Project Deliverable C - Conceptual Design, Project Plan, and Feasibility Study

Submitted by

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30/09/2021

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Abstract

This report reveals the functional decomposition of our project to create a Guiding Cane for people who are visually impaired. Additionally, the conceptual design decisions and figures created and thought up by each team member, the analysis of those design decisions and ideas, and the group decisions that were made towards the functionality of the Guiding Cane and what designs and concepts should be developed for the first prototype of the product.

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Introduction

The conceptual design portion of this project allows for a creative phase of the design process. Beginning with a functional decomposition, our group broke down the main functions and subfunctions of our product, giving us a better idea of the features to include in our design, to resolve our client's needs. Once the functions of the design were clear, our team was able to brainstorm in a judgement-free environment to generate nearly 20 creative concepts. All of the concepts were created with the problem statement in mind, to ensure the designs were possible solutions to our client's current issues. From here, the concepts were analyzed against the target specifications set in deliverable B to determine the most promising concepts, which were then expanded upon and turned into a single global concept. This concept will be our starting point for prototype 1, allowing us to receive feedback and iterate over this process, with the goal of improving the features and feasibility of our design as much as possible.

1. Functional Decomposition

Functional Decomposition: breaking down required functions into sub functions and sub-system boundaries. List of tasks required to satisfy customer needs.

