External Sensors and Concept Screening and Scoring AEV Executive Summary

Submitted to

Dr. Janiszewska

Prepared by

Nick Stassen,

Matthew Geiger,

Ben Bazan

Engineering 1182

The Ohio State University

College Of Engineering

Newark, OH

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The purpose of this lab was to introduce the lab group to become familiar with the external sensor hardware and how to code them effectively while using different troubleshooting techniques.

The lab group was given an external reflective sensor, directions on how to use/code it, as well as an example scenario to get used to coding an AEV using the reflective sensor. The example scenario required the AEV to move in different directions at various percentages and distances using absolute positioning as well as relative positioning code.

Overall, the AEV executed its programming well. This experiment was to test if the AEV could complete a mission down the rail by 10 feet and then return lowering the thrust produced by its motors after 6 feet. The AEV succeeded in this test after a few minor adjustments. During the experiment, the AEV traveled smoothly even when it changed direction, as well as staying on the track the entire time including when it was rounding the turn. The only change that would be made to the design would be to add some aerodynamics as well as improving the center of gravity. The “forward” direction is when the AEV is being pushed by the propellers and when the reflective counters count in the negative direction.

Concept Screening and Scoring

Success Criteria	Reference	Design A	Design B	Design C
Stability	0	0	+	+
Eco-fuel	0	0	0	0
Look	0	+	+	0
Maintenance	0	0	0	0
Durability	0	-	+	0
Cost	0	-	-	0
Environmental	0	0	0	0
Sum +'s	0	1	3	1
Sum 0's	7	4	3	6
Sum -'s	0	2	1	0
Net Score	0	-1	2	1
Continue?	Combine	No	Yes	No

(Table 1) Concept screening used to determine unweighted score depending on success criteria.

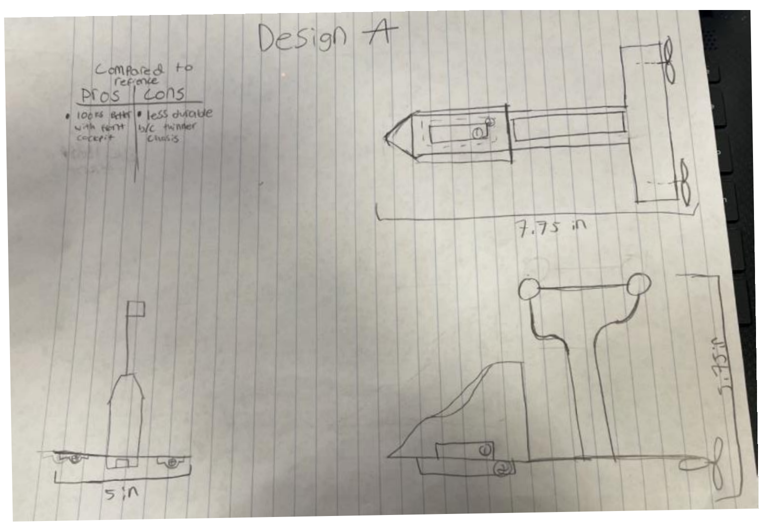
The concept screening looks at different major criteria aspects that will either aid or hinder the performance of different AEV designs using the reference AEV as the base design. For each AEV design the group rated each criteria as better, worse, or the same when comparing them to the reference AEV. If the design was worse in a certain criterion, they received a “-”, if it was better, it received a “+”, and if it was the same it received a 0. The total +’s and -’s were added together, and a net score was calculated based on total +’s and -’s.

		Refrence		Design A		Design B		Design C	
Success Criteria	Weight	Rating	Weighted score	Rating2	Weighted score	Rating3	Weighted Score4	Rating5	Weighted Score6
Balance	5%	3	0.15	4	0.6	4	0.6	4	0.6
Minimal blockage	15%	3	0.45	3	1.35	3	1.35	3	1.35
Center-of-gravity location	10%	2	0.2	4	0.8	4	0.8	4	0.8
Maintenance	25%	3	0.75	3	2.25	3	2.25	3	2.25
Durability	15%	2	0.3	2	0.6	4	1.2	4	1.2
Cost	20%	3	0.6	2	1.2	2	1.2	3	1.8
Evironmental	10%	3	0.3	3	0.9	3	0.9	3	0.9
Total Score			2.75		7.7		8.3		8.9
Continue?			No		no		yes		no

(Table 2) Concept scoring used to compare designs to a base model using weighted success criteria.

