GNG 2101 Deliverable C

Conceptual Design, Project Plan, and Feasibility Study

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1.0 Introduction

This report will show the process that was taken during the ideation phase of the project, from idea generation to the narrowed down objectives for a specific design. We will begin by breaking down the many functions of the device to understand each element more easily rather than trying to take on such a complex system all at once, but we of course still keep in mind the main objective as outlined in the problem statement in the previous deliverable. Next, we generated ideas pertaining to each individual stage outlined during the functional decomposition phase. Using a variety of factors including measurements, calculations, and the target specifications from when we defined the problem, we will then narrow down and possibly combine our ideas into one specific design. Once we select a design, we will sketch it and outline the particulars in a brief form so it is easier to come back to later. Finally, with all that we establish, we will develop a schedule to adhere to and do a final feasibility analysis to ensure all our final ideas and timelines make sense.

2.0 Functional Decomposition

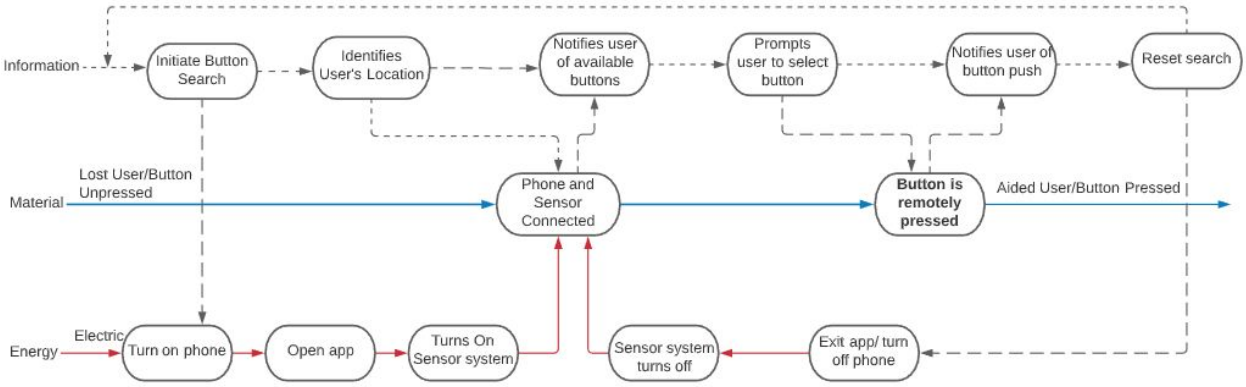

Figure 1. Functional decomposition of pressing button task.

2.1 General Process Taken by Product

1. Initiate button search (*for either automatic button or crosswalk button*).
2. Identifies user's location.
3. Lists nearby buttons *(within #m radius)*.
4. Notifies user of nearby buttons.
5. Prompts user to select a button *(vibration/audible)*.
    a. Guides users to button.*(Vibrates when the user's device is pointed directly at the button or vibrations points out the button's exact location and height. Although the client might not prefer this because buttons can be obstructed sometimes.)*
    b. Remotely press buttons for users *(A future problem might be getting the city to implement it)*.

3.0 Design Criteria

Table 1. Design criteria

#	**Design Criteria**
1	Cost
2	Presses buttons remotely
3	Usability
4	Phone integration
5	Notifies user to problem
6	Size and Weight
7	Route planning feature
8	Wearability
9	Waterproofing

Before the team started ideating over product concepts and features we made sure to go over the design criteria established in Deliverable B, which is seen in Table 1. With these criteria in mind for our product, we took some time to individually design product concepts.

4.0 Product Concepts

4.1 Gianluca's Product Concepts

Table 2. Gianluca's Product Concepts and Team Discussion

Product Concepts	Discussion
1.0 Worked on notification system for the buttons the app found/audible announcement notifications for crosswalk. 1.1 This can be an audible notification (such as the ones heard when driving with GPS navigation) which would inform the user when approaching a location that has an accessible button along with its location. This allows the user to become aware of the accessible buttons nearby without bringing out their personal device/smartphone.	Instead of audible notification specifically for directions, we would still like to incorporate this notification system in our app to notify users of changes, successful attempts or error messages.
2.0 Worked on guiding users to the button. 2.1 Due to the client's preference, she would like for this device to locate without needing to have a smartphone in hand. We can make a system such as Waze where users are able to report locations of the accessible buttons and set warnings if the buttons have some issue (blocked, dirty, broken, etc).	This is a good future step that our product can branch out into. We could allow users to flag any deficiencies with buttons.
3.0 Bluetooth low-energy beacons. 3.1 These could be placed around accessible buttons and send a notification via Bluetooth. The beacons are low-energy and would absorb solar energy to power them (Con: this would be much more expensive due to the need of bluetooth beacons near every accessible button). 3.2 See for reference: https://en.wikipedia.org/wiki/Bluetooth_low_energy_beacon	We will look more into detail on this when discussing the material we want to use to create our product and see if this fits our budget.

