Critical Design Review

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Executive Summary

Testing of the Advanced Energy Vehicle's (AEV) motor and propeller configurations were done in order for Group L to grasp and fully understand how both components are important for final testing. Factors such as energy and time are crucial to total cost. After testing, Group L improved and enhanced the prototype AEV design in order to save the most money. Advanced research and development was conducted for being able to create a transit service from Linden to Polaris and Easton in the near future.

According to testing, the push propeller configuration resulted in more constant power, roughly 8 watts, being produced by the motors on the AEV compared to the pull configuration, 7 watts. Although the push configuration used more wattage, the test data showed less energy used at 16.67 joules. The pull configuration used 20.80 joules. The pull configuration using more power is directly correlated to the energy equation [Appendix A]. With the pull motors taking a long time to travel 0.6 meters, the total time elapsed was 0.8 seconds longer than the push motor. Since the power going to the motors was almost constant, the energy graphs appear to be linear.

The results of the small and large propeller were similar to the push/pull test. Power consumption was very consistent over each test. The large propeller was found to consume more power -- 15 watts versus 11 watts -- but consume less energy overall due to the smaller time taken to complete the trial. The large propeller consumed only 17 Joules, while the small propeller consumed 31 Joules. Performance Tests 1 and 2 allowed the team to see how the AEV would perform on the full run. After Performance Test 2, the AEV used 209 Joules. The team redesigned the AEV where the push configuration was used to get the caboose back to the starting point. The Final Performance Test used 223 Joules in 45.6 seconds.

Errors within lab occurred when the group was not able to test in the same room consistently and how the reflectance sensors would be oriented when starting the test. When the track would change every other time Group L would test, the data collected could have been inconsistent due to possible slopes, friction, or smoothness. To solve this, testings should be done within the same room. When the AEV was placed on the track, the reflectance sensor would not be in the same location on the wheel every test. With inconsistent starting positions, the AEV would go 1 or 2 more marks than expected. To solve the reflectance sensor position, the group would need to rotate the wheel so that the sensor is in the same place as before.

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Introduction

As Columbus looks to be at the forefront of smart city development in the 21st century, transportation has arisen as one of the primary areas to increase personal opportunity and address climate change. In accordance with this goal, the team was tasked with creating a model Advanced Energy Vehicle (AEV): an electric, autonomous vehicle that could be used to simulate a potential solution for transporting people from Linden to Easton and Polaris. It was stipulated that this design would be on a monorail system and would use propellers for propulsion.

The team's primary task was to develop a design that would be able to run on a model track, move to a caboose and pull it back to the starting area, which would simulate the transport of people. In order to make an informed decision about what design the AEV should have, the team choose to do a session of Research and Development. Propeller testing and motor configuration testing were chosen because they seemed easily testable together -- very similar code was used for both -- and because it was determined that propeller and motor configurations would have the greatest impact on the final objective. Minimizing time and energy usage is imperative for completing the final run under the mandated budget of $500,000 (explained in Appendix B), and changing the propeller and motor configurations will be the easiest way to meet this goal. The team also ran three different performance tests to evaluate the progress made so far. These tests informed the team about how close to the budget cap the runs were.

This report enumerates the steps taken during the R&D testing and its findings. The group then used the results, along with a few prototyped AEVs, to make a final design that should be optimally suited for the task at hand.

Experimental Methodology

At the beginning of each lab day the reflectance sensors were tested. The motor configurations tested were push and pull. These setups can be seen in figure 1 and 2. First, the code for the push method was written on a computer in Sketchbook [Appendix B]. The code was then transferred to the Arduino through a usb port. The code was tested off the rail to insure the code and reflectance sensors were working. If the code was not working, all equipment was checked and the procedure was restarted. The code was run five times and data was collected from each run using the Matlab data extraction tool. First, pull motor configuration was tested by reversing the motors in Sketchbook. Power was set to 35% for 50 marks. The AEV was placed on a flat rail and was tested 5 times. After each trial, data was collected and a "Joule over time" graph was made. When the propeller configurations were tested, the code for push was altered to have the propellers run at 50% power. The AEV was set up in push motor configuration, five tests were conducted on the same track and data was taken each time.

Two performance test were conducted. Performance Test 1 consisted of the AEV going from the starting zone and stopping at the gate, the AEV waited 7 seconds and then went through the gate. Performance Test 2 consisted of Performance Test 1 and had the AEV also go down to the loading zone, connect to the caboose, wait for 5 seconds and proceeded out of the loading zone. The codes for both Performance Test were writing by using the measured distances to each checkpoint, converting the distances to marks and changing the code based on what the AEV did at each checkpoint[Appendix C.5-6]. During aR&D 3 the AEV was redesigned to push the caboose back to the starting zone and can attached to the caboose. The code for the final performance test was written based on the code from Performance Test 2 [Appendix C.7]. Data was collected from the new prototype. The data collected and was compared to the data from Performance Test 2 and the budget was reanalyzed.

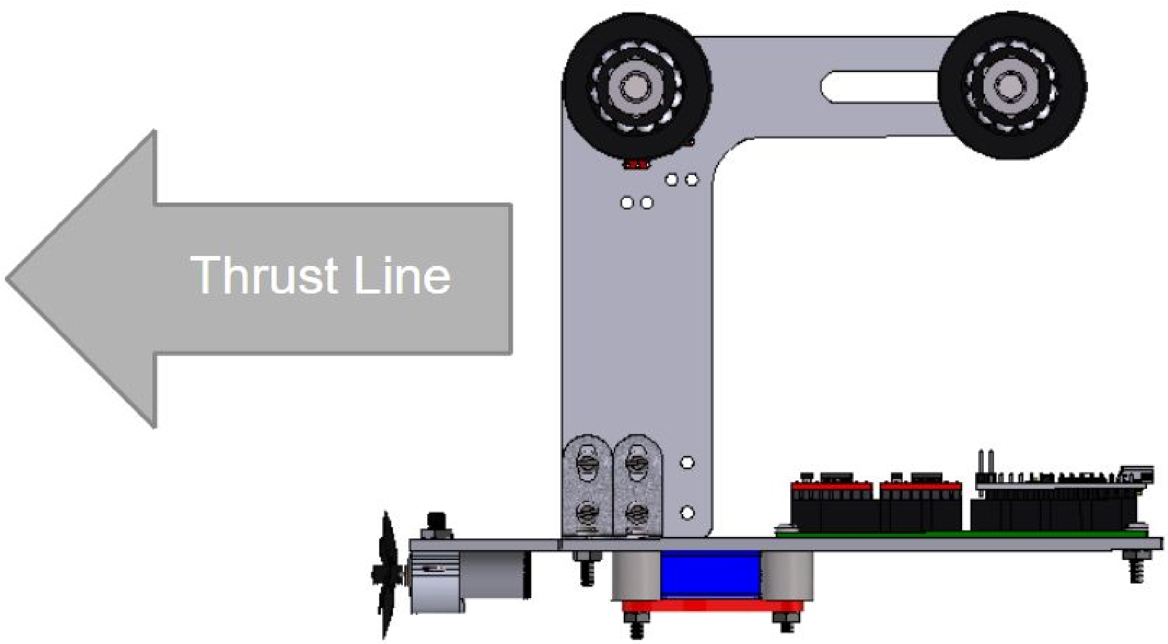


Figure 1 Motor in pull configuration

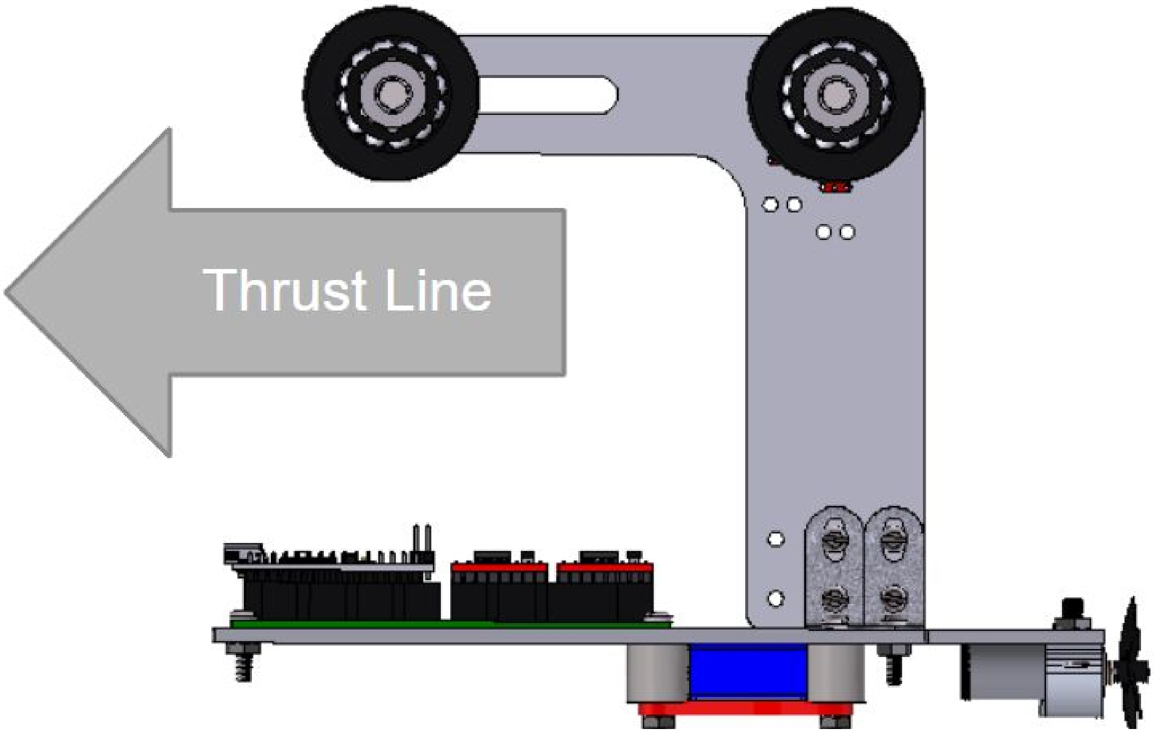


Figure 2: Motor in push configuration

Equipment

The standard AEV design pictured below was used for all testing. This consisted of a long rectangular piece with two smaller plastic pieces to hold the motors and act as a base. A black plastic L shaped piece was used to hold the wheels and suspend the AEV from the tracks. The AEV also had an arduino, to run the code, and a battery to power the AEV. A computer is needed with a usb cord in order to upload to code to the arduino. No extra equipment was needed for the push and pull testing because the only thing that changed was the direction the propellers spun. However, the large propellers were replaced by smaller ones in the propeller test. The propellers can be seen in figure 3. All of the equipment used was given to the team in the plastic boxes at the beginning of the semester.

