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Team 522: Vision Impaired Technology



# Abstract

# Disclaimer

# Acknowledgement

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# Notation

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# Section One: EML 4551C

## 1.1 Project Scope

### 1.11 Project Description:

The objective of this project is to design a product that improves the quality of daily life for visually impaired people. Visual impairment is defined as “a decrease in the ability to see to a certain degree that causes problems not fixable by usual means, such as glasses,” (Blind vs. Visually Impaired: What's the Difference? : IBVI: Blog 2020). Daily life activities could include household tasks, such as cooking, cleaning and increased reliability when locating specific items; as well as tasks outside of ones’ home, which can range from grocery shopping, getting to and from locations, and distinguishing people in common areas. Customers have expressed that having increased mobility can aid in a safer environment for the visually impaired.

### 1.12 Key Goals:

The team wishes to create a product to improve the quality of life for the visually impaired members of society which is broadly accessible. This project is set out to assist in the mobility and independence of the visually impaired in their daily activities, promote individuals to become more active and keep them safe while completing complex tasks. .

### 1.13 Market:

The primary market is people who have severe visual impairment, to the point of total lack of vision. Also, in this market are people who have drastically poor/low vision but retain some vision or sense of light. Any member of the general public that uses public facilities while also having issues with navigation around public spaces could be a possible consumer of our product . l

The secondary market for our device will also be rehabilitation clinics for use during Orientation and Mobility training. Another product consumeris transportation facilities; state/local Departments of Transportation and other transit systems such as subways, bus-stops and cross walks.

### 1.14 Assumptions:

The team will be operating under specific assumptions. First, the team assumes that the visually impaired are those whose vision is not functional enough to gather sufficient information to discern new surroundings. They will also be assumed to have undergone Orientation and Mobility training/rehabilitation. They will assume impaired people are not fully comfortable in current society due to said condition. Finally, they will assume the device must either have a simple interface or not require visual assistance in its use.

### 1.15 Stakeholders:

Shayne McConomy (Advisor) | (850) 410-6624 | [smcconomy@eng.famu.fsu.edu](mailto:smcconomy@eng.famu.fsu.edu)

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Jerris Hooker (Advisor) | (850) 410-6463 | [hooker@eng.famu.fsu.edu](mailto:hooker@eng.famu.fsu.edu)

Jeff Whitehead (Visually Impairment Rehabilitator/Potential Tester) | (407) 883-7107 | [Jeffwhitehead@dbs.sldoe.org](mailto:Jeffwhitehead@dbs.sldoe.org)

FSU-FAMU College of Engineering

The funding for this project is offered by the FAMU-FSU College of Engineering. Dr. McConomy, Dr. Devine, and Dr. Hooker will all be Team 522’s advisors on the project and will therefore be stakeholders. Jeff Whitehead is a potential user and tester of our product, as well as a mentor and advisor.

## 1.2 Customer Needs:

### 1.21 Data Collection

Initial Question, Posted on the Facebook group, “Blind and visually impaired support group.”:

“I am not visually impaired myself, but I joined this group to learn more about some of the trouble people who are visually impaired go through. I am a part of an Engineering project at Florida State University who’s goal is to help people who are visually impaired navigate around public spaces. I was wondering if anybody had ideas on what this could be or any input that could help us narrow down a product that could be helpful. Any information or help is appreciated!”

* Customer Statement: “RFID beacons in stores, let people know what isle they’re in. Same for schools etc. “
  + Interpreted Need: The design needs to help the customer know their specific location within larger locations.
* Customer Statement: “Google Blind Architect.You will find an article relating to an architect who went blind and continued in his field using techniques for buildings (and I believe a transit system) that incorporate systems to make travel and locatation more safe for blind/VI.”
  + Interpreted Need: The design needs to be able to help the customer be able to work despite being visually impaired. They also want to have a way to maintain an occupation they used had before being visually impaired.
* Customer Statement: “Idk but we need a legit work from home jobs that we can do using our smartphones (different accessibility) thank you. I live in west Pasco co”
  + Interpreted Need: The customer wants to have a larger range of incomes. Design used on work-situations
* Customer Statement: “I would like more audible crosswalk signals, announcing the street you are about to cross, wait, walk, ect. Also accessability tools need to be more affordable. A small device like the Orcam is $3,000 and beyond the reach of most people”
  + Interpreted Need: The customer wants affordability within the product. There is also a need for transportation type products, specifically ones that are audible.
* Customer Statement: “I really would like to see more exploration of sonar technology. I have a sunu band and it works well, but has limits.”
  + Interpreted Need: The design needs to have the same capabilities of sonar technology.
* Customer Statement: “Volunteer with Be My Eyes - An app that allows visually impaired individuals to call in and speak with sighted individuals to complete tasks. I’m sure your questions would be answered while also providing a beneficial service to the visually impaired community. I Will help where I can, but volunteering with this service will allow you to make observations and get a clearer picture of what you are wanting to research.”
  + Interpreted Need: The customer needs to be able to contact sighted individuals.
* Customer Statement: “Good evening from Indiana, I think this is a tough one. There r so many things on the market today from the basic cane most of us use to a more high end one with a talking like g p s. I think most of us can agree, if your team is exploring some sort of mobility tool, hopefully, it is some thing affordable because a lot of the tools geared towards us can b so over priced, that it will more than likely sit on the shelf. Honestly, I can not even begin to say, but, if u r on campus, I think it is always better to talk to people in person. Have u tried contacting the office of disability resources on your campus? If u search u tube, there r many who speak of the different tools we r using and r on the market. From mobility tools to apps that helps or assist us with reading print and actually reading hand writing including identifying money, bills at least because coins we can identify r selves. But, good for u and your team keeping us in mind, there r apps available that calls live operators that can assist with when to cross a street, they tell u when the light is green or red and the list goes on and on and on. R biggest complaint is most times we r not included in creating some thing that we can use and that usually it is over priced. Good luck, hope u and your team can create some thing. There r even robotic dogs being worked on to use as guide dogs, they r not on the market yet.”
  + Interpreted Need: The customer wants to ensure that the product is affordable making it accessible. Making apps that are easy to learn and are not time-consuming.
* Customer Statement: “An app that can identify the store, classroom, building, etc. Theoretically, an app that communicates with an external device could be utilized anywhere that the external device is placed.”
  + Interpreted Need: Device identifies precise location and communicates it to user.
* Customer Statement: “I’m not sure how much the class discusses blindness, but it occurs on a spectrum from totally black to extremely poor/low vision. Im totally black sight in the left and poor on the right. For me personally, increased contrast would make a huge difference. For instance, the small wheelchair ramps to cross streets have large bump dots on them but they are are dull washed out muddy color. If they were high contrast and slightly reflective (like brighter not mirror) it would help. The same goes for signs. I’m sure that you’ve noticed that some signs stand out more than others, or that some street lanes are marked with a much better paint. As someone said above, if the street signs announced which street it was would be great. And if my phone could tell me where it is when I can’t find it!”
  + Interpreted Need: The design needs to improve the contrast between colors of objects such as street signs and other objects the partially impaired may interact with.
* Customer Statement: “I'm sighted. I care for my Aunt who just recently went blind due to a stroke. My grandmother was blind from age 7 (horse kicked her). But I am just at a loss at the lack of things that have not been done to help the blind. Yes there are a few more new gadgets...very expensive ones...but there is nothing new. Nothing that really helps. And the employment? It's so bad. Why isn't there a company out there that REALLY works to help them obtain employment? It's crazy!”

“Sorry to hear of your aunts situation, definitely, tough. There r more things on the market now that r a little lower priced and there r more free apps available that might assist her with regaining her independence. If she uses an i phone, u can visit [applevis.com](http://applevis.com/?fbclid=IwAR3iNIZmncia19exMbgO7mzHquzGg0fQkl69krKdLn-fGNuZjb041lHWzn8) and that is a website that u can find apps for the i phone either free or at a price, good luck and hope your aunt has a healthy and quick recovery.”

* + Interpreted Need: Design must be accessible financially. Design assists people in work tasks.
* Customer Statement: “I don’t know if there’s a product that can help us navigate. It would be interesting. I depended on my guide dog and made sure to remember my skills I learned from orientation and mobility.

I’m sorry people aren’t happy about your research. Not all of us are the same. When there are dozens of doctors that evaluate me on my rare condition, I let people ask questions or look. So that doctors can be as educated as possible.

There are visually impaired and blind people that feel like test subjects. They want to be understood, but don’t want to be questioned. Which is ironic. But, everyone is different.

