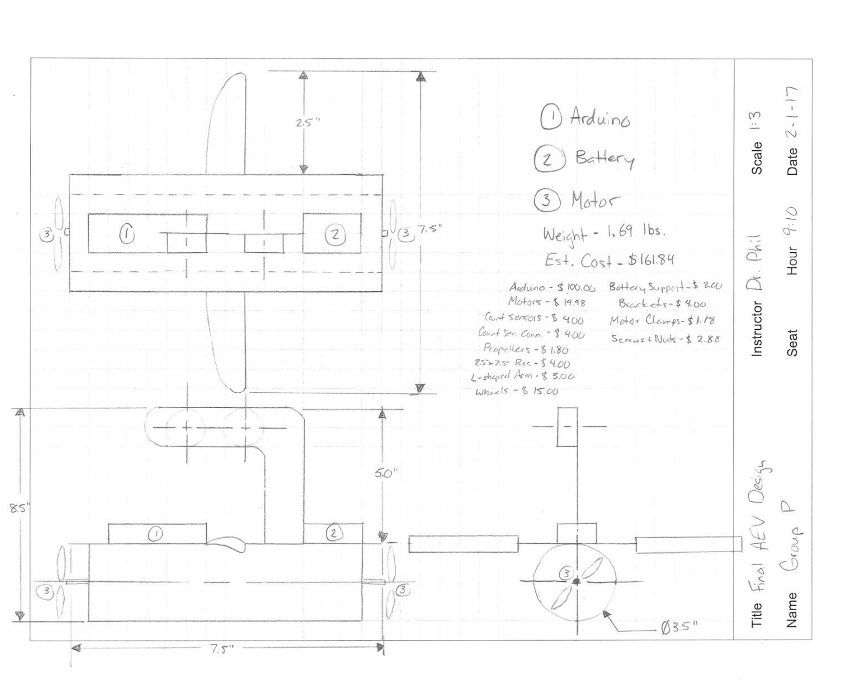


Figure 7: Push/Pull Combo System

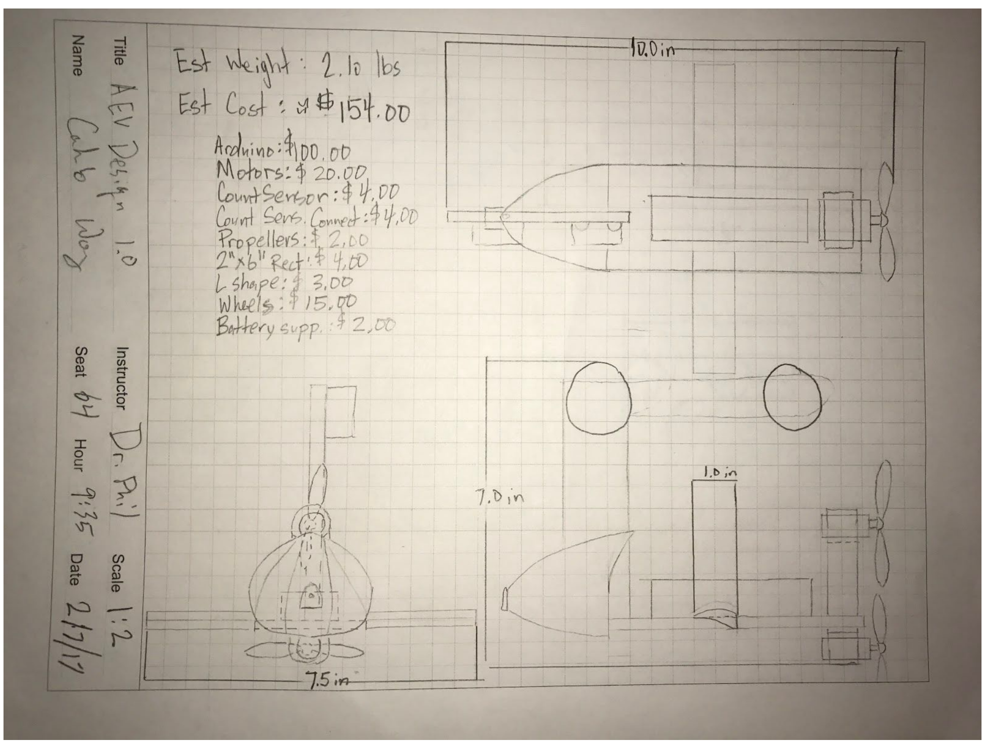
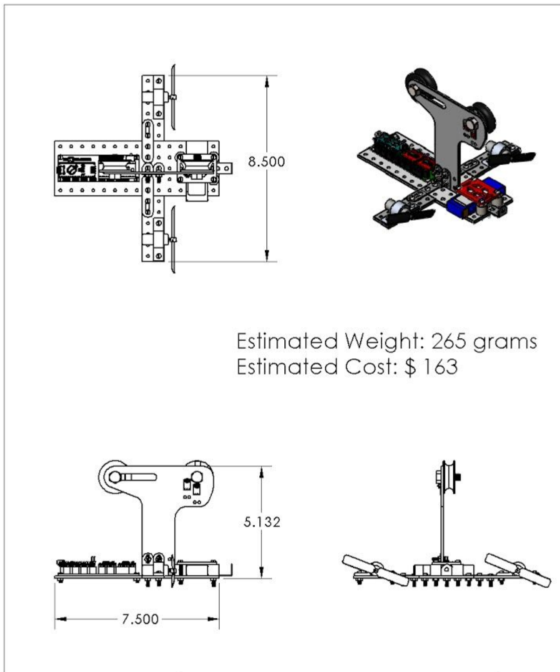


