February 15, 2017

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University Burnaby
British Columbia V5A 1S6

RE: ENSC 405W/440 Functional Specification for **Mobility Cane Improvement – The NavCane**

Dear Dr. Rawicz,

The following functional specifications for the NavCane were prepared by CaneTech as a course requirement for ENSC 405W/440W. The goal of our Capstone Project is the innovative redesign of current mobility canes while employing a cost effective approach. The NavCane will give the visually impaired the freedom and independence to travel with confidence, even while alone.

Through proximity detection, the NavCane will provide the user with the ability to avoid obstacles that would not be noticed using a conventional cane. The NavCane will communicate to the user, primarily using haptic feedback, to indicate locations of objects outside the range of a conventional mobility cane and overhangs that a conventional cane would not detect.

CaneTech will also be developing a RFID pod system that can be set up in a building to assist with navigation within. The NavCane will detect the network of RFID pods in a particular indoor environment, and use the signals from each pod to navigate to points of interest.

This functional specification document will discuss the high level design, showing which requirements our system will need to meet in the preliminary prototype stages and in the final realization of our project. It will also be used as a guide to keep our team on track in order to meet our timeline goals. The overall system requirements are included in this document, along with the specific hardware, electrical, mechanical, and software requirements that our product will need to meet. Additionally, we discuss the engineering standards we will abide by and the sustainability and safety concerns for the project.

I would like to thank you for your time and efforts. Please feel free to reach out with any questions or concerns concerning our project to our Chief Communication Officer Ryanpreet Sihota by email or phone at rsihota@sfu.ca or 778-908-2545.

Sincerely,

Ishika Luthra

Ishika Luthra

CEO
CaneTech

Enclosure: Functional Requirements and Specifications for the NavCane

Functional Requirements and Specification

The NavCane©

An improved mobility cane for the visually impaired

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Abstract

For the visually impaired, independent navigation in unfamiliar and changing environments can be a challenge. This closes off the world of a visually impaired individual to a small, learned path and reduces accessibility for locations they have never been to. This is a problem, and the most commonly used solutions are the use of mobility canes and GPS apps designed for the visually impaired. These solutions for independent navigation, however, carry many drawbacks and don't address certain dangers. Mobility canes can only identify nearby obstacles they make physical contact with, and do not help to detect low overhangs. Navigation applications can lose GPS coverage in buildings, making them inapplicable for indoor use. This results in an antiquated and limited method of obstacle detection, and a lack of decent indoor navigation solutions. These are the two areas of inadequacy we hope to address with our product.

We at CaneTech believe that it is possible solve these two problems using the technology of today. Our solution is two pronged: firstly, we will upgrade the classic mobility cane to have proximity sensors that have a greater detection range than physical contact. These proximity sensors will be able to detect upcoming obstacles at a distance, and provide warning for low overhangs. This information will be conveyed in an intuitive manner to the user through haptic feedback, to help them avoid hazards. Secondly, we will create a system of RFID Pods for indoor navigation. Networks of these pods could be set up in public buildings, and the NavCane will be able to use these pods to direct the user to points of interest within the building. Together, these solutions will make up our product, the NavCane.

In this functional specification report we discuss our proposed solution and the expectations we have for our project. To start we fully lay out the problems we are trying to solve and the system we conceptualized to solve those problems. From here we subdivide the system, which is comprised of several different components, into separate categories where we outline requirements that must be met to properly meet our vision. After this we state some standards that we hope to maintain through the project. Combined, this will describe what we hope to achieve with our project.

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Acronyms

CEO – Chief Executive Officer

GPS – Global Positioning System

IR - Infrared

RFID – Radio-Frequency Identification

AC – Alternating Current

1 Introduction

It can be difficult for someone who is visually impaired to travel outside of the environment they are familiar with. Using technology to extend the sensory access of an individual opens doors for more independent travel. The current mobility cane gives feedback regarding nearby obstacles and surface texture, but it has shortcomings in certain areas: obstacles outside of the range of the cane and low overhangs are not detected, making exploration of new areas or buildings extremely difficult. The restriction of only being able to detect obstacles within the range of the cane limits the user's walking speed, as there is a minimum time needed to react to hazards. Increasing this range of detection will give the user more time to react to obstacles. Navigating unfamiliar areas can not only be difficult, but dangerous for the visually impaired due to the lack of experience and knowledge of their surroundings. Mobility specialists are often hired to guide a visually impaired individual through a new area so they can become more comfortable and familiar with an area. We believe that our product, the NavCane, can solve these problems.