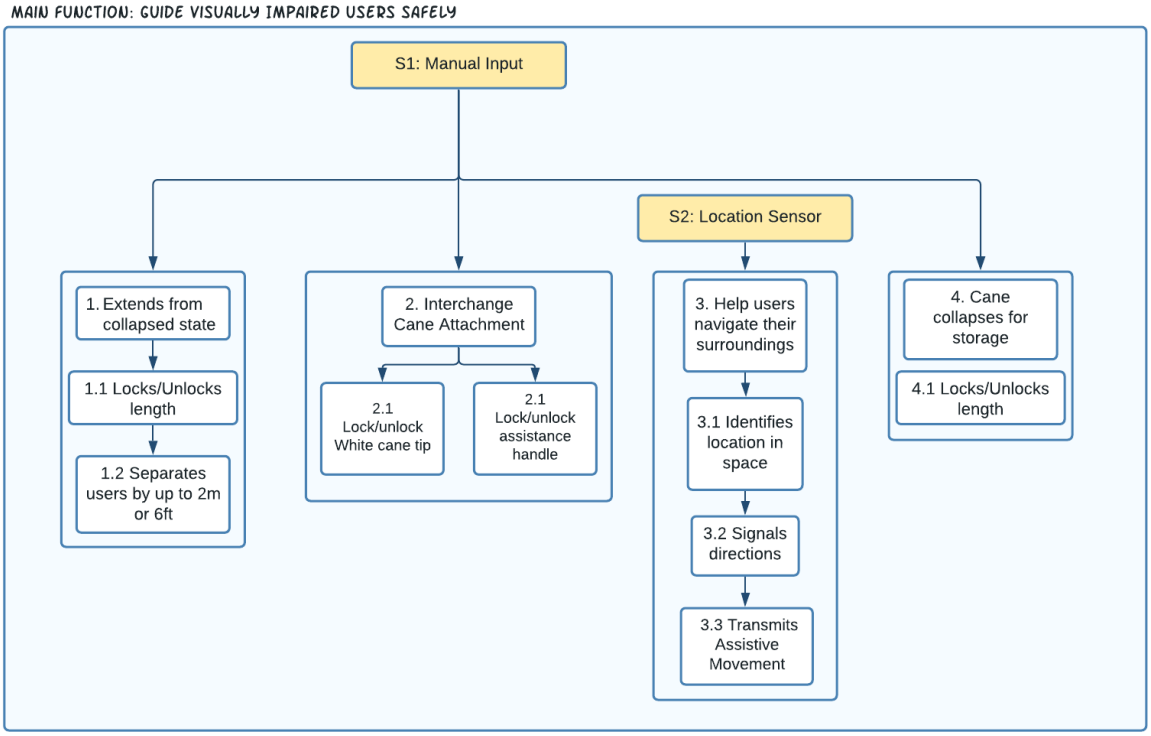


Figure 1: Functional Decomposition of the Guiding Cane

2. Individual Concept Ideas

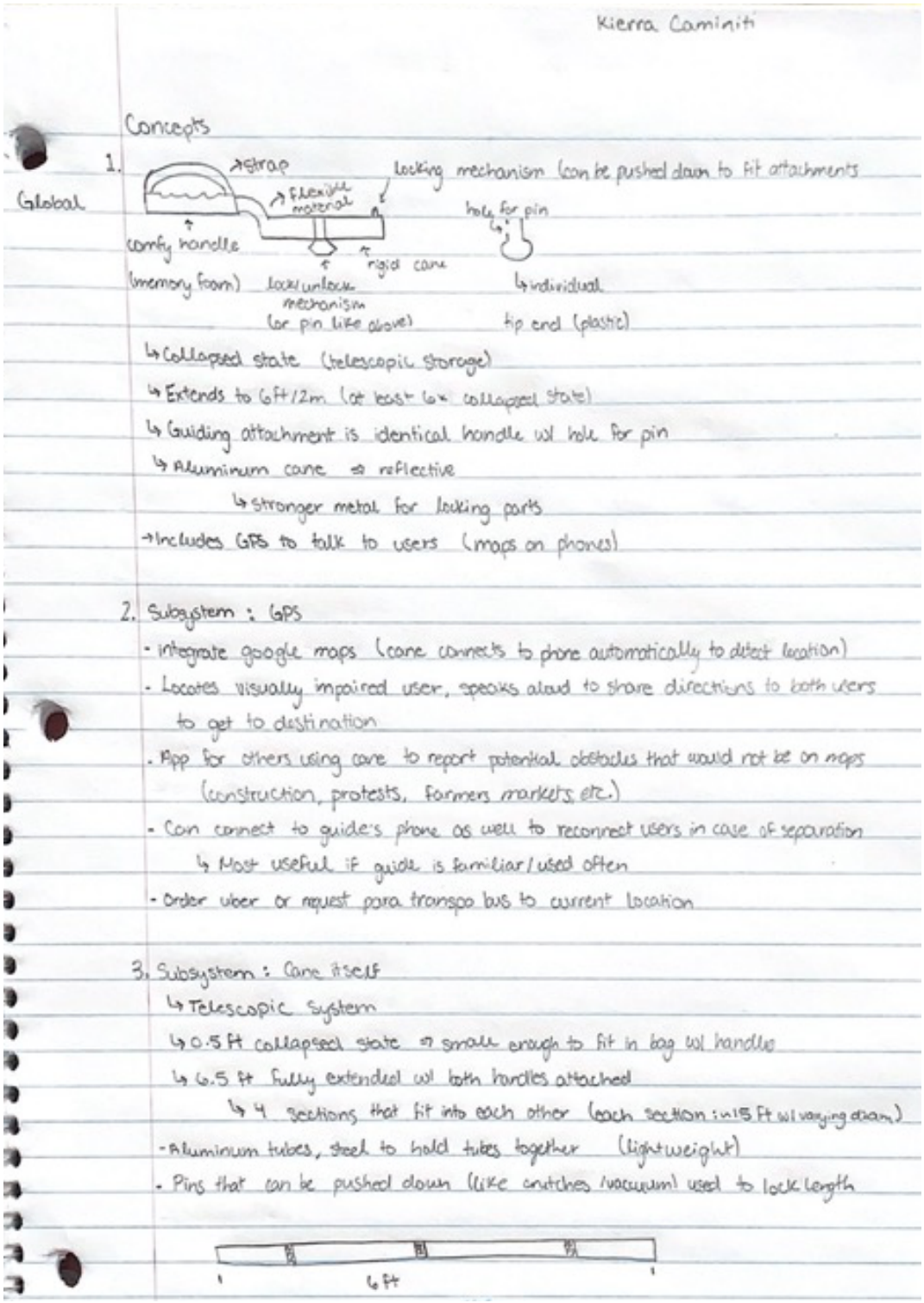


Figure 2: Kierra's Concepts

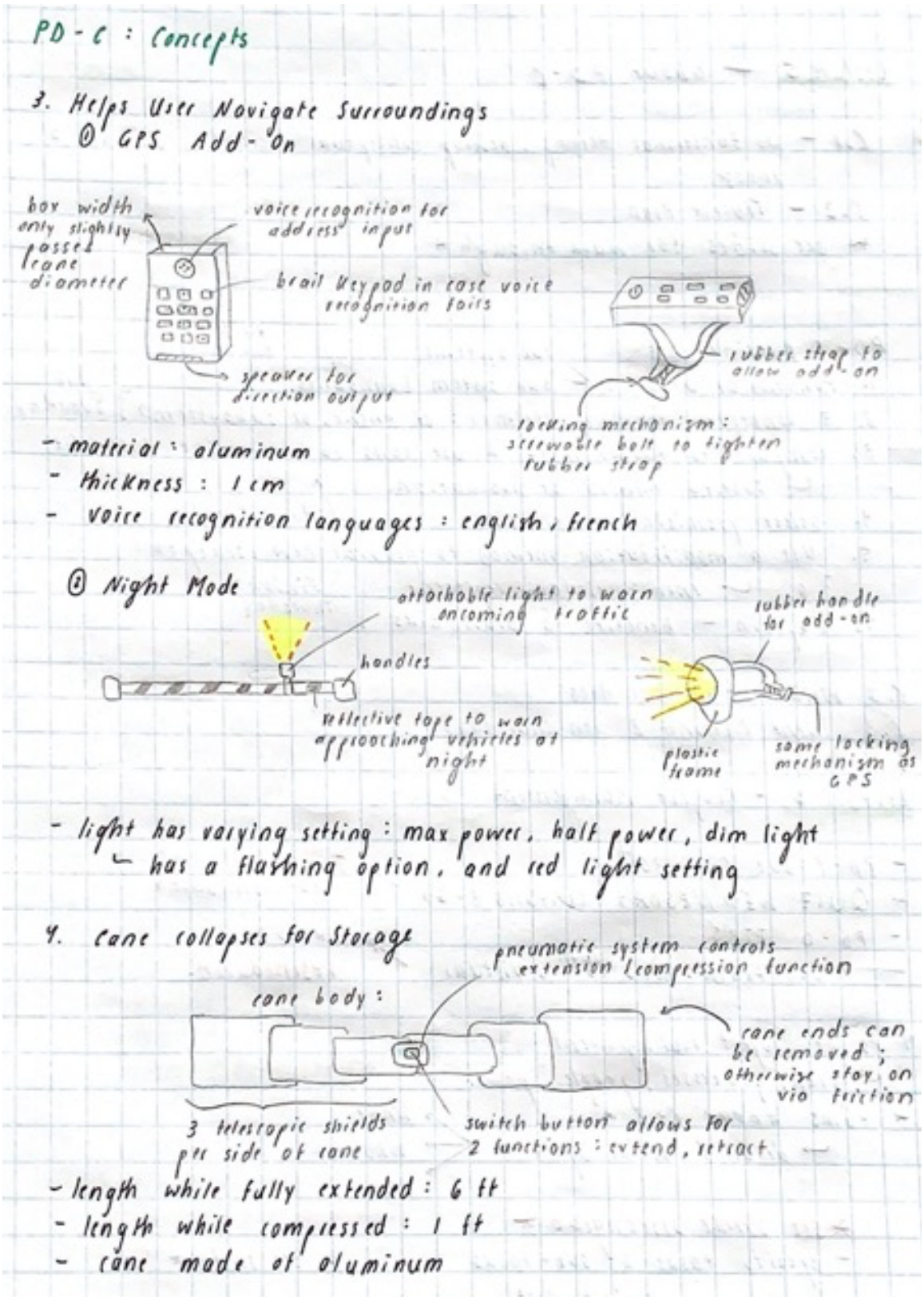
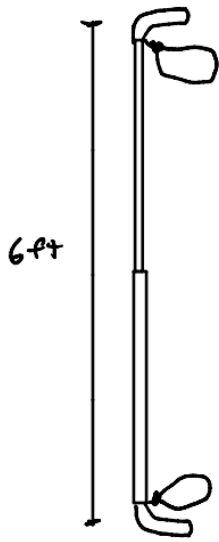


