Report of Progress

Situation

The past two weeks of R&D labs were dedicated to finding efficient AEV designs and gaining a deeper understanding of AEV operation. The team's two research investigations were motor configuration and servo calibration and use. Motor configuration was chosen due to the possibility that energy efficiency and speed could be affected by choice of pusher-verses-puller motors. This was tested by running the puller code which was the default, next running the pusher code which was the same code but with all motors reversed, and finally running the code that had one pusher and one puller motor, so the team could collect and compare each runs' energy output. Servo calibration and use was chosen due to its ability to help stop the AEV at a desired position on the track, without having to depend on the inconsistencies that occur when coasting stop. This was tested by attaching the servo and a brake arm to the AEV. The servo arm was then coded with a default angle and an end angle so that the brake arm could make contact with the AEV's wheels, add friction, and stop the AEV faster.

Results and Analysis

During the first R&D, the team tested three motor configurations with two motors to determine which method was most effective. The motor configurations tested were two puller motors, two pusher motors, and one puller and one pusher motor. The puller method pulled the AEV in the same direction as the propellers and the pusher method pushed the AEV in the opposite direction of the propellers. All tests accelerated the AEV to 25% power in two seconds then supplied 25% power for 99 marks before braking. The code for every test can be found in Appendix A. As seen in Figure 1, the pusher method travelled an average of 0.565 meters farther in 1.53 seconds less than the puller method. However, the pusher method's power usage was an average of 0.545 watts greater than the puller method. All data recordings and corresponding graphs can be found in Appendices B and C, respectively. The third method tested was one pusher and one puller motor. Since both motors were located at the front of the AEV, the AEV did not move. Better motor placement, such as one motor at each end of the AEV, could improve the functionality of this method.

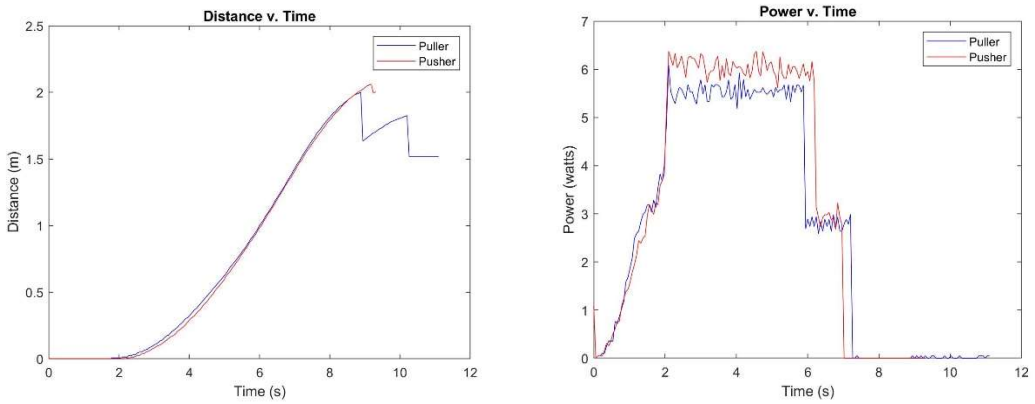

Figure 1. *Comparing puller and pusher motor configurations*

During the second R&D, the team tested the effect of a servo on the AEV. The servo was used to control a brake arm that makes contact with the track to add friction and assist the AEV with braking. To test the effectiveness of the servo brake, the AEV was tested twice with and without the brake. During every test, the AEV was programmed to travel at 40 percent power for 99

marks. The code used for these tests can be found in Appendix A. The time, distance, and power usage were recorded using the MATLAB data analysis tool. The average value from the brake tests are shown in Table 1, and all the data recorded during the tests can be found in Appendix B.

