Critical Design Review Report

Submitted to:

Richard Busick
Sheng Zhu

Created by:

Watt's Science Division - Team F
Bradley Moyer - Electrical and Computer Engineering
Emily Laudo - Chemical Engineering
Nick Besancon - Aerospace Engineering
Sarabeth Hewa - Mechanical Engineering

Engineering 1182
The Ohio State University
Columbus, OH
28 March 2019

Executive Summary

The purpose of the Advanced Energy Vehicle (AEV) Design Project was for the team to create the most energy efficient and time efficient vehicle the fulfilled all of the project's requirements. The vehicle contained two blade-propellers that were used as its motors. The main design project requirement was to successfully navigate the rail system located on the ceiling of the lab room.

The AEV was required to travel a certain distance, stop for 7 seconds in the range of a stopping gate triggered by a motion sensor, and continue down the track in order to pick up a caboose. The AEV then had to travel back through the motion-triggered gate with the caboose, and make a safe return. Objectively, the team focused on creating a lightweight design with a strong center of gravity that was consistent in multiple runs.

The research that was done throughout the semester consisted of testing various forms of code to see which method would prove the most efficient. Results of the conducted performance tests were synthesized in MATLAB, using its data analysis tool. Further research into the AEV was conducted by having each individual of the team submitting their own individual design. This research allowed for the comparison of efficiency, mass, center of gravity, durability, and aesthetic.

Advanced R & D Testing was performed, where the AEV's battery and reflectance sensors were tested. The group took 2 different batteries and tested them going for varying times and recorded the energy required to move a certain distance. For the reflectance sensor test, the AEV was tested going for different marks, and was analyzed to see the variation on how accurate the reflectance sensors were based on distance.

Performance Test 1 involved the testing of 2 propellers against 1 propeller. To observe different energy consumption, the team ran the AEV for a certain amount of time and recorded its total energy against the distance traveled. In Performance Test 2, two variations of codes were used. "goFor(s)", which ran the AEV for a certain amount of time, and "goToRelativePosition()", which ran the AEV for a certain amount of marks. These two codes helped the AEV attach to the caboose, and not aggressively collide with it.

Ultimately, the final performance test was completed with the same AEV design by performing all of the tasks required with the main focus being on the servo motor's accuracy.

Table of Contents

Introduction

The Advanced Energy Vehicle (AEV) design project focused on optimizing the energy efficiency of the AEV. The AEV is small, electric, propeller-driven vehicle suspended from a monorail track mounted on the ceiling. The main design project requirement was to successfully navigate the rail system located on the ceiling of the lab room. The AEV was required to travel a certain distance, stop for 7 seconds in the range of a stopping gate triggered by a motion sensor, and continue down the track in order to pick up a caboose. The AEV then had to travel back through the motion-triggered gate with the caboose, and make a safe return. The purpose of this project was to develop an autonomous system which can deliver cargo with minimal energy without violating design constraints.

The purpose of this report is to show the results of observations made through testing of the AEV, further continuing to try and improve the efficiency of the AEV. Section 2, Experimental Methodology, discusses AEV Performance Testing as well as Advanced R & D Testing. Section 3, Results, covers the results from the performance tests R & D Testing.. Section 4, Discussion, examines the results from the performance tests and R & D tests and illustrates trends found from these tests; furthermore, this section includes an overall analysis of the AEV's ability to complete the MCR. Section 5 is a summary of main points from previous sections and a conclusion on the AEV's performance in being able to complete the MCR. Overall, this report states research, tests, and conclusions in order to create a singular design process to complete the Columbus Smart City Plan using the best AEV design of the team's ability.

Experimental Methodology

To begin the Advanced Energy Vehicle (AEV) project, each member of the team was tasked with brainstorming and created an individual design for how the AEV should be designed by the group. Each team member needed to meet the minimum requirements of including: a base, the arduino, 2 motors and propellers, wings and rail mounts, along with a battery holder for the battery to be stored in. The team was then tasked, through the use of concept screening and scoring matrices, to pick two AEVs out of the four designed to move on to the actual build stage. The concept screening and scoring matrices looked at center of balance, durability, weight, along with others to determine this. The team eventually decided on a final design (see Appendix D) which consists of the t-shape base with the arduino mounted directly on top of it and the battery mounted directly beneath it towards the front. The two propellers are mounted at the back of the AEV, with the L-shape arm directly between the two, using two 90-degree brackets. The

team also implemented a servo motor on top of the arm next to the front wheel to serve as a brake. The reflectance sensors are also on the L-shape arm behind the reflective wheel by using zip ties. The reflective sensors, each time they rotated a certain distance served as a mark, so that way it was an accurate way to measure distance in order to perform tasks. With these parts, the AEV was ready to perform any tasks needed to be performed.

The AEV was tested over several different tests, with the two tests for the purpose of the project being called the Performance Test 1 and 2, but prior to doing this the group was assigned to test the AEV for two separate tests. These tests tested the battery and tested the reflectance sensors. For the battery testing, the group took 2 different batteries and tested them going for varying times (2, 4, 6 seconds) and recording the energy required to move a certain distance. For the reflectance sensor test, the AEV was tested going for marks of 50, 100, 150, 200, and was analyzed to see the variation on how accurate the reflectance sensors were based on distance. For Performance Test 1, the AEV was required to go forward to a loading zone, stop for 7 seconds, proceed through the loading zone, and stop. The team needed to go through a series of trial and error in order to get the AEV to stop at the right point by testing various mark counts for the AEV to go through. For Performance Test 2, the AEV was required to perform the same task as stated in Performance Test 1, but was then required to go forwards and attach to a caboose at the end of the track without hitting the caboose hard enough for it to rebound. The AEV-caboose system then needed to stop for 5 seconds, and the the AEV had to pull the caboose out of the loading zone by going in the reverse direction.

Results of the conducted advanced research and development and performance tests were synthesized in MATLAB, using its data analysis tool. This data tool would show energy usage, thus allowing the team to determine which code allowed for the most efficient run of the AEV on the track.

