RFID Technology to Aid in Navigation and Organization for the Blind and Partially Sighted

Exploring the use of RFID for the blind and visually impaired in association with the Danish Society for the Blind in Copenhagen, Denmark

An Interactive Qualifying Project report submitted to the faculty of Worcester Polytechnic Institute in partial fulfillment of the requirements for the Degree of Bachelor of Science

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May 11th, 2009

Abstract

This report has been prepared for the Danish Association of the Blind, who together with their sister organizations, the Danish Institute for the Blind and the Visually Impaired Knowledge Center, began to investigate radio frequency identification (RFID) as a form of aid for the blind. This study explores the current ability and potential uses for this emerging technology. RFID has the potential to be a useful aid with further standardization of RFID tags and improvement of current RFID readers.

Acknowledgements

Authorship

This report was a collaborative effort by all team members. All research and writing was done by equal contributions of each author.

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Executive Summary

The Danish Association of the Blind (DAB) is an independent private organization that is run by many members of the blind and visually impaired community. The organization was developed for the benefit of blind and visually impaired individuals in Denmark. With their best interests in mind, the DAB strives to ensure equal rights for the blind and visually impaired community. They also look to discover and optimize new technology and ideas to increase the standard of living for the blind.

Radio frequency identification (RFID) has been an emerging technology in recent years. A basic RFID system consists of a reader and tags. When both components are used properly, information can quickly be relayed to the user. It has been used in the transportation of packages, as part of the luggage system in airports, in passports, and security access cards. While studies have been conducted to explore RFID as an aid for the blind since 2004, only recently have any finished products been released on to the market. Currently there are very few such products available, the Milestone 312 from Bones Inc. and the TellMate from Gaishan Technology being the most prominent. Prior to this project the DAB had already "played around" with the Milestone 312 and, based on their experience, was ready to conduct a more formal study on its applications for indoor navigation and organizational tasks for the blind.

The primary objectives of this project were to explore the current ability of these two products, find areas where they can be improved, and recommend future uses with the goal to benefit blind individuals. In order to accomplish the tasks at hand, seven blind and visually impaired individuals volunteered to be interviewed and test both readers. There were three separate interviews for each test subject, each with a different goal. The interviews were intended to gain general information on each test subject, obtain information regarding specific challenges they encounter with navigational and organizational tasks, and gauge how they felt about the two readers after having tested them. The tests focused on navigating within an unfamiliar environment and distinguishing between items of identical physical features since these tend to be two of the most difficult challenges that the blind and visually impaired face.

Throughout the testing and interviewing phases, the test subjects pointed out which features they personally like about each reader and which features could be improved. Bones Inc. and Gaishan Technology both received recommendations on how they can improve their

product. While a combination of the features from each device would result in an ideal RFID reader, the Milestone 312 was favored overall.

At this point in time, for someone to use an RFID system, they would be required to place RFID tags on every item in their house and have no way to set up a system in public locations. Via the final interview it was determined that this is too much work for one person to accomplish, even though it would be very useful for identifying foods and other personal belongings. In addition to the time involved to tag their belongings, there is also an added cost that needs to be considered. RFID tags are much cheaper when bought in bulk, $0.07-$0.20 each, but are much pricier when bought for consumer use. Generic tags cost roughly $0.75-0.80 cents each, and specialty tags, like ones used on clothing, cost about $2-4 each (RNIB, 2009). If tags were already placed on items before they buy them, then almost every test subject would buy an RFID reader, or at least have a greater incentive to buy one. Wal-Mart has recently been investing in the replacement of barcodes with RFID tags. Given the fact that this implementation has placed significant cost burdens on Wal-Mart's suppliers, significant incentives will have to be provided by Danish retailers for their respective manufacturers to follow suit. The incentive is there for retailers to begin adapting an RFID infrastructure since it would benefit all consumers.

The final recommendation for the DAB pertains to the use of RFID in public locations. While public transportation in Denmark has adjusted to accommodate for the needs of the blind, many of these adjustments have been noisy and disruptive to the rest of society. An RFID system could be virtually silent. It could also relay more information to a blind person than a beeping noise on busy street intersections. While it will be costly to initiate a switch to RFID and primarily assist the blind and visually impaired, it can still benefit society as a whole.

Chapter 1: Introduction

Of the 6.7 billion people that populate the world (CIA, 2008), 161 million are visually impaired (WHO, 2002). Each visually impaired individual faces a unique and different set of challenges based on their specific level of vision. That is to say, the obstacles that these individuals are confronted with can vary since there is one blind person for every 3.4 visually impaired people worldwide (WHO, 2002). With the rise of various support-based organizations, more visually impaired people have been given the opportunity to receive an education as well as training with various aids. One such organization within Denmark, the Danish Association of the Blind (DAB), specializes in developing technology for the disabled in order to improve their daily lives. Some of the work that the DAB has already done consists of working with banks to install synthetic speech automated teller machines (ATM), as well as designing blind-friendly websites to assist with everyday tasks (Mørk, 2009). Along with addressing these specific problems, tackling the issues of navigation and organization has been a primary focus of many organizations.

The issues of navigation and organization for the blind are very diverse and complex in nature. Navigation can be especially troublesome for a visually impaired person. Walking down the street to the local coffee shop is something that is easily accomplished by a person with normal vision. However, for a visually impaired person, doing things such as reading traffic signals and street signs can be extremely challenging, if not impossible. In order to overcome these challenges, a visually impaired person might use none, one, or even a combination of the following means of aid depending on their skill level and personal preference: walking cane, guide dog, and sighted guide (Cataruzolo, 2009). The sighted guide can be immensely effective, as well provide social comfort, though it restricts the independence of the blind individual (Cataruzolo, 2009). Guide dogs and walking canes allow for a more independent means of travelling, although they are limited in unfamiliar environments (Gharpure, 2004). Global positioning systems (GPS), which are a relatively new technology, can be rather efficient in unfamiliar environments, but are still very expensive and unusable indoors (Coverstone, 2007). Organizational tasks can also be especially difficult. Items such as packaged foods and medicine bottles cannot be easily distinguished by touch alone. Braille can be very useful for identifying objects, but this technique may be limited by the literacy rate. For example, only 25% of all blind Americans can interpret Braille (Cataruzolo, 2009). Supplementation of these

current methods is needed in order to increase the independence and mobility of the blind and visually impaired.

RFID, or radio frequency identification, is one such technology that could be used to supplement organizational and navigational aids. RFID uses radio waves to communicate information between a tag, which stores information, and a reader, which interprets said information (Bonsor & Gibson, 2007). This technology is used in many different areas including scanning passports, shipments, and automatic highway toll collecting. The beauty of RFID technology is that due to the inherent technical nature of any basic RFID system, there are endless possibilities for numerous applications. More specifically, unlike similar technologies such as GPS, RFID does not rely on long distance wireless communication, but instead upon relatively short range radio waves for data transmission. Research has been done at the University of Florida in which a visually impaired person's cane would be supplemented with an RFID reader, which would then accordingly notify the individual via their cell phone about his or her current location (Helal, 2005). A similar project was done in a small Italian town, in which over 1000 tags were placed in sidewalks as part of a larger RFID infrastructure designed to help the visually impaired with outdoor navigation (Peck, 2008). Overall, the results of preliminary studies such as these have shown that there is promise in the use of RFID as a means of aiding the blind.