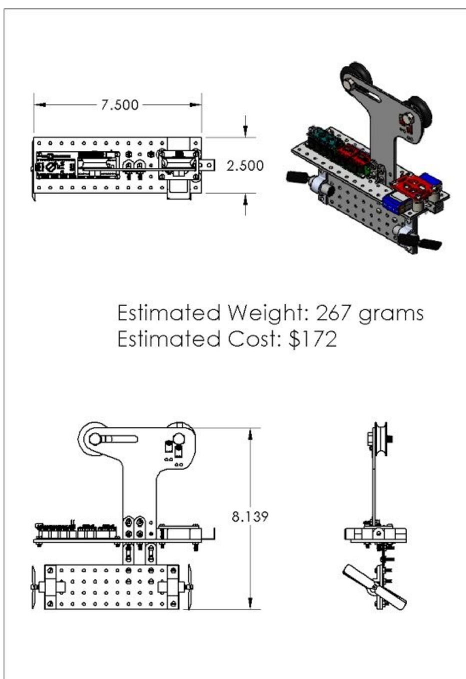
Figure 8:Design with Potential Wing



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	5-16 - 18 Hex Nut		1
2	AEV Arduino Assembly		1
3	Tiny Rectangle		2
4	flat bracket		2
5	Motor Mount Clip Aluminum		2
6	AEV Motor		2
7	Prop 3inch		2
8	Battery Spacer		3
9	Battery Pack Clamp Plate Narrow		1
10	90-deg bracket		3
11	Support Arm 1 2 Sensor Holes V2		1
12	Housing w-reflective tape		1
13	Housing		1
14	hex bolt_ai		2
15	Rotation Sensor Board		2
16	pan slot head_ai		4
17	pan slot head_ai		19
18	flat head 100 screw_ai		2
19	pan slot head_ai		4
20	machine screw nut hex_ai		27
21	machine screw nut hex_ai		2
22	Battery Sleeve		1
23	Kapton Tape		1
24	machine screw nut hex_ai		2

The Ohio State University First Year Engineering | Dwg. Title: AEV Design 1 | Scale: 1:4 | Inst.: Dr. Phil | Units: inch | Dwg. No.: 1
Drawn By: Team P | Hour: 9:10 | Seat: P | Date: 3/27/17

Figure 9: AEV Prototype 1 Orthographic Views/Details



BOM Table			
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
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5	Prop 3inch		2
6	Battery Spacer		3
7	Battery Pack Clamp Plate Narrow		1
8	90-deg bracket		5
9	Support Arm 1 2 Sensor Holes V2		1
10	Housing w-reflective tape		1
11	Housing		1
12	hex bolt_ai		2
13	Rotation Sensor Board		2
14	pan slot head_ai		4
15	pan slot head_ai		11
16	flat head 100 screw_ai		2
17	pan slot head_ai		4
18	machine screw nut hex_ai		15
19	machine screw nut hex_ai		2
20	Battery Sleeve		1
21	Battery		2
22	Kapton Tape		1
23	machine screw nut hex_ai		2
24	Medium Rectangle		1
25	flat bracket		2
26	SL-PHMS 0.112-40x0.5x0.5-S		10
27	MSHXNUT 0.112-40-S-S		14