Figure 3: Erika's Concepts

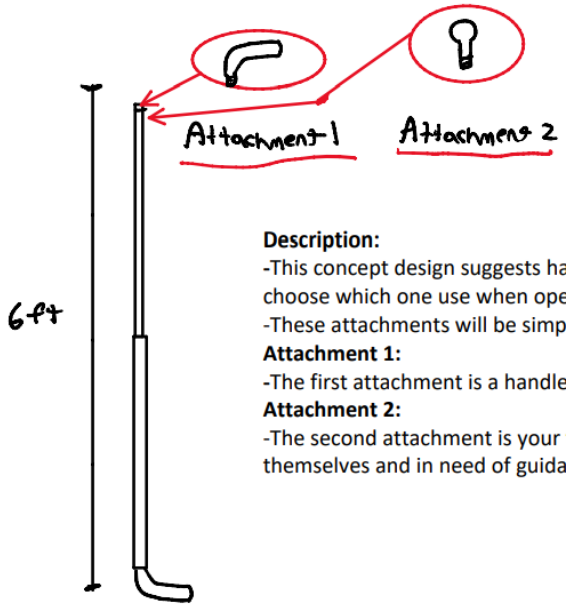
1. **Handle Subsystem: Wrist strap for cane**



Description:
-Wrist strap for both the user and guide to attach to wrist
-The wrist strap would ensure that user and guide feel secure through their travels
-The wrist strap is adjustable

Figure 4: Nathan's Subsystem Concept 1

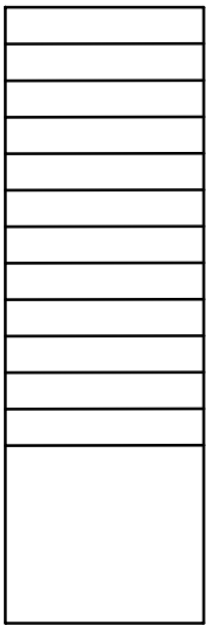
2. **Handle Subsystem: Interchangeable handle/ White cane tip**



Description:
-This concept design suggests having two different interchangeable attachments in which the user can choose which one use when operating the cane
-These attachments will be simply screwed on to the end of the threaded shaft
Attachment 1:
-The first attachment is a handle which would be used for the user to be guided by another person
Attachment 2:
-The second attachment is your typical white cane tip ball which is to be used when the user is by themselves and in need of guidance

Figure 5: Nathan's Subsystem Concept 2

3. **Handle Subsystem: Memory Foam Handles**



Description:
-This handle is made out of a very comfortable memory foam
-It has lines in the foam to add additional comfort

Figure 6: Nathan's Subsystem Concept 3

1. Replaceable Ends:

- End one
  - A handle that would be held horizontally
  - Foam handle for comfort
  - Wrist strap to ensure you can't drop the cane
  - Spring clip would lock into a hole in the end of the main pole for easy switching
  - Would come with 2 one for each end
  - 6 inches wide
- End two
  - A simple ball end so that the cane can be used as a simple white cane
  - Also has the spring clip
- End three
  - A handle for when using as a simple white cane
  - Foam handle for comfort
  - Also has the spring clip