The NavCane will provide information regarding obstacles outside of the range of a common mobility cane, using an array of proximity sensors to detect overhanging objects or impedances in the user's path. The handle of the cane will provide haptic feedback to the user in order to help steer them away from the detected obstacle. This project also includes an indoor navigation system that interfaces with the NavCane, which will help with the exploration of public buildings that have the system installed. When the user enters the building, the active RFID pods that make up the navigation system will transmit the mapping information of the building to the NavCane. The signal strengths from these pods can then be used to calculate the position of the user within the building. The user will be able to use this navigation system to query and locate points of interest through the smartphone application. Some examples of points of interest would be washrooms, staircases, or exits. The application will communicate to the cane through a Bluetooth connection, allowing the cane to guide them to the desired location.

When designing the NavCane, it is crucial to preserve the functionality of current mobility canes. Although we will design our product to be robust, it is reliant on battery power and it is important for users to not be left stranded in case of a loss of power, especially for users who fully rely on the product. To avoid this, we are starting with a conventional mobility cane and working to add to the utility it provides without interfering with the original function. The goal of the NavCane is not to replace the common mobility cane, but enhance it.

A cane that has the ability to connect to a smartphone's hardware and software resources will allow for an even greater feature set. The NavCane mobile application will allow the user to customize their device by changing the sensitivity settings for obstacle detection and haptic feedback. This helps a user change their experience if they find the NavCane to be overwhelming. The app will also be used to provide an audio feedback option. Through the

Bluetooth connection with the processor on the NavCane, signals will be sent to the phone application, which will in turn output appropriate audio feedback. The audio feedback gives the user a more familiar channel though which to receive information from the NavCane. The app will provide a more widely accessible experience to user.

In order for our product to be user friendly it will need to be comfortable and easy to learn. The NavCane will need to be light to avoid instilling fatigue onto the user, which creates size and weight constraints on all components of our product. Another important factor is the design of the handle and haptic feedback system; the NavCane needs to be able to convey navigation directions and warnings to the user while maintaining user comfort. The haptic feedback system will also need to be easy to understand: having an overcomplicated user interface will introduce the possibility of the user misinterpreting the feedback, causing them to put themselves in danger. The mobile application will also need a simple user interface so that a visually impaired individual could easily navigate the app.

The NavCane must be reliable to earn the trust of the user. If the user does not believe that our product will guide them correctly, they will not be likely to continue using it. In order to avoid this, we will require that the NavCane's features are reliable and accurate. The obstacle detection feature will need to able to locate a wide variety of obstacles so that it's perceived to be consistent in many environments. This perceived consistency is also affected by timing: feedback needs to be sent to the user with minimal delay so that they have time to react.

The NavCane will need to be useful, reliable and user friendly. These are the key factors that were taken into consideration when creating the functional requirements of our product. The requirements outlined in this document will cover the general, mechanical, electrical, software and hardware requirements of the NavCane.

1.1 Requirement Code

In this document, all functional requirements will follow the following coding scheme:

$$\left[\boldsymbol{R}[\boldsymbol{section\ number}].[\boldsymbol{subsection\ number}]-[\boldsymbol{Stage\ Code}]\right]$$

$$\boldsymbol{example}:\boldsymbol{R1.1}-\boldsymbol{PROT}$$

The section number corresponds to the particular section the requirement aligns to while the subsection number corresponds to the different requirements within a section. The stage code corresponds to the stage of development at which the requirement is expected to be met. The tables below provide a legend of all the possible codes for the stage code and section number components of our coding scheme.

Table 1: Stage Code Explanation

STAGE CODE	***explanation***
POCT	proof of concept
PROT	prototype
PROD	Hypothetical production model

Table 2: Section Descriptions

SECTION#	***explanation***
1	General requirements
2	Hardware requirements
3	Electrical requirements
4	Mechanical requirements
5	Software requirements

2 System Overview

The NavCane will aid the user in both indoor and outdoor environments. The simple yet effective visualisation in figure 2 establishes a general sense of our product and its surroundings.