The Ohio State University First Year Engineering | Dwg. Title: AEV Design 2 | Scale: 1:4 | Inst.: Dr. Phil | Units: inch | Dwg. No.: 2
Drawn By: Team P | Hour: 9:10 | Seat: P | Date: 3/27/17

Figure 10: AEV Prototype 2 Orthographic Views/Details

Table 5: Concept Screening Scoresheet Week 6

Success criteria	Reference	Design A (push/pull)	Design B (push-one moter)	Design C (pull-one moter)
Balanced in turns	0	+	+	+
Minimal blockage	0	+	+	+
Center-of-gravity	0	+	+	-
Maintinance	0	0	0	0
Durability	0	+	+	+
Cost	0	-	-	-
Environmental	0	+	-	+
Sum +'s	0	5	4	4
Sum 0's	7	1	1	1
Sum -'s	0	1	2	2
Net Score	0	4	2	2
Continue?	no	yes	no	no

Table 6: Concept Scoring Matrix Week 6

		reference		design A (push/pull)		design B (push-one)		design C (pull-one)	
Success criteria	weight	rating	weighted score	rating	weighted score	rating	weighted score	rating	weighted score
balanced	5%	2	0.1	4	0.2	3	0.15	3	0.15
minimal blockage	15%	4	0.6	3	0.45	4	0.6	3	0.45
center of gravity location	10%	2	0.2	4	0.4	3	0.3	2	0.2
maintinance	5%	4	0.2	4	0.2	4	0.2	4	0.2
durability	15%	3	0.45	4	0.6	4	0.6	4	0.6
cost	20%	4	0.8	2	0.4	3	0.6	3	0.6
environmental	30%	1	0.3	4	1.2	3	0.9	3	0.9
total score			2.65		3.45		3.35		3.1
continue?			no		yes		no		no

Table 7: Project Schedule

Task	Start Date	Finish Date	Team Members	Est. Hrs
Lab 1	1/18/17	1/18/17	All	1 hr
Progress report Week 2	1/22/17	1/22/17	All	3 hrs
Lab 2	1/25/17	1/25/17	All	1 hr
Progress report Week 3	1/27/17	1/29/17	All	3 hrs
Lab 3	2/1/17	2/1/17	All	1 hr

Revise Progress Week 2	2/4/17	2/4/17	Caleb	1 hr
Update Portfolio	2/5/17	2/5/17	All	2 hrs
Designed First Protoype	2/5/17	2/5/17	All	1 hr
Progress Report Week 4	2/5/17	2/7/17	All	3 hrs
Lab 4	2/8/17	2/8/17	All	1 hr
EEPROM Data Analyzed	2/12/17	2/12/17	All	1 hr
Progress Report Week 5	2/12/17	2/14/17	All	3 hrs
Lab 5	2/15/17	2/15/17	All	1 hr
Progress Report Week 6	2/19/17	2/21/17	All	3 hrs
Update Portfolio	2/19/17	2/19/17	Matt	.5 hr
Draw Wings to be 3D Printed	2/19/17	2/19/17	Kenny	1 hr
Lab 6	2/22/17	2/22/17	All	1 hr
Draw Motor Supp. to be 3D Printed	2/22/17	2/23/17	Caleb	2 hrs
Draw Nose Piece to be 3D Printed	2/22/17	2/22/17	Matt	1 hr
Draw Servo Supp. to be 3D printed	2/22/17	2/22/17	Sam	1 hr
Lab 7	3/1/17	3/1/17	All	1 hr
Lab 7 Exec. Summary	3/3/17	3/7/17	All	3 hrs.
Lab 8 Report	3/8/17	3/9/17	All	4 hrs
Lab 8a	3/10/17	3/10/17	All	1 hr
Lab 8b	3/20/17	3/20/17	All	1 hr

