

Person with Visual Impairment (Fig 1.)

Echo-locator

assistive technology for people with visual impairment

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## Executive summary

The Echo-locator is a groundbreaking device for people with a visual impairment. It is affordable for everyone, effective and hands free. Our group: Danny, Hugo, Kenneth, and Lukasz have designed the Echo-locator which transforms the way people with visual impairment navigate.

We believe that vision is the most important sense, that’s why we decided to create a product for people with a visual impairment. We deeply believe that by increasing spatial awareness, and enhancing the ability to navigate, people with a visual impairment will have a greater level of confidence and independence.

Our product, the Echo-locator is a portable device which gathers data through two ultrasonic sensors. The sensors are attached on a strap that the user wears as a chest mount. This mount holds the sensors right in the center of the user’s chest to scan the surrounding area. This data is then translated onto a square patch on the user’s abdominal area. The information is sent to vibrators located in the patch and is set up in a three by three manner. The vibrating patch with 9 vibrators will indicate to the user that there is an obstacle in front of them and tell the user where it is. The specific location of is dictated by which vibrators are vibrating and the frequency of the vibration. If the object is really close, the frequency of the vibration would be intense compared to the frequency of vibration if the object was far.

Our product allows users to have a unique interaction with their surroundings allowing for a heightened spatial awareness. Our device is hands-free and doesn't burden the user by having to use a hand to carry a cane.

## Target

Waking up in the middle of the night to go to the bathroom is pretty normal. You get up, turn on the lights and walk out of your room towards the bathroom. But now imagine if you can’t turn on the lights. With the room being so dark it would be difficult to see things, making it hard to navigate. Such a simple task would be turned into something much more challenging. This is an example, describing the incomparable difficulties people with a visual impairment face everyday. We believe that vision is the most important sense, that’s why we decided to create a product which can help people with a visual impairment cope better with their disability. We deeply believe that by increasing their spatial awareness, we can boost their morale, enhance their navigation skills, give them confidence and foster their independence.

## Difficulties, Obstacles, and Challenges faced by People with Visual Impairment

Visual impairment varies in severity, thus people with visual impairment experience very broad spectrum of obstacles in their daily lives (*Vision Impairment)*. Nonetheless, the challenges could be categorized into two main groups: Physical, and Socio-environmental (*Vision Impairment)*. The first one pertains to the physical reality, whereas the latter mainly to how adjustable is the environment to people with various vision conditions (*Vision Impairment)*. According to a survey conveyed by The World Access for the Blind, people with severe visual impairment often have a difficult time navigating even well-known environments, such as their homes (WAB). Traveling or walking down a crowded street may pose great difficulty (WAB). It appears that physical constraints are the main issue for people with visual impairment (WAB). As for the second category - socio-environmental, people with this condition often struggle with integration (WAB). Many face loneliness and isolation (AFB). According the a study from The World Access for the Blind, an impaired ability to get around and function well in the world, together with substantial barriers to conventional forms of reading and writing are likely to compromise the ease and freedom of interaction between people with vision impairment and sighted people (WAB).

## Visual Impairment

According to the Centers for Disease Control and Prevention a visual impairment is when someone’s eyesight cannot be corrected to a “normal” level (Thompson). It means that no glasses or surgery can solve the impairment (Thompson). This difficulty is measured by the same metrics used in measuring normal eyesight (Thompson). 20/20 is perfect eyesight, and someone with a visual impairment can experience 20/200 vision (Thompson). To illustrate it, a person with 20/200 vision standing 20 feet away from an eye chart sees what a person with unimpaired (20/20) vision can see from 200 feet away (Low). There are multiple causes leading to this condition. One of them are genes, which can be passed on to a child. Complications at childbirth can also cause vision impairment (“Blindness”, What). Other factors include conditions such as Glaucoma (optic nerve damage) or Cataract - lens clouding (Glaucoma, Cataracts, Thompson). FInally, any severe damage to the eye can be responsible for impairment in vision (Glaucoma, Cataracts, Thompson).

