Project Deliverable F - Prototype 2 & Client Feedback

Submitted by

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1. Introduction

Having created an AutoCAD model of our chosen design concept for prototype #1, our group was able to prove the design's feasibility, as well as solidify our vision of the cane. It is, therefore, essential at this point in the design process, to begin improving upon the features and concepts included in the first prototype. The creation of prototype #2 allowed our group to explore each of the cane’s main features in detail, including the telescopic extension, the haptic feedback system, as well as the compartment in which the electronics will be stored. Creating various focused prototypes allowed our group to perform an in-depth analysis of multiple features, while limiting the cost and time required to do so.

This document outlines the feedback received from our client on prototype #1, as well as on our current progress, and ways in which this feedback was applied to our design. Multiple prototypes are included through pictures and code, while their testing process is also outlined to summarize the conclusions drawn from each investigation. Finally, the prototypes are compared to the target specifications determined earlier in the design process, to prove whether the goal of this project is being met.

2. Client Feedback

The focus of the third client meeting was to provide an update on the first/second prototype design and receive feedback on how the design could be improved. The primary goal of the second prototype was to program the vibration motor’s feedback responses, as needed for the navigational system. It was also decided that we would work on assembling the pipes to test the cane’s telescopic extension mechanism, and that the navigational storage component would be created on CAD software.

Firstly, with regards to the Arduino code, we let our client know that the program currently works for immediate navigational instructions, such as to turn left, or turn right. Our client was very pleased with this product feature, but also recommended that it would be useful to provide notice before a physical response should be performed. It was suggested that we include vibrations that give notice of future directions, for example: a pulsing vibration for when your turn is in 500m. We weren't told specifically of the type of vibration that should be included, or what distance we should make note of before the person must change direction, but within our next prototype we plan to include this feature in order to fulfill the client's needs.

When discussing the cane assembly, it was mentioned that there would only be one spring pin used per tube segment, implying that the cane could work across 5 different lengths. Our client agreed that this was a good number of lengths to include, and that including any more would only cause confusion. Also, after describing the dimensions of the first prototype to the client, we were able to determine that the cane should collapse to a shorter length in the second prototype. Additionally, we proposed to the client that we intend to use PVC as the material for the cane instead of carbon fiber due to how costly it is; she approved this decision.

All in all, the cane is seemingly "simple and easy to use". We had received nothing but positive feedback from our client and seem close to instilling a final design. One last improvement that was suggested however was that we could add a bag for the cane when it is in its completely collapsed state. This way, the cane won't directly interact with its surroundings when being stored in a bag. This ensures that the product is stowed in a cleanly and compact manner.

2.1 Prototype 2 Objectives

The primary goals of our second prototype included programing the vibration motors for the navigation system, optimizing the dimensions of the cane in our CAD, and determining the feasibility of the spring pin lock extension mechanism using the physical mechanisms in question. The following three prototypes were all focused, low-fidelity prototypes since the team wanted to ensure that we were optimizing the use of available materials.

2.1.1 Navigation System Focused Prototype Objectives

The objectives of the navigation system focused prototype included programming the vibration motors in Arduino IDE. The goal was to program the motors to vibrate once to turn right, twice to turn left, and three times to stop during navigation. After the creation of this preliminary code the team will then be able to begin creating the Arduino circuit to control the motors and connect the Arduino to our Bluetooth module to allow for google maps connectivity.

2.1.2 Mechanical Components (CAD) Focused Prototype Objectives

The objectives of the updated CAD model included determining more permanent dimensions for the cane, verifying the canes weight using the new material, and adding an extra extendable segment. The dimensions in our first CAD model were very preliminary and now that the team has a better understanding of the materials widely available to us, we wanted to determine dimensions with more accuracy for this prototype. Additionally, based off the client's approval, during the meeting, we decided to go with PVC as our new material for the cane. With choosing PVC as the new material, it is required to verify in this prototype SolidWorks that the weight of the cane will still be light. Lastly, another objective of this prototype was to have the canes collapsed length be shorter than in prototype one. The team's decision to fix this issue involves adding an extra segment to the cane and verifying that the cane is now a shorter collapsed length in a technical drawing.

2.1.3 Physical Apparatus Focused Prototypes Objectives

The objectives of the physical prototype included determining the feasibility of the spring pin lock mechanism and the collapsing mechanism of the tube segments. This prototype will give the team the first physical look at how the mechanism involved in collapsing and extending will work and its feasibility. The goal will be to drill holes in a few PVC pipe segments that fit into one another and to insert the spring pin clips. Once this is done various tests can then be performed on the collapsing/ extending mechanism.