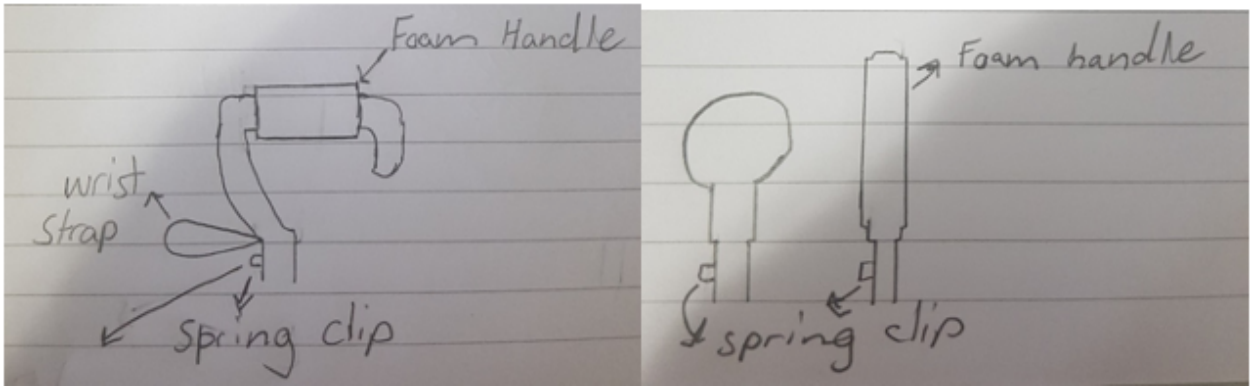


Figure 7: Zach's Subsystem Concept 1

2. Telescopic Pole:

- Has holes at each end so that the ends can be swapped out
- Collapses for easy storage
- Extends to 6ft for proper social distancing
- Collapses to 1ft for easy storage
- Button to release the separate parts similar to a suitcase handle

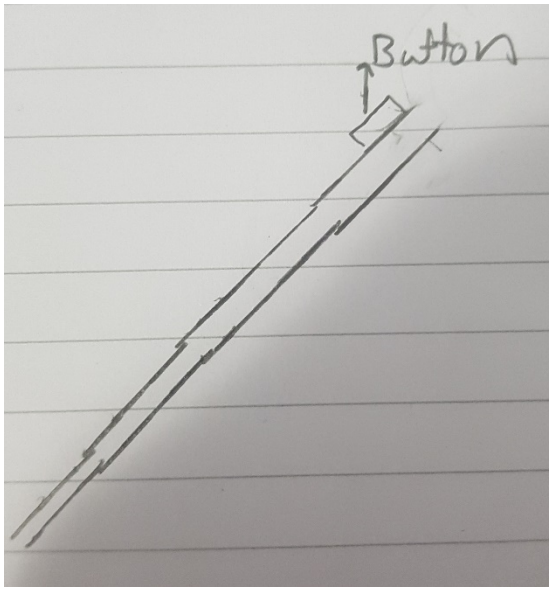


Figure 8: Zach's Subsystem Concept 2

1. **GPS System**

- Small 3D printed box attached to the side of the side of the pole
- Contains an Arduino that can connect to your phone through Bluetooth

- Box would need holes for ventilation
- Small speaker as well to give the directions to both users at the same time