I hope your research goes well.”

* + Interpreted Need: Design allows navigation compared to guide dogs and skills that were learned prior.
* Customer Statement: “As someone who lives in a big city, I think a proximity function to other people would be extremely useful, as it would help me in socially distancing myself from others, especially while on the subway. In addition, any way a blind person can identify if someone near them is wearing a mask would be great”
  + Interpreted Need: device senses proximity and relays information to user. Senses physical features of objects as well.
* Customer Statement: “hello, Madison,

i am a structural engineer,but i started losong vision 5 uears ago.now i am legally blind. i jave been thinking about this isuue a lot. being an engineer,i always want to make things better.

project is fascinating.message me,we can collaborate.i could be the ‘guinea pig’ to try things out.i love in crescent city, fl”

* + Interpreted Need: Device allows user to perform work tasks.
* Customer Statement: “I think one problem with a lot of new blind technology, is there is a lot of overlap. There are actually already some interior navigation applications. I think one is called the Beacon and it lets you leave indoor markers so you can navigate better. There are already products like the WeWALK smart cane, Sunu band, Orcam et Cetra. And there are applications like be my eyes and Ira, which can help navigate also. Maybe you could create A Bluetooth camera that pairs with iPhones and fits on a pair of sunglasses. This way blind people could have both of their hands free, will the head camera sends all the information they need to the iPhone. Good luck.”
  + Interpreted Need: Device is hands-free and identifies objects, then relays information to mobile device.
* Customer Statement: “I am an orientation and Mobility specialist working on solutions for folks using wheel chairs with VI or blindness”
  + Interpreted Need: Device is accessible to people in wheelchairs.

### 1.22 Explanation of Results:

The customer statements were gathered by putting out a post in Facebook support group for the blind and visually impaired. The consensus is that the customers need a product that can enhance mobility and independence, improve potential to obtain or maintain employment, and to have a reasonable cost.

## 1.3 Functional Decomposition

### 1.31 Data Generation

To generate the concepts and data required to perform functional decomposition, various experts on the teaching and rehabilitation of visually impaired people were contacted. Dr. Eileen Bischof, an Orientation and Mobility expert, was of great help in the development of our design requirements. Dr. Bischof helped us deconstruct the functions of the classical white walking cane most severely visually impaired people use. The white cane is primarily used to detect changes in their path, be them in terms of terrain, elevation, or objects potentially blocking their path. The team then analyzed various products/gadgets sold to aid the visually impaired. Many of these are sensors mounted onto glasses or arms in order to provide haptic feedback regarding the distance between the person and their surroundings. All of these included a slick and simple design with minimal usage of buttons for ease of use. Dr. Bischof also made it clear that most visually impaired people depend solely on their Orientation & Mobility training, which means whichever device they might want must synergize with those skills. The team also contacted Jeff Whitehead of the Rehabilitation council of the Florida Division of Blind Services, who emphasized to the group that whatever design they came up with, it had to be compatible with skills they develop through the O&M training, but it should also interface with known technology for a sense of familiarity.

The following graphics are here to display our team’s analysis of the what our design needs to do. The information within these graphics are based on our interpretation of our customers’ feedback. We are showing what are design should look like by breaking it down into systems and then showing the functions each system needs to achieve. The three systems we defined for our design are orientation, mobility, and utility. These systems can also be the major functions of our design while the functions can also be described as minor functions compared to the systems. These graphics make our objectives for our design clear and give us a bit of a plan of how to check and ensure we fulfill all the required functions.

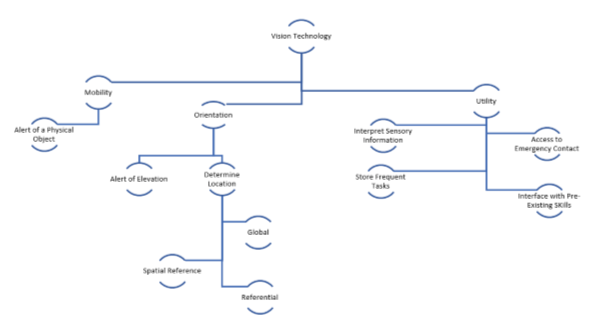


Figure 1: Functional Decomposition

### 1.32 Discussion of Results

Our functional decomposition was gathered by defining what we wanted our final product to do. As a group, we decided that the most important product specification was to give individuals with vision impairment a way of navigating the world around them. From there, we decomposed exactly what navigation was, and the substance our product will need to complete that task in a safe, efficient and intuitive manner. We broke down our vision impairment device into three primary functions: Mobility, Orientation, and Utility. To navigate the world, we need to first make the individual comfortable with moving. This includes moving around static and dynamic objects, as well as identifying dangerous obstacles such as low hanging signs or steps. The orientation function will be used to allow the user to understand where exactly he/she is as well as alert the user of a change in elevation grade. The utility function is mainly to supply the user with an intuitive and safe interface.

The functions our product will be comprised of are similarly related. The mobility and orientation functions are completely dependent on each other, as you can’t navigate the world without the ability to walk safely as well as know where you are. The utility function feeds off these both. Ideally, the utility function will be able to assist in both the mobility and orientation of the user. This can be accomplished by keeping track of commonly used paths to assist the user in the safest way to their desired location, as well as interacting with emergency contacts in the case of an emergency. In all, these three functions will provide for a seamless design as well as overall user satisfaction.

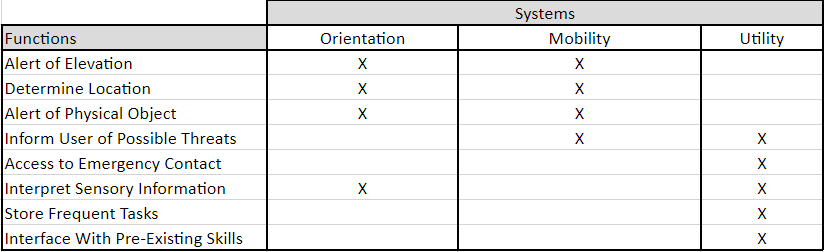


Figure 2- Cross Reference

The hierarchy of the system begins with creating a theoretical vision technology product. It is then broken down into three main categories that Team 522 wants to encompass in the project. These three sections are mobility, orientation, and utility. These were all based on the previously mentioned O&M techniques for the visually impaired. Orientation and mobility had to be separated for the distinction of the user knowing where they are compared to the user being able to move in said surroundings. Utility goes on to encompass all extra features which were strongly encouraged by the people kind enough to provide their input in the matter.

The priority ranks are best shown in the functional decomposition cross reference table. This is because functions that are encompassed by more than one system will be given a higher priority. Many functions overlap with the systems of orientation and mobility. This is reiterated in the teachings taught at secondary schools for people who are visually impaired. Often times people who are visually impaired are taught orientation and mobility hand in hand as it lets people use their senses to know where they are positioned in their environment. These teachings are used for the rest of their lives to help navigate around areas they are not familiar with. Informing the user of possible threats has a cross sub-system relationship with mobility and utility, while interpreting sensory information is overlapped with orientation and utility. These two functions will also be a high priority in the product as it helps in two different areas of focus.

Since orientation and mobility are so closing related for the visually impaired, many functions will have cross sub-system relationships. Alerting the user of changes in elevation allows them to both gauge their walking path and obtain a sense of orientation (be it through memory or relative to surroundings) while also ensuring they can properly navigate through said terrain. Similarly, being alerted to physical objects in their path is tied to the ability to move around said objects, as well as using them to orient themselves across a path. The design should be able to determine the user’s location; however, much of this can be tied to the user’s skill and training since informing the user of a distance is irrelevant if they are unable to process what it means. Informing the user of threats relates to any imminent risk they should be aware of and try to avoid, but unlike a physical object that might be stationary, this might wound or hurt the user (such as fast-moving objects). Interpreting sensory information mainly focuses on detecting information unavailable to the visually impaired, such as text or signs. This can be a very useful feature to the design so the user “read” what they couldn’t previously, but it can also allow them to read street signs and orient themselves in their town/community.

### 1.33 Action and Outcome

Overall, the product must give access technology to people who are visually impaired. The product must help them navigate around areas they are not familiar with and provide sensory information that they would not be receiving otherwise. The white cane is the most widely used physical tool for people who are visually impaired. This is because the white cane is cheap and typically taught in Orientation & Mobility School. For our product, we want the learning to be intuitive with the knowledge they have already obtained. This will allow confidence when taking on tasks that should be accessible to everyone with ease.