There are, however, many questions that have yet to be answered regarding the usage of technology to aid the visually impaired with navigational and organizational tasks. Two of these questions are primarily of interest. The first is just how economically viable it is. The extremely high unemployment rate for the visually impaired of 70% in the U.S. plays a major role in determining the types of aids that are realistically available to them (Cataruzolo, 2009). This is not only due to the fact that an individual might not be able to afford it, but aid based agencies might not be able to subsidize the technology due to cost. For instance, GPS is extremely limited in availability due to its high price (Cataruzolo, 2009). The other question is regarding how technology can be used as an aid with organizational tasks due to the limited availability of organizational aids. RFID appears to be the most viable option for navigational tasks at this time based on previously mentioned research. While there has been no specific research done into RFID for organizational purposes, because of its apparent accuracy at close range and its previously mentioned technical advantages, it appears to be the most realistic option for this

application. Recently, Bones Inc., an engineering company based in Switzerland that designs aids specifically for the blind, and Gaishan Technology, a company based in Singapore, developed RFID based products specifically designed for the purpose of aiding the blind with organization. The effectiveness of products like these is yet to be determined though.

The primary focus of our project was to investigate the usage of RFID technology in conjunction with the Danish Association of the Blind as a viable means of aiding the blind with organization and navigation. We began this process by investigating and identifying the challenges that blind people encounter on a regular basis. From there, once we familiarized ourselves with the products of interest, we designed testing systems, commenced testing, and obtained feedback accordingly from our test subjects. These systems consisted of interactive experiments designed to explore the benefits and limitations of RFID for organizational and navigational issues. We have found that at its current state, the RFID readers cannot be used to their full potential as an aid for the blind. However, with the aid of the government and local companies and merchants, RFID technology can prove to be a valuable and important addition. All of testing process was executed in cooperation with the Danish Association of the Blind, including seven visually impaired individuals who tested the systems alongside us. Finally, we compiled our data and made recommendations to the manufacturers of each RFID reader, as well as suggesting systems and applications that should be explored in further depth to the Danish Association of the Blind. While RFID is still very much in its infancy, it has shown a lot of promise in public areas such as stores and public transit systems. We have also mentioned to manufacturers that an increase in range would be highly beneficial to expand the capabilities of RFID technology as an aid for the blind.

Chapter 2: Background

Mobility and independence are significant issues for those who are blind and visually impaired. While blind people can and do live productive lives, as well as receive full educations, there are still some areas where greater independence could be achieved. The following section delves into some of the challenges associated with blindness and visual impairment, as well as ways people overcome these obstacles. It describes the well-established aids available to the blind such as Braille, sighted guides and GPS, as well as discusses the uses and limitations of each. Finally, we examine RFID as a promising supplemental aid for the blind, including early research into outdoor and indoor navigation. By investigating RFID technology as an aid for organizational tasks, the Danish Association of the Blind can potentially increase the independence of and options available for the blind and visually impaired.

2.1 Social Considerations

There is a significant social aspect to a project that is designed to further aid the blind and visually impaired. It is important to fully understand the challenges faced by blind individuals when considering any system to potentially improve their independence. Institutions such as the Perkins School for the Blind in Watertown, Massachusetts, as well as organizations like the Danish Association of the Blind, have played extremely important roles in raising awareness of challenges as well as finding solutions for the blind.

2.1.1 Project with Purpose

There are 161 million people worldwide that are visually impaired, with 37 million being classified as blind (WHO, 2002). Those who are classified as partially sighted have visional acuities ranging from 20/70 to 20/200, with 20/20 being perfect vision. Legal blindness is classified as a visional acuity of 20/200 to no sight at all. The percentage of visually impaired individuals is much lower in developed countries: approximately 1% in Denmark, or 50,000 people (Lester, 2006). Every day in Denmark there are three to four people who lose their sight. There are many reasons a person may lose their sight, however age related causes such as cataract and glaucoma are the most common, as shown in Figure 1 below.
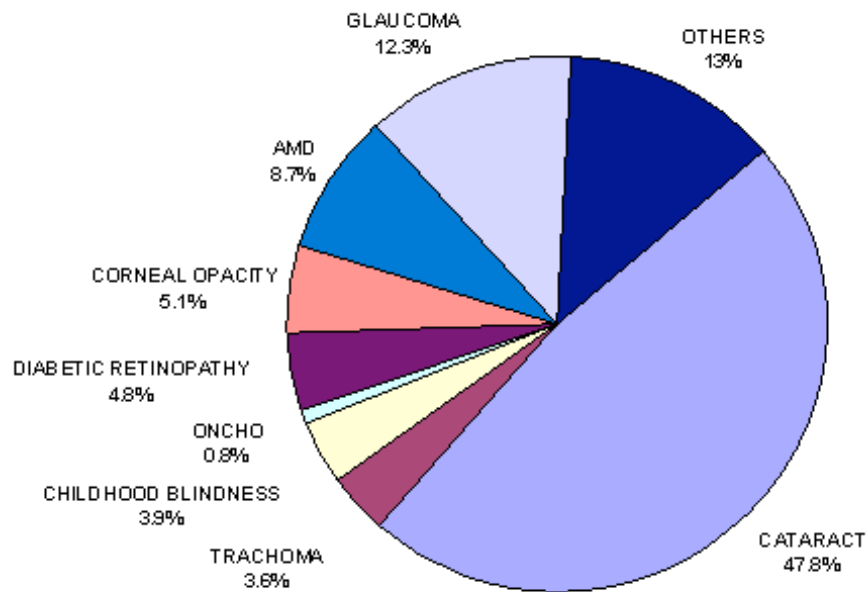
There are many challenges that come with being a visually impaired or blind person. For those who have congenital blindness or blindness from a very young age, it can be very difficult to imagine objects and scenery in their mind, such as a sunset, or even a dog (Cataruzolo, 2009). These challenges require extra ingenuity to overcome, such as using an oversized, beeping softball and grassy indicators for baseball (Paolucci, 2007). Another significant challenge is employment. With unemployment rates of 55% for the visually impaired and 70% for the blind in the United States (Kirchner et al., 1999), it can be daunting to try to form a career for a blind person.

Some of the most difficult physical challenges for the blind are navigation and organization, especially in unfamiliar areas. Maneuvering through a city or town can also be potentially dangerous. Places such as the Perkins School for the Blind in Watertown, MA have designed their buildings to be easy to navigate, with floor indicators and symmetry throughout the building, shown in Figure 2, in addition to the use of acoustics (lower ceilings creating echoes) to indicate to the person that they have moved into a different room, or there are paths to the left and right of them.