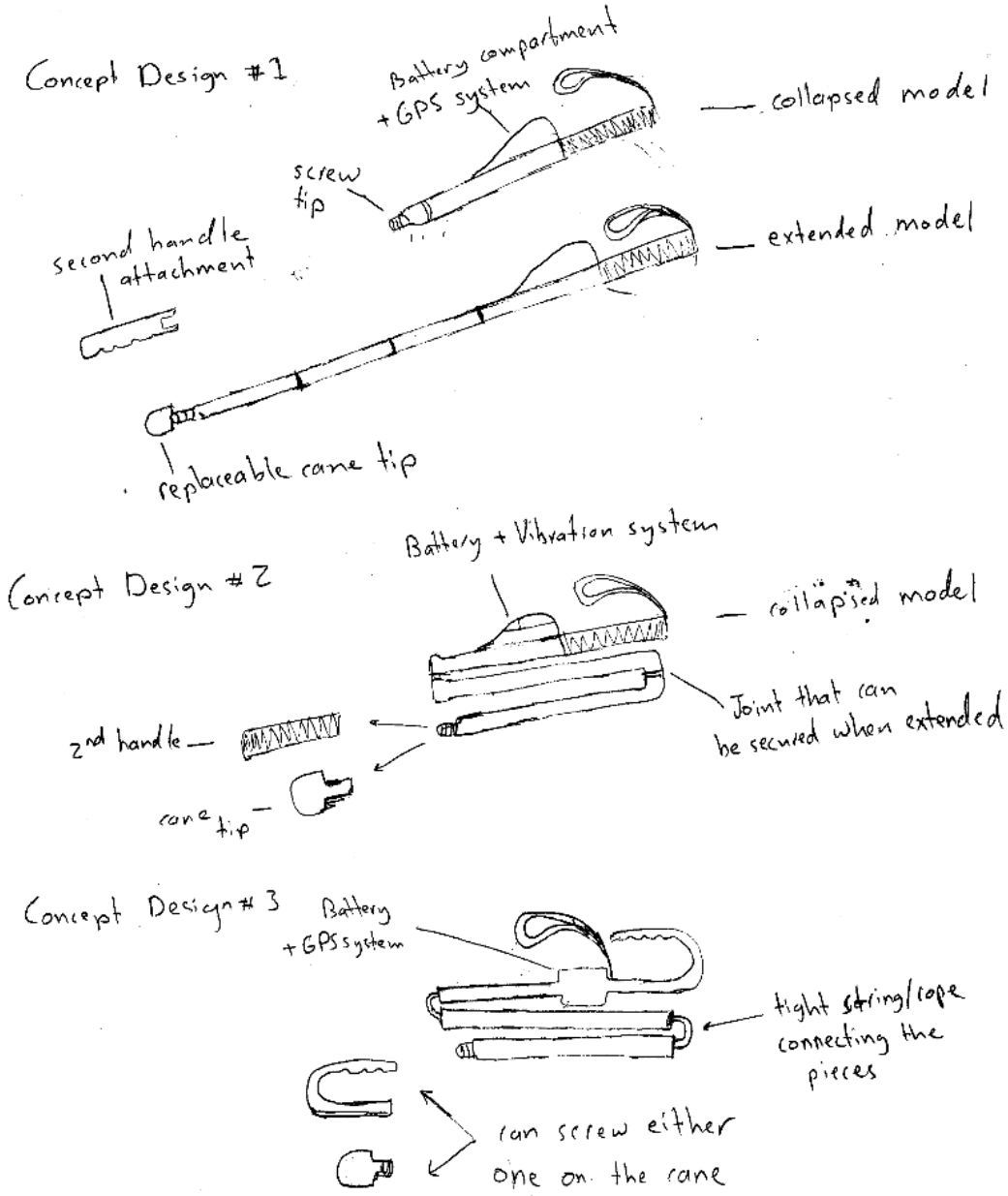


Figure 9: Qassim's Concepts

1. **Subsystem - Guiding Handle**

- Pivoting handle helps the user know what direction the guide is going
- Ball and socket joint to give feedback when the guide goes all directions
    - Joint has a small latch to remove and replace the handle

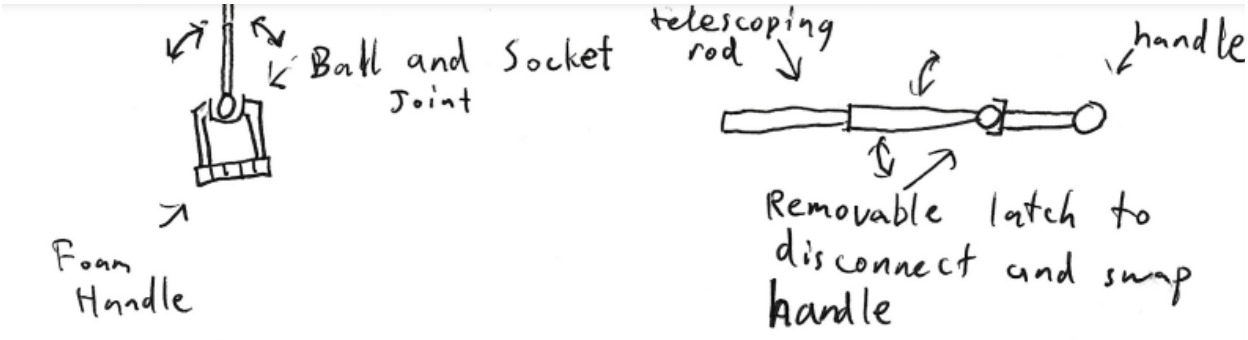


Figure 10: Dominic's Subsystem Concept 1

2. **Subsystem - Haptic Feedback for Navigation**

- Motors inside of the user's handle on the left and right sides vibrate indicating what direction the guide should turn
- Arduino or another device for communicating with the user's cell phone through Bluetooth is embedded into handle
    - Needs a rechargeable battery OR make the battery replaceable through a latch
    - Might need a Bluetooth chip for the Arduino to communicate with the user's cell phone
- Google Maps API is used to synchronize with directions on the cellphone

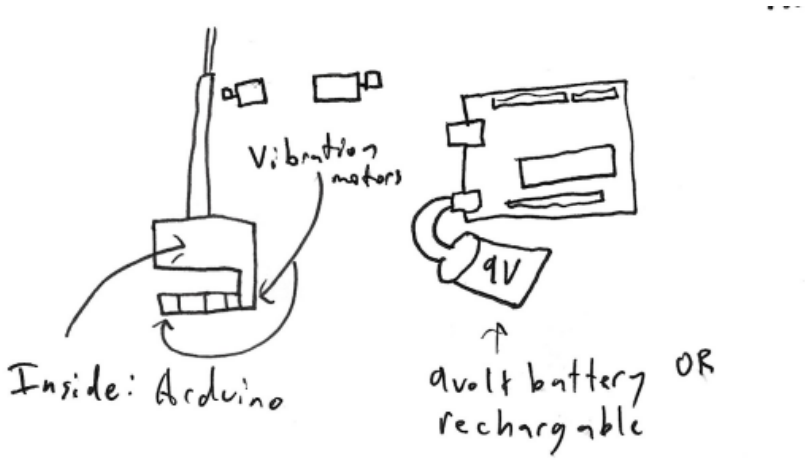


Figure 11: Dominic's Subsystem Concept 2

3. **Subsystem - Visibility of the Users in Low Light**

- Three lights with similar functionality to a bike light are attached at three places on the rod - user end, guide end, and in the middle
- Light has three modes - Stable On, Strobe/Flashing, Off
- Emits a red light or a white light, all three should be the same color