## 1.4 Targets Summary

**Table 1 Targets and Metrics**

|  |  |  |
| --- | --- | --- |
| **Function** | **Target** | **Metric** |
| Alert of Elevation\* | 0.25 to 12 inches | Distance |
| Determine Location\* | Margin of error of at most 16 feet | Distance |
| Alert of Physical Object\* | 65 inches | Distance |
| Identify Possible Threats\* | Up to 60 miles per hour | Velocity |
| Access Emergency Contact | 15 seconds | Time |
| Interpret Sensory Information\* | 7 seconds | Time |
| Store Frequent Tasks | 1 GB | Memory Allocation |
| Interface with Pre-Existing Skills | 70% | User Satisfaction |
| Compete within Market | 20% | Price Range USD ($) |
| Remain Lightweight | <5.1 lb | Weight |
| Remain Discrete | 70% | User Approval |

*\*identifies critical targe\**

### 1.41 Critical Targets and Metrics

One of the few obstacles that someone who is visually impaired might encounter is a change of elevation. The change in elevation we are primarily concerned about is some sort of step such as stairs or a curb on the side of the street. Our goal is to be able to detect changes in elevation as small as one quarter of an inch all the way to elevations as large as one foot. Our quarter inch value comes from the ADA (Americans with Disabilities Act), where they describe a ‘trip hazard’ “as any vertical change of over ¼ inch or more.” The value, twelve inches, is derived by looking at what the vertical curb height is which comes from the Mt. Shasta Municipal Code, Chapter 12.04. This is the largest height value for any obstacle that we assume a visually impaired person may have to step on or over. Our metric for this target will be distance in inches because our larger target is 12 inches, and our smaller target is a quarter of an inch. Determining how far one of these changes in elevations are is covered in our ‘Alert of a Physical Object’ target. We will test our device by using it and validating if it meets the target specifications using a tape measure and from there, we will adjust our product until it meets our target.

For determining location, we would like to be able to have accuracy comparable to a typical GPS (global position) that a smartphone would use. According to GPS.gov, the accuracy of a smartphone GPS has a margin of error of about five meters (16 feet) which is its optimal performance in clear weather and away from large objects such as buildings, bridges, and trees. For determining our accuracy of being able to determine location we will use a metric of distance in feet. Our test for finding the accuracy at which we can determine a location will be to have a test user stand at specific location with our device and compare their true location to what the device says their location is. The accuracy will be measured by a tape measure and be compared to the GPS of a smart phone held by the test user.

To keep our user safe, our device will be able to detect any physical objects in the path of the user. We want to be able to detect these objects early enough so that the user will be able to avoid the objects. Our metric for this will be distance in inches and our target distance of detection will be a minimum distance of sixty-five inches. This target was derived by taking the average height male and determining how long his white cane (visually impaired cane) is likely to be. The white cane is usually four inches shorter in length than the visually impaired person’s height according to The BAWA Cane Team. With the average height male in the United States being 69 inches (5’9”), a white cane for them would be 65 inches. Therefore, to remain competitive with a white cane, our device must be able to detect objects this far from the user. We will be testing whether our product meets the target minimum distance to detect an object by placing objects around a test user and measure at what distances our device will alert the test user of their presence. These results will be measured by a tape measure and objects used to test the device will vary in shape and size.

A way of informing the user of a potential threat is a critical target in our project since our project is intended for use in high traffic areas where danger may be more prominent. Often there will be an unexpected disturbance. This target falls within the systems of mobility and utility. The method of validation for this target could be to have a blindfolded person not in our senior design group walk through the FAMU-FSU College of Engineering hallway while using our device. This would help test if threats, such as people, chairs, tables, etc., are notifying the user. This metric could be interpreted for distance in terms of velocity (feet per second), and acceleration (feet per second squared). The average person walks three to four miles per hour, allowing for a relative velocity of six to eight miles per hour (Cronkleton, 2019). Standard speed limits in Florida where walking on a sidewalk would be common range from 20 miles per hour in school zones, 30 miles per hour in business or residential areas, and up to 55 miles per hour on other roads and highways (Speed Limit Laws). Therefore, our target would be a device that is able to detect velocities up to 60 miles per hour to ensure that all possible threats are accounted for.

Interpreting sensory information is critical to ensure that the user is obtaining all the information they do not know they are missing. This target is one of the key features of our product, it will allow the user to understand all the other targets mentioned. Being able to interpret sensory information related to the product itself, as well as the user. Current products on the market use audio, haptic feedback, and braille to relay the sensory information obtained back to the user. There are many studies that have occurred about whether sensory compensation occurs in people who are visually impaired. For people who are visually impaired, their sense of touch, hearing, and smell is proven to be heightened (Miller, 2017). This heightened sense will likely receive a quicker response time than somebody who is not visually impaired. This metric can be measured by how long it takes the user to be notified of sensory information and how quick the user is to interpret the supplied information; this may vary per person. The metric will be measured in seconds with a standard timer and have a desired time of seven seconds. The timer will begin once the device is able to interpret the sensory information and once the user reacts to the supplied information the timer will stop.

The device itself also needs to be able to evaluate the information it needs to relay. This involves interpreting the distance of how far disturbances are located, processing the information, and relaying the information to the user properly. This metric can also be determined with a timer. Ideally, we would want the response time to as small as possible but aim for it be less than five seconds in resemblance of real-time sensory information. The device should be able to detect object 20-30 feet away from the user, this can be tested and measured with an open reel measuring tape. A possibility for implementation is using LIDAR.

## 1.5 Concept Generation

In order to facilitate the brainstorming process, specific methods of concept generation are used. Brainstorming, biomimicry, and the morphological chart were all used within our concept generation to come up with various ideas. Brainstorming is the main concept generation tool that we had used to gather ideas, during which each team member writes as many ideas as possible disregarding their overall quality or feasibility. This method is quick and efficient but requires the team to go back to revise each concept and verify if they are feasible or not.

Biomimicry is used to develop innovation that is inspired by nature, through the analysis of different animals, plants, ecosystems, etc. Most of these, such as bats, use echolocation thanks to their highly adapted bodies, while some, such as the star-nosed mole and the naked mole-rat, use highly sensitive tactile tissue. From this, the team considered a variation of radar or a device that enhances the user’s sense of touch (much like the standard white cane). Developing ideas from what occurs naturally can extend the thought process and create efficient systems.

Another tool used in the brainstorming process is a morphological chart. Morphological charts list out the functions for the desired design and lists possible solutions for that function. This allows mixing of different system solutions and produce a greater number of plausible concepts. For example, the critical functions included alerting of elevations, determining locations, and alerting of physical objects; the ideas that can achieve these incorporate a cane or sensor, as well as a GPS device. Many of the ideas were derived from the morphological chart, seen in Table 2.

Table 2: Morphological Chart

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Alert of Elevation | Determine Location | Alert of Physical Object | Inform of Possible Threats | Interpret Sensory Information |
| Sensor | GPS Through Wi-Fi/Internet Signal | Distance Sensor | Heat | Camera |
| Stick/Cane | GPS w/ Maps Downloaded | Velocity Sensor | Vibrate | Text Conversion |
|  | Camera to Read Street Signs and Other Landmarks | Lidar | Noise | Live Imaging Scanned to PDF |
|  | Memory Storage of Previous Paths |  | Poke | Text to Braille |

By combing all the functions and resolutions we were able to come up with over 50 plausible concepts. Although some of them are similar, we were able to eliminate the ones that served no purpose. For example, having a cane that could memorize paths and send you messages in braille. More morphological chart concepts can be seen in the concept generation list.

Another process used throughout the brainstorming process was getting into the perspective of our user. As our primary market is for people who are visually impaired, it is very difficult for us to naturally find ways to make something work. One way to come up with something new was by physically attempting to be our user. In somewhat of a form of biomimicry, we would try to navigate in our surrounding space with our eyes closed, completely detaching ourselves from our sense of sight. By trying to navigate in this sense, we were able to grasp what seemed important in a device. We quickly realized that it is beneficial to have some form of physical device in contact with the ground. By being able to feel things, we could get sense of what was there. Going off that principle, we were able to further develop that idea into a fully functioning device.

Our high fidelity and medium fidelity ideas are determined after the brainstorming has been completed. From this point, it was determined that these ideas seemed to be the most fitting for our customer needs. This will be tested and determined in concept selection. The decision to move these ideas from the general population to either high or medium fidelity are discussed and reasoned in a group effort. The medium fidelity ideas are ones that incorporate the needs of the customer but are lacking in some areas. The high-fidelity ideas are the most realistic and implementable ideas.