2.2 Assumptions

One important assumption we have made is that the vibration motor will be strong enough to propagate the vibrations through the pipe material. This is important to consider because the client must be able to distinguish between the number of vibrations as the number of vibrations represents the navigational instructions. Another assumption regarding the navigational compartment is that it would be big enough to fit in all the required components, while also not taking up too much space as to hinder efficient use of the cane. Moreover, another assumption we have made is that the spring locking mechanism would be intuitive for visually impaired people as ease of use is extremely important for our client and anyone who could benefit from this cane in the future.

3. Prototype 2 Design

For prototype 2 our team decided to go with 3 focused prototypes to better determine some of the smaller details of the guiding cane. The second prototype was broken down into the following three focused prototypes in this section.

3.1 Navigation System Focused Prototype

The purpose of this prototype was to create the software needed to instruct the guiding cane's Arduino, in charge of operating the vibrating motors, communication with the user's phone, and handling directions from Google Maps. As shown in Figures 1-7, the code was written in Arduino 1.8.16, and uses (or plans to use) Adafruit's Bluetooth Module library, Brian Lough's Google Maps API library, and Daniel Eichhorn's json-streaming-parser library to translate information thrown by the Google Maps API.

The current progress on this prototype is very elementary, as it only instructs the vibration motors to pulse accordingly and does not currently handle directions from Google Maps API nor communicate with the user's phone. Currently, progress on this code has been hindered by the unavailability of an Arduino while coding to help with debugging and testing; consequently, this code has not been tested with an Arduino. Although real-world implementation of the code cannot yet be achieved, the early development of the code has proven to reveal and shed light on certain problems that should be addressed while developing the guiding cane.

For the next seven figures, explanations for the entire code as well as plans going forward can be found.

GuidingCane | Arduino 1.8.16

File Edit Sketch Tools Help

GuidingCane

```
#include <Adafruit_ATParser.h>
#include <Adafruit_BLE.h>
#include <Adafruit_BLEBattery.h>
#include <Adafruit_BLEEddystone.h>
#include <Adafruit_BLEGatt.h>
#include <Adafruit_BLEMIDI.h>
#include <Adafruit_BluefruitLE_SPI.h>
#include <Adafruit_BluefruitLE_UART.h>

#include <JsonListener.h>
#include <JsonStreamingParser.h>

#include <GoogleMapsApi.h>
#include <GoogleMapsDirectionsApi.h> //not sure if this is actually imported
```

Figure 1: Screenshot of importing libraries

In Figure 1 above, libraries, made by other programmers, can be imported in order to have access to tools that are able to communicate with the phone, interpret files, and access Google Maps information respectively.

```
/*
 * Code for vibration motor for the guiding cane project.
 * Vibrating motor pulses to communicate with user:
 *
 * A small vibration warning happens before each turn
 *
 * 1 pulse = turn right
 * 2 pulses = turn left
 * 3 pulses = stop
 *
 */
```

Figure 2: Screenshot of notes of the code

Throughout the code, the greyed-out text as shown prominently in Figure 2 shows notes and documentation that has been laid out throughout the entire code. This documentation not only helps with tracking everything the code does, but also helps track goals and tasks that have to be developed in the future (prefixed with //TODO). All comments are marked with a "//" prefix and are in grey font to help distinguish the real code from all documentation.

```
//init where pins are
int motorPin = 3; //or any other PWM pin

int BLUEFRUIT_UART_MODE_PIN = 12;
String BLUEFRUIT_HWSERIAL_NAME = "replace"; //TODO find serial name of module

//direction - 0 is forward, 1 is right, 2 is left, 3 is stopped
int dir = 0;

void setup()
{
  pinMode(motorPin, OUTPUT);
  //Adafruit_BluefruitLE_UART ble(BLUEFRUIT_HWSERIAL_NAME, BLUEFRUIT_UART_MODE_PIN);
  //TODO - setup google maps communication
}
```

Figure 3: Screenshot of initializing variables

For the Arduino to be able to move the motors and other tools it has access to, it must know what "pin" the Arduino is connected to. The section of code shown in Figure 3 shows the initialization of all the pins and variables that must be created and "be let known" to the Arduino for our code to be allowed to control vibration and navigation. Currently, our code only uses the vibration motors, and so that is the only pin currently initialized in "setup()". There is some progress for Bluetooth connectivity, but it has been commented out for the sake of simplicity.

```
void loop()
{
  /*
   * TODO - communicate with maps to indicate a turn/direction
   * INCLUDING delay and warning (warnDir()) before a turn
   * NOTE: warning will not trigger for stopping
   */
  if (dir == 1){
    turnRight();
  }else if (dir == 2){
    turnLeft();
  }else if (dir == 3){
    stopping();
  }
  dir = 0;
}
```

Figure 4: Screenshot of looping code

Considered the "main" section of the code, Figure 4 shows the loop() portion of the code, responsible for indefinitely executing the code that is inside of it (inside of the external {} brackets). This code will handle all the methods (also known as functions) and execute those methods under the right circumstances.

