To: Dr Janiszewska

From: Ian Claggett, Ed Doerring, Stuart Fanko (Group Jasper)

Subject: ENGR 1182.01

Date: April 6, 2021

Executive Summary:

The purpose of this lab was to design and test two different AEV designs and to compare the data collected from the runs to deduce stronger traits and variables that make an AEV more efficient, lightweight, and consistent. Utilizing data from previous labs and designs, the AEV saw several changes to the design to create a much stronger and refined AEV than the initial design. From there, the changes could be implemented and melded with the positive designs of the initial AEV to create the strongest and most reliable body for the half track run. Once the design is refined and produced, the code would be altered and refined to allow for an accurate and consistent track run every time the vehicle is to travel its course on the railway. From here, fine tuning would be implemented to the code and to the designs to create the most energy efficient design as possible through trial and error adjustments to find which program performs the best.

The AEV is required to transport tourists along a monorail within a park to the most interesting spots of the attraction. However, the design is required to use as minimal power as possible to reduce any chance that the vehicle may run out of power and leave the tourists stranded in the wild. The scaled-AEV requires a focus on energy management, operation efficiency, and operational consistency. These three factors govern the designs implemented and the adjustments created so that the final AEV design would fit the requirements given by the contractor to complete the request. The track also has several inconsistencies due to its design, and thus requires the AEV to be able to adapt and control itself while traversing the entirety of the track. Meaning the AEV must not ever fall off the track or lose parts of itself while completing its travel around the parks. The designs implemented within the final design account for this in several ways. First, the design features a consistent balance of weight and equilibrium so that the AEV will not dislodge itself from the track. This has been a focus for the design process since the initial design, and continues to be a centralized focus. The weight being in the middle of the design and on the hook allows the AEV to travel across turns and inclines without removing itself from the track. The design also features a twin-wing design, having propellers on both sides of the vehicle. This allows for an equal thrust of the vehicle and centralized propulsion which benefits the AEV greatly while traveling across turns on the track. The AEV final design and program meets the first requirement of energy management, by utilizing inclines to propel the vehicle forward without redundant use of energy. It also meets the third requirement: operational consistency. The vehicle experiences little to no issues while traveling the track, and never dislodges itself on the curve of the track. However, the second requirement of energy efficiency is still in the progress of being implemented into the final code. While the final design is much more efficient than the Indefatigable design, it can still see several improvements to the programming to allow for the most efficient design. Overall, the final design meets the expectations given by the lab and the contractor, and allows for a safe and efficient method of transporting tourists from one attraction to another within the park without fear of incident or accident.

Introduction:

After finishing the first design of the AEV and going through testing, a second design was drawn and constructed. After testing this and collecting data, the second design is compared to the first and reviewed to see which one would be more optimal to use for the remainder of the project. Things that are looked at are power efficiency and better implementation of design to make the AEV easier to use.

Results:

The first of the final designs drafted was the indefatigable design. This design presented a dual wing design which would place propellers equally on both sides. The hook for the track would be placed in center, with the battery attached to the back and the arduino motherboard attached to the front of the AEV. It mimicked design 2, having a dual propeller setup on both sides of the aev, allowing for a strong propulsion of the aev as well as a balanced and equal thrust. As well as having the weight centered similar to the first design of the AEV, it drew from all of the designs to construct an efficient and centralized model for the final design of the AEV. It is due to the balance of the AEV and weight distribution in regards to the hook for the track that allows it to steadily stay on the track for the entirety of the run. It is also due to this design that allows for efficient repair and programming adjustments so that the AEV experiences little to no disturbances while accounting for different variables and situations which may arise as the AEV travels along the half track. Overall, the design was a very safe and stable choice for beginning the design for the AEV, and provided a draft of code which could be adjusted easily to whichever new design would be created.