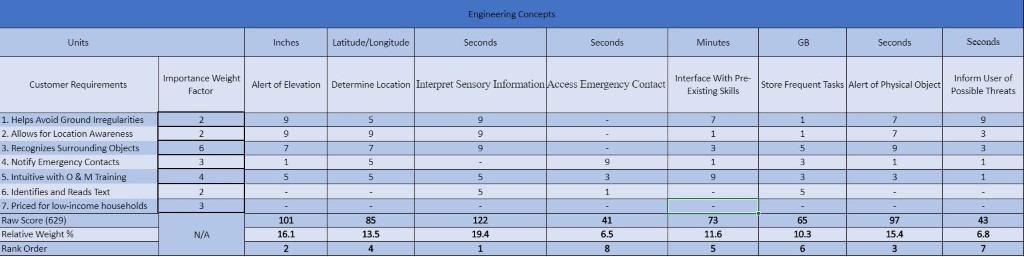
## 1.6 Concept Selection

There are many techniques that can be used to narrow down the multitude of concepts generated by our design team. The techniques include the creation of an Importance Weight Factor through Binary Comparison Chart, followed by a House of Quality, two Pugh Charts, and lastly the Analytical Hierarchy Process to determine the final concept selected. These work well as a set, as the Binary Comparison lets the engineers know how important each costumer need is, which can then be used to find how important each engineering characteristic is during the House of Quality. The importance weight factor generated by the Binary Comparison was the team’s first task, as that determines what aspects of the design are most important. Once the Importance Weight Factor was made, the team can perform analysis of the engineering characteristics using the House of Quality. This in turn lets the team know the importance of each function in terms of the customer needs while avoiding as much bias as possible. Once that was determined, the Pugh Charts allowed the group to compare their top eight ideas made during concept generation. It should be noted that selecting ideas directly does introduce a certain amount of bias to the analysis; however, these ideas were chosen by the four team members for their feasibility and usability. These ideas were then compared to a current market solution for the same issue the team is addressing.

## House of Quality

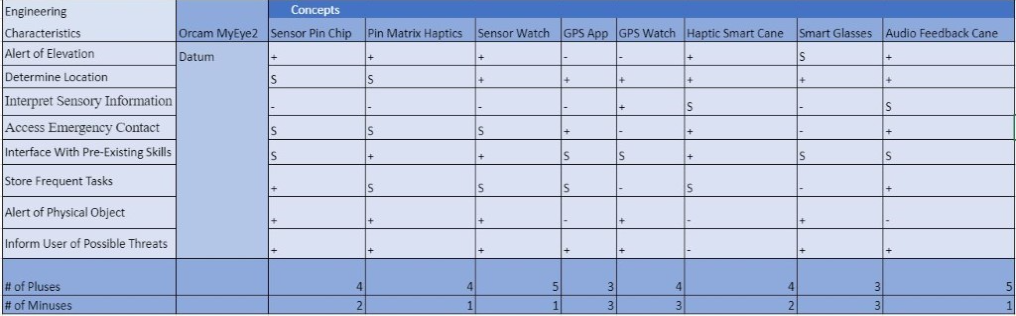
The House of Quality is a crucial step in the design process, as it allows the team to understand the weight of each engineering concept in relation to their costumer needs without skewing the data on relative notions. In the top row, the team’s engineering concepts, and their units are listed, while in the first column the customer requirements and their weight factors are listed. These are then ranted on a basis of 0,1,3,5,7,9 depending on importance. Even numbers are not allowed as these are often “safety” numbers which lead to less defined results. The House of Quality can be seen below in Table 3. From this table you can see that our most important customer requirement was being able to recognize surrounding areas followed by being intuitive with O&M training and notifying emergency contacts. Our engineering concepts that ranked the highest in this table were interpreting sensory information, alert of information, and alert of a physical object. Out of a raw score of 629 they scored 122, 101, and 97, respectively. After this analysis, these will be the concepts the team will be most focused on.

## Table 1: House of Quality



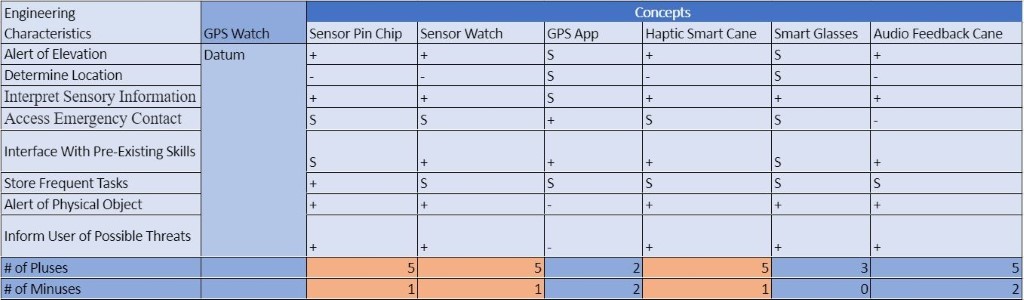
From the House of Quality, the crucial engineering concept was the ability to “Interpret Sensory Information.” This characteristic obtained the highest raw score and highest relative weight, which did not surprise the group as the primary goal of the design was enhancing the ability for a person who is visually impaired to navigate with no adverse consequences. In terms of importance, “Alert of Elevation” and “Alert of Physical Object” were the next most important characteristics, since “Alert of Elevation” ensures the user does not trip over treacherous terrain, and “Alert of Physical Object” ensures they do not hit an object while in motion. These three are crucial for a person walking around attempting to decipher what is around them.

## Table 2: Pugh Chart 1



The Pugh chart is a method of comparing designs directly to each other based on how well they fulfill our designated engineering concepts. The chart also uses a datum to compare each potential product to and score against. This process is conducted by lining up our potential designs and using a system of pluses and minuses to score each idea. A plus means that the product would outperform the datum and a minus means an idea would underperform compared to the datum. An “S’’ means that a potential design matches up with the datum evenly in terms of fulfilling the need of an engineering concept. In our original Pugh chart, the 3 high-fidelity design ideas and the 5 medium fidelity design ideas were all compared to an existing product on the market, the OrCam MyEye2. The team selected the top 6 design ideas from the original Pugh chart to compare to a new datum. This Pugh Chart can be seen in Table 3.

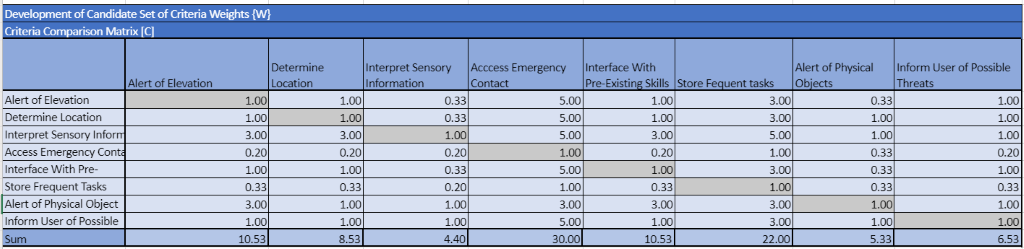
## Table 3: Pugh Chart 2



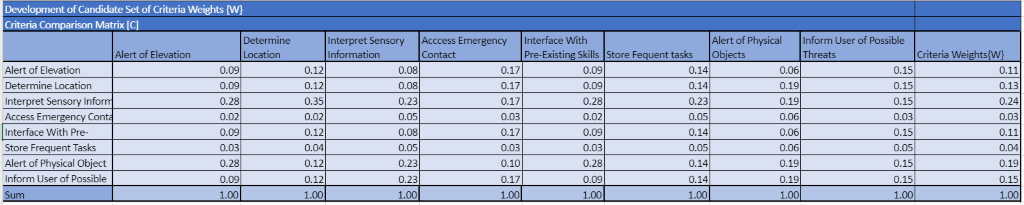
That new datum was selected from the original eight designs from the first Pugh chart. In this case, the GPS (global position) watch was selected as the datum in the second Pugh chart. At the end of this process, the sensor pin chip, sensor watch, and the haptic smart cane were all chosen to move on to further selection.