Figure 3: Propellers

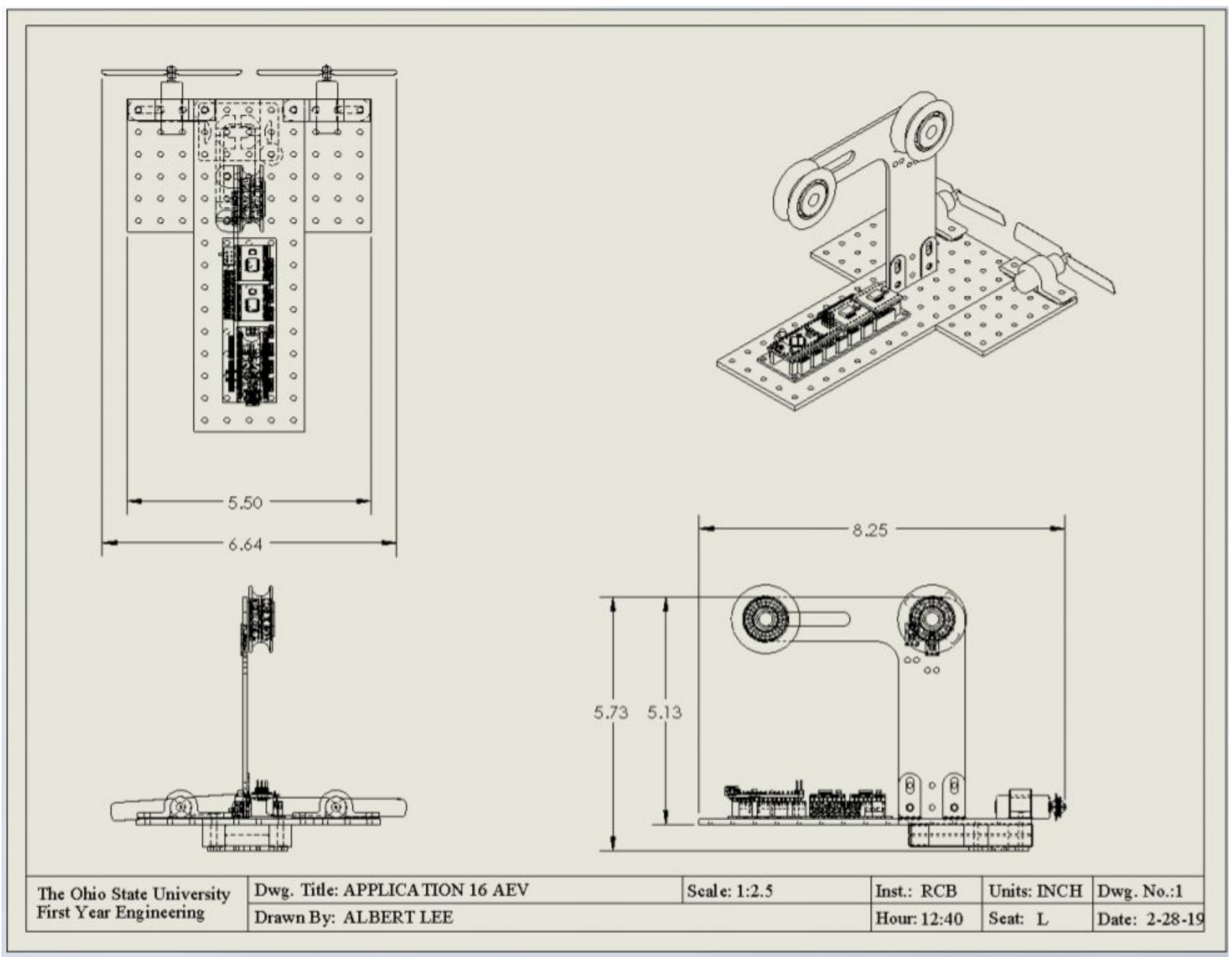


Figure 4: Second AEV Design

Results

The research was done in two different steps. The first was comparing the push and pull configurations and the second was to compare the small and large propellers. Shown in Figures 5 and 6 is the energy usage over time for push and pull configurations, respectively.

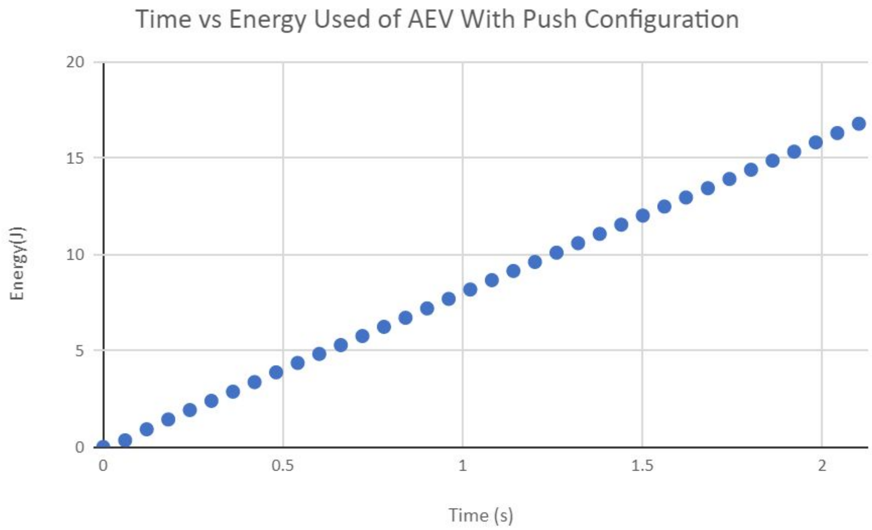


Figure 5: Push Configuration

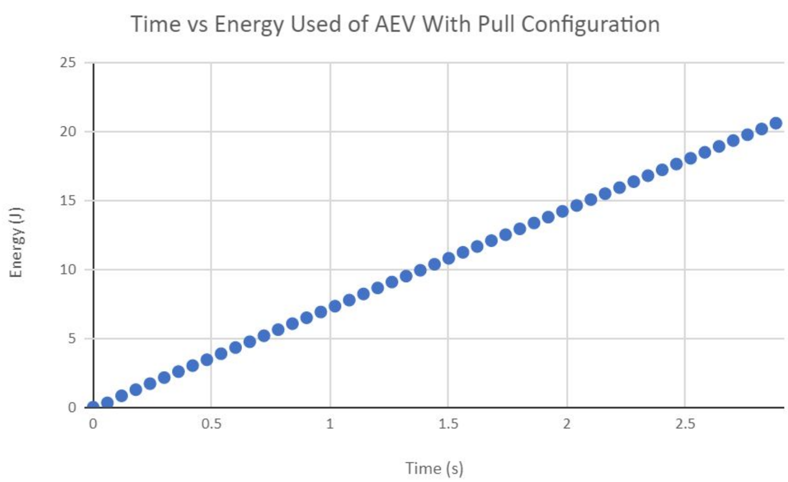


Figure 6: Pull Configuration

Both the push and pull configurations used the large propellers. The push test was faster than the pull test taking just 2.1 seconds to go the 0.6 meter distance and used 16.67 J of energy. The pull test took longer with a time of 2.9 seconds to go the same distance and used 20.80 J of energy. The data allows the team to see that the push configuration used less energy and took less time to travel the 0.6 meter compared to the pull configuration. The pull configuration also caused the AEV to use less power than the push configuration. The pull configuration used roughly 7 watts, and the push configuration used roughly 8 watts [Appendix D]. The next test compares large and small propeller configurations using the same code. Once again, energy is plotted over time in Figures 7 and 8 for large and small propellers, respectively.