## Statistics & Demographic Distribution of People with Visual Impairment

Over 285 million people in the world experience some sort of visual impairment, of whom 39 million are completely blind and 246 million have moderate to severe visual impairment (WHO). Not surprisingly then, there is a large number of people with visual impairment in the United States as well (ACS). Based on a disability status report conducted by the American Community Survey, approximately 7.3 million people in the United States have a visual disability, which accounts for 2.2% of the total american population (ACS). The disability is distributed rather evenly in regards to gender, age, and race (ACS). What is worth mentioning that the population of females who have visual impairment is approximately 10.8% more than that of the population of males (ACS). However, with increasing age, the incidence of visual impairment tends to equalize between males and females (ACS). In terms of ethnicity, the proportion of the percentage is distributed fairly even among all different races.

Furthermore, we can also observe that elderlies who have visual impairment do not necessarily outnumber the population of adults in general (ACS). The population of people who have this condition who are aged 18 to 64 is roughly 10.6% higher than that of the population of people who are aged 65 and older (ACS). Aside from adults and elderlies, there is also a notable amount of population for children (aged under 16) who are visually impaired; approximately 700,000 children in the United States are legally blind. For the causes of visual impairment, globally speaking, 43% of the population have visual impairment caused by uncorrected refractive errors (myopia, hyperopia or astigmatism), 33% of the population has visual impairment caused by unoperated cataract, followed by 2% of the population who has glaucoma (WHO).

## Vision

Navigation and spatial awareness are among the most challenging aspects of daily life for visually impaired people. These two affect every operation from the first time a person wakes up until the last moment she or he falls asleep. No wonder why most of the assistive technology circles around those two. However, it seems that the self esteem of a visually impaired person has been entirely forgotten. Can you imagine walking around with a white stick, poking around trying to figure out what is around you? That must be uncomfortable and causes people with visual impairment to experience emotional distress. Wouldn’t it be great if people had a choice? A choice to be independent despite their condition. This is our vision and we intend to accomplish that with Echo-locator.

## Consumer Requirement

Our group has conducted two successful personal interviews in order to obtain the optimal feedbacks from people with visual impairment. The interviewees are both from different background, gender and age group so as to erase any biased opinions based on the factors mentioned; Indeed, these people are just like any of us, we all want quality. Especially when it comes to products that directly influence the daily life of a person with a visual impairment. Subject interviews allowed us to narrow the requirements down to five main ones: user-friendliness, cost, functionality, appearance, and reliability.

In the first interview with Hans, 83 years old man with visual impairment, he shares with us about his daily activities. He lives alone with nobody else to help. Therefore, for Hans, it is crucial to be able to easily put on the device in the shortest possible time. Hans jokes that “nobody wants to spend more than 30 seconds on tying shoelaces, therefore, I would never want a device that takes me more than 30 seconds to be put on.” As a result, our group concluded that the first customer requirement is the product’s user-friendliness. By definition, user-friendliness means easy to use, operate and understand (Merriam-Webster). Time is valuable, however, with the quality mentioned above in regards to user friendliness, it helps conserve user’s time to use, operate and attached on. Furthermore, he also mentioned that any assistive devices that he would consider to try must be easy to operate because he often finds it hard to adapt to new technology. Besides, Hans also suggests that assistive devices should be light, small and portable because he often need to travel around. Hanks suggests that a nice feature would be a hands-free option that would increase his mobility. In short, assistive devices should be designed in a user-friendly manner, self-explanatory without the need of training, and in a manageable size for the convenience of carrying the device.

Another key customer requirement is the device’s cost. According to Hans, retired people do not have the same financial capabilities thus the price could a limiting factor in his decision to purchase a new device. Low cost is a must.

Furthermore, the device must serve its actual purpose - be helpful. Hans mentioned products that he had purchased in the past just to soon realize that they were not as functional as he thought? That feeling is surely frustrating. Often times, customers buy a product that they are not satisfied with and return them. Regardless, having an assistive device that actually helps and increase their spacial awareness is considered a major customer requirement.