An additional feature, seen in Figure 3, shows how Perkins buildings are predominantly symmetrical, to allow blind individuals to navigate by themselves quickly and with greater ease through the campus.

While all of the steps taken so far have been helpful in increasing independence for the blind and partially sighted, there are still many everyday obstacles that are difficult to overcome. Organizational tasks can be difficult to do for a blind or partially sighted person. Packaged food

items are indistinguishable by touch, as are other common items such as medicine bottles. Additionally, navigation can be difficult for the blind when attempting to determine what room he/she is about to enter, or what street they are turning on. For a blind person, a simple trip down to the local convenience store can be mentally tiring. Unlike a sighted individual, they can never allow their mind to wander, and must always carefully observe their surroundings (Cataruzolo, 2009). Preliminary research into the use of technology has shown an improvement with this aspect of navigation, with one user indicating that it "successfully decreased the cognitive load that must be devoted to navigation so that he could concentrate more on conversation"(Mau, et. al. 2008). This is precisely why any advancement in navigational and/or organizational aids can make a serious difference.

2.1.2 The Danish Association of the Blind

The Danish Society for the blind, more commonly known as the Danish Association of the Blind (DAB), was founded in 1911. Since then, it has expanded to 22 branches throughout Denmark with 11,000 members, half of whom are blind themselves (Lester, 2006). The DAB also works with blind associations in surrounding countries, as well as the Danish Institute for the Blind (DIB) and Visual Impairment Knowledge Center (VIKC) right in Copenhagen. In addition, the DAB contributes aid to developing countries towards equality for the blind. They seek to improve independence for those who are blind or partially sighted, with education, technology and legislature.

With regards to technology and its role in aiding the blind, the DAB understands the significance of any advancement that can be made. The organization has previously explored GPS technology as a means of aiding the blind with outdoor navigation with another Worcester Polytechnic Institute student project (Coverstone, 2007). A conclusion that was reached was that GPS and RFID technology could clearly play a significant role in aiding the blind in the future. The Danish Association of the Blind has also been working with banks to install synthetic speech ATMs and designing blind-friendly websites to assist with everyday tasks (Mørk, 2009).

2.2 Navigation for the Blind

Navigation can be especially troublesome for the blind. For most people it is not a daunting task to walk from their home to the grocery store by themselves; however, it can be for a blind person. Street signs and traffic signals cannot be read; obstacles ahead cannot be seen

and unfamiliar routes can be potentially dangerous. It can also be difficult for a blind person to tell which room he/she is about to enter, unless they are very familiar with the building. However, there has been a long history of navigational aids for the blind, which have increased the ability of a blind individual to freely maneuver around. These aids range from simple indicators on doors to complex technological systems. Ranging in more than just simplicity, navigational systems for the blind vary significantly in terms of price and social interaction.

2.2.1 Braille

Braille was originally introduced during the 19th century by Louis Braille (Tennessee Council of the Blind, 2009). The basic Braille system consists of cells, each of which contains different arrangement of six raised dots. What each arrangement means varies depending upon the specific grade of Braille one is working with. There are currently three grades, two of which are standardized. The first grade is the most fundamental in that the entire alphabet, all digits, all punctuation, and even compositional signs are included. The grade one alphabet can be seen in Figure 4 below.

a	b	c	d	e	f	g	h	i	j	k	l	m
n	o	p	q	r	s	t	u	v	w	x	y	z

Figure 4: Grade One Braille Alphabet (Tennessee Council for the Blind, 2009).

Since grade one is the most fundamental and basic form of Braille, it is usually only used by beginners. Usually once a blind person becomes fluent in grade one Braille, they move on to grade two Braille. Grade two Braille makes writing simpler since each arrangement of dots represents words and phrases that are often used. It is for this very reason that grade two compositions consume much less space than grade one compositions. Grade three, which is not standardized, is typically more informal and only used for short hand. Contrary to popular belief, only 25% of all visually impaired Americans can actually read Braille (Cataruzolo, 2009). Because of this, it cannot be widely used as an effective means of conveying information.

2.2.2 Guide Persons

Sighted guides are considered to be the simplest and most straightforward way of guiding blind individuals. Sighted guides tend to be particularly useful in areas that are "crowded or

confusing" (Tennessee Council of the Blind, 2009). Mike Cataruzolo from the Perkins School for the Blind also hinted at the fact that there is of course the social element that comes into play. That is, a blind person can be much more relaxed and at ease when they know that they can have confidence in the person whose guiding them, as well as when conversation gets going. They also have the added benefit of being able to make human judgments, which technology does not. If there is a change in the path, such as a snow pile, a sighted guide is able to inform the blind individual of the obstacle, as well as maneuver safely around it.

2.2.3 Guide Dogs

Guide dogs were first seen in European nations centuries ago (Fishman, 2003). Archeological excavations in Pompeii have even led researchers to believe that the usage of guide dogs could date as far back as 79 CE. Smaller dogs were typically used up until the medieval era, but within the last 100 years, German Shepherds have become one of the most common dogs to be used (Fishman, 2003). Labradors and Golden Retrievers are also

Figure 5: A guide dog in Action. Image provided by guidedogs.com

commonly used (Tennessee Council of the Blind, 2009). Along with the variation in dog breed, the role that the walking cane should play in conjunction with the guide dog is something that has varied over time (Fishman, 2003). Although the walking cane can be used independently, because of its limitations, it lends itself better as a supplemental aid. At this time, of the 9 million visually impaired people in the United States, approximately 10 percent use guide dogs (Tennessee Council of the Blind, 2009). Another benefit that the guide dog can provide, in addition to adaptability, is companionship. Clearly, the guide dog has been a means of aiding the blind for some time (Fishman, 2003).

The so called science of guide dog training further reinforces the idea of just how effective the method is as a means of aiding the blind with navigation. Beginning when they are one to two years old, guide dogs are trained for an average of five months (Dark, 2008). They are taught how to move unaffected in many different environments like busy streets, so they do

not become stressed or panicked. After this time they have learned approximately 150 commands and can learn a route in 3-5 'trials' (Gharpure, 2004).

2.2.4 GPS

Global Positioning Systems (GPS) have been a major breakthrough in the usage of satellite technology, allowing users to identify their real time location anywhere in the world. GPS based products which can plan routes within seconds are already widely available to consumers. Ground shipping companies have started to take advantage of GPS since it has the ability to provide useful real time information (Moore, 2007). As previously mentioned, in 2007 a group of WPI students, in association with the Danish Association of the Blind and the Euman Company, attempted to design a user-friendly GPS system to help navigation for the blind and partially sighted so that they can travel independently (Coverstone, 2007). At the end of their project they concluded that this form of navigation is plausible, however it currently faces too many limitations that need to be overcome in order for the user to consider it a replacement to alternative methods.