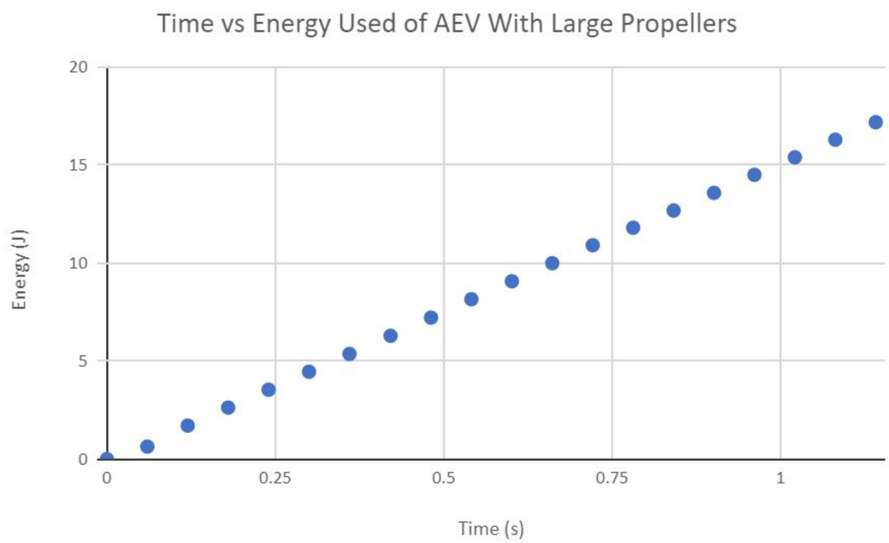


Figure 7: Large Propellers

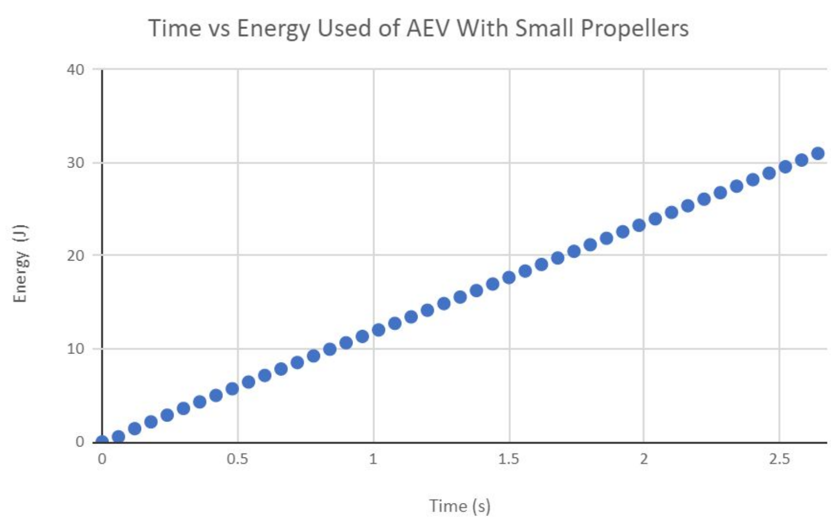


Figure 8: Small Propellers

The small propellers were not powerful enough to move the AEV with the code used for push and pull, so the code had to be changed in order to see results between the small propellers and large propellers. The large propeller configuration took 1.1 seconds to travel the 0.6 meters and used 17.17 J. The small propeller configuration was slower taking 2.6 seconds to travel the same distance and used 30.97 J of energy. The small propellers, like the pull configuration, used less power than the large propellers at about a constant 11 watts. The large propellers used about a constant 15 watts [Appendix C].

Two performance tests were also run. These consisted of a mock run to a certain part of the track, culminating in a complete run for the third test. Performance test 1 lasted 18.903s and used 57.62J, this data can be seen in figure 9. As shown in figure 10, Performance Test 2 lasted 38.883s and used 209.711 J. In aR&D 3, the final test was completed with the new design which allowed for the caboose to be pushed along the track instead of being pulled, which was seen in the previous designs. Figure 11 shows a graph of the full run which shows the amount of energy used in joules over the time it took it to complete the run.