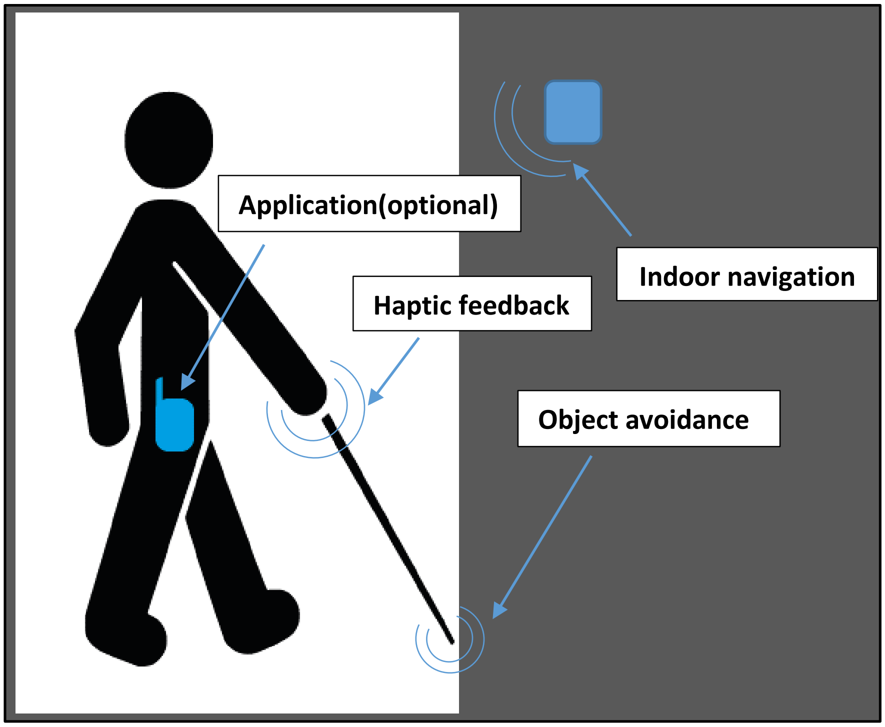

Figure 1: System Overveiw

The obstacle avoidance system and phone application will be usable for both indoor and outdoor applications. The indoor navigation system will use RFID pods to triangulate the users position within a building. RFID has 3 common frequencies, low frequency (LF), high frequency (HF), and ultra-high frequency (UHF). Each frequency has benefits and drawbacks. LF is practical for applications where you need to transmit through viscous mediums, and HF systems are good for customer tracking or book scanning as the range is usually very small. CaneTech will most likely use UHF because of the range it provides up to 15 meters. [1] For further information on RFID frequency ranges please refer to figure 3 below. The proximity sensors, processor and haptic feedback will be in continuous operation to ensure the safety and satisfaction of the user. The proximity sensors will be taking in data about upcoming obstacles from the environment and relaying that data to the processor. The haptic feedback mechanism will take data from the processor and convey a meaningful response to the user, so that they can avoid the oncoming obstacle. The haptic feedback user interface will be refined as the product is developed to meet the needs of users. A couple of possibilities in which we wish to implement the haptic feedback are as follows: the use of an unbalanced motor to provide vibrational feedback, a servo motor that rotates back and forth within a specified range that will provide pressure on the users fingers. The processor will need to be able to maintain effective operation as long as the user is using the cane. Depending on whether the user is indoor or outdoor, the components of our system will communicate information that is most relevant to the environment the user would find themselves in. Based on the user's surroundings some feedback will be more critical to provide to the user than others. For example, when the user is trying to find the washroom, the navigation circuit shouldn't be the only component running, as the obstacle avoidance circuit should still be in effect. The processor needs to be able to determine what environment the user is in, and then turn on the necessary components in a timely manner so the cane can be used seamlessly during travel. To deal with the merging of data, a priority system will need to be set so that all components can work in harmony. The phone application is another component sub block that will be in continuous use Although the application will be an optional part of our system, it enhances the overall system by providing audio feedback and cane customization options.

For all these modules to work cohesively a key part of this project will be having components running simultaneously. In order to achieve this, parallelism needs to be possible with the on board processor. If true multithreading is supported on our processor, this can be done on multiple cores, but the most likely solution will be to implement virtual multithreading. This is an important aspect of our product because all the components will provide information as inputs that need to be processed in a time sensitive manner since the user will require real time results. These real time constraints will be considered when considering which processor will run our system.