Results

In performance test 1, two prototype AEV designs were culminated. The team compared a design consisting of 2 propellers and a design consisting of 1 propeller. To observe different energy consumption, the team ran the same code on the same platform. These two designs can be shown in Appendix D.3. In Appendix D.1 and D.2, orthographic and isometric drawings can be shown of Prototype 1, and in Appendix D.3 and D.4, orthographic and isometric drawings of Prototype 2 can be shown. The team created 4 designs in the Preliminary Research and Development manual. (Reference Appendices A.1-A.4) Many of these designs focused on improving the AEV to make it more lightweight. None of the originally drawn designs incorporated only using one propeller,

but the team wanted to test if removing the weight of one propeller would be more beneficial and energy efficient than having the weight and using the energy of two propellers. It was found that, although only one propeller made the AEV more lightweight, it made it harder to move, and more energy had to be compensated for movement. It can be shown in Appendix F.1, that Prototype 2 consumed almost 5 more J than Prototype 2 to move to the relatively same distance. This data further supports that Prototype 1, the one consisting of 2 propellers, should be the prototype used in further testing. The group also implemented a servo motor, which served as a braking mechanism by using its lever arm to drop down on the front wheel, to be highly beneficial because there was no error in drift for the stopping of the AEV. This consistency was critical for the AEV to stop at the right point in front of the loading zone for the sensors to register the AEV and then lift the stop sign. The servo motor was a critical part of the design and will be moving forward.

Screening and scoring matrices were made in order to compare the different prototype designs. In the screening matrix, which can be found in Appendix B.1, it is shown that prototype 1 outbeat prototype 2. The battery placement of both prototypes was highly favored, however the propeller placement in prototype 2 was deemed insufficient. The scoring matrix, found in Appendix B.2, shows that prototype 1 scored a cumulative score of 4.05, with prototype 2 scoring a cumulative score of 3.86. The main reason that prototype 2 scored poorly against prototype 1 was because of it's propeller placement.

The group originally expected that the design with 2 propellers would perform better. This proved true, and can be seen in the above results. The team knew going into the performance testing that the prototype with only one propeller would most likely need to consume more energy to travel the same distance as prototype 1, since it was at a loss of power coming from the propeller. Prototype 2 had a more difficult time keeping up sufficient acceleration and speed throughout the test run.

The team then performed Advanced R & D Testing for the battery and reflectance sensors of the AEV. These tests were conducted by implementing code; and these codes can be found in Appendix G of the report.

The first test the team performed was testing battery 1 for the distance traveled (m) vs. total energy (J) while using the goFor(2) command. As seen in Appendix E.1, the AEV traveled a total distance of roughly 0.8296 meters once the battery reached its peak energy output. The second test performed was testing battery 2 for the distance traveled (m) vs. total energy (J) while using the goFor(2) command. As seen in Appendix E.2, the AEV traveled a total distance of roughly 0.7925 meters once the battery reached its peak

energy output. From this, the group determined that battery 1 performed better for this test in comparison to battery 2 because it traveled a greater distance.

The third test the team performed was testing battery 1 for the distance traveled (m) vs. total energy (J) while using the goFor(4) command. As seen in Appendix E.3, the AEV traveled a total distance of 1.94405 meters once the battery reached its peak energy output. The fourth test the team performed was testing battery 2 for the distance traveled (m) vs. total energy (J) while using the goFor(4) command. As seen in Appendix E.4, the AEV traveled a total distance of 2.167 meters once the battery reached its peak energy output. From this, the group determined that battery 2 performed better for this test in comparison to battery 1 because it traveled a greater distance.

The fifth test the team performed was testing battery 1 for the distance traveled (m) vs. total energy (J) while using the goFor(6) command. As seen in Appendix E.5, the AEV traveled a total distance of 3.8881 meters once the battery reached its peak energy output. The sixth test the team performed was testing battery 2 for the distance traveled (m) vs. total energy (J) while using the goFor(6) command. As seen in Appendix E.6, the AEV traveled a total distance of 4.2596 meters once the battery reached its peak energy output. From this, the group determined that battery 2 performed better for this test in comparison to batter 1 because it traveled a greater distance.

The final test the team performed was testing the reflectance sensors by using the goToAbsolutePosition(n) command for positions of 50, 100, 150, and 200 marks. As seen in Appendix E.7, distance increases with mark count and as mark count increases, the distance becomes more linear, leading to less error. When graphically analyzed, the 400 mark count was the most linear. This code can be shown in Appendix G.

Performance Test 2 consisted of testing different coding scenarios in order to see which scenario would conserve the most energy and be the most accurate. The two variations of codes used were "goFor(s)", which ran the AEV for a certain amount of time, and "goToRelativePosition()", which ran the AEV for a certain amount of marks. These two codes helped the AEV attach to the caboose, and not aggressively collide with it. The code that was the most accurate was the "goToRelativePosition()" code (Appendix G). It performed consistently, and hit the caboose every time, since the AEV traveled an exact and certain amount of marks. The "goFor(s)" command did a mediocre job at performing. Sometimes it would hit the caboose, and sometimes it wouldn't, even with going for the same amount of time. The "goFor(s)" command was found to be inaccurate and inconsistent, however it utilized less energy than the "goToRelativePosition()" command. Since the goFor(s) command allows the AEV to

coast longer, it gives more leeway to the variability in if it will hit the caboose or not. However, the AEV would be coasting without energy rather than using energy to reach a certain point. The "goToRelativePosition()" was more accurate, however less efficient. Since a certain number of marks had to be reached, energy had to be used up until the distance the marks determined. This allows the AEV to stop at the same place every time, but uses more energy than just going for a certain time. Team F decided to use the more accurate code, "goToRelativePosition()", since the energy usage was not that significant.

Discussion

In performance test 1, two prototype AEV designs were culminated. The team compared a design consisting of 2 propellers and a design consisting of 1 propeller. To observe different energy consumption, the team ran the same code on the same platform. The trend found in Performance Test 1 was that the prototype 1 with two propellers performed significantly better than prototype 2 with only one propeller. The group determined this not only visually watching the AEV prototypes run, but also through the data collected from MATLAB. The overall energy consumption for the 1 propeller prototype consumed a much more significant amount of energy to execute the same task as compared with the 2 propeller design. This was in line with the group's theory, since the group believed that the overall deficit of a propeller would have had a greater impact on performance, outweighing the lightweight benefit of the design. The group determined from this that the 2 propeller design will be used going forward. Therefore, the AEV used will be the best design generated by the team since it not only performed the tasks well, it also had less energy consumption doing so. Error could include computer/hardware error from the data collection tool in MATLAB, but the group had no way of determining this. Another source of error could include varied track conditions between the one propeller and two propeller runs that would have been more beneficial to the two propeller test, but the group had no way of determining this.

Further proving this data, Screening and scoring matrices were made in order to compare the different prototype designs. In the screening matrix, it is shown that prototype 1 outbeat prototype 2. The battery placement of both prototypes was highly favored, however the propeller placement in prototype 2 was deemed insufficient. The scoring matrix shows that prototype 1 scored a cumulative score of 4.05, with prototype 2 scoring a cumulative score of 3.86. The main reason that prototype 2 scored poorly against prototype 1 was because of its propeller placement.

