# NaviSense

## *Indoor navigation solution designed ~~for~~ with people with visual impairments*

Honors Academy Bachelor

Empowerment for Health and Wellbeing

Final Report

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# Introduction

## Problem

Imagine yourself navigating through a building with complex layout, while having a visual impairment. How would you handle going from the entrance door to your appointment without knowing where to go or how to get there?

In the Netherlands, there were an estimated 311,000 people living with visual impairments in 2008, a number expected to increase of as much as 18%, to 367,000 by 2020 (Limburg & Keunen, 2009). For these individuals, navigating through large, and intricate buildings can pose a real challenge. Whether it is a hospital, municipality building, or university campus, the complexity of the layout of those places, especially when unfamiliar, can lead to feelings of being lost, confusion and frustration. This research focuses on hospitals, as navigation through those buildings poses additional problems, as the patient needs to locate a specific room, or a waiting area. Additionally, this often involves locating one's number on a screen display – a task that is impossible for those with visual impairments. Even if people with visual impairments would know the room number for their appointment, it would only solve a small fraction of the overall problem. They still need to navigate through the building to reach their destination, often navigating without a clear point of reference, facing challenges such as obstacle detection, object recognition, and orienting themselves in space. While the simple solution might seem to go accompanied by a partner, friend, or a family member, or to rely on the hospital staff for assistance, this also does not solve all the problems. For the hospital, hiring additional personnel to aid visually impaired individuals would be costly, and for the individuals themselves, it takes away their independence and autonomy, as it would pose a challenge for them to go somewhere on their own.

In Navi Sense we want to bring back this sense of autonomy and reduce the anxiety, often experienced by people with visual impairments when visiting new or simply complex buildings. Our goal is to create a device that helps people navigate through indoor spaces while also considering stairs, elevators, and doors. This way people with visual impairments people can get actively engaged in society without having the struggle of always having to ask someone for help. In this project the motto will always be: "Design with people with visual impairments, not for people with visual impairments".

## Background/Research

To start this project, it was decided to first do more research and get acquainted with the problems that people with visual impairments struggle with in their day-to-day lives. To do this we did research about the designs and technologies that currently exist on the market. To get acquainted with the problems we went to several events for innovation and experienced how it is to have a visual impairment ourselves by going to the muZIEum in Nijmegen (muZIEum, 2024).

Some outcomes of the design research were that a navigation device for people with visual impairments should be portable, not heavy, comfortable to use and provide real-time feedback. Some existing designs are easy to be split up into two categories, namely handheld and handsfree. The white cane, which makes use of tactile feedback, falls in the handheld category. The cane could be extended with an attachment that makes use of vibrations. The mobile phone

(with apps), using audio, vibrations, or both, also falls in the handheld category. In the handsfree category fall (smart)glasses making use of audio feedback, bone-conducting headphones, or a headset (Wainwright, 2014), also making use of audio, and wearables. These wearables could be positioned on the wrist, neck, upper body or could be worn as a belt and they make use of vibrations. An important thing that was found in the research is that people with visual impairments do not like their ears to be blocked by in-ears, since they rely on sounds from their surroundings a lot. (Kuriakose, Shrestha, & Sandnes, 2022)

The research about existing technologies led us to solutions available on the market today. However, none of this form a solution to all the pains that people with visual impairments experience. Therefore, there is a lot of potential on this market and a lot of room for improvements to help these people.

The first and most known solution is an app made by eZwayZ. This app will guide you to your destination with a combination of dynamic visuals (images), vibrations, and spoken instructions. These options of feedback can be changed in the app giving the user an optimal experience. Next to navigation the app also has a function to scan the room 360 degrees and give you a description of your surroundings. The app uses visual positioning with the camera and sensors of your phone to determine the position of the users. The downside is that in order to use the app, eZwayZ has to make a scan of the building with a unique mobile 3D-scanner. Therefore, the building needs to be rescanned if the layout is changed or if there are big obstacles in the hallway. Another downside is that the user has to hold their phone in their hand, while they might need their hand to carry other things like the white cane or a bag. (eZwayZ, n.d.)

Another option that is currently on the market is produced by WeWalk. They developed a cane attachment that has enhanced obstacle detection, accessible navigation, live updates for public transport, etc. This smart cane allows you to navigate through the city without the need to carry an extra device in your hands besides the cane. The product uses haptic and audible feedback to give you alerts. Furthermore, it understands audio in a way that you can ask for the nearest coffee shop or for travel tips. This all sounds very promising and is therefore also an inspiration to our own product. However, in our project we focus on indoor navigation while this cane is for outdoor uses. (WeWalk, n.d.)

An option that has been discontinued is the Sunu wristband. This wristband uses ultrasonic technology to detect obstacles up to 5.5 m away. This feedback is provided to the user through vibrations. The closer you get to an object, the more frequent the vibrations. Unfortunately, this product has been discontinued due to unknown reasons and therefore no longer available for people with visual impairment. However, this technology could potentially be helpful for future products. (House, 2023)

Lastly there are glasses made by Envision. The glasses are not made for navigation purposes, but instead they can read written text out loud. They allow for people to transform text into spoken language. Besides reading text, it is also possible for one to scan their environment and get a description of the objects and people around them. Although this is not navigation related, the technology might still be useful as it recognizes its surroundings. (Envision Glasses, n.d.)

# Method

In this section we will describe what we did during this project. At the start of the year our goal was to design and prototype an indoor navigation device for people with visual impairments. Soon after we started, this goal deviated, and we started focusing more on validating the idea by conducting and analysing these interviews.

## Interviews

At the beginning of this project, we started brainstorming about what specifications and features an indoor navigation system for people with visual impairments would need to have. We did this by researching websites and paper on the internet. However, quite soon we realized that we would only really know what was necessary and wished for in such a device if we ask the people who will be using the device in the end. That is when we decided that it would be a good idea to conduct interviews with people with visual impairments.

The process of starting the interviews consists of a few aspects. First of all, we needed to have a consent form for the interviewees. Our coach Astrid Kappers was really helpful in this process, as she has experience with interviews and consent forms for a similar group of participants. She helped us with getting an example consent form and she helped us with contacting the ethical committee who makes decisions in this matter. The process of making the form and sending it for approval took quite some time but has taught us all how processes like this go in the university.

Next to the consent form, we constructed an interview guide containing all the interview questions we wanted to ask the participants. During the interviews itself, we noticed that we deviated from this guide from time to time, but it was a good and helpful guide. In practice, you want the conversation to flow naturally, and every conversation is different. In figure 1 the list of our interview questions can be found.

### Interview questions:

1. How long have you been visually impaired?
2. How often do you visit public buildings? (government / hospitals)
3. What (if any) aids do you use now? How often do you use the aids and in what situations? Why did you choose these specific aids?
4. Did you have any training on orientation or how to use aids?
5. What characteristic of the aid you are using helps the most?
6. Do you have a problem navigating indoors, specifically public spaces?
7. What things are you missing and how would you improve them.
8. What sense do you like most when navigating through a space?

*Extra questions*

1. What kind of feedback would you prefer in a (technical) navigation aid? (audio, vibrations, tactile)

Ask feedback if the questions make any sense or if we missed any.

*Figure 1 Interview guide.*

The last and obvious aspect of the interviews is arranging the interviewees. Juan had contacts in Spain that he contacted for interviews and Jilke and Kirsten contacted possible participants in the UK and in the Netherlands. The Dutch interviewees were contacted by emailing several Oogcafés in the Netherlands and some individuals with visual impairments whose contact information could be found on the internet. The Oogcafés were very willing to help, and they forwarded our request to people that would be willing to help us.

In total we found 20 participants for the interviews, of which 19 were proper interviews and 1 was an audio fragment from someone who was unable to give an interview. In total we had 15 Spanish participants, 1 Peruvian participant, 3 Dutch participants and 1 participant from the United Kingdom. The interviews with the Peruvian and the Spanish participants were held in Spanish, the interviews with the Dutch participants were held in the Dutch and the interview with the person from the United Kingdom was held in English. The interviews were mostly held online or by phone call due to the interviews being international, but we also had one in-person interview. Most interviews took around 30 minutes. The interviews were recorded and later transcribed with TurboScribe (TurboScribe, 2024).

In *Appendix B: Anonymized demographics table* we have an overview of some of the demographics of the interviewees, listing more information.

We had all participants sign an informed consent form which was approved by the Ethical Board of the Human-Technology Interaction group of the Technical University of Eindhoven. The consent form was sent to the participants via e-mail, after which they gave consent via email.

## Thematic Analysis

As the interviews provided a lot of rich, qualitative data, we decided to use thematic analysis as our analysis method. The interviews were often relatively long, with participants willing to talk about their experiences in detail. Thus, to preserve as much information as possible, we aimed to identify patterns and recurring themes in and across the interviews. Initially, we tested several thematic analysis/data analysis software tools, like MXQDA 24 or ATLAS.ti, but they lacked the nuanced understanding required to capture more complex ideas and tended to mark only very clear and direct answers to the questions asked. As a result, we decided to manually read and get acquainted with all the interview material to fully understand the content, even when the participants answers were not straightforward.

In the first iterations of analysing the interviews, we assigned codes to each sentence or group of sentences that seemed relevant to our research. These codes represented the essence of said part of the text and varied significantly and were highly individual to each interviewee because, as we decided to use the semi-structured interview structure, respondents had considerable freedom in what they shared. During later iterations, the initially identified codes were categorized into broader themes that were more consistent across all interviews. The discovered and selected themes included:

1. Current Aids Used: Referring to the aids the interviewees currently use.
2. Thoughts on Previously and Currently Used Aid: Incorporating thoughts on previously and currently used aids if the person had much to say about them.

3. Impairment: Describing the person's impairment, which varied widely from those with some vision left to those who were both blind and hard of hearing. This context was crucial as it influenced their responses and preferences.
4. Challenges in Indoor Navigation: Challenges in navigating indoor spaces specifically, as this was key to our project.
5. General Navigation: Issues in navigating outdoor spaces or navigation in general, as those remarks could still prove useful, although they were not directly related to our study.
6. Perception and Senses Used: Referring to the senses and modes of feedback that a person uses currently in their day-to-day life.
7. Preferred Modes of Feedback: The distinction between preferred feedback modes and actual perceptions and senses used, as we did not only want to know what is currently being used but also what would be desirable to use for our tool.
8. Design Considerations: Remarks about what would be useful in our design and tool, highlighting important aspects to consider.

These general themes allowed us to use them across interviews, facilitating the later stages of data analysis.

## Design

With not much time left in the Honors year (1 month), we wanted to make use of the interview results to start thinking about what our product could look like. Moreover, the team thought it would be nice to have a more visual reference of our progress to show on Demo Day. We contacted Malaika Shankar from the Usono team (Empowerment for Health and Wellbeing track) to organize a brainstorming session. We knew which elements our product needed to have, but we needed someone with expertise in Industrial Design to guide the brainstorming.

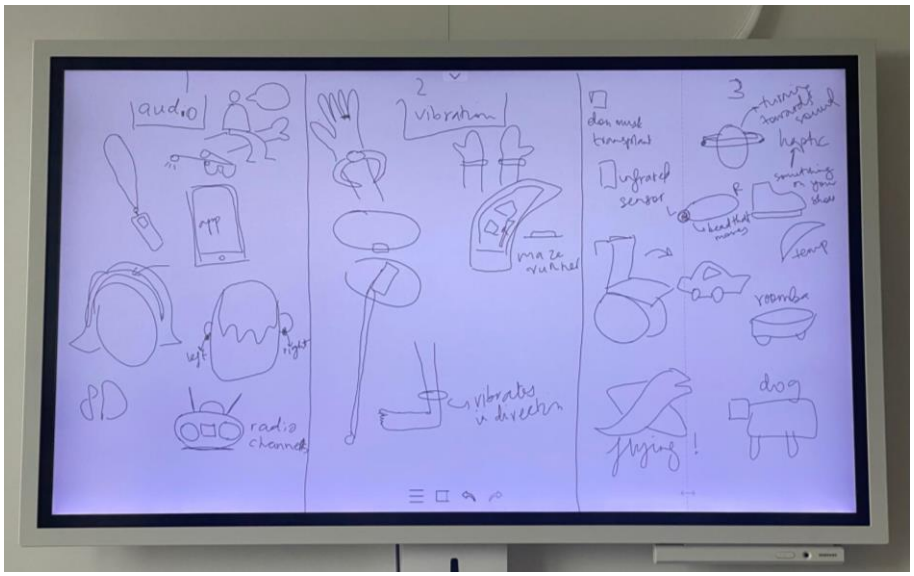


*Figure 2 Outcome of the brainstorming session with Malaika Shankar.*

She was very helpful, and in the first session, she came up with a great idea: previously, we were limiting ourselves to one design, one solution. Why not present 3 designs with 3 different aspects at the core? The team liked that idea, so we focused on three possibilities: a product focused on vibration, another one focused on sound, and a third ambitious abstract idea.