One such limitation is that the GPS device cannot determine one's orientation. This becomes an issue especially when the user is in an unfamiliar environment. Another setback is that GPS at a consumer level tends to be unreliable in determining exact position. As a University of Rochester professor found out, "(GPS) isn't precise enough to locate a doorway," (Mottley, 2004). This results in the device missing waypoints, leading the user in the wrong direction, which can have many consequences. The imprecision and dependence on satellites also restricts the device to outdoor navigation. The most significant restriction to GPS is that it cannot warn the user of oncoming traffic and obstacles (Coverstone, 2007)

In addition to the inherent technical limitations of GPS, Mike Cataruzolo from the Perkins School for the Blind made it clear that the number of blind and visually impaired people that actually utilize this technology for navigation is extremely low, in part due to cost. In the United States, the unemployment rate for the blind is 70%, making it difficult for them to afford such a system on disability pay. It is for this reason that expensive technology such as GPS may be limited in its availability to the blind. RFID systems, however, can be much cheaper than GPS systems in many cases. One such example is an RFID system that was developed in 2007 by Texas Instruments in conjunction with the World Wildlife Fund, which tracked a certain animal species located in the Amazon in order to provide them with protection. The RFID

system implemented was shown to be 100 times cheaper than the GPS alternative, and yet 30% more effective at the same time (Burnell, 2007).

2.3 RFID Technology

Radio frequency identification (RFID) systems, which date back to the 1970s, were originally implemented as a means of tracking only very large shipments, primarily due to the cost at that time (Bonsor & Gibson, 2007). A given RFID system consists of two fundamental components: tags and readers. The reader and the tag communicate via the transmission of electromagnetic waves. A reader is what the user interfaces with to transmit information to and from the tag, and tends to be much larger than the tag. Tags store and process information, and can be extremely small, on the order of 3 mm. The key differences between the different types of tags on the market today lie in the power source and maximum range. A passive tag is solely dependent upon the reader for power, whereas an active tag has an internal battery that provides power. Correspondingly, this is why active tags tend to broadcast over long ranges than passive tags. Based on figures gathered from multiple sources, active tags can effectively broadcast up to distances around 90-100+ feet, whereas passive tags are limited to around 10-20 feet maximum (Bonsor & Gibson, 2007; OpenLearn, 2009). However, the range on passive tags can be as little as a few centimeters. Another difference between the two types of tags is the way the signal is transmitted. Passive tags rely on the signal from the reader to transmit information, whereas active tags are able to transmit information to the reader independently (Beal, 2005). There is also the semi-active tag, which derives power for broadcasting from its reader, whereas an active tag uses the internal battery for all of its power requirements (Bonsor & Gibson, 2007). Figure 6 below shows a graphical representation of an RFID system including reader and tag, with numbers corresponding to that specific part of the system (Brown, 2007).
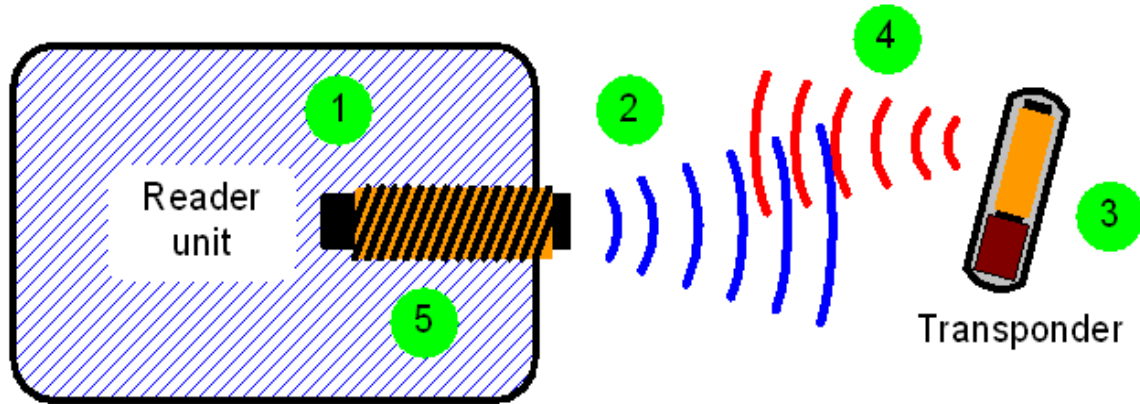
1. The processor controlling RFID sending/receiving
2. The antenna sending high frequency electromagnetic waves out
3. The transponder, or tag, which converts the waves into an electric current
4. The tag responding with its own unique radio wave
5. The reader unit receiving the tag's wave, which is then processed to retrieve information

At this point in time, passive tags tend to be the cheapest, largely due to the fact that they do not require independent power sources. The price of most passive tags can range from seven to twenty cents. Some specialty tags, such as button tags that are washing machine safe, can cost up to $2-4 (RNIB, 2009). Active tags are not as easily categorized when it comes to pricing, but are generally more expensive. Readers such as the TellMate, developed by Gaishan technologies, can cost up to hundreds of dollars (O'Connor, 2007). Fortunately, not nearly as many readers as tags are usually required for any generic RFID system to serve its intended purpose. Best Buy and Wal-Mart both have such a system, in which stock can be easily kept track of by having many RFID tags implanted in products and much fewer readers utilized by employees. Product tracking is not the only application currently utilizing RFID though. "Outside the realm of retail merchandise, RFID tags are tracking vehicles, airline passengers, Alzheimer's patients, and pets" (Bonsor& Gibson, 2007).

2.3.1 Outdoor Navigation for the Blind

There has been promising research into RFID to aid the blind for outdoor navigation. While GPS has been tried in the past to make getting around cities and towns easier, this has not been very effective because of the lack of accuracy and a slow response time (Coverstone, 2007).

Early research has shown promising results for RFID as a replacement or supplement to GPS. In Seattle, Washington a company called Awarea has installed active RFID tags with speakers throughout the city near retail stores (O'Connor, 2004). As a blind or visually impaired person passes by with the RFID reader, the tag audibly announces the information stored on it. As seen in Figure 7, the RFID reader is a small, handheld device called My Omni. While the main use is to announce current deals and special offers going on within the nearby stores, it has been useful as a way to announce at bus stops when the bus will arrive.

Figure 7: RFID Reader Used by Awarea (O'Connor, 2004)

A similar system has been implemented in a Swiss transit system called St. Gallen to assist blind individuals when traveling by bus (Neely, 2008). This is a major step towards fulfilling the EU regulation that states all transit systems must provide more information for the blind and visually impaired by 2013. Bones, Inc. has designed the Personal Assistant for Visually Impaired People (PAVIP®) system that consists of a handheld RFID reader and high frequency tags placed at bus stops and on the busses. It enables the user to scan the tag to determine the bus routes and destinations, and when the bus is arriving. It also gives the user the ability to alert the bus driver that they would like to board with the push of a button.