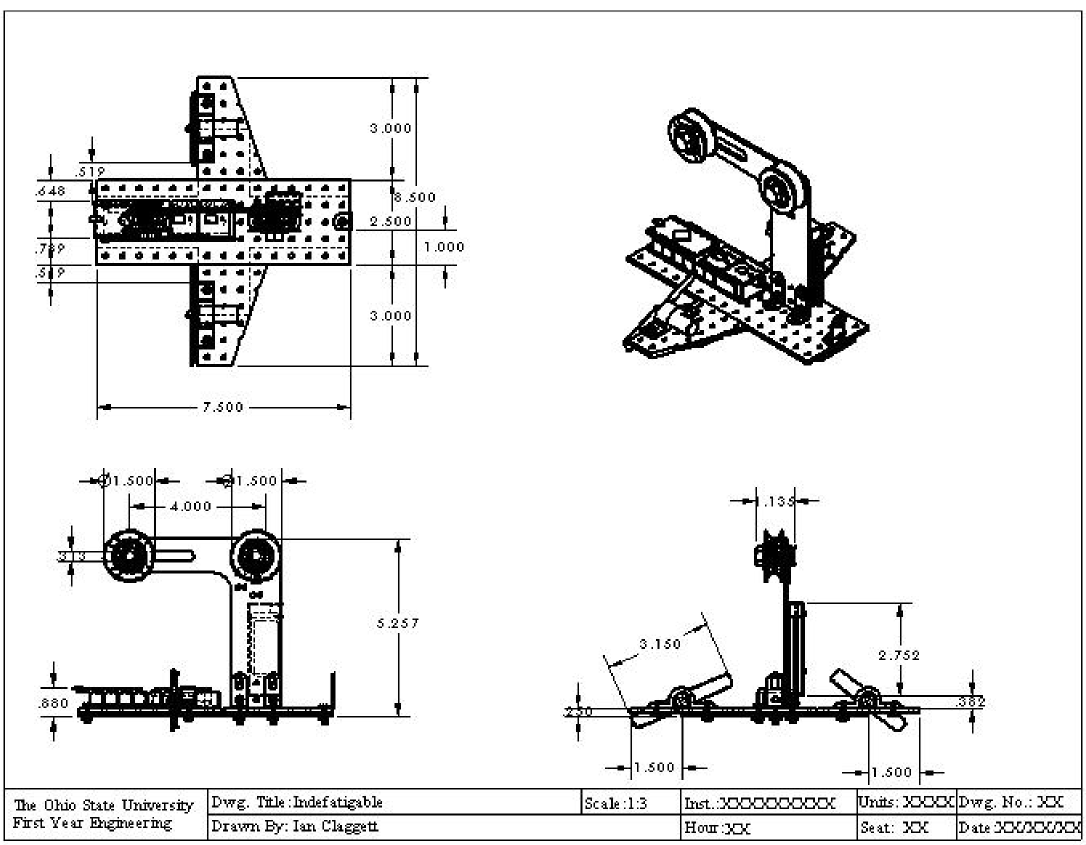


Figure 1: The Indefatigable design, the final design created after several adjustments, and the first of the final designs produced for the experiment.

The second of the final designs drafted is the T-shape design. The T-shape puts the battery and hook of the AEV on the back, with the arduino chip facing the front bottom of the AEV. The design also features two propellers on both sides of the AEV, allowing for an equal propulsion similar to the first final design. Utilizing the Indefatigable design, the T-shape design was drafted to be much lighter and more efficient while performing the half track run. There was considerably less material used to construct this design, and at the expense of space the design was much lighter and faster than the previous design. With several adjustments given to the design, the AEV was almost immediately available to run the entirety of the track due to the similarities between the Indefatigable and the T-shape. The second design also utilized a centralized weight system on the AEV, allowing for an equal distribution of weight along the entirety of the AEV. This would guarantee that the AEV would not encounter any sharp turns or speed issues which may cause the AEV to dislodge itself from the track.