The group originally expected that the design with 2 propellers would perform better. This proved true, and can be seen in the above results. The team knew going into

the performance testing that the prototype with only one propeller would most likely need to consume more energy to travel the same distance as prototype 1, since it was at a loss of power coming from the propeller. Prototype 2 had a more difficult time keeping up sufficient acceleration and speed throughout the test run.

The trend found in the battery testing was that Battery 1 performed better than Battery 2 for a shorter time frame, whereas Battery 2 performed better over a longer time frame. The group determined this by comparing the energy consumed with the total time traveled for each battery, with a lower energy output being more desired. The group was unsure as to why this is, since theory would suggest that Battery 1 would have performed better on all time frames given its performance on the shorter time frame of 2 seconds. The group realized after the battery testing was performed that batteries can have an immense effect on total energy consumption by the AEV, but unfortunately the group can't determine which battery to use in future tests due to the nature of how batteries are passed out randomly. Error for the battery test may or may not have included computer/hardware error based on the total energy consumption displayed, but the group had no way of determining this.

The trend found in the reflectance sensor testing was that the reflectance sensors appear to be more accurate and precise when travelling longer distances. The group determined this by looking at the data collected and looked for which distance had a more linear trend to it. The linear trend was desired because it has less variance in the overall shape of the graph, and therefore less variance in reflectance sensor mark counting. The group did not have a theory going into the reflectance sensor test, but the group was not surprised to have seen this trend because the is a larger percentage of error for the reflectance sensor per unit distance. Fortunately for the group, the AEV tests are conducted for a large distance, which means that the AEV should perform better for this. Error for the reflectance sensor test could have included human error based on where the reflectance tape was on the wheel in relation to the sensors at the start gate. If the tape was as far away from the sensors as possible, then the AEV would travel about half a wheel circumference before registering a mark, which would increase the distance. Computer/hardware error could have also been a factor with the data collection tool in MATLAB, but the group had no way of determining this.

The trend found in Performance Test 2 was that although the goFor(s) command was more energy efficient compared to the goToRelativePosition(m) command, the goToRelativePosition(m) command was much more consistent. The goToRelativePosition(m) command also performed the action of attaching to the caboose

correctly very consistently, whereas the goFor(s) command did not. In the end, this was what the group desired because the AEV needs to make very fine movements to attach to the caboose properly, and outweighs the greater energy consumption required. These findings were in line with the group's theory, since prior experience and testing with the AEV have shown that time commands were extremely inconsistent, and the only way to fully achieve consistency was through the use of a distance command. From these findings, the group further solidified its opinion on using distance commands, and these commands will be used as often as possible. A source of error can be machine/hardware error within the Arduino itself when comparing these two types of commands, but is highly unlikely since the group would have been able to visually see these errors, and none were seen. Another source of error could have been the MATLAB data collection tool, but the group had no way of determining this.

Conclusions & Recommendations

This project has lead to many conclusions on what design is best when developing and testing the AEV. Many tests were conducted and data was collected to determine what makes certain factors of the AEV better than others. Advanced tests were performed by Group F to test the reflectance sensors and the batteries for the AEV. After data was collected for these tests, two prototype AEVs were then compared to see which design should be used for final testing.

Solutions to certain errors when comparing two different factors of the AEV include taking multiple trials to truly determine the superior design components. For example, when conducting the Advanced R&D tests for the battery, a total of 3 tests for each of the two batteries were taken. This provided a greater sample size and therefore helped determine that battery two was a better battery to use. This same solution was done for the reflectance sensor test and when testing each prototype. Another error mentioned included error within the program used for data collection, MATLAB, or the Arduino server. The is no possible way of resolving this error due to constraints of the lab.

Recommendations for future design are as stated before. The battery used for the AEV should be the second battery tested because it performed better under a longer time frame, such as the time frame used for the performance test. The reflectance sensors are better when testing longer mark counts, so a larger mark count may be better when preparing the code. Lastly, for the overall design of the AEV, team F determined that a more standard design, such as prototype one, will perform better due to the aerodynamics

with multiple propellers. These observations made throughout the past few weeks are crucial for the entirety of the Watt's Science Corporation's part in the Columbus Smart City Plan.

Another recommendation that could be made includes the Servo. As stated before, the servo sensor adds as a braking mechanism and reduces the overall energy required to stop the AEV, decreasing the budget. Lastly, three inch propellers traveled further than the two inch propellers for less energy. Therefore, it is highly suggested that these types of physical characteristics are applied to the final design of the AEV.

References

"Are More Propeller Blades Better?" *Hartzell Propeller*, 28 Aug. 2018, hartzellprop.com/are-more-propeller-blades-better/.

"First Year Design Project." *Engineering Education*, The Ohio State University, Mar. 2017, eed.osu.edu/advanced-energy-vehicle-project.

Rother, Andrew. "What to Do with a Swollen Battery." *IFixit*, Jan. 2019, www.ifixit.com/Wiki/What_to_do_with_a_swollen_battery.