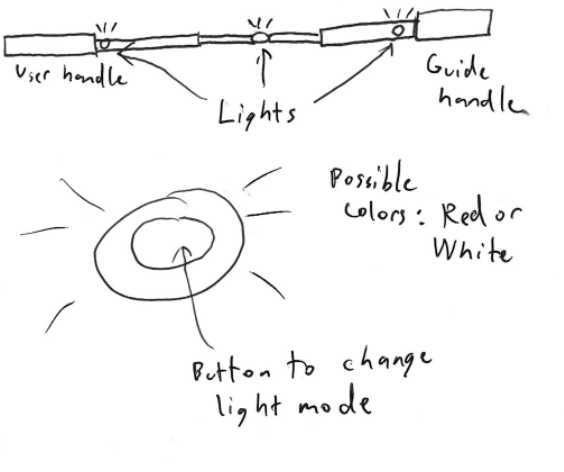


Figure 12: Dominic's Subsystem Concept 3

Table 1: Summary of Concepts Generated and Issue Being Addressed

Group Member	Issue Being Addressed		
Kierra	**1. Global Concept Features**: Collapsible rigid cane with ability to lock length, comfortable handles, allows for interchangeable cane ends with ability to lock end in place, includes GPS for directions.	**2. Subsystem**: Navigational Aid – GPS **Features:** integrate google maps, ability to connect to user's or guide's phone.	**3. Subsystem**: Collapsible cane **Features:** Telescopic storage, manual extension and lock, 0.5ft when collapsed, 6ft when extended.
Erika	**4. Subsystem:** Navigational Aid – GPS **Features:** brail keyboard, audio recognition, speaker to feed directions, rubber strap with adjustable twist	**5. Subsystem:** Navigational Aid – Night mode **Features:** reflective tape around the cane, attachable light with numerous settings, rubber strap with adjustable twist	**6. Subsystem:** Collapsibility **Features:** Pneumatic, telescopic body Features: switch button to control pneumatic system extension
Nathan	**7. Subsystem:** Handle **Features:** Wrist Strap for both user and guide to attach to wrist to ensure that the cane is not lost when dropped.	**8. Subsystem:** Handle **Features:** Interchangeable white cane tip/ handle	**9. Subsystem:** Handle **Features:** Comfortable handle made from memory foam with lines engraved in it for even more comfort.
Zach	**10. Subsystem:** Handle **Features:** Replaceable types for guiding or regular cane	**11. Subsystem:** Main Body **Features:** Collapsing pole Collapses similar to suitcase handle	**12. Subsystem:** Navigational Aid - GPS **Features:** Arduino that connects to phone and has a speaker so that both users can get directions
Qassim	**13. Subsystem:** Replaceable (screw on) tip OR handle	**14. Subsystem:** Telescoping extension mechanism **Features:** Haptic feedback system for navigation, wrist strap	**15. Subsystem:** Sectioned cane that snaps together. Sections are connected by strong elastic rope inside the sections **Features:** connect to mobile device for Google Maps access, wrist strap

Dominic	**16. Subsystem:** Guiding Handle **Features:** Handle is attached to the rod with a ball-and-socket joint, making it easy for the user to know what direction they are going	**17. Subsystem:** Haptic Feedback for Navigation **Features:** Vibration motors in the handle are activated based on what direction the user needs to turn (using Google Maps API)	**18. Subsystem:** Visibility of the Users in Low Light **Features:** There are 3 lights on the cane, one for the user and the guide, and one in the middle of the cane so others can see the users at night

3. Analysis of Concepts

Table 2: Analysis of Concepts using a Weighted Matrix

Selection Criteria	Weight of the cane	Length of the cane (Extended)	Length of the cane (Collapsed)	Handle Length	Reflectiveness of the material	Production Cost	Segment Length (Collapsible Parts)	Comfort	Navigation tools	**Total Score =**
Weight / Concept #	0.1	0.2	0.2	0.05	0.05	0.2	0.05	0.1	0.05	1
	9	10	7	5	10	5	6	6	4	
1	0.9	2	1.4	0.25	0.5	1	0.3	0.6	0.2	7.15
	0	0	0	0	0	5	5	0	10	
2	0	0	0	0	0	1	0.25	0	0.5	1.75
	8	8	8	8	0	8	9	7	0	
3	0.8	1.6	1.6	0.4	0	1.6	0.45	0.7	0	7.15
	6	0	0	0	0	2	0	6	10	
4	0.6	0	0	0	0	0.4	0	0.6	0.5	2.1
	6	0	0	0	10	8	0	4	8	
5	0.6	0	0	0	0.5	1.6	0	0.4	0.4	3.5
	3	8	7	0	0	1	8	8	0	
6	0.3	1.6	1.4	0	0	0.2	0.4	0.8	0	4.7
	0	0	0	0	0	9	0	10	0	
7	0	0	0	0	0	1.8	0	1	0	2.8
	7	0	0	7	0	8	0	8	0	
8	0.7	0	0	0.35	0	1.6	0	0.8	0	3.45
	0	0	0	0	0	8	0	10	0	
9	0	0	0	0	0	1.6	0	1	0	2.6
	8	0	4	6	0	8	0	10	0	
10	0.8	0	0.8	0.3	0	1.6	0	1	0	4.5
	5	8	7	0	0	5	9	7	0	
11	0.5	1.6	1.4	0	0	1	0.45	0.7	0	5.65
	0	0	0	0	0	7	0	0	10	
12	0	0	0	0	0	1.4	0	0	0.5	1.9
	0	8	8	9	0	6	7	8	8	
13	0	1.6	1.6	0.45	0	1.2	0.35	0.8	0.4	6.4
	4	8	8	8	0	4	8	8	10	
14	0.4	1.6	1.6	0.4	0	0.8	0.4	0.8	0.5	6.5
	4	8	8	8	0	5	9	8	8	
15	0.4	1.6	1.6	0.4	0	1	0.45	0.8	0.4	6.65
	6	7	7	7	0	6	8	10	10	
16	0.6	1.4	1.4	0.35	0	1.2	0.4	1	0.5	6.85
	5	0	0	7	0	7	7	4	10	
17	0.5	0	0	0.35	0	1.4	0.35	0.4	0.5	3.5
	7	0	0	7	10	7	0	0	10	
18	0.7	0	0	0.35	0.5	1.4	0	0	0.5	3.45