Figure 8: User with RFID Cane and Reader in Italy (Peck, 2008)

There have also been recent breakthroughs in walking navigation through cities and towns. A small town in northern Italy, Laveno-Mombello, implemented 1260 RFID tags in the sidewalks and linked them together into one network (Peck, 2008). With the use of an RFID-reading cane, a blind person can maneuver around the streets and know the status of traffic signals. This project began after students at the University of Rome wanted to find a way to reuse

RFID tags collected from slaughtered cattle (Ceipidor, et. al., 2007). This system is not without its problems, however, including the need for alternative routes and the issue of who will control the RFID tag network.

2.3.2 Indoor Navigation for the Blind

Indoor RFID technology has seen some major developments in recent years. A group of Carnegie Mellon students worked on developing a portable electronic travel aid (ETA) for the blind that could be used in order to navigate a public area, such as an airport (Mau, et. al, 2008). This involved the use of a cell phone with Windows Mobile and the IDBlue RFID reader. The complete system was quite expensive, over $1100; however it cost $240 to set up known locations within the airport, leaving a cost of $860 for each user. As the user walked through the airport, the RFID reader would receive information from the tags. Next, the reader would communicate with the PDA device via Bluetooth®. The PDA device would then be able to audibly inform the user of the next direction they should take to get to their desired location. Initial testing showed a 15% reduction in the time it took to maneuver the airport, as well as very positive reviews and a desire to have a system like this in the future. Although a very effective system, many would consider the large price a deterrent, along with the fact that it is still possible to get lost even when using the system.

A group of professors from King Mongkut's University of Technology in Bangkok, Thailand has developed a unique indoor RFID navigation system (Chumkamon, 2008). Their system includes the use of RFID tags, an RFID reader built into cane, General Packet Radio Service (GPRS), a microprocessor unit (MCU), and user input which comes to a combined total of around $250. They created a 4x4 grid with each square in the grid labeled with a letter A-P. The locations were programmed into the reader as an audio menu, a function not on most current readers unfortunately. The system works by first having the user input their current location and destination. Next the reader sends the input via GPRS to the server (or MCU), which determines the best route. The server then sends the route back to the device and the user can start moving towards their destination. While the user is on route, the device is constantly sending its location back to the server in case the user strays from the path. If this happens the server simply determines a new route and sends it to the RFID reader. Their goal was to create an audible directional map for the user, which they felt was the key to a successful product. After running their trials they were able to conclude that once the user became familiar with the device it was

fairly easy to use. The advantage of this system is that the user does not need to be familiar with the building's layout, but only the name of their destination and current location. Furthermore, blind individuals are not the only intended consumer for this product. It can be used to help firemen find their way through a building that is filled with smoke. The disadvantages include the necessity of a reader that allows user input and the lag time between the reader and the server, which currently varies between 30 and 60 seconds. As it is clear from Figure 9, it is also fairly bulky to wear.

Figure 9: User Testing the System (Chumkamon, 2008)

Two professors at the University of Florida have been developing an RFID navigation system since 2004 (Helal, 2005). Their system requires that passive RFID tags be placed once every square foot at $1 per square foot. They intend for their system to become a building requirement as part of ADA (Americans with Disabilities Act). Tags will include information, at the bare minimum including coordinates. They might also include the name of the location, the surroundings, type of door, description of stairs and anything else that might be useful. The information is transmitted to a reader roughly the size of a quarter embedded into a walking cane. Because of the small size, the cane appears no different than an ordinary one. The reader then transfers the information to the user's cell phone via Bluetooth®. Because the reader is so small, they were able to implant a slightly larger reader into the soles of shoes in addition to the cane. The significance in this is that the reader can easily detect the orientation of the user. The reader in the cane cannot perform this function because there is no current way to detect the orientation of the cane with respect to the user.

While the system was originally set up for inside campus buildings, it has expanded to walkways around campus (Helal, 2005). This was easier to implement than normal outdoor navigation because the user does not have to worry about traffic. Because walkways are so small, they are able to place a single line of tags instead of a grid. For this to be feasible they introduced a NAVCOM belt. The belt consists of 14 pager motors spaced out evenly around the belt. As the user approaches an object (wall, door, furniture, etc.) the appropriate motor vibrates. The level of vibration increases as they move closer to the object. This will allow them to use the walkways without bumping into people and other obstacles. It will also allow them to move freely in areas that are too small for their cane. Their most recent development has been using the NAVCOM belt as a form of Braille. There would be a designated 3 motors on the left and another set on the right. Unfortunately, it may be too slow to be used. In the United States only 25% of the blind population is able to read Braille. While the device is good in theory, it requires a very high cognitive ability to operate effectively. Because we want an RFID system to benefit more than 25% of the blind community, and require less concentration than a walking cane, this device cannot be required for the final system.

2.4 Summary

There are many social and economic considerations for improving navigational and organizational aids for the blind. While there has been a significant amount of research devoted to navigational issues, little has been done in the area of organizational issues. The Danish Institute for the Blind has performed some informal testing of RFID pertaining to the application of office identification to simply experience some of the capabilities of RFID technology (Daniel, 2009). Table 1 below illustrates the positive additions and limitations of each major organizational and navigational system used by the blind. Many of the disadvantages of RFID were considerations for us when deciding how to design the RFID test systems, as well as how ultimately viable it will be.

Aid	Advantages	Disadvantages
Braille	Good for organization, Braille labels are inexpensive	Low literacy rate of Braille among blind, Very expensive braillers, limited use for navigation
Guide dogs (in conjunction with walking cane)	Social experience, autonomy for changing environments	Difficult in unfamiliar environments, possible allergies, not usable for organization
Guide Persons	Social experience, most helpful both outdoors and indoors, autonomy for changing environments	Dependence on another person
GPS	Effective for outdoor navigation, can be used anywhere with access to satellites	No organizational help, cannot use indoors, 'cold' technology (no social interaction), expensive systems, long start-up/response times, high cost for accurate systems
RFID	Good for organization and indoor navigation, inexpensive tags	Difficulty implementing outdoors, 'cold' technology, only works in areas where tags have been established, somewhat pricey readers

Table 1: Analysis of Navigational Systems

Chapter 3: Methodology

The primary goal of this project was to assist the Danish Association of the Blind in analyzing an effective RFID system to aid the blind and partially sighted with navigation and organization. We arrived in Copenhagen, Denmark on March 15th, 2009 and after a week of orientation we began working on our project for seven full weeks and presented our results on May 12th, 2009. The Danish Association of the Blind was looking for experimental results directly obtained from our testing of several two RFID systems, as well as feedback we obtained from users testing the systems. Our team produced these results for the Danish Association of the Blind by completing the following objectives while we were in Denmark:

    * Identify Challenges the Blind Face on a Daily Basis with navigation and organization

    * System Design and Testing

    * Obtain Feedback from Testers about Systems

    * Analysis of Systems

Figure 10 shows a graphical representation of the entire scope of our project; encompassing both background research at Worcester Polytechnic Institute as well as the testing and interviewing that was completed in Denmark.