The next following figures display the code of the methods developed to run during the aforementioned loop() function in Figure 4.

```
/*
 * Method to read google maps and communicate with the phone
 * to find direction instructions. Also uses warnDir() before left and right turns
 * TODO - Google maps integration, bluetooth communication, throw warning pings
 *
 * @return random temporary integer from 1-3 to simulate a direction
 *         and test the vibration system
 */
int readMap(){
  int rand = random(1,4); //getting random int
  if (rand == 1 || rand == 2){
    warnDir(); //sends warning ping
    delay(3000); //waits for 3 seconds
  }
  return rand;
}
```

Figure 5: Screenshot of the map interpretation progress (read documentation in screenshot)

```
/*
 * Method for making a small vibration pattern
 * to indicate a turn coming up
 */
void warnDir(){
  digitalWrite(motorPin, HIGH); //vibrate
  delay(100);
  digitalWrite(motorPin, LOW); //stop vibrating
  delay(300);
  digitalWrite(motorPin, HIGH);
  delay(100);
  digitalWrite(motorPin, LOW);
  delay(50);
  digitalWrite(motorPin, HIGH);
  delay(100);
  digitalWrite(motorPin, LOW);
}
```

Figure 6: Screenshot of the warning ping vibration method

```
/*
 * Turning right, pulses motor once
 */
void turnRight(){
  digitalWrite(motorPin, HIGH); //vibrate
  delay(500);  // on .5 seconds
  digitalWrite(motorPin, LOW);  //stop vibrating
}

/*
 * Turning left, pulses motor twice
 */
void turnLeft(){
  digitalWrite(motorPin, HIGH); //vibrate
  delay(500);  // on .5 seconds
  digitalWrite(motorPin, LOW);  //stop vibrating
}

/*
 * Stopping, pulses motor three times
 */
void stopping(){
  digitalWrite(motorPin, HIGH); //vibrate
  delay(500);  // on .5 seconds
  digitalWrite(motorPin, LOW);  //stop vibrating
}
```

Figure 7: Screenshot of the direction vibration methods (in order: right, left, stopping)

3.2 Mechanical Components (CAD) Focused Prototype

The updated CAD model of the mechanical components of the cane is included below. The main difference between this model and that from prototype #1 is the creation of an additional segment, in order to reduce the size of the collapsed cane. As shown in this focused prototype, in figure 8, there now exists five segments, each measuring 13 inches, featuring one 0.25-inch hole on each end, for the spring pins to fit into.

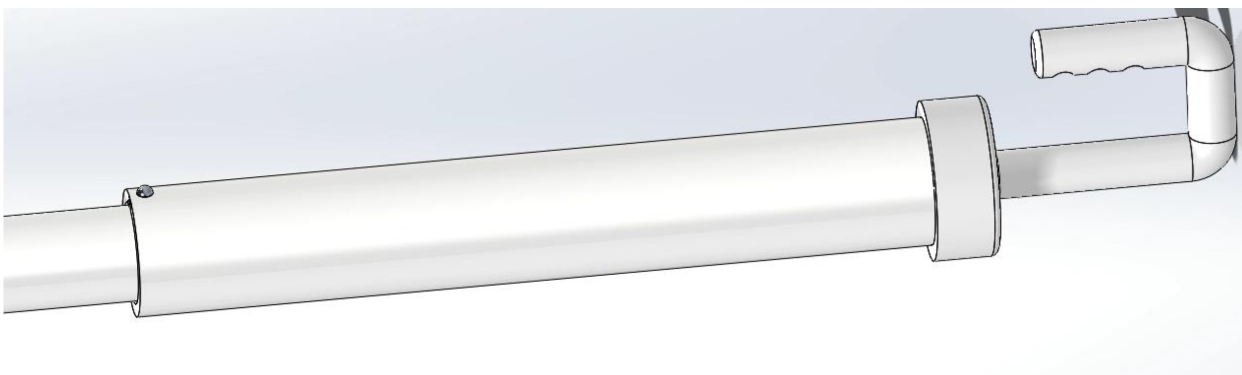

Figure 8: Spring Pin Mechanism and Handle

These drilled holes and pins will allow the segments to collapse into one another, a process explained in detail in section 3.3. The inclusion of a fifth additional segment allowed for the reduction of the length of each segment, without overcomplicating the design by including many small cane segments, as seen below in figure 9.

