<u>CDR</u>

<u>Group A</u>
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Abstract

The purpose of this lab is to create the most efficient AEV in terms of energy usage and time, as well as to be safe for smart city Columbus. The AEV's use will be to pick up carts of people and deliver them through a gate. It is important that the cargo of people arrive to their destination safely. This includes preventing bumping when picking up the train of people and minimizing sway of the train. It is also important that the AEV can complete the task in a reasonable amount of time in order to save money. Likewise, it needs to be able to complete the task as fast as possible while using the least amount of energy. More specifically, this report lies out the details of two different AEV designs, what they look like, and how they performed. It is important to have the most efficient AEV design to save money and time.

The results show that the final AEV design created by the team was best utilized for its time and energy usage. The design could stop at a quick rate and could also travel quickly between gates and pick ups, finishing the overall performance test in 59 seconds. The compact design and smaller pieces used allowed for the energy used to be lower, clocking in at 281 Joules. These results are so favorable mainly due to the push motor configuration, in which the team had 1 motor on each end of the AEV so that the motors could be pushing when going forwards and backwards. Lastly, the compact design allowed for low capital cost of $163,040. Receiving an overall grade of 93.5%, the team was pleased in the overall perfect run score and the AEV's execution of all code.

Based off of preliminary research and development, the team recommends that absolute and relative position commands are used over power and time commands. This is because of the inconsistencies of the track, battery, and error that can be overridden by position commands. The team also recommends power breaking over coasting to a stop because this cut down on a lot of time and made stopping more exact and consistent. Lastly, it is recommended to use a compact and low center of gravity design to minimize sway and weight. That, combined with one motor on the front and one motor on the back to optimize pull motor configuration will provide for the most powerful, yet energy efficient, AEV.

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Introduction

The purpose of this experiment is to create an alternative energy vehicle that can transport people from low income cities in Columbus, Ohio. The goal is to create an AEV that can travel fast, conserve energy, be safe, and be consistent.

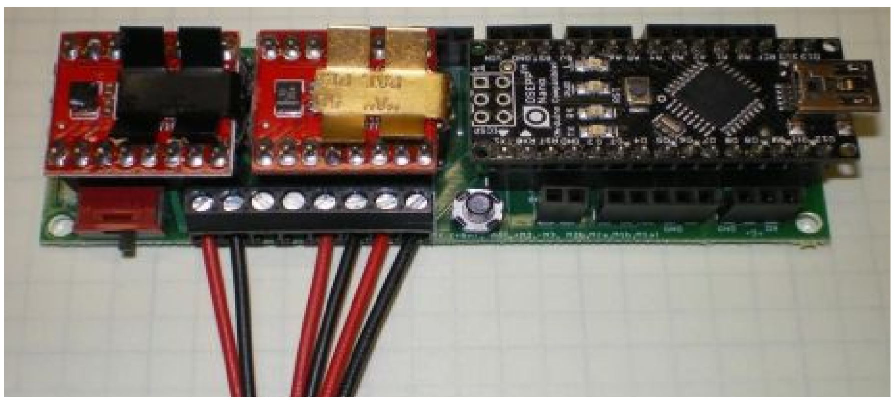
This lab has a been a challenge to create the most efficient, reliable, consistent AEV from analyzing results from research and development to performance tests. There were multiple components to consider during the design and testing of the AEV and using tools of analysis such as the scoring and screening matrices. The points of emphasis are safety, energy efficiency, speed, cost, and consistency. Throughout the process, data from tests were used to make design decisions and improve upon the AEV, focusing on the points of emphasis. During research and development, motor quantity and propeller configuration were tested to determine whether one or two motors using push and pull methods were more energy and time efficient. The main goal of this lab is to analyze results and data to build upon the design and approach at creating the most efficient and cost effective AEV.

Experimental Methodology

Preliminary R&D involved many basic steps to get used to the commands and materials being used. First the team created a code that ran the motors for a few seconds and turned off. Then, reflector sensors were tested by connecting their wires to the AEV arm and Arduino. They were tested by spinning the wheels and reading the feedback from the command window. The team started to develop their own ideas in preliminary R&D in which each team member drew up their own concept sketch of an AEV. In advanced R&D the team tested propeller configuration and motor quantity. Propeller configuration was tested by running two identical codes, one with both propellers thrusting from the back of the AEV for push and one with the propellers thrusting forward from the front of the AEV for pull. The runs were completed multiple times to confirm results. Motor quantity was tested by running code in which one or both motors were running. Tests were completed for each scenario: one motor push, one motor pull, two motor push, two motor pull. Results were compared to see which combination resulted in going the furthest distance on the least amount of energy.

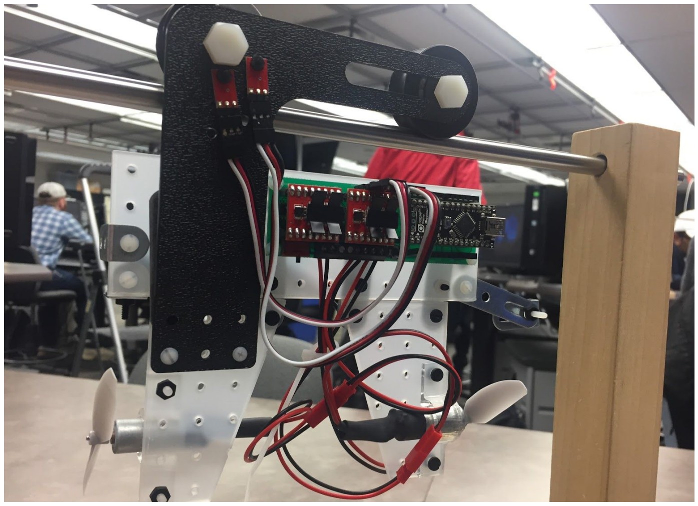
In performance test one the AEV needed to reach a gate and go through the gate. The AEV started behind a piece of red tape and had to move forward approximately 3 meters. Arriving to the gate, the AEV had to stop between sensors for 7 seconds to trigger the gate to open and then the AEV had to proceed through the gate. In performance test two, the AEV needed to compete everything that performance test one did but it also had to pick up a caboose at the opposite side of the track and move it out of the loading zone. Continuing from where performance test one left off, the AEV traveled down the back half of the track and connected to the caboose. The connection needs to be gentle because the front wheel of the AEV was not allowed to hit or go past the red tape. After connecting, the AEV needed to sit still for 8 seconds. After the wait, the AEV pulled the caboose out of the loading zone. The final performance test picks up from where performance test two left off. Continuing, the AEV needed to pull the caboose back to the gate and into the zone where the sensors were to trigger the gate. After sitting for 7 seconds, the AEV needed to travel through the gate and back to the starting zone. The AEV needed to land in a specific zone about 2 feet wide between two posts. At this point, once the AEV fully stops, the performance test would be completed.

Equipment used includes an AEV kit to build a custom AEV. In the kit, there were large plastic rectangles ranging from 2x6 inches to 3x6 inches. Likewise, there were small rectangles and trapezoids. Also included were clamps, screws, and hex nuts to hold all the pieces together. More specific equipment used includes an Arduino Nano, in which was the controller of the AEV, pictured below. The Arduino could connect to a computer via a USB cord so that commands could be loaded onto it. Wires attached to the Arduino connect to reflectance sensors



[Figure 9] Arduino Nano

that inform the Arduino of the AEV's position. The reflectance sensors also attach to the an arm that connect the base of the AEV to the wheels which lie on the track. The arm and wheels are both made of plastic, in which a basic set up is pictured below. Also connected to the AEV are