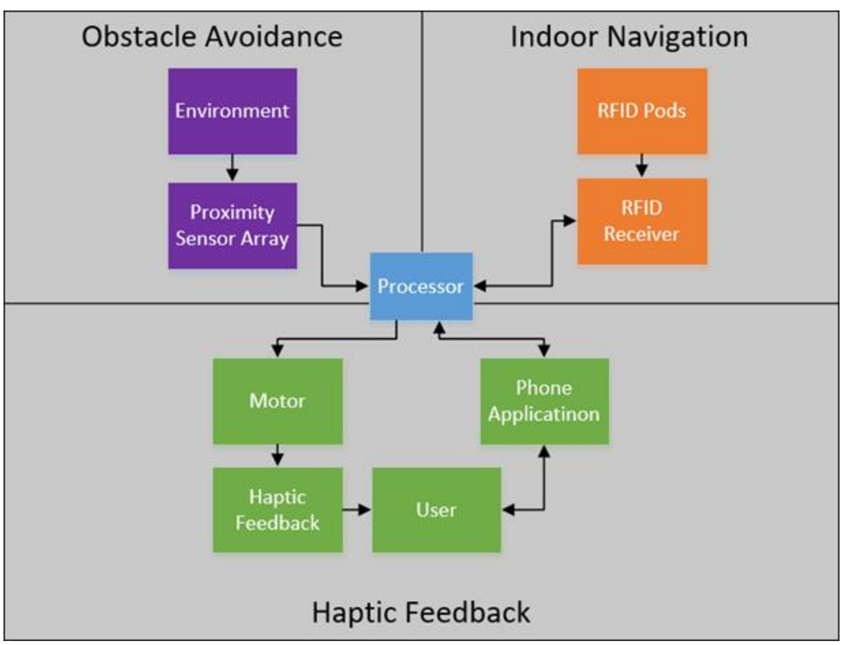

Figure 2: System Block Diagram

- Low frequency, or LF, (125 – 134 kHz)
- High frequency, or HF, (13.56 MHz)
- Ultra-high frequency, or UHF, (433, and 860-960 MHz)

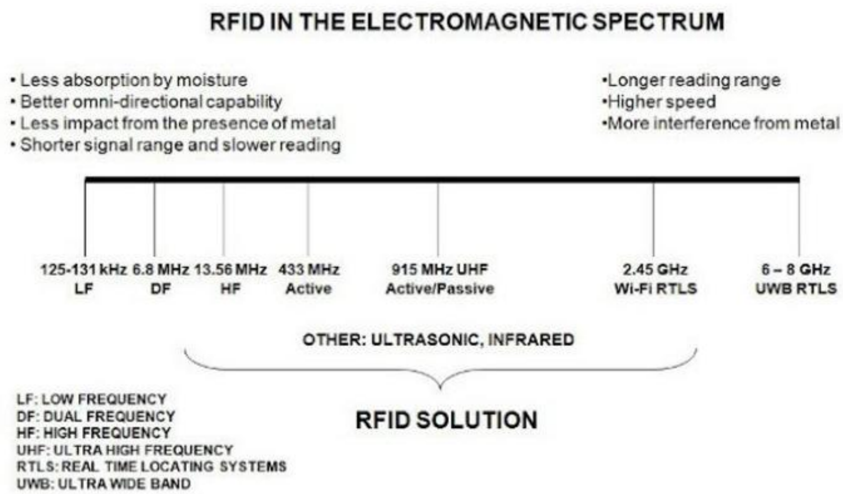

Figure 3: RFID Frequency Range

3 General Requirements

Before going into detail regarding the hardware, electrical, mechanical and software requirements, the following table will outline the general requirements for the NavCane.

The following table will summarize the overall final design and functionality requirements for this system:

Table 3: General Requirements

Requirement ID	Requirement Description
R3.1 - PROD	The system will cost no more than $300.00
R3.2 - POCT	The system will allow users to navigate situations while warning them of obstacles in their path within 3 meters of the sensor.
R3.3 - POCT	The warning signs sent to the user will be deployed in a non-intrusive way using haptic feedback.
R3.4 - POCT	The system will guide the user around obstacles at ground level, to steer them a safe distance away.
R3.5 - POCT	Feedback for upcoming obstacles will be provided given enough time to prevent collisions or falls.
R3.6 - PROD	The system will be constructed using waterproof equipment allowing for use in all weather circumstances.

R3.7 - PROT	The battery life of the system will be long enough for the user to go safely through the day while operating the NavCane; approx. 9 hours.
R3.7 - PROT	The device must use only rechargeable batteries for a power source
R3.9 - PROT	The weight of the system will not bear strain on the users' wrists or arms.
R3.10 - PROT	The use of the NavCane will be very intuitive, allowing people of all ages to learn and use its functionality.
R3.11 - PROT	The ergonomic design will make sure it is comfortable for users and sure that the cane is used in the proper orientation (with sensors pointing in the correct directions).
R3.12 - PROD	All materials used in the mechanical enclosure must be non-toxic
R3.13 - PROD	All electronics solder in the NavCane should be lead free

3.1 Safety Concerns

Users of the NavCane will be relying on it to provide important feedback so it must be a robust system, where the chances of failure are small. As users will be entrusting the device to give them the information they need to move safely and effectively in various situations. Taking this into account, our design criteria is to build a system that will give the user the confidence to rely on our product so that they may explore new areas without the risk of injury or getting lost. In the rare condition, where the NavCane fails, by preserving the original white cane in our system, the user will always be equipped to guide themselves to safety.