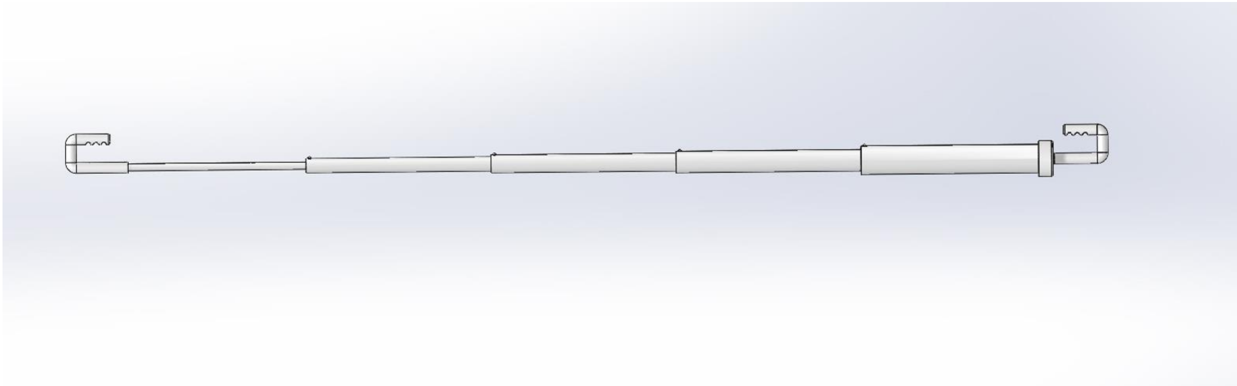

Figure 9: Prototype 2 Guiding Cane (Extended)

These holes also allow for the connection of each segment and the removable handle. This prototype includes a visual of the one permanent handle, attached to the wide end of the guiding cane, as well as the removable handle and its pin, which will hold it in place when the user wishes. Releasing the pin also allows the user to replace the handle by the removable white cane tip.

Finally, this prototype displays the projected extended length of 73.05 inches or 6.01 ft (seen in figure 10), as well as the projected collapsed length of 21.18 inches or 1.76 ft (seen in figure 11). Although these values may vary slightly since it is not possible to perfectly replicate an ideal AutoCAD model, they are accurate enough to show whether the design must be altered to meet our target specifications, as shown in section 4. Additionally, the mass of the cane was found to be 2.41 lbs in SolidWorks using PVC as the cane's material and ABS plastic as the handles.