Appendices

Appendix A: Individual AEV Designs

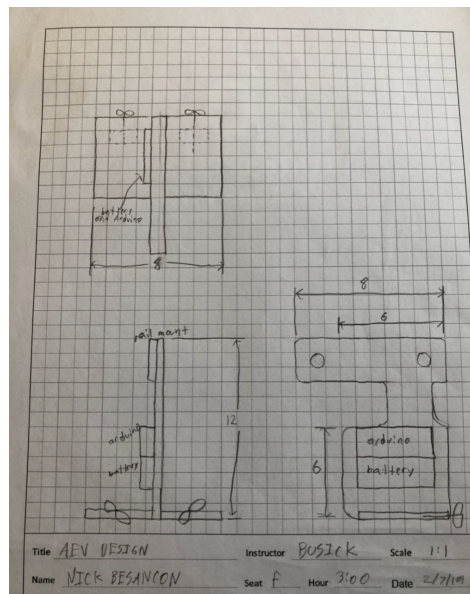### A.1: Bradley Individual Sketch
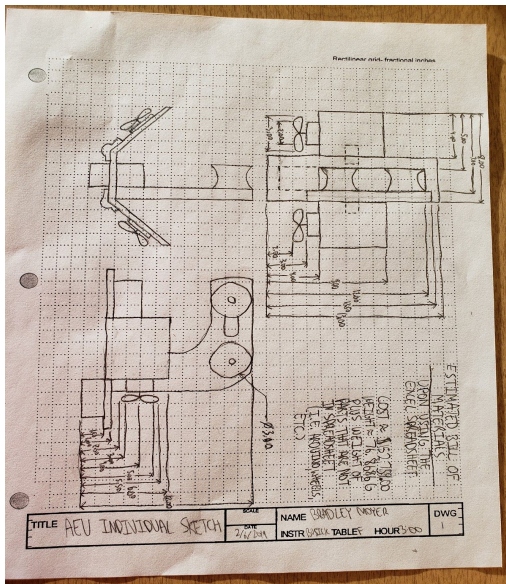
A.2 Emily Individual Sketch
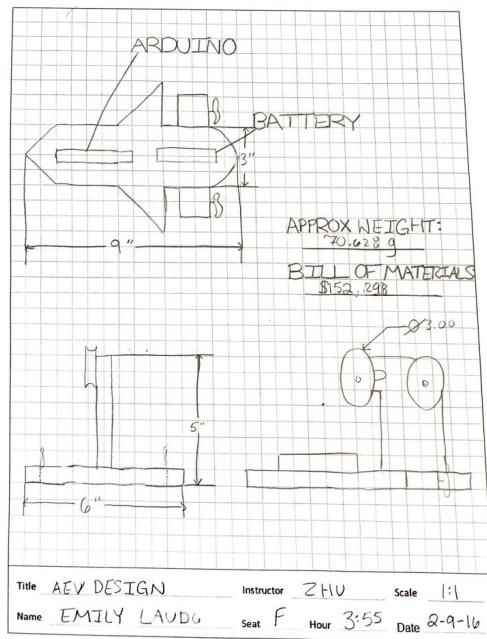
A.3: Sarabeth Individual Sketch
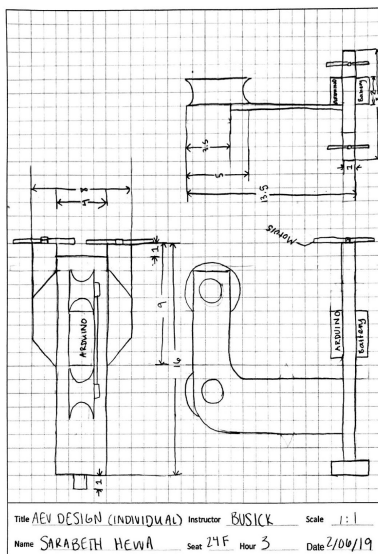
A.4: Nick Individual Sketch

Appendix B: Screening and Scoring Matrices

B.1: Screening Matrix

Success Criteria	Reference	Prototype One	Prototype Two (Excludes One Propeller)
Shape	0	0	0
Wings	0	0	0
Battery Placement	0	+	+
Propeller Placement	0	0	-
Sum +'s	0	1	1
Sum 0's	4	3	2
Sum -'s	0	0	1
Net Score	0	1	0
Continue?	Combine	Yes	Yes

B.2: Scoring Matrix

Success Criteria	Weight	Reference		Prototype One		Prototype Two	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Shape	45%	4	1.8	5	2.25	5	2.25
Wings	20%	4	0.8	4	0.8	4	0.8
Battery	20%	4	0.8	2	0.4	2	0.4
Propeller Placement	15%	4	0.8	4	0.6	1	0.15
Total Score			4		4.05		3.6
Continue?		Develop		Yes		No	

Appendix C: Team Working Schedule
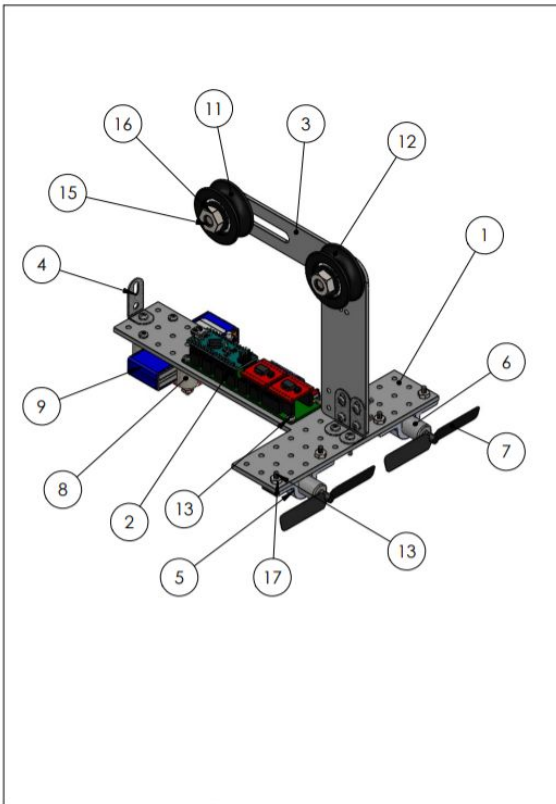
C.1: Schedule as of March 27, 2019

| Task	Start Date	Due Date	Percent Complete
Committee Meeting 2	3/27/19	3/28/19	90%
aR&D 3 Methodology	3/28/19	4/1/19	0%
Progress Report 3	3/28/19	4/4/19	10%
Final Oral Presentation Draft	4/4/19	4/8/19	10%
Final Performance Test	4/8/19	4/11/19	0%
Critical Design Review	3/27/19	4/18/19	75%
Final Website	4/11/19	4/18/19	70%
Final Oral Presentation	4/11/19	4/18/19	0%

Appendix D: Solidworks Design of AEV and Actual AEV

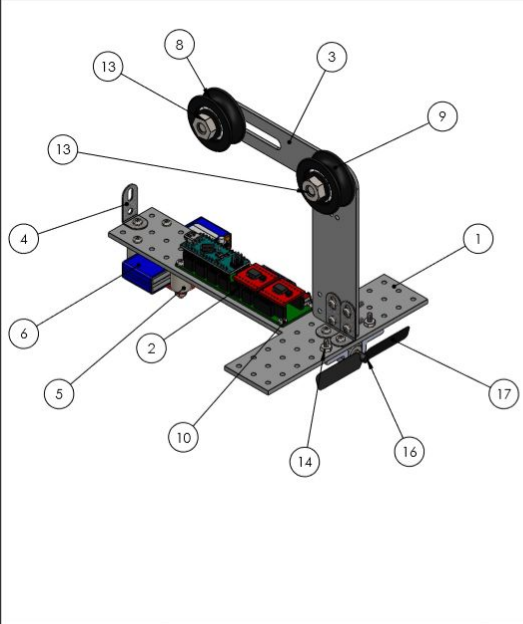D.1: Drawing of Prototype One with Bill of Materials