The session was highly productive. We already had some ideas ourselves, like glasses with cameras on them to recognize the 3D space, or an app on your phone that could guide you. Nevertheless, we came up with more crazy and innovative ideas. Why not a headband that tells you with sound and/or vibration where you need to go? That way we can give indications on a 360° plane. Or some special soles for your shoes, which after attaching them guides you through vibrations in your foot. The brainstorming was productive and fun. The outcome can be found in figure 2.

The next step was to narrow this down to 3 or 4 options that the NaviSense team liked and wanted to elaborate further on. This resulted in 4 main ideas:

1. A headband that gives feedback through audio.
2. A wristband that gives you feedback through vibrations.
3. A device that is an attachment to your white cane. It gives indications through vibrations and sound.
4. An audio guide-like device hanging around your neck that gives indications through audio.

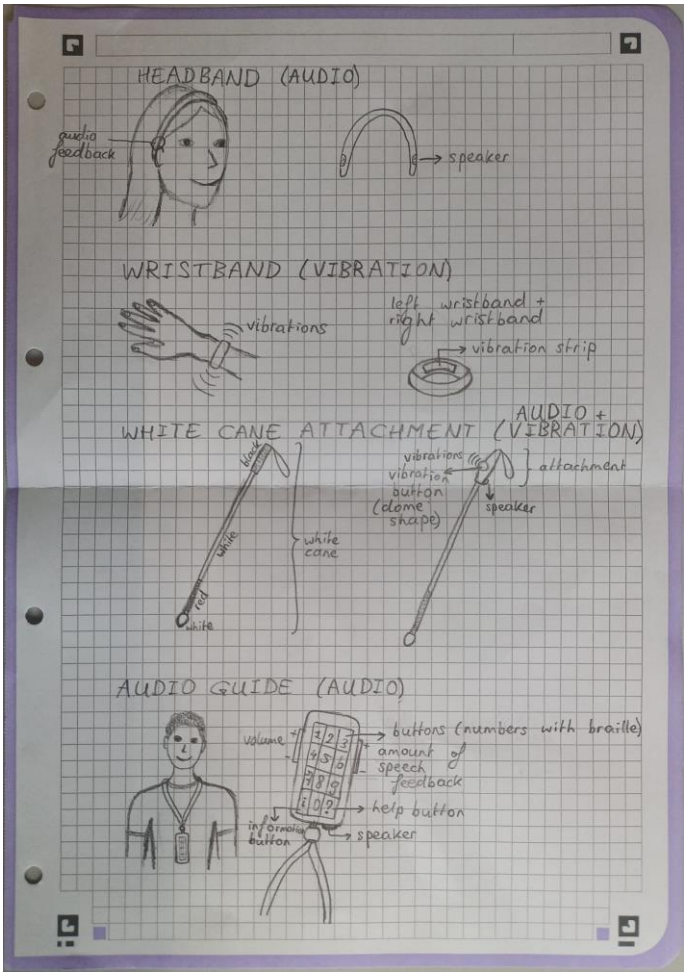


*Figure 3 Preliminary sketches of design ideas.*

Some of these ideas take inspiration of existing projects. For example, the cane attachment is similar to the smart cane from WeWalk (WeWalk, n.d.), however our product is more focused on creating a navigation method, while theirs is more oriented towards voice assistance. The wristband takes inspiration from the Sunu band (House, 2023) which did not develop.

After selecting the main ideas, we made more elaborate sketches to give a better idea of how the design would look like. These sketches can be seen in figure 3.

To make these sketches more professional, we send them to Malaika. With her expertise in design, she helped us by making the sketches into professional basic designs. This design task was something we wanted to add as a nice touch for the Demo Day, but it will be worked on in the future more thoroughly and patiently.

# Results

## Design

The result of Malaika's work were some nice designs of the four ideas. All of the designs make use of the same location technology, namely Ultra-Wideband technology (UWB). The hospital (or building) will have to place beacons on the walls of the indoor space. All four solutions will contain an Ultra-Wideband tag, which will connect with the beacons to triangulate the position of the user within the hospital. The designated room will contain another tag, so we will know where the user needs to go. The devices will then create the shortest path and give accurate instructions to the user on how to navigate the space. It is in this last step of giving feedback where the four methods differ, as well as in aesthetic and use. For all of the designs it was taken into account that the device can be cleaned easily as it will be used by multiple people in a hospital.

White Cane Attachment (Figure 4):

The white cane attachment is a device that uses audio and vibration to guide the user to their destination. On the front of the device is a vibration button (shaped like a dome) that will give direction indications on a 360° plane. A speaker on the side will also give feedback to the users through audio.

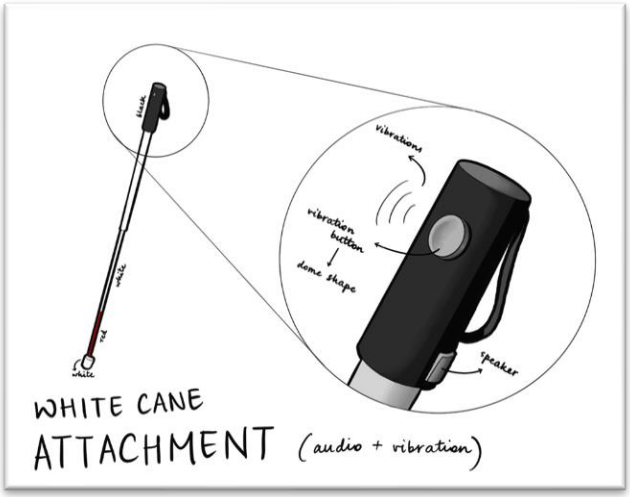


*Figure 4 White cane attachment design idea.*

The main strength of this idea is that it can be coupled with an essential and familiar aid for them: their white cane. This element is used by the vast majority of people with visual impairments and is an essential for them. The device would be compatible with different types of canes and should not elongated the cane. The latter one is important as the cane is a specific height to be able to use it correctly. There are a wide variety of canes in the market, so making the attachment universal would be very important to make it accessible for everyone.

Audio Guide (Figure 5):

The audio guide is a device that the user will carry around their neck, like an audio guide, making the solution handsfree. The product contains buttons with numbers, to input the number of the room (this can be done by the user or the receptionist of the hospital). To make it inclusive the

numbers will be written and in braille. The instructions for the navigation will be given through a speaker on the bottom of the audio guide. The speaker is on the bottom as the device is hanging upside down, this way the speaker is closest to the ears of the user.

On the device there is also a button to ask for assistance if needed and a button for information on how to employ the device. Once the latter is pressed, a recording will play with the instructions on how to use the device. If the assistance button is pressed the hospital staff will be alerted to come to the users location to help them.

On the sides of the device there are buttons to adjust the and a button to regulate the amount of


*Figure 5 Audio guide design idea.*

feedback given to the user. The button to adjust the volume will be on the lefthand side as this is similar to a iPhone and most people with visual impairment are iPhone users. In the interviews multiple people expressed their desire for a solution that lets them decide how much feedback they need to understand the navigation. Therefore it was decided to add the button to regulate the amount of feedback given to the user, this button will be on the righthand side of the audio guide.

When entering the hospital, the user will go to the reception and they will receive an audio guide from a member of the staff. The receptionist will put in the room number by clicking the correct buttons. After the receptionist has handed over the device to the user the information recording on how to use the guide will be played. This will explain the different buttons and how to use them.

Headband (Figure 6):

The third solution is a headband with a speaker on either side. This product will give indications through audio feedback. Another dimension could be given to the audio where the intensity of the audio is regulated on each side depending on the direction they have to go. If they have to go left, the audio will be stronger on the left side.

An important aspect indicated in the interviews is that people with visual impairment use their hearing to determine their position in the room. Therefore it is important to not completely block of their ears to make sure they can still hear their surroundings. In this device the speakers are

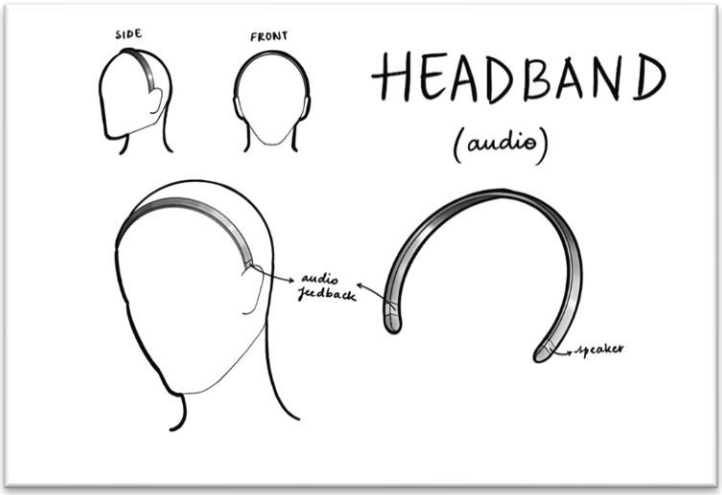


*Figure 6 Headband design idea.*

not located in the ear, but just behind them, to allow the users to hear stimuli from the real world. This prevents accidents, low reaction span, etc.

Wristband (Figure 7):

The last idea consists of two wristbands, one on each side. The directions will be given by vibrations. The left wristband will vibrate if a turn to the left is upcoming, and vice versa for the right. Another dimension is the frequency of the vibrations. The vibrations will become more frequent the closer you are to the point where you need to take a turn. This method uses vibrations only, so creating an easy, interpretable language made from combinations of vibrations is key to the development of this idea.

The design is also quite discrete, which some people prefer.

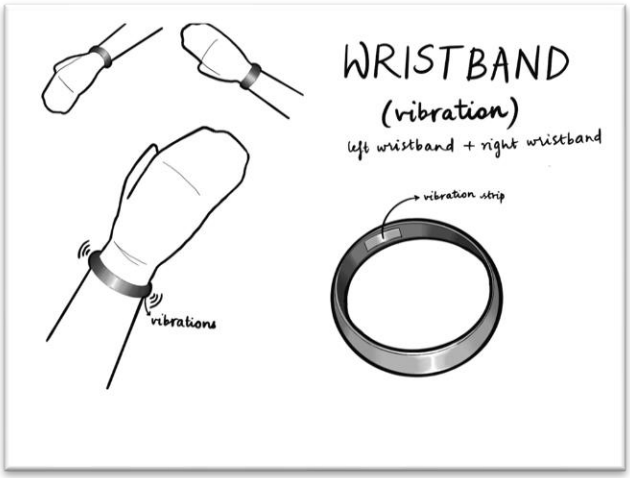


*Figure 7 Wristband design idea.*

## Thematic Analysis

Our idea was validated as only one person (5% of total participants) indicated no need for an indoor navigation device.

After the initial sketches of designs that were made based on literature and background research, we aimed to use the conducted interviews to gather ideas and feedback on our initial propositions of solutions. Thematic analysis conducted on the 20 interviews indicated that the most used aid among our participants is a white cane, indicated by 85% of participants, followed by mobile applications ranging from navigation to text recognition apps by 60% of participants. However, many issues were mentioned with mobile applications, as they require holding the phone in one hand, as underlined by one fifth of the interviewees (20%).

Asked about the preferred mode of feedback, 50% of interviewees indicated a preference for vibrations, although not many used it daily already. While 40% already used audio feedback, 3 participants (15%) indicated drawbacks with this mode, proposing as alternative translating messages into vibrations. It was mentioned that the audio feedback should not override the sounds of the surroundings, as many people with visual impairments rely on the auditory cues from the surroundings to ensure their safety. One fourth of the participants (25%) indicated that they use tactile feedback, mostly in the form of braille.

Regarding challenges in indoor navigation, the main and most common issue across the interviews was dependence on the help of others, as indicated by 55% of the respondents, which indicated limited autonomy and lack of independence especially when visiting new spaces. The second most indicated issue was orientation, explained as either a lack of references and clear instructions or problems with obstacles and navigation through complex building layouts, noted by 25% of the interviewees. Additionally, 25% of interviewees mentioned that hospitals rely too much on visual cues, posing a lack of accessibility. Furthermore, 20% of the interviews highlighted the problem of unclear labelling or indications on doors, especially when doors look similar. 10% of the participants also indicated problems with displaying the queue numbers on the screen, which also related to the dependence on visual stimuli issue. Other challenges that were mentioned are steps and rotating doors.

When discussing general navigation issues, the most frequently mentioned problem was familiarity with the route, mentioned by 40% of participants. New routes were often described as requiring more attention, creating additional stress and anxiety, and increasing dependence on either help from others or on technology. Autonomy was identified as the second most pressing issue, with 30% of participants mentioning the challenge of needing assistance or constant help. The need to ask for help was indicated by 15% of participants. Additionally, 10% of the interviewees mentioned dependence on technology and the need for attention and memorization (short-term memory) as significant problems. Other issues mentioned included the lack of symbols indicating help, inadequate solutions, and problems related to public transport.