In the second interview with Sally, a 17 years old girl with visual impairment. Much like anyone else at her age, she is a senior high school student. When we asked about the obstacles she would face on a daily basis, Sally was emotional: “I feeling abnormal from anybody else around me because I always carry a cane, I feel like I am a weirdo.” although in the reality, her classmates are all very understanding and barely anyone insulted her because of her impairment. Besides, she complains that the cane makes her look bad but she does not have a choice as that is the only tool that helps her navigating. Therefore, our group has taken another important customer requirement into consideration: appearance. We understand that people generally care about how they look because one’s outlooking directly implies his/her impressions towards others, especially for teenagers (Vijai).

Another customer requirement we conveyed is reliability. After we spoke with Sally in regards her opinion towards assistive technology, she mentions that she is always concerned about the battery life, usage and lifespan when it comes to technology. “I would not want the device to run out of battery or for whatever reason it doesn’t work at the critical moment I needed it.” Sally says. She elaborates that people with visual impairment are really rely on their tools that help them navigate, therefore, it is crucially important to make sure the device is reliable and that the users can trust it and use it comfortably without any worries.

## Products Available in the Market

Assistive technology for visually impaired people has made a significant progress in recent years. When it comes to discussing what assistive technology has to offer, the white stick seems like a perfect place to start.

White Stick, according to the article “An Introduction to Orientation and Mobility Skills” posted on visionaware.org, canes have been used for centuries as a mobility tool, but it didn’t happen until after the World War II, that they became white and widely spread (An). According to the source, the popularization of the white stick is credited to Richard E. Hoover’s of the Valley Forge Army Hospital, who used it in veteran’s rehabilitation process (An). Length of the cane is based on the user’s heights, and traditionally extends from the floor to the user's sternum. Its white color alerts others of the bearer's visual impairment (An). Our interviewees points out the advantages and disadvantages of the white cane. Simplicity of use, its price, and providing excellent information/feedback of upcoming surface are the greatest advantages of the white stick. The disadvantages are usually caused by the difficult to use it when travelling (buses, taxi), its inflexibility, making the cane susceptible to snapping or cracking, and its weight causing strain on the user’s wrist.

UltraCane’s inventors describe it as “an electronic mobility aid for use by visually impaired people that delivers a "step forward" in assistive technology(...putting).” The idea for UltraCane was developed by observing the echolocation system used by bats and dolphins (...putting). By emitting, timing and capturing ultrasonic waves, the device is able to calculate the distance to the object (...putting). The advantage of the UltraCane is its two range functionality: a short range mode, and a long range mode (...putting). The first one operates on a range up to two meters, while the second one detects objects within four meters (...putting). The vertical range is approximately 1.6 meters (...putting). Thanks to the ability to detect objects at head height, it reduces the danger of hitting one’s head, possibly causing more severe health issues (...putting). On the other hand, though, the UltraCane is quite complex is use (...putting). It poses the risk of discouragement and frustration, which could negatively affect emotional health of visually impaired people (...putting). The biggest disadvantage though is the price of the UltraCane. The producer advertises it for $979.99 (...putting).

iGlasses - AmbuTech, the “revolutionary” travel aid is a pretty, little, and functional solution for the head and upper body protection (Ambutech). The device is worn as regular glasses, and claim is to enable “more informed, confident, and efficient pedestrian travel” (Ambutech). Similarly to the UltraCane, it uses echolocation to detect objects in the user’s path (Ambutech). It communicates the distance through gentle vibrations (Ambutech). The manufacturer discloses that the primary use is merely supplementary and is meant to complemented by the traditional cane or an assistive dog (Ambutech). The advantages of iGlasses are most visible in their comfort, portability, ease of use, and hands free operation (Ambutech). However, the low level of feedback and inability to use the device as a main source of information does not add much to what the market already offers (Ambutech).