One example of such an effort is our mandate that the NavCane's electrical equipment will follow the RoHS Directive, excluding any hazardous or toxic materials [2]. This compliancy will allow us at CaneTech to not harm the health of our users or negatively affect the environment during our manufacturing or disposal of the NavCane. The electronics will also all be properly built and designed to eliminate the chance of any shock or burn to the user.

3.2 Battery

Due to the constraints of weight and size when designing the NavCane, the battery will also have a restricted capacity. It is crucial to balance the benefit of high battery capacity with the disadvantage of size and weight required for a longer battery life. If the battery of the NavCane dies while the user is out and about, the user is left simply with a cane that they are already used to. To avoid any issues, we will predetermine the maximum battery life and clearly warn users before they begin using the NavCane of the expected battery life. Vibration or other feedback methods will be used to give a clear warning of when the NavCane needs to be recharged.

This system will run using a small amount of current, and therefore will not produce excess amount of heat. To prevent a situation where the cane starts to heat up, we will thermally ground each component at risk of overheating.

3.3 Haptic Feedback

When providing users with haptic feedback it will be necessary for the user learn how to use the NavCane and its functionalities. Our aim is to create very simple and easy to understand signals that will minimize the time before a new user can effectively use the NavCane. Through appropriate testing of our prototypes we will determine ideal parameters for haptic feedback to prevent errors with feedback interpretation. It will also be important that the NavCane will not direct the user away from one hazard and towards another. For example, the NavCane should not make a user step off the sidewalk or curb while steering them away from a small obstruction. Extensive testing of different scenarios using our various sensors will confirm NavCane's abilities to navigate safely.

3.4 Materials

The materials used to enclose all the circuitry and sensors of the NavCane will be structurally sound, to prevent damage to the cane or injury to the user in case of falls. This will also increase the life of the NavCane such that it will only have to be replaced in exceptional situations. It will also be built to be water resistant so that the NavCane can be used regardless of weather conditions. A material that is being considered for our product is aluminium, and the reason is because of the weight reduction, the fact that it is non-ferromagnetic, it has zero sparking capability, and it is easy and cheap to manufacture.

3.5 Sustainability Concerns

At CaneTech we are passionate about creating products that are not only user friendly, but are also sustainable and environmentally friendly. An example of such an effort is our requirement that the NavCane will operate on only rechargeable batteries. This is because they consume 23 times less non-renewable resources than disposable batteries [3]. In turn this will protect the environment from all the heavy metals, chemicals and corrosive materials that disposable batteries would contain. In addition to this philosophy a careful selection of materials will be considered to ensure they are reusable and non-toxic; an example of a traditionally toxic material that is still used today, but is being phased out, is solder that contains lead. NavCane will ensure lead-free solder will be used. To ensure CaneTech follows a sustainable design approach, CaneTech will follow a cradle-to-cradle, C2C, design philosophy. The C2C design process is one which talks about how human design methods impact the earth and more specifically how the cradle-to-cradle design approach also includes the design of when a product "dies". When a product dies cradle-to-cradle reuses the manufactured parts to be put back into the life cycle of another product; therefore, waste is minimal and the manufacturing companies gain from materials being reused. It is said that the approach “encourages rethinking conventional design approaches and focus[es] on [the use] of design as a positive force, seeking to become ‘more good’ rather than simply trying to be ‘less bad’” [7]. The opposite approach to cradle-to-cradle design is cradle-to-grave, which is when the design only takes in consider the products useable lifespan and does not take into account what happens to the product once its use is gone. In todays world It can be seen that such products are very hard to dispose of and can take huge amounts of resources to dispose of, for example such products are batteries, engineering plastics such as plexiglass, PVC, and many more. These products provide zero technical and biological nutrients. Technical nutrients are materials that are not organic but, have the ability to be completely recyclable, such materials can be types of metals or fabrics. Biological nutrients are materials that can be composted or are organic in nature and are also completely recyclable, such materials are wood, biodegradable plastics, or paper along with many other materials. Due to the nature of our product we will likely have no biological nutrients aside from maybe the use of wood in the prototyping phase. The NavCane design will use the C2C approach to make sure that the impact on the environment is minimized when its useful life cycle has ended. We will try to design such that it is easy to separate our product down to homogenous collections of technical nutrients. A likely technical nutrient candidate during the prototyping phase is aluminum, as this would make the most sense because it is light, non-ferromagnetic, cheaper, and can be 100% recyclable. Another possible choice of technical nutrient is steel, which is the most recycled metal in North America, and like aluminum can be 100% recycled as well [8]; the only issue with steel is the sheer weight it would put on the user which would be substantial in comparison to an aluminum NavCane. Outside the structural design of the cane, components that are left such as sensors or PCB’s are not biodegradable nor technical nutrients, and therefore cannot be considered nor avoided in a true cradle to cradle design approach; another possibility for implementing sensors into this approach would be to consider whether or not it is feasible to fix certain sensors that are not fully broken, but deemed possible to repair so that not all of the components go to waste. CaneTech will strive to achieve a cradle-to-cradle design approach. Even though taking this design can be more complicated and time consuming at first, in the end the manufacturer will deliver a product that they can say they are proud of while helping the environment out, and at CaneTech we strive for this very feeling.