Examining Challenges Faced by the Blind
-Biggest navigation problems
-What organizational tasks are most difficult

Research Navigational and Organizational Aids
-GPS
-Guide dogs
-Braille

Obtain Feedback
-Interview users after testing
-Direct observation

Evaluate Navigational and Organizational Applications of RFID

Test RFID Readers
-Design navigation and organization systems
-Have 7 blind invidividuals test them

Background Research
Methodology
Results

Conclusions
-Did RFID work well here?
-Was it easy to use?
-Was one system better?

Recommendations
-Future applications of RFID
-Additional features to be implemented

Figure 10: Graphical Overview of Our Project

Table 2, seen below, also shows the timeline in which we completed these tasks. There were unforeseen delays during this process, including difficulty procuring a Milestone 312 RFID reader from the manufacturer. We also had issues setting up sessions with the test subjects, as many of them work full time jobs. Because of this, there was ample time to conduct extensive pretesting to insure all safety precautions were taken, as well as allowing ourselves to become fully familiar with the devices before using them.

Task	Week						
	1	2	3	4	5	6	7
Consult with DAB	■	■					
Examine Challenges	■	■	■	■			
Set Up Systems	■	■					
Test Systems				■	■	■	
Evaluate Results			■	■	■	■	
Re-Design Systems				■	■		
Conclude Final Developments						■	■

Table 2: Tentative Timeline

3.1 Identify Challenges Faced by the Blind on a Daily Basis

We created two interviews, one consisting of a series of short answer and the other consisted of multiple-choice questions. Since interviews are time consuming, we were only able to interview a limited number of people; however, this was not a problem because the information we were looking for was qualitative in nature. The information resulting from the interviews was useful during the design of the systems, as well as when assessing the effectiveness of RFID for this application during our analysis. Both interviews were given individually prior to testing. Interview A was designed to give us a solid overview of just how familiar the test subjects are with RFID technology, as well as how they navigated at the time. An additional purpose of this interview was to give us an idea of how independent our test subjects were while navigating. These questions primarily focused on navigational concerns, as well as the types of aid that our test subjects used at the time. The first question, asking people what motivated people to come in for testing, was added to give us a greater understanding for

the reasons people devote time and energy into advancing this technology. Questions from Interview A are listed below.

1. What motivated you to meet us for testing today?

2. Of the following, which do you currently use as a form of navigation? (Circle all that apply)

A. Sighted Guide **B**. Guide Dog **C**. Walking Cane **D**. GPS   **E**. Complete Independence

Are you familiar with Radio Frequency Identification?

If not, radio frequency identification, otherwise abbreviated as RFID, is a technology that uses radio waves to relay information. It consists of two parts: the tag and the reader. The reader scans the tag for information and can audibly relay it back to the user.

If so, skip to question 3.

3. Have you ever personally experienced this technology? In what way? Yes   No   N/A

4. How often do you need to navigate through unfamiliar environments?

A. Almost daily **B**. Weekly **C**. On occasion **D**. Hardly ever

5. On a scale from one to ten, how easy is it for you to navigate to places that are familiar to you?

6. On a scale from one to ten, how easy is it for you to navigate to places that are unfamiliar to you?

7. Are there any other issues related to navigation that you feel we should be aware of?

Interview B consisted of free response questions intended to determine specific tasks that were especially difficult for the test subjects to complete as they went about their daily routines. These questions were extremely helpful when designing our systems, as they provided us with insight regarding organizational needs and concerns, as well as the existing systems in use by our test subjects at the time. Since we were interacting with them throughout the testing process, we were able to continuously modify our systems for the next testing session. In addition, Interview B allowed for smoother initial testing. Questions from Interview B are listed below.

1. When in an unfamiliar indoors environment, what pieces of information would you find to be the most important in order to successfully navigate?

2. Do you feel that the usage of technology to aid the blind has been effective?

3. Do you have difficulty identifying transitional parts of buildings, such as entrances, elevators and/or staircases?

4. Do you have difficulty identifying the different types of packaged food that you have in your cupboard?

5. What current system do you have to aid you in discerning between different objects such as food, clothing, medicine, etc.?

6. What organizational task(s), such as some of the tasks previously mentioned, would you say you have the most difficulty with on a regular basis? What are the least difficult? Why?

Aside from the four volunteers the DAB selected, Daniel Gartmann, a blind individual from the Information Technology department of the VIKC, also introduced us to three additional test subjects to test our different RFID systems.

3.2 RFID Readers to be Tested

RFID is a fairly new technology, and because of this there are only a limited number of RFID readers that are designed to aid the blind. The most developed products on the market at this time are the Milestone 312 and the TellMate. Both RFID readers can be obtained from their manufacturers, however the Milestone 312 can also be found from local venders. We used both readers in our testing. These readers were each designed to aid with organizational tasks. Navigational-based RFID readers are incorporated into canes, and at this time no finished products are available. However, we still examined any capabilities the TellMate and Milestone 312 had as navigational aids.

3.2.1 Milestone 312

The Milestone 312 is manufactured by Bones Incorporated, a company based out of Switzerland.   While the Milestone 312 is small enough to fit behind a credit card, it has RFID features built in and advertizes a range of up to 10 cm.   It has a secure digital (SD) card slot that can support up to 32 Gigabytes. It has a built-in speaker as well as a headphone jack for privacy, as seen in Figure 11. The device has six buttons, which are

Figure 11: Milestone 312 (Bones, 2009)

used to detect tags in the area, record messages onto tags, and control many other non-RFID features such as a clock function.

3.2.2 TellMate

The TellMate, shown in Figure 12, was created by Gaishan Technology, a company based out of Singapore. It was also designed specifically to aid the blind and visually impaired (Gaishan Technology, 2009). While it is newer and less well known than the Milestone series, it has many of the same features. It primarily works as an RFID tag reader with an advertized range of up to 5 cm. Like the Milestone, the TellMate has an external speaker and headphone jack. It also has an SD mini memory card slot allowing for the storage of additional data. There are five main buttons on the front of the reader and five other buttons located on the sides. These are used to operate the RFID-related features as well as the many other features incorporated into the device.

Figure 12: The TellMate (Gaishan, 2009)

3.2.3 Using the Reader

As described in the background, the RFID reader communicates with tags through the use of radio waves. These readers work by scanning the tags to relay audible information. In order to do this the user must activate the search feature on the device, such as a button or switch, which will scan for RFID tags within a specified range. Once a tag is detected the user can record a voice memo of information relating to the tag on the reader, which will then be replayed each time the tag is scanned. There is no time limit on recorded messages, and there can be as many messages as there is room for on the memory card.