Table 1. *Averaged data from servo R&D lab*

Brake Type	Time (seconds)	Distance (m)	Max Power (watts)
No brake	8.102	2.96	10.88
Servo	8.073	2.82	15.01

With the brake, the AEV was able to travel the desired distance in a shorter time and spend less time coasting to a stop, which decreased the AEV's overall distance travelled. However, the AEV used significantly more power, approximately five watts, when using the servo brake. Currently, the extra five watts of power is more significant than the brake arm's ability to stop the AEV 0.14 meters faster. The improved ability to brake could possibly outweigh the cost of increased power usage if the brake arm was improved. When conducting this particular test, the brake arm was still flimsy and unsecure even when attached to the servo. Improving the brake arm's connection to the servo, with better tape or string, could improve overall braking.

Takeaways

The experimental research step of the Engineering Design Process was implemented. The next step in the Experimental Design Process is to analyze the results and compare options in order to make decisions for future performance tests. The motor configuration was an example of a test that directly changed the AEV, and the Servo calibration and use was an example of a test that did not change the AEV. From the results of motor configuration, the pusher method was the most efficient and therefore was used for the first performance test. The success of the pusher method makes sense taking into account the starting point of the track, wheel placement, and desired direction of travel. No data could be collected from the third type of code because the AEV could not travel with opposing forces. From the results of servo calibration and use, the AEV was able to break faster when the servo break was implemented. However, the break arm of the servo was unstable and unable to directly hit the wheels consistently, and consumed more energy, therefore it was decided not to be implemented in the first performance test.

Future Work

Situation

In the next few weeks, the first task to be completed is the R&D oral presentation. During this presentation, each company will meet to share what factors they tested that improve, limit, or do not affect the AEV design so that each team can make improvements to their AEV. Next, the second performance test will ensure that the team's AEV is performing the required tasks properly by checking if the AEV can make it through the gate and pick up the caboose. The third task is the CDR draft. This document will outline the entire AEV project and will allow the team to describe their design process, research, and design improvements to the Smart City staff. Additionally, the team will meet with the Smart City staff during the second committee meeting to share their progress and ask for advice involving human resources, public relations, budgeting, and research. Lastly, the team will continue conducting R&D labs to test how the AEV can be improved as well as how previous improvements are affecting the AEV's performance.

Upcoming Goals

Last progress report, the team had a goal of creating weekly plans to outline all of the upcoming work and assign tasks to team members. These weekly plans have helped improve clarity and distribute the work more evenly among the team. The team plans to continue creating weekly plans every Friday. Additionally, the team also wants to allow each team member to have hands-on experience with the AEV. To encourage this, each team member will write code for the AEV at least once, whether the code is for a performance test or a R&D lab, before the next progress report. After writing code, team members will be asked if they feel more experienced with the AEV to determine if writing code helps expand their AEV knowledge or not.

Upcoming Schedule

R&D Oral Presentation: In the upcoming oral presentation, each team member will be responsible for speaking one to two minutes of the total presentation time. Tatum will discuss the team's approach to the MCR, Paige and Miho will share the R&D studies, and Rachel will describe the plan for the two performance tests. Each person will be responsible for creating their own presentation slides and script, which should take about an hour per person.
Performance Test Two: Rachel and Miho will be responsible for writing the code for the second performance test. They will each write their own version of the code necessary to complete the test and each version will be compared to determine the best approach. Writing the code should take about 20 minutes.
CDR Draft: There are five major sections included in the CDR: lab report (Paige and Tatum), executive summary (Miho and Rachel), results (Paige and Rachel), conclusions and recommendations (Tatum and Miho), and appendix (Paige and Tatum). Two people, as shown in parenthesis next to each task, will be assigned to each task to review what needs to be completed and assign necessary roles based on the amount of time each task takes to complete.
Committee Meeting Two: During this meeting, each team member will be responsible for attending one committee meeting. Paige will attend human resources, Miho will attend research and development, Tatum will attend public relations, and Rachel will attend budgeting. These are the same assignments as the first committee meeting so preparation should take approximately 30 minutes.
R&D Three: The team will select another topic to investigate during the third R&D. Rachel is responsible for overseeing methodology and assigning tasks for each person to complete. Every team member should spend 10 to 20 minutes completing their portion of the methodology and the team will work together to implement the methodology over the course of three class periods.