4 Hardware Requirements

ID/Number	Requirement Specification Text
R4.1-POCT	Proximity sensors should be able to detect objects in the range of 3m
R4.2-POCT	Objects as wide as 10 cm should be detected
R4.3 -PROT	Processor capabilities ensure real time processing to give user sufficient response time
R4.4-PROT	Each RFID tag should be able to map at least 10 m radius around it.
R4.5-PROT	Low power mode and sleep mode should be implemented to ensure longer run time on battery

Our requirement for proof of concept is to be able to detect objects within the desired proximity to the cane and have a system in place to alert the user. There are different proximity sensors, for example: ultrasonic and infrared; each have their own advantages and disadvantages. We at CaneTech believe it will be a good idea to implement a system with different sensors so that most of the objects within our recommended range of approximately three to four metres can be detected. The processor that will be chosen should be able to handle monitoring of all sensors and components while providing alerts in real time so that the user has sufficient time to react. The processor must be able to handle all input in real-time, with minimal delay, as this would accumulate error over time. In the proof of concept stage we will implement a basic one to one RF communication with distance detection to demonstrate how indoor navigation could be implemented. Our indoor navigation works on the premise of introducing nodes that create a small network so that the interaction of these nodes with the NavCane will provide such a system so that the user can find points of interest. Since the NavCane will be battery powered, a sleep mode will be activated when the NavCane has no change in sensor input for an extended period time, and a low power mode can be used when certain features are not in use. These electrically sound measures would help save power and increase the total use time of cane after a full battery charge.

5 Electrical Requirements

Table 4: Electrical Requirements

ID/Number	Requirement Specification Text
R5.1-POCT	Easy access interchangeable fuses for motor circuit
R5.2-POCT	Precise motor control
R5.3 -PROT	Processor will have proper circuit protection
R5.4-PROT	Battery must supply power for a day's usage
R5.5-PROT	Wiring code will be upheld
R5.6-PROT	No injury will occur due to electrical failure
R5.7-PROD	Ensure over charging is dealt with by proper charging circuit implementation

Within the POCT phase we at CaneTech found there only to be one electrical requirement that will be necessary to implement early on which is circuit protection within the motor circuit. This will be needed as the servo motor within the haptic feedback system will be loaded by the user, which in turn will draw more current than what is considered acceptable as an input to the processor. The next phase of our project is the prototype. Within this phase we have the following requirements: circuit protection for all pins of the processor, as each pin has a max current input of approximately 50 mA, ensuring the battery lasts a full day's use from the power supply, and lastly proper universal wiring code. These requirements are necessary for the following reasons: if each pin is not protected then the danger of damaging the processor is substantially higher, if the battery does not last a full day's use then the product will be rendered useless, and finally, the wiring code needs to be upheld so that if there is further development on the product it will be easy to understand the product electrically. The last phase of this project is beyond the scope of this class. It would be ensured that the product follows proper charging regulations as you would most likely be plugging into a wall. An appropriate AC adapter would be provided, proper materials would be used, and appropriate circuit protection would be included. Without the proper circuity in place while being plugged into the wall, fatal damage to the NavCane would be a risk.

6 Mechanical Requirements

Table 5: Mechanical Requirements

REQUIREMENT CODE	REQUIREMENT DEFINITION
R4.1-PROT	Product is light and easy to manipulate
R4.2-PROT	Use does not cause discomfort over long periods of time
R4.3-PROT	Standard cane functionality is not impacted
R4.4-PROD	Product is impact resistant
R4.5-PROD	Product is water resistant
R4.6-POCT	Feedback does not overload senses or distract user
R4.7-POCT	Feedback is easily distinguishable from environmental noise
R4.8-PROT	Feedback does not cause discomfort over log periods of time
R4.9-POCT	Product is easy to learn how to use
R4.10-PROT	Ergonomics discourage improper orientation
R4.11-PROT	Sensors are protected
R4.12-PROT	Product can easily be disabled, but can not be accidentally turned off

The mechanical design of the NavCane is arguably the most crucial part of the design. A poorly shaped handle, an uneven weight distribution, or non-intuitive haptic feedback system will render the product impractical.