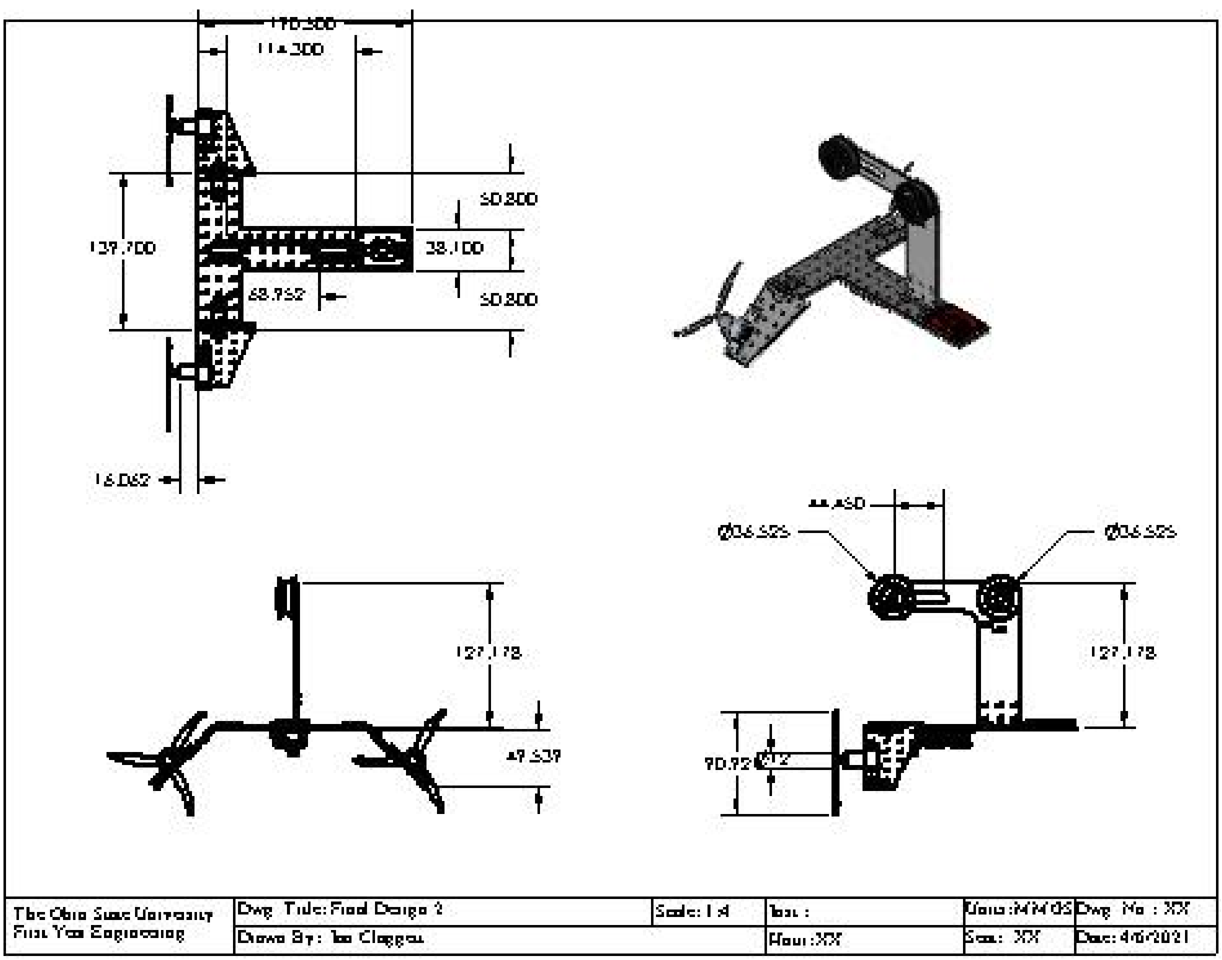


Figure 2: The final T-shape design for the AEV that would be implemented within the experiment. This design allowed for a much more lightweight and stronger build which would assist the AEV greatly in reducing the energy consumed by the AEV.

Scoring Matrix:

Success Criteria			Reference		Ed Doerring		Stuart Fanko		Group design
	Weight	Rating	Weighted score	Rating	Weighted score	Rating	Weighted score	Rating	Weighted score
Stability	15%	3	0.45	2	0.3	4	0.6	4	0.6
Look	10%	2	0.2	2	0.2	2	0.2	4	0.4
Maintenance	15%	3	0.45	2	0.3	3	0.45	4	0.6
Durability	15%	2	0.3	2	0.3	2	0.3	4	0.6
Cost	5%	3	0.15	2	0.1	4	0.2	1	0.05
Balanced	20%	3	0.6	3	0.6	2	0.4	4	0.8
Minimal Blockage	10%	3	0.3	3	0.3	2	0.2	3	0.3
Environmental	10%	3	0.3	2	0.2	2	0.2	2	0.2
Total score			2.75		2.3		2.55		3.55
Continue ?			Combine		combine		combine		Develop

Figure 3: The scoring matrix of the Final design alongside design 1 and design 2 of the initial AEV construction. Compared to the first two designs which would contribute to a conglomerated final design for the experiment.

Screening Matrix:

Success Criteria	Reference	Ed Doerring	Stuart Fanko	Group design
Stability	0	-	1	1
Look	0	0	-	1

Maintenance	0	-	1	1
Durability	0	0	0	1
Cost	0	0	1	-+
Sum +'s	0	0	3	4
Sum 0's	5	3	1	0
Sum –'s	0	2	1	1
Net Score	0	-2	2	3
Continue ?	Combine	combine	combine	Develop

Figure 4:

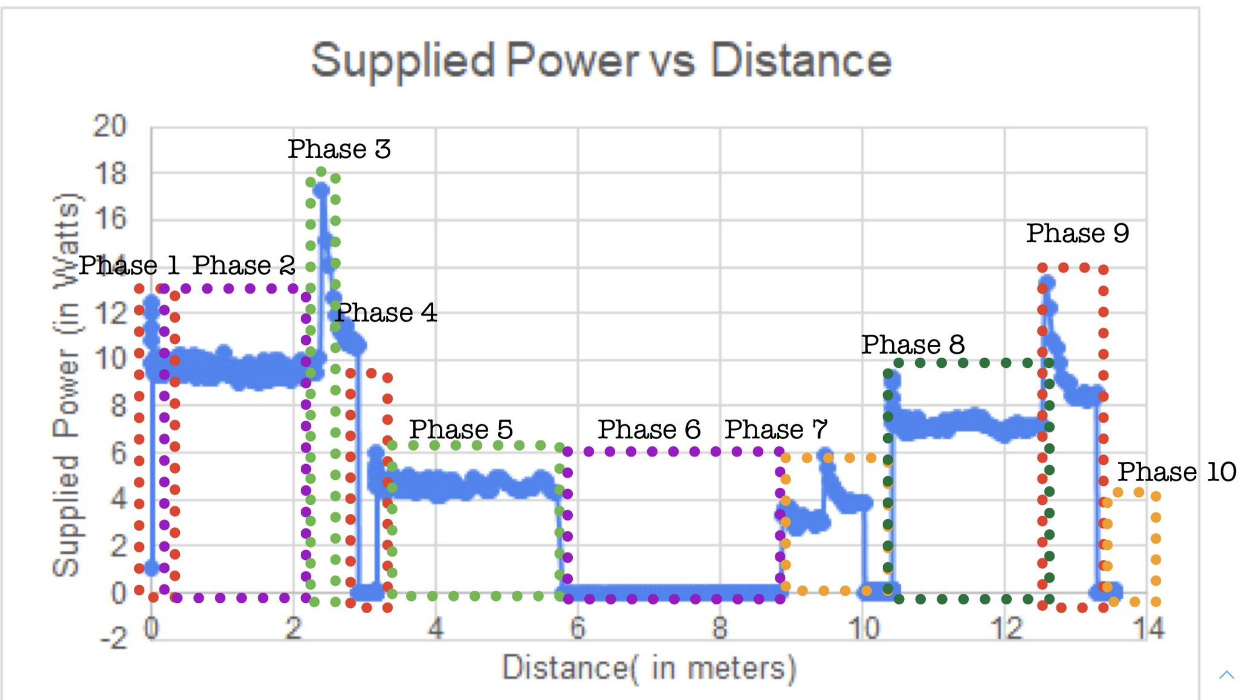


Figure 5: The supplied power and distance traveled by design 1 of the AEV half track run. Divided into different phases dependent on stops, inclines, and other variables.

Phases:	Arduino Commands:	Energy Used:
Phase 1	reverse(4); motorSpeed(1,32);	1.094331999 joules

	motorSpeed(2,32);	
Phase 2	goToAbsolutePosition(-187);	920.5736485 joules

Phase 3	motorSpeed(1,38);
	motorSpeed(2,38);
	goFor(1.2);
		234.0542747 joules

Phase 4	brake(4); goFor(2);	0 joules

Phase 5	motorSpeed(1,20);
	motorSpeed(2,20);
	goToAbsolutePosition(0);
		377.9765279 joules

Phase 6	brake(4); goToAbsolutePosition(250);	0 joules

Phase 7	motorSpeed(1,15);
	motorSpeed(2,15);
	goToAbsolutePosition(300);
	brake(4);
	reverse(4);
	motorSpeed(1,17);
	motorSpeed(2,17);
	goFor(1.2);
	brake(4);
		131.7761761 joules

Phase 8	motorSpeed(1,27);
	motorSpeed(2,27);
	goToRelativePosition(170);
		482.2230164 joules

Phase 9	brake(4);
	reverse(4);
	motorSpeed(1,30);
	motorSpeed(2,30);
	goFor(1.2);
		187.3552307 joules

Phase 10	brake(4);	0 joules
Total Energy Used:		2339.711108 joules

Figure 6: Chart of code performed by design 1 on the half track run, divided into phases according to its stopping point and actions.

Scoring Matrix:

Success Criteria			Reference		Ed Doerring		Stuart Fanko		Group design
	Weight	Rating	Weighted score	Rating	Weighted score	Rating	Weighted score	Rating	Weighted score
Stability	15%	3	0.45	2	0.3	4	0.6	4	0.6
Look	10%	2	0.2	2	0.2	2	0.2	4	0.4
Maintenance	15%	3	0.45	2	0.3	3	0.45	4	0.6
Durability	15%	2	0.3	2	0.3	2	0.3	4	0.6
Cost	5%	3	0.15	2	0.1	4	0.2	1	0.05
Balanced	20%	3	0.6	3	0.6	2	0.4	4	0.8
Minimal Blockage	10%	3	0.3	3	0.3	2	0.2	3	0.3
Environmental	10%	3	0.3	2	0.2	2	0.2	2	0.2
Total score			2.75		2.3		2.55		3.55
Continue?			Combine		combine		combine		Develop

Screening Matrix:

Success Criteria	Reference	Ed Doerring	Stuart Fanko	Group design
Stability	0	-	1	1
Look	0	0	-	1
Maintenance	0	-	1	1

Durability	0	0	0	1
Cost	0	0	1	-+
Sum +'s	0	0	3	4
Sum 0's	5	3	1	0
Sum –'s	0	2	1	1
Net Score	0	-2	2	3
Continue ?	Combine	combine	combine	Develop