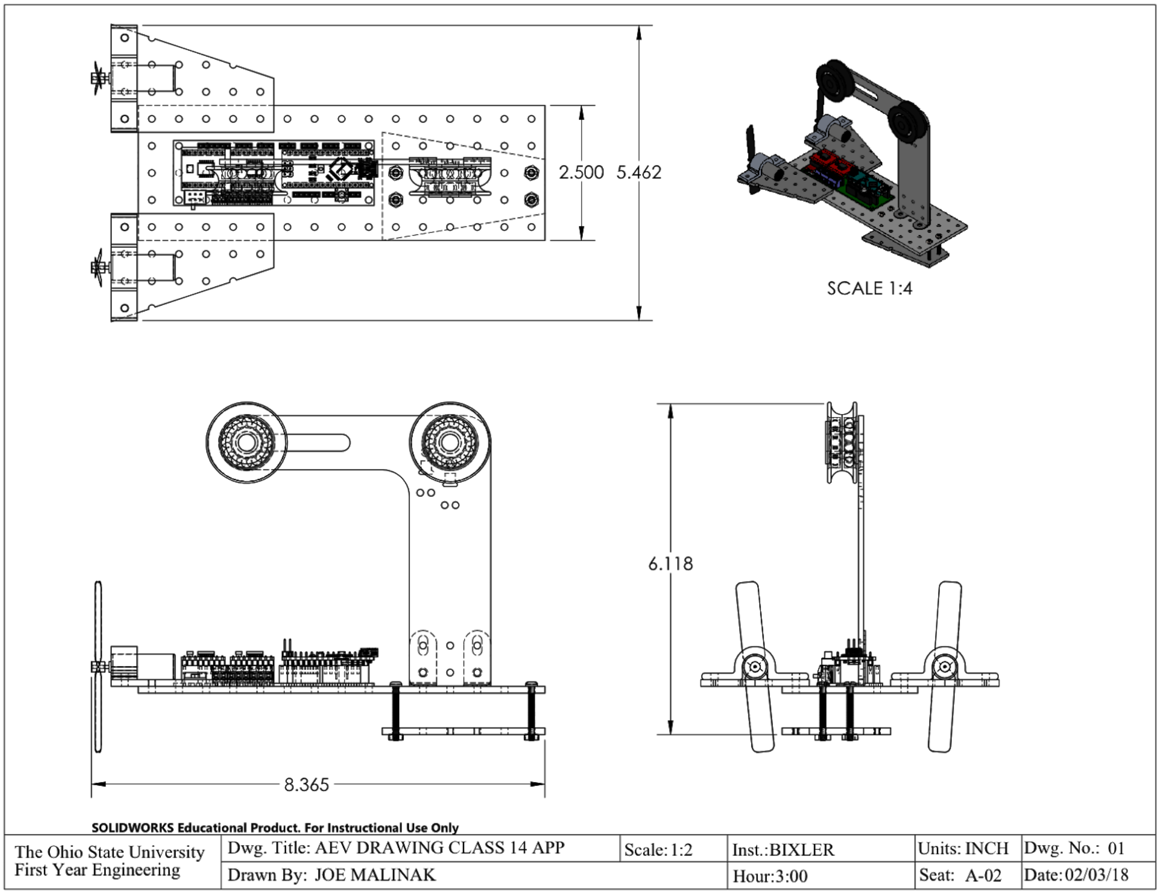


[Figure 10] Arduino with Reflectance Sensors on Arm with Wheels

ports for motors to be connected. The motors are round and metal and have a skinny metal rotating rod that plastic propellers coincide with, pictured in Figure 10. The AEV runs on a cylindrical metal track that travels only north-south. The track has a slight incline and decline on either side of the gate, located in the center.

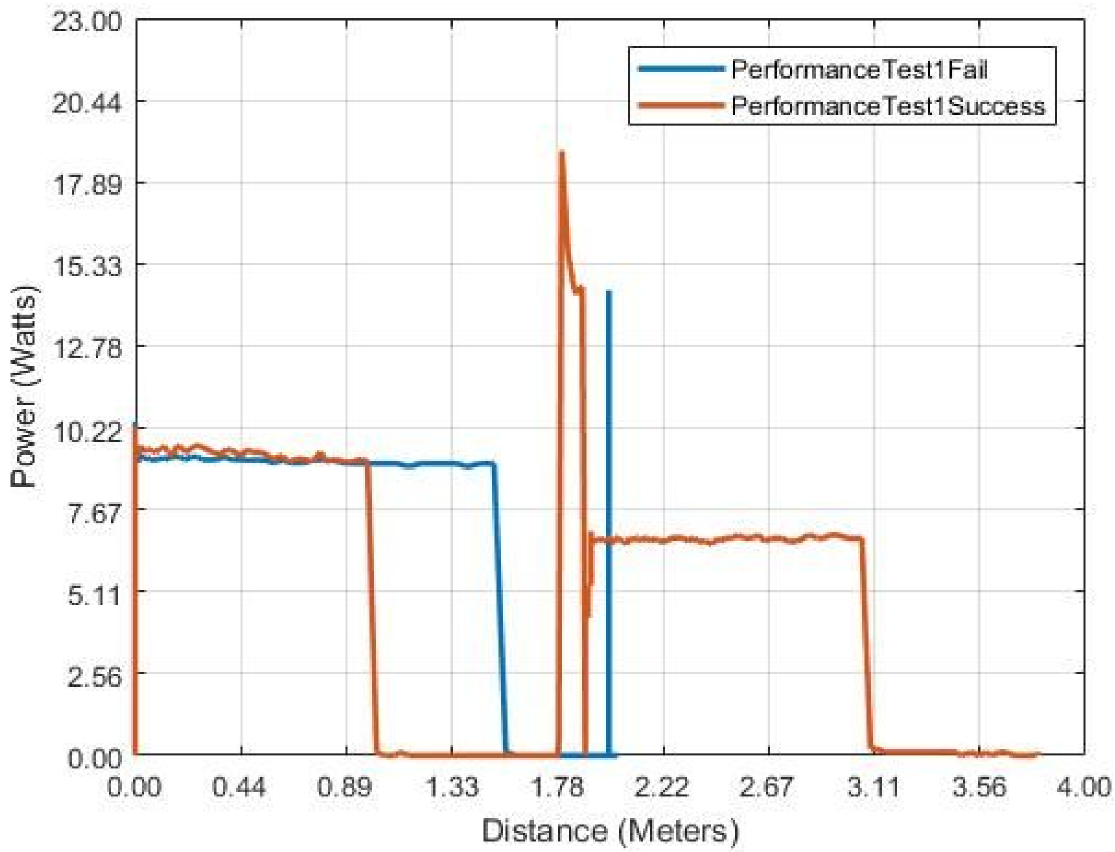
Results

During performance test one, team A tested two different AEV designs. The first design was made based off of original concept screening [*Chart 1*] and concept scoring [*Chart 2*] charts and lab work done in preliminary R&D. In the concept scoring chart, Jordan received a score of 3.45, outscoring the next best design by .3 points. The AEV was designed off of Jordan's sketch, made with the large rectangle, two right trapezoids jutting out either side on the rear, and the battery situated on the bottom, as shown on page 4 [*Figure 4*]. This design used two motors, both pushing from the rear. The AEV was very stable, safe, and had a lot of forward thrust. Also, the battery located under the large rectangle allowed for less swing when running and a more even distribution of weight. The design was heavy, long, and wide, considering it used the largest rectangle and had pieces coming out of each side. Attempting to complete performance test one with this design, the team concluded that there were problems with the design and that it could not be continued.