Concerning design issues, 20% of participants expressed openness to new technologies, saying they are willing to adopt innovative solutions. In addition, 15% underlined the importance of a simple, discrete, and intuitive design, to make sure the use does not require devoting more attention than necessary. For audio feedback, 10% of participants indicated the need for short, clear instructions like "right" or "left," rather than relying on coordinates, like many of the navigation applications do nowadays. They mentioned that navigation should follow straight

paths if possible and include reference points, such as walls, to help with orientation. In addition, 10% of participants talked about the importance of adaptability in design, understood that it should be intuitive and easily adaptable to different environments and user needs.

Detailed information about the results of the analysis can be found in *Appendix C: Thematic Analysis Table* containing the themes, codes, and corresponding quotes from the interviews.

The results of the thematic analysis validated the initial design ideas and helped to further develop them. Since the white cane was the most mentioned aid, the first design, "White Cane Attachment", builds on this commonly used tool and incorporates audio and vibration feedback, which were identified as the most useful forms of feedback. The second design, "Audio Guide" is built on the preference for audio feedback. It is designed to be simple and hands-free (a preference often indicated by the participants), hanging from the user's neck, and includes tactile feedback through braille descriptions on the buttons. The "Headband Solution" uses the idea of keeping the hands free and relies on preferred audio feedback. The audio output is closer to the ears, making it easier to operate in loud environments without completely blocking surrounding sounds, an important consideration highlighted in the interviews. The "Wristband Solution" also keeps the hands free and uses simple vibration language with clear instructions like "left" and "right." This design is discrete, which was preferred.

# TU/e Contest

Next to our general Honors work, we have also decided to participate in the TU/e Contest. This contest is about experiencing what it takes to develop a product or service while also focussing on the business side of things. They let you think about how to continue with your project after Honors Academy has officially ended.

For the contest, we have participated in numerous events. It started with a 2-day kick-off full of brainstorming sessions about your problem, solution, and teamwork. After this, everything was divided into 3 sprints, with each sprint representing a different part of the project. The first sprint was about the problem and how to validate this, the second one was about the solution and the last one had us talk about our team and the roadmap for the project. The main goal of these sprints is to let you think about the project direction. Next to this, the TU/e Contest is also a nice opportunity to talk with companies, get more feedback from peers, and look at your project from a different perspective.

Although we do think that the contest can be a nice opportunity for projects, it was not the right timing for our own. As we have been busy conducting interviews and validating the problem, we have not been focussing on the business side of things. It did however lead us to our conclusion for the project direction. We would like this project to stay an Honors team rather than working on it in a startup or student team. Hopefully, we can participate again next year and show a real prototype in a shot to win this contest.

# Discussion

Throughout this project, we encountered several challenges, which we want to address in this section.

One of the main factors contributing to these challenges was time constraints. At the start of the project, we were very ambitious, and we wanted to design and prototype an actual navigation device for people with visual impairments. When the project took another turn with the interviews however, we noticed that the process of conducting interviews takes quite some time. So much time even, that there was very little time for our original idea of designing and prototyping an actual device with somewhat working technology in it.

Besides that, we decided to join the TU/e Contest, which is a contest for students to cultivate their entrepreneurial skills, and to let them experience what it takes to develop a product or service, as stated on their website (Soapbox B.V., 2024). Preparing for each workshop and feedback session or other event also took time and we had to shift focus from time to time to be able to do well in the contest. Even though the project we participated with in the TU/e Contest and our Honors project are the same project, the focus is very different. The Honors project focusses more on the content of the project and the TU/e Contest focusses more on the entrepreneurial side of it. Looking back, we could have achieved more content-wise, if we had not joined the TU/e Contest, but we would have never learned some key entrepreneurial skills then. It differs from person to person whether they value these skills.

During a feedback session, we got the advice to go to the hospital ourselves and to get an idea of the actual need for a product we had in mind to design. In the end, this is one of the things that we did not do. What we did do is go to an event for people with impairments, visit the muZIEum where we experienced what it is to have a visual impairment ourselves and conduct interviews with people with visual impairments. We decided to focus more on the information we got from our interviewees, but it would not have hurt to go to a hospital and observe ourselves. The main reason why we did not do this was again time; we did not find time to go a full day or a day part to a hospital observing people with visual impairments navigate indoors.

During the Meet & Greet event with partners organized by the TU/e Contest on the 24th of April, we heard that there are Ultra-Wideband (UWB) beacons, a technology we were considering for navigation, at innovation space and at the faculty Industrial Design that we could have used for our project. If we had known this more at the start of our project, we would possibly have chosen another direction, namely focusing more on the navigation technology.

Some ways we could have improved our work with are the following. We could have done more interviews, although we have already done quite an impressive number. More interviewees would have led to a more reliable analysis with better results. A better representation of possible end-users in the interviews would also have decreased a possible bias.

It would be beneficial for the thematic analysis if more people could read the interviews to identify the codes, and possibly themes, as the qualitative data that we obtained from the interviews, often nuanced and complex responses, can be interpreted in many ways. Due to lack of time, as our team consisted of only four members, we could only delegate one person to perform the thorough thematic analysis, which resulted in just one interpretation of the content of the interviews. More analysis could possibly bring richer results.

# Conclusion

To conclude this project, it can be said that we learned a lot during this year. We were able to visit conferences, experience firsthand what people with visual impairments encounter on a daily basis by going to the muZIEum, and most importantly, talk to the people who are important for this project. By doing the interviews, a lot of new insights were gained that could not have been learned from simply reading papers.

The outcome of these interviews was used to create some preliminary designs which can be used as a base for future projects. This may not have been the outcome we expected to have at the beginning of the project, but that does not mean it is a bad outcome. The project was steered in a different direction to work through all the steps that come in play when designing a product, instead of just designing a solution without verifying the problem first.

Although we had to adjust the trajectory of our project, we managed to end with tangible results. We decided to dedicate this year to research, to have a stronger basis for the actual product development in the future. We have learned a lot during this year, as the research approach we have taken required organizing the interviews, proper scheduling with our participants, as well as preparing the study outline for ethics committee approval, creating consent forms, and managing the personal information of the participants accordingly.

Getting acquainted with how the actual research project are conducted, the entire procedure was a new but valuable experience for us as researchers and scientists. Then came the interviews themselves, preparing the questions, conducting the talks, and analysing results. The goal of the project evolved from just designing a solution to understanding the problem deeply and involving the users in the design process. This shift in focus has provided us with a solid foundation for future creation of impactful solutions for individuals with visual impairments.

The data analysis method we chose - thematic analysis - allowed us to extract valuable insights from our rich interview data. By identifying recurring patterns and themes, such as the fact that the most commonly used aids were white canes and mobile applications, and what precisely are the challenges that the people with visual impairment face in indoor navigation, we gained a more nuanced and informed understanding of users' needs and preferences. This allowed us to tailor the design of our navigation device, to the actual needs indicated by those who experience the struggles, we only imagine or read about.

Throughout our work on this project, we could see first-hand how important designing with the target group, not just for them is. Thanks to individuals who generously shared their experiences and daily challenges, often providing specific details, and showed us kindness in our search for answers, we were able to conclude the year with design sketches that we hope to develop further in the future. These designs were crafted with care, incorporating everything we learned along the way.

Every step of this journey taught us something valuable. We learned how to adapt when we recognized the need for adjustments in our approach, we had to understand that holding onto a path that did not feel right—simply because it was our predetermined plan for the year—would not bring us the desired results. Accepting that some tasks might take longer than initially anticipated was crucial for maintaining realistic expectations. The acquired knowledge not only allowed us to present the findings of our study, but also to grow as researchers and scientists.

# Future plans

As discussed within the team, not all of us will continue next year with this project, due to other projects and obligations. An early decision has been made to take the project to the Honors Academy. This project still needs support to “get on both feet”, but we still want to have a sense of control, so we believe that this would be the best for our project.

Juan will not be part of the Honors Academy anymore as of next academic year but will bring the project to the Honors and collaborate externally. Alicja will be in her second Honors year, so she will be the reference for the rest of the team and the expert at the beginning of the project. A meeting will be organized with Victor Donker (track coordinator for the Health and Well-being track) to discuss this possibility.

As was mentioned before, we had to create a road map for the future of the project in one of the sprints of the TU/e Contest. We will use this road map and this plan encompasses around a year of time and work.

The first step is to gather the team. We will need people with knowledge in electronics and 3D design, to be able to prototype the idea. Once the team is formed (around October at the latest), two paths will be started. On the one hand we want to work on a proof of concept for our product. It is essential that our idea is viable so most of the resources will be allocated to this. On the other hand, we need to validate the idea with possible clients. Therefore, we will organise meetings with hospitals (and/or other establishments) to discuss our idea and if their needs and requirements align with our product.

These two things will be the main focus for the following year, and if we have time, discussions with the Patent office and The Gate will be organised to “professionalize” the team and to help develop a business plan.

Additionally, as mentioned in the discussion section, having more people read the interviews for thematic analysis, or at least examining the text and already gathered data to identify additional codes and potential themes, could improve the insights and add a fresh perspective. Given the nuanced and complex, often story-like style responses, different analysts may find different information. Thus, by new people reviewing interviews, we can gain additional data, or new understanding of the issue. Another benefit of having the new team members read through the interviews, is that they will familiarize themselves with the project and it will give them a deeper understanding of the needs of the end users.

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# Appendix A: Individual Contributions

## A.1 Kirsten Heinen

Within our project, I was responsible for contacting the Dutch interviewees via the Oogcafés and following up with all the reactions we got from that. We got around 6-7 reactions of possible participants on the emails I sent but we were not able to plan in an interview with all of the people, because of scheduling issues. In the end I was able to plan in 3 interviews, of which 2 interviews were conducted together with Jilke and me and 1 was conducted by Jilke alone, since I was unavailable. We also decided on some point around the end of April/beginning of May to stop with conducting interviews, otherwise I would have been able to plan in more.

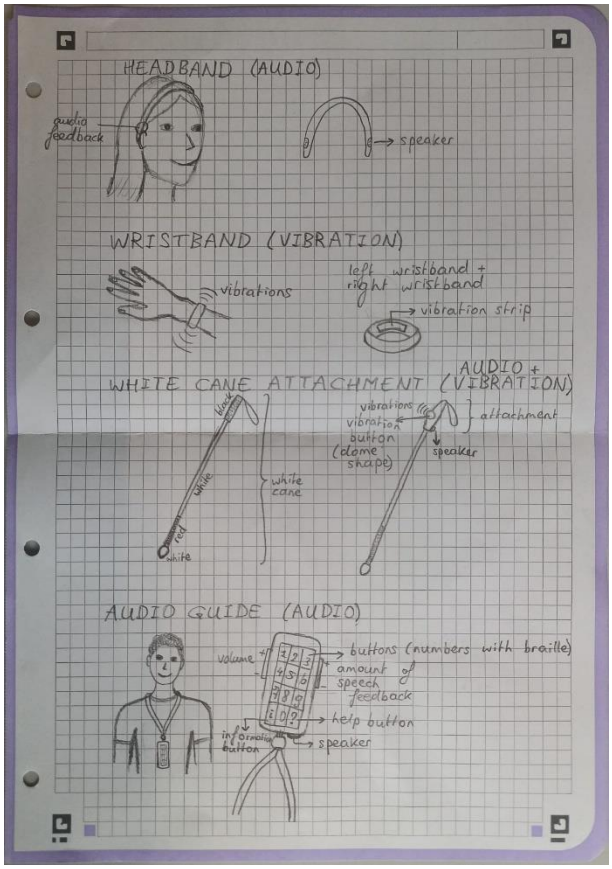
For me, actually contacting people for interviews was a big step, since I was really uncertain about how to deal with people with an impairment. Looking back, I think by myself that I should have started earlier, but I was quite hesitant about this. It helped that I could do my interviews together with Jilke. When actually conducting the interviews, the people were actually very "normal", by which I mean that they were independent and they did not expect anything from me, as long as I just acted normal myself. They were very willing to share their story and in the end I found the interviews very inspiring, especially the one that was conducted in person here at the university.

At the start of the project, when we did not yet focus on conducting interviews, I did research about possible designs and design features for an indoor navigation device for people with visual impairments. Some of the outcomes of this study came back in the interviews, namely the preference for a device that was not in-ear (not sound-blocking). In the study I found that there are possibilities for handsfree (e.g. (smart)glasses, wristband) or handheld devices (e.g. cane with attachment, phone). Some conditions I found were that it should be portable, not heavy, comfortable and real-time. I shared this knowledge with the team and I think that this background knowledge gave us a good base for the interviews and that it helped us further in what direction we should think for a possible device. Later we continued with design ideas and I drew some sketches (see *A.1.1 Design Sketches*) that we wanted to send to Malaika to draw them more professionally. I also worked on the design of our PowerPoint presentations to make them interesting and coherent.

