Project Deliverable D - Detailed Design, Prototype 1, BOM, Peer Feedback and Team Dynamics

Submitted by

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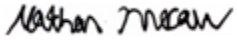
Nathan Meraw 300112438 

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1. Introduction

Having chosen a design concept to develop, and received direct feedback from our client, the next step in the design process is the creation of the first prototype. Prototypes are essential in the early stages of a design, when determining a product's feasibility, as well as whether or not a concept will be successful. The first prototype is an effective way of pointing out any major flaws with the initial design, as well as to clearly communicate the group's vision with the client. In our case, however, the client is visually impaired. This means that a physical prototype will not be as useful for our client but will be used as a method to test various aspects of the original design, as outlined below.

This document explores the feedback received on our groups design concept, as well as how this feedback was welcomed into our improved design, through an updated sketch. The prototype itself is included through screenshots of the CAD model of our guiding cane, which will be used to clarify any gray areas within our group about the integration of certain functions. This report also outlines any assumptions made about the design, which could then be tested and evaluated throughout the prototype testing phase. Finally, a bill of materials (BOM) is included to prove the materials can be acquired while remaining below our $100 budget.

2. Client Feedback

Throughout our second client meeting, our team was able to present our concept to gain feedback and opinions on how to improve the selected design. Our client, Kim, was very helpful in clearly stating her opinions on our design, as well as shedding light on certain aspects that our group did not consider. To begin, our client welcomed the idea of varying cane lengths, using a telescopic mechanism with spring pins to lock the length in place. Locking the cane at various lengths will allow the product to be used for 3 different purposes: socially distanced guiding, close guiding by a familiar acquaintance, as well as individual use by users of all heights. Regarding individual use, our client enjoyed the interchangeable cane ends and believed a marshmallow tip would be the best idea, as it is the most versatile cane end. The spring pin locking mechanism was appreciated as it would allow the visually impaired user to count the holes before deciding in which to insert the pin. This information encouraged our group to decide upon specific amounts and locations of pin holes, in order to maximize comfort and useability. We decided that it would be done by placing three holes, equidistant apart, including one hole that would make the cane 46 inches and one making it 56 inches. These specific dimensions are the average white cane lengths and would allow for comfortable use when being used alone or with a guide. One concern that our client brought up regarding the structure of the cane, was the durability of the locking mechanism and whether this feature would work if it trapped sand, or other foreign matter. Fortunately, our group was able to mitigate these concerns by presenting research that had been done on typical spring pins and their strength and flexibility [1]. We also explained that since the cane was hollow (due to its telescopic design), any small amounts of foreign particles would not

get trapped in the locking mechanism, but in the hollow tube instead, which would not inhibit the products functionality.

Our client also enjoyed the idea of a “J-shaped” handle. She believed that this shape would allow use from those with varying hand sizes, increasing the versatility of our cane. Kim also pointed out the importance of the portability of this handle, especially the removable one, as it must be able to be carried around in a bag, to then be attached to the cane when necessary. This also means that both handles must be small and light enough to fit into a bag for portability, while remaining large enough to hold onto when in use. These requirements encouraged our group to maintain the J-shaped design, while focusing on using a lightweight material to facilitate portability.

Further, our client also enjoyed our concept’s navigation method. She believed haptic feedback would be the best way to communicate directions, as to avoid the need for headphones which would block out all sound, as well as eliminate the danger of having directions spoken aloud in public. She did recommend considering the intensity of the vibrations so that the user could feel it through a glove, without making it too overwhelming. Our client also suggested an “off” switch, as there will not always be a need for a navigation system. Finally, she inquired about the battery life, as well as how the system would be charged. Based on this advice and these questions, our group decided to include a charging port on the cane’s permanent handle, which would be protected by a rubber cover. The navigation system would be charged by plugging a charger into this port.

Finally, our group also brought up the idea of including a light on the cane, as a safety feature, along with the reflective tape. Our client did not find this feature to be a priority, as she was worried it may affect the use of other features, as well as increase the cost of the

product. She also noted that other tools already exist if the guide needs a light, such as a phone, flashlight, or headlamp.