4.2 Gabriel's Product Concepts

Table 3. Gabriel's Product Concepts and Team Discussion

Product Concepts	**Discussion**
1.0 Worked on ideas for the sensor 1.1 On the button itself with an external device to push the button remotely. 1.2 Inside the circuitry and connected to the triggering mechanism for the button. 1.3 Connected to the Traffic or walklight.	The team decided to use idea 1.2 of having the sensor inside the circuitry of the button and connected to the pushing mechanism because 1.1 could lead the sensor being damaged by external sources and 1.3 would cause the device to be difficult to install.
2.0 Worked on the connection/interaction between the app and the external device 2.1 When the app is activated, if there is a device compatible within the range and the phone auto-connects to it. 2.2 Using the GPS of the phone, the app tracks your location and can give you audible information about Intersections and buttons/sensors nearby. 2.3 Sensor has a wifi network/Bluetooth to which the user can connect (manual or automatic) through the app.	We are going to try to use all the ideas in section 2.0 in our final product.

4.3 Hiruni's Product Concepts

Table 4. Hiruni's Product Concepts and Team Discussion

Product Concepts	**Discussion**
1.0 Worked on App features 1.1 Make sure to make the key feature, ex/choosing the button to navigate to, works with Apple VoiceOver or Android TalkBack. 1.2 Use descriptive language on every framework of the app. 1.3 Have auditory cues for actions taken in the app. Ex/error sound, a sound for when a button was clicked successfully in the app, sound for when the screen changes to a new module, etc. 1.4 List intersections in order of relative distance to users.	A lot of the ideas have to do with making sure the app portion of our product is user compatible with people that have low visibility, so we'll try to incorporate as many of these features into the final product. We are also going to integrate Hiruni's 1.3 idea with Gianluca's 1.1 idea because they are both about notifications.
2.0 Worked on finding user's location 2.1 Use GPS location of phone to track users current location and movements 2.2 Smartphone camera to capture key features in the area to figure out the user's location and guide to the next step. See for reference: https://www.researchgate.net/publication/261494029_Smartphone_based_guidance_system_for_visually_impaired_person 2.3 An external pin that can be attached to buttons, that will push the button. This way we won't need to integrate the system with existing structures thus it's more likely that cities will implement it.	Hiruni doesn't prefer 2.1 because it's inaccurate and won't be able to tell them how to move relative to a vertical object placement. Idea 2.2 also doesn't seem feasible with our team's capacity and we still have the problem that our client talked about, which is even if the user could locate the button sometimes the user is obstructed from being able to push it. The team will discuss 2.3 as a potential idea for our final group design.

4.4 Thuy-Vi's Product Concepts

Table 5. Thuy-Vi's Product Concepts and Team Discussion

Product Concepts	**Discussion**
1.0 Setting Routes 1.1 Google Maps (indicators of crosswalks can be uploaded via spreadsheet when using map routing feature) 1.2 Pining locations of crosswalk buttons using GPS	The team likes the idea of 1.2 for our final group design as it seems like less manual work.
2.0 Initiation Process for Search 2.1 Manual initiation of search feature: I. User holds down button to check if in area of button II. Sends out bluetooth signal to phone app III. App finds user location and checks if within radius of a button IV. App notifies wearable there is a button nearby V. User double presses button to remotely push button OR User selects button to push. 2.2 Automatic initiation of search feature: based on user route, can have the app automatically signal button to be pushed once in range. Phone or wearable then notifies the user that button has been pushed.	We will use 2.1 as the process to follow when a user wants to initiate a search for buttons since it allows users to have more control.