ITEM NO.	PART NUMBER	QTY.
1	Tee	1
2	AEV Arduino Assembly	1
3	Support Arm 2 2 Sensor Holes	1
4	90-deg bracket	3
5	Motor Mount Clip Aluminum	2
6	AEV Motor	2
7	Prop 3inch	2
8	Battery Spacer	4
9	Battery Pack	1
10	Battery Pack Clamp Plate Narrow	1
11	Pulley Assembly	1
12	Pulley Assembly w-reflective tape	1
13	SL-PHMS 0.112-40x0.5x0.5-S	13
14	SL-PHMS 0.112-40x1x1-S	4
15	HBOLT 0.3125-18x0.875x0.875-S	2
16	MSHXNUT 0.3125-18-S-S	2
17	MSHXNUT 0.112-40-S-S	17

The Ohio State University First Year Engineering	Dwg. Title: PROTOTYPEONE	Scale: 2:5	Inst.: BUSICK	Units: IN	Dwg. No.:1
	Drawn By: NICK BESANCON		Hour: 3:00	Seat: F	Date: 3/28/19

SOLIDWORKS Educational Product. For Instructional Use Only.

D.2: Orthographic Drawing of Prototype One

| The Ohio State University First Year Engineering | Dwg. Title: PROTOTYPEDIMENSIONS | Scale: 1:3 | Inst.: DB | Units: IN | Dwg. No.:2 |
| | Drawn By: NICK BESANCON | | Hour: 3:00 | Seat: F | Date: 3/28/19 |

SOLIDWORKS Educational Product. For Instructional Use Only.
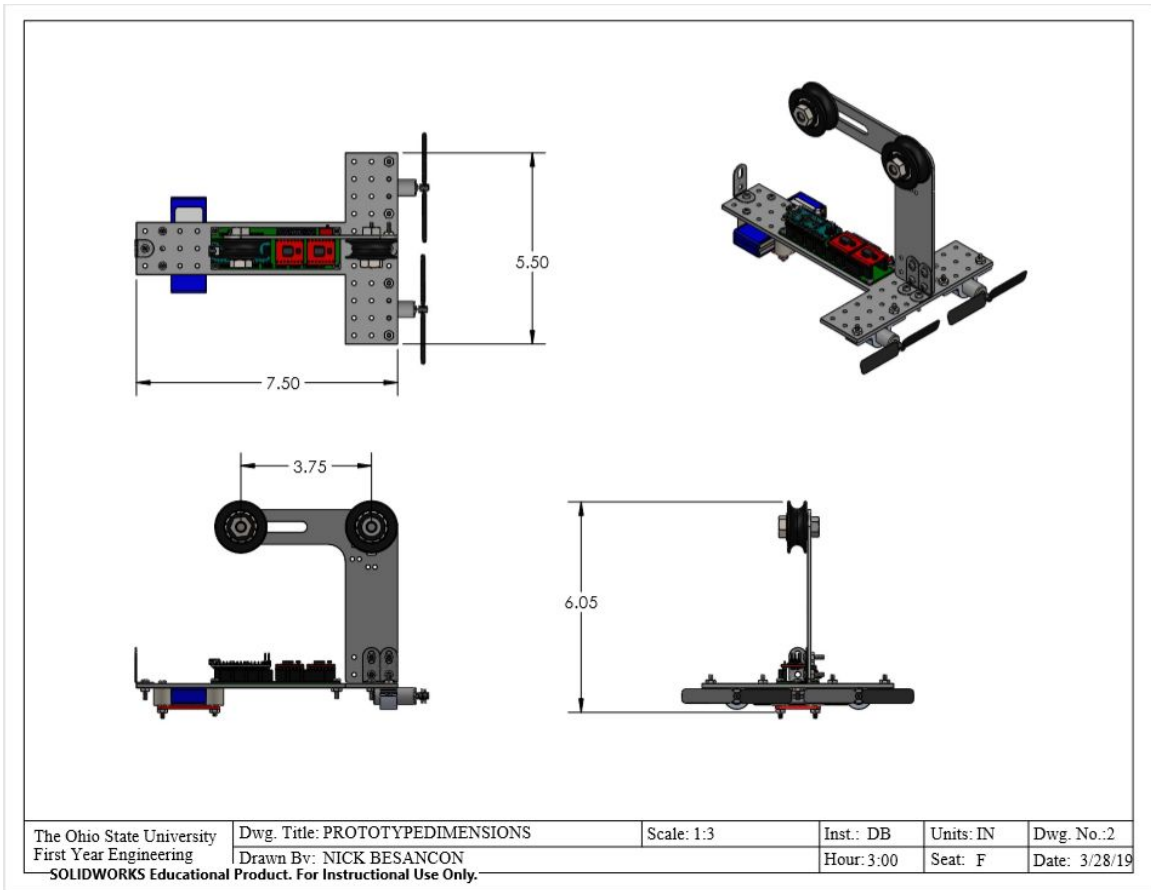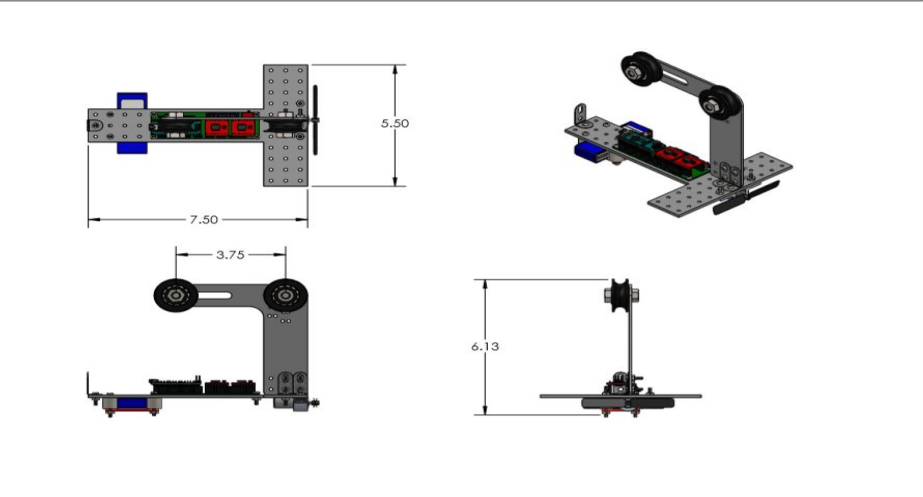
D.3: Drawing of Prototype Two with Bill of Materials