## Analytical Hierarchy Process

## Table 4: Criteria Comparison Matrix



## Table 5: Normalized Criteria Comparison Matrix



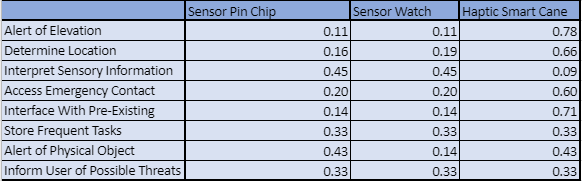
The Analytical Hierarchy Process is a method of evaluating and selecting a final design concept in a mathematical way. The first step of this process is developing a rating scale for our pairwise comparison and giving each engineering concept a weight. This is then normalized and analyzed for possible bias, and once it is determined to be no major bias, the team may proceed. Once each engineering characteristic has its respective weight and no bias, the high-fidelity concepts are further compared to them. In doing so, the best concept can be determined.

The team started the process by creating a criteria comparison matrix which evaluates the value of the engineering concepts our design will include. That matrix is then normalized so that each column of rankings has a sum of 1.00. We then found the values of the weighted sum vector and the consistency vector which were then used to conduct a consistency check. From this check we found values for the average consistency, consistency index, consistency ratio, and RI value. If the consistency ratio is less than 0.10 then the analysis was determined to be unbiased. After doing this process for each engineering concepts together, we then reiterated this process for each engineering concept by itself versus our 3 high-fidelity design ideas. The Analytical Hierarchy Process showed that the haptic smart cane is the best design based on this evaluation.

## Final Selection

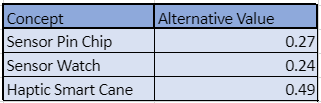
To finalize the selection process, the team did the Final Rating Matrix to determine as objectively as possible which concept was the most fit for the project in terms of the engineering characteristics. This is referenced in Table 8, where a percentage score was given to each concept in terms of each engineering characteristic.

Table 6: Final Rating Matrix



Once the Final Rating Matrix was created, each one of the concepts had their overall score in each characteristic aggregated and turned into a percentage to display the most effective concept. Table 7 displays the percentage of success between the three possible concepts. As such, the chosen concept should be the one with the highest Alternative Value.

Table 7: Alternative Value Matrix



This concept was the Haptic Smart Cane, which consists of an attachment to the standard white cane for the visually impaired. This device would also work with voice-recognition if possible and include a camera (ideally the camera from the user’s smartphone) faced upward near the handle of the shaft which can detect objects and relay the information to the user view haptic sensations such as vibrations. An alteration to this idea is relaying these items as audio; however, this is not ideal as it would interfere with the user’s hearing of any external noises.

# Appendices

# Appendix A: Code of Conduct

**Mission Statement:**

Team 522 is devoted to designing a better quality of life for the impaired. Team 522 embraces the innovation of technology to provide equal service for all individuals.

**Project Description:**

The team is in the process of developing a new design to assist the visually impaired in their daily life, primary during commute and commerce.**Team Roles:**

Madison Jaffe (Project Manager and Manufacturing/Controls Engineer)

* Lead discussion and guarantee all members are heard
* Keep team on schedule

Nicolas Garcia (Design Engineer and Resource Manager)

* Manage budget and resources provided
* Keep record of meeting’s main points in Engineering Journal
* Ensure product design meets customer needs.

David Alicea (Field/Test Engineer and Quality Control)

* Edit final version of deliverables prior to submission
* Test and inspect product while it is in use
* Evaluate alternative solutions

Ethan Saffer (Systems/Design Engineer)

* Evaluate all design ideas and prototypes
* Ensure design is user-friendly

All members are expected to contribute equally to the progress of the product. Members will operate with equal authority and no team leader will be assigned. Any task not inherently covered by job descriptions will be determined between the group through discussion.

**Communication**

Team members will be expected to communicate mainly through text messages and reply in no more than 24 hours under regular conditions. Basecamp’s messenger can be used as a supplementary form of communication, however it is not mandatory. The transfer of files shall be done exclusively through FAMU-FSU services or Basecamp. The date for meetings with sponsors and advisors shall be agreed to by all members at least one day before formally scheduling said meeting.

**Dress Code**

It is expected that the team members of Team 522 will comply with the dress code stated below. Team meetings will be in casual attire. Team meetings include meetings in which only the members of the team are included. Official sponsor/advisor meetings will be in business casual attire. This includes a button up shirt, dress pants, and closed toed shoes; however, this may also be a collared shirt if the group agrees beforehand. Group presentations and competitions will be in business professional attire. This will entail a dress shirt along with a jacket and professional footwear. If a team member is found in violation of this code, they will be asked to change, or asked to leave if they are unable to change attire.

**Attendance Policy**

Attendance is mandatory for all meetings; valid excuses must be submitted two hours prior. Emergencies are an exception; proof is required within 48 hours after missed meeting. Meetings will begin at the scheduled time, with a 10-minute window for late arrival. In the case of a late arrival, the member will be recorded as being late. Excessive late arrivals will be reported to advisor(s).

**Ethical Behavior**

Group members are expected to act civil and cordial in all meetings, and amongst each other through all kinds of communication. They are expected to follow the NSPE Code of Ethics for Engineers.

**Group Disagreements**

In the event of members disagreeing on something critical and subjective, the other group members will mediate a meeting to resolve said issue. If there is no satisfactory conclusion to the disagreement, the issue will be taken to the group’s advisor, with each member bringing their supporting evidence. If a group member is discontent with the result of the meeting and stops collaboration, said team member will be contacted before further steps are taken with the advisor.

**Amendments**

The code of conduct shall be amended only after a unanimous vote by all team members. This will be permitted on a case-by-case basis, to be determined in group discussion.

**Statement of Understanding**

I have read, understood, and swear to comply with the policies and regulations established in this Code of Conduct.

*Please submit a signed hard and soft copy of the document.*

Madison Jaffe

Nicolas García

David Alicea

Ethan Saffer

# Appendix B: Concept Generation

**High Fidelity:**

1. LIDAR/ RADAR sensor that can be pinned or chipped to shirt or breast pocket, sensors connected to others in hand grips of white cane. Haptic feedback provided through vibrations on cane. (Brainstorming)
2. Handheld technology with 3x3 pin system on the hand and LIDAR, which alerts the user of relative distance depending on which pin is pressed down and how intensely. (Brainstorming)
3. Watch with LIDAR/RADAR sensor and computer/GPS to indicate direction and location of user. Haptic feedback through sensors encompassing wristband. Watch connected to white cane like product with connection wrist strap like a Wii Controller (Brainstorming)

**Medium Fidelity:**

1. Smartphone application using Lidar and feeding user information through haptics, computer and GPS incorporated to track and locate user. (Brainstorming)
2. Watchwith sensor and computer to indicate where the user is, haptic feedback provided through vibration on wrist. (Brainstorming)
3. Smart cane – haptic feedback, voice-activated, and phone compatible (Brainstorming)
4. Eyeglasses that have a sensor and computer /GPS to indicate where user is, haptic feedback is provided through sensors on frame of glasses (contact points like bridge of nose and grips on the ends) - or haptic feedback provided through contact on cane (Brainstorming)
5. Smart cane – audio feedback, manual or voice-activation, phone compatible, ability to interpret the environment (Brainstorming)