The first mechanical requirement that needs to be met is the weight restriction. Users of the NavCane will be holding it in front of them, sweeping it back and forth for extended periods of time. Conventional mobility canes make this possible without applying too much stress to the user's wrist through very lightweight construction. Weight added to implement our system will be small in magnitude and balanced.

In a similar way, the ergonomics of our final product is incredibly important. As our target market will comprise of mostly previous users of mobility canes, we will need to develop a product with minimal change to the user experience: adding useful features without causing any detriment to previous functionality or requiring the user to change their methods.

Finally, our user interface is firmly rooted in our mechanical design. Since our primary method of communicating with the user will be through tactile and haptic feedback it will have a significant impact on the user's experience. There are several aspects to this that we will have to consider. First and foremost, we must not harm the existing functionality of a mobility cane. The user must still be able to rely on physical feedback through tapping or sliding the cane over the ground and across obstacles. In theory this is not a difficult problem, but certain vibrations employed as methods to convey sensor information could be confused with impact vibrations from the end of the cane if not properly designed. The inverse is also something to be aware of: our methods of feedback should be easily distinguishable from other environmental noise such as mechanical vibrations of the cane itself or other objects touching the user's hand. Our methods of feedback need to be nonintrusive and easy to ignore or disregard if the user does not need them in a particular situation. For example, a user standing at the side of the road having a conversation would likely not want to be interrupted by a vibrating cane every time someone walking past triggers the proximity sensors. This could be implemented using feedback that is subtle, or by including a way for the user to turn the system off. These options will be explored as we go through the semester. For the same reasons for which holding the NavCane must be comfortable over long periods of time, the haptic feedback must also be comfortable for the user. Interpreting the feedback from the cane should not be tiring or painful in any way. Lastly, the learning curve for a user accustomed to using a regular mobility cane should not be difficult. The user interface should require little if any explanation to use.

7 Software Requirements

Table 6: Software Requirements

REQUIRMENT CODE	REQUIREMENT DEFINITION
R5.1-POCT	Proximity data is collected and collated in real time
R5.2-POCT	User feedback is continuously calculated
R5.3-POCT	Motors are driven efficiently and accurately
R5.4-PROT	No sensor or actuator is subject to CPU starvation unless non-critical
R5.5-PROT	On-board processor can communicate with the user's smartphone
R5.6-PROT	On-board processor can communicate with RFID beacons
R5.7-PROT	App is easy to use to customize experience
R5.8-PROD	App has audio interface for the visually impaired
R5.9-PROT	Advanced customization options are available for advanced users
R5.10-PROT	App and cane are easy to connect

There are two components to the software of the NavCane. The first is the software programmed into the cane itself, and the second is the optional smartphone app that could be used to customize and interface with the NavCane.

The software embedded in the NavCane will have several requirements that all must be met simultaneously. The first task is receiving signals from our proximity sensors and processing them. This involves taking in the raw data from each sensor in our array, and collating them to form a rough representation of relative locations of obstacles for an instant in time. This data will have to be compared with the data from previous time slices as a method to cancel noise and smooth out data. The second task is to take that data and calculate what signals to send to the user: type of signal to send (e.g. audio vs. haptic feedback), magnitude of feedback based on proximity or type of obstacle, and indicated direction of feedback. The third main task the software will have to execute will be any motor controlling signals. Depending on the final form of our haptic feedback system, this may be a PID controller, a PWM signal, or a simple output voltage.

The previous three tasks are vital to the operation of the system, and must run in virtual parallelism if not simultaneously in multiple CPU cores. Additionally, though, there are a few less critical functions our software may need to support. The first, and most likely, is Bluetooth communication to the user's smartphone. This may involve anything from receiving customization settings to sending signals to be relayed to the user through sound to receiving GPS information. This Bluetooth communication will likely be a less critical and time sensitive function than the fundamental three tasks described above (as important signals will likely always be transmitted to the user via haptic feedback), but will need to be run fairly often to provide feedback to the user in a useful and reliable time frame. As a Bluetooth connection can be easily and often lost in the event of interference or if the user's smartphone is turned off, keeping high priority signals non-reliant on a Bluetooth connection will help our system be more consistent and robust. Additionally, it is important to design the NavCane as a system with Bluetooth connectivity as an optional feature, to maximize our market.