ITEM NO.	PART NUMBER	QTY.
1	Tee	1
2	AEV Arduino Assembly	1
3	Support Arm 2 2 Sensor Holes	1
4	90-deg bracket	3
5	Battery Spacer	4
6	Battery Pack	1
7	Battery Pack Clamp Plate Narrow	1
8	Pulley Assembly	1
9	Pulley Assembly w-reflective tape	1
10	SL-PHMS 0.112-40x0.5x0.5-S	11
11	SL-PHMS 0.112-40x1x1-S	4
12	HBOLT 0.3125-18x0.875x0.875-S	2
13	MSHXNUT 0.3125-18-S-S	2
14	MSHXNUT 0.112-40-S-S	15
15	Motor Mount Clip Aluminum	1
16	AEV Motor	1
17	Prop 3inch	1

The Ohio State University First Year Engineering	Dwg. Title: PROTOTYPETWO	Scale: 1:2	Inst.: DB	Units: IN	Dwg. No.:3
	Drawn By: NICK BESANCON		Hour: 3:00	Seat: F	Date: 3/28/19

SOLIDWORKS Educational Product. For Instructional Use Only.

D.4: Orthographic Drawing of Prototype Two

The Ohio State University First Year Engineering	Dwg. Title: PROTOTYPE_TWO_DIM	Scale: 1:3	Inst.: DB	Units: IN	Dwg. No.:4
	Drawn By: NICK BESANCON		Hour: 3:00	Seat: F	Date: 3/28/19

SOLIDWORKS Educational Product. For Instructional Use Only.

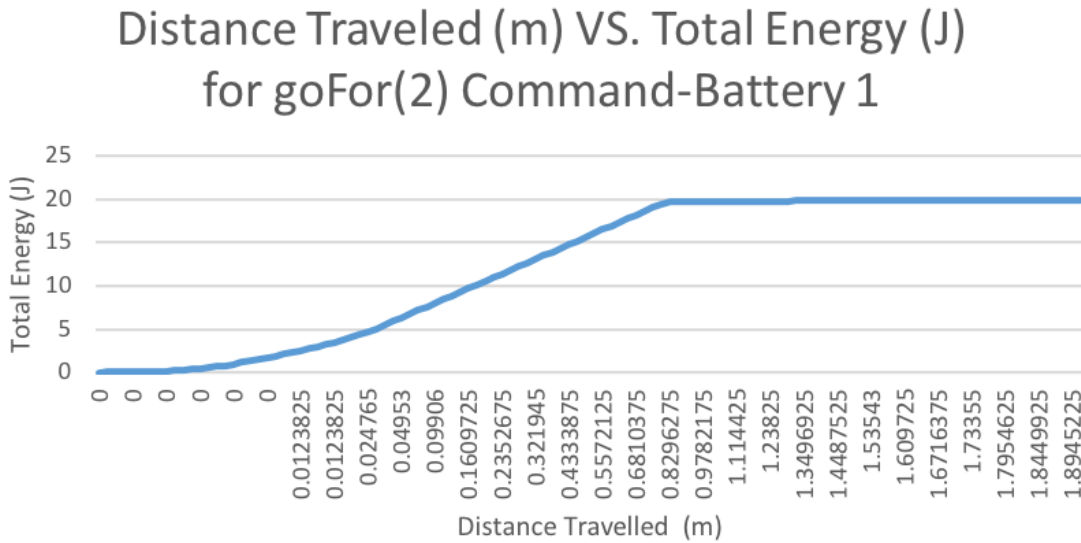D.5: Actual Photo of Prototype One for Performance Test 1
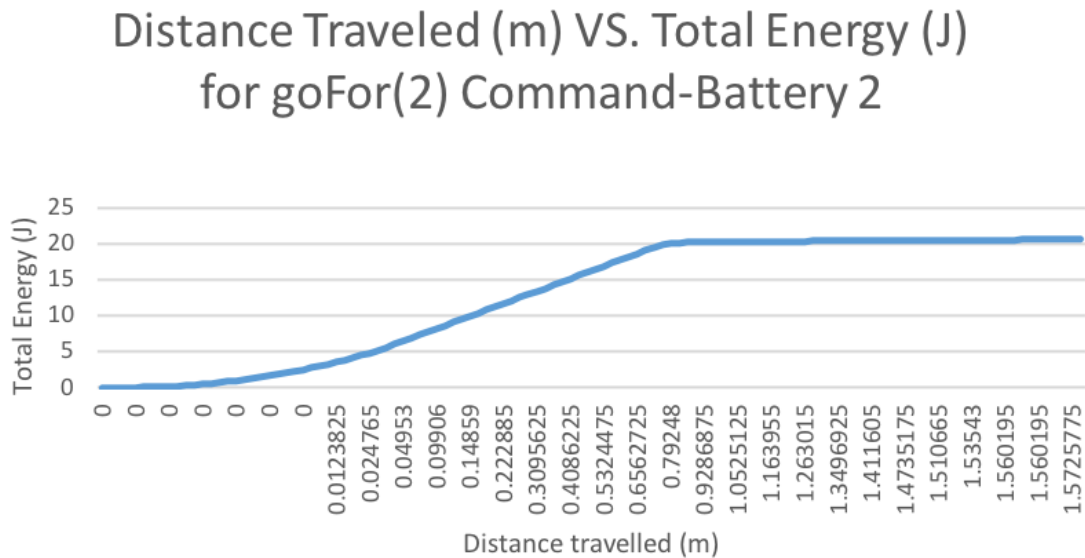
D.5: Actual Photo of Prototype Two for Performance Test 1