**Ideas**

**Brainstorming**

1. Watch with LIDAR/RADAR sensor and computer to indicate where the user is, haptic feedback provided through vibration on wrist.
2. Watch with LIDAR/RADAR sensor and computer/GPS to indicate where the user is, haptic feedback provided electrical stimulation of sensors under face of watch and encompassing wristband.
3. Watch with LIDAR/RADAR sensor and computer/GPS to indicate where the user is, audio feedback provided through volume/ speakers in the watch. Volume adjustable via knob or smartphone.
4. Watch with LIDAR/RADAR sensor and computer/GPS to indicate direction and location of user. Haptic feedback through sensors encompassing wristband.
5. Watch with LIDAR/RADAR sensor and computer/GPS to indicate direction and location of user. Haptic feedback through sensors encompassing wristband. Watch connected to white cane like product with connection wrist strap like a Wii Controller.
6. Eyeglasses that have LIDAR/RADAR sensor and computer /GPS to indicate where user is, haptic feedback is provided through sensors on frame of glasses (contact points like bridge of nose and grips on the ends)
7. Eyeglasses that have LIDAR/RADAR sensor and computer/GPS to indicate where user is, audio feedback provided through speaker on frame of glasses.
8. Eyeglasses with LIDAR/RADAR sensors and computer/ GPS to indicate where user is and what is near them, haptic feedback provided through electrical stimulation of sensors located on various parts of body.
9. Hat with LIDAR/RADAR sensor and computer/GPS to indicate direction and location of user. Haptic feedback provided through sensors in contact with skull from the inside of the hat.
10. Hat with LIDAR/RADAR sensor and computer/GPS to indicate direction and location of user. Audio feedback provided through speakers in hat.
11. Shoes with LIDAR/RADAR sensor and computer/GPS to indicate direction and location of user. Haptic feedback through sensors in soles of the shoe.
12. Shoes with LIDAR/RADAR sensor and computer/GPS to indicate direction and location of user. Haptic feedback through electrically stimulated sensors elsewhere on body.
13. LIDAR/ RADAR sensor that can be pinned or chipped to shirt or breast pocket, sensors connected to others in hand grips of white cane. Haptic feedback provided through vibrations on cane.
14. LIDAR/ RADAR sensor combined with computer and GPS to indicate location of user. These systems are integrated into a white cane with haptic vibration feedback through grip on handle.
15. Sensors with computer and GPS integrated into a watch, the watch will provide haptic feedback through intensity of temperature change.
16. White cane attachment with distance sensor on middle of shaft and near handle, which then triangulate objects at a distance
17. White cane attachment with camera connected to neural net, analyzing objects in proximity
18. White cane attachment with camera connected to neural net, meant to identify objects
19. Harness with sensors on shoulders and hip, providing 360 area coverage through sensors.
20. Gauntlet with camera attachment connected to analysis tool
21. Glasses attachment with camera; therefore, enable people to easily aim at object in front of them.
22. Application on mobile device utilizing Lidar
23. White cane with built in GPS and route tracking, feeding information to user via audio
24. White cane with built in GPS and route tracking, feeding information to user via haptic feedback
25. White cane with built in GPS and route tracking, feeding information to user via braille pad
26. Smartphone application using Lidar and feeding user information through haptics
27. Smartphone application using Lidar and feeding user information through audio feedback
28. Trackers on wrists
29. Lidar scanner on handheld attachment, actively scanning for quick object movements
30. Lidar scanner but with distance sensor to maximize range and efficiency
31. Hat with attachable headphone for audible feedback
32. Hat with pressure point feedback
33. Robot that strolls alongside the person (hold hand)
34. Drone that flies ahead to predict future walking path
35. Smell-induced feedback
36. Autonomous wheelchair
37. Temperature related feedback
38. Product identifier by barcode
39. Product identifier by label
40. Voice-activated technology
41. Smart cane – audio feedback, voice-activated, and phone compatible
42. Smart cane – haptic feedback, voice-activated, and phone compatible
43. Audible stop for pouring liquids
44. Short stick that does all the same functions of a smart cane, except does not extend to the ground (more discrete)
45. Audible street signs for pedestrians
46. Smart glasses for low light situations
47. Smart glasses that read currency
48. Smart glasses that interpret manuscript
49. Watch that has multiple rhythmic beats indicating the height difference in front of the user
50. Getting help from surrounding people
51. Device with camera that translates text scanned into braille on small screen
52. Clip-on device for the hat that uses LIDAR

**Morphological Chart**

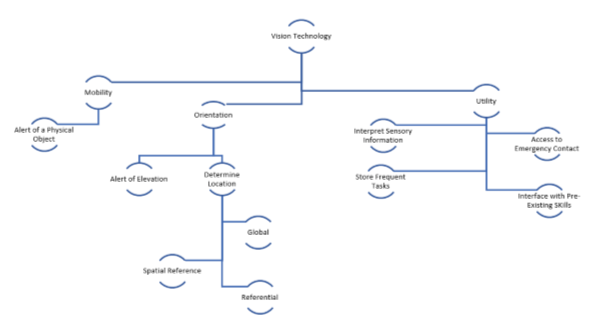
1. Sensor GPS with internet with distance sensor that alerts the user through heat differentials and uses a camera to identify objects
2. Sensor GPS with internet with distance sensor that alerts the user through heat differentials and uses scanning and image to text conversion to interpret items
3. Sensor GPS with internet with distance sensor that alerts the user through vibration and uses scanning and image to text conversion to interpret items
4. Sensor GPS with internet with lidar that alerts the user through poking the user’s hand softly and uses a camera to identify objects
5. Sensor that uses GPS with internet that uses a distance sensor and informs the user of possible threats through vibrations and interprets sensory information with a camera.
6. Stick/cane that uses a camera to read street signs and interpret sensory information with a velocity sensor to alert for physical objects and uses a heat sensor to inform user of possible threats
7. Cane with offline GPS using velocity sensors to find physical objects and makes noise to alert user of possible threats.
8. Cane with a GPS that uses downloaded maps, a distance sensor to alert the user of physical objects, uses noise to inform user of possible threats, and interprets sensory information with a camera.
9. Sensor, GPS with internet, velocity sensor, uses noise to inform of possible threats, text to braille for interpret sensory information.
10. Cane with internet connectivity for orientation, detection of short-range objects with distance sensors, altering using noise and utilizes scanning to turn text into user-friendly output.
11. Cane with internet connectivity for orientation, detection of short-range objects with distance sensors, altering using heat and utilizes scanning to turn text into user-friendly output.
12. Cane with internet connectivity for orientation, detection of short-range objects with distance sensors, altering using haptic touches and utilizes scanning to turn text into user-friendly output.
13. Sensor with camera and lidar that vibrates to inform user of objects, while scanning certain objects to PDF to identify text on it
14. Sensor with GPS through internet that has a distance sensor to alert for physical objects, vibrates to inform user of possible threats, and live imaging scanned to pdf for interpreting sensory information.
15. Sensor, camera to read street signs, Lidar, noise to inform of possible threats, live imaging scanned to pdf.
16. Cane with path storage that alerts user of objects found by lidar using vibration, while surveying the area with a camera.
17. Cane with path storage, using velocity sensors, vibrates to inform user, converts information through camera
18. Cane, camera that reads street signs, Lidar, pokes user to inform of possible threats, text to braille to interpret sensory information.
19. Cane, memory storage of previous paths, distance sensor, makes noise to inform of possible threats, text conversion for interpreting sensory information.
20. Sensor, GPS through internet, distance sensor, inform of possible threats by heat, interpret sensory information by text to braille.
21. Cane, GPS through internet, LIDAR, heat to inform of possible threats, interpret sensory information by text to braille.
22. Cane, GPS through internet, LIDAR, heat to inform of possible threats, interpret sensory information by live imaging scanned to pdf.
23. Cane, GPS through internet, LIDAR, heat to inform of possible threats, interpret sensory information by text conversion.
24. Cane, GPS with maps downloaded, LIDAR, heat to inform of possible threats, interpret sensory information by text to braille.
25. Cane, GPS with maps downloaded, LIDAR, heat to inform of possible threats, interpret sensory information by live imaging scanned to pdf.
26. Cane, GPS with map downloaded, LIDAR, heat to inform of possible threats, interpret sensory information by text conversion.
27. Cane, GPS through memory of storage of previous paths, velocity sensor, pokes to inform user of possible threat, camera to interpret sensory information.
28. Cane, GPS through memory of storage of previous paths, velocity sensor, uses heat to inform user of possible threat, camera to interpret sensory information.
29. Cane, GPS through memory of storage of previous paths, velocity sensor, vibrates to inform user of possible threat, camera to interpret sensory information.
30. Cane, GPS through memory of storage of previous paths, velocity sensor, uses noise to inform user of possible threat, camera to interpret sensory information.
31. Cane, GPS through memory of storage of previous paths, velocity sensor, pokes to inform user of possible threat, text conversion to interpret sensory information.
32. Cane, GPS through memory of storage of previous paths, velocity sensor, pokes to inform user of possible threat, live imaging scanned to pdf to interpret sensory information.
33. Cane, GPS through memory of storage of previous paths, velocity sensor, pokes to inform user of possible threats, text to braille to interpret sensory information.
34. Cane, GPS through memory of storage of previous paths, Lidar, pokes to inform user of possible threat, live imaging to interpret sensory information.
35. Cane, GPS through memory of storage of previous paths, Lidar, pokes to inform user of possible threat, camera to interpret sensory information.
36. Cane, GPS through memory of storage of previous paths, Lidar, uses heat to inform user of possible threat, camera to interpret sensory information.
37. Cane, GPS through memory of storage of previous paths, Lidar, vibrates to inform user of possible threat, camera to interpret sensory information.
38. Cane, GPS through memory of storage of previous paths, Lidar, uses noise to inform user of possible threat, camera to interpret sensory information.
39. Cane, GPS through memory of storage of previous paths, Lidar, pokes to inform user of possible threat, text conversion to interpret sensory information.
40. Cane, GPS through memory of storage of previous paths, Lidar, pokes to inform user of possible threat, live imaging scanned to pdf to interpret sensory information.
41. Cane, GPS through memory of storage of previous paths, Lidar, pokes to inform user of possible threats, text to braille to interpret sensory information.
42. Cane, GPS through memory of storage of previous paths, distance sensor, pokes to inform user of possible threat, camera to interpret sensory information.
43. Cane, GPS through memory of storage of previous paths, distance sensor, uses heat to inform user of possible threat, camera to interpret sensory information.
44. Cane, GPS through memory of storage of previous paths, distance sensor, vibrates to inform user of possible threat, camera to interpret sensory information.
45. Cane, GPS through memory of storage of previous paths, distance sensor, uses noise to inform user of possible threat, camera to interpret sensory information.
46. Cane, GPS through memory of storage of previous paths, distance sensor, pokes to inform user of possible threat, text conversion to interpret sensory information.
47. Cane, GPS through memory of storage of previous paths, distance sensor, pokes to inform user of possible threats, text to braille to interpret sensory information.
48. Sensor, GPS through memory of storage of previous paths, distance sensor, pokes to inform user of possible threat, live imaging scanned to pdf to interpret sensory information.
49. Cane, GPS through memory of storage of previous paths, distance sensor, pokes to inform user of possible threat, live imaging scanned to pdf to interpret sensory information.
50. Sensor, GPS through memory of storage of previous paths, distance sensor, pokes to inform user of possible threats, text to braille to interpret sensory information.