XploR, fairly new product under development is claimed to be the “smart” cane (Stinson). This device is extremely similar to one’s smart phone but with functionalities catered to the visually impaired. This cane has an embedded camera, facial recognition software and a gps (Stinson). The cane’s gps communicates the directions to the user, as far as where and when to turn left or right (Stinson). It’s a great way for someone with a visual impairment to be independently mobile and be able to explore new locations without any assistance. Nonetheless, Chris Danielsen, a spokesperson for the Federation of the Blind in the United States, points out that “XploR is an overly complicated (and expensive) hybrid of two things blind people might already own—a cane and a smartphone”. (Stinson). Danielsen brings up an interesting point, the cane XploR doesn’t bring a creative solution to the table, but rather an application of things already invented and used daily.

## Product Description

Our product the Echo-locator is a portable device which gathers data through two ultrasonic sensors. The sensors are attached on a strap that the user wears as a chest mount. This mount holds the sensors right in the center of the user’s chest. To scan the surrounding area the sensors are set to move 160 degrees in the x-axis and 120 on the y-axis. This data is then translated onto a square patch on the user’s abdominal area. The information is sent to vibrators located in the patch and is set up in a three x three square in the patch. These vibrators vibrate when an object is nearby and depending which vibrator vibrates tells the user where that object is. For example, a vibrating patch with 9vibrators (the same amount in our prototype) in a 3x3 fashion will indicate to the user that there is square box right in front of him at his/her feet by vibrating the middle two vibrators on bottom row and the same two vibrators in the column above. If this box is really close to him/her, the frequency of vibration would be intense compared to the frequency of vibration if the object was really far. If it was far, the user would feel a weak vibration. Echo-locator communicates the surroundings in 3D manner, allowing the user to have greater spacial awareness.

The Echo-locator has many perks, which help it stand out from the crowd. It relieves the use of the cane, opening up the users to being able to use two arms freely. It does, although, leave a lot of trust on the product to direct the user correctly. But it's just like getting use to anything, like driving a car or writing with your finger on an ipad, it takes practice and soon enough the user will master the technology and it will become more than any non-technological device could ever hope to be. The ability to help a person with a visual impairment and increase the spacial awareness is significant, giving the user the 3D map. We believe this is due to our design, and how we chose the placement of each component. We started off with an arduino board, as that is the brain of the Echo-locator. The ultrasonic sensors we used are very sensitive and can detect an object four meters away. We mounted these sensors in the middle of the chest with a chest strap similar to a gopro mount. This allows for the sensors to be able to detect everything in front of the user and the mount is comfortable and holds the sensors steady. The mount doesn’t slip, adjusts to any size, and is easy to put on. We used vibrators because they are able to detected and differentiated, this is important because there’s no use in detecting a vibration but not knowing where it's coming from. The patch of vibrates used to transfer the information is located at the abdomen because after testing we found that it is the best place for the user to locate each vibrator. The test results indicated a 95% success rate on a brand new user being able to identify specific vibrators vibrating in different locating, meaning that if two vibrators were vibrating in the top row, he can identify which two are vibrating. These are necessary features that may not be so appealing to the customers: The strap mounting the sensors, having a patch on the abdominal area, and having to have a device in your pocket. With these disadvantages, having physical equipment to wear and use, in essence it is the same burden as carrying a cane. Although a one major drawback is that the sensors and vibrating patch cannot successfully transmit to the user a hole in the ground. We plan to fix this in future designs by having a different method of communication, like a vibration or sound, that tells the user when there’s a sharp difference in depth in front of them. We also plan to place sensors in gloves to allows the users to have a more integrated experience with the technology and give them the opportunity to detect things on their own. We are aware that this device may be a little complicated for a brand new user, that is why we plan for the product to have a training program able to be used when the user desires. Without the need to visually read a handbook it will orientate the user on how the product words via speaker on the arduino and vibrating patch. It will simulate objects approaching by vibrating the appropriate vibrators in the patch and the voice in the arduino will explain what is happening. This type of in depth training will be available on command, but every time the device is turned on the vibrating patch will vibrate and speak to the user to make sure that the patch is placed correctly. Given that the patch is a square it is can easily be placed incorrectly. It will orientate the user by a voice via speaker on the arduino which vibrators should be vibrating, for example it will say right side and the right column of vibrators should be vibrating. If there's an inconsistency of the voice and the vibrating patch, the user will be notified that the patch is placed incorrectly. Another issue we faced was the battery life and how to let users know how much longer the device could stay on. We plan to integrate a system that with the same speaker and voice that will tell the user how much more time the device can be on when prompted via button. The user can press the button at any given moment and the device will respond with a percentage and time of battery life. This allows the user access to the battery life whenever he/she please so that he/she can make a decision if the device has enough battery to use throughout the day or just for a certain task. We hope to make the battery life at least 16 hours. We believe that twelve ours is long enough for someone to function without the need to charge it at any point. We came to this conclusion on the basis that if someone sleeps 8 hours at night, they have the rest of the 16 hours of the day to be outside. In the unlikelihood event that someone is outside of their house or anywhere that they can’t charge the device, we do plan to have the ability to swap the batteries. These batteries can be recharged, giving the user the piece of mind of knowing in case of emergency there are spare batteries available. We do plan to have a holder for the spare batteries in the device so that the spare batteries can be charged while the main battery is being charged. Our device can be charged via usb. This decision came from the wide variety of options the usb charger offers, usb car charger, usb wall plug ins, and you can even charge it on your computer. This makes the device easy to charge anywhere the user goes.