3.3 Test Subjects

We worked with a group of seven blind individuals during the process of our evaluation. The Danish Association of the Blind asked four of these individuals to meet with us specifically

due to their experience and knowledge of technology. Daniel Gartmann also recommended to us thee other blind individuals who were willing to interview with us and test the systems.

One major concern that we kept in mind during the testing phase of our project was the safety of the individuals we worked with. The test environments were indoors and did not involve the use of any staircases or other hazards. We also monitored each individual throughout the course of testing to ensure that the tests were safely completed.

3.4 System Design and Testing

Each system was designed to test real situations that are known to be difficult for blind individuals.   They accurately represented everyday challenges faced by the blind and visually impaired. The testing location was determined by our team based on factors such as availability, safety considerations, convenience, and applicability to real world situations. We performed testing in the library inside the Visual Impairment Knowledge Center and the hallway outside it. In addition to convenience, this was ideal because there are no stairs or other harmful objects in close vicinity. Our original designs were created to allow for simplicity of use. We had each test subject commence testing first with the TellMate, followed by the Milestone 312. Through our tests we determined benefits and limitations of each device.

3.4.1 Organizing Our Results

Before we started testing, it was important for us to take into account that we were testing two different readers. All results between the two readers were kept separate. This allowed us to determine which reader performed better in the same situations. Furthermore we wanted to take note of the cognitive abilities of the test subjects, including their sight capabilities and age such that we might see a difference in our results depending on how skilled the user is.

3.4.2 Pretests

Prior to having anyone else test the systems we tested them ourselves. It was important for our results that we test the systems the same way that they were setup for our test subjects. We completed every task that we had our test subjects complete. When everything was found to be in proper working, we proceeded with our tests. Expected flaws in our system included missing tags, defective tags, incorrect recordings assigned to tags, and potential safety hazards.

As expected all safety hazards were low risk, and all of them were discovered during the pretesting stages. Potential risks included bumping into objects, falls due to bumping into

objects, inaccurate information from the system directly causing the user to be injured, and frustration if the system was too difficult, which could have led to injury from jarred movement. All major concerns were addressed in our Institutional Review Board (IRB) application.

3.4.3 Training the Test Subjects

We set up a tutorial that allowed the test subjects to learn how to use the device. Our tutorial was given prior to testing. We began by familiarizing the test subject with the readers, such as button placement and function. The tutorial consisted of scanning several household objects that blind individuals attempted to identify using the reader. We placed tags on each item and recorded a message. The user then used an RFID reader to scan tags on these familiar objects. They were instructed on how to record their own messages onto different items. This system gave the user a feel for the basic RFID related functions of the reader. We then continued the tutorial until the test subject was satisfied that he/she has a good enough understanding of the reader.

3.4.4 Navigational System

Our goal for navigational testing was to create an experimental system that can be used both in public places as well as within the user's own home. The system was designed to cater to the realistic, every day needs of blind individuals by giving them more information about their surroundings. This included the room they were about to enter at any given time, the location of objects within the room, and any other information deemed to be important as our evaluation moved forward. The definition of navigation in this application was fairly liberal and dealt more with locating objects, as well as determining the room one was about to enter. Another application of the system, in addition to being used in public places, was that it could be utilized in the homes of a blind user's friends.

3.4.4.1 Navigational System Design

Because the reader has a range on the order of a few centimeters, a navigational system can only work properly if tags are strategically placed. We set up our system in a small library, which is part of the Visual Impairment Knowledge Center. It consists of one bathroom, several bookshelves, and a couple of desks. We designed the test room such that the user was able to understand how the tags were placed within a room. We preprogrammed recordings for the tags into the reader prior to testing. The layout of the room and tag placement can be seen in Figure

13. The first tag was placed next to the doorknob on the left hand side of the doorframe corresponding to the entrance to the room. The tags acted as an indicator that allowed the user to identify the room they were about to go into, along with a general layout of the section of the room that they would be testing. The information on the tag in our actual system signified that the room is the library, the location for the bathroom, and the location of eight cupboards that have RFID tags on them. Initially the tag only included the name of the room, however, after the first two test sessions, it was evident that more information would be more useful for the test subjects. The second tag was located in the same fashion on the doorframe of the bathroom. While this type of system can be used in unfamiliar environments, it may be unnecessary within one's home. However, one possible use for their homes is to record mental notes in these tags. This can include chores that need to be done within the room (i.e. water the flowers every Wednesday) or to remind them of any new objects in the room.
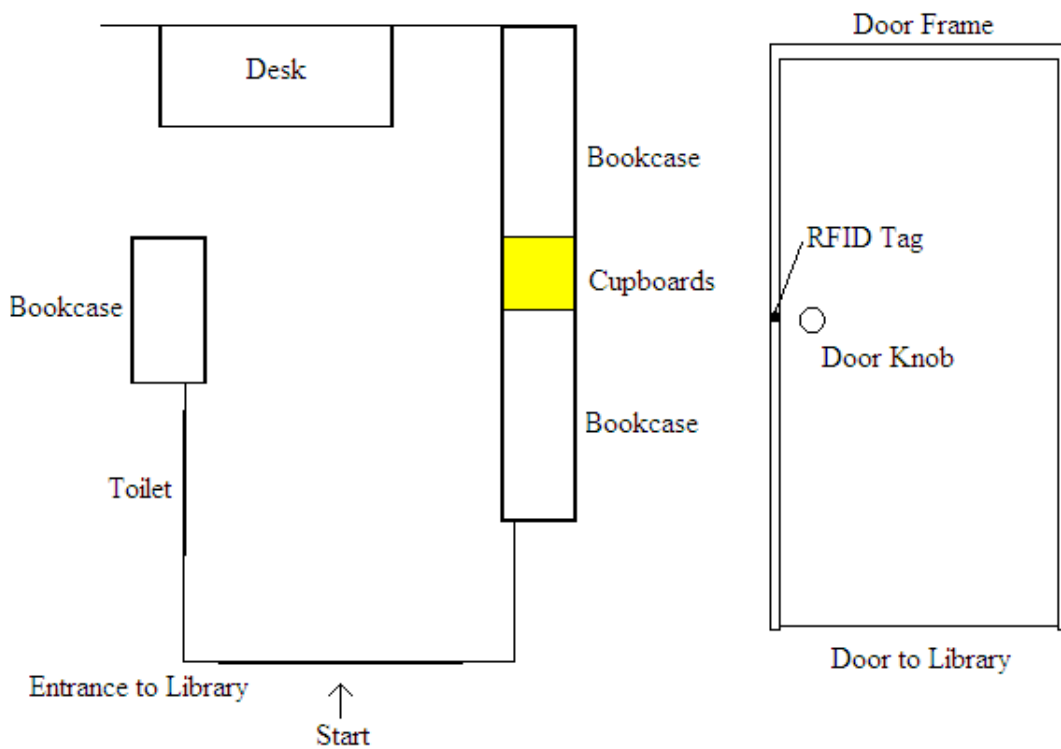
Figure 13: Library Layout and Tag Placement

The other set of tags was to be predominately used within indoor environments. They were placed in cupboards to identify the items inside them. Their placement was designed to be ideal when used in rooms where the items were frequently changing places or are new to the user. In our case, the tags were located on the lower left hand corner of each of the eight

cupboards that have been previously mentioned. Figure 14 displays the exact location of these tags during testing. The user can identify what types of items there are in a certain location when storing and retrieving them. The idea of this part of the system was to allow the user to have many items without having to worry about remembering exactly where each item was. The final aspect of our system was to use a Velcro system. However, prior to actual testing, this part of the system was removed because of feedback from our liaisons, who both have visual impairments.