**Biomimicry**

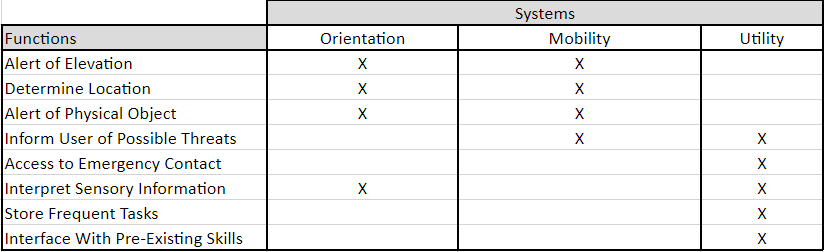
1. Bats: Blind, use sonar. Dolphins use sonar to communicate through water. Sonar
2. Mexican Blind Cavefish: Measures through shouting.
3. Star-nosed mole: Feels way around using nose. Much like the white cane is used to feel around but has limited range. Could use a laser ruler

# Appendix C: Figures

**Functional Decomposition**

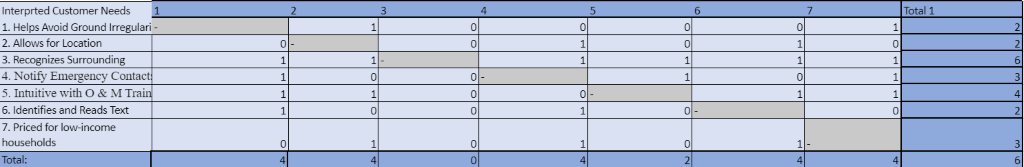
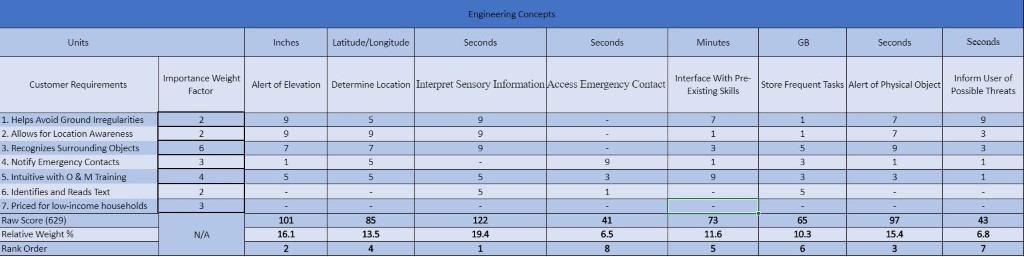
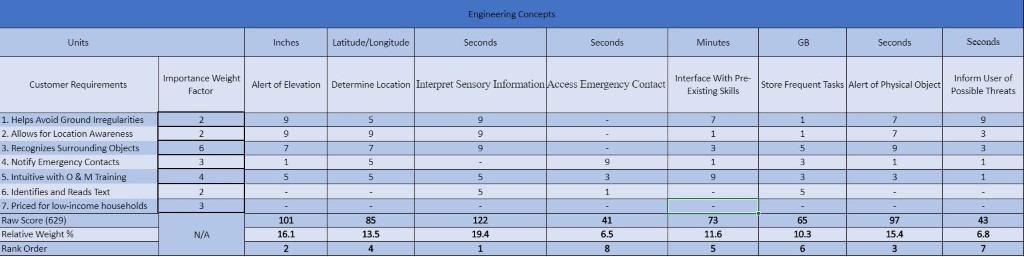
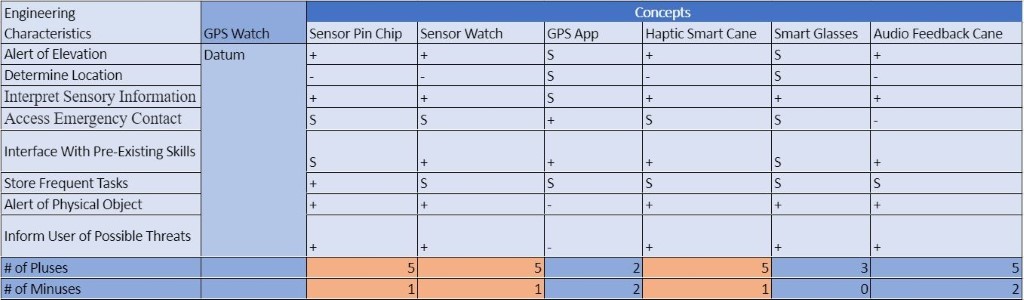
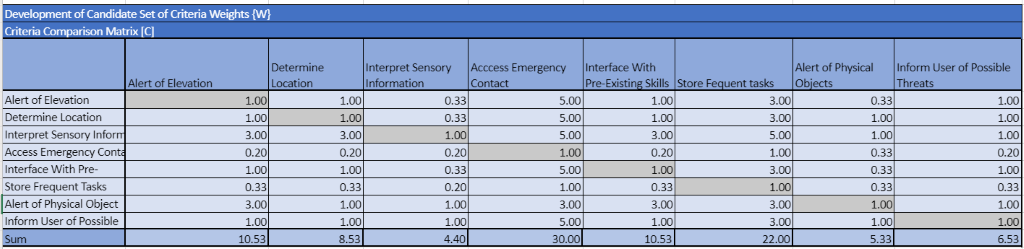
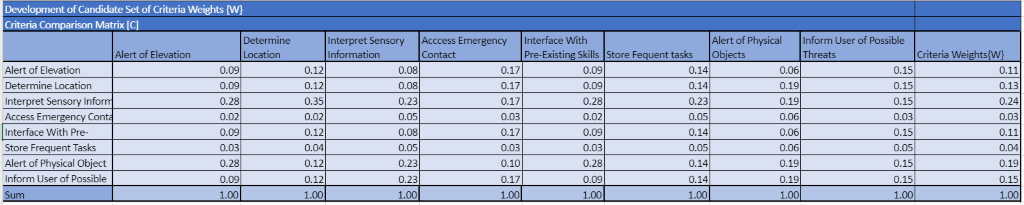


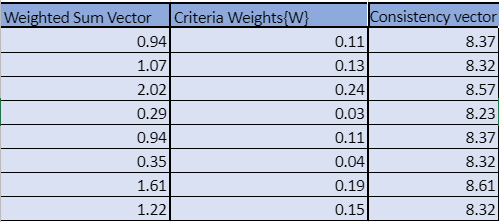
# Appendix D: Tables

**Functional Decomposition:****Targets and Metrics:**

|  |  |  |
| --- | --- | --- |
| **Function** | **Target** | **Metric** |
| Alert of Elevation\* | 0.25 to 12 inches | Distance |
| Determine Location\* | Margin of error of at most 16 feet | Distance |
| Alert of Physical Object\* | 65 inches | Distance |
| Identify Possible Threats\* | Up to 60 miles per hour | Velocity |
| Access Emergency Contact | 15 seconds | Time |
| Interpret Sensory Information\* | 7 seconds | Time |
| Store Frequent Tasks | 1 GB | Memory Allocation |
| Interface with Pre-Existing Skills | 70% | User Satisfaction |
| Compete within Market | 20% | Price Range USD ($) |
| Remain Lightweight | <5.1 lb | Weight |
| Remain Discrete | 70% | User Approval |