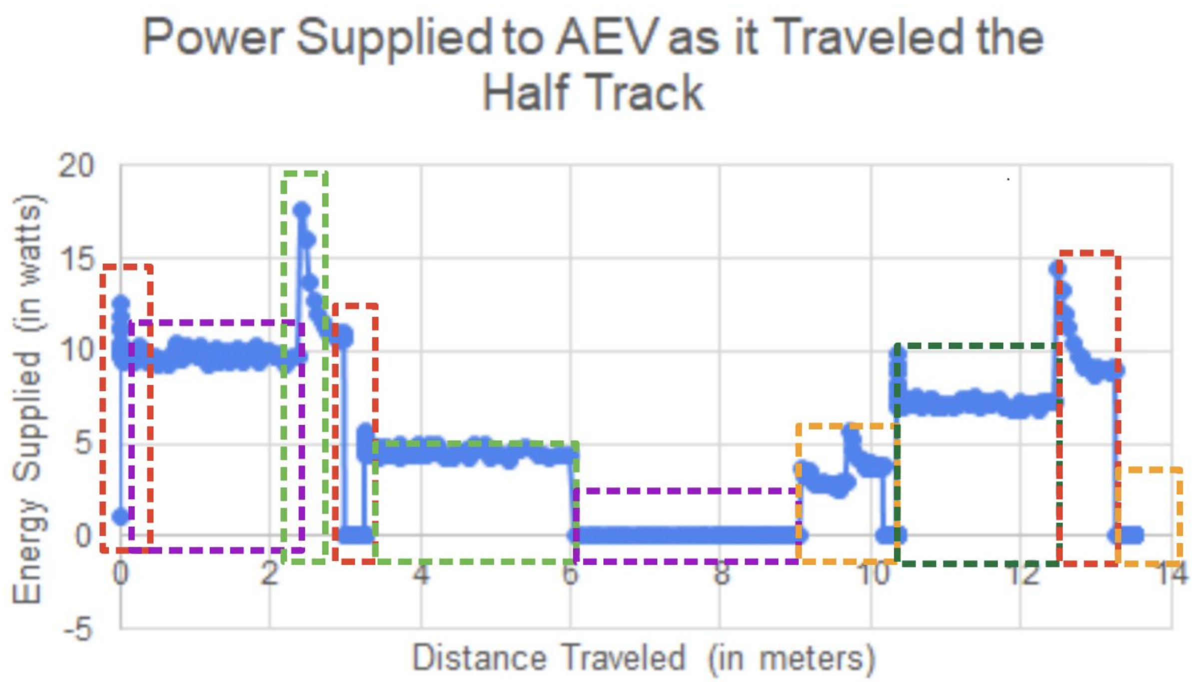


Figure 7: Power supplied to AEV Design 2 as it traversed the half track run. Separated into different phases according to the actions taken by the code to complete the full run of the track.

Phases:	Arduino Commands:	Energy Used:

Phase 1	reverse(4);
	motorSpeed(1,32);
	motorSpeed(2,32);
		1.092239586 joules

Phase 2	goToAbsolutePosition(-170);	719.5627599 joules

Phase 3	motorSpeed(1,38);
	motorSpeed(2,38);
	goFor(1);
		234.4035174 joules

Phase 4	brake(4); goFor(2);	0 joules

Phase 5	motorSpeed(1,20);
	motorSpeed(2,20);
	goToAbsolutePosition(0);
		133.6218746 joules

Phase 6	brake(4); goToAbsolutePosition(250);	0 joules

Phase 7	motorSpeed(1,15);
	motorSpeed(2,15);
	goToAbsolutePosition(300);
	brake(4);
	reverse(4);
	motorSpeed(1,17);
	motorSpeed(2,17);
	goFor(1.2);
	brake(4);
		356.2981781 joules

Phase 8	motorSpeed(1,27);
	motorSpeed(2,27);
	goToRelativePosition(180);
		408.4846703 joules

Phase 9	brake(4);
	reverse(4);
	motorSpeed(1,30);
	motorSpeed(2,30);
	goFor(1);
		197.7427297 joules

Phase 10	brake(4);	0 joules
Total Energy Used:		2051.20597 joules

Figure 8: Chart of all the phases AEV Design 2 underwent during the half track run. Divided into 10 phases, each one with an appropriate chunk of code and the joules of energy used to complete the program provided.

The performance test showcased the vast improvements between the two designs, and the refinements given to the AEV which can be utilized to make the AEV more lightweight, energy efficient, and durable. When comparing the EEPROM data collected from both runs of the designs, there is considerably less energy consumption due to the weight differences of the AEV. This allows for much faster and stronger thrust for the AEV, which will benefit the design greatly as a heavy cart of passengers will need to be transported along the track. This test also showcased a new programming which would account for a much more precise stop and go for the vehicle to travel along the track. Due to the new weight of the AEV, the motorspeed required several fine-tunings to allow for the AEV to stop and go within the black lines of the stops on the track. It also went considerably farther than the Alaska station when first performing the original code. This was resolved by adjusting both the stop distance at the Grand Canyon, as well as the stopping distance at the Alaska station.

Observations:

After rebuilding the design a few unexpected observations were made. The new design was lighter, which was expected, but the previously used code still ran perfectly with the design. In fact, it was found that the new AEV design was more efficient with its power usage. The smaller mass is the inferred cause, because lower mass would make it easier for the motors to get the AEV up to speed. It also allows the AEV to slow down faster during braking. It was not expected for the code to run as well as it did, some changes are still necessary to finish the full run, but this new finding will allow for more progress to be made on the code. This performance test showed that the original design was not the optimal design for the project. It was found that a lighter design is the most optimal design for power efficiency. The new design also made the Arduino more accessible as well as made a more optimal place to put the battery and the servo motor.