## Business Model

Having a great product that helps many people may sound great, but it doesn’t mean much unless we are able to deliver it to the customers. With that thought, we have to consider three business aspects that are crucial to our ultimate success: finding high-value customers, offering significant value to customers, and delivering significant margins (Debelak). Besides the keys to success, we are obliged to take into consideration the potential obstacles: difficulties in satisfying customers, trouble maintaining market position, and problems generating funding for growth (Debelak).

High-valued customers are those who are easily located, allowing us to sell the product at profitable price, interested in our product without much marketing expenses, and can generate enough profit to meet our sales and profit objectives. Could we consider people with visual impairment a high-value customer? Yes, because they are easily located through ophthalmologists, disability centers, and hospitals. According to Assistive Technology Industry Association, there is a number of assistive technology devices that people with a visual impairment can obtain for close to nothing (What). This satisfies the requirement of selling the product at profitable price. ATIA mentions that some schools pay for the devices if the help students in their learning (What). Moreover, the government pays for some assistive technology if it’s prescribed by a doctor (What). Private health insurance can also subsidize the purchase of an assistive technology device. Clearly, with the support of such agencies, people with visual impairment can obtain our product. According to our interviews and studies, we found out that new products enhancing user’s daily experience are always sought after. Large marketing campaigns would not be necessary. Can we generate enough profit? I believe we can. The cost of manufacturing is relatively cheap ($30-40) and the price of competitive products is very high (hundreds of dollars). We can make a 100% margin and sell the product for $60-80, still leaving the competition far behind. Offering significant value to customers can be explained by studying the customer requirements. Our product meets the requirements on a scale not seen before. In summary, our model meets all three criterias for a successful business.

The discussion about risks can be divided into three parts: difficulties in satisfying customers, trouble maintaining market position, and problems generating funding for growth. Is it going to be difficult to satisfy customers once they buy? It depends on how much support the customer will require. With the simplicity of our design and the user-friendliness, we believe that extensive technical support will not be required. Moreover, product installation is also simple, thus making our customers satisfied. Finally, by issuing warranties and quick return we can believe that our customers will be thrilled.

Maintaining market position may be tricky. As explained before, our technology already exists and thus our competitors can quickly come up with another product similar to ours. To stay ahead, we will constantly improve the Echo-locator and expand our operations into other fields of disability, creating a reliable and trustworthy brand that our customers would stay loyal to.

Assistive technology market remains a niche, needing more innovation and competition. The customer base is very large making it a profitable industry. Potential profit will attract investors and for those reasons we believe that generating funding for growth will happen naturally.

## Closing Statement

Echo-locator is a portable device which gathers data through a set of ultrasonic sensors. It then translates the data into a 2D mapping system representing the outside reality. Echo-locator will enable our users to regain their confidence in their ability to independently navigate in crowded places without being looked at. Its accurate sensory system combined with durability and ease of use is a great tool to improve one’s spatial awareness and make navigation in a physical world a lot easier.

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