4.5 Tony's Product Concepts

Table 6. Tony's Product Concepts and Team Discussion

Product Concepts	Discussion
1.0 Locating the automatic buttons 1.1 The camera of the device can be used to locate the buttons. It's job would be to find objects/shapes similar to crosswalk or accessible buttons (object recognition). 1.2 Most crosswalks emit sounds that have a specific frequency within a specific radius. So, as long as our product is capable of detecting the sound frequency, it can bring the user closer to where the sound is being emitted. 1.3 Usually, the buttons are presented in contrasting colors (crosswalk: yellow, red and grey, accessible button: black, blue and grey). We can use the camera to detect such contrasts to pinpoint where the button would be for the user. 1.4 Instead of pushing the button, the app connects with a device set up at the crosswalk and pushes the button remotely.	A lot of the ideas aligned with a device that navigates users to a button, which wasn't the other direction some of the other team members were thinking of for the product, so this brought up a larger discussion of possible methods to implement our solution. The key points of the discussion can be found in Table 7. Our team decided to take idea 1.4 and incorporate it into the final design. Other members also suggested a similar idea.
2.0 App to phone connection (notifications) 2.1 Once a button is located a vibration can notify the user. Then as the user walks in the direction of the vibration, it becomes stronger. 2.2 A sound can play when the user is facing the button, and it stops playing once they aren't facing it anymore. Which forces the user to walk in the direction of the sound. (Could be used wearing headphones so that it isn't a disturbance to people around)	We decided to integrate Tony's vibration and audible notification suggestions with the ones that Hiruni and Gianluca suggested.

2.3 (Assuming a phone is being used) Since phones are capable of detecting distances, the product can announce how far the user is away from the button once it is located. This way the user can have a sense of how much they have to walk. 2.4 “Button is pressed” type message can be announced or some sort of vibration that signifies that.	

After looking at all the group members' ideas for potential features we noticed that the team’s ideas were split between this product being a device that navigates users to buttons versus a product that would push buttons remotely after getting a request from a phone app. Thus we decided to create a pros and cons table of both options so that we could have a discussion about which is the best direction for our product. This table can be found in the next section in Table 7.

5.0 Discussion of Navigating System Vs. Remote

Table 7. Pros and Cons for a Navigating Product Versus a Remote Button Access Product

Navigation System		**Remote Button Access**	
Pros	Cons	Pros	Cons
Less costly	Doesn't solve snowbanks issue	Can press remotely (No obstructions possible)	Would need development of device (2 devices needed: app + button pusher)
No dependency on government to install	Button still needs to be pressed	More reliable in unisolated system (won't have to be concerned about other people or objects mid navigation)	Many separate devices needed. Basically a whole city's worth of streets and buildings.
Works for all buttons software is set up to detect	The user has to worry about their surroundings	0% need to touch surfaces	Need city/establishments to implement
	Need 1-2 devices (phone & wearable)	Don't have to locate button, can just establish remote link	Durability issues
	Guiding requires some measurement of height for the button and phone/person relative to it.	Wheelchair accessibility	
	Lots of research needed to figure out		

After using Table 7 to help facilitate a discussion on which direction to take our product, we decided to make a product that would remotely push buttons for users because it seemed like the more feasible project to manage for our capacity and would satisfy most of the client's needs.

6.0 Final Chosen Features

1. Sensor inside the circuitry and connected to the triggering mechanism for the button.
2. Sensor has a wifi network/Bluetooth to which the user can connect (manual or automatic) through the app.
3. Make sure to make the key feature, ex/choosing the button to navigate to, works with Apple VoiceOver or Android TalkBack.
4. Use descriptive language on every framework of the app so that a screen reader can tell the user what's happening on each page.
5. Have auditory cues for actions taken in the app. Ex/error sound, a sound for when a button was clicked successfully in the app such as "Button was pressed", sound for when the screen changes to a new module, etc.
6. List intersections in order of relative distance to user.
7. An external pin that can be attached to buttons, that will push the button when it receives a signal from the app. This way we won't need to integrate the system with existing structures, thus it's more likely that cities will implement it .
8. Route mapping using Google Maps.
9. User presses the button and will initiate the searching for the button if the user is within range of the button.

6.1 Possible Future Features:

1. We can make a system such as Waze where users are able to report locations of the accessible buttons and set warnings if the buttons have some issue (blocked, dirty, broken, etc).

6.2 Final Design Concept

We took a combination/integration of the best ideas produced from the ideation of individual functions and properties which resulted in this new concept that we believe will accomplish the set of tasks as described in the FD as best as possible.

Figure 2. Adapted image from article titled "Do Pedestrian Crosswalks Actually Do Anything?" (2015) to visualize our button pusher application.