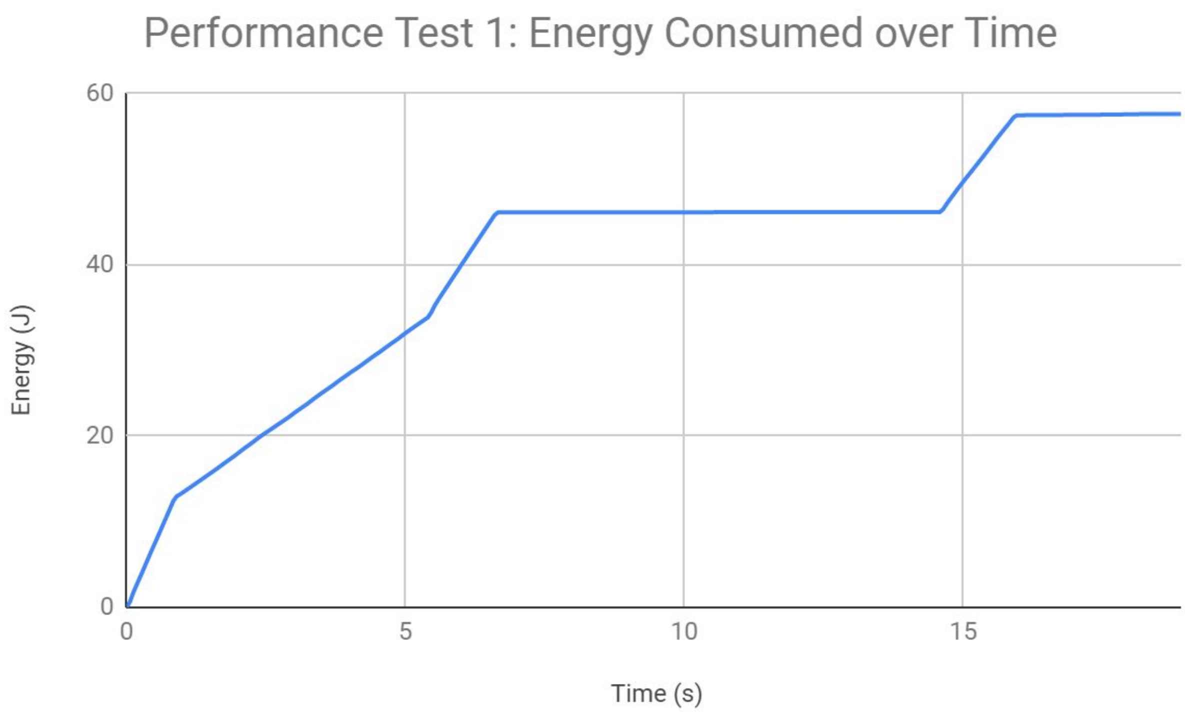


Figure 9: Energy and time used in Performance Test 1

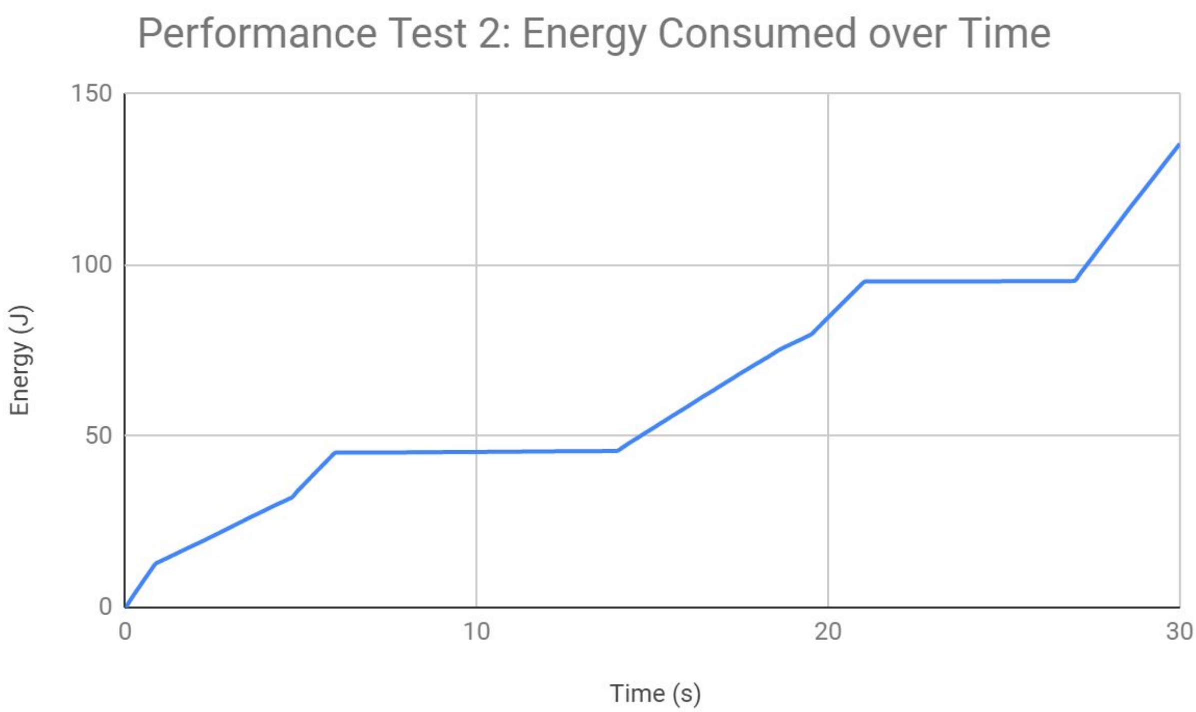


Figure 10:Energy and time used in Performance Test 2

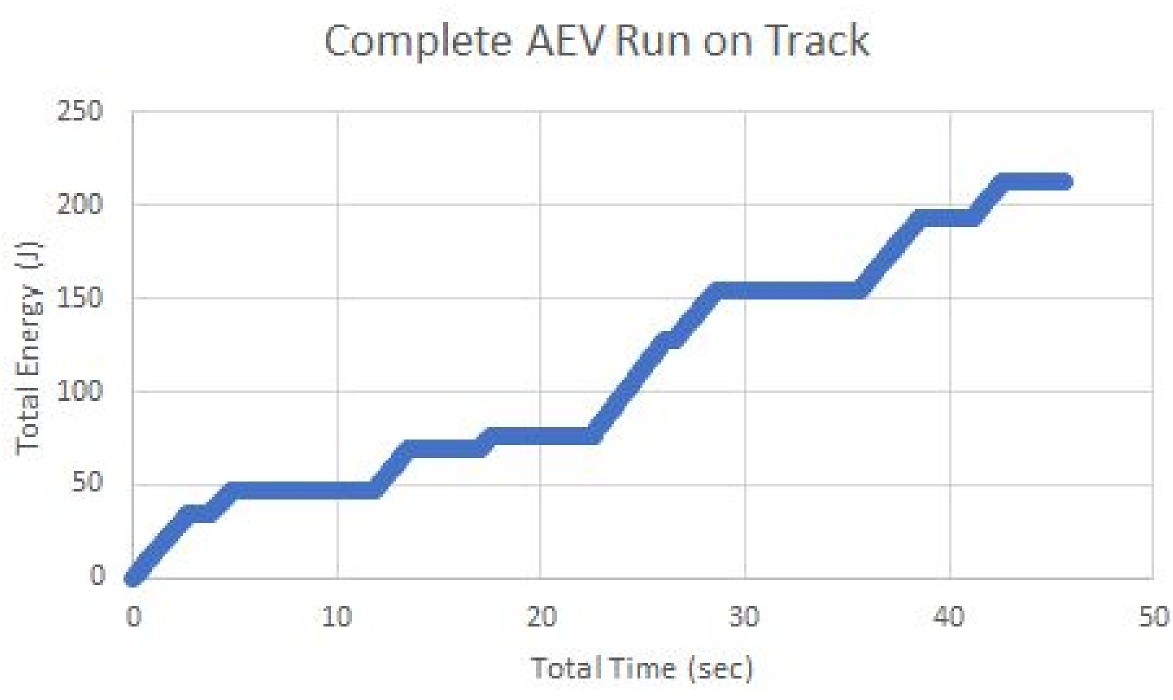


Figure 11: Full run with new design

In the final performance tests, the AEV used an average of 223J and it took an average of 45.6s to complete the run. This resulted in a total cost of the run to be $561,285 [Appendix B].

Discussion

The test of the two propeller sizes showed that the larger propellers are more suited for the task at hand. Even though the larger size use about 36% more power, they used just 55% of the energy of the small propellers [Results, Figures 4 and 5]. The large propellers were able to accelerate the AEV through the trial more quickly, meaning the motors were consuming power for much less time.

These results fit the expectations the group had. The group witnessed that the AEV did not move when the smaller propeller and less than 30% motor speed was used, meaning the motors were just consuming energy without putting out any useful work. Thus, it makes sense that the configurations that output the most force are the most efficient.

It was noticed during testing, that the push configuration moved 2.1 seconds faster, than the pull configuration, 2.9 seconds [Results, Figures 2 and 3]. The wattage throughout the test distance stayed roughly constant for pulling and pushing. With constant supply of power, the total energy expended would just be relied upon the total duration of time the AEV took to travel the 0.6 meters. Also, the constant power allowed the energy usage to be linear when graphed. Even though pushing used 1 more watt compared to pulling, the push configuration used less energy. With slower speeds, the total time is increased and had the energy rise consistently as a result.The research done did not match the team's initial hypothesis that the faster the AEV, the more energy would be used. After trials and data collecting, the team concluded that pushing and increasing the AEV motor speed was more energy efficient.

Systematic error while testing the motors occurred by testing on different tracks within two rooms of Hitchcock Hall. Advanced R&D spanned over a few weeks of testing; over the days of testing, Group L had to test within the room assigned. With different tracks, possible inconsistencies like slight incline or smoothness of tracks could have affected the power allocated to the motors, which would then affect overall energy used. The team was not able to gather data whether or not both rooms varied with overall data. Random error within testing occurred with the reflectance sensors. Even though the wheels of the AEV started at the same position, the reflectance sensors were at random positions. With the sensor position being inconsistent, the distance count could have been one or two marks above or below the intended distance and could have affected the stopping points for stopping at the stop signs and picking up the caboose.

Unfortunately, the team did not manage to account for the potential error that would arise from the AEV still having speed at the end of the trial. For the more powerful configurations (large propellers and push), the reported efficiency will be lower than actual because some of that energy was wasted in the final speed. Fortunately, this did not stop the team from getting the correct relative results, as correcting for this error would actually make the gap between push and pull, and large and small propellers larger.

Each test informed the group about how close to budget the project was. The second test cost $598,000 [Results, figure 10] without completing a full run, informing the team that major design changes would have to be made to get under the $500,000 budget. Also, most of the energy was consumed when the AEV had to pull the caboose back to the gate, suggesting that changing this part to a push configuration would result in large efficiency gains. The group completed the final performance test successfully, with the scoring broken down in Appendix E.

Prior to Advanced R&D, Group L's members drew prototypes of a new AEV; the prototypes were an improvement from the initial design given. In order to decide which designs were to be used, criteria such as weight, power, speed, aesthetic, and balance were used in a concept screening matrix. By first using +, -, and 0 markers, the group was able to determine which design got points in a scoring matrix, seen below.

Concept Screening Matrix for AEV

Success Criteria	Reference	Design T	Design C	Design A	Design L
Weight	0	0	0	-	0
Aesthetic	0	0	+	+	+
Power	0	0	+	+	0
Balance	0	+	0	0	+
Speed	0	0	0	+	+
Sum +'s	0	1	2	3	3
Sum 0's	5	4	3	1	2
Sum -'s	0	0	0	1	0
Net Score	0	1	2	2	3
Continue?	Combine	No	No	Yes	Yes

Figure 6: Concept Screening Matrix

Concept Scoring Matrix for AEV Design

		Reference		Design T		Design C		Design A		Design L	
Success Criteria	Weight	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Weight	30%	3	0.9	3	0.9	3	0.9	2	0.6	3	0.9
Aesthetic	5%	3	0.15	3	0.15	4	0.15	5	0.25	4	0.2
Power	25%	2	0.5	3	0.75	4	1	5	1.25	3	0.75
Balance	25%	2	0.5	4	1	3	0.75	3	0.75	4	1
Speed	15%	2	0.3	3	0.45	3	0.45	4	0.6	4	0.6
Total Score			3.25		3.25		3.45		3.45		3.45
Continue?		No		No		No		Yes		Yes	

Figure 7: Concept Scoring Matrix

According to the scoring matrix, designs C, A, and L tied at 3.45, but the A and L designs were finally chosen due to having higher balance [Appendix F]. Parts from both designs were implemented in the formation of the second design of the AEV. The second design of the AEV had the propellers in the back as well as a push configuration on the way to the caboose. On the way back to the starting position, the AEV pulled the caboose, which was too slow and consumed too much energy. After rethinking and redesigning, Team L created the final AEV design. The team's final design features large propellers located near the center of the AEV to allow for the pull configuration during the first part of the test, and a push configuration for when the caboose has to make it back to the start of the track. The arduino rests on top of the main platform and the battery is secured below in a holder [Appendix F.3]. This design is sturdy and follows the results determined in the research and design phases of the project. The design maximizes efficiency by using the large propellers and a push configuration for the harder portion of the track.

Conclusions & Recommendations

During Advanced Research & Development a series of tests were conducted on two different propeller sizes and two different motor configurations, push and pull. It was observed through testing that the push configuration used more watts over the total run than the pull configuration. But, the push configuration used less energy over the same distance traveled at a much faster speed. It was also observed through testing that although the large propellers used more watts over the 0.6 meter, the large propellers used less Joules to get to the same distance and in a shorter time. It is recommended to use the push motor configuration to push the caboose and large propellers in all AEV designs. The final designed featured the AEV pulling for the first half of the run and the AEV pushing the caboose to reduce cost and time on the second half of the run. The large propellers were implemented in the final design to cut down on power usage for the total run [Appendix F.3].

To remove possible sources of error the team should attempt to start the runs in relatively the same position on the track. To remove inconsistency on how the AEV performed on different days and different rooms, a servo motor could be implemented into the design, as well as different codes for different rooms. The main focus of aR&D 3 was to implement the findings of the previous aR&D's. The team rebuilt the AEV during lab and did not account for the metal contact point, this resulted in time lost during aR&D 3. The team was not able to bring down energy usage to a reasonable amount resulting in the team being over budget. The team did not do a full run with the second prototype AEV, therefore it is unknown how much energy was saved from implementing the findings in aR&D 1&2.