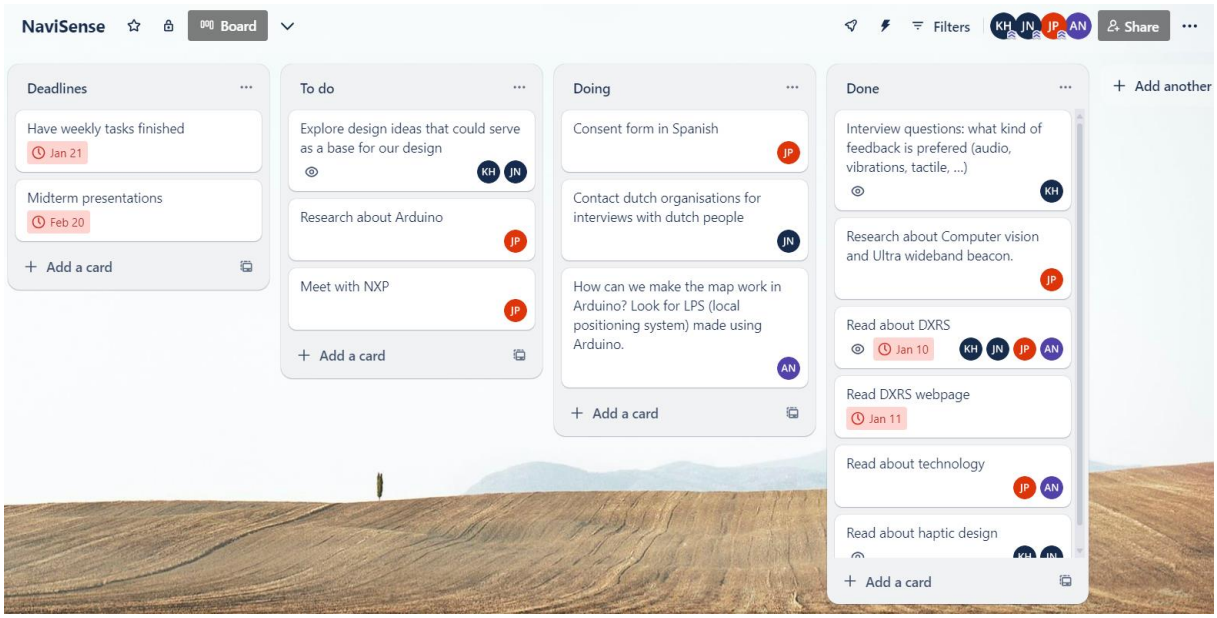
As was written in my PDP, I like to use organization tools like Trello and Notion to structure tasks when working in a team. In my board year at H.S.A. Confluente we use Notion to keep track of our action points, which is really useful, because not every action point is set to be done by next meeting. In this Honors team I also suggested to use such a tool for structure and insight in each other's tasks, but I suggested Trello instead of Notion, since it is a bit less daunting and we do not need many functionalities. Basically, we used a board with 4 columns: Deadlines, To do, Doing and Done. You could move a task to the according column, assign a task to a person and assign a deadline to a task. In the beginning of the project it worked pretty well and the board was updated every week during the meetings. However, around the midterm presentations when we switched to focusing more on the interviews and when we joined the TU/e Contest, we did not really keep up with using Trello. It served its purpose really well in the research phase, but later we just put the action points in the minutes. I guess that at this time for the project it was not really necessary anymore to use Trello, since the minutes were clear enough and Trello would just add another aspect to our project. I also think that using Trello or Notion only works if people really feel the need for it and if without it, keeping an overview is impossible. I am happy

that I gave it a shot to implement it in this team, but I have learned that an extra organizational tool is not always necessary. To get an idea of how Trello works I included a screen shot below (see *A.1.2 Trello*).

## A.1.1 Design sketches




## A.1.2 Trello



## A.2 Alicja Napieralska

During the first months, I – like my teammates – focused on background research. At first, it was general, with many literature reviews on people with visual impairments, their experiences and preferences when it comes to aids, starting with a paper published by our coach. Then, my area of research narrowed, as I focused on indoor navigation systems, specifically the technology used for indoor positioning.

This task was initially challenging because, in our team, I was considered the most familiar with coding and software/hardware. However, as a data science student, those things were never the primary focus of my studies, so I had to go beyond only what I learned in lectures. After the literature review and getting acquainted with possible technologies, I decided to expand my search outside just academic sources and searched blogs and YouTube channels to get more hands-on information like, for example, sample codes for Arduino. When the background research phase was done, we decided to conduct interviews to gather even more information on how to even approach our design creation, I focused on conducting the data analysis, to develop my skills as a data scientist. Thus, towards the end of the time when my teammates were conducting the interviews, I started researching suitable analysis methods.

As we ended up with a lot of very rich qualitative data, that needed not only to be analyzed, but firstly organized, the initial idea with semantic analysis was discarded by me, and I decided to perform the thematic analysis instead. Semi-structured interviews allowed in way participants to share personal experiences more freely, often in the form of stories and anecdotes, rather than direct responses to questions, so the data was different from the usual numerical tabular data I am used to, which at the begging was a bit of challenge to me, as it could get overwhelming at times. Especially, since the data was so nuanced and context dependent software was not the most suitable method for thematic analysis, as it missed a lot of the data shared in the stories. Thus, I decided to conduct the analysis by hand, to preserve this valuable data, so I reviewed all the interviews several times to find codes and themes. The manual thematic analysis took longer, but it allowed me to get a richer and deeper understanding of the actual stories, daily struggles, and thoughts. This type of data was also so different from what I typically worked with as a data scientist (numerical, often tabular data), so it was interesting to step outside what was so known to me. The full thematic analysis conducted by me can be found in the appendix below *Appendix C: Thematic analysis table*.

As mentioned before, the thematic analysis took quite a bit of time, but by creating codes and themes consistently across the interviews (try to make them as universal as possible, without the loss of generality), the final data analysis became relatively easier afterwards. I was also responsible for the final analysis of the data from the thematic analysis, which consisted mostly of counting instances of particular design ideas, challenges, aids used, etc., being mentioned across all the interviews.

All this collected knowledge helped me later during the design phase. Having read 20 interviews, I felt that I could validate the design ideas with precise quotes from the interviews.

Throughout the project, I also attended the weekly meetings and participated in decisions about the current state of our works, plans, and ideas. I have learned a lot about group work, I feel I became better at communicating with my teammates.

## A.3 Jilke Nooijen

Within our project I did not have one big responsibility, but I focused more on different small tasks throughout the year. At the start of the year I made sure that we planned a first meeting with the team where we could decide on the project direction and discuss what each of our goals were for the rest of the year. At this meeting it was decided that I would be minute taker during the team meetings. This meant that I was responsible for putting all of the important information on paper and making sure that everybody knows what their action are points for that week.

At the first meeting with our coach Astrid Kapper, she referred to an event happening in Utrecht called inclusive innovations and that it might be interesting for our project. To gain more information for our project Juan and me went there together. The event started with a workshop in the morning. The workshop I did was in groups working on a solution for an inclusive working environment. The problem we decided to work on was loud noises in the workspace. Working on this problem and talking with experts and people who are visually impaired gave me a lot of new and useful insights that could be useful for our own project. After the workshop there was also a networking moment where Juan and me talked to companies with interesting solutions, we also used this moment to exchanged contact info with companies like eZwayZ. Next to this, we talked with people with a visual impairment, and got their email addresses. I emailed them afterward to arrange an additional meeting but unfortunately we did not get a response anymore.

After the event I tried to arrange more interviews by emailing organizations for people with visual impairment. After emailing with them I posted a few messages on different Facebook groups and websites, this resulted in one interview with someone from the UK. Unfortunately there were not more responses and looking back I could have taken a more pro-active approach in arranging these interviews.

Before we could do these interviews, we needed to get approval from the ethics committee. The study proposal and English consent form were made with the entire team in one of our weekly meetings. My responsibility was to make the Dutch consent form and change some last minor things before Astrid could send it to the ethics committee.

After arranging the interviews I conducted four of them. I did two of the Dutch ones together with Kirsten, and I did one Dutch and one English one by myself. Afterwards I made sure to transcribe these interviews and upload them so they could be used for the thematic analysis. I also filled in the demographics table for these interviews such that we have all information in one spot.

Lastly, I have taken an active role in doing presentations for the team over the past year. I did pitches for track meetings, Honors Academy workshops and the TU/e contest. We used these presentations to get feedback and use that to make our project better.

## A.4 Juan Pintado Benavent

In my first Honors year, I got an important piece of feedback from my coach René van Donkelaar He told me that sometimes I took a leading position within the team, but that I did not see myself as the leader. He suggested to me that for my second Honors year I improved on this by maybe becoming the chair of a team, and that is exactly what I did.

In my first Honors year I took a course on entrepreneurship, where we had to develop a product idea for a societal problem. My group and I came up with an indoor guidance system for people with visual impairments indoors. I really liked this idea, so after asking permission to my team, I decided to take it to the Honors Academy to keep working on it. I had a meeting with Victor around April/May 2023, and it was made clear to me that there were a few tasks I needed to organise before proposing it to the Honors Academy. The next few months I did research on similar projects and companies, and I concluded that there was potential in this idea. During the summer I looked for coaches and experts to help us, and I came across Astrid Kappers, who had great expertise in haptic interactions and had previously made a study on navigation and people with visual/hearing impairments. I met with her online and she was happy to be our coach.

In September/October the second years of Honors started, and the project was re-born. We wanted to give it a completely new angle, so we did not use any of the previous work in my entrepreneurship course.

When we decided to conduct interviews for problem validation, I had a contact at a Spanish university who was working on a study with people with visual impairments, so she talked to them about the project and they were eager to be interviewed. As the most proficient member in Spanish, I conducted the interviews. This task took me most of my time between September and April. The people who I interviewed at the beginning shared what I was doing, and that raised the number of interviews (in Spanish) to 15. I definitely enjoyed this experience. I met with people from different parts of the country, with different stories and different outlooks on their disabilities. I learnt a lot not only for the project but for myself. There are many pearls of wisdom found in those interviews and I had wonderful conversations getting to know them.

To Transcribe the interviews I found a program called Turboscribe, which we ended up using.

After they were transcribed I went over them to make sure the program had not made any errors, and made corrections where necessary.

Around November, we were studying possible options for the location system that our product will use. I made a study of the possible options to find the best solution and although it is not definite, we were able to discard a lot of possibilities and elect certain ideas as the most promising ones (Ultra wideband technology). Around the same time, I spoke with Victor and he helped me organise a meeting with the company DXRS, who are tackling the indoor location problem in their own way. The whole team met with Victor van Dinten (co-founder of the company) and we learnt a lot about what other people were doing to solve a similar problem.

During the year I was also responsible for presenting in some TU/e contest and Honors events. These presentations went very well and I was able to answer well all questions that were asked about the project.

My functions as a chair were done well. I made agendas and booked meetings (with the team and with Astrid). Communication was a key aspect for me, so I was always open for feedback.

At times I asked for it and adapted to these suggestions. The team as a whole has found this year to be very productive, and with a lot of substance to it. I am happy that in my role as a chair I could help to achieve that.

# Appendix B: Anonymized demographics table

| Code | Age | Gender | Onset of impairment | Cause of impairment | Nationality | Country of residence | Interview language | Online / via telephone / in person interview | Transcribe method | Anything else? |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 56 | F | 21 years old | Rod and cone macular degeneration | Spanish | Spain | Spanish | WhatsApp audio | TurboScribe | Long audio describing her problems and answers, not an actual interview |
| B | 54 | M | Since birth | Hereditary+glaucoma | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |
| C | 45 | M | 21 years old | retinitis pigmentosa | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |
| D | 42 | M | 17 years old | retinitis pigmentosa | Spanish | United Kingdom | Spanish | Telephone Call | TurboScribe | |
| E | 19 | F | Since birth | Lack of oxygen at birth | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |
| F | 32 | M | Since birth | Optic nerve hypoplasia | Peruvian | Peru | Spanish | Telephone Call | TurboScribe | |
| G | 62 | M | 37 years old | Glaucoma | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |
| H | 63 | M | Since birth | retinitis pigmentosa (congenital) | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |
| I | 34 | M | Since birth | Leber congenital amaurosis | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |
| J | 40 | F | Few days after birth | Retinopathy of prematurity | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |

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|---|---|---|---|---|---|---|---|---|---|---|
| K | 44 | F | Since birth | Micophthalmia and cataracts<br>Both congenital | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |
| L | 33 | F | Degenerative since birth and fully since 2 years old | Leber congenital amaurosis<br>(not confirmed) | Spanish | Spain | Spanish | Zoom | TurboScribe | |
| M | 22 | M | 4 months old | Alström syndrome | Spanish | Spain | Spanish | Teams | TurboScribe | |
| N | 58 | M | Sudden loss | Explosion of device in army maneuvers | Spanish | Spain | Spanish | Zoom | TurboScribe | |
| O | 79 | F | Since birth | Myopia magna | Spanish | Spain | Spanish | Telephone Call | TurboScribe | |
| | | | 79 years old | Deterioration | | | | | | |
| P | 46 | F | 23 years old | Alström syndrome<br>ALMS 1 | Spanish | Spain | Spanish | Zoom | TurboScribe | |
| Q | 68 | M | Since birth | Retinitis pigmentosa (RP) | Dutch | Netherlands | Dutch | Teams | TurboScribe | |
| R | 50 | F | 20 years ago | Retinitis pigmentosa | Dutch | Netherlands | Dutch | In person at TU/e | TurboScribe | Was guided by a friend |
| S | ** | F | ** | ** | Dutch | Netherlands | Dutch | Teams | TurboScribe | |
| T | Around 35 | F | Since teenage years | ** | English | United Kingdom | English | Teams | TurboScribe | |