Appendix A: Code

Table A.1. *Code to test two pull motors*

Code	Comments
celerate(4, 0, 25, 2);	// Accelerate all motors from 0% to 25% power in 2 seconds
motorSpeed(4, 25); goToRelativePosition(99);	// Run both motors at 25% power for 4ft (99 marks)
brake(4);	// Brake both motors

Table A.2. *Code to test two push motors*

Code	Comments
reverse(4);	// Reverse the motors
celerate(4, 0, 25, 2);	// Accelerate all motors from 0% to 25% power in 2 seconds
motorSpeed(4, 25); goToRelativePosition(-99);	// Run both motors at 25% power for 4ft (99 marks)
brake(4);	// Brake both motors

Table A.3. *Code to test one push and one pull motor*

Code	Comments
reverse(1);	// Reverse motor 1
celerate(4, 0, 25, 2);	// Accelerate all motors from 0% to 25% power in 2 seconds
motorSpeed(4, 25); goToAbsolutePosition(99);	// Run both motors at 25% power for 4ft (99 marks)
brake(4);	// Brake both motors

Table A.4. *Code to test servo brake*

Code	Comments
rotateServo(90);	// Rotate servo to 90 degrees position
celerate(4, 0, 40, 2);	// Accelerate all motors from 0% to 40% power in 2 seconds
motorSpeed(4, 40); goToRelativePosition(99);	// Run both motors at 40% power for 4ft (99 marks)
rotateServo(0);	// Rotate servo to 0 degrees position
brake(4);	// Brake both motors

Table A.5. *Code to test no brake*

Code	Comments
celerate(4, 0, 40, 2);	// Accelerate all motors from 0% to 40% power in 2 seconds

motorSpeed(4, 40); goToRelativePosition(99);	// Run both motors at 40% power for 4ft (99 marks)
brake(4);	// Brake both motors

Appendix B: R&D Data Collection Tables

Table B.1. *Data for two pull motors*

Run #	Distance (meters)	Max Power (watts)	Time (seconds)
1	1.54	5.98	11.1
2	1.50	6.19	11.101

Table B.2. *Data for two push motors*

Run #	Distance (meters)	Max Power (watts)	Time (seconds)
1	2.14	6.79	9.181
2	2.03	6.47	9.962

Table B.3. *Data for one pull and one push motor*

Run #	Distance (meters)	Max Power (watts)	Time (seconds)
1	0	0	0
2	0	0	0

Table B.4. *Data for servo brake*

Run #	Distance (meters)	Max Power (watts)	Time (seconds)
1	2.90	14.80	8.043
2	2.74	15.22	8.102

Table B.5. *Data for no brake*

Run #	Distance (meters)	Max Power (watts)	Time (seconds)
1	3.05	10.91	8.102
2	2.87	10.85	8.101