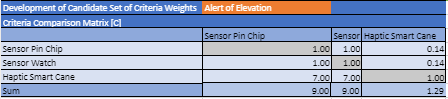
**Concept Selection:**

Binary Comparison ChartHouse of QualityPugh Chart 1Pugh Chart 2Analytical Hierarchy: Criteria Comparison MatrixAnalytical Hierarchy: Normalized Criteria Comparison MatrixConsistency Check

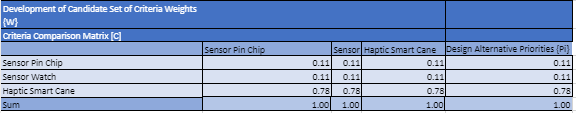


Consistency RatioAnalytical Hierarchy Charts:

Alert of Elevation:

Criteria Comparison Matrix

Normalized Criteria Comparison Matrix



Consistency Check

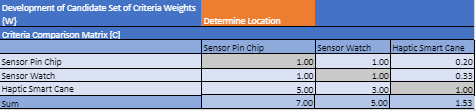


Consistency Ratio

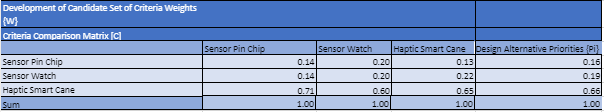


Determine Location:

Criteria Comparison Matrix



Normalized Criteria Comparison Matrix



Consistency Check



Consistency Ratio

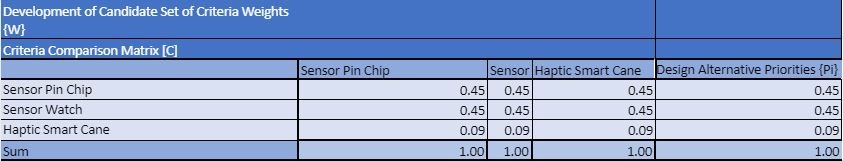


Interpret Sensory Info:

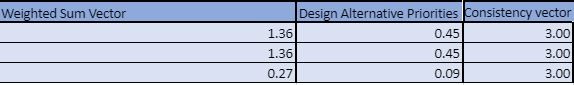
Criteria Comparison Matrix



Normalized Criteria Comparison Matrix



Consistency Check

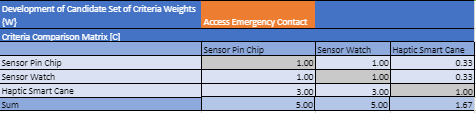


Consistency Ratio

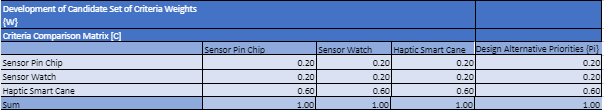


Access to Emergency Contact:

Criteria Comparison Matrix



Normalized Criteria Comparison Matrix



Consistency Check

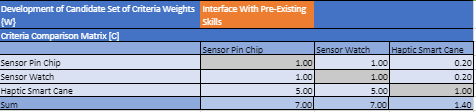


Consistency Ratio

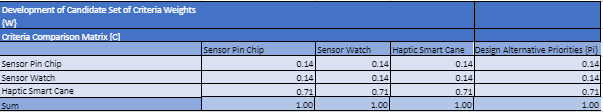


Interface with Pre-existing Skills:

Criteria Comparison Matrix



Normalized Criteria Comparison Matrix



Consistency Check

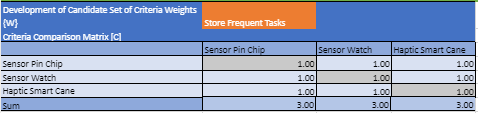


Consistency Ratio

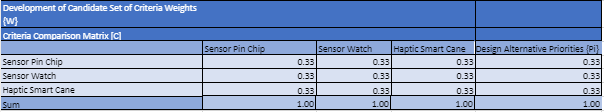


Store Frequent Tasks:

Criteria Comparison Matrix



Normalized Criteria Comparison Matrix



Consistency Check

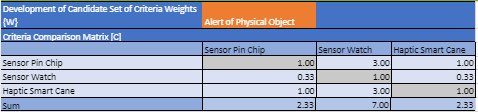


Consistency Ratio

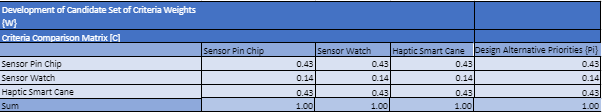


Alert of a Physical Object:

Criteria Comparison Matrix



Normalized Criteria Comparison Matrix



Consistency Check

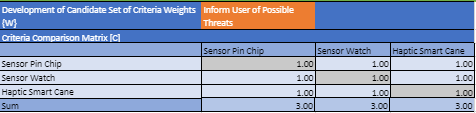


Consistency Ratio

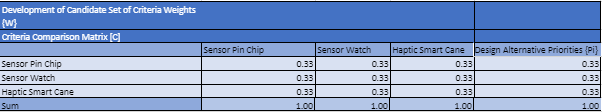


Inform User of Possible Threats:

Criteria Comparison Matrix



Normalized Criteria Comparison Matrix



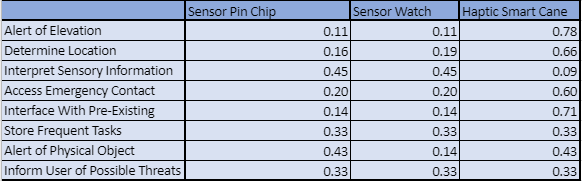
Consistency Check



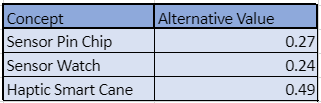
Consistency Ratio



Final Rating Matrix



Alternative Value Matrix



# Appendix E: References

ADA Compliance. (n.d.). Retrieved October 30, 2020, from

<https://www.alwayssafesidewalks.com/ada-compliance.html>

Blind vs. Visually Impaired: What's the Difference?: IBVI: Blog. (2020, April 02). Retrieved September 25, 2020, from https://ibvi.org/blog/blind-vs-visually-impaired-whats-the-difference/

Boshell, B. (2017). Average App File Size: Data for Android and iOS Mobile Apps. *Sweet*

*Pricing*.

Brisbin, S. (n.d.). Stay Safe and Independent: Get Help in an Emergency with Mobile Apps and

Services. *American Foundation for the Blind*.

Cronkleton, E. (2019). What Is the Average Walking Speed of an Adult? *healthline*.

GPS Accuracy. (n.d.). Retrieved October 30, 2020, from

<https://www.gps.gov/systems/gps/performance/accuracy>

*How to pick the correct length of a white cane for a blind person?* (2018). BAWA.

<https://www.bawa.tech/blog/pick-the-correct-length-of-a-white-cane/>

Kumar, A., Kumar, A., Veluvolu, K. C., & M, P. (2020). *Active Volume Control in Smart*

*Phones Based on User Activity and Ambient Noise* (Tech.). MDPI.

Miller, S. G. (2017). Why Other Senses May Be Heightened in Blind People. *Live Science*.

McConomy, Shane (2019). Chars Functions Targets and Metrics 180919, EDM

Sunu. (n.d.). Retrieved October 28, 2020, from <https://shop.sunu.com/default.aspx?ref=landing&cl=171786&_ga=2.267895822.1808423009.1604077418-22699059.1604077418>

OrCam. (n.d.). Retrieved October 30, 2020, from

<https://www.orcam.com/en/myeye2/specification/>

Winter, B. (n.d.). 10 fascinating facts about the white cane. Retrieved from <https://www.perkins.org/stories/10-fascinating-facts-about-the-white-cane#:~:text=O&M>

Wuensch, K. L. W. (2013, November 22). *Sensory Compensation*. Ecu.Edu.

<http://core.ecu.edu/psyc/wuenschk/Anosmia_Core/SensoryCompensation.htm>

Zingale, C., Ahlstrom, V., & Kudrick, B. (2005, November). *Human Factors Guidance for the*

*Use of Handheld, Portable, and Wearable Computing Devices* (Tech.). Retrieved October 29, 2020, from DOT/FAA/CT website: <https://hf.tc.faa.gov/publications/2005-human-factors-guidance-for-the-use-of-handheld/full_text.pdf>

(n.d.). Retrieved October 30, 2020, from

<https://www.codepublishing.com/CA/MtShasta/html/MtShasta12/MtShasta1204.html>