** indicates missing values

# Appendix C: Thematic analysis table

## Participant A

| Themes | Codes | Quote |
|---|---|---|
| Thoughts on Previously and Currently Used Aid | Maintenance Requirement for a Real Dog | "A real dog... has many needs that you have to meet, I mean he needs to go out three times a day no matter what..." |
| | Attachment to Real Dog | • "And when you have to retire it, well, you don't know what to do if you keep it..." |
| Design Considerations | Artificial Guide Dog | "My idea was, with artificial intelligence, a guide dog, but artificial... I mean a little computer program." "Because there are many people who are allergic to dog hair..." |
| | Usage of AI | “[...] so my idea was, with artificial intelligence, a guide dog, but artificial, I mean, there is already a dog robot [...]” |
| | Analysis of the Surroundings | “[...] , really the only thing a guide dog does is find a space so that both he and the person can pass. that goes to your right and that there are more or less no low obstacles, I mean the height and width.” “Then you can tell the guide dog to look for an elevator or to look for a zebra crossing, but I think that those things can be done exactly by an artificial intelligence, that is, I mean a little computer program”” |

## Participant B

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | Guide Dog | "I use something that is a bag of fleas that I have lying around, in the yard it is scattered there, which is my guide dog." |
| | Navigation Applications | “It's true, I carry my cell phone with me in a situation in which I am totally lost. Yes, I use my mobile phone, I try to find the solution through Internet browsers, be it Google Maps. In my case I also usually use the Apple one.” “. And well, from time to time I use some other GPS that I have specifically, that is, that I have bought in the Apple store and so on. “ |
| | Partner’s Help | “I'm going with my dog but with my partner too, okay?” “[...] if I get a letter my partner reads it [..]” “For example, I pull my partner and it is much easier” “In other public administrations, blind people either know or always ask for help, so generally when I go to do any task in a public space I am only accompanied by my partner and I finish sooner, you know?” |
| Thoughts on Previously and Currently Used Aid | Lack of interactions in the case of White Cane | “ I have used a cane before, but going with a cane is not the same as going with the dog. You can argue with the dog whatever you want, this or that, he even looks at you with a dirty face. The cane doesn't, it doesn't respond or anything. It is very boring. The cane is that thing that I define as a long, white skin, uglier than hitting a parent.” |
| | Emotional Support and Companionship of Guide Dogs | “And the dog, whether you like the dog or not, always gives you life. Always at a given moment he decides |

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| | | that he wants to go to a certain bar, because it smells good there, hey, and at a given moment a little beer with a few beers, the dog won't feel bad. And of course, the dog wants that." |
| Thoughts on Previously and Currently Used Aid | Adaptation period to the Aid | "So it's totally different. I am lucky, first, that I had to adapt to working with the cane and then to using the dog. Regarding new technologies, I admit that I do not usually use new technologies to move excessively." |
| | Navigation Apps Not Intuitive | "But I admit that those programs, I don't know, maybe I'm very clumsy, sometimes they are not very intuitive. Who have they done it to? And it is true that not all of them are 100% accessible." |
| Challenges in Indoor Navigation | Lack of Accessibility in Public Buildings | "It is not really considered in public buildings, if I do not know them, buildings public if I don't know them it would be impossible for me." |
| | Complicated Layout of Hospitals | " [...] because there are more corridors to see and a lot of twists and turns, the queries [...]" |
| | Reliance on Visual Cues | "[..] at any given moment are all written in ink, so what to say, okay, if I'm looking for a query determined, I cannot see where that consultation is or what consultation I am in [...]" |
| Preferred Modes of Feedback | Human Assistance | "At a given moment, the option... is that I have the option of using human help or that I can use new technologies depending on what I want to do." |
| General Navigation | Dependence on Technology | "Of course, in this situation, if I live continually hooked on these types of devices and I get used to them doing the work for me, I, at the end of |

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| | | the day, am totally dependent on them.” |
| | Fear of Relying too much on Technology as it may be Unreliable | “I told him very clearly, precisely for the same reason that I have already told you, if I dedicate myself solely and exclusively to knowing how to do things with new technology, if I depend on the mobile phone, the data rates were different, if any of those are missing three things, I'm left stranded, and then what do I do? I don't know how to resolve situations. “ |
| General Navigation | Desire for Autonomy nad Independence | “Know? And I prefer to be dependent on myself, on my own ability. OK?” |
| | Self Reliance | “That's why I don't usually use it regularly. OK? What's more, with my partner in the car we often go somewhere and he says, let's see, turn on Google Maps and we turn on Google Maps and at the end of the day I say, well, what does it matter? If at the end of the day you miss the same or more than if you didn't go with Google Maps. But hey, you see, it's true, they are help and support. OK?” |
| | Need for Assistance (of any sort) in New Locations | “Of course, if you go to a totally unknown place you absolutely need the support of the new technologies that are there for that. “ |
| | Dependence on Help of Others | “Yes, you are usually easier and faster. For example, I pull my partner and it is much easier. I understand that, furthermore, failure, if committed by a human being, is always possible.” “[...] , I can't go there alone [...]” |
| Design Considerations | Does not use New Technologies Much | “Regarding new technologies, I admit that I do not usually use new |

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| | | technologies to move excessively.” |
| | Struggles with Usage of New Technologies | “And in this case I think it's a matter of knowing how to use it and that's why I more or less get by with these things when I need to, you know?” |
| | Device Running out of Batter as Loss of Autonomy | “With electronic devices you have a little problem. If the device runs out of battery or loses coverage, Houston, what do we do?” |
| | Distrust in AI | “I still don't trust AI too much. They say, no, look, this is created by man, by human beings, therefore, it cannot have much intelligence. It has the same as man has at most. What can you learn? I'm scared of it. I liked the Terminator movies” “So, I'm telling you, I'm skeptical about that kind of thing. It's just that I'm weirder than a green dog” |
| Design Considerations | Acknowledgment that Usage of Technology is Inevitable | “And I already tell you, that's why many times, for many things in that the technological part is part of my life, among other things, because I like it too.” |

## Participant C

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | "Yes, yes, well, movement, mainly the cane, most of all, the white cane." |
| Preferred Modes of Feedback | Non-invasive navigation aids | "The thing is that it be as least invasive in quotes as possible because for example there are ideas out there that are good in general but of course to use it only in sporadic water, punctually in a hospital..." |
| General Navigation | Struggles with navigating large and densely bulit-up areas | "La Paz, for example, in Madrid, is a city. It's horrible, it has many buildings, it's gigantic, even without any disabilities." |
| General Navigation | Navigating both familiar and new routes | "I marry both things. Because I'm a bit of a kamikaze, a bit of a latchkey in that sense." |
| Perception and Senses Used | Tactile Feedback form the White Cane | "Because you feel or touch and when you touch it you feel perfectly where you are, the distance, the curb of the sidewalk, a staircase, you notice it perfectly." |
| Perception and Senses Used | Perception of Lumps | "But hey, in general to everyone, if you have a visual disability. With the lateral part of the visual field we see the lumps around us a little, but we are not able to read a sign, for example." |
| Design Considerations | Inclusivity | "It would be interesting to have a solution or something that is as inclusive as possible, that is not something only for the blind." "The target audience would be as large as possible so that if you are blind, then you use it because it has this function that is good for a blind person or this other function that is good for a deaf person, but it is good for everyone." |
| Design Considerations | Precision | "But you need a precision of 5 centimeters, a margin of |

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| | | error of 5 centimeters for it to be reliable.” |
| Design Considerations | Intuitive Design | "It has to be as intuitive and as easy as possible, the least invasive, and you don't have to learn anything new.” |

## Participant D

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | “For mobility I use WayCane, the blind stick.” |
| Current Aids Used | Mobile Applications | “And then I have several applications, I have BlindSquare, I have Movie, I have [...] All Access, which is another application. The Moovit, which is another application. Around Me, which is another pretty good app. Bus Times, which tells me the little things there are. [...] And Lazarillo. Those are mainly the ones I use for mobility. Then it depends on space, I've been using a few others. PAW type which is like claw in English, which marks paths for you when you are inside. What else? I use Be My Eyes.” |
| Current Aids Used | Text Recognition Applications | “And Recognizing AI too. Although those are for text recognition, I can use them offline many times when I'm on the subway, I put the phone on my chest and it reads the signs. Or when I'm waiting for the bus or whatever.” |
| Current Aids Used | Navigation Applications | "Yes, yes, I have a lot of orientation and I also move a lot. And I also use GPS.” |
| Challenges in Indoor Navigation | Need for Clear and Concise Instructions | "The instructions must be clear and concise, do you understand me? If I have to walk 20 meters, before reaching those 20 meters, give me another one and tell me in 3 meters turn right." |
| Preferred Modes of Feedback | Audio Feedback | "Audio, audio. I put on a earpiece and an audio interaction that can also regulate the speed, important." |
| General Navigation | Difficulty in Unfamiliar Spaces | "The first day will be difficult, the second not, but the third I |

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| | | still know how to do it on my own." |
| General Navigation | Desire for Autonomy and Independence | "I don't mind asking for help, but if there is a way I can do it independently, I prefer." |
| Perception and Senses Used | Audio Feedback | "In any case, I like to go normally knowing where I'm going and with my ears free and pick up the information that is in the environment." |
| Design Considerations | Possibility of Selection | "Being able to select that route, being able to select... Look, imagine that I arrive at a hospital and we enter the first floor, okay? And I have to go to Dr. Pérez's, okay?" |
| Design Considerations | Simple and Clear Design | "Give me the possibility of selecting the route to get to Dr. Pérez and focus me on that path." "Yes, the possibility of introducing other languages, having other languages in the range, okay?" |

## Participant E

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | "For mobility, what I use is the white cane [...]" |
| | Computer Programs | "[...] and computer programs to describe the images, describe the environment." |
| | Navigation Apps | "Yes, Apple Maps." |
| Impairment | Visually Impaired since Birth | " [Speaker 1]<br>[...] Well, Blanca, tell me, how long have you been visually impaired?<br>[Speaker 2]<br>From birth, but they detected it when I was three years old." |
| Challenges in Indoor Navigation | Lack of Labels | "The truth is, yes, because since the doors are not marked and such, in the area of hospitals, health centers and such, it is difficult for me to find the doctor's office and I have to be accompanied." |
| | Unadopted appointment system | "For example, the time to get the paper for the appointment, to be able to go to the consultation. It is touch-sensitive, it does not have what is supposed to be a screen reader, it is not accessible." |
| | Difficulty with Similar Doors | "The signage on the doors of the surgery, because they are all the same and it seems that if you go alone, you will get lost." |
| Preferred Modes of Feedback | Audio Feedback | (To a question about their preferred medium) "By audio." |
| General Navigation | Navigation Familiar Routes | "Mostly I do routes that I know..." |
| | Asks for Help | "But when I do new routes, what I do is ask people and they locate me and such." |
| | Companion Assistance | "He is a companion, a family member, a companion." |
| Perception and Senses Used | Sight | "What I am most attentive to is, since I have a little sight, what I see are lights, I locate |

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| | | myself by the lights and movement [...]” |
| | Sound | “[...] and by hearing." |
| Design Considerations | Interest in Indoor Navigation Solutions | "Well, that would be wonderful." |
| | Audio Navigation Assistance | "By audio." |

## Participant F

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | "No, as I said, first of all, a cane, one hundred percent. And the help in people, help without, how could I say it? “ |
| Current Aids Used | Human Help | "No, as I said, first of all, a cane, one hundred percent. And the help in people, help without, how could I say it? Unintentional, which sometimes leaves people on the ground, what do I know, edges, backs, floor changes, all those things that one can use as aids, in quotes, right?" |
| Current Aids Used | Training | "I received trained personal help when I was a child, but the new generations don't have it so easy, right?" |
| Challenges in Indoor Navigation | Unavailability of Alternative Aids | "No, those are the only help available, right? Let's say, Guide Dogs are something impossible and unsustainable, both economically and socially. And other typhlotechnical or typhological aids are prohibitive, from their purchase to their maintenance, right? Because there are no workshops, there are no training centers and there is no money to buy either." |
| Challenges in Indoor Navigation | Hard to Foreseen Obstacles in Closed Spaces | "Above all, there are people who like to put different things at different levels. Or let's say if it's a semi-open space or a little... He likes to put centerpieces, for example, or mannequins or statues or other objects." |
| Preferred Modes of Feedback | Vibration Feedback | "But let's say if it had some source of vibration or there was, I also told another person from NaviLens that they could use the skin like electrotherapy or physiotherapy electrodes use |