Update Portfolio	3/20/17	3/20/17	Sam	.5 hr
PDR	3/21/17	3/26/17	All	6 hrs
Lab 8c	3/22/17	3/22/17	All	1 hr
Lab 9a	3/24/17	3/24/17	All	1 hr
Lab 9b	3/27/17	3/27/17	All	1 hr

Arduino Code

Week 1

```
//1. Accelerate motor one from start to 15% power in 2.5 seconds.
celerate(1,0,15,2.5);
//2. Run motor one at a constant speed (15% power) for 1 second.
goFor(1);
//3. Brake motor one.
brake(1);
//4. Accelerate motor two from start to 27% power in 4 seconds.
celerate(2,0,17,4);
//5. Run motor two at a constant speed (27% power) for 2.7 seconds.
goFor(2.7);
//6. Decelerate motor two to 15% power in 1 second.
celerate(2,27,15,1);
//7. Brake motor two.
brake(2);
//8. Reverse the direction of only motor 2.
reverse(2);
//9. Accelerate all motors from start to 31% power in 2 seconds.
celerate(4,0,31,2);
//10. Run all motors at a constant speed of 35% power for 1 second.
motorSpeed(4,35);
goFor(1);
//11. Brake motor two but keep motor one running at a constant speed (35% power) for 3 seconds.
brake(2);
motorSpeed(1,35);
goFor(3);
//12. Brake all motors for 1 second.
brake(4);
goFor(1);
//13. Reverse the direction of motor one.
reverse(1);
//14. Accelerate motor one from start to 19% power over 2 seconds.
celerate(1,0,19,2);
//15. Run motor two at 35% power while simultaneously running motor one at 19% power for 2 seconds.
motorSpeed(2,35);
motorSpeed(1,19);
goFor(2);
//16. Run both motors at a constant speed (19% power) for 2 seconds.
motorSpeed(4,19);
goFor(2);
//17. Decelerate both motors to 0% power in 3 seconds.
celerate(4,19,0,3);
//Brake all motors.
brake(4);
```

Week 2

```
//Runs reflectance sensor test
reflectanceSensorTest();
```

Week 3 and Week 4

```
//1. Run all motors at a constant speed of 25% power for 2 seconds.
reverse(4);
motorSpeed(4,25);
goFor(2);
//2. Run all motors at a constant speed of 20% and using the goToAbsolutePosition function
//   travel a total distance of 16 feet (from the starting point).
motorSpeed(4,20);
goToAbsolutePosition(394);
//3. Reverse motors.
reverse(4);
//4. Run all motors at a constant speed of 30% power for 1.5 second.
motorSpeed(4,30);
goFor(1.5);
//5. Brake all motors.
brake(4);
```

Week 5

```
// Program between here--------------------------------------------------------------------

//1. Run all motors at a constant speed of 30% power for 2 seconds.
reverse(4);
motorSpeed(4,30);
goFor(2);
//2. Run all motors at a constant speed of 30% and using the goToAbsolutePosition function
//   travel a total distance of 16 feet (from the starting point).
motorSpeed(4,30);
goToAbsolutePosition(394);
//3. Reverse motors.
reverse(4);
//4. Run all motors at a constant speed of 30% power for 1.5 second.
motorSpeed(4,30);
goFor(1.5);
//5. Brake all motors.
brake(4);
```

Week 6

```
//1. Accelerate back motor from start to 25% in 3 seconds.
reverse(2);
celerate(4, 0, 25, 3);
//2. 2. Run back motor at a constant speed (25% power) for 1 second.
goFor(1);
//3. Run back motor at 20% power for 2 seconds.
motorSpeed(4,20);
goFor(2);
brake(4);
goFor(.5);
reverse(4);
//4.Run all motors at a constant speed (25% power) for 2 second.
motorSpeed(4,25);
goFor(2);
//5. Brake all motors.
brake(4);
```

Week 7

```
reverse(4);
celerate(4, 0, 25, 7);
goFor(1);
brake(4);
```

Week 8

```
//Reverse motors to correct position
reverse(4);
//Run all motors at 30% power for 4 seconds
motorSpeed(4,30);
goFor(4);
//Cut power to motors and continue to record data for 10 seconds
motorSpeed(4,0);
goFor(10);
```