References

[1] Leah Wahlin, "5.1 Lab Report and Lab Memo." [Course documentation]. Available: Ohio State Pressbooks: Fundamentals of Engineering Technical Communications. [Accessed Mar. 26, 2019]

Appendices

Appendix A: Energy Equation

1. Energy

$$Energy = watts * time$$

Appendix B: Budget

	RUN 1	RUN 2	RUN 3
Capital Costs	$ 167,035	$ 167,035	$ 167,035
Energy Costs	$ 232,000	$ 239,500	$ 238,500
Time Costs	$ 160,500	$ 157,500	$ 157,500
Accuracy Penalty	1	1.052631579	1
R&D Costs	$ -	$ -	$ -
Safety Violations	$ -	$ -	$ -
TOTAL COST	**$ 559,535.00**	**$ 584,929.74**	**$ 563,035.00**

Appendix C: Code for Testing

1. Push Configuration

```
 // initially reverses motors
 reverse(4);
// sets all motors to 35% power
  motorSpeed(4, 35);
// continues for 50 marks
  goToAbsolutePosition(50);
// cuts power to motor
  brake(4);
```

2. Pull Configuration

```
// sets all motors to 35% power
  motorSpeed(4, 35);
// continues for 50 marks
  goToAbsolutePosition(50);
// cuts power to motor
  brake(4);
```

3. Large Propeller

```
// sets all motors to 50% power
  motorSpeed(4, 50);
// continues for 50 marks
  goToAbsolutePosition(50);
// cuts power to motor
  brake(4);
```

4. Small Propeller

```
// sets all motors to 35% power
  motorSpeed(4, 35);
// continues for 50 marks
  goToAbsolutePosition(50);
// cuts power to motor
  brake(4);
```

5. Performance Test 1

```
  int myPositon = 0;
```

```
int myTime = 0;

//motorSpeed(4,10);
//goFor(3);

//motorSpeed(4,30);
//goFor(3);

//motorSpeed(4,50);
//goFor(3);
//brake(4);

//Accelerate AEV
reverse(4);
motorSpeed(4, 50);
goToAbsolutePosition(25);

//Maintain speed for 13.5 feet
motorSpeed(4, 20);
goToAbsolutePosition(280);

//Brake
reverse(4);
motorSpeed(4,40);
goFor(1.18);
brake(4);
reverse(4);

goFor(8);
motorSpeed(4,30);
goToRelativePosition(10);
brake(4);
```

6. Performance Test 2

```
//motorSpeed(4,10);
//goFor(3);

//motorSpeed(4,30);
//goFor(3);
```

```
//motorSpeed(4,50);
//goFor(3);
//brake(4);

//Accelerate AEV
reverse(4);
motorSpeed(4, 50);
goToAbsolutePosition(25);

//Maintain speed for 13.5 feet
motorSpeed(4, 20);
goToAbsolutePosition(280);

//Brake
reverse(4);
motorSpeed(4,40);
goFor(1.18);
brake(4);
goFor(8);


//goFor(8);
//motorSpeed(4,30);
//goToRelativePosition(10);
//brake(4);

//Go until AEV gets to 510
reverse(4);
motorSpeed(4, 25);
goToAbsolutePosition(510);

//Slow AEV
reverse(4);
motorSpeed(4,20);
goToAbsolutePosition(590);

//Stop AEV at caboose
motorSpeed(4, 40);
```

```
goFor(1.5);

//Pause for six seconds
brake(4);
goFor(6);

//Move back to center
motorSpeed(4,50);
goToAbsolutePosition(355);
brake(4);

//Brake
reverse(4);
motorSpeed(4,45);
goFor(2);
brake(4);
```

7. Final Performance test

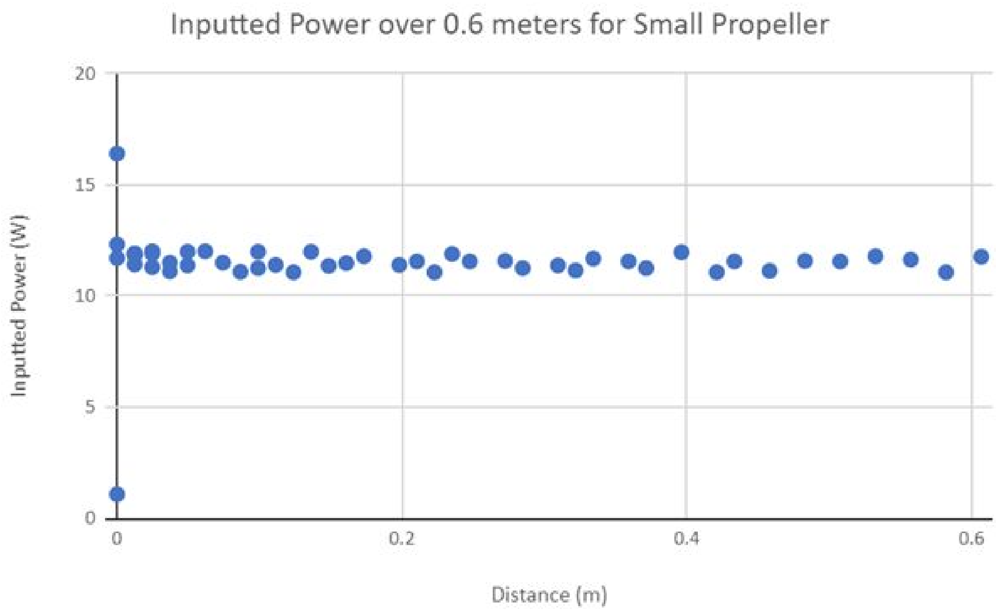
```
//motorSpeed(4,10);
//goFor(3);

//motorSpeed(4,30);
//goFor(3);

//motorSpeed(4,50);
//goFor(3);
//brake(4);

//Accelerate AEV
//reverse(4);

motorSpeed(4, 50);
goToAbsolutePosition(35);

//Maintain speed
motorSpeed(4, 45);
goToAbsolutePosition(170);

//Coast until 258
```

```
brake(4);
goToAbsolutePosition(255);


//Brake
reverse(4);
motorSpeed(4,45);
goFor(1);

brake(4);
goFor(7);


//goFor(8);
//motorSpeed(4,30);
//goToRelativePosition(10);
//brake(4);

//Go until AEV gets to 450
reverse(4);
motorSpeed(4, 50);
goToAbsolutePosition(375);


//Coast until 595
brake(4);
goToAbsolutePosition(604);

//Stop AEV at caboose
reverse(4);
motorSpeed(4, 40);
goFor(.65);

//Pause for six seconds
brake(4);
goFor(5);

//Move back to center
motorSpeed(4,50);
```

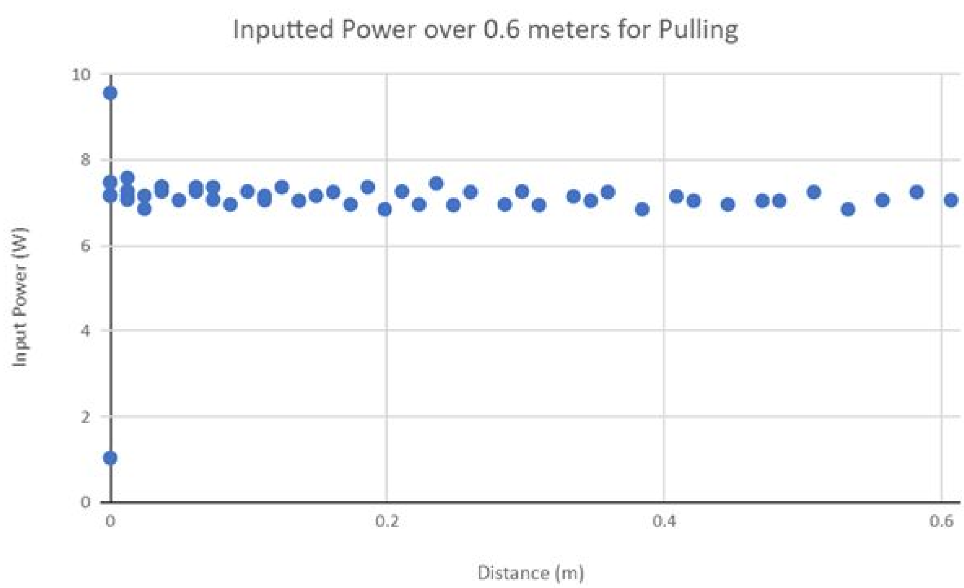
```
goToAbsolutePosition(490);
brake(4);


//Coast
goToAbsolutePosition(462);

//Brake
reverse(4);
motorSpeed(4,50);
goFor(2);
brake(4);
goFor(7.5);

//Accerating back to beginning
reverse(4);
motorSpeed(4,45);
goToAbsolutePosition(250);

//Coast until back to 50 marks
brake(4);
goToAbsolutePosition(110);

//Brake at beginning
reverse(4);
motorSpeed(4,50);
goFor(2.5);

//reflectanceSensorTest();
```