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| | | to send certain low-frequency electrical waves to alert us." |
| General Navigation | Challenges with Navigating Open Spaces | "Calculate distances a little, because the worst enemy, I think, for the blind is open spaces." |
| Design Considerations | Reparability | "And make it simple, both to repair and exchange. I think there is a lot of help for people with disabilities, from what I have heard abroad, especially in Spain." |
| Design Considerations | Adaptability | "I believe that most devices are focused on making things easier for the blind in the short term, but few require the blind to train and become familiar with the device and the two form a symbiosis in the medium and long term. Where neither of them loses." |

## Participant G

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | "The cane is key, it is clear, the cane is undoubtedly one of the main aids. It covers you from the waist to the feet." |
| Current Aids Used | Magnifying Glass | “[...] or the magnifying glass.<br>[Speaker 2]<br>Do you use the magnifying glass on your cell phone or is it a physical one?<br>[Speaker 1]<br>No, no, it's a small pocket one, small, very small, which is one that I can always carry with me [...]” |
| Current Aids Used | VoiceOver | "I use VoiceOver more or less [to read], it helps me deal with... the mobile phone." |
| Current Aids Used | Training | "They assign you a tutor and that tutor teaches you a series of things... the cane, right? How to handle the cane." |
| Challenges in Indoor Navigation | Dependence on Help of Others | "If it is a place I don't know, I always try to go with someone." |
| Preferred Modes of Feedback | Audio Feedback | “By audio, by voice, by touch, by vibration, what would you prefer?<br>[Speaker 1]<br>Audio.” |
| General Navigation | Difficulty in Unfamiliar Spaces | “[Speaker 2]<br>[...] I'm referring to places that are maybe a little more unknown and, that is, closed but spacious spaces, yes, like the subway, How can it be in the hospital, how can it be...<br>[Speaker 1]<br>In these places I am lost, it is clear.” |
| General Navigation | Use of Memorization | "In principle... I have memorized the house." |
| General Navigation | Infrequent Visits to Public Buildings | "Doctors... I have to go, I don't know, more or less three or four times a year." |

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| Perception and Senses Used | Reliance on Touch | "Each [coin] has a peculiarity that means that with your fingers, you can distinguish which type of currency you are touching." |
| Design Considerations | Preference for Discreet and Lightweight Solutions | "The more integrated it is into the person, the lighter it is, the more discreet it is." |
| Design Considerations | Simple and Clear Design | "It has to be something simple, it can't be something complicated." |
| Design Considerations | Discrete Design | "Integrated in the mobile phone or whatever... Some system that wouldn't involve too much of a show to put it on." |

## Participant H

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | "I have the cane right now." |
| | Mobile Applications | "Well, I use my cell phone for routes. I use an application that you know called Blind Square to tell me the centers of interest that I am passing through. Yes indeed." |
| Challenges in Indoor Navigation | Lack of Labels | "Of course because it is not marked at all in general, yes." |
| | Dependence on Help of Others | "Well, if I have to go alone there is no problem either. You ask and that's it. But maybe do it once a month." |
| Preferred Modes of Feedback | Vibration Feedback | "Well, if that is what I know, vibration, we would have to see what type of vibration. Of course, you can always give yourself much less information, you know? Yeah." |
| General Navigation | Navigation Familiar Routes | "I generally move around the neighborhood. When I have to go far, I either take the subway or take a taxi by public transportation." |
| | Dependence on Help of Others | "I just leave with plenty of time and with plenty of time you take your cane and ask and ask if it reaches everywhere." |
| Design Considerations | Preference for Mobile Applications | "I think that right now everyone has a phone, everyone who is independent enough to try to go somewhere alone is going to have a cell phone. And you make a system that goes with your mobile and stays with you forever." |
| | Interest in Beeping Systems | "Here on 11 in the 11 building in Madrid there is a system where you press your cell phone and then it beeps. And then you locate the place by the beep and from there it also tells you with your cell phone." |

## Participant I

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | "Well, to move I use a cane, because I have also had a guide dog, but it has already died." |
| | Navigation Apps | "As for GPS, I have used Google Maps, Apple's Maps application, and then, well, it depends, also Moovit, I have used several applications to try." |
| Challenges in Indoor Navigation | Reliance on Visual Cues | "Well, when it comes to shopping centers, when I have to go alone they make me very lazy. A lot of laziness because they are places that are very difficult for a blind person." |
| | Dependence on Help of Others | "And then once you arrive at the hospital, go to the reception and ask. And so maybe someone will accompany me, basically." |
| Preferred Modes of Feedback | Direct Guidance | "Well, you decide where the future goes... But I imagine that, in reality, what I told you before, it cannot be that we are using an invention from a hundred or so years ago that, after all, is a stick with a wheel." |
| General Navigation | Desire for Autonomy and Independence | "I want to live alone and without depending on anyone and that's it." |
| Perception and Senses Used | Audio Feedback | "If I'm lucky that the subway is close and it's an easy route, well, I guess by following Google Maps or maps or whatever, well, I'll be able to get there." |
| Design Considerations | Potential for Robots | "Well, now Fundación 11 has been testing guide robots in some shopping centers, in fact." |
| | Interest in New Technologies | "I try to be as up-to-date as I can and I try to stay alert." |

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| | Robot Guidance | "Well, indoors I believe that the tests that are being done now are on the right path. In the end, you have a building mapped on a robotic guidance system that takes you directly." |
| | External Guidance over Mobile Applications | "Yes I think so. We could talk about that because there are also considerations on the other side." |
| Design Considerations | Dissatisfaction with Ultrasonic Baton | "I have tried quite a few gadgets such as ultrasonic batons and these types of stories that I have not been particularly convinced by any of the ones that have come out on the market so far." |

## Participant J

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | Guiding Dog | "I had a guide dog and well he passed away recently so what I have is the cane. “ ”The dog is much better than the cane but good for accessing the next dog because it takes time..." |
| | White Cane | "I had a guide dog and well he passed away recently so what I have is the cane." |
| | Mobile Applications | “Yes, I have to try this one they are now using VoiceVista. I used Lazarillo before, which also works well.” |
| Challenges in Indoor Navigation | Revolving Doors | “They have revolving doors, that cannot be installed because the guide dogs can get their paws caught.“ "Tomorrow I go here in Madrid to the Infanta Leonor, which is a hospital, it is supposed to be new as far as possible because it is one of the last ones that have been built, well, man, it is a bit embarrassing that has a revolving door and that has no alternative to enter." |
| | Dependence on Help of Others | "Although many people who are blind to these things go with people they see to hospitals, they do not go alone." |
| Preferred Modes of Feedback | Tactile Feedback | "You have to support the technology on a physical basis of accessibility. That's with textures, with signs labeled in braille and in large relief, you know?" |
| Perception and Senses Used | Help of the Personel | "You have to mark it on the floor or give it to guards or specific personnel who accompany you inside the hospitals." |
| | Vibration Feedback | "That is, or if I can choose how it should be transmitted to me, because maybe I don't |

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| | | need it to vibrate because I hear well, but maybe a classmate is coming behind me and it turns out that the poor thing, in addition to not seeing, He hears poorly and the vibration is great for him. Then, select the mode you want it to guide you. I don't know, voice mode, voice and vibration mode, vibration mode. Something like that." |
| Perception and Senses Used | Audio Feedback | "Guides you through sounds. So, if you go off the path, it also allows you to record routes." |
| Design Considerations | Importance of Accessibility | "We cannot deny it because we also pay taxes. So, we have to make it accessible to everyone. And how do you do that?" |
| | Change in Physical Environment | "You can't rely solely on technology to make it accessible." |

## Participant K

| Themes | Codes | Quote |
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| Current Aids Used | Screen Readers | "Screen readers, that is, whether with the mobile phone or the computer, braille line, [...]" |
| | Braile | "[...]obviously until new technologies emerged I read books, well, everything in braille." |
| | White Cane | "And the cane." |
| | Navigation Apps | "Yes, I have Blind, I have several applications installed. Like BlindSquare." |
| Thoughts on Previously Used Aids | Navigation Applications as Unreliable | "Then, of course, maybe it tells you... Turn left and maybe it's on the next street or the previous one. And now you've passed, okay? Or on your left you have the number and maybe it is an open field. And you, let's see, I think it's not here. These are examples that come to mind suddenly, you know?" |
| Challenges with Indoor Navigation | Dependence on Help of Others | „I ask people and ask them to come with me or I tell them that they can come with me.", "I ask and almost always have them come with me because I don't see the door number or the milk that brought it." |
| Preferred Mode of Feedback | Preference for Tactile Feedback (Although Not Feasible) | " [...], the plan, for example, a tactile plan is very cool to get the idea, but obviously you can't walk with a clear tactile plan, for example, in Madrid or in many subways you have a tactile reference on the railings that you can touch while you go down, yes, on railings or things like that, or on the wall, maybe I'll get used to it, but of course, for example, I'm thinking of a hospital or In many places you have chairs against the wall of course, either they put the chair further in or I eat the |

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| | | person who is sitting to touch the wall, you know?" |
| | Combination of Vibration and Audio Feedback | "[...]To have my tactile reference it is a bit clear, a series of conditions or factors would have to be present that would favour perhaps the most practical thing is audio and vibration [..]", "But I think that both options could be very cool combined." |
| General Navigation | Similarity of the Streets | "Because all the streets are the same... It's all very same." |
| Perception and Senses Used | Reliance on Auditory Cues and Prior Experience for Navigation | "I do know the place because I've been there before, because it's very..." |
| Design Consideration | Feedback Methods as Complementary | „But of course that on the one hand, and then the issue of feedback, of course, they all actually complement each other..." |
| | Want for Braile on Office Doors | "When you have already arrived, for example that you have your product or your application or whatever, when you have already arrived what he sees confirms it number 3, well, he sees it directly but at the door." |
| | Need for Prior Descriptions of Indoor Spaces to Aid Navigation | "It would be good... yes, yes let's see, it doesn't have to be super mega." |

## Participant L

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | Guide Dog | "I have a dog guide and for the administrative buildings, well, the collaboration of the staff basically, because there is not much else." |
| | Navigation Applications | "Not indoors, I use Google Maps to get there, but once inside I usually ask. I don't know other things that are useful for interiors." |
| Challenges in Indoor Navigation | Finding Target Locations | "It does give me the ability to say, okay, look for the elevator or look for the stairs, but I have to know more or less where it is." |
| | Issues with Displays of Queue Numbers as they Lack Audio Feedback | "The screens are not usually audible, unfortunately, that is very fun. All of that greatly complicates the issue of things that have an appointment." |
| Preferred Modes of Feedback | Vibration Feedback | "We always try to go along the edges or as close to the edges as you can. And if not, then you could still use something that vibrates or beeps or sounds in a certain way, if you are going straight and if you turn, it will give you some indication." "I was thinking about the vibration. That is, your cell phone vibrates when you see yourself approaching the beacon in some way. It can be very interesting because you can also include deafblind people." "Or very short sentences, or vibration or that, so as not to over-inform too, because sometimes excess information can also be a bit confusing." |
| | Audio Feedback | "We always try to go along the edges or as close to the edges as you can. And if not, then you could still use |

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| | | something that vibrates or beeps or sounds in a certain way, if you are going straight and if you turn, it will give you some indication." "Or very short sentences, or vibration or that, so as not to over-inform too, because sometimes excess information can also be a bit confusing." "The screens are not usually audible, unfortunately, that is very fun. All of that greatly complicates the issue of things that have an appointment." |
| General Navigation | Desire for Autonomy and Independence | "Well, it depends, the truth is that if I have the possibility, sometimes I go with people, sometimes I don't, it depends, there is everything." "It is also loss of independence this for me, so I try not to bring up the topic too much." |
| | Guide Dog as a way to Maintain Independence | "So, it gives a lot more freedom in that sense, much easier to find things." |
| Design Considerations | Keeping a Straight Line and Navigating around Objects | "We always try to go along the edges or as close to the edges as you can. And if not, then you could still use something that vibrates or beeps or sounds in a certain way, if you are going straight and if you turn, it will give you some indication." |
| | Short, Concise Instructions | "Or very short sentences, or vibration or that, so as not to over-inform too, because sometimes excess information can also be a bit confusing." |
| | Direct commands such as "left" or "right" | "Of course, I think it's easier with some type of signal, be it sound or vibration, because it's faster than having to listen to short phrases. Or simply say right or left, that |

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| | | is, make it something short and brief if it is in text." |
| | Open to New Technology | Well, so, you've mentioned it before, but would it suit you or are you looking for an idea that gives you a little more autonomy, so to speak? [Speaker 1] I think it could be useful, yes. |
| | Dislike of having to Hold their Phone Constantly | "I don't like it at all, because having to go with my cell phone focusing everywhere on the subway, because it's a cry of, I have a cell phone in my hand, very close at hand, take it away from me, you know? And it scares me a lot." "It makes me feel very exposed and the fact that the orders are, and are text, short." |
| Design Considerations | Concern about Safety | "I don't like it at all, because having to go with my cell phone focusing everywhere on the subway, because it's a cry of, I have a cell phone in my hand, very close at hand, take it away from me, you know? And it scares me a lot." |
| | Simple and Clear Design | "Then you pressed the button for the one you were interested in, because they had a name, and the door buzzer sounded. So, of course, you have your cell phone, but you have it in your pocket, you don't have to have it there in the air and you are guided by the sound of the gadget. I liked that, honestly, it was cool." |