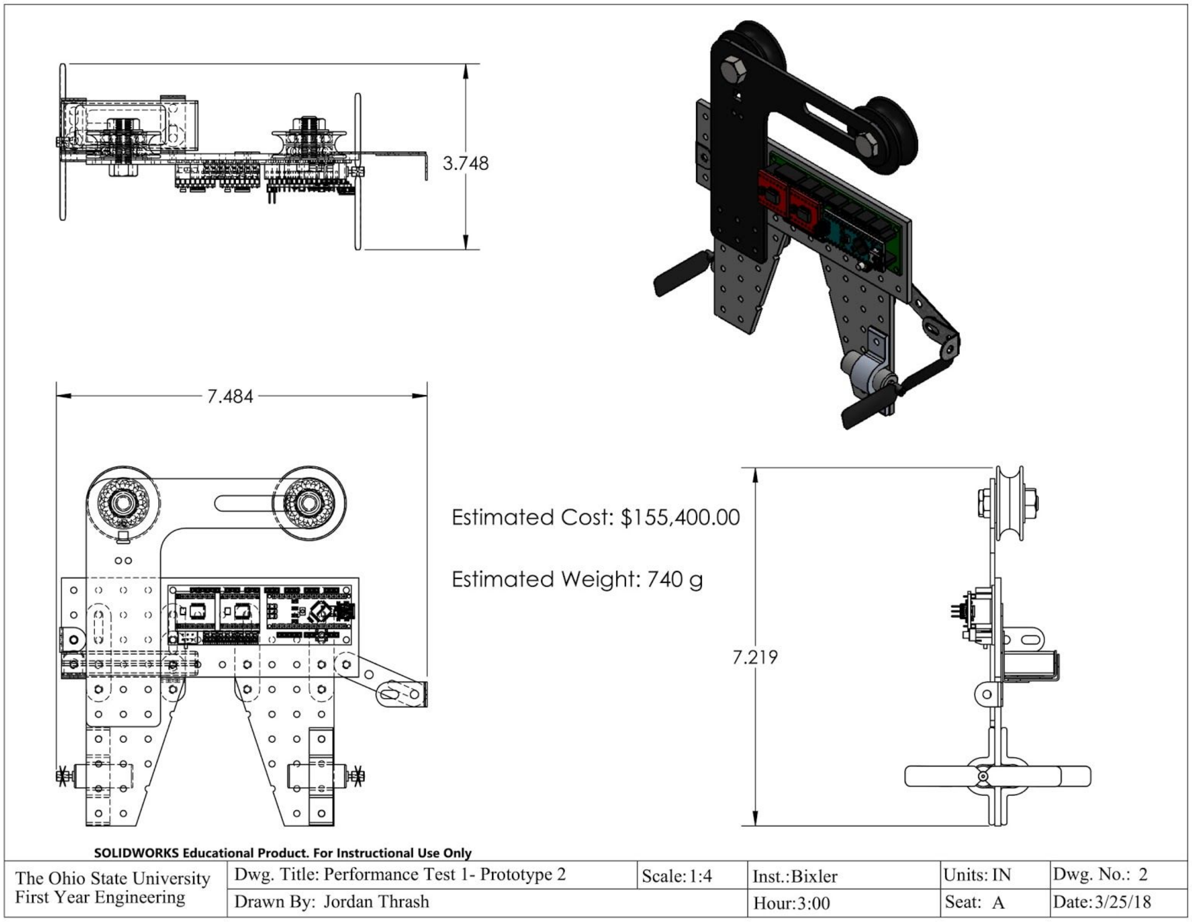
[Figure 4] Horizontal AEV Design

The problems included not being able to stop proficiently and being extremely inefficient when going backwards, due to both motors pulling. As shown in the power vs distance graph, shown below on page 5 [*Graph 1*], the run had to be discontinued because of the inability to stop and fact that it was going to overrun the stop gate in the waiting zone.



[Graph 1] Power vs Distance Graph for both AEV Designs

Team A made an alternate design primarily based off of preliminary and advanced R&D results. Testing proved that push propeller configuration was more powerful and efficient than pull. The testing was completed during advanced R&D and displayed the push motor configuration to go a distance of 3.75 meters [*Graph 3*], two times further than that of the pull configuration[*Graph 4*]. To utilize this, the team designed an AEV with one motor at the front and one motor at the rear. This design allowed for one motor to push forward for optimal speed and power usage in both directions. Also, it allowed for precision breaking, as the opposite end motor could run in the push direction and break the AEV effortlessly.



[Figure 2] Drawing of Vertical AEV Design

The new AEV created is small and lightweight. It utilizes the small rectangle hanging vertically with two right trapezoide hanging down on either side, which hold a motor, pictured above [*Figure 2*]. The battery and controller are fastened to the small rectangle. The new AEV design completed performance test one with no mistakes. It was able to able to stop on a dime due to the rapid push motion of the front motor, as shown in the power vs time graph [*Graph 2*].

The team expected that the first AEV design, based off of Jordan's design, would be the AEV that the team would stick with. When compared to other designs that other team members created, it proved to be the best. But, the weight and difficulty it had stopping was alarming. The performance test results were not what the team initially expected. With the new AEV, the team got results that were expected. The AEV was able to stop where it was supposed to and was able to stop quickly. But, the team did not expect the new design to be very wobbly. It was designed to be compact, with a center of gravity close to the rail to maximize stability. Instead, the AEV will swing if stopped fast or if set on a turn. More safety concerns have arisen with the new design.

For the final performance test, no additional changes were made to the construction of the AEV. All together the capital cost of the parts were $163,040. The run was completed with no problems or help needed from the team, receiving a score of 40/40. The AEV completed the first half of the run smoothly and just as planned, especially when it landed at the first gate in a position that the team expected. The caboose was picked up by the AEV gently and the front wheel did not go past or onto the red tape. The only part that looked like it may not work was entering the second gate, in which the AEV barely made it into the zone. The final stretch was completed by coasting down the back hill and lightly running into the back bumper, but staying within the parameters. The run was completed in 59 seconds as shown in the power vs time graph [*Graph 6*] , above the class average by 10 seconds. Finally, the run consumed 281 Joules, which was 62 Joules less than previous runs completed by the team. Altogether, the total cost came to a little over $600,000 giving the team a final score of 93.5%.

Discussion

Each team member's design was taken into consideration when choosing the final team designs. Jordan's[*Figure 5*] was narrow at the top with the propellers thrusting out of the back sides to catch more air. His battery was located under the AEV because it was the heaviest object to provide stability. Joe's[*Figure 6*] AEV was the same as Jordan's except the battery was located on the top side of the AEV. This design was rocky and very heavy in the rear. Tyler's[*Figure 7*] design was aerodynamic because the wings with propellers jutted up at a 45 degree angle. It was deemed very stable for being condense but also unsafe. Nick's[*Figure 8*] design also uses the 45 degree angled wings that center the thrust of the AEV. But Nick's design was also very unstable The horizontal design [*Figure 4*] was chosen based off of Jordan's high score on both the concept screening [*Chart 1*] and concept scoring [*Chart 2*] results. This did not result in much derivation because of the similarities that all four team members AEV's took. At the time, Jordan's design was the best due to its safety, stability, ease of assembly, ability to go forward, and made the most sense with the team's education at the time. Jordan received a score of 3.45 on the scoring chart, which was .3 higher than the second best. After advanced R&D, testing, and hearing other team's results, the team came up with a design that encompassed everything they had learned. Displayed as the vertical AEV design [*Figure 2*], the team used the small rectangle to reduce weight. Furthermore, the propeller configuration was decided based off of the results of advanced R&D; that push was much more efficient than pull. The team put one motor on each side so that pull could be used going forwards and backwards. The base and all of its parts are as close to the wheels as possible to allow for a smaller center of gravity. The vertical AEV takes into account everything that has been learned in preliminary R&D, advanced R&D, and through the teams personal testing of AEVs.

Based off of advanced R&D testing, it was expected that the vertical design would perform better. Having one propeller on either side did in fact enhance team A's performance.

While still being able to obtain a fast speed, the AEV was able to stop precisely. This is because of the motor on the front. The front motor was able to use push propeller configuration even though it was traveling in the opposite direction. This allowed for very efficient breaking and overall stopping of the AEV. This method worked even better than expected. This was put into the code by having the front motor push for just about one second. The horizontal AEV design's propeller configuration did not go as expected. Team A thought that the AEV would at least be able to come to a stop through breaking with the pull propeller configuration. Not enough thrust was allowed by the propellers, making the AEV glide past the sensors and into the gate.

During performance test one, both the old, horizontal AEV design was tested as well as the new, vertical design. The horizontal design had enough thrust but was not able to break. As shown in the power vs distance graph [*Graph 1*], the AEV went way past the point in which the team wanted it to stop. The AEV had to be stopped by a team member so that it would not hit the gate. This is shown by the large spike up at the 2 meter mark in which the line goes straight up and doesn't come down because it was taken off of the track. The vertical design was able to come to a screeching complete stop right at about the 1.85 meter mark. As shown by the large spike up in the graph [*Graph 1*], where breaks were used and the AEV stopped. The power vs time graph [*Graph 2*] shows very similar readings. This is because a similar code was used, and it does not depend on the movement of the wheels and therefore couldn't tell when the AEV was taken off of the tracks. This graph is not very helpful in our deduction of which AEV performed better due to the constraint that comes with using time as a variable.

Performance test two did the exact same thing that performance test one did but continued down the track and ran into the caboose. The team had to make a connector that extended out and reached the caboose that also would not interfere with the front propeller. Even though the AEV came in very fast and slammed into the caboose, the caboose stayed connected showing how strong the magnet was. Likewise, the team was able to deduct that they could go down the back half of the track slower and coast to save energy and conserve speed for future runs. The AEV was also able to pull the caboose out of the loading zone with no problem showing that the AEV had enough power. One test was completed with both motors running the whole time and averaged 12 Joules of energy. Another test was completed in which the front motor, which pulled, was disconnected. The run was completed successfully all the way through. This enlightened the team that only one motor needed to be used for the first half of the final run, cutting that energy usage in half! Using only one motor for performance test two aided the team in concluding that push configuration was far more powerful and energy efficient.

The final performance test was completed with no marks taken off. The AEV made it to the first gate and landed in the spot that was expected by the team. Continuing slowly down the back half of the track and braking, the AEV barely connected to the caboose, allowing the front wheel of the AEV to stay behind the red tape line. Returning to the bate, the AEV barely made it to the very edge and was able to trigger the sensor. In previous runs the AEV was very consistent to making it to the middle of the second gate. The team thinks that battery power available effected where the AEV landed for the second gate. After proceeding through the gate the AEV ran into the bumper and bounced back, but was still able to stay in the zone. The team was very happy with using 281 Joules because when both motors were being used the run consumed 341 Joules. The time of the run could not be improved without adding additional energy, which wanted to be avoided by the team. The final performance test results show how the team was able to adapt to research found throughout the experience and put it toward making the most energy and time efficient AEV.