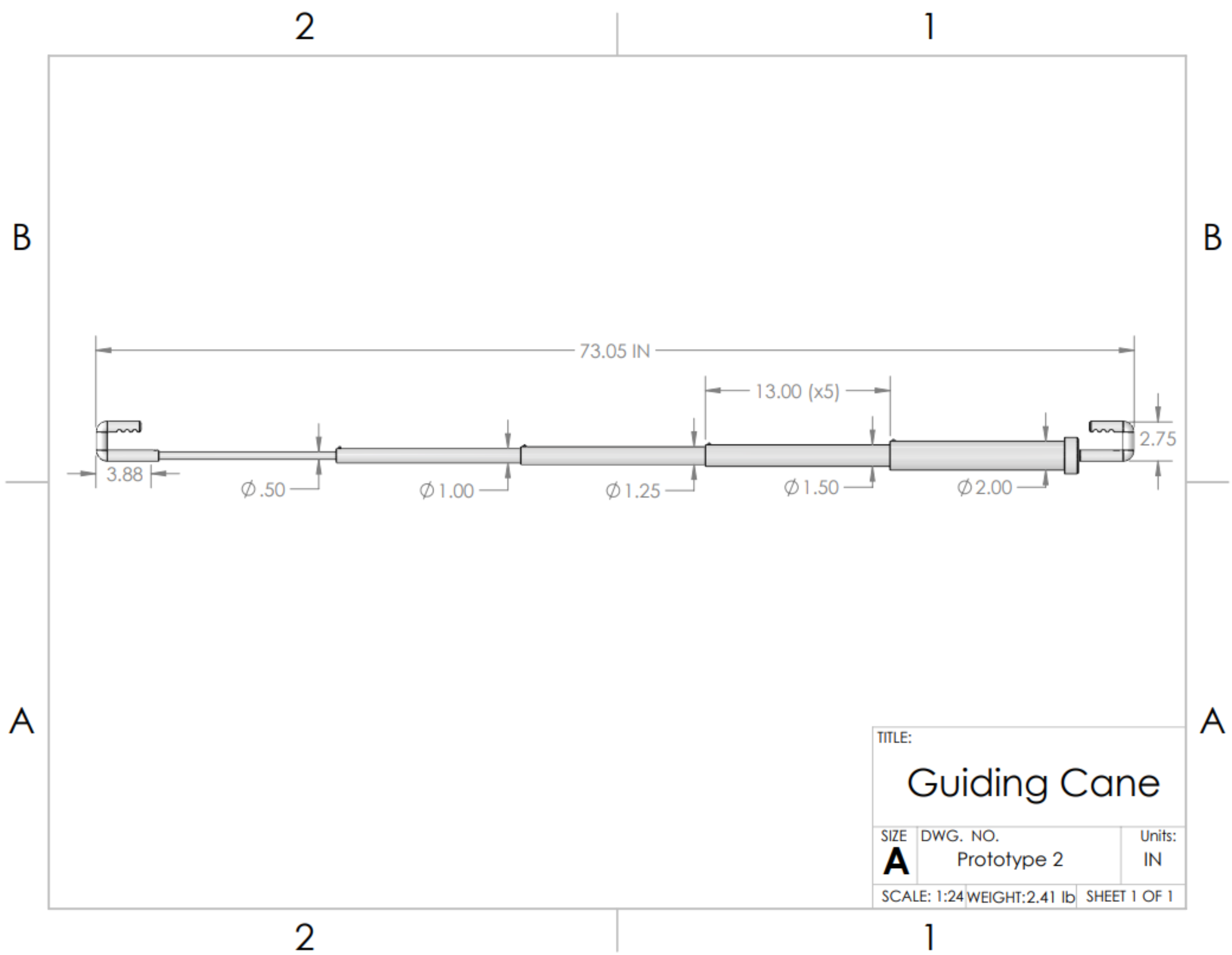

Figure 10: Prototype 2 Guiding Cane (Extended)