Based on these recommendations, our group was able to update our concept to improve our design, as outlined below.

2.1 Updated Design

Based on our second client meeting and the constructive feedback that was provided, our team has kept the general outline of our initial design but has included certain modifications to better meet the client needs. The guiding cane's body will be made of aluminum, as it is one of the cheapest materials within the industrial market and has a density lower than most metals. This material selection was positively received by the client as it addressed 2 of her major requirements: that the cane be low cost and light weight. The use of aluminum will help meet the target specification that the cane's weight ranges between 3-5lbs, and that the overall product cost does not surpass the $100 budget.

With regards to the construct of the cane's body, the cane will consist of 4 hollow tube segments which will decrease in radius so that they can collapse into one another for effective storage purposes. The telescopic extension mechanism enables the users to be distanced within 1.9-6.3ft of each other. The collapsed length of 1.9 feet ensures that the cane does not take up too much room when being transported in a bag, whereas the full extension allows for Covid social distancing purposes.

Not only does the cane fully extend and contract but includes intermediary lengths which can be locked in place using a spring pin. The client provided 2 reasons for why including intermediary lengths was a good design concept. For one, the users can be separated from each

other depending on their familiarity with one another and comfortability of being close to another. Secondly, when the cane is being used as a regular white cane, the user can modify the cane's length depending on their height. Since typical canes range anywhere from 46inches (3.83ft) – 56 inches (4.67ft), the maximum and minimum extension lengths of our designed cane fulfill the ranging lengths of a regular white cane. The use of a spring pin was also well thought out, since as the user gets more comfortable with the design of the cane, they will be able to count the pin slots to recall what cane lengths they wish to use depending on circumstance.

The cane is also multi-purposed. One end of the cane will be permanently attached to the cane body. The permanent end consists of a J shaped handle, designed to fit the average person's hand. A rubber foam handle grip will be used to cover the handle for maximum comfortability. The foam will also have 4 grooves for finger placement.

On the other end of the cane the user will be able to swap between using a marshmallow white cane tip, and a handle depending on whether they are walking alone or being guided with someone else. The white can tip will be purchased online and will consist of the regular design of usual marshmallow cane tips. The handle will be a replica of the permanent user handle. Similar to the cane's extension mechanism, spring clips will be used to pop off the end of the cane.

With regards to safety and navigation, reflective tape (purchased online) will be wrapped spirally down the cane's body to ensure that the user can be seen by ongoing traffic when walking at night. A GPS navigation system will also be used to help guide the user when travelling to unfamiliar destinations. This navigation system is permanently located on the permanent end of the user's cane and has a charging port protected by a rubber cover to mitigate debris deposition. An off/off switch is also located on the system for battery conservation purposes. This system will be created using an Arduino and a 9000rpm motor vibration system

purchased online. After the user has input the location address, the navigation system will send vibrational impulses to the user to signify whether to turn left, right, or proceed forward. To communicate the directions to the user, the handle will vibrate once to go straight, twice to turn left, and three times to turn right.

As is noticeable through the description of our product, creativity and simplicity was an integral part of our guided cane design. In our opinion, the use of a haptic feedback system is innovative and has not been covered much within the industry. The fact that the cane can be used for two purposes also plays into the effectiveness and creativity of the design. Not to mention, the cane is simplistic in that it does not include many confusing features. The only tasks the user must focus on is exchanging the ends of the cane and using the navigation system when required. In all, this preliminary design considers all aspects of the client needs, as well as provides original ideas of how to tackle the problem at hand. See the diagram below for a visual representation:

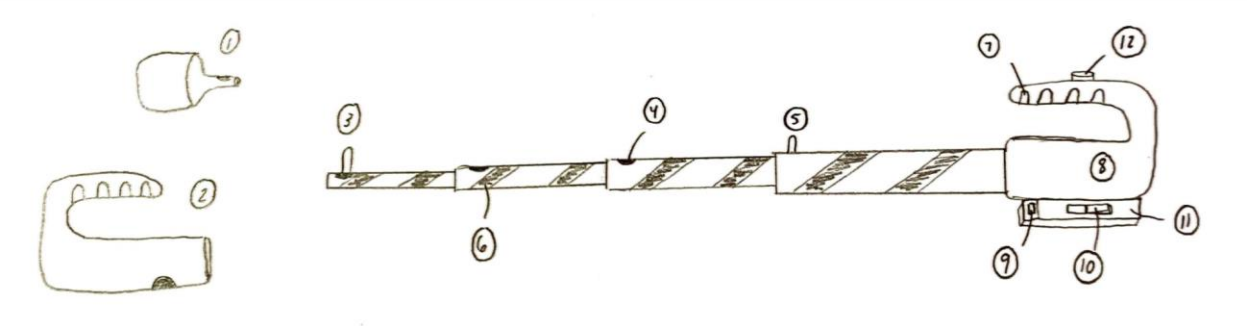

Figure 1: Sketch of our updated design concept

1. The marshmallow white cane tip that will be attached via the spring pin.
2. The J-grip handle used for when the user is being guided. Also attached via the spring pin.
3. The spring pin at the end of the cane connects either end.
4. The pin slots on each of the 4 segments allows for telescopic extension/contraction.
5. The spring pin which holds the length of the cane in place.
6. The reflective tape which helps the user with nighttime navigation.

7. The foam handle with 4 finger grips.
8. The J-grip handle permanently attached to the end of the cane.
9. The new charging port which allows for the navigation system to be recharged.
10. The new on/off switch designed to preserve the navigation system battery.
11. The housing unit of the Arduino, and vibrational system inner workings.
12. The vibrational motor located on the top of the handle, designed for user detection.

2.2 Assumptions

Some of the assumptions that we have made at this point are that we have the tools and materials available to us to create this product, materials we have access to will be strong enough while remaining light enough to work for our product, we'll be able to get third party products (such as the spring clips) in time to have the project finished, and that we are capable of creating this GPS system while keeping it light and compact to fit within the product. When it comes to the material that we would like to use, it is key that we can get enough of it at a low cost to keep the project within our budget and make sure that it is a material we are capable of working within the lab spaces we have access to. It is also key that the material is lightweight enough for anyone to use well still not being to flimsy well fully extended to ensure it doesn't bend or snap. We also plan on using spring clips in our project which we will have to order from amazon and at this point we assume that we will be able to receive these in time. Finally, we have the GPS that we plan on implementing and it is very important to keep this light and small to make sure we reach our target specifications. In addition, some of the assumptions to be tested with this deliverable include the locking mechanism of the length of the cane, as well as the removable handle. It is essential to determine the functionality of these features in the early stages of the design, as these are essential components of the guiding cane.

3. Prototype 1 Design

The main purpose of this prototype is to validate any design ideas, as well as provide a basis for some of the system's target specifications, including length, collapsibility, and weight of the cane. Since this prototype was developed in the early stages of the design, as well as due to our limited time and money, our group decided to create a low fidelity, comprehensive prototype. This type of prototype tends to be less costly, and allowed our group to verify multiple assumptions quickly, and with limited resources, while still getting a concrete idea of every attribute of our design. With the use of AutoCAD technology, our group was able to test the aforementioned assumptions using the methods outlined in Testing.

Since our client is visually impaired, our prototype is mainly being used to assist our group in determining whether our initial design is feasible. Since our group is composed of engineering students with a strong proficiency in understanding CAD models, we decided that this would be the clearest, most cost-effective method of gaining a clear understanding of our current concept.