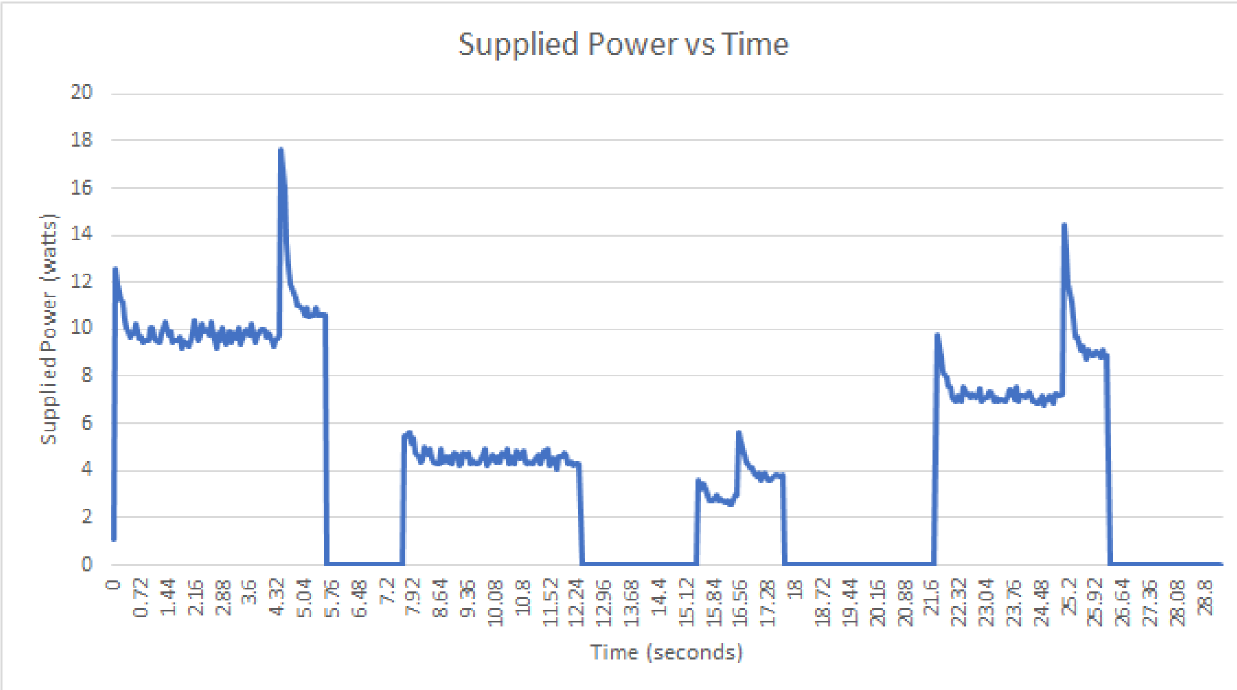
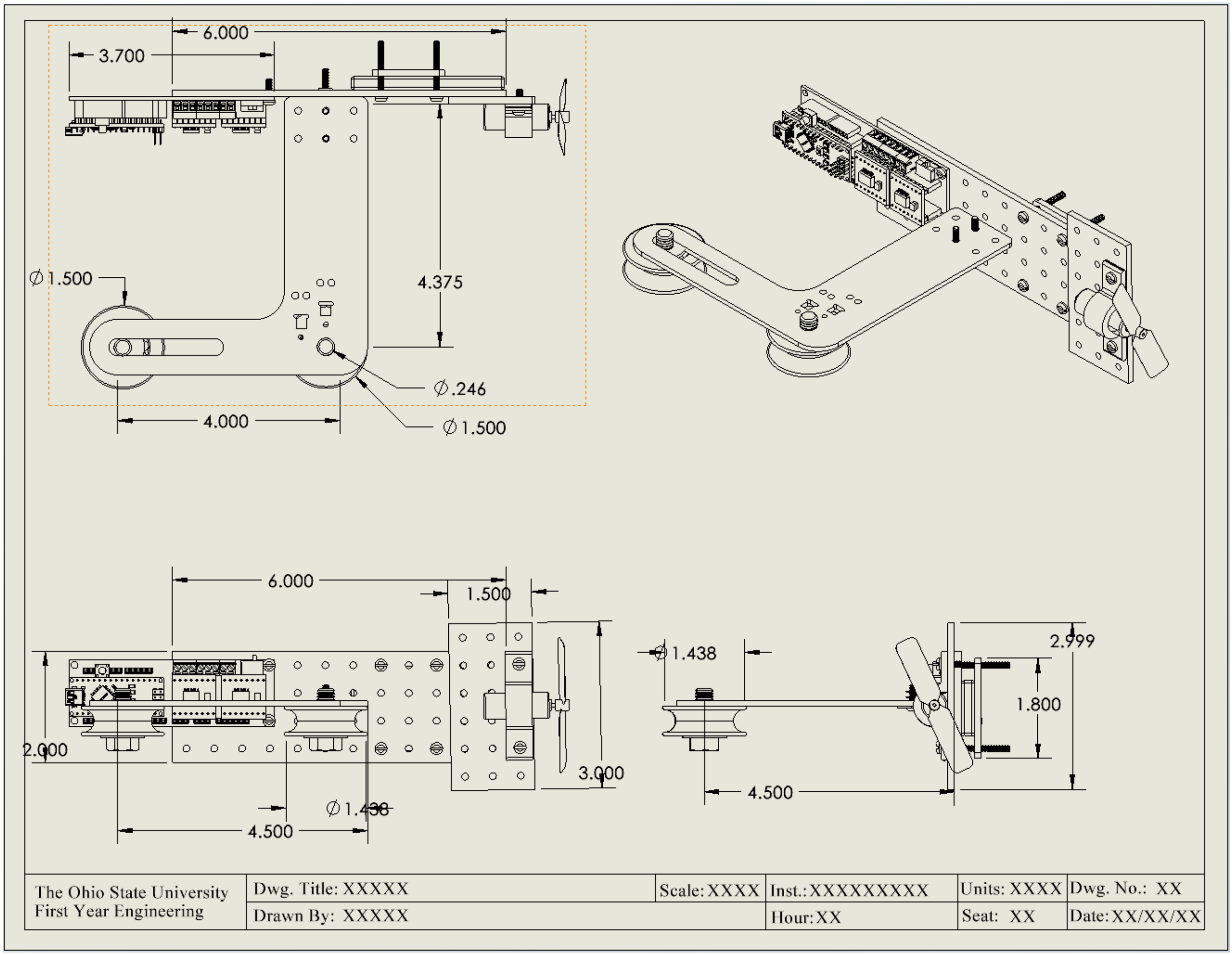


Figure 9: Chart of the supplied power vs the variable time as final design 2 completed its travel across the half track run.