Appendix C: R&D Graphs

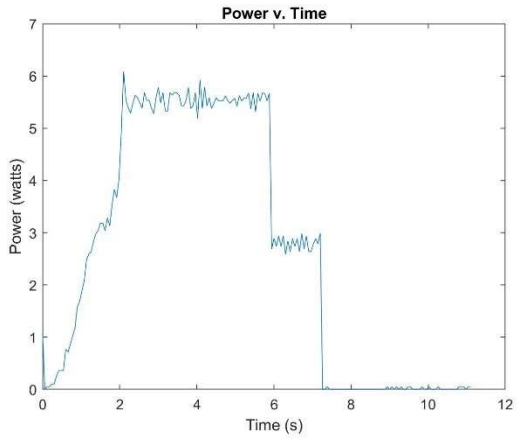

Figure C.1. *Power v. Time graph for puller method (average)*

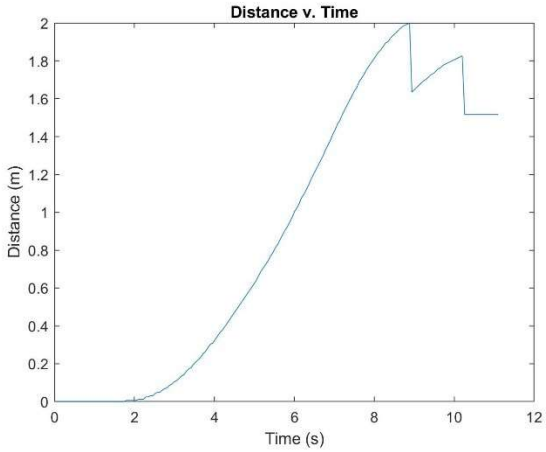

Figure C.2. *Distance v. Time graph for puller method (average)*

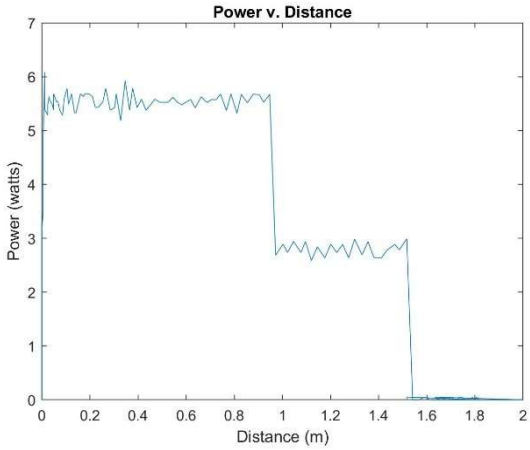

Figure C.3. *Power v. Distance graph for puller method (average)*

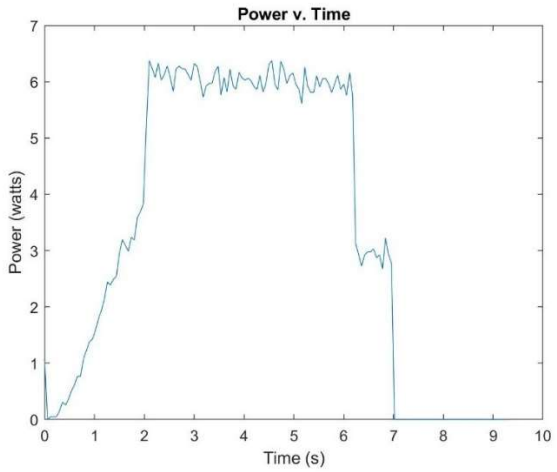

Figure C.4. *Power v. Time graph for pusher method (average)*

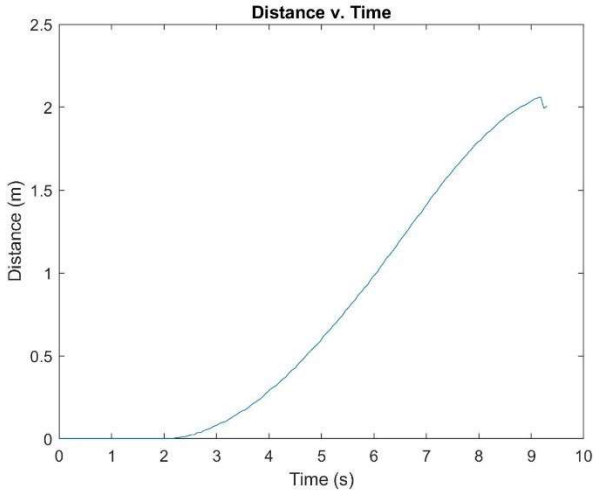

Figure C.5. *Distance v. Time graph for pusher method (average)*

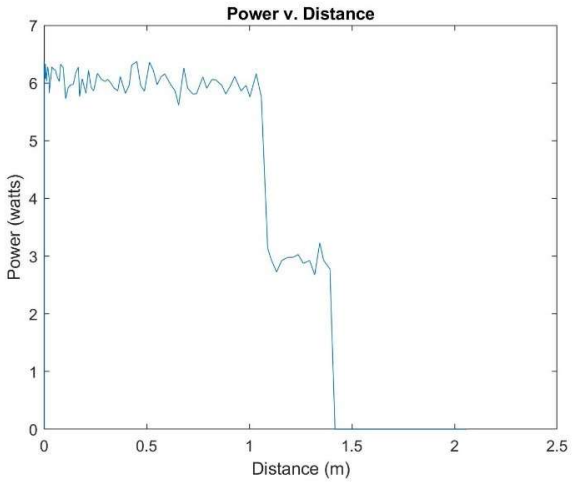

Figure C.6. *Power v. Distance graph for pusher method (average)*

Appendix D: Team Meeting Minutes

Date: 12 – Feb – 2019
Time: 8:00 pm-9:30 pm
Location: Drackett Tower
Members Present: Paige Bormann and Tatum Wilmes
Topics Discussed: Progress Report and Team AEV Design
Objective: The main focus of this meeting was to finish labs four and five, design the team AEV, and discuss the progress report.
To-Do/Action Items: Inform Miho and Rachel about our progress and tell them their assigned roles (PB)
Decisions: Tomorrow, Miho and Rachel will choose to each do two of the following to complete the progress report: upcoming schedule, takeaways, meeting minutes, or upcoming goals.
Reflections: We were able to complete labs four and five and design the team AEV. Since Miho and Rachel weren't at the meeting, Tatum and Paige had to make most of the decisions. Team members need to establish an outside of class meeting time and location that works for all members.

Figure D.1. *First team meeting minutes*

Date: 13 – Feb – 2019
Time: 9:00 am-9:30 am
Location: HI 316
Members Present: Paige Bormann, Rachel Roman,and Miho Kaburagi
Topics Discussed: Progress Report and Team AEV Design
Objective: The main focus of this meeting was to finalize the data collected and discuss the design of the AEV
To-Do/Action Items: Upcoming Schedule, Takeaways (RR); Meeting Minutes, Upcoming Goals (MK)