## Participant M

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | "For movement I only use the cane, I have used the white and red cane from Tesoro Blindness, for a long time now. And well, practically I only use that tool, which is for movement." |
| | Training | “And well, also from before I am being taught techniques on how to handle myself, by the way, a journey done alone.”” |
| Challenges in Indoor Navigation | Reliance on Visual Cues | "The problem is that it is all visual." “Because yes, everything is reflected, everything is very visible, towards people who have sight. Someone who doesn't see, especially on social security, you have nothing.” “Yes, to get there, to be inside, to go from one place to another, all the bureaucracy is also all visual.” “Inside many buildings, especially public ones, the problem is that it is all visual. Then the necessary measures are not created or have the necessary measures to make them accessible." |
| | Dependence on Help of Others | “Sometimes I have to ask for help, especially at important intersections.” “[...] but you have to go at least here accompanied no matter what.” “Yes, to get there, to be inside, to go from one place to another, all the bureaucracy is also all visual.” |
| Preferred Modes of Feedback | Direct Guidance | "I've been asking for a guide dog for a long time." "People are going to pay a lot of attention to it, so it will serve as a tool for me to ask for help and move much better." |

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| | Tactile Feedback | "You, for example, believe that the feedback that you would prefer would be tact, it would be the best for you." |
| General Navigation | Lack of Symbol of Help | “In the end, a cane, yes, the white cane has always been known, but the white and red cane attracts very little attention, people know very little about it.” |
| General Navigation | Dependence on Help as Lack of Autonomy | “That I depend, effectively, as you mentioned, on there being those people.” |
| | Lack of General’s Public’s Awareness | "But there are people who have never seen a blind person in their life, let alone a deaf-blind person, and then they don't even know how to act and practically do nothing." |
| | Lack of Customized Solutions | "Current GPSs are not designed for a blind person. They are designed for a person who moves without any problem, without any disability." "The main problem is that someone, a programmer I imagine, would have to put the orders into that GPSD." |
| Perception and Senses Used | Smell | "As for the sense that I use the most, it is touch and smell, because of course, I don't see, I practically don't hear." |
| | Tactile Feedback (Braile) | "The text could be output through a braille line." |
| Design Considerations | Open to New Technology | "Let's see, it sounds pretty good to me. I am a very technological person and anything that uses technology to help seems very good to me." "In the end, whoever can make a blind person, not really blind, who hears nothing and sees nothing, be able to handle themselves much more autonomously has the goose that lays the golden eggs." |

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| | Lack of Testing of the Target Group | "The main problem that the technology is having now is that it is launched on the market, but very little is tested with the people it is actually aimed at." |
| | Product as a Symbol for Help | “In other words, you are looking for something that identifies you from the rest, that makes you stand out a little, right?<br>[Speaker 1]<br>Yeah.” |

## Participant N

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | "Well, currently I only, well, use what would be the obvious companion, which is commonly known as a guide, right? The white cane, also called a long cane, is the guiding mobility cane for blind people, usually in familiar places." |
| | Mobile Applications | "Then I also use some scene and object recognition applications." |
| Challenges in Indoor Navigation | Issues with Displays of Queue Numbers | “And then one of the places that I find most difficult within the hospital itself are the screens that announce the person's turn, which are not accessible in most hospitals, so you have a lot of dependence on third parties and on them. “ |
| | Orientation | "And then, well, a hospital is a complicated place because you also have to be very careful not to go where you shouldn't and truly, if it is not very modern and the distribution is very well done, be coherent, make it logical." |
| | Dependence on Help of Others | "Logically, at the time of Ginese, not alone and alone. I don't... Furthermore, it would not be useless to be there, not because of the risk issue, but because I would have to constantly ask questions to find my way and locate myself in the places and be able to take out." |
| | Only One Hand Available | "Well, it could be, yes, it could be better. It could be better because keep in mind that you have a cane on your right and carry your cell phone." |
| Preferred Modes of Feedback | Audio Feedback | "Of course it would be comfortable, just like if you give me a device. Plus, I can |

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| | | take my phone, activate it and put on headphones and not have to do anything else." |
| General Navigation | Unfamiliar outside routs | "The exterior is a much more open place and more difficult to control because logically more actors enter the scene when you are moving and you can encounter many things. An interior is usually much more controlled and logically so memorizing it and learning it and then going through it a second time is much easier." |
| General Navigation | Preference for Known Locations | "I am very timid when it comes to moving around and so on using a cane and I am not a risk taker. I usually go only to well-known and well-known places." |
| | Preference for Online Services | “I don't get in there. I prefer to buy online.” |
| Perception and Senses Used | Vibration Feedback | "Yes, yes, preferably that. And vibrations you have to consider and even other types of outputs that would also be compatible with two things, with hearing aids for people who are old and have poor hearing, which exist. OK?<br><br>Well, that has to do with the connectivity of the device, of the mobile phone, which everyone usually has. And then vibrations too, in some cases because there is deaf blindness, and they could use that too. But come on, basically what people are going to ask you for is audio." |
| Design Considerations | Familiarity of Potential App | "If you provide something that looks a lot like WhatsApp or a lot like TikTok, I'm giving you an example in terms of structure, not function. Something that looks familiar, you know? And that they know how to do it because they have been |

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| | | communicating in this way for a long time or consuming leisure in this way, because it would be as simple as loading the hospital application and then having Toby, your virtual guide dog, appear there." |
| Design Considerations | Different Levels of Acquaintance with New Technologies | "Keep in mind that each person has a level of skill with technology. There would be people who would give it to him and walk away with it and other people who would really be posing a problem because he is still clumsy when handling technology, not because of his blindness but because of his lack of skill. " |
| | Standardization in Several Environments | “Achieving a standardization that everyone complied with and that would help you go to a supermarket as well as a hospital, as well as to a public administration. That would be another story, but keep in mind that there is more technological work, which I am sure you have overcome." |

## Participant O

| Themes | Codes | Quote |
|---|---|---|
| Current Aids Used | White Cane | “Yes, I use the cane. “ |
| | AI Applications | "I have on my phone, I have Scene with AI, right? Viewing with artificial intelligence." |
| | Mobile Applications | "There are two applications that work quite well. One of them is Lazarillo... the other one... Take me on foot." |
| Impairment | Some remaining Vision | “At the age of 45 I became disabled due to my eyesight and since then I entered eleventh grade because I wanted to learn braille and thus be able to read all the books that I had not been able to. And nothing, since 45 years it has been degenerating, degenerating and now I have 0.04% left, which allows me to go out during the day with a cane and more or less have an idea of where I am going.” |
| Challenges in Indoor Navigation | Difficulty with New Technology | "It's getting more and more complicated for us because we have to get the ticket from the machine and all that." |
| | Problem with Steps | "Because the problem is that when there is a step, practically everyone falls and we do not detect it." "I go less and less because I see less and less." |
| Challenges in Indoor Navigation | Dependence on Help of Others | "Whenever they go out to buy there are people who are accompanied." "When I pick them up, I approach them and touch them, because I see more. And I am not able to move calmly through a store in an enclosed space." "So they give me the paper that is in the machine and then they tell me, I will accompany her to the place and tell the boy that when he calls her, to call her out loud." |

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| | Drawbacks of Audio Feedback | "I have an iPhone, right? Then, since he talks to you, the whole room is going to find out about the messages. Then I pick up and put on the headphones and I can listen." |
| Challenges in Indoor Navigation | Only One Hand Available | "Well, it could be, yes, it could be better. It could be better because keep in mind that you have a cane on your right and carry your cell phone." |
| Preferred Modes of Feedback | Audio Feedback | "You focus on any product, it reads it and it reads the composition." "Man, of course, by audio it's much easier because you say stay still, go ahead and so on." |
| General Navigation | Navigation Familiar Routes | "In known areas I move alone and where I don't have to ask for help." "So I go to the town hall square, which is relatively close, to a doctor or to solve something very simple." |
| | Navigation at Night | "At night I don't go out because I see very little and I'm afraid of falling." "I'm getting more and more scared and lazier. Keep in mind that I am already 78 years old." |
| | Desire for Autonomy and Independence | "My philosophy is what I can solve for myself, not let someone else solve it for me." |
| Perception and Senses Used | Tactile Feedback | [Texture] "I pay a lot of attention to the texture of the pants, I know that the green one has a rough feel." "For example, name the jars of lentils, beans, or chickpeas to see the difference, although if you open them and touch them, you will realize what is there." |
| | Vibration Feedback | "Now, vibrations, well, I don't know how to interpret them. So the audio would be more comfortable, but if there was a problem with a beep, for |

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| | | example, loud for you to stop and a softer one for you to start walking, it wouldn't be bad either." |
| | Audio Feedback | "Since I have the location and I am on, well, connected, it tells me, you are on such and such street, such and such number." (Electric cars are a problem) |
| | Human Assistance | "If I have an arm, I'm much better than with a cell phone." |
| Design Considerations | Object Location | "That the ideal would be to find, that is, more precision in finding things. It seems that artificial intelligence is also helping a lot but I haven't started to use it yet." |
| Design Considerations | Object Recognition | "And as far as I know, everyone who is blind, because I have been at ONCE for many years and that, everyone who is blind who is going to buy has to bring company. It's something we don't know how to do. Of course, the phone could focus on you and say bag, but hey, bag, bag, bag, how do we... differentiate one bag from another?" |
| | Preference for Hands-free device | “What happens is that with your cell phone you now put it in your bag, you put on your iPhone and then you don't need to carry it." |

## Participant P

| Themes | Codes | Quote |
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| Current Aids Used | White Cane | "But I go with a cane, [...]" |
| | Mobile Applications | "[...]my cell phone is my tool right now for everything..." |
| | Navigation Applications | "When I have to see something on my phone, I turn to a corner, I turn into the street, I ask Siri what I have to ask, because it is much faster many times..." |
| Impairment | Visually Impaired since Adulthood | "I was born with vision problems, already with retinitis pigmentosa. What happens is that I was diagnosed in the year 2000, that is, in the year 2003 I was diagnosed. And in 2006 I became blind, but I have always been a person with low vision." |
| | Color Blind | I have never seen colours, only black and white. And he didn't control the movements either. And the perceptions that I had were based on the contrast between sun and shadow, okay. |
| Thoughts on Previously and Currently Used Aid | Lack of Orientation as a Limitation for Owning a Guide Dog | "I have had a guide dog, what happens is that now I can't have it because I am implanted in one ear, I have a natural ear in one ear and an implanted ear in the other, artificial. So the information that comes to you from one side is not the same as that that comes to you from the other, so I can't orient myself well and I can't have a guide dog." |
| | Guide Dog Requires Control | "But now I find myself with the situation that I cannot ask for, that since you cannot control where the dog goes and re-educate it, even if the dog knows the paths, you have to control where it goes |

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| | | and where it stops going, if it stops going. |
| Challenges in Indoor Navigation | Reliance on Visual Cues | "It is assumed that at the doors there are physical maps where they indicate things, but for us it is of no use." "There are arrows on the floor, but the arrows on the floor are not tactile [...]" “[...] it has a sign on the elevator and it's also tiny.” |
| Challenges in Indoor Navigation | Dependence on Help of Others | “This one that I tell you is the biggest, you see that, then in the other one that I go to, that I go for that, you enter through a door and since everything is with little screens, you have to go with a person who will read to you with a little screen.” |
| | Lack of References for Canes | For example, the hospital I'm telling you about has a large hall where on the sides you have chairs... And you have to pass in the middle, you have to make a central line where you do not have any reference with the cane [...]” |
| | Complex Hospital Layout | "Because one of the hospitals I touch is FE, which is the largest right now in Europe. It goes by wings, they are corridors that are a little strange to define [...]” |
| Preferred Modes of Feedback | Vibration Feedback | "And if once you do that, you have those sounds or those vibrations that tell you that you are going wrong or that you are going to hit the wall directly or such and such, I see that as quite feasible.", ‘’ Let's see, anything that involves depriving your hearing of what you have to hear around you, I would transfer it to vibrations. The best thing there is are the vibrations.’’ |
| General Navigation | Constant Need for Attention | "Because on the left you have this, on the right you have that, I mean, no, because I |