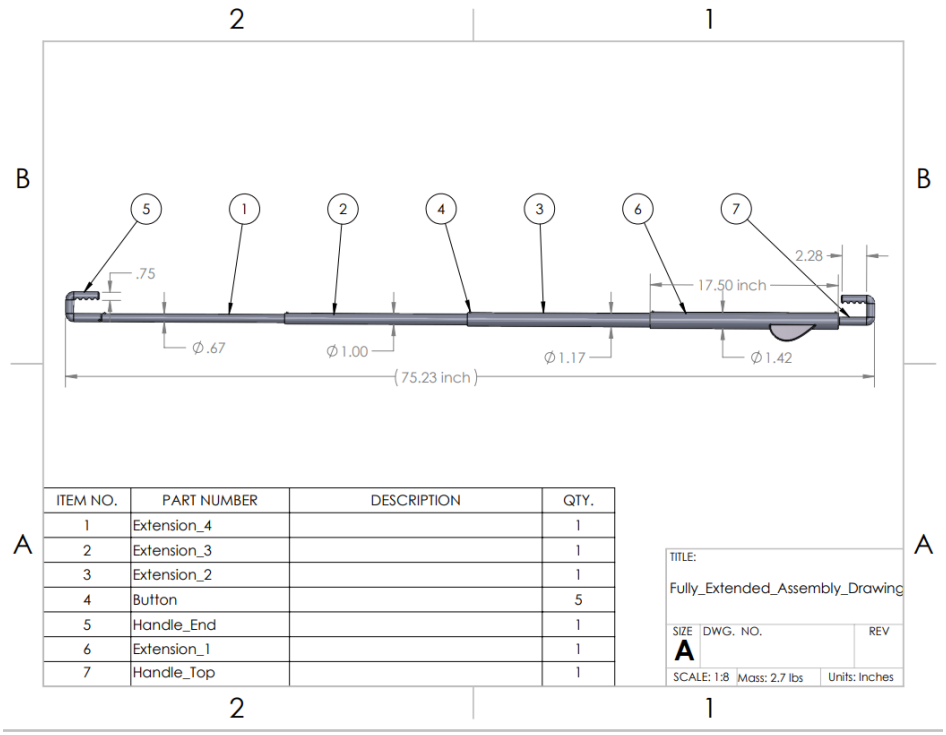

Figure 2: Fully Extended Assembly Drawing

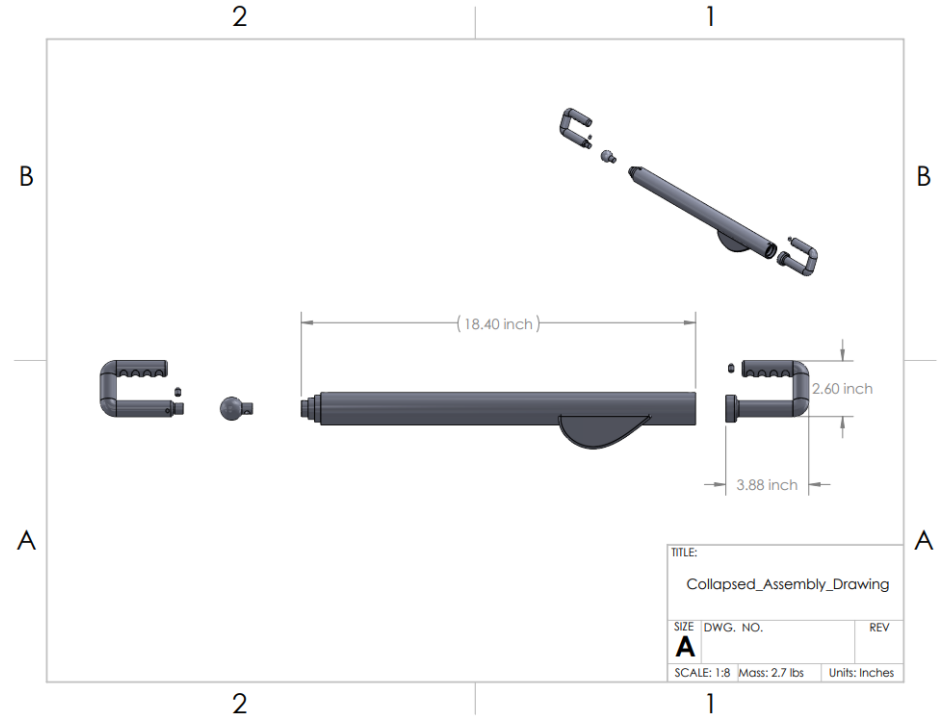

Figure 3: Collapsed Assembly Drawing

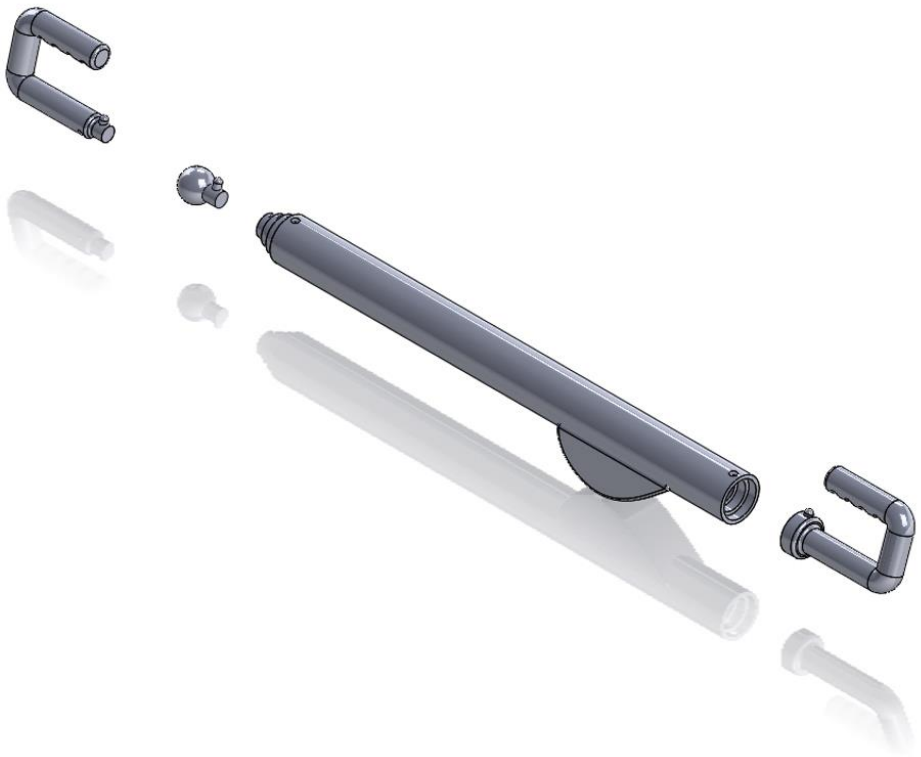

Figure 4: Collapsed Assembly with Interchangeable & Removable White Cane Tip/ Handle Attachments

Figure 5: Fully Extended Assembly with Handle Attachment

Figure 6: Fully Extended Assembly with White Cane Tip (Ball) Attachment

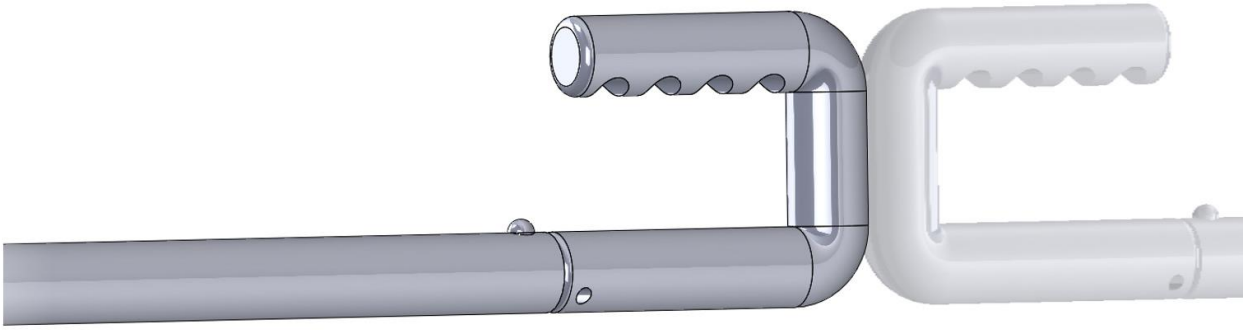

Figure 7: Handle Attachment Close-up

3.1 Testing

Our main goal regarding the testing of this prototype, was to verify whether our cane components were compatible with one another and could create a feasible solution to our problem statement. AutoCAD technology was used to evaluate this as well as to give our group an accurate visual representation of our product so we could immediately pinpoint any flaws, or problems as they arose.