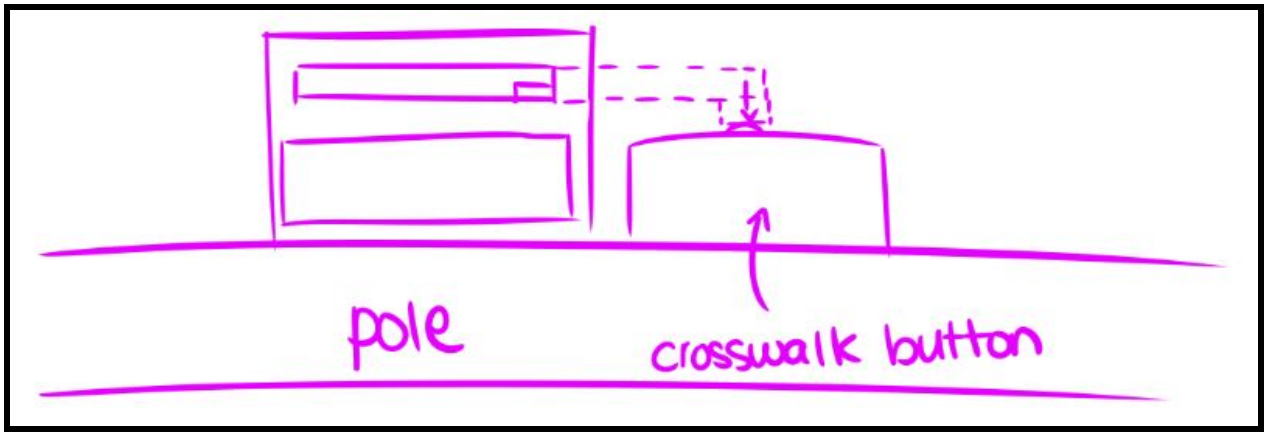

Figure 3. Side profile view of the button pusher concept.

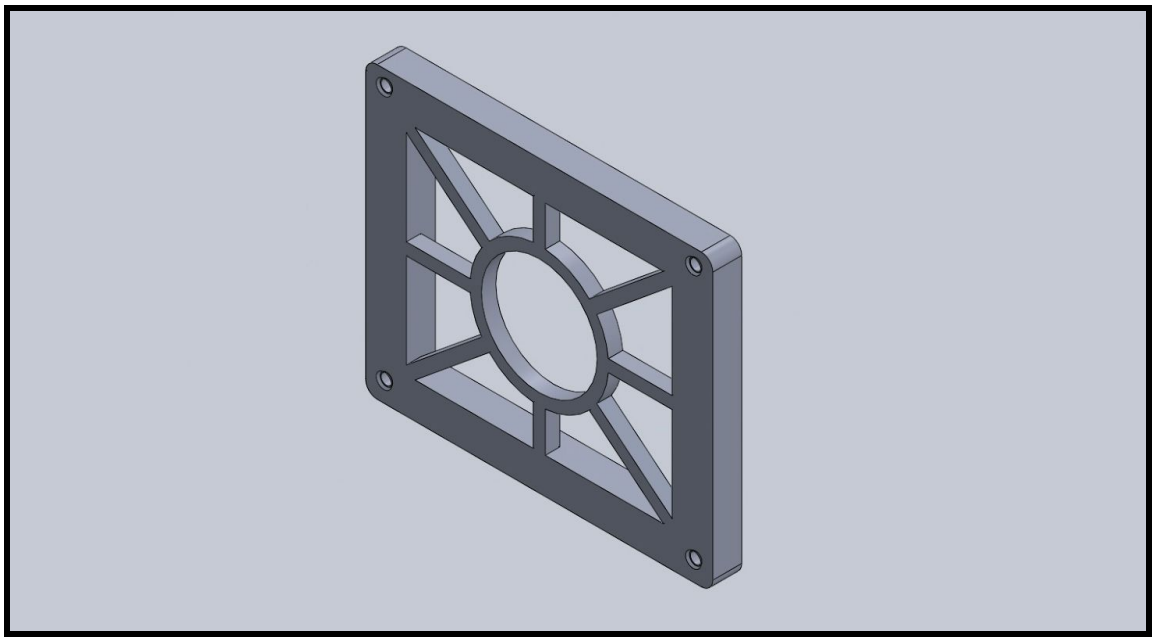

Figure 4. Solidworks drawing of final group design.

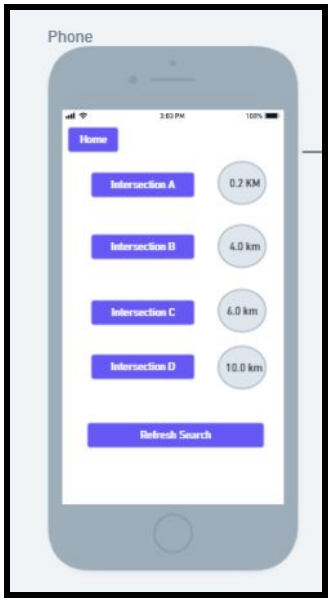

Figure 5. Sample design of phone applications user interface.