Table 2: Analysis of Concepts using a Weighted Matrix

Since most of the concepts generated by our group were subsystems instead of global concepts, some great solutions rated low as they did not address all the target specifications. For this reason, it would not be wise to choose solutions based on those with the highest overall ratings. Instead, we decided to develop the concepts that scored the highest for each individual target specification, to then amalgamate these subsystems into a single global concept.

4. Promising solutions to Develop Further

4.1 Global Concept #1

One of the promising solutions our group has chosen to develop further is global concept #1. Since this concept is one of the only ones encompassing an overview of the entire product and all its features, we believed it would be beneficial to keep this one in mind and expand on some of its components. This concept also had the best rating in the weighted evaluation table, further proving that it would be worthwhile to focus on.

Since global concept #1 provides a general overview of the main components our cane would include, we also thought it necessary to develop some of the subsystem concepts. Two of the most important subsystems include: a method of navigation and the cane itself. Based on the evaluation table, it was decided that the best method of navigation is concept #17.

4.2 Subsystem Concept #17

Another one of the concepts the team would like to develop further is concept #17. This concept involves integrating a haptic feedback system into the handles of the guiding cane for navigation purposes. This system would be incorporated with the assistance of a google maps API for directions. To communicate the directions to the user the handle would vibrate once to go straight, twice to turn left, and three times to turn right. This system would involve an Arduino or another device for communicating with the user's cell phone through Bluetooth which is embedded into the handle. Some of the additional components involved in this subsystem would be haptic motors, Bluetooth chip, and a rechargeable battery.

4.3 Subsystem Concept #11

Further, we would also like to expand on the telescopic cane design concept (Concept #11). This method allows for the appropriate collapsed and extended lengths, as well as allows visually impaired people to easily store and use the product with the push of a button. Since the design meets most, if not all, of our client's needs, it was concluded that this is the most efficient design for the main body of the cane.

4.4 Subsystem Concept #10

Finally, our group has decided to expand on the detachable handles and cane tip. Since typical white canes tend to be very expensive, this multipurposed design will allow our client to navigate her surroundings individually, or with the help of a guide, for the price of a single

product. Based on the evaluation table, we have decided to focus on concept #10, which maximizes comfort with the use of foam handles that are not directly in line with the cane. Although this design did not score highest in our evaluation for size of the handle, it did score highest for comfort. Since the size of the handle can be easily modified as needed, our group decided there was no need to focus solely on size and it would be more worthwhile to design based on the user's comfort.