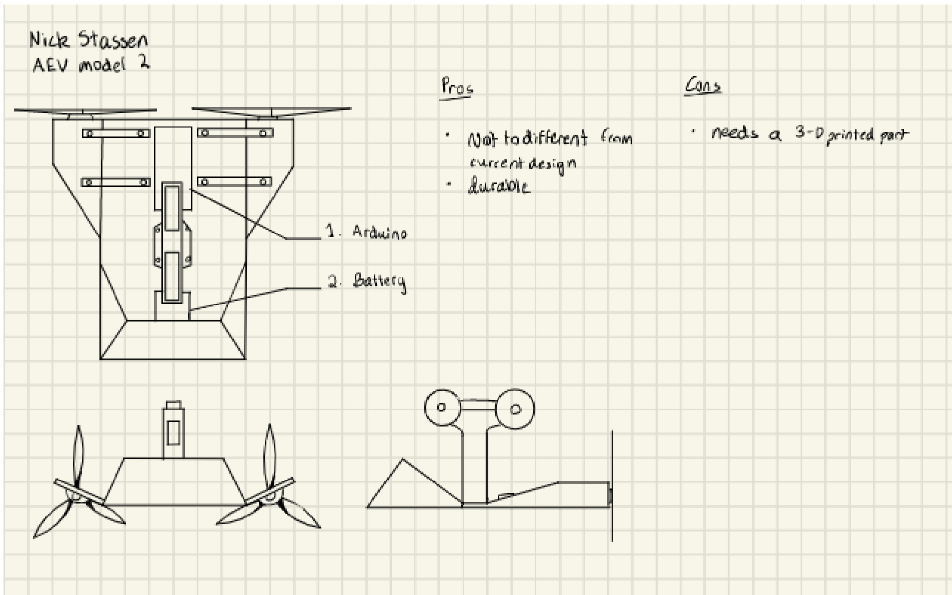
The Concept scoring matrix lists different criteria that, again, will either aid or hinder the performance of the AEV designs and assign a weight to them, so some criteria affect the scoring more than others. Each design was rated on the criteria using a 0-5 scale (5 being a superior design) the reference AEV model was neutral receiving scores of 3 for each criterion. If the specific design was determined to be better than the reference design, it received above a 3, if it was worse than the reference, it received below a 3, and if it was similar, it received a 3. The ratings were then multiplied by the weight of each criteria giving the weighted scores, and the sum of the weighted scores gave the total score for each design.

Using these matrices Design B was selected to be continued and built. While Design C's score is higher than Design B, thus making it preferable to pick, Design B was chosen because the benefits of the added parts outweighed the costs of the added parts. These benefits included better aerodynamics making the energy used per unit of mass lower. Design B will continue to be changed to fit the necessities of the mission but overall, this design is the best starting point for the AEV out of all the designs. One change that needs to be kept in mind is adding a servo that will connect the AEV to a cart allowing the AEV to pull the cart.



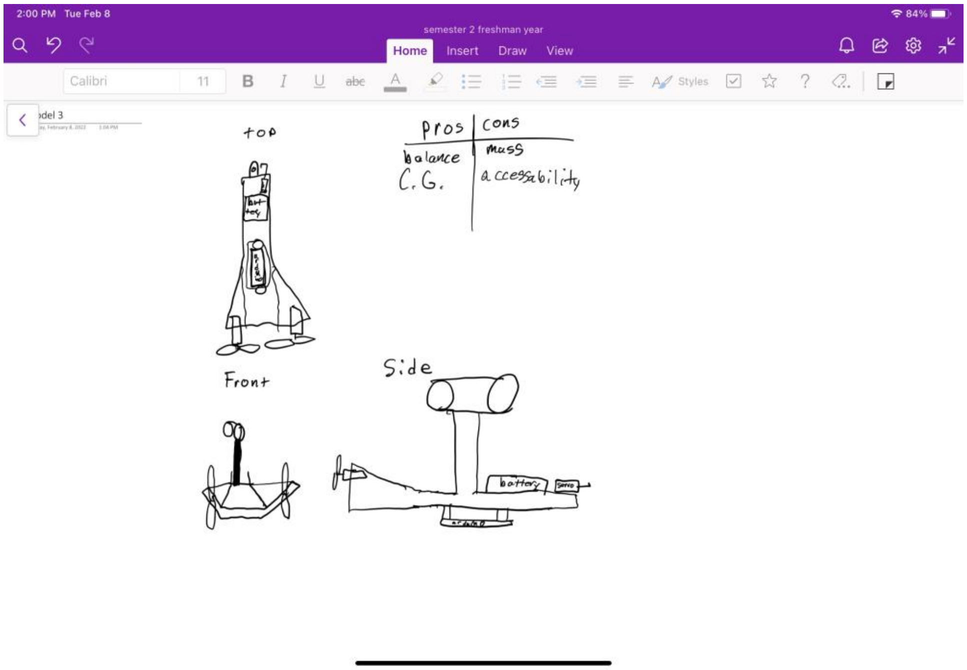
(Figure 1) Orthographic projection of design model A (Drawn by: Ben Bazan).