Appendix D: Data Graphs

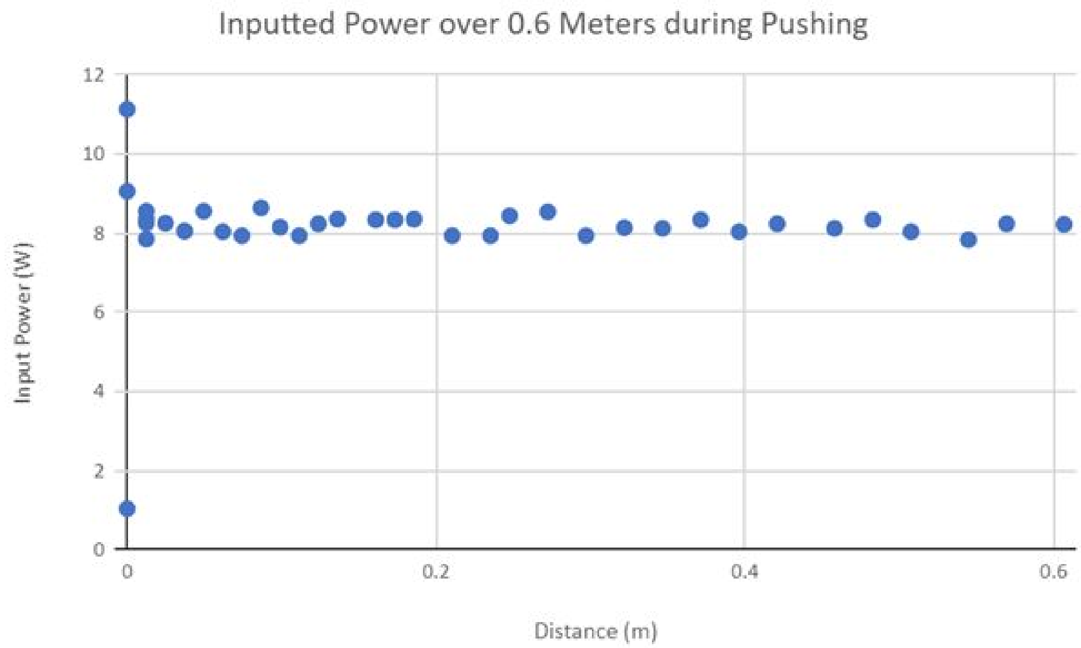
1. Small Propeller



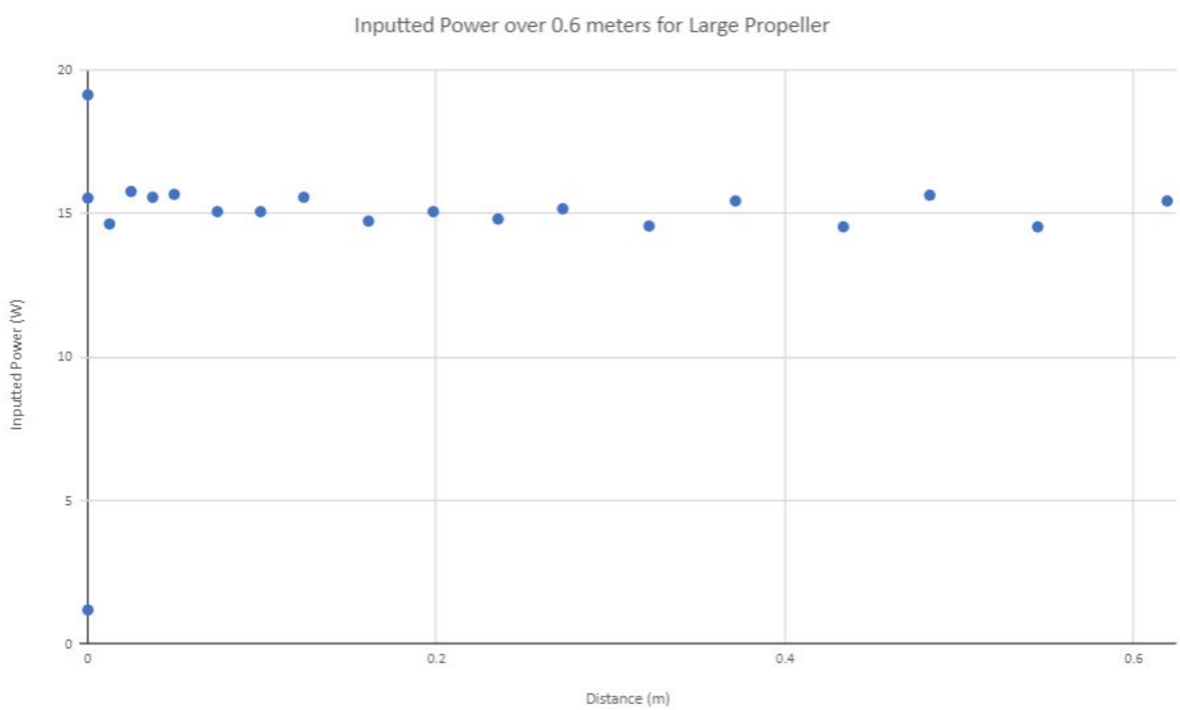
2. Pull Configuration



3. Push Configuration



4. Large Propellers



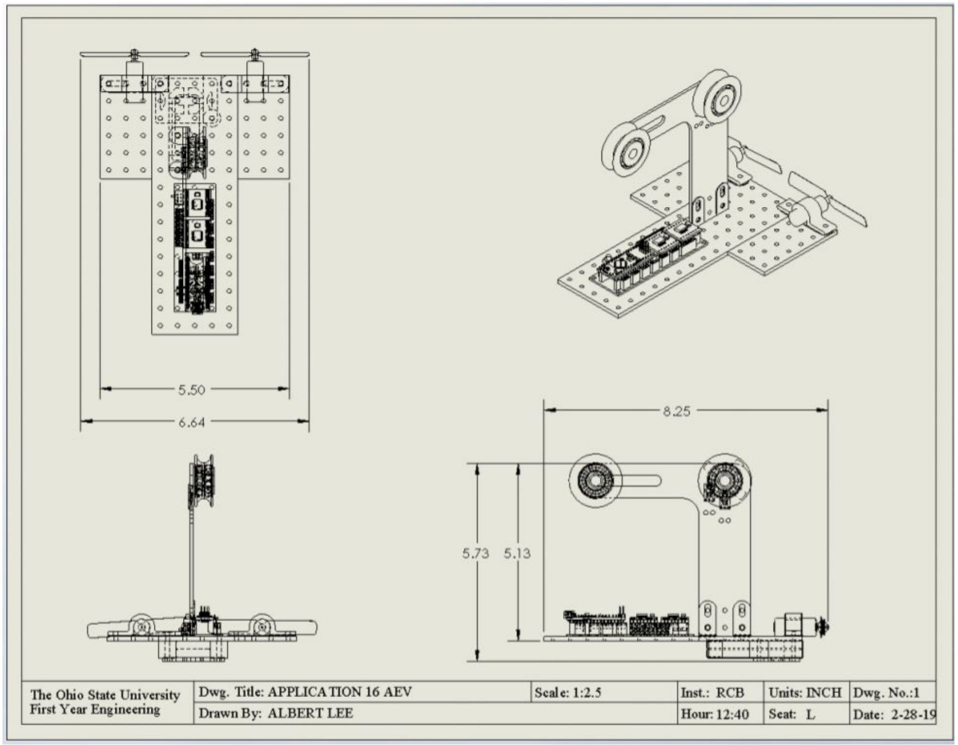
Appendix E: Final Performance Test Scoring

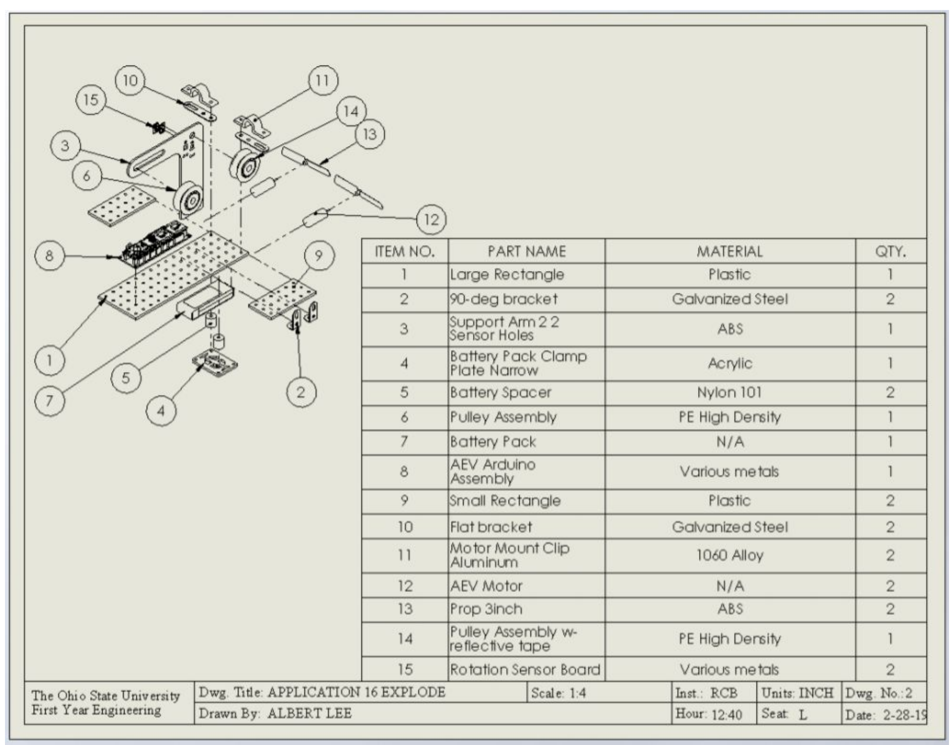
1. Run 1, 2, and 3 Information

Run 1 - 40/40pts, 47s, 214J
Run 2 - 38/40pts, 45s, 229J
Run 3 - 40/40pts, 45s, 227J