This prototype was used to test the following assumptions: strength and weight of the material, size of parts and their ability to fit into the design, spring pin locking mechanism, and handle removal. The tests were carried out through the creation of the CAD model, as shown in the figures above. By selecting the appropriate materials and lengths, we were able to determine that our product will weigh 2.7lbs, without the navigation software components (including all components, the total weight is estimated to be 3.5lbs). This fits into our target range of 3 – 5lbs, meaning the material was deemed acceptable for our design. Next, the model allowed for the verification of the collapsibility, and along with this, the determination of the extended and collapsed lengths. As displayed in figure 4, the telescopic structure of the cane allows for the collapsibility of the hollow aluminum tubes into a collapsed length of 1.9ft. Unfortunately, this is slightly too long for our group's standards and will interfere with the portability of the product. The collapsibility will have to be improved upon in future designs. Conversely, the extended cane reaches a length of 6.3ft, 3 inches over the required for socially distancing measures. This test confirmed that we are using sufficient amounts of material to maintain safe COVID measures. Finally, this prototype allowed for the testing of the spring pin locking mechanism. Whether this mechanism is being used for the extension of the cane, or for the removal of the handle, the prototype clearly demonstrates that the design can withstand 4 holes and 2 pins to allow for versatility of the cane.

Overall, this prototype allowed our group to verify that the product parts will indeed fit together, without creating a bulky or unappealing design. We were able to verify target specifications and learn from this experience to determine what can be improved upon in our next physical prototype.

Table 1: Testing Table

Assumption Tested	Testing Method	Expected	Actual
Cane can extend and collapse	Use CAD to collapse telescopic segments into each other and extend them again.	Telescopic segments fit into one another. (Value: N/A)	Telescopic segments fit into one another. (Value: N/A)
	Measure length of segments.	Segments are between 10 – 25 cm.	17.5 inch = 44.45cm (Fails)
	Use CAD to determine whether the pins fit into the slots (to lock).	Spring pin mechanism allows length to be locked. (Value: N/A)	Spring pins fit into slots to lock (Value: N/A)
Cane handle is removable	Use CAD to determine whether the pins fit into the slots (to release).	Spring pin mechanism allows handle to be locked and removed from product. (Value: N/A)	Spring pins fit into slots to lock (Value: N/A)
Cane handle is portable	Measure length of the handle	Between 10 – 15 cm.	9.86cm
Extended length is acceptable	Measure length of the extended cane	At least 6ft	6.3 ft
Collapsed length is acceptable	Measure length of the collapsed cane	Max 1.5 ft	1.9ft
Product's weight is acceptable	Measure weight of the product with all components, using the correct materials	Between 3-5 lbs	2.7lbs without additional equipment (estimated to be up to 3.5 lbs with all components)
Product components all fit	Ensure there is space for all components, while remaining aesthetically pleasing.	All required components fit comfortably on product (Value: N/A)	All required components fit comfortably on product (Value: N/A)

Table 1 summarizes the assumptions tested and the methods used to do so. From the actual values obtained, the cane segments, as well as the collapsed length of the cane both display unacceptable values outside of our target range. Since these components vary with one another, by increasing the number, and decreasing the length, of our segments, we will, in

turn, be able to decrease the overall length of the collapsed cane. This modification will be a top priority for prototype 2.

4. Client Meeting Plan

Our team will describe our progress to our client, Kim, to make sure we satisfy all needs and wants of the client as well as make sure she is happy with every specification. Firstly, to the best of our ability, we will describe to our client the 3D model developed for the product and gather feedback for all the developed concepts and specifications that were incorporated (Table 1). We will also read the list of parts we intend to use and the pricing of those parts to make sure the client agrees with the materials used. After describing our model, we can ask the client to express any concerns or appreciated ideas with the product, and we will utilize that feedback to create a physical prototype of the product based off our 3D AutoCAD model.