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| | | have to keep my ears constantly focused on the cars, the people there [...]" |
| | Confusion and Uncertainty | “because you don't know exactly where you are [...] “"You get to a corner and you say, well, I'm on this street, no, okay, I'll come back again, I'm on this other street [...]” |
| | Navigation without Reference Points | “"Because where we have the most problems are not the places where there are the most obstacles, but where we have to go in a straight line, in a central place where we have no reference." |
| General Navigation | Learning the Routes | "Because once you've followed it three or four times, you know, okay, then to the left, to the right..." |
| | Automatic Aids are Expensive | “As far as I know, I do know that there have been canes that have beeps, but I don't know to what extent, because they are expensive.” |
| Perception and Senses Used | Audio Feedback | “Let's see, I can't be on the street listening, because on the left you have this, on the right you have that, I mean, no, because I have to keep my ears constantly focused on the cars, the people there, if they open or close the car doors because the sidewalks are not exactly wide, if there is something on top of the sidewalk, etc.” |
| | Relying on Light Shadow Contrast | "And the perceptions that I had were based on the contrast between sun and shadow [...]" |
| | Remaining Vision | "And the perceptions that I had were based on the contrast between sun and shadow..." |
| Design Considerations | Lack of Scheduling Option | “But as of today there are hardly any applications that have those options for you to plan before, for example I'm |

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| | | going to give you an example, there is an application called, if I'm not mistaken, Mobile, that you can enter the route, but it tells you the bus that you have at this moment in five minutes, if you want to make a route for, for example, tomorrow and you want to see a little, plan your schedules and such, you don't have that option, they are immediate applications and there are times when we work by planning things ahead of time." |
| | Only One Hand Available | "And the issue of touch is that if you go with the cell phone in your hand, I go with a cane, you go with the cane, with the other, touch the cell phone, the cell phone screen so that it answers something [...]" |
| Design Considerations | Need for Spatial Reference Point | ""And, for example, in the case of what you mentioned before about the central corridors where there are no references [...]" |
| | Customized Navigation Options (Either General or Detailed Description of an Obstacle) | "You cannot say that you have both options and that the user... because depending on where you are, you're going to need one option or another, right?" |
| | Clear and Concise Instructions | "Through other interviews we have been told that one thing that also works poorly is that the instructions are not given for blind people, that is, the descriptions are poorly done. Instead of saying, well, you have a wall to your right to use as a reference...<br>[Speaker 1]<br>As a guide, yes.<br><br>[Speaker 2]<br>That is preferable to being told in 50 meters to turn right. |

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| | | [Speaker 1]<br>There I do agree. I mean, for example, many times when people say no, you have the C-step to nothing. And that doesn't help me at all.", ''You have to tell me, two steps away you have the wall and when you reach the end of the wall turn left because you can follow the wall. That does work for me.'', '' Well, I need you to tell me, you are entering through zone A, you have to turn left . In my case it would have to tell me that I have to go in a straight line without being able to follow the wall because I have obstacles on the wall and I have obstacles so many meters to the right. Let's say they are double hallways. I have chairs on the left, in the middle I have counters and on the other side I have a hallway again. So, every X meters there are counters.'', '' So, let's say that this is not very well thought out for the blind. I have to know that either I have to continue on the side of the counters or I have to continue on the side of the chairs but a few meters away so that I don't bump into the chairs and the trash cans. So, the information that would be useful to me is, you have to go to the right but two meters away so as not to collide with the chairs.<br>That information for me would be good if you mean that. Or you can't go through the center of the room because there are obstacles to your right. So, I would choose if I want to go for the part with the chairs at two meters or if I want to go for |

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| | | the part with the obstacles pending the obstacles that come at me.'' |
| Design Considerations | Guidance and Surroundings Description | ''[Speaker 2]<br>So for you, this idea with description would have that aspect of guidance and would have that aspect of describing the surroundings, right?<br>[Speaker 1]<br>Exactly, yes, because if one can get an idea and can choose and can say, well, today I'm going here and tomorrow I'm going there.'' |
| | Left or Right over Coordinal Directions | '' But well, in principle I think that it is much more important that you tell me, like, for example, Google Map tells you west and you say, damn, where is west?'' |
| | Hanging Device | ''Or hung somehow somewhere where you don't have to rely on your hands? '', "what I'm telling you, I don't see it as viable, for me I don't see it as viable, you would have to carry your cell phone hanging around your neck in a certain place so that it can face you [...}" |
| Design Considerations | Does Not Like Glasses | '' But, personally, I am not in favour of those types of solutions. In fact, I went to Castellón to try some glasses of that style and I don't see them as functional.'' |
| | Transfer to Vibration to Not Rely on Hearing | ''Let's see, anything that involves depriving your hearing of what you have to hear around you, I would transfer it to vibrations. The best thing there is are the vibrations.'' |
| | Vibration Patterns | '' [Speaker 1]<br>Unify criteria so that each vibration means one thing and exists as a kind of script in which it is always |

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| | | explained what each vibration means so that when people notice it they really know what is being said. You need basic learning, but hey, what doesn't need basic learning? If you want to have autonomy, within the technology that exists, the possibilities that exist, that is better than nothing.<br><br>If we assume that there is nothing for them, or almost nothing. I have given you more complications than solutions.<br><br>[Speaker 2]<br>No, but this is perfect, because this makes us think.” |
| | Deafblind Individuals cannot Rely on Audio Feedback | “But those of us who are deafblind really have no visual rest, there we have, let's say, very little to do, or very little solutions for us.” |
| | Sound with Vibration | “[...]either you use vibrations, or you use sound with vibration, well, for those who have some remaining hearing it can be useful, [...]” |

## Participant Q

| Themes | Codes | Quote |
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| Current Aids Used | White Cane | “Then you have to assume that if I enter a public space, that I always have that cane with me." |
| Impairment | Visually Impaired since Childhood | “Well, I was born with a condition. Only at that moment it was still unknown. At some point my parents saw as a child that I... that there was something with my eyes. I was not able to grab things and stuff. So of course, they took me to the doctor and a specialist, as is normally the case. And then they found out what I had. I have RP, retinitis pigmentosa. And then the specialists could already say, that the disease would progress. And at some point I'll be completely blind. And so I actually already had... in my childhood...” |
| Challenges in Indoor Navigation | No Need for an Indoor Navigation System | “They are also far along with the indoor navigation And maybe I'm a bit deviating there At least I sometimes have the idea that I don't really need the indoor yet If you go to the hospital you see that most people don't come alone.”, “ . But yes, I also think that in my case I am easy to ask for help. So if I arrive at the municipality and I don't know it yet, I just talk to people And people always want to help.” |
| General Navigation | Lack of Clear and Specific Instructions | “And yes, I want to have a look, but I also wait for my bus. Oh, there's my bus already, so it's coming, do I have to find someone else?" |
| | Difficulties with Navigating New Spaces | “Exactly, a new building, that's also possible A platform you don't know, I |

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| | | think that's a bit strange, with a train or something.” |
| | Need for a Proper Navigation Device | “But I still find it very difficult that nothing has been found so far.” |
| Perception and Senses Used | Tactile Feedback | “When I walk on the road, I don't know if you can imagine that, the road is always a bit convex, so you feel like you're walking in the middle of the road, or on the edge of the road." |
| Design Considerations | Direct Information about Buses | “And I think, those drivers who arrive in the bus, they also get a signal You have to go to that stop And I think, wouldn't it be possible to get that information on an app? So you say, line 6 is coming, and it's going to stop at this and that stop.” |
| | Audio Feedback should Not Override the Sounds of the Environment | "If you say, for example, I would put ears in it, you should especially be able to use your ears to be able to listen to the environment." |
| | Battery Life Concerns | "Then you have another device where you have to keep an eye on the batteries, charge them, and so on."+ |

## Participant R

| Themes | Codes | Quote |
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| Current Aids Used | White Cane with Jumbo Roller | “I have a cane.”, “"I have a 'jumbo roller' on it. But there are also other attachments available. But I just really liked this one." |
| | Guide Dog | “And I have a beautiful dog at home.” |
| Thoughts on Previously and Currently Used Aid | Guide Dog Deals Well with Obstacles of any Size | "He helps me with obstacles. So when there is a branch on the ground. He avoids potholes." |
| Challenges with Indoor Navigation | Lack of Accessibility | “It should actually be more accessible. For people like me.” |
| | Too Much Light | "Yes, the light. If there is a lot of light somewhere, then I can't be bothered. Because then it's just very annoying." |
| | Find it Challenging to Find the Right Room | "I would never have found the right room here." |
| | Dependance on Help of Others | “If I really didn’t make it, then I would have... asked people who came by... then I would have just called you.”, “Just tell me where I have to go. Or accompany me there. Put me on the right bus.”, “If new places have to be visited, then I prefer to do that with someone for the first time.” |
| General Navigation | Usage of Public Transport and Taxis | “I certainly go by public transport... I often take a taxi.” |
| | Clear Directions | “I would like to have an app... so many meters and then we go left here. Or so many meters and then we go right here.” |
| | Desire for Autonomy | “It would of course be nice if I could do it all on my own." |
| | Reliance on Familiar Routes | “And it was the well-known routes, for example to the supermarket... I know all of that.” |
| | Challenges with New Locations | “If new places have to be visited, then I prefer to do |

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| | | that with someone for the first time.", "I always check where this is, where that is... But if I have someone with me, then I don't have to look anywhere." |
| Perception and Senses Used | Limited Vision | "I see a small gap. So I don't see anything left, right, up or down." |
| | Audio Feedback | "My hearing is a lot better, fortunately. If that would also diminish... Then it would be difficult." |
| | Tactile Feedback | "If you move indoors, do you also use a lot of... Yes, by touch is not completely, but with the sticks, the tactile... Yes, in principle yes." |
| Design Considerations | Lack of Accessibility in Public Transport and Buildings | "No, it should actually be more accessible. For people like me." |
| | Application Solution | "I would like to have an app for that... so many meters and then we go left here. Or so many meters and then we go right here." |

## Participant S

| Themes | Codes | Quote |
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| Current Aids Used | White Cane | “Yes, a dog and a cane.” |
| | Guide Dog | “Yes, a dog and a cane.” |
| Thoughts on Previously and Currently Used Aid | Dislike for White Cane | “Well, I hate the cane If I am being very honest... But the dog just knows everything.", “ Because I know that the dog indicates where the stairs are... So that works for me.", “ If I don't have the dog with me, I need the cane to make sure that I don't stumble over anything." |
| | Training for the Guide Dog | “You have two weeks of training and then for two weeks someone walks with you to learn how to walk with the dog." |
| Preferred Mode of Feedback | Audio Feedback | " I did like it very much... Because at that moment you know, okay, it keeps ticking right." |
| Challenges in Indoor Navigation | Dependence on Help of Others | “Then I just knock on someone's door and say, hey, I have to go there... There are always people who do help.", “B ut if I'm in a hospital, for example, I don't know where to go... I always have to ask for help." |
| | Difficulty in Navigating Unfamiliar Spaces | “But if I'm in a hospital, for example, I don't know where to go... I always have to ask for help." |
| | Inaccuracy of Navigation Apps | “If I just work with Google Maps, for example, a lot... They don't work accurately, so to speak." |
| General Navigation | Need for Accurate Navigation | “I t has to be pretty accurate... If you want to get out of there well." |
| Perception and Senses Used | Audio Feedback | “I did try VisiGo once... And then it had a tick on the left or right. And then you had to stick to that side, so to speak.” |
| Design Considerations | Consistency in Navigation Aids | “If you would make something in a hospital, for |

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| | | example, in terms of a beacon or something, then it has to stay there." |
| | Ease of Use and Maintenance | “Because then it is also ... Look, in a store you have the Saturday help. And then they don't know that something has to be done in a certain way." |

## Participant T

| Themes | Codes | Quote |
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| Current Aids Used | White Cane | “So, um, but I've kind of started using the long white cane, uh, about, uh, in my mid twenties. So about 10 years ago.” |
| | Navigation Applications | „I do use, um, like a GPS on my phone as well when I'm outside.” |
| | Dependence on Help of Others | “So inside buildings... like, for example, I went to the hospital today... for that, I did need a sighted guide to help me around the building." |
| Preferred Modes of Feedback | Vibration Feedback | “So like, yes, like staying in a straight line in open spaces is always an issue and stuff. So like knowing where walls are and stuff would be useful." |
| | No Audio Feedback as it is Distracting | “I think speech, I probably wouldn't prefer speech because, uh, um, I try to, to, uh, to listen for, for other stuff, you know, around me and, uh, uh, yeah, I think speech can get a bit too, too distracting." |
| General Navigation | Lack of Training in Cane Usage | “Like, uh, I've had like very basic training, uh, from the, from the, you know, like the local government services, but it's, it's, it's not like, um, as thorough or as, um, like long as I would have liked and stuff." |
| Perception and Senses Used | Reliance on Tactile Feedback on Navigation | “Like if I was walking, uh, into the building, then, uh, like just, just getting an idea of, uh, like in front of me, uh, like if there was a wall, maybe get an indication of when I was nearing the wall." |
| Design Considerations | Consistent Layout and Tactile Cues in Buildings | “Having like a consistent, like a consistent layout to, to where the design of the stands, for example, in bus stations, uh, or like, uh, |

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| | | having braille labels on, on, on the stands or, uh, on, on different places around the buildings." |
| | Wearable Device over Handheld | “So, uh, if it was attached to my body in some way that that would be better and stuff.” |