The team encountered many errors along the way that affected each run of the AEV. First of all, the horizontal design used power and go for commands while the vertical vehicle that worked used absolute position commands. This creates different variables and different errors. For example, the specific battery used would affect the run of the horizontal design because of the amount of power going to the motors. Some runs would go too far, while others came up very short even though the same code was used. Errors were also created through the use of different rooms. Room 308 had a more slick track and therefore needed more power added to the code. Also, the absolute position code needed to be adjusted. There were errors that were uncontrollable by the team that made each run different and not at all consistent. In order to minimize errors, the team decided to use the absolute position command. With the absolute position command, the AEV worked more precisely and became slightly more consistent. The team was able to solve the problem of track variance from room to room by creating a seperate code for each room. Human errors were also present. For example, if a team members hand was behind one of the propellers upon starting, the AEV would travel a shorter distance. Similarly, if the AEV was swinging upon start at all, it would travel a shorter distance. This problem was solved by making sure the AEV wouldn't fall by watching it from the bottom and by keeping the AEV steady upon start.

Conclusion & Recommendations

Throughout the whole design and testing process, our AEV design and performance has only improved by fixing mistakes in code and eliminating flaws in design. The research development led us from the horizontal model to the vertical model with a motor on each side because utilizing the push method for both directions makes stopping the AEV more efficient. According to graph 3 and 4, the push configuration could go farther using the same amount of power as the pull method. Which in turn, makes vertical model faster, but is also safer, and more stable than the horizontal design. Another huge obstacle that was overcome during testing was inconsistency. Instead of using power and go method, absolute position was a lot more consistent, which was utilized on the vertical design. Making that improvement on the code decreased the error and allowed us to complete performance test one and two. Throughout the process of testing and improving on the AEV, eliminating error was crucial in the development of the vertical design and new code. The Final Performance test was a real challenge to complete the run in the most efficient way to drive the cost down. The plan involved more coasting to save energy, and our second method to save money was to start the motors slightly early during breaks to make our runs faster. Using the plan to save money, the energy was minimized by 60 joules. The final run finished with a time of 63 seconds and 281 joules, which was decreased from the initial run that used 341 joules.

Team A recommends using a push propeller configuration and a single motor on each side to utilize push motor for going both directions. The vertical design has proven through tests that it is safer, more efficient, and faster than the horizontal model, which used two motors with a pull method for one direction and a push for the other. The motors were the main source of error because they tend to delay to start or even not run at all during tests. If better motors and connectors were available that would be able to engage instantaneous to the start of the code, the test runs would be more consistent. Overall the research development and performance tests have led to a more time and energy efficient AEV.

References

Works Cited

The Ohio State University Advanced Energy Vehicle Design Project Mission Concept Review and Deliverables.

The Ohio State University Advanced Energy Vehicle Design Project Lab Manual Preliminary Research and Design.

The Ohio State University Advanced Energy Vehicle Design Project Advanced Research and Development and Performance Tests.

AEV Lab Manual. Arduino Programming Basics. u Osu.edu. April 19th, 2018. https://u.osu.edu/engr118204spr2016groupc/executive-summaries/executive-summary-2/

Appendix

Charts

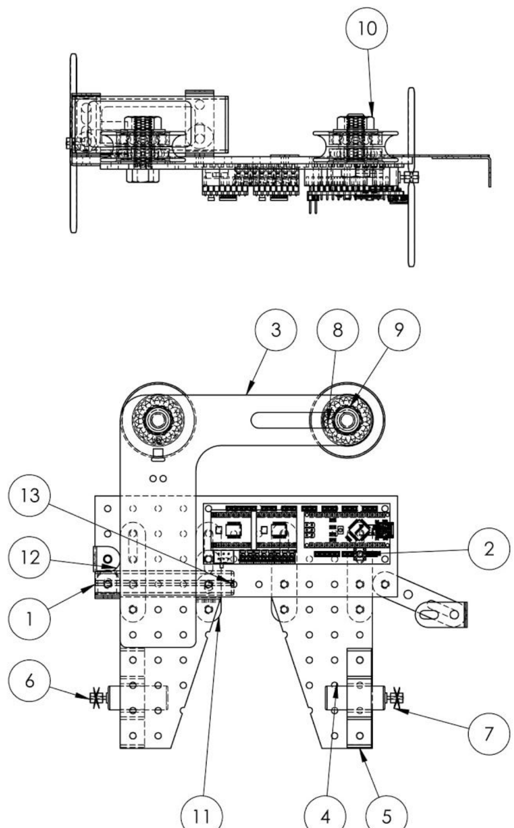
Success Criteria	Refernce	Joe's Design	Tyler's Design	Jordan's Design	Nick's Design
Stability	0	0	(-)	(+)	(-)
Minimal Blockage	0	0	(-)	(-)	0
Maintenance	0	(-)	(+)	0	(+)
Durability	0	0	0	0	0
Safety	0	(+)	0	(+)	0
Sum +	0	1	1	2	1
Sum 0	5	3	2	2	3
Sum -	0	1	2	1	1
Net Score	0	0	-1	1	0
Continue?	combine	revise	no	yes	revise

[Chart 1] Concept Screening Chart for Team A's Original Designs

		Reference		Joe's Design		Tyler's Design		Jordan's Design		Nick's Design	
Success Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Stability	25%	3	0.75	3	0.75	2	0.5	4	1	2	0.5
Minimal Blockage	10%	3	0.3	3	0.3	2	0.2	2	0.2	3	0.3
Maintence	15%	3	0.45	2	0.3	4	0.6	3	0.45	4	0.6
Durability	20%	3	0.6	3	0.6	3	0.6	3	0.6	3	0.6
Safety	30%	3	0.9	4	1.2	3	0.9	4	1.2	3	0.9
Total Score			3		3.15		2.8		3.45		2.9
Continue?			No		Develop		No		Develop		No

[Chart 2] Concept Scoring Chart for Team A's Original Designs

Figures



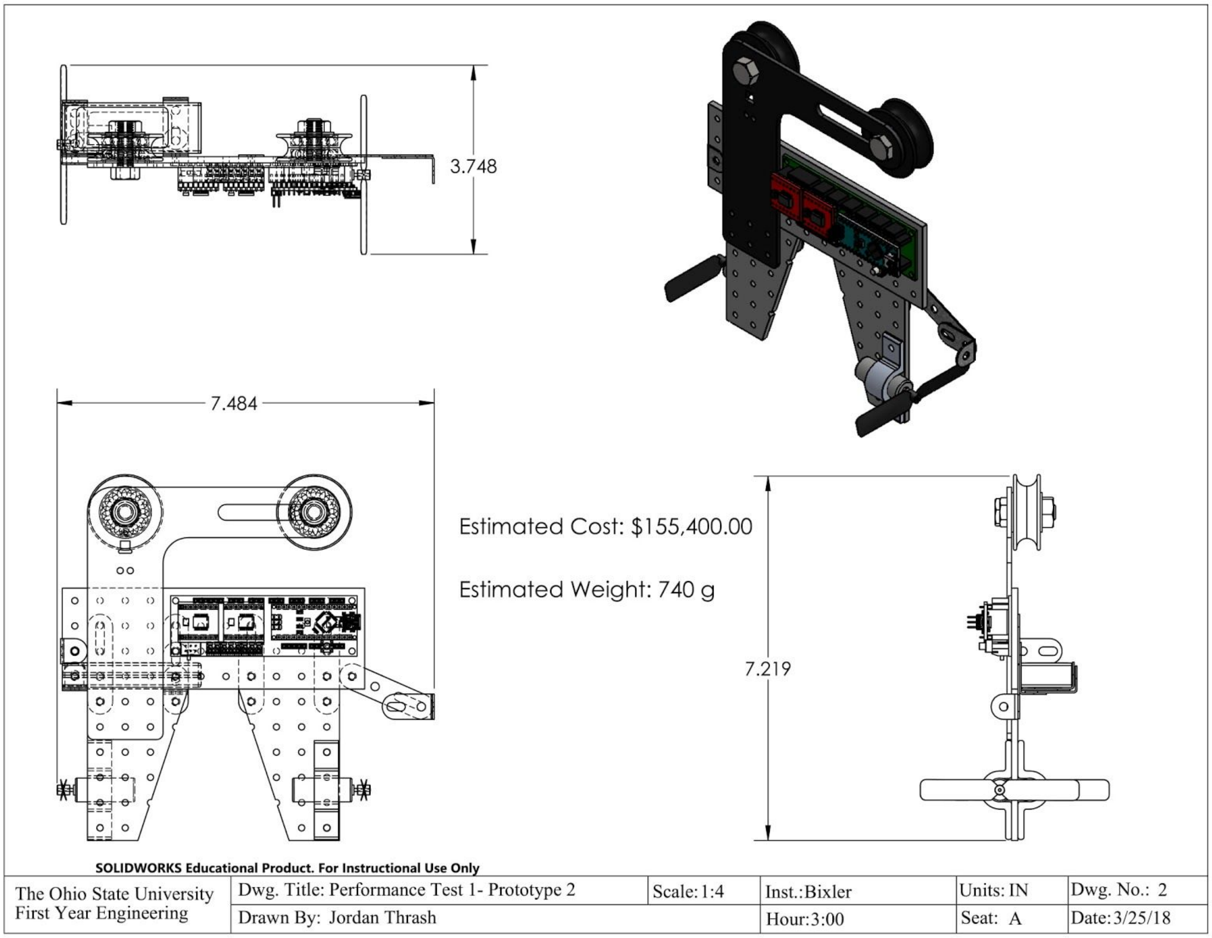
ITEM NO.	PART NUMBER	QTY.
1	Medium Rectangle	1
2	AEV Arduino Assembly	1
3	Support Arm 2 ABS	1
4	Right Trapezoid	2
5	Motor Mount Clip Aluminum	2
6	AEV Motor	2
7	Prop 3inch	2
8	Pulley Assembly	2
9	HBOLT 0.3125-18x0.875x0.875-S	2
10	MSHXNUT 0.3125-18-S-S	2
11	flat bracket	5
12	90-deg bracket	6
13	Battery Pack	1