5. Bill of Materials

Table 2: Bill of Materials

Item	Description	Price (CAD)	Reference
1	1"x8' Aluminum Round Tube	30.09	https://www.lowes.ca/product/round-metal-tubes/hillman-aluminum-plain-tube-55978
2	3/4x3' Aluminum Round Tube	13.29	https://www.lowes.ca/product/round-metal-tubes/hillman-34-in-dia-x-3-ft-l-mill-finished-aluminum-round-tube-216096
3	1/2"x3' Aluminum Round Tube	8.09	https://www.lowes.ca/product/round-metal-tubes/hillman-12-in-dia-x-3-ft-l-mill-finished-aluminum-round-tube-215889
4	6 Pack Wrist Lanyard Strap	8.99	https://www.amazon.ca/Wisdompro%C2%AE-Lanyard-Keychains-Holders-Portable/dp/B07GXJT9SC/ref=sr_1_8?dchild=1&keywords=wrist%2Bstrap%2Blanyard&qid=1633478082&sr=8-8&th=1
5	Reflective Safety Tape (4-Pack)	9.99	https://www.lowes.ca/product/safety-tape/hillman-reflective-safety-tape-4-pack-34093
6	1" ID Foam Handle Grip (1m)	14.99	https://www.amazon.ca/uxcell-Tubing-Handle-Support-Length/dp/B0952241J9/ref=sr_1_6?dchild=1&keywords=foam+handle&qid=1633478894&sr=8-6

7	3 Pcs 9000RPM Flat Vibration Motor	11.99	https://www.amazon.ca/9000RPM-Vibration-Module-Electronic-Components/dp/B08GS1TYY4/ref=sr_1_5?dchild=1&keywords=vibration+motor+arduino&qid=1633479269&sr=8-5
8	Arduino/Raspberry Pi	0.00	Provided by Zach
9	Battery for Arduino/Raspberry Pi	0.00	Provided by Zach
10	Filament for 3D Printing Prototype	0.00	Provided by Makerspace Resources
11	Spring clips (for locking the telescoping cane)	0.00	Provided by Dom (https://www.amazon.ca/MagiDeal-Pieces-Stainless-Outdoor-Camping/dp/B078V4C74W?psc=1&pd_rd_w=m8Uh6&pf_rd_p=f520a640-ccf5-417d-98d0-fb721ea0a7f6&pf_rd_r=XB72TY484590AFNX2H0P&pd_rd_r=15ca854a-8c24-4a81-a590-849c30bd2b5a&pd_rd_wg=JkAJE&ref_=sspa_dk_rhf_search_pt_sub_2&spLa=ZW5jcnlwdGVkUXVhbGlmaWVyPUEyUjU0SDNGTUVERzFCJmVuY3J5cHRlZElkPUExMDI1MTM2M0xFVDBSQU9DRDA1QiZlbmNyeXB0ZWRBZElkPUEwNTA2MzM2MTVYNTgxQkJYMk5ROSZ3aWRnZXROYW1lPXNwX3JoZl9zZWFyY2hfcGVyc29uYWxpemVkJmFjdGlvbj1jbGlja1JlZGlyZWN0JmRvTm90TG9nQ2xpY2s9dHJ1ZQ==)
Total Price		97.43	
Note: Amazon Prime for free shipping, shopping in Lowes in-person.			

6. Conclusion

To conclude, our decisions regarding all of the specifications and features were presented to Kim, our client, where it received praise, claiming that the design was already “awesome”. Although the design was great for the client, she still had some suggestions, such as including an “off” switch for the navigation features and increasing haptic feedback strength so that she can feel the vibration through gloves. Additionally, she also expressed concerns with battery life, showing a preference for rechargeability. With this feedback, we improved our current model and solidified design concepts, and we plan on presenting it to her in the next client meeting.

To prepare for the next client meeting with Kim, we have decided to create an AutoCAD model of our prototype that incorporates all the changes requested by the client including previous measurements and agreed design concepts. This model allows us to test the different components together to make sure they all fit, as well as avoid any unseen conflicts with design and comfortability. With the use and examination of a non-physical prototype, we can report our findings to our client and solidify the dimensions of the product without the costs of a physical prototype.