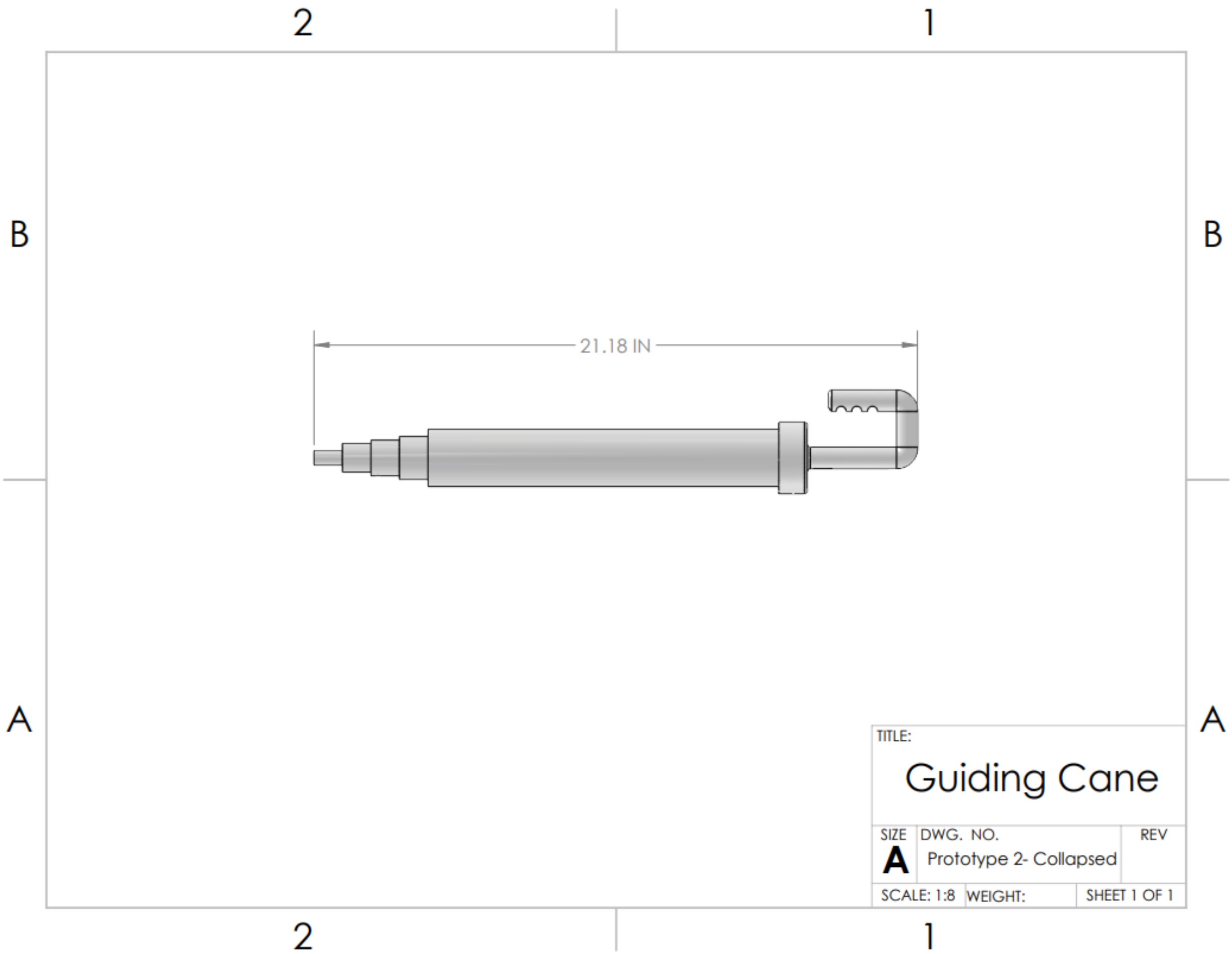

Figure 11: Prototype 2 Guiding Cane (Collapsed)

3.3 Physical Apparatus Focused Prototype

With regards to the cane assembly, five tube segments and 6 spring pins make up the overall design. The tubes vary from 0.5”-2” in outer diameter and fit perfectly into each other for optimal structural integrity. The spring pins are used to secure the ends, and the lengths of the cane in place.

The purpose of this physical prototype was to test the connection between two pipes. After drilling a hole on both ends of the tube segments, a spring pin was placed into the smaller pipe, with the arch of that pin placed internally, as seen in Figure 12. The larger tube segment can then slide on top of the smaller one, shown in Figure 13, until its hole aligns with the top of the spring pin. Figure 14 demonstrates the final locked position of the cane segments.

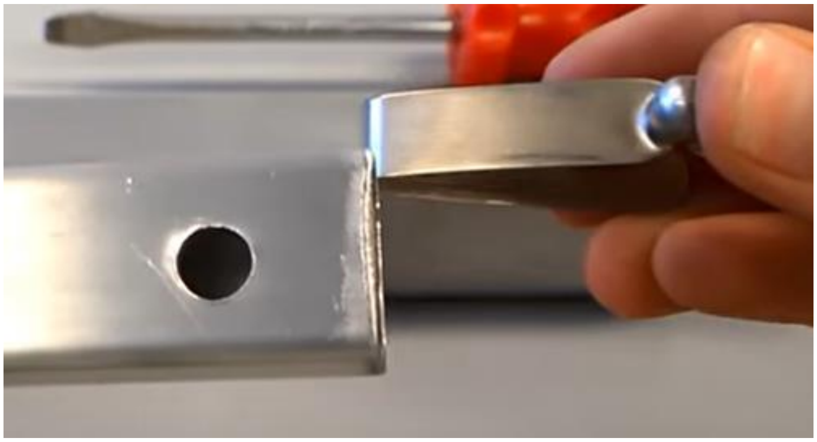

Figure 12: Demonstration of the Push Pin being Inserted into the Smaller Segment [1]

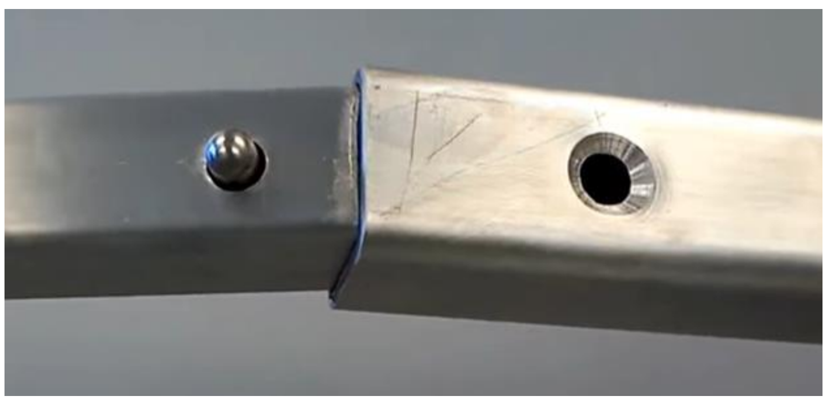

Figure 13: Demonstration of the Larger Segment Sliding over Top of the Smaller one [1]

Figure 14: Demonstration of the Locked Spring Pin Mechanism [1]

If the user wishes to collapse these two segments, all they would need to do is push the spring pin down, so that the smaller cane segment can be pushed into the larger one.