One pro of Design model A is that it is lightweight, compared to the reference model, meaning that the energy used per unit of mass is high. This is preferable for the park since energy is a scarce resource and this design will make good use of that energy. Another main pro is that this design features an aerodynamic structure on the front of the design. This will improve aerodynamics, offering lower drag and again increasing the energy used per unit of mass. However, the main con for this design is its lack of stability. This design uses a T-block as its main chassis, this makes the vehicle highly unstable as opposed to the reference model. This was one of the main flaws in the design and was the reason it was given such a low score in the concept screening and scoring. Lower stability could not be sacrificed for lower mass. Another con was the cost of the aerodynamic structure, this part could not be 3-d printed and would need to be bought from a manufacturer.



(Figure 2) Orthographic projection of Design model B (Drawn by: Nick Stassen)

The first pro for Design model B was its nose cover. This nose cover would function as a shield for the electronics, decreasing the chances that relative wind would knock connections loose or cause other problems. The nose cover would also offer aerodynamics, decreasing the drag on the vehicle and allowing the AEV to use less energy for the same mission. The next pro this design offered was its stability, this design used a more stable chassis in comparison to the reference model and kept the center of gravity location in mind. One main con for this design was the cost of the nose cover, this cost was considered both in the time it would take to design the part and in the cost of materials (and renting a 3-d printer if need be).



(Figure 3) Orthographic projection of Design model C (Drawn by: Matthew Geiger)

The main pro of Design model C is its balance/ center of gravity location. This contributes to the overall stability of this design allowing it to complete turns easily with no chance of flipping off the track or tumbling over. A different pro is that this design is compact allowing for less mass, in contrast to the reference model, to be used on chassis thus increasing the energy used per unit of mass ratio. The main con of this design is its lack of aerodynamics and the accessibility of the Arduino nano. The lack of aerodynamics makes the AEV less energy efficient with the added drag forces. With the Arduino nano on the bottom of the AEV it will be much harder to upload the code and to activate the AEV when necessary.

The code was self-explanatory until the AEV was ran on the track. The sensors read negative values when the vehicle goes forwards. This issue was fixed by switching the positioning values to negative. Before this problem arose, there was the issue with determining what values need to be used in the parameters of the positioning functions. This was fixed by creating a formula to convert inches to marks (since the function took in marks as its parameter and we knew inches). This equation could be directly put into the function parameters.

$$marks = inches \cdot \left(\frac{8}{3.902}\right)$$

The AEV also would skid 1-2 feet after it got to its required position. This issue was resolved by stopping the AEV a foot in advance of its target to give it time to decelerate.

The coding of the AEV will most likely require use of all the functions at some point. However, some will be used more frequently than others. This likely includes: goToAbsolutePosition(), goFor(), and celerate(). These will be used more often because they are specific and realistic. Start-stop functions like brake() and motorSpeed() aren't realistic because nothing can instantly start or stop. These will still decelerate and accelerate like the other functions, just uncontrollably. These functions are also very unspecific because they rely on time with the goFor() function and trying to figure out where the AEV would be on the track after a certain number of seconds at a certain motor power would be more difficult than it must be. This issue is solved by the goToAbsolutePosition() and goToRelativePosition() functions. These allow the AEV to simply traverse the track at specific measured points. The AEV's ability to know its position is crucial to accomplish the final track run.