Decisions: We assigned roles for the remaining parts of the Progress Report and discussed a plan of action for the completing the grant proposal.
Reflections: We were able to communicate who needs to do what by when, and work together as a team to meet project deadlines. In the future, we should assign roles earlier in the project so that we can complete tasks faster and more efficiently.

Figure D.2. *Second team meeting minutes*

Date: 15 – Feb – 2019
Time: 9:35 am-10:55 am
Location: HI 224
Members Present: Paige Bormann, Tatum Wilmes, Rachel Roman, and Miho Kaburagi
Topics Discussed: Grant Proposal
Objective: The main focus of this meeting was to present the team's part and propose to get the grant.
To-Do/Action Items: Present the Grant Proposal (ALL)

Decisions: We decided that since we didn't get the grant, that we were going to use parts given and not spend the money on creating a part.
Reflections: The other teams got a little more creative in the parts they were proposing. In the future, we will try to be more creative.

Figure D.3. *Third team meeting minutes*

Date: 19 – Feb – 2019
Time: 9:10 am-10:05 am
Location: HI 308
Members Present: Paige Bormann, Tatum Wilmes, Rachel Roman, and Miho Kaburagi
Topics Discussed: Team AEV Assembly (Class App #16)
Objective: The main focus of this meeting was to assign roles and establish deadlines for the team AEV assembly and documentation due next week.
To-Do/Action Items: Detailed drawings of housing with reflective tape, right trapezoids, battery spacers, and battery pack clamp (MK); Detailed drawings of large rectangle, support arm, motor mount clips, and 45 degree bracket (RR); SolidWorks assembly with bill of materials (TW & PB)
Decisions: We assigned roles for the upcoming assignment and decided that everyone should have their assigned role completed by February 26 (next Tuesday).
Reflections: Team members were more involved with role assignment during this meeting than they have been. Everyone was able to pick what they wanted to do and should have plenty of time to complete the assigned tasks.