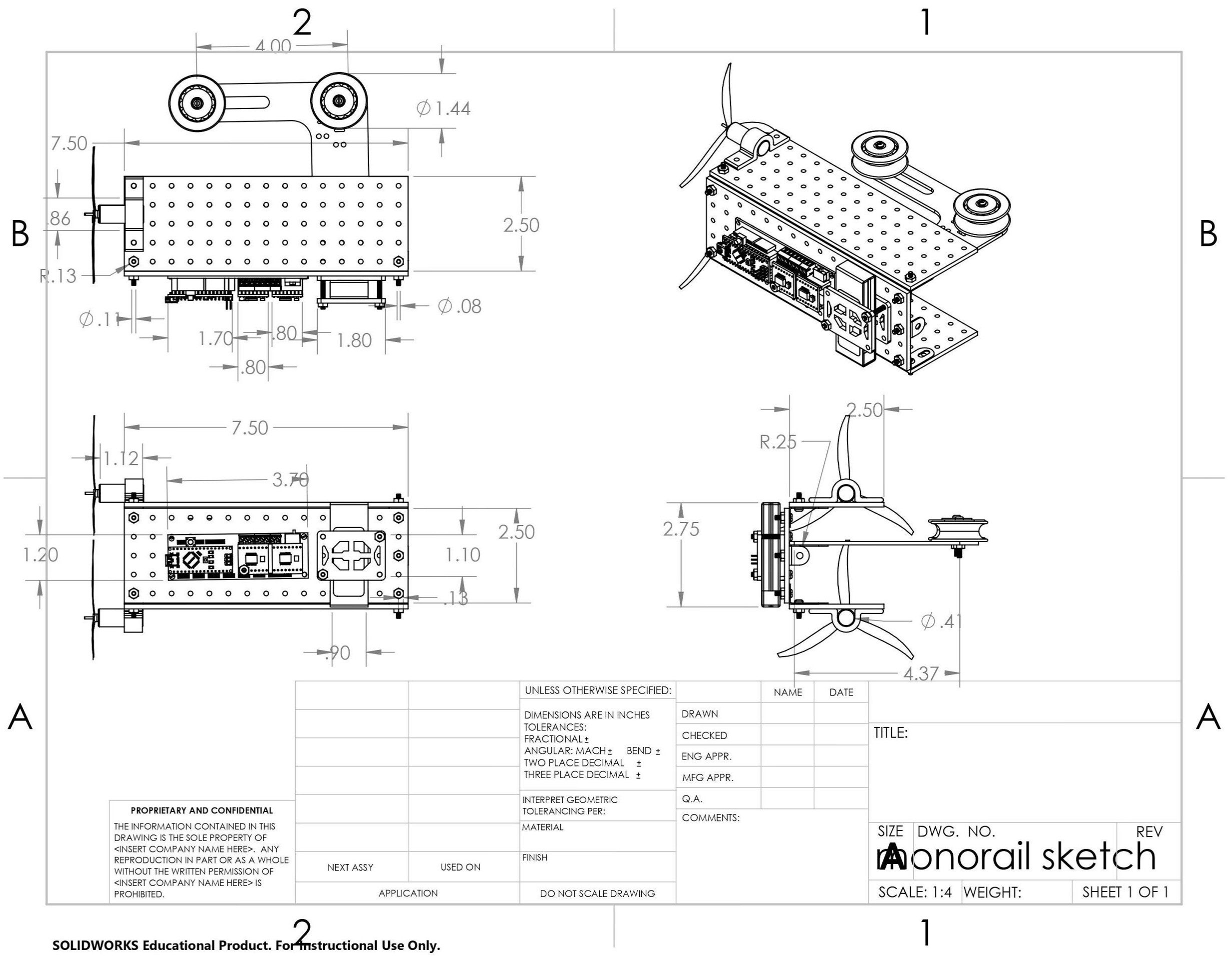
Conclusion:

After redesigning and constructing a new AEV tests were run on the track to compare to the first design. It was found that the new design was lighter and thus more power efficient as it made the run on the track. It was also found that the new design was more convenient to use as the components were placed in more accessible places. It was easier to start the Arduino code and the wires were better managed to keep them out of the rotors. Because of these great advantages over the first design, it was decided to pick the second design to continue to do the project with.

Appendix:



Design 1 of the AEV designs, utilized in the Indefatigable design by centralizing the weight around a small and thin body. It would also see reference in the second final design as well, utilizing the same T-shape for equal weight distribution.