Appendix F: Prototype Designs

1. Design A



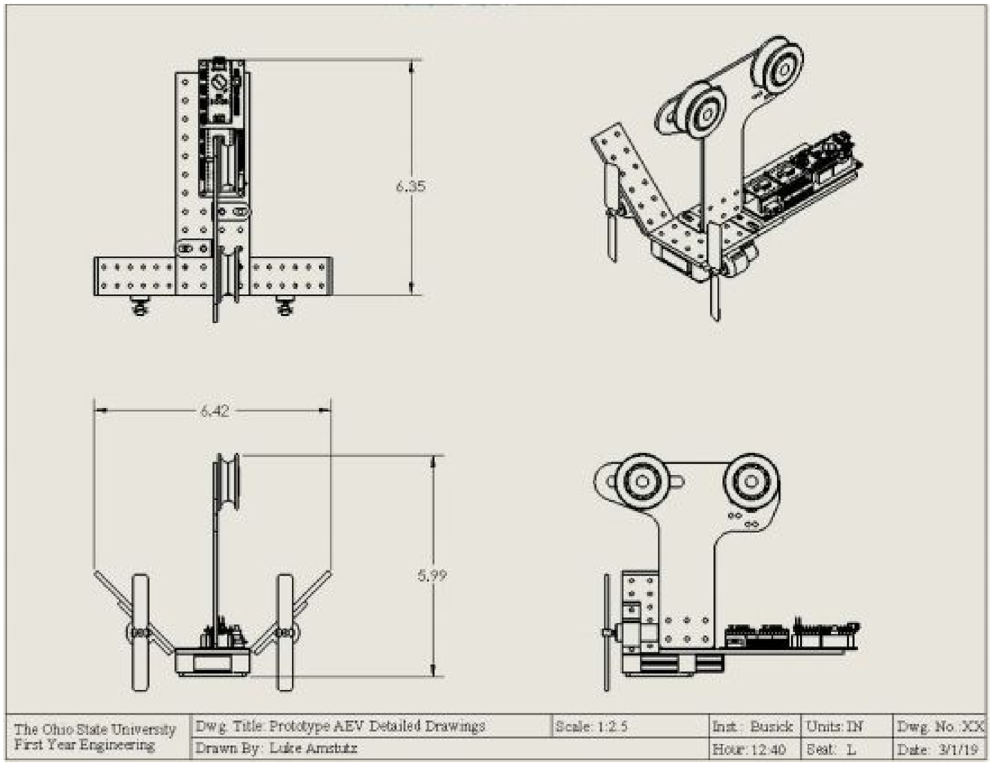


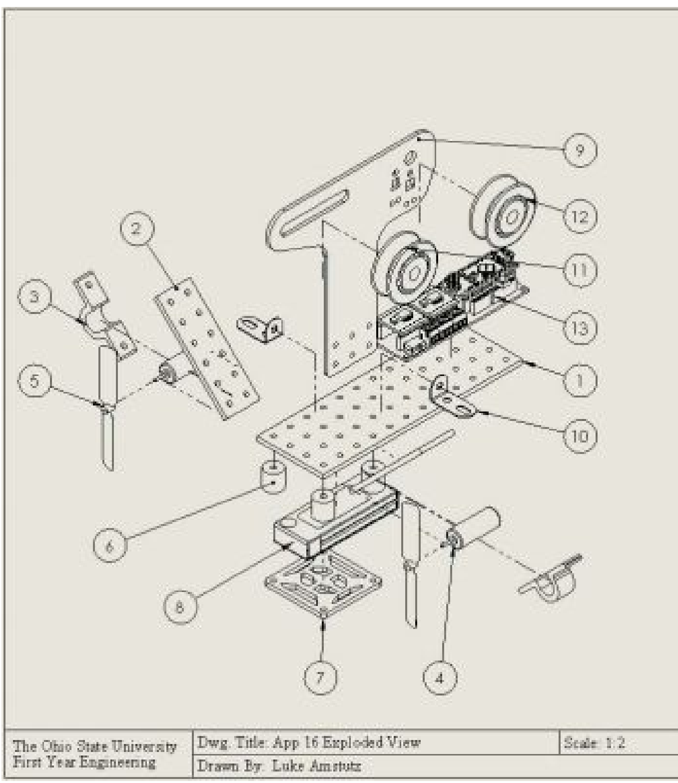
ITEM NO.	PART NAME	MATERIAL	QTY.
1	Large Rectangle	Plastic	1
2	90-deg bracket	Galvanized Steel	2
3	Support Arm 2 2 Sensor Holes	ABS	1
4	Battery Pack Clamp Plate Narrow	Acrylic	1
5	Battery Spacer	Nylon 101	2
6	Pulley Assembly	PE High Density	1
7	Battery Pack	N/A	1
8	AEV Arduino Assembly	Various metals	1
9	Small Rectangle	Plastic	2
10	Flat bracket	Galvanized Steel	2
11	Motor Mount Clip Aluminum	1060 Alloy	2
12	AEV Motor	N/A	2
13	Prop 3inch	ABS	2
14	Pulley Assembly w-reflective tape	PE High Density	1
15	Rotation Sensor Board	Various metals	2

Cost: $162,920

Weight: 150.22 g

2. Design L

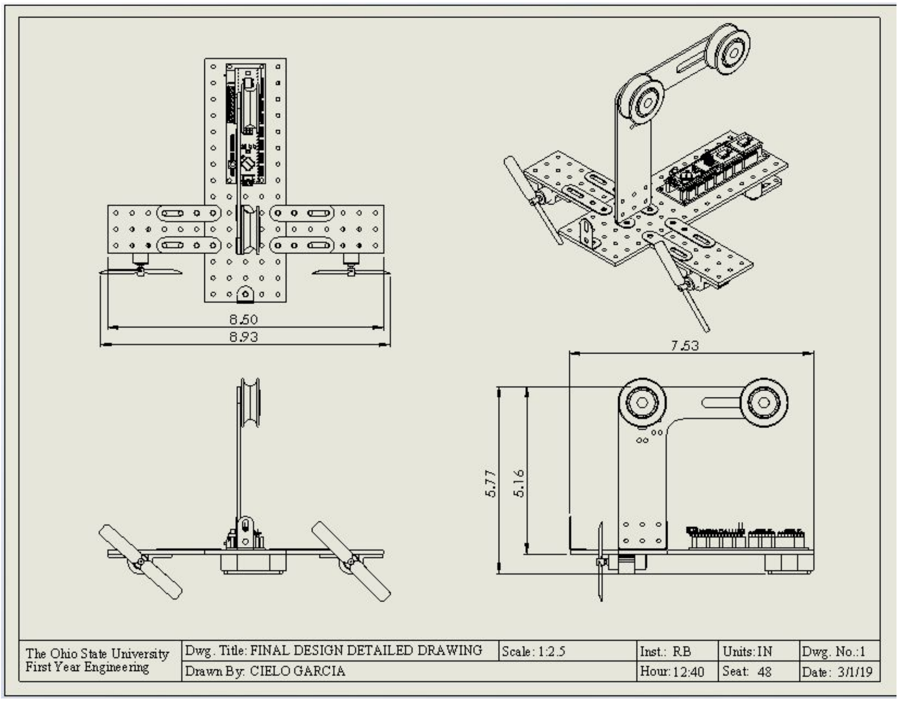


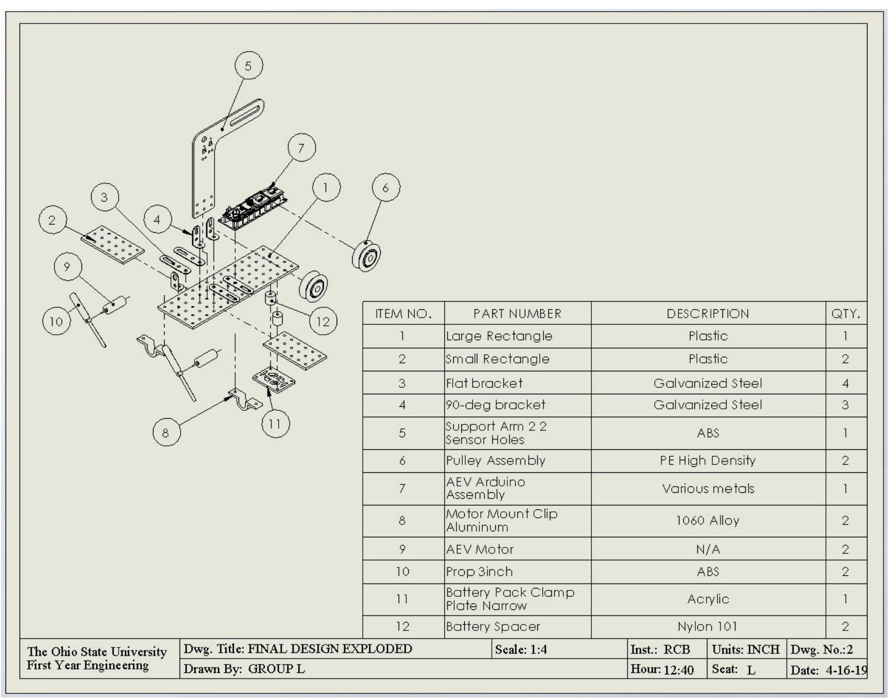


ITEM NO.	PART NUMBER	MATERIAL	QTY.
1	Medium Rectangle	Plastic	1
2	Tiny Rectangle	Plastic	2
3	Motor Mount Clip Aluminum	Aluminum	2
4	AEV Motor		2
5	Prop 3inch	Plastic	2
6	Battery Spacer	Plastic	4
7	Battery Pack Clamp Plate		1
8	Battery Pack		1
9	Support Arm 1 2 Sensor Holes V2	Plastic	1
10	90-deg bracket	Steel	2
11	Pulley Assembly		1
12	Pulley Assembly w-reflective tape		1
13	AEV Arduino Assembly		1