7. References

[1] M. Froese, “What are spring pins?,” *Fastener Engineering*, 30-Jul-2021. [Online]. Available: https://fastenerengineering.com/what-are-spring-pins/. [Accessed: 04-Oct-2021].

Appendix: Updated Project Plan

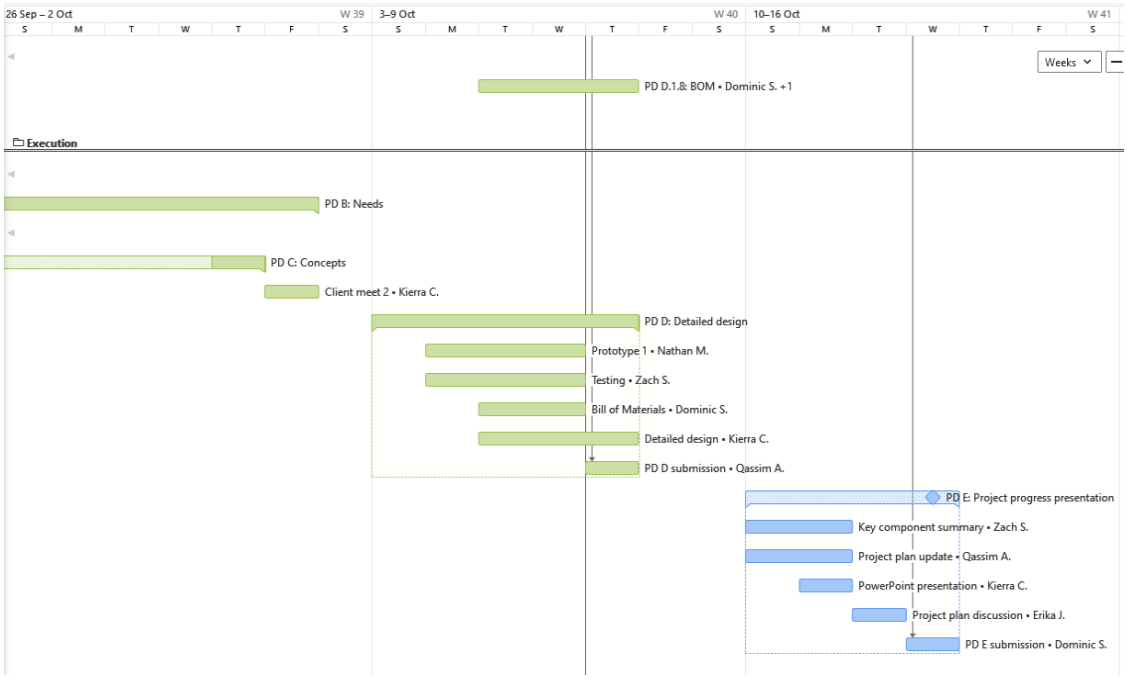

Figure 8: Updated Gantt Chart

28	Execution			
29	Client meet 1	21/09/2021	21/09/2021	36FS
30	PD B: Needs	22/09/2021	01/10/2021	29FS, 37FS
35	PD A: Team set-up	13/09/2021	16/09/2021	
38	PD C: Concepts	30/09/2021	30/09/2021	
42	Client meet 2	01/10/2021	01/10/2021	
43	PD D: Detailed design	03/10/2021	07/10/2021	
44	Prototype 1	04/10/2021	06/10/2021	40FS
45	Testing	04/10/2021	06/10/2021	
	Bill of Materials	05/10/2021	06/10/2021	
47	Detailed design	05/10/2021	07/10/2021	
48	PD D submission	07/10/2021	07/10/2021	7FS
49	PD E: Project progress present...		13/10/2021	
50	Key component summary	10/10/2021	11/10/2021	
51	Project plan update	10/10/2021	11/10/2021	
52	PowerPoint presentation	11/10/2021	11/10/2021	
53	Project plan discussion	12/10/2021	12/10/2021	
54	PD E submission	13/10/2021	13/10/2021	8FS

Figure 9: Updated project plan table