Estimated Cost: $155,400.00

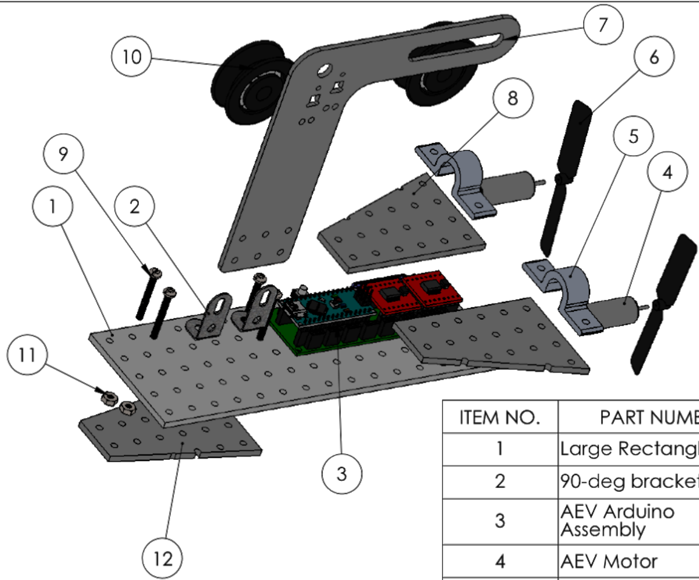
Estimated Weight: 740 g

The Ohio State University First Year Engineering	Dwg. Title: Performance Test 1- Prototype 2	Scale: 1:4	Inst.: Bixler	Units: IN	Dwg. No.: 1
	Drawn By: Jordan Thrash		Hour: 3:00	Seat: A	Date: 3/25/18

[Figure 1] Drawing and BOM for Vertical Design



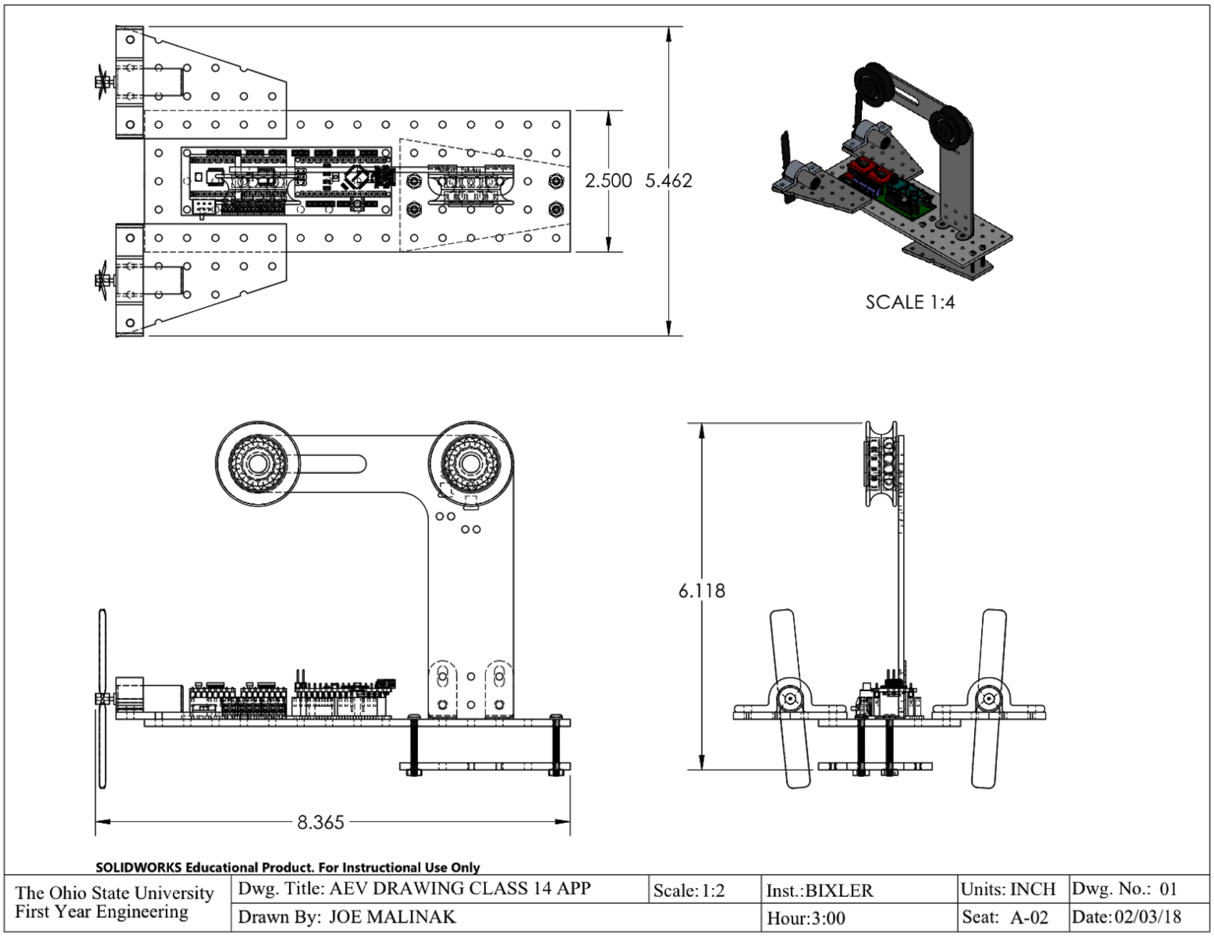
[Figure 2] Drawing of Vertical AEV Design



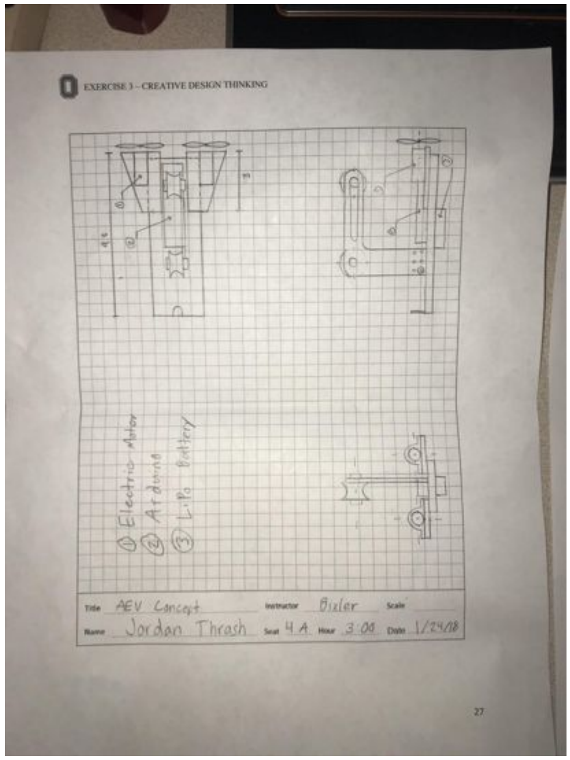
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	Large Rectangle	Plastic	1
2	90-deg bracket	Metal	2
3	AEV Arduino Assembly	Various	1
4	AEV Motor	Metal	2
5	Motor Mount Clip Aluminum	Plastic	2
6	Prop 3inch	Plastic	2
7	Support Arm 2 2 Sensor Holes	Plastic	1
8	Right Trapezoid	Plastic	2
9	pan slot head_ai	Plastic	4
10	Pulley Assembly	Plastic	2
11	machine screw nut hex_ai	Plastic	4
12	Trapezoid	Plastic	1