Cost: $165,440
Weight: 153.57 g

3. Final Design





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Large Rectangle	Plastic	1
2	Small Rectangle	Plastic	2
3	Flat bracket	Galvanized Steel	4
4	90-deg bracket	Galvanized Steel	3
5	Support Arm 2 2 Sensor Holes	ABS	1
6	Pulley Assembly	PE High Density	2
7	AEV Arduino Assembly	Various metals	1
8	Motor Mount Clip Aluminum	1060 Alloy	2
9	AEV Motor	N/A	2
10	Prop 3inch	ABS	2
11	Battery Pack Clamp Plate Narrow	Acrylic	1
12	Battery Spacer	Nylon 101	2

Cost: $167,035

Weight: 154.22 g

Appendix G: Schedule

1.Preliminary R&D 1
Start Date: 1-9-19
End Date: 1-9-19
Completed: 1-9-19
Percent Completed: 100%
Tate:
Task: Write skeleton Code
Percent completed: 25%
Albert:
Task: Code in the AEV sketchbook
Percent completed: 25%
Luke:
Task: Write skeleton Code
Percent completed: 25%
Cielo:
Task: Code in the AEV sketchbook
Percent completed: 25%

2. Preliminary R&D 2
Start Date: 1-10-19
End Date:1-16-19
Completed: 1-16-19
Percent Completed: 100%
Tate:
Task: Website Update, Team Meeting Minutes, Lab 2
Percent Completed: 25%
Albert:
Task: Website Update, Team Meeting Minutes, Lab 2
Percent Completed: 25%
Luke:
Task: Website Update, Team Meeting Minutes, Lab 2
Percent Completed: 25%
Cielo:
Task: Website Update, Team Meeting Minutes, Lab 2
Percent Completed: 25%

3. Data Extraction Tool
Start Date:2-1-19
End Date:2-1-19
Completed: 2-1-19
Percent Completed: 100%
Tate:
    Task: Data Extraction
    Percent Completed: 25%
Albert:
    Task: Data Extraction
    Percent Completed: 25%
Luke:
    Task: Data Extraction
    Percent Completed: 25%
Cielo:
    Task: Data Extraction
    Percent Completed: 25%

4. Preliminary R&D 4&5
Start Date:2-6-19
End Date: 2-6-19
Completed:2-6-19
Percent Completed: 100%
Tate:
    Task: Brainstorm, AEV drawing
    Percent Completed: 25%
Albert:
    Task: Brainstorm, AEV drawing, Website Update
    Percent Completed: 25%
Luke:
    Task: Brainstorm, AEV drawing
    Percent Completed: 25%
Cielo:
    Task: Concept Scoring and Screen, AEV drawing
    Percent Completed: 25%

5. Grant Proposal
Start Date: 2-7-19
End Date:2-13-19

Completed: 2-12-13
Percent Completed: 100%
Tate:
    Task: Progress Report 1-Results
    Percent Completed: 25%
Albert:
    Task: Progress Report 1- Takeaways, proposal drawing
    Percent Completed: 25%
Luke:
    Task: Progress Report 1- goals & schedule
    Percent Completed:
Cielo:
    Task: Powerpoint, Progress Report 1- Situation
    Percent Completed:

6. Advanced R&D Brainstorm & Committee Meeting
Start Date: 2-20-19
End Date: 2-20-19
Completed: 2-20-19
Percent Completed: 100%
Tate:
    Task: Committee Meeting-CFO, Brainstorm
    Percent Completed: 25%
Albert:
    Task: Committee Meeting- Website. Brainstorm
    Percent Completed: 25%
Luke:
    Task: Committee Meeting- R&D, Brainstorm
    Percent Completed:25%
Cielo:
    Task: Committee Meeting- HR, Brainstorm, Methodology
    Percent Completed: 25%

7. Advanced R&D 1
Start Date: 2-27-19
End Date:3-1-19
Completed:3-1-19
Percent Completed: 100%

Tate:

Task: Code, Test

Percent Completed: 25%

Albert:

Task: Code, Test

Percent Completed: 25%

Luke:

Task: Main Coder

Percent Completed: 25%

Cielo:

Task: Code,Test

Percent Completed: 25%

8. aR&D 2

Start Date:3-5-19

End Date:3-6-19

Completed:3-6-19

Percent Completed:

Tate:

Task: Code, Test

Percent Completed: 25%

Albert:

Task: Code, Test

Percent Completed: 25%

Luke:

Task: Main Coder

Percent Completed: 25%

Cielo:

Task: Code Test

Percent Completed: 25%

9. Performance Test 1

Start Date: 3-8-19

End Date:3-19-19

Completed: 3-19-19

Percent Completed: 100%

Tate:

Task: Progress report- Results, Code

Percent Completed: 25%

Albert:

Task: Website Update, code, Progress Report-Takeaways

Percent Completed: 25%

Luke:

Task: Main Coder, Progress Report- Goals & schedule

Percent Completed: 25%

Cielo:

Task: Progress report -Situations, code

Percent Completed: 25%

10. aR&D Presentation

Start Date: 3-17-19

End Date:3-20-19

Completed: 3-19-19

Percent Completed: 100%

Tate:

Task: Presentation- Conclusion

Percent Completed: 25%

Albert:

Task: Presentation- Data Analysis

Percent Completed: 25%

Luke:

Task: Presentation- Problem Definition

Percent Completed: 25%

Cielo:

Task: Presentation- Plan

Percent Completed:25%

11. Performance Test 2

Start Date:3-22-19

End Date: 3-26-19

Completed: 3-26-19

Percent Completed: 100%

Tate:

Task: Code

Percent Completed: 25%

Albert:

Task: Code

Percent Completed:25%

Luke:

Task: Code

Percent Completed:25%

Cielo:

Task: Code

Percent Completed: 25%

12. aR&D 3 Brainstorm & Committee Meeting

Start Date: 3-27-19

End Date: 3-27-19

Completed: 3-27-19

Percent Completed: 100%

Tate:

Task: Brainstorm, Budget Sheet, CDR draft-abstract, Results, Equipment

Percent Completed: 25%

Albert:

Task: Brainstorm, Committee Meeting-Website, CDR draft-abstract, Discussion, Appendix, Experiment Methodology

Percent Completed: 25%

Luke:

Task: Brainstorm, Committee Meeting-R&D, CDR draft-abstract, Introduction, Discussion, Experiment Methodology

Percent Completed: 25%

Cielo:

Task: Brainstorm, Committee Meeting, Systematic Methodology, CDR draft- abstract, Conclusion & Recommendations, Experiment Methodology

Percent Completed: 25%

13. aR&D 3

Start Date: 3-29-19

End Date: 4-3-19

Completed: N/A

Percent Completed: 50%

Tate:

Task: Code, Data Collection, AEV rebuild

Percent Completed:25%

Albert:

Task: Code, Data Collection, AEV rebuild

Percent Completed: 25%

Luke:

Task: Main Coder, Data Collection, AEV rebuild

Percent Completed: 25%

Cielo:

Task: Code, Data Collection, AEV rebuild

Percent Completed:25%

14. Work Days

Start Date: 4-3-19

End Date: 4-5-19

Completed: 4-20-19

Percent Completed: 100%

Tate:

Task: Prepare for Final Performance Test, Progress Report 3, Final Oral Presentation Draft-Evolution of Design

Percent Completed: 25%

Albert:

Task: Prepare for Final Performance Test, Progress Report 3, Final Oral Presentation Draft-Data

Percent Completed: 25%

Luke:

Task: Prepare for Final Performance Test, Progress Report 3, Final Oral Presentation Draft-Introduction

Percent Completed: 25%

Cielo:

Task: Prepare for Final Performance Test, Progress Report 3, Final Oral Presentation Draft-Final Design

Percent Completed: 25%

15. Final Testing

Start Date: 4-9-19

End Date: 4-10-19

Completed: 4-10-10

Percent Completed: 100%

Tate:

Task: Catch AEV

Percent Completed:

Albert:

Task: Catch/Start AEV
Percent Completed:
Luke:
Task: Catch AEV, Edit Code
Percent Completed:25%
Cielo:
Task: Catch AEV 25%
Percent Completed: 25%

16. Final Oral Presentation
Start Date:3-10-12
End Date: 3-17-19
Completed: 3-17-19
Percent Completed: 100%
Tate:
Task: CDR-edit, Final Oral Presentation Poster-Edit, Final Oral Presentation- Evolution of Design
Percent Completed: 25%
Albert:
Task: Website Update, Final Oral Presentation Poster-Edit, Final Oral Presentation- Data
Percent Completed: 25%
Luke:
Task: CDR-edit, Final Oral Presentation Poster-Edit, Final Oral Presentation- Introduction
Percent Completed: 25%
Cielo:
Task: CDR-edit, Final Oral Presentation Poster-Edit, Final Oral Presentation- Final Design
Percent Completed: 25%