Design 2: Referenced in the Indefatigable design for the twin propeller design. Having equal propulsion upon both sides would allow for an equal thrust and centralized weight, allowing for a safe travel once hitting the curve of the track.

	Task Name:	Ian	Stuart	Ed	Team Jasper						
March 23	PDR	Performance Test 2	Programming PT2	Memo Work PT2	Test Readiness review 3	Performance Test 3	PT3 Memo work	Final Testing	Oral Presentation	Work Session	
S											
M											
T											

W											
T											
F											
S	Finished										
March 30											
S											
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T			Finish								
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S		Finish									
April 6											
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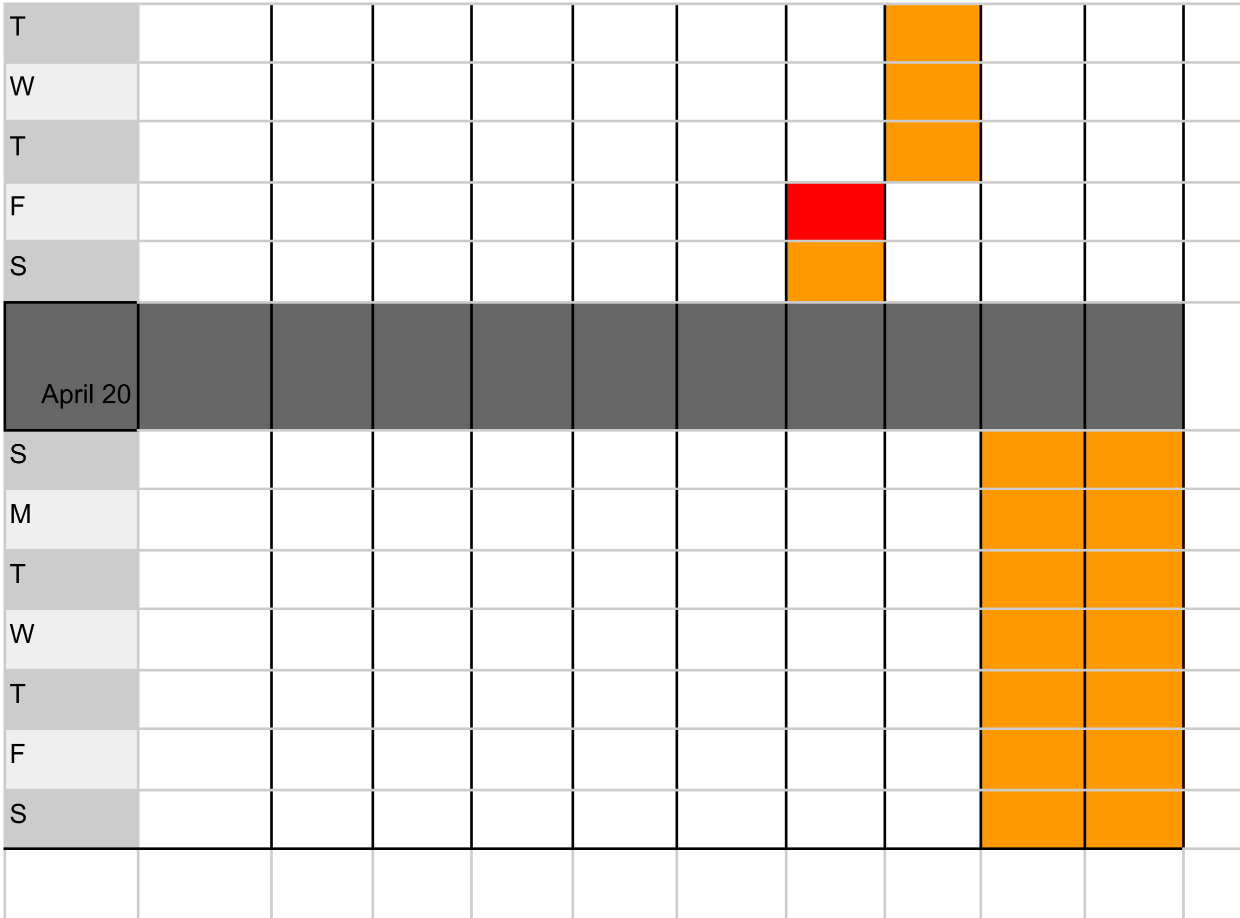

Team Work Schedule: The work schedule and progress expected for teams to complete by the due dates provided within the DAL.

Lab 7: PDR Grading Rubric		
Report Content		
Executive summary		
	Purpose/Results/ Recommendations	10
Introduction		10
	Background/Purpose	
Experimental Setup		
	Procedure/Equipment	10
Results/Discussion		70
	Objective presentation	
	Analysis of results	
	General Observations	
	Figures and Tables	
	Description of the two designs	
	Potential Error	
	Screening and Scoring Matrices	
	Observations from track run	
Conclusions		20
	Summary/ Recommendations	
	Resolving error	
Attachments		
	Project Schedule	15
	SolidWorks Model	15
Writing Total		
	Spelling/Grammar Language Usage	50
Total		200

Instructor signature ______________________________

Work division for this summary

Student Name: Description of work

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