The knowledge of sensors and the *goToAbsolutePosition* command gained in this experiment will be used to create an AEV that will be able to detect the distance that it has travelled. This is an integral part of the mission because the AEV needs to travel specific distances, and this is the easiest way to accomplish this. Other methods including an accelerometer would be too prone to error to provide accurate distance data. The *goToAbsolutePosition* command will be an integral part of the preliminary code allowing the AEV to complete the scenario stated in the mission concept review.

Ben Bazan completed how the AEV behaved, descriptions for both the criteria screening and the criteria scoring, as well as the drawing for AEV design A. Matthew Geiger completed the knowledge of sensors, How the matrices were used to determine which AEV design was continued, as well as the Pros/Cons of each design. Nick Stassen completed the error resolution, the code implication for the Mission Concept Review scenario, the commands that will likely be used in the AEV design, and which commands which will likely be used more sections.

Appendix

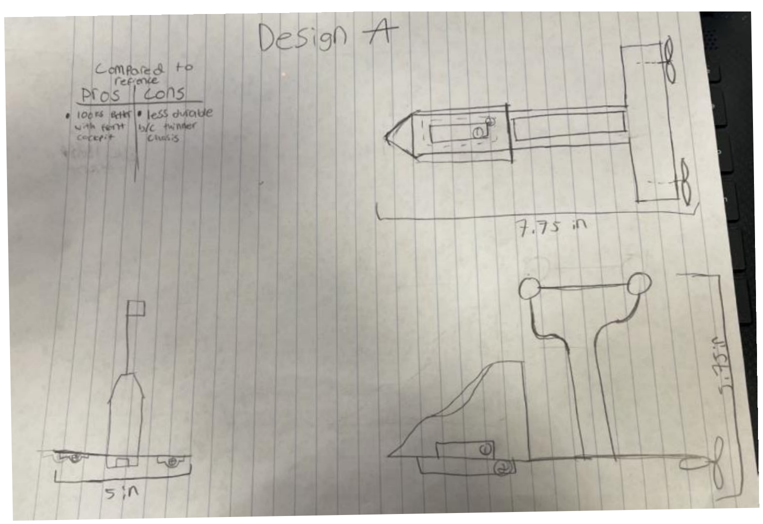


Figure 1 Orthographic projection of design model A (Ben Bazan's Design)

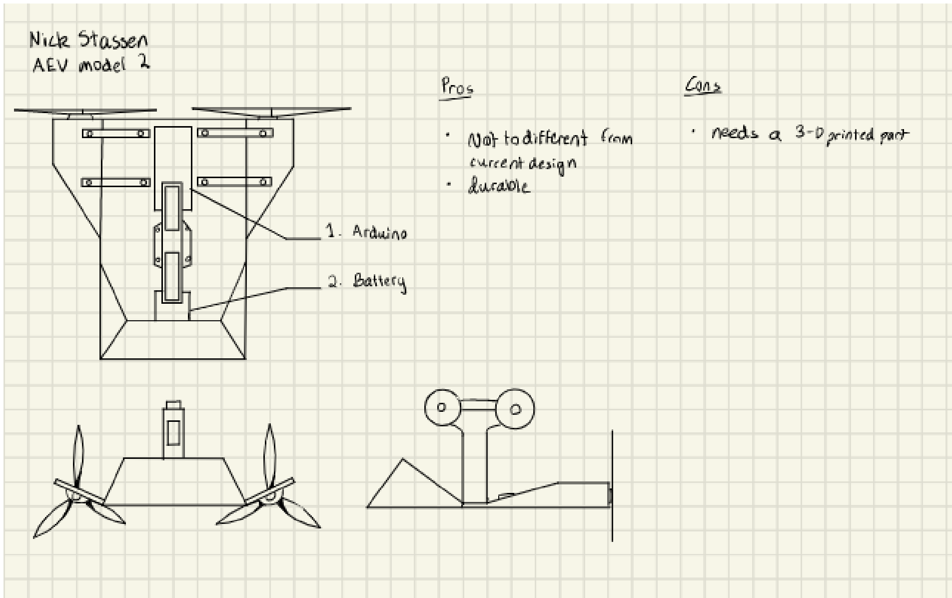


Figure 2 Orthographic projection of design model B (Nick Stassen's Design)