The Ohio State University First Year Engineering	Dwg. Title: EXPLODED AEV GROUP A	Scale: 1:2	Inst.:BIXLER	Units: INCH	Dwg. No.: 02
	Drawn By: JOE MALINAK		Hour:3:00	Seat: A-02	Date:03/03/18

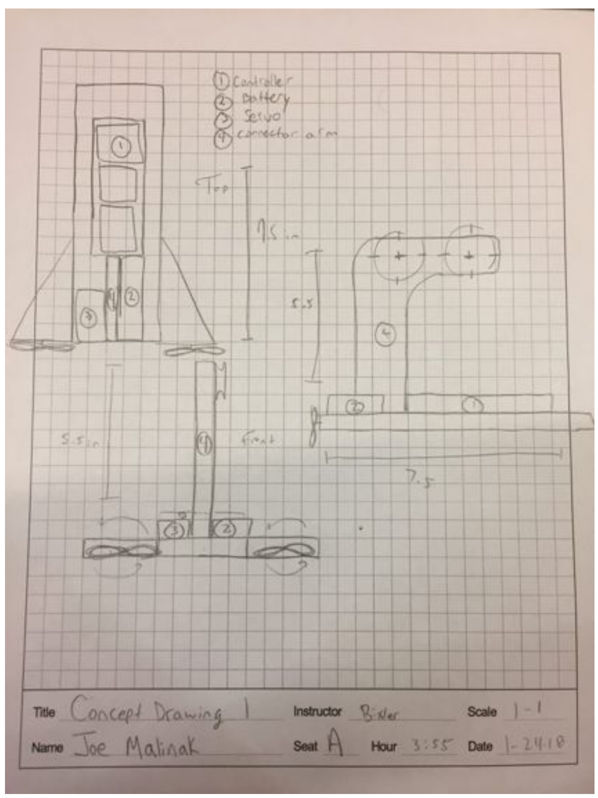
[Figure 3] Exploded View and BOM of Horizontal AEV Design



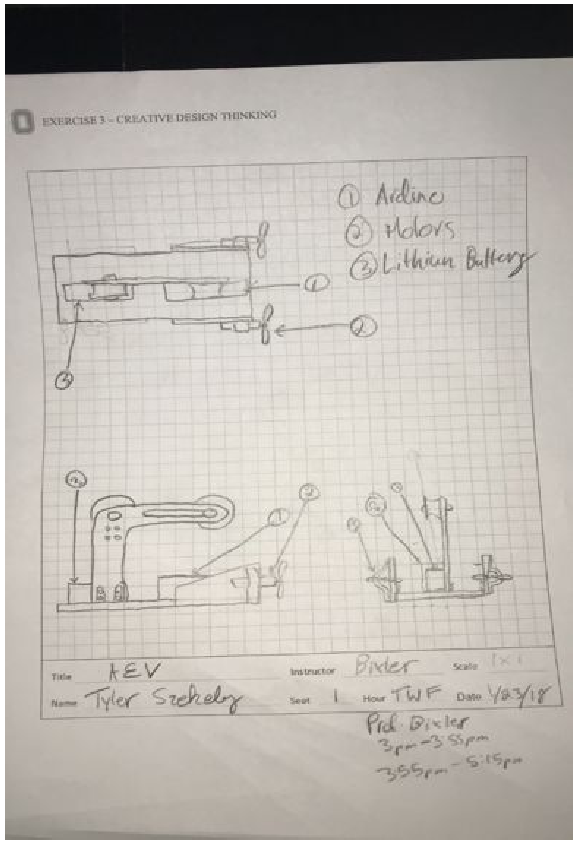
[Figure 4] Drawing of Horizontal AEV Design