*Note that the figures included above are taken from an online resource. The connections between the round PVC pipes were tested in person and worked, but due to materials being kept at different locations, we were unable to take pictures of the completed test.

4. Testing and Prototype Specifications

In the following section the testing of the three focused prototypes is summarized and compared to the target specifications. The navigation system and the 3D model were tested analytically using software and the physical apparatus was tested using the physical components. Note that the target specifications are included in table 2 for reference.

Table 1: Prototype 2 Testing

Prototype	Assumption Tested	Testing Method	Expected	Actual
Navigation System	Can vibrate the motors in specific patterns	Use code and an LED to simulate	Navigation system code can control the	Navigation system code can

		code and patterns.	Arduino to power a motor.	control the Arduino.
	Can indicate what direction to turn and when to stop.	Use code to create methods for indicating when to turn right and left.	Arduino can vibrate the motors in specific ways to indicate directions.	Three methods are made to control respective directions and stopping.
Mechanical Components (CAD)	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.	13.0 inch = 33.02 cm (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 length and width.	9.9 cm x 6.9 cm
	Extended length is acceptable	Measure length of the extended cane	At least 6ft	6.01 ft
	Collapsed length is acceptable	Measure length of the collapsed cane	Max 1.5 ft	1.77 (Fails)
	Product's weight is acceptable	Measure weight of the product with all components, using the correct materials	Between 3-5 lbs	2.41 lbs 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)
Physical Apparatus	Length of Cane Segments are small enough to be stored	Measure each length of pipe	< 25cm	13” = 33.02cm
	The cane is rigid	Hold the pipe horizontally to see whether the pins can resist the force of gravity	Spring pin locking mechanism is strong enough to withstand gravity	Spring pin locking mechanism is strong enough to withstand gravity
	The segment diameters fit perfectly into one another	Slip the pipes into one another to see whether they fit	Segments fit into each other, and there is no space between diameters	Segments fit into each other, and there is no space between diameters

Table 1 summarizes the tests performed on the second prototype, and their respective outcomes. Although many of the tests are successful in respecting the design’s target specifications, there are a few features that failed when tested. The results display that the overall collapsed length of the cane is larger than anticipated by our target specifications. Although reducing the length of each segment, and in turn the length of the collapsed state, to the appropriate size was a priority for this prototype, our group discovered that reducing the length of each segment to less than 25cm would require 8 segments in total. This means that our design would include 8 PVC pipes with varying diameters, implying the largest segment, that into which the rest of the pipes collapse, would have a diameter far too large to ensure a sleek, comfortable design. Additionally, our group realized that as the diameter of the pipe increases, the thickness of the pipe also tends to increase. This leads to more material, and in turn an increased weight. Finally, decreasing the length of the segments also increases the number of pipes and spring pins being bought, which would greatly increase the cost of our project. To summarize, respecting our target specification of having each segment measure at most 25cm would lead to an increased weight, cost, size and number of moving parts. Therefore, to maximize the useability and comfort of our design, our group decided it would be acceptable to increase the collapsed length of the cane to 1.77ft, or 0.54m, with each segment measuring 13", or 33.02cm.

As for the remainder of the tests performed on the mechanical components, it was determined that the PVC pipes fit perfectly into one another, while the spring pins fit into the holes to allow the telescopic collapse of the cane. As previously mentioned, the collapsed length, as well as the length of each segment, would be increased to 1.77ft and 33.02cm, respectively, an improvement from the original 1.9ft and 44.4cm in prototype 1. This reduction in length also led to a reduction in the cane's extended length, from 6.3ft to 6.01ft. However, since this length remains over 6ft, it is still considered acceptable. Moreover, the size of the handles and the overall weight of the product both respect their designated target specifications, with the weight being reduced from 2.7lbs in prototype 1 to 2.4lbs in this prototype.

For testing the software prototype, real test-case scenarios couldn't be created as we do not have access to a functioning Arduino while compiling and creating the code; however, given the simplicity and documentation of the code, it is safe to assume the code works as intended. Currently in table 1, the test cases that have been made are similar to the test cases for physical prototypes, making sure that there is progression in the code and that certain essential features are properly incorporated in the code. In the future prototypes, current progress on the code will be tested prior to creating any new methods and implementing any new features.