Figure D.4. *Fourth team meeting minutes*

Date: 22 – Feb – 2019
Time: 9:35 am-10:55 am
Location: HI 224
Members Present: Paige Bormann, Tatum Wilmes, Rachel Roman, and Miho Kaburagi
Topics Discussed: Committee Meeting #1
Objective: The main focus of this meeting was to talk to the TAs and instructors to get feedback on our work and information about what is coming up.
To-Do/Action Items: Meet with respective groups (ALL); Assign Roles for the Procedure for the next lab (RR)
Decisions: We re-assigned roles and came up with a game-plan moving forward. We decided who would do what for the lab procedure.
Reflections: The meetings gave us a better understanding about the project and website. The team was able to communicate more and understand what we need to modify about our teamwork.

Figure D.5. *Fifth team meeting minutes*

Date: 26 – Feb – 2019

Time: 9:10 am-10:05 am
Location: HI 308
Members Present: Paige Bormann, Tatum Wilmes, Rachel Roman, and Miho Kaburagi
Topics Discussed: Class App 16
Objective: The main focus of this meeting was to check in with the progress on App 16, readjust deadlines for when work should be done, and decide who is submitting the application on Carmen.
To-Do/Action Items: Finish and upload descriptive drawings of parts to BuckeyeBox (MK & RR); Finish and upload the AEV assembly and exploded drawing with bill of materials on BuckeyeBox (TW & PB)
Decisions: Each team member is responsible for completing and uploading their work to BuckeyeBox by tomorrow (2/27) at 6pm. This will give Tatum enough time to consolidate all the documents and turn them in on Carmen before class on 2/28.
Reflections: The meeting allowed the team to ask TAs for help with finishing their respective tasks and set a deadline for when all the parts should be completed. All team members are now aware of who is responsible for what as well as how and when they should have their assignment completed. The planning for this assignment started a week ago and planning ahead has saved our team from being stressed about finishing this assignment by next class.

Figure D.6. *Sixth team meeting minutes*

Date: 28 – Feb – 2019
Time: 9:10 am-10:05 am
Location: HI 308
Members Present: Paige Bormann, Tatum Wilmes, Rachel Roman, and Miho Kaburagi
Topics Discussed: LAB 7
Objective: The main focus of this meeting was run a lab testing the motor push or pull methods and how it effects the AEV.
To-Do/Action Items: Create a procedure before lab (ALL); Write a code for the AEV to follow with different push/pull methods (PB); Start Methodology for the lab (RR); Update Website (TW)
Decisions: The team decided on having the same basic code for all tests so the data is comparable, but changing the direction of the way the propellers move for the different tests.
Reflections: The lab became more clear since the TAs were walking around, asking us questions, and giving us ideas to keep us on track.

Figure D.7. *Seventh team meeting minutes*

Date: 1 – Mar – 2019
Time: 9:35 am-10:55 am
Location: HI 224
Members Present: Paige Bormann, Tatum Wilmes, Rachel Roman, and Miho Kaburagi
Topics Discussed: LAB 8

Objective: The main focus of this meeting was run a lab testing the motor push or pull methods and get data.
To-Do/Action Items: Write a code for the AEV to follow with different push/pull methods (PB); Start Methodology for the servo lab (RR); Update Website (TW); Test the AEV on the track and load the data (ALL)
Decisions: The team decided on testing each motor configuration (pull and push) twice due to restricted time on the tracks.
Reflections: The lab tested our skills of using the data analysis tool, and we felt confident with our methodology.

Figure D.8. *Eighth team meeting minutes*

Date: 5 – Mar – 2019
Time: 9:10 am-10:05 am
Location: HI 308
Members Present: Paige Bormann, Tatum Wilmes, Rachel Roman, and Miho Kaburagi
Topics Discussed: LAB 9
Objective: The main focus of this meeting was finish the methodology and code for testing servo motors.
To-Do/Action Items: Write procedure and methodology for servo motor lab (ALL); Update Website (TW); Write code for servo testing (PB & RR); Assign Roles for Progress Report (ALL)
Decisions: The team decided on increasing the power from the first lab so the ability to brake is clearer.
Reflections: The team learned about the purpose of the servo motor and how to attach it to the AEV in order to contribute to braking.

Figure D.9. *Ninth team meeting minutes*