Appendix E: Advanced R&D Data Collection
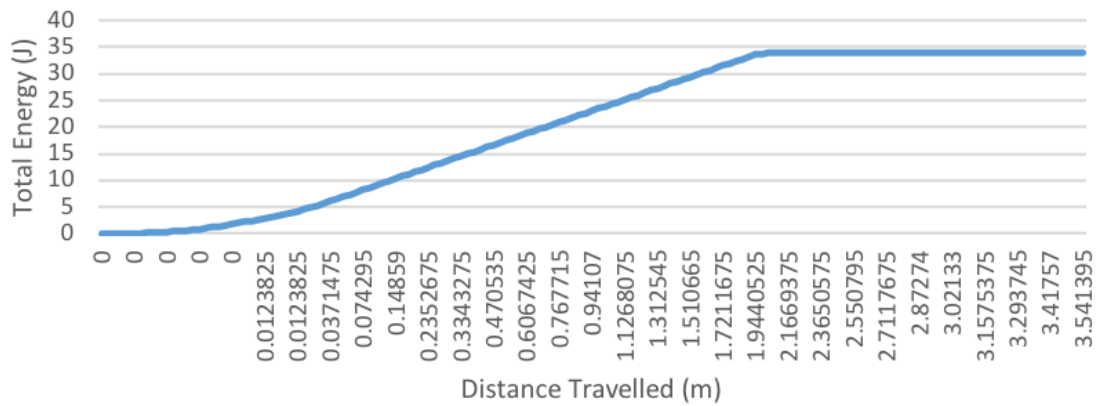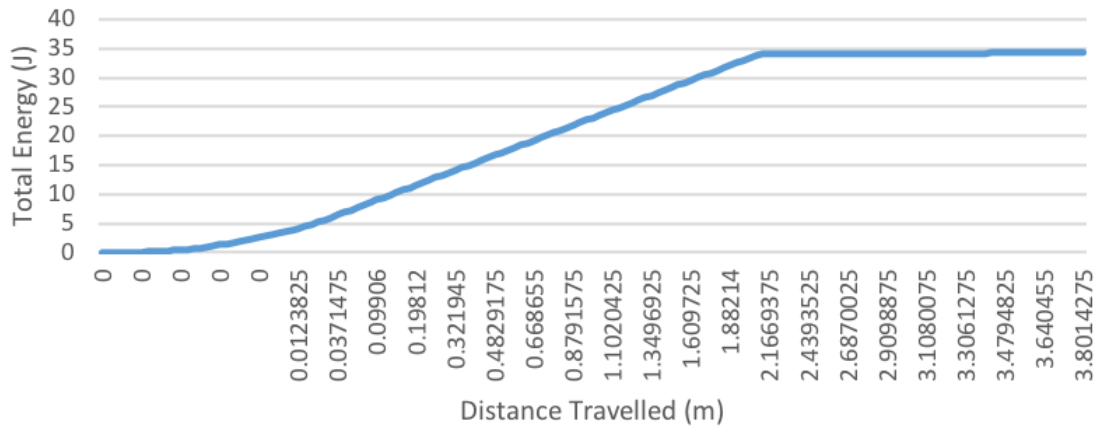
E.1: Testing 'goFor(2)' for the First Battery

Distance Traveled (m) VS. Total Energy (J) for goFor(2) Command-Battery 1
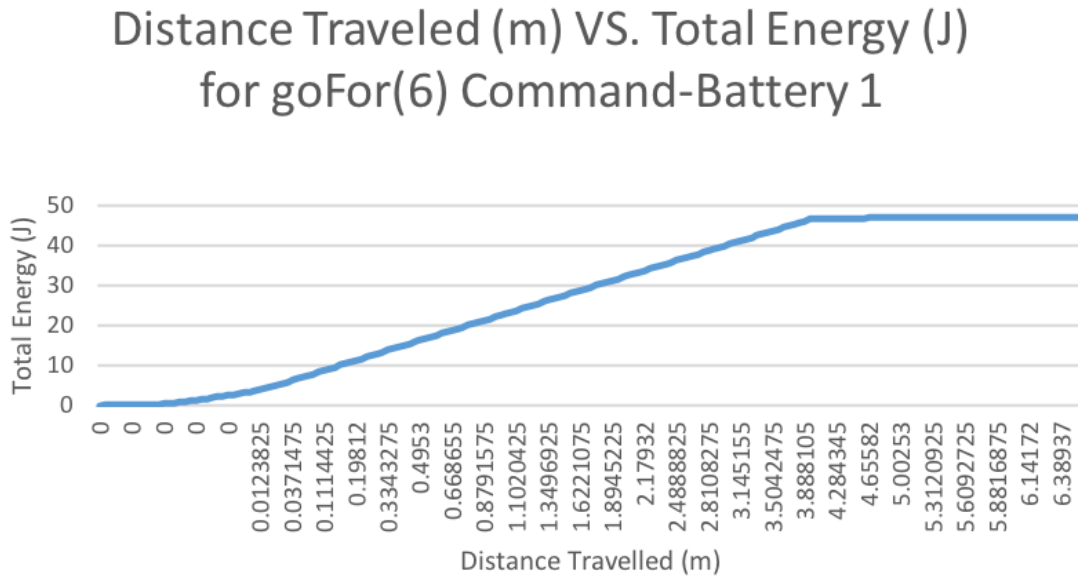
E.2: Testing 'goFor(2)' for the Second Battery

Distance Traveled (m) VS. Total Energy (J) for goFor(2) Command-Battery 2

E.3: Testing 'goFor(4)' for the First Battery

Distance Traveled (m) VS. Total Energy (J) for goFor(4) Command- Battery 1
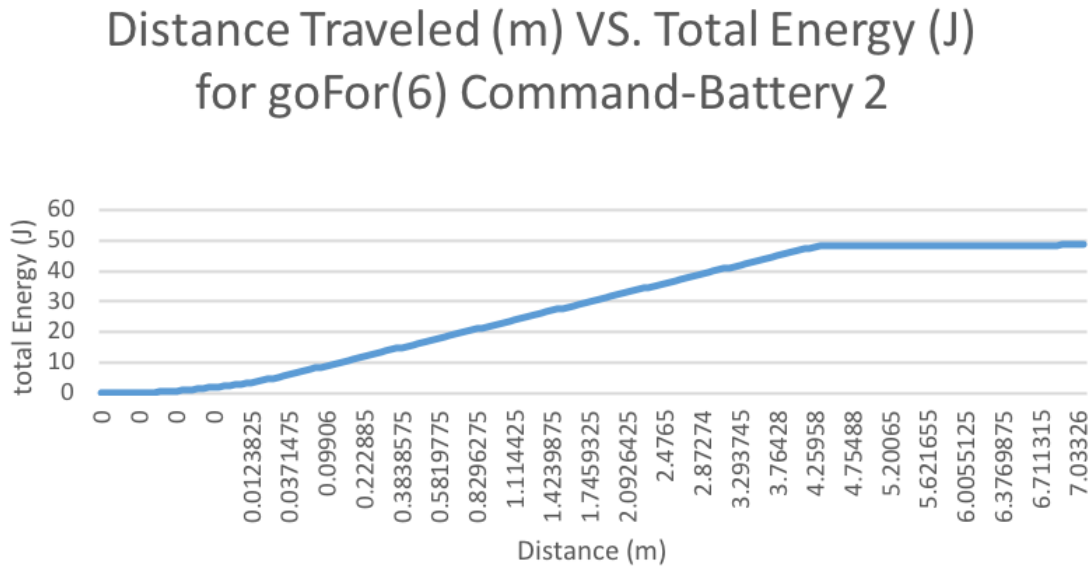
E.4: Testing 'goFor(4)' for the Second Battery