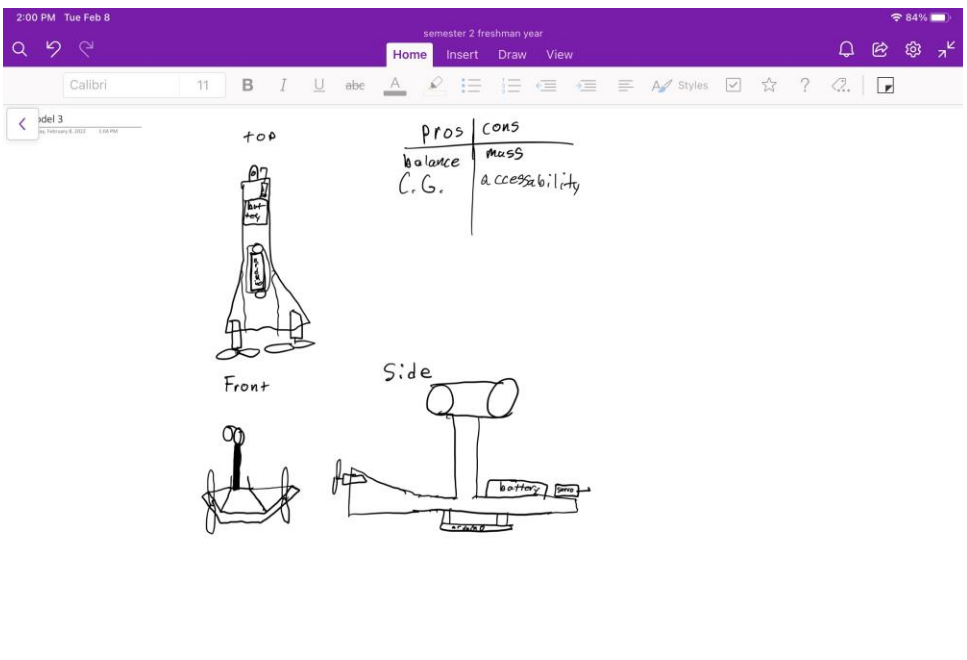


Figure 3 Orthographic projection of design model C (Matthew Geiger's Design)

```
reverse(4);
//our motors start turning in the opposite direction, requiring an initial reverse statement.
motorSpeed(4,30);
goFor(2);
motorSpeed(4,25);
```

```
goToAbsolutePosition(-120*(8/3.902));
brake(4);
reverse(4);
motorSpeed(4,30);
goToRelativePosition(-48*(8/3.902));
motorSpeed(4,25);
goToAbsolutePosition(-12*(8/3.902));
//end before 0 because vehicle will drift at least a foot
brake(4);
//goToRelativePosition(-41);
//44: (44 marks)*(3.902/8) inches = 21.46 inches
//circumference of wheel is 3.902 inches
//goToAbsolutePosition(M);
```

Figure 4. Arduino Code for Sensor Lab

Concept Screening and Scoring				
Success Criteria	**Refrence**	**Design A**	**Design B**	**Design C**
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Look	0	+	+	0
Maintenance	0	0	0	0
Durability	0	-	+	0
Cost	0	-	-	0
Environmental	0	0	0	0
Sum +'s	0	1	3	1
Sum 0's	7	4	3	6
Sum -'s	0	2	1	0
Net Score	0	-1	2	1
Continue?	Combine	No	Yes	No

Table 1. Concept Screening for designs

		Refrence		Design A		Design B		Design C	
Success Criteria	Weight	Rating	Weighted score	Rating2	Weighted score	Rating3	Weighted Score4	Rating5	Weighted Score6
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Minimal blockage	15%	3	0.45	3	1.35	3	1.35	3	1.35
Center-of-gravity location	10%	2	0.2	4	0.8	4	0.8	4	0.8
Maintenance	25%	3	0.75	3	2.25	3	2.25	3	2.25
Durability	15%	2	0.3	2	0.6	4	1.2	4	1.2
Cost	20%	3	0.6	2	1.2	2	1.2	3	1.8
Evironmental	10%	3	0.3	3	0.9	3	0.9	3	0.9
Total Score			2.75		7.7		8.3		8.9
Continue?			No		no		yes		no

Table 2. Concept scoring for designs