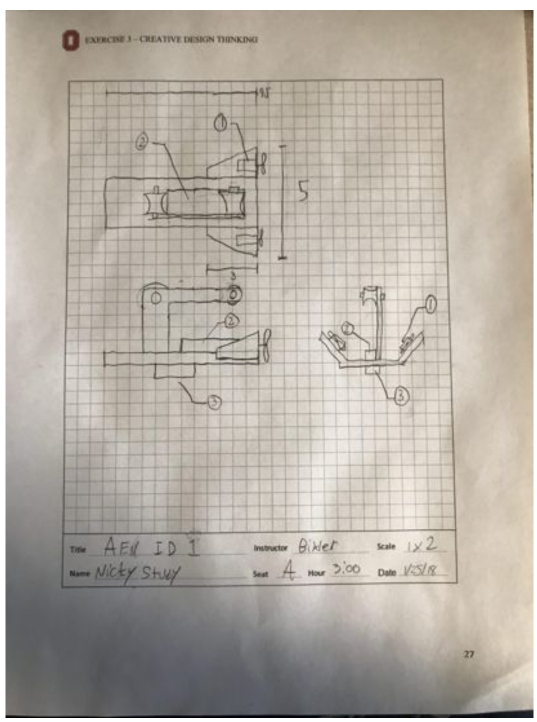
[Figure 5] Jordan's AEV Concept Sketch



[Figure 6] Joe's AEV Concept Sketch

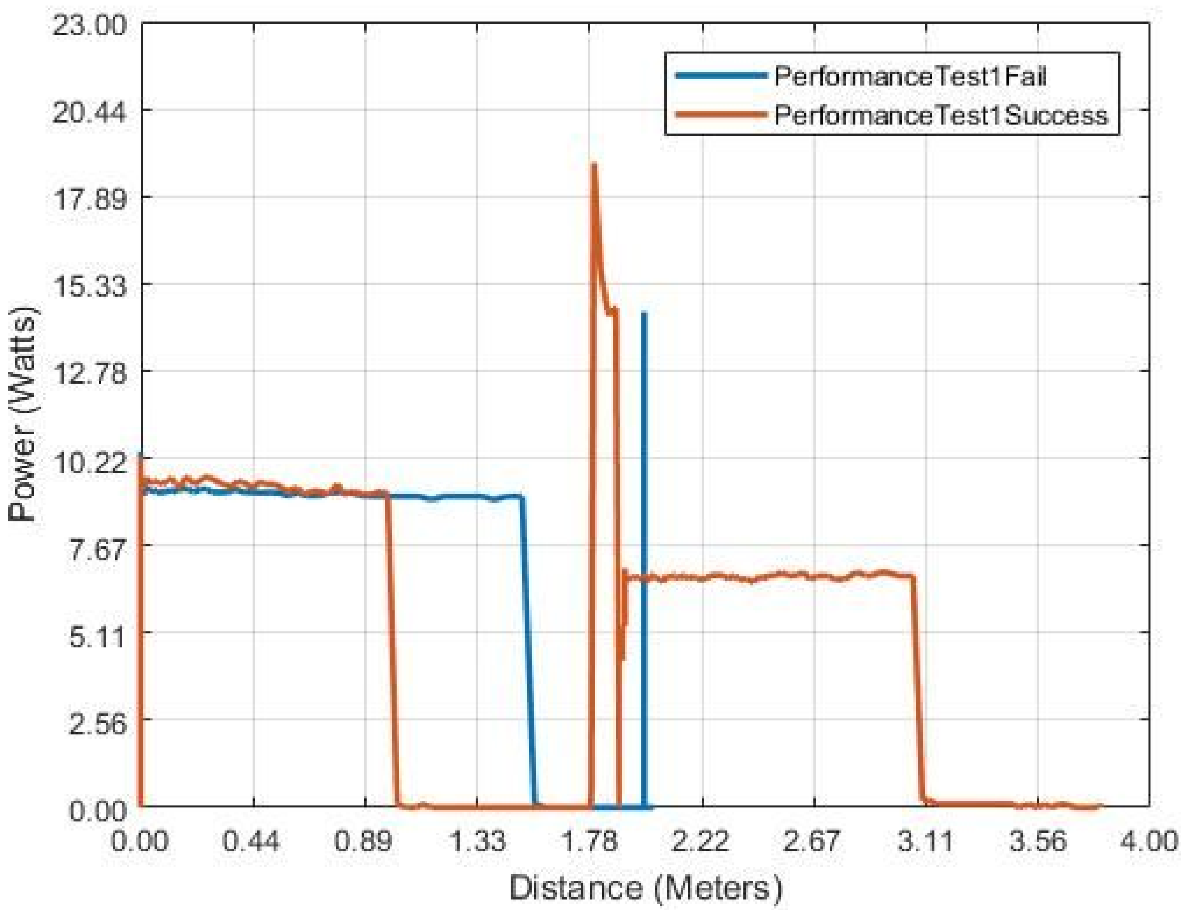


[Figure 7] Tyler's AEV Concept Sketch

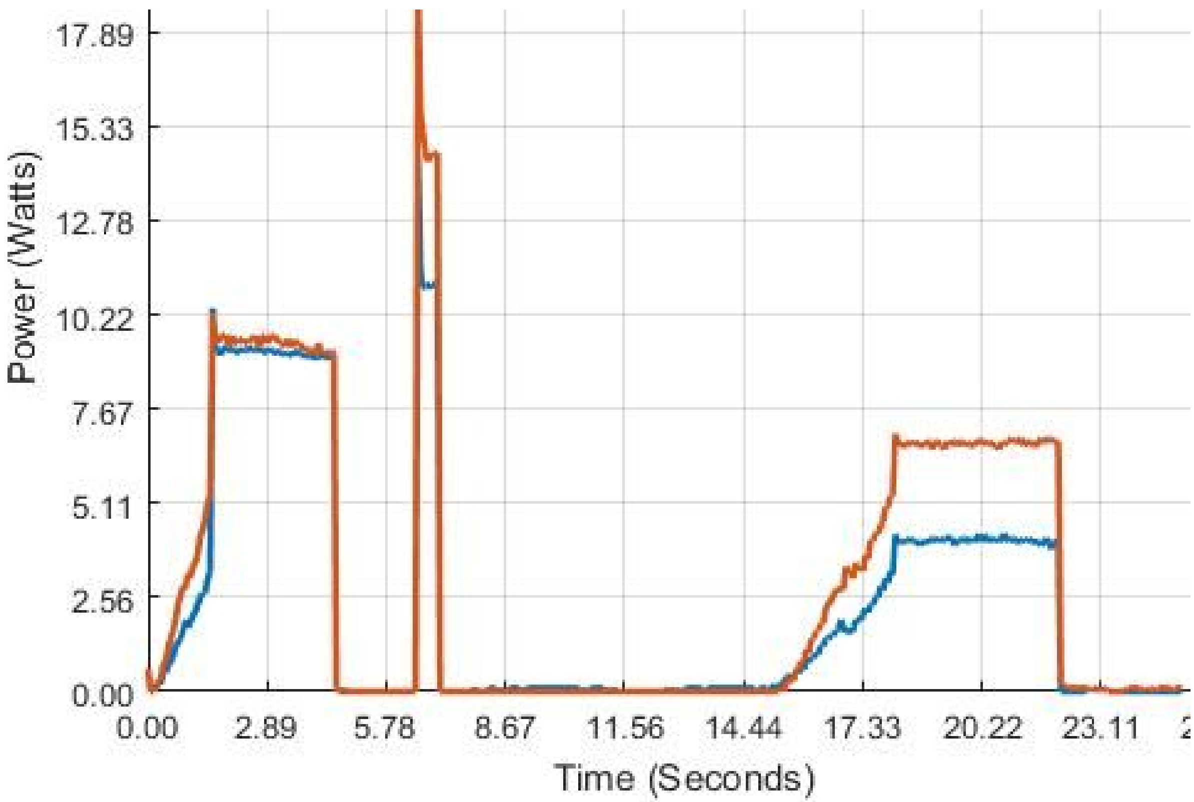


[Figure 8] Nicky's AEV Concept Sketch

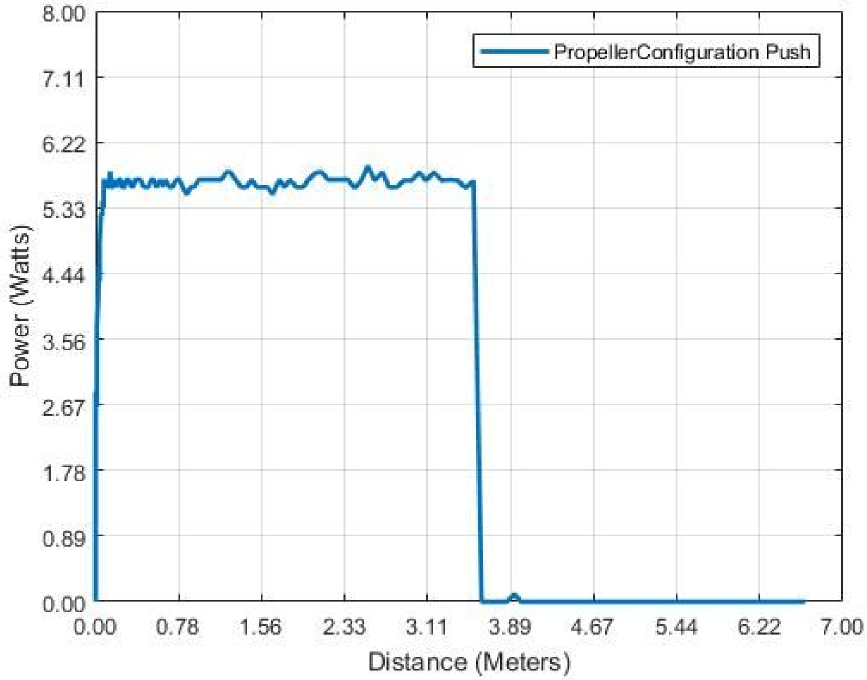
Graphs



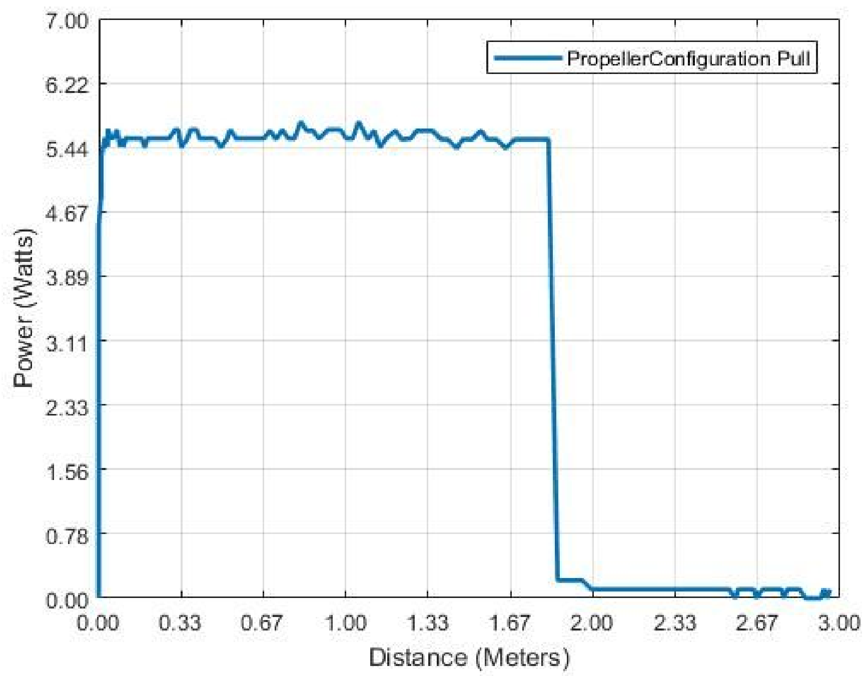
[Graph 1] Graph of Power vs Distance for both AEV Designs