5. Group Design Concept

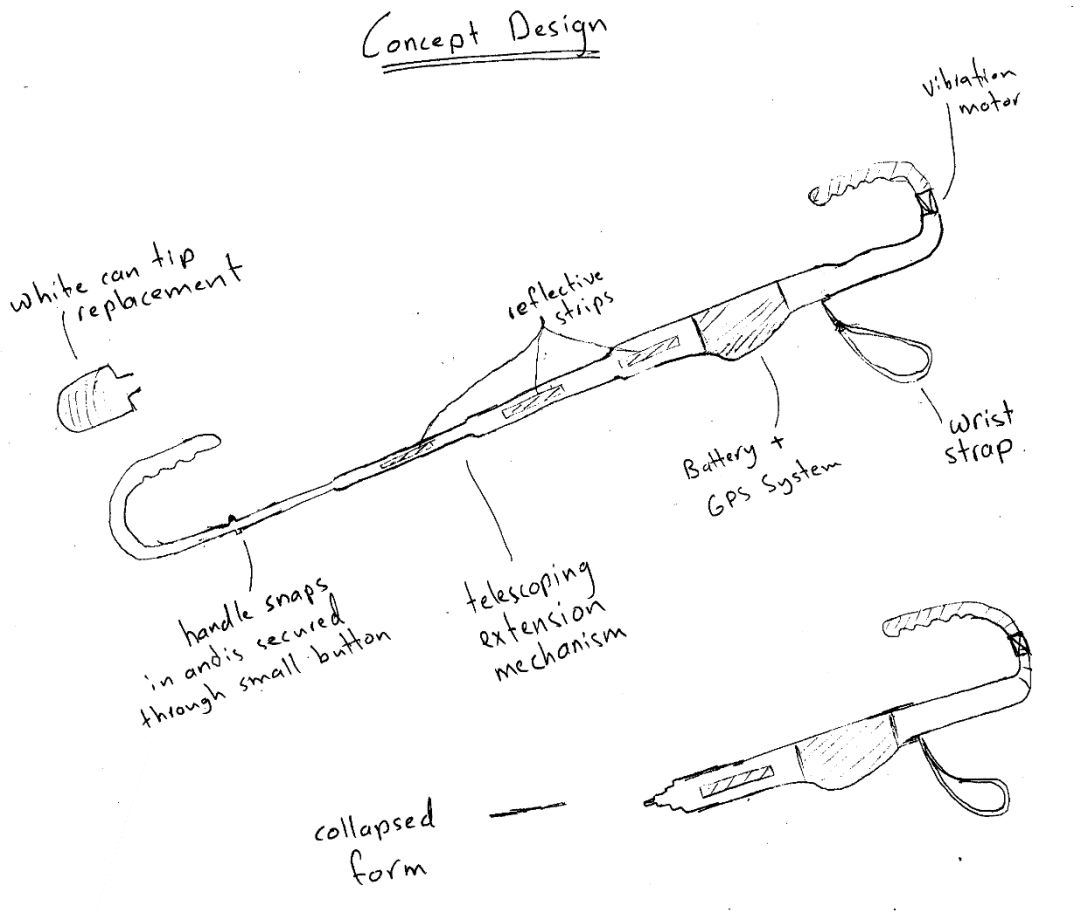


Figure 13: Guiding Cane Concept Design

5.1 Concept Description

Note:** The description of our product is slightly longer since our client is visually impaired. Having additional details in the description instead of the sketch will be useful during Client Meeting #2.**

Our group chose this design concept since it not only respects our target specifications, but also responds to our client's needs. The aluminum cane will be a hollow tube when extended due to its telescopic extension mechanism. The extension method, as well as the removable cane ends (handle or tip) will be locked in place by a spring pin. These features ensure the product will be very light (between 3-5lbs), while also allowing for a collapsed length of 25cm and an extended length of 200cm. These dimensions allow for portability and storage, as well as social distancing when in use. In addition, the pin will allow the cane to function at various lengths when being used alone. The permanent and removable handles on this cane also maximize comfort based on their length and width, designed to fit the average person's hand. The reflection strips on the cane will be used to ensure the user's safety when walking at night. This design also includes a navigation system, which will vibrate the handle to alert the user when to turn right or left, in order to direct them and their guide to the correct destination. Finally, through the use of cheap and limited amounts of materials, as well as a simple navigation system, our product will remain within our target production cost of $40-$60 CAD.

This design is clearly very beneficial as it aims to meet the majority of our client's needs, including a simple and effective navigation system, social distancing, and portability, among others. One of the potential drawbacks with this design is the fixed handle size. Since the design does not offer varying lengths and widths of the handle, it may be difficult for two people of drastically different sizes to use the same product.

6. Conclusion

When generating concepts for the guide cane design, several brainstorming techniques were used. These predominantly included sketching, synthesis, and morphological analysis. Using a variety of strategies pertaining to concept ideation led to an increased number of generated solutions. After compiling all our ideas, a weighted matrix analysis seemed to be the best idea in ensuring that all client needs were properly met. Though some ideas only tackled subsystems that had been created through functional decomposition, the weighted matrix still enabled us to assess the merit of each solution in comparison to other ideas which addressed the same client need. With prototyping being the next step within this design journey, it will be crucial that all members stay on top of their work as well as practice regular communication to ensure the prototype is a successful first solution to this project.

Updated Project Plan

Execution					
PD A: Team set-up		Completed	13/09/2021	16/09/2021	4d
Client meet 1	Nathan Meraw	Completed	21/09/2021	21/09/2021	1d
PD B: Needs		Completed	22/09/2021	23/09/2021	2d
PD C: Concepts		Completed	30/09/2021	30/09/2021	1d
Functional decomposition	Zach Shields	Completed	26/09/2021	30/09/2021	5d
Conceptual design	Qassim Alkassir	Completed	27/09/2021	30/09/2021	4d
PD C submission	Nathan Meraw	Completed	30/09/2021	30/09/2021	1d
Matrix analysis of concepts	Erika Johnson	Completed	28/09/2021	30/09/2021	3d
Client meet 2 preparation	Kierra Caminiti	Completed	30/09/2021	01/10/2021	2d
Client meet 2	Kierra Caminiti	Completed	01/10/2021	01/10/2021	1d

Figure 13: Updated project plan table

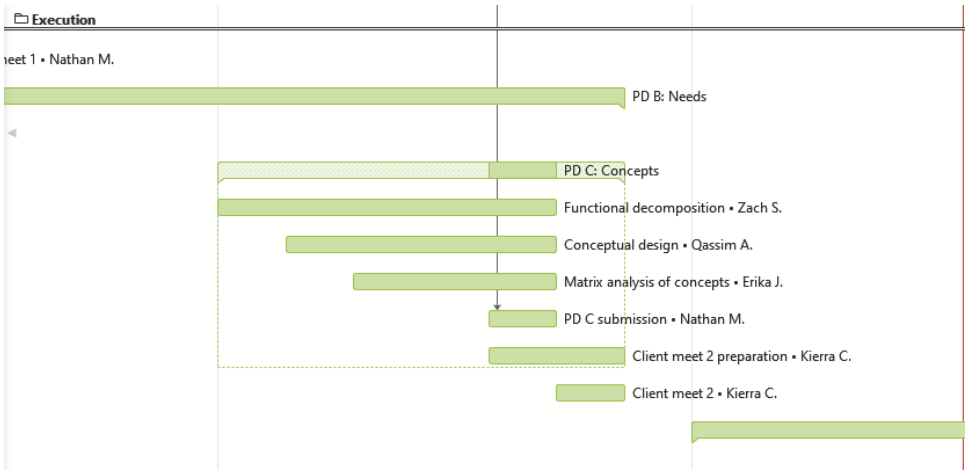


Figure 14: Updated Gantt Chart