8 Related Engineering Standards and Regulations

It is intended that the NavCane is to be first sold in the Canadian market. As such it is to abide by any regulations set forth by the Canadian government. In terms of federal regulations, our device would be considered an assistive device [4]. As such it is not required to follow medical device regulation.

In the following section some voluntary standards are listed that will be considered while designing the NavCane. The majority of the standards are drawn from CSA, SCC and ISO as they are some of the most reputable bodies of standardization/certification to a company operating in Canada. A measurable effort will be made to abide by these standards in this project. As by the time a production model is designed it is intended CSA certification will be sought out.

In addition, all external components and modules in used in the NavCane should be FCC and CSA certified.

8.1 Electrical

The NAVCANE is going to be powered with electrical power. As such it would be pertinent that proper precautions be taken into consideration in the design to make it electrically safe and reliable. The following standards should be adopted.

Table 7: Electrical Standards

Electrical Standards	
Number	**Description**
CAN/CSA-C22.2 NO. 61508-1:17 -	Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements (Adopted IEC 61508-1:2010, second edition, 2010-04, with Canadian deviations) [5]
CAN/CSA-C22.2 NO. 0-10 (R2015)	General requirements - Canadian electrical code, part II [6]

8.2 Environmental

The NavCane *should minimize its environmental footprint with our careful design. The design should consider the materials used and the lifecycle of our product. This is well reflected in the following standards and thus they should be adopted.*

Table 8: Environmental Standards

Environmental Standards	
Number	**Description**
CAN/CSA-ISO/TR 14062-03 (R2013)	Environmental Management - Integrating Environmental Aspects into Product Design and Development (Adopted ISO/TR 14062:2002, first edition, 2002-11-01) [7]
CAN/CSA-ISO 14040-06 (R2016)	Environmental Management - Life Cycle Assessment - Principles and Framework (Adopted ISO 14040:2006, second edition, 2006-07-01) [8]

8.3 Mechanical

The NAVCANE is to take proper safety precautions in the mechanical design of the stick attachment. The design must be ergonomic and not hurt the user. Below is a standard that outlines how to prevent pinching injuries and should be adopted. In addition, the standard below outlines some tips for ergonomics and haptic feedback, this also should be adopted as the NAVCANE is going to use haptic feedback.

Table 9: Mechanical Standards

Mechanical Standards	
Number	**Description**
ISO 13854:1996	Safety of machinery -- Minimum gaps to avoid crushing of parts of the human body [9]
ISO 9241-920:2009	Ergonomics of human-system interaction -- Part 920: Guidance on tactile and haptic interactions [10]

9 Conclusion

The NavCane will be a robust, safe and effective device that gives liberation to visually impaired users to travel with greater confidence. We hope that by focusing on minimizing the impact of our design modifications on the current functionality of the mobility cane, many users will feel comfortable trying our product. By keeping cost low, we hope NavCane will be used globally by people in all economic situations. Users will be able to detect obstacles in their path sooner than a typical mobility cane would, helping to avoid collisions, falls, and accidents. Users will also be able to take advantage of our indoor navigation system to travel through unfamiliar public buildings with ease. Our passionate, broadly skilled team will deliver a product that incorporates our key success factors: reliability, affordability, user friendliness, and simple learning curves. We plan to achieve these factors by following our indicated functional requirements stated throughout this document for all stages of the product.

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[6] CSA Group, "CAN/CSA-C22.2 NO. 0-10 (R2015) - General requirements - Canadian electrical code, part II," CSA, Mississauga, 2015.

[7] CSA Group, "CAN/CSA-ISO/TR 14062-03 (R2013) - Environmental Management - Integrating Environmental Aspects into Product Design and Development (Adopted ISO/TR 14062:2002, first edition, 2002-11-01)," CSA, Mississauga, 2013.

[8] CSA Group, "CAN/CSA-ISO 14040-06 (R2016) - Environmental Management - Life Cycle Assessment - Principles and Framework (Adopted ISO 14040:2006, second edition, 2006-07-01)," CSA, Mississauga, 2016.

[9] ISO, "ISO 13854:1996 Safety of machinery -- Minimum gaps to avoid crushing of parts of the human body," ISO, Geneva, 1996.

[10] ISO, "ISO 9241-920:2009- Ergonomics of human-system interaction -- Part 920: Guidance on tactile and haptic interactions," ISO, Geneva, 2009.

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