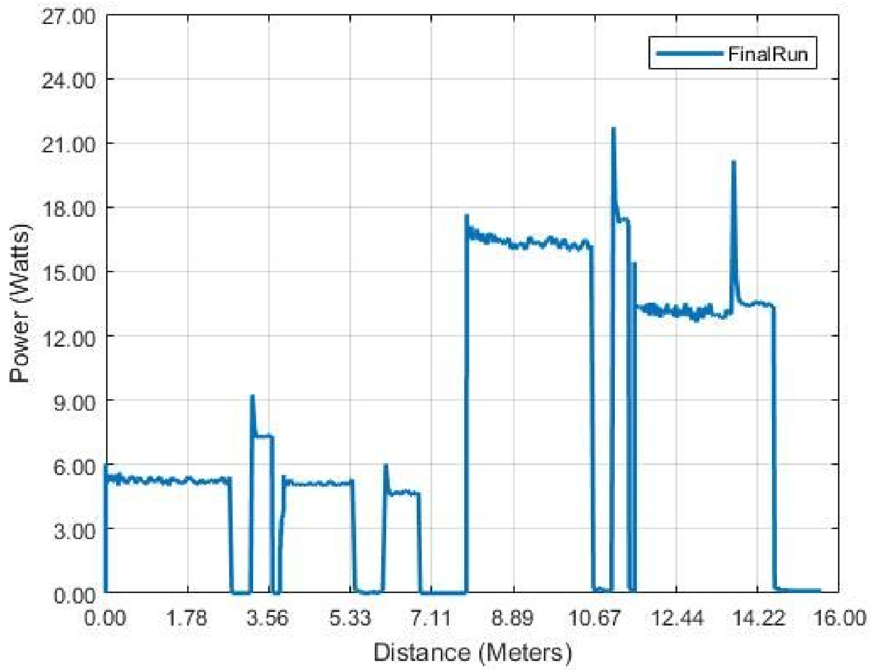
[Graph 2] Graph of Power vs Time for both AEV Designs



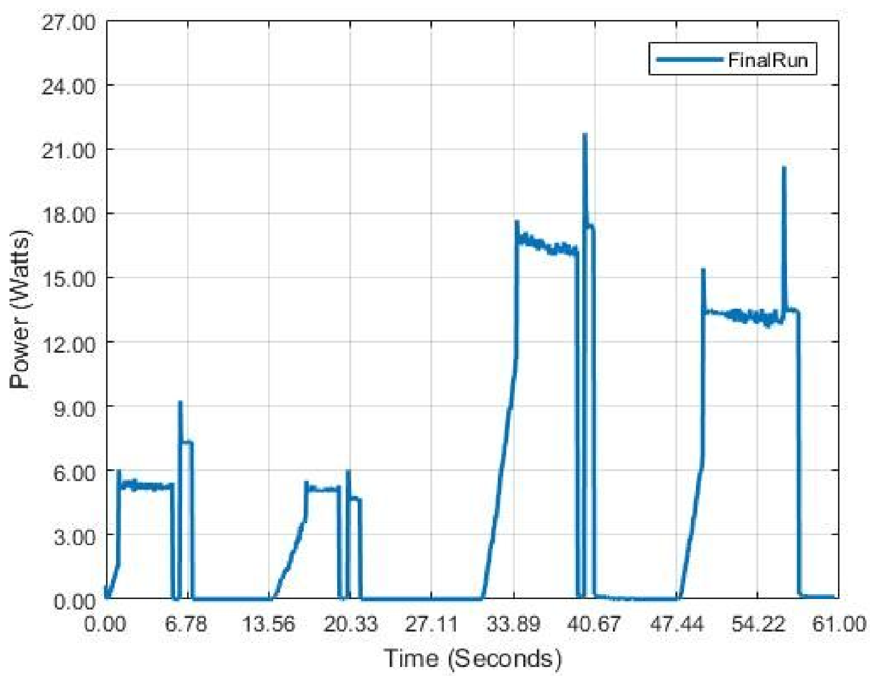
[Graph 3] Graph of Power vs Distance for Push Propeller Configuration Test



[Graph 4] Graph of Power vs Distance for Pull Propeller Configuration Test



[Graph 5] Graph of Power vs Distance for Final Performance Test



[Graph 6] Graph of Power vs Time for Final Performance Test

Code

Performance Test 1

```
 //accelerate up the track and cut power at top
celerate(4,0,40,1.5);
motorSpeed(4,40);
goToAbsolutePosition(-220);
motorSpeed(4,0);
goToAbsolutePosition(-236);

//stop at the gate and wait for 7 seconds
reverse(4);
motorSpeed(4,80);
goFor(0.55);
brake(4);
goFor(8);

//proceed through gate
reverse(4);
celerate(4,0,30,3);
goToRelativePosition(-200);
reverse(4);
motorSpeed(4,40);
goFor(.5);
```

Performance Test 2

```
 //accelerate to the top
celerate(4,0,40,1);
motorSpeed(4,40);
goToAbsolutePosition(-220);
motorSpeed(4,0);

//roll to gate and brake
goToAbsolutePosition(-264);
reverse(4);
motorSpeed(4,80);
goFor(0.55);
```

```
brake(4);
goFor(8);//stop at the gate

//proceed through gate
reverse(4);
celerate(4,0,40,3);
motorSpeed(4,40);
goFor(2.75);
motorSpeed(4,0);
goToAbsolutePosition(-520);

//slow down before connecting to caboose
reverse(4);
motorSpeed(4,25);
goFor(.6);
motorSpeed(4,0);

//wait for 5 then pull caboose
goFor(10);
celerate(4,0,60,2);
goFor(4);
```

Final Performance Test

```
//accelerate to the top
celerate(2,0,40,1);
motorSpeed(2,40);
goToAbsolutePosition(-220);
motorSpeed(2,0);

//roll to gate and brake
goToAbsolutePosition(-275);
reverse(4);
motorSpeed(2,60);
goFor(1);
brake(4);
goFor(6.5);//stop at the gate

//proceed through gate
```

```
reverse(4);
celerate(2,0,40,3);
motorSpeed(2,40);
goFor(2.75);
motorSpeed(2,0);
goToAbsolutePosition(-490);

//slow down before connecting to caboose
reverse(4);
motorSpeed(2,35);
goFor(1);
motorSpeed(2,0);

//wait for 5 then pull caboose
goFor(10);
celerate(4,0,75,3);
motorSpeed(4,75);
goToRelativePosition(220);
motorSpeed(4,0);

//roll to gate and brake
goToRelativePosition(35);
reverse(4);
motorSpeed(4,80);
goFor(0.75);
brake(4);
goFor(6);//stop for 7 seconds

//go through gate and return to the start
reverse(4);
celerate(4,0,60,2);
goToRelativePosition(10);
goToRelativePosition(155);
reverse(4);
motorSpeed(4,35);
goFor(1.25);
```

Schedule

Task	**Start Date**	**End Date**	**% Complete**	**Members**	**Description**
Preliminary lab 1	1-16	1-16	100%	All members	Get familiar with coding and materials
Website update	1-15	1-18	100%	All members	Tyler-Team meetings, Nick-contact info, Joe, Jordan-new pages
Preliminary lab 2	1-16	1-23	100%	All members	Reflectance sensors, basic run
Preliminary lab 3	1-23	1-30	100%	All members	Each member create design for AEV
Preliminary lab 4	1-30	1-30	100%	All members	Joe, Nicky-Assemble AEV and Jordan, Tyler-collect run data
Website update 2	1-24	1-30	100%	All members	Tyler-Update meeting minutes Joe, Nick, Jordan-add all pR&D info
Preliminary lab 5	1-30	2-07	100%	All members	Analyze whole teams designs
Progress report 1	2-04	2-07	100%	All members	Joe- forwards looking plan

					Nick, Tyler-backwards looking plan Jordan-appendix
Advanced R&D	2-07	2-12	100%	All members	Motor configuration, propeller configuration
Grant proposal	2-14	2-14	100%	All members	New base to be made and presented to class with slide
Committee meeting 1	2-14	2-14	100%	All members	Joe- R&D, Jordan-HR, Nick, Tyler-PR
Website update 3	2-20	2-28	100%	All members	tyler-Meeting minutes Joe, Nick Jordan- add all advanced R&D info
Oral presentation 1	2-22	2-28	100%	All members	Slides and presenting on aR&D
Progress report 2	3-04	3-07	100%	All members	Joe- forwards looking plan Nick, Tyler-backwards looking plan Jordan-appendix
Performance test 1	3-07	3-18	100%	All members	Run AEV to first gate

CDR draft	3-20	3-22	100%	All members	Joe- Results, Discussion, Abstract Tyler-conclusion Nick-methodology Jordan-intro
Performance test 2	3-22	3-28	100%	All members	Go pick up caboose
Final performance test	3-28	4-13	100%	All members	Full run and full testing with times
Final oral presentation draft	4-15	4-15	100%	All members	Make slide draft with notes
Final oral presentation	4-15	4-18	100%	All members	Final run and progress present to class
Final website update	4-17	4-20	100%	All members	Tyler- meeting minutes Nick-video Jordan-add code Joe-format and write
CDR	4-16	4-20	100%	All members	Joe- Results, Discussion, Abstract Tyler-conclusion Nick-methodology Jordan-intro