During development, a plan of incorporating an additional quick “buzzing” pattern three seconds before a direction is given was created and discussed with the team and the client. After some glowing feedback, the code is capable of warning the user with a “eeee-e-e" vibration pattern three seconds before issuing a direction vibration pattern (left or right). In the next prototype, the code will be able to read Google Maps and instead issue a warning a given distance before the turn instead of issuing a warning a certain time after noticing a turn.

Table 2: Target Specifications

Metrics Description	Range	Unit
Weight of the cane[1]	3 - 5	Lbs.
Length of the cane (Extended)[2]	180 - 200	Cm
Length of the cane (Collapsed)[3]	20 - 25	Cm
Area when compact[4]	60 - 100	Cm^2
Handle Length[5]	10 – 15	Cm
Handle Width[6]	3 - 4	Cm
Reflectiveness of the material[7]	80-95	%
Production Cost[8]	40 - 60	$ (CAD)
Segment Length (Collapsible Parts)[9]	20 - 25	Cm

5. Conclusion

To conclude, our client was satisfied with our progress so far and has approved of the decisions we made regarding the number of segments. Our client has a suggestion regarding the navigational system where she proposed adding vibrations that give notice of future directions.

This would help alert the user of an upcoming turn which could improve the reliability of the navigational system. With this feedback, we will be attempting to add the future directions functionality into the navigational system and testing it to ensure that it works as intended.

Our client also recommended adding a storage bag where the cane can be stashed away to keep it out of the way and to keep it clean when not in use. To prepare for our next client meeting, we hope to have an assembled prototype utilizing PVC pipes so that the client can get an idea of the dimensions of the cane in addition to an approximate weight as the cane is expected to be light. Some additional testing will be done to ensure that all the PVC pipe segments fit into each other.

6. References

[1] YouTube. (2014). *Installing Locking Button in Telescoping Tube*. *YouTube*. Retrieved November 4, 2021, from https://www.youtube.com/watch?v=y3V6o3eca0g.

Appendix: Updated Project Plan

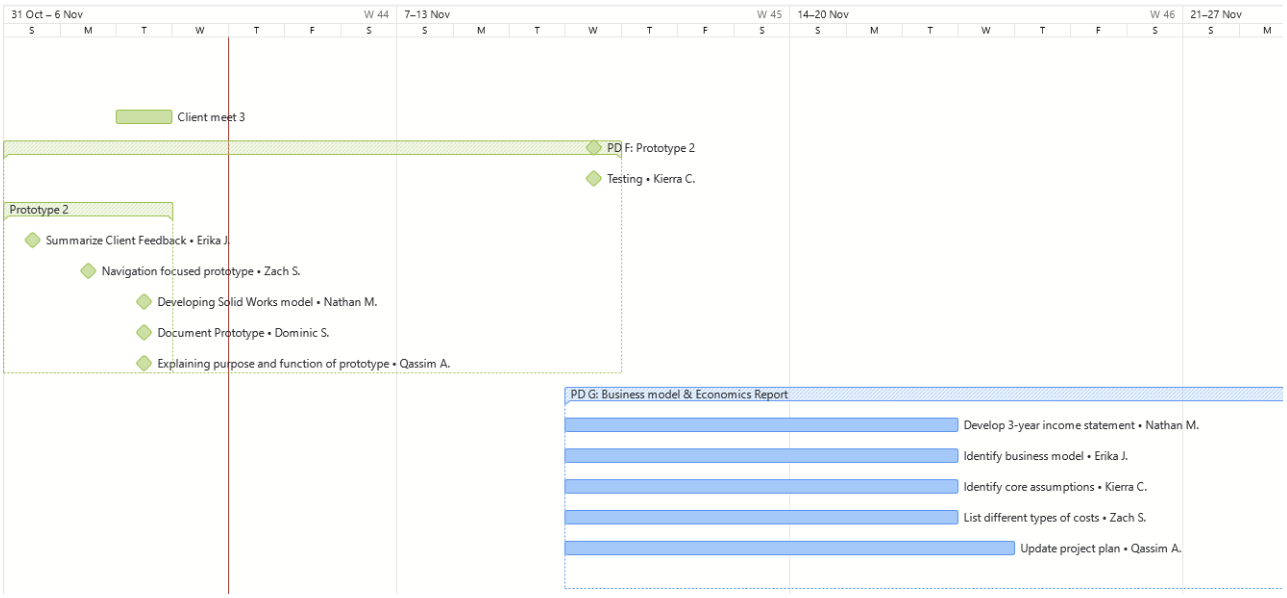

Figure 15: Wrike Project Plan