The design includes a phone app which, after input has been given to do so, gives audible notifications about the buttons nearby and if you're at an intersection, lists the streets in the order in which they can be selected. It will also notify you that the button has been pressed and uses descriptive language as much as possible for ease of use with a screen reader. The design also includes a sensor system which will activate the button remotely without the need for the button itself to be pressed and is connected to the phone via a Bluetooth connection, ideally solar powered.

7.0 Decision Matrix

Table 8. Decision Matrix to Compare Group Design to Our Reference Product

Decision Matrix	**Designs**	
Design Criteria	Reference (Key2Acces)	Combined design
Cost	N/A	N/A
Presses buttons remotely	+	+
Usability	+	+
Phone integration	-	+
Notifies user to problem	+	+
Size and Weight	N/A	N/A
Route planning feature	-	-
Wearability	-	+
Waterproofing	N/A	N/A
Total Score	0	4

8.0 Feasibility Report

8.1 Technical

With the variety of engineers on board (SEG, ELG, MCG, CEG), our team should have the technical ability to complete the software and hardware components of the device. In addition, we can use our experience with previous years' projects and the skills developed over this course. The rest of our technical resources can be covered by the MakerLab. It can provide us with information, materials, tools and machines. The only issue we will have conflict with is time so we won't be able to implement the device with the city, but we will be able to create the device that can be implemented in the future.

8.2 Economic

Economically, this is a beneficial design because the device(s) would be fairly small and the accompanying phone app would be generally cheap, resulting in an inexpensive solution to our client. We may have to consider some costs that are included with the software aspect of the product. Even though it would have to be installed at each button, this is still the most logical way to locate and press buttons without having to locate and touch unnecessary surfaces or run into physical obstructions. However, we are more focused on the prototype aspect for this course to help visualize our client's goal and test functionality while also remaining on a budget. Our ideal budget would allow us to implement our product in all of Ottawa's accessible buttons and crosswalks.

8.3 Legal

The main concern with creating an additional facet to public structures is the city and government regulations around it, since our button pusher application would need to be installed directly on pedestrian crosswalk buttons. In the future if our product was to be implemented city-wide then we would need to work alongside city officials, similar to Key2Accesses, to get approval. In the meantime, in terms of just building a prototype and testing it on crosswalks, according to By-law No.2003-50 of the City of Ottawa, it says “No person shall place a sign on a traffic control device or on a utility pole or other pole or post except as provided in Sections 7 to 18 inclusive of this by-law” (Dept., T. S., 2019). Thus by extension we assume it’s unlikely that we will get approval to place a device on a crosswalk pole to test. To work around this we’ll need to find a couple button samples that we will be able to test our prototype on within our research environment.

8.4 Operational

There are a few organizational factors that affect the feasibility of this project. First, this project is being run remotely, which has its benefits and shortcomings. One drawback to remote work is limited access to equipment from the MakerLab when building the physical product. However, working remotely makes it easier to meet up with the team, as meetings are held online and there is no hassle to find a place to work. In addition to remote work, this project is run by students, and busy schedules will impact the scale of the project and the quality of the final product. Despite this, by setting realistic goals and having a clear and descriptive plan, we should be able to complete this project to a satisfactory degree.

8.5 Scheduling

Our chosen deadlines seem reasonable and attainable with the current plan. Though there are various dependencies, the overall critical path is acceptable within the limits of the semester. Each task has a reasonable length of time associated with it based on the complexity and difficulty of the task. We will work in parallel for the parts we can to reduce the overall time of the project, and, if any task becomes very difficult, we can group together to ensure it gets done within the chosen time.

9.0 Conclusion

This stage of the project has brought us from the general requirements to solve the problem to a genuine, specific design concept for our solution. We used the brainstorming process to generate ideas and used our target specifications, design criteria and some analysis as noted in the corresponding section, to choose this design. This design is a culmination and integration of the best parts of the ideas presented.

Going forward, this stage will be very important as it will be the basis for our first prototypes and a resource to come back to if something goes wrong or it becomes apparent that we are straying from solving the correct problem.

References

Dept., T. S. (2019, November 07). Signs on City Roads (By-law No. 2003-520). Retrieved September 27, 2020, from https://ottawa.ca/en/living-ottawa/laws-licences-and-permits/laws/law-z/signs-city-roads-law-no-2003-520

Do Pedestrian Crosswalks Actually Do Anything? (2015). Retrieved October 01, 2020, from https://www.quora.com/Do-pedestrian-crosswalk-buttons-actually-do-anything