Distance Traveled (m) VS. Total Energy (J) for goFor(4) Command-Battery 2

E.5: Testing 'goFor(6)' for the First Battery

Distance Traveled (m) VS. Total Energy (J) for goFor(6) Command-Battery 1

E.6: Testing 'goFor(6)' for the Second Battery

Distance Traveled (m) VS. Total Energy (J) for goFor(6) Command-Battery 2

E.7: Reflectance Sensor Tests Showing Distances Traveled at Four Different Mark Counts

Testing Four Different Mark Counts to Determine the Differences in the Distance They Traveled
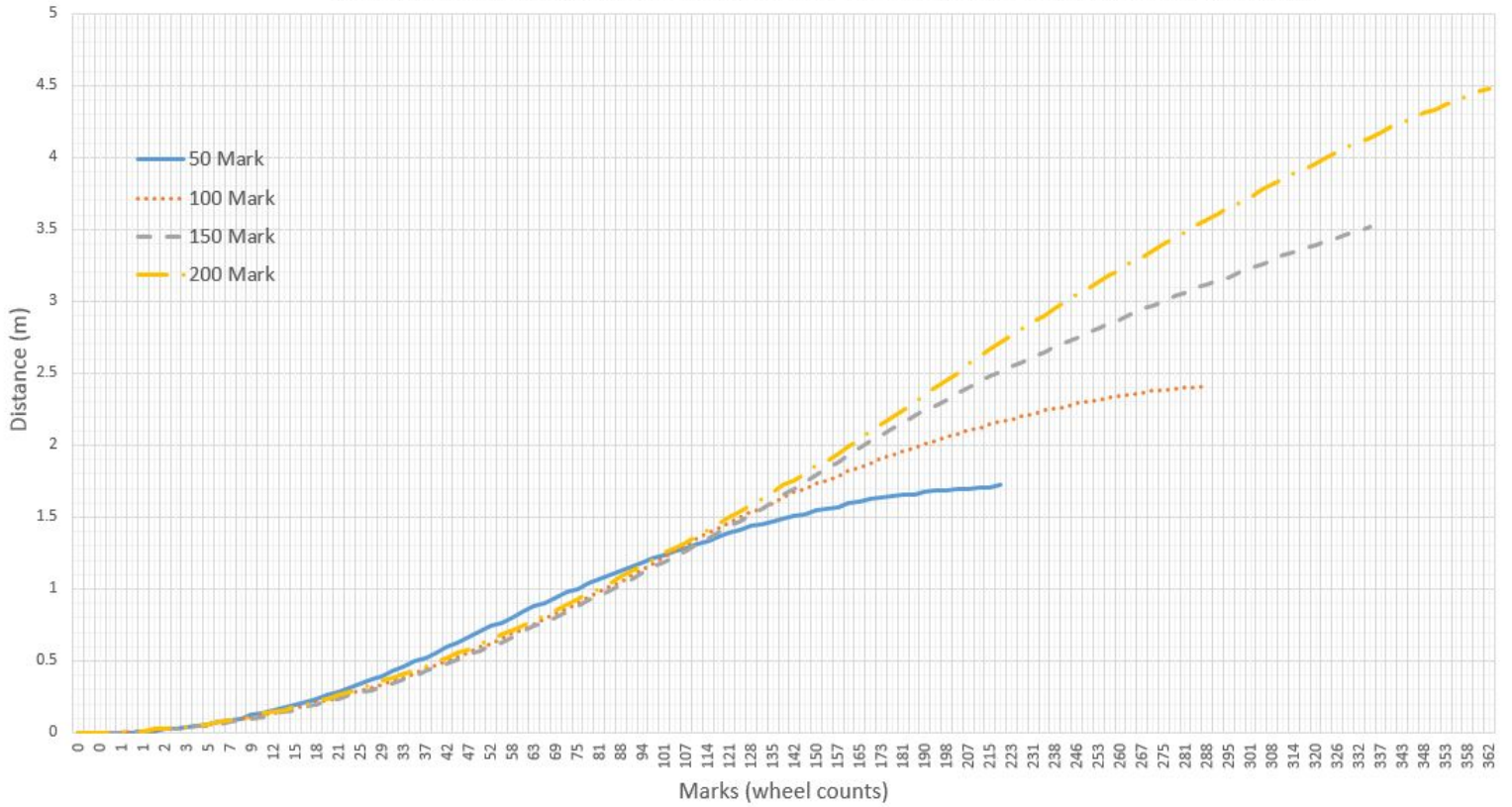
Appendix F: Performance Test 1 Data Collection

F.1: Distance Traveled and Energy Used For Each AEV

	Prototype 1 (2 propellers)	Prototype 2 (1 propeller)
Distance Traveled:	0.853 meters	0.831 meters
Energy Used (in J)	20 J	25 J

Appendix G: Codes

G.1: Testing "goFor(2)" for First Battery

```
motorSpeed(4,20);
goFor(2);
brake(4);
```

G.2: Testing "goFor(4)" for First Battery

```
motorSpeed(4,20);
goFor(4);
brake(4);
```

G.3: Testing "goFor(6)" for First Battery

```
motorSpeed(4,20);
goFor(6);
brake(4);
```

G.4: Testing "goFor(2)" for Second Battery

```
motorSpeed(4,20);
goFor(2);
brake(4);
```

G.5: Testing "goFor(4)" for Second Battery

```
motorSpeed(4,20);
goFor(4);
brake(4);
```

G.6: Testing "goFor(6)" for Second Battery

```
motorSpeed(4,20);
goFor(6);
brake(4);
```

G.7: Testing 50 marks using "goToAbsolutePosition(50)" for reflectance sensors

```
motorSpeed(4,20);
goToAbsolutePosition(50);
brake(4);
```

G.8: Testing 50 marks using "goToAbsolutePosition(50)" for reflectance sensors

```
motorSpeed(4,20);
goToAbsolutePosition(100);
brake(4);
```

G.9: Testing 50 marks using "goToAbsolutePosition(50)" for reflectance sensors

```
motorSpeed(4,20);
goToAbsolutePosition(150);
brake(4);
```

G.10: Testing 50 marks using "goToAbsolutePosition(50)" for reflectance sensors

```
motorSpeed(4,20);
goToAbsolutePosition(200);
brake(4);
```