Figure 14: Navigational Testing: Exact Placement of Tags on Cupboards

3.4.4.2 Navigational Testing

We set the system up in the library, as seen in Figure 13 and Figure 14. Before the system was tested, we explained our methods to the blind individuals on how the tags are set up. Once finished with the tutorial, we had the visually impaired test subject test the system with our guidance. We lead the test subject to the room. They scanned the first tag, which allowed them to gain the information on the location of certain items in the room. The message was intended to give them two tasks. Find the toilet and find the cupboards, in that order. Using the information they gained from the tag, they would find their way to the bathroom. From there, they would continue to find the cupboard with RFID tags and scan each tag. One member of our team would take detailed notes on each test session and/or all present members would observe each test session.

3.4.5 Organization System

Our organizational system was setup in order to test whether a blind individual could distinguish between items with similar physical features, which could lead to a significant increase in the independence each blind individual has in their home. By not having to focus so heavily on tedious organizational tasks, such as taking the correct medication or using the right food ingredients, a blind individual could devote time to more important things.

3.4.5.1 Organizational System Design

The organizational system was designed to allow blind individuals to distinguish between items with similar physicals features. In this system we programmed all tags with a voice recording prior to being tested. The items we used included different types of packaged foods consisting of bags of potato chips, boxed goods, and items in plastic wrap. Books were also used specifically in the first tutorial involving the TellMate. The tutorial for the Milestone 312 involved using the same packaged goods that were used in testing the TellMate. Determining ideal tag placement was part of our investigation, and we decided to place tags on the upper right hand corner of each object to be consistent. Because the readers have a fairly short range, we needed to strategically place the tags so that they were easy to find. We suspected that tags on items such as CDs might be easier to identify so our testing focused on bagged and boxed foods, which we expected to require more trial and error to determine the best location for tags. A CD tag can be seen below in Figure 15.
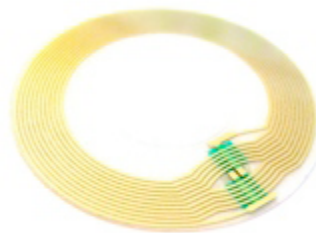
Figure 15: Tag Specifically Designed for CDs (Bones, 2009)

Our actual test system consisted of six items. Each item had another item that was physically similar to it but contains a different food product. This included bags of chips, dry dough mix, and dessert foods. We planned on using canned food too, however during the pre-testing stage we found that the metal on the can interfered too much with the radio waves used in the system. This causes the RFID reader to not be able to pick up the tag located on the can. Tags were placed on the upper right hand corner of the item. Because the test subjects are blind,

they usually cannot tell the orientation of the items, and the only significance for them is that it is in the corner of the item. Each tag contained information about the type of food product and expiration of the food inside the packaging.

3.4.5.2 Organizational Testing

All seven blind individuals tested this system. We provided a test environment in which the blind user tried to distinguish between the six items, which were laid out on a flat surface in front of the test subject. We then asked the test subject to identify different objects in random order using the reader. The learning curve of the system was observed throughout testing process.

3.5 Obtaining Feedback

After each test session, we conducted a ten to twenty minute interview with the following questions, which are shown below.

1. How difficult was it to use the system? Why?

2. How useful would you find the system for your home? Why or why not?

3. How useful did you find the system in the library? Why?

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

5. How reliable did you feel the device was? How consistent? Why?

6. How comfortable would you say you were when using the system?

7. What did you like least about the device? Why?

8. What did you like most about the device? Why?

9. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Range?

10. What features would you want to add?

11. Would you consider investing in a home system in the future given a typical cost of 350-380 Euros? Why or why not?

12. Overall, which reader did you prefer based on today's testing?

13. How do you see this technology complementing or substituting your current methods of organization and navigation?

14. Is there any other area that you think RFID would be useful in?

Certain modifications were made to these questions as the overall testing process progressed due to new insights we received, with the finalized questions shown here. Question 12 was only

asked after both readers were tested, and questions 13 and 14 were only checked after testing with the second reader to see if the answers changed in any way. We also made design modifications to our system as the overall testing process progressed based on feedback we may have received from this interview.

Chapter 4: Results

The way in which we obtained results from testing largely consisted of a number of different methods. The first method, our initial testing, was to simply test the readers ourselves to get a feel for how they behaved and acted in certain situations. More thorough initial testing was conducted with the TellMate than the Milestone 312, primarily due to time constraints as well as the fact that the Milestone 312 took much longer to get working once we actually received it. The second component of how we obtained results was via testing with the actual test subjects. This was done, as previously mentioned, through direct observation and note taking. The last method of obtaining results was the interviewing of our test subjects to obtain background information, as well as feedback on how they each felt about our system design and the individual readers.

4.1 Initial Testing

Before we began testing with the test subjects, it was important for us to become familiar with the readers ourselves. This was done not only so we could gain a better understanding of how RFID readers work, but also so that we could give a thorough and accurate tutorial to each test subject before they began using the devices. We noticed similar drawbacks to each system, such as range. We also observed that each reader had different features that we found easier to use or better performing, making us have no real preference for one reader or another.

4.1.1 Initial Testing for the TellMate

The TellMate has shown to be a very promising product for use as an aid for the blind. The reader has a well-placed layout, which allows the user to quickly learn how to successfully operate the device. We found that the recording and music features work very well and are easy to use. When the reader is held in the correct position it is highly reliable. If the reader is used mostly for its RFID capabilities, the battery life is not a problem; however, using the music features will drain the battery faster.

We have come across several flaws and restrictions in the TellMate design. Addressing some of these issues could result in a more expensive and physically larger product. While this is an unfortunate downside, RFID technology is still fairly new and will continue to improve with time, which will hopefully account for these negative issues. The first issue concerns the RFID antenna imbedded into the devices. We initially found that the user has to hold the device

in a non-intuitive manner when scanning for a tag. Based on what we initially saw, both the tag and reader would have to be aligned in such a way that the antennas are parallel in order to achieve maximum read range. To further illustrate this concept, Figure 16 shows the ideal situation for reading a tag inside of a card.

Figure 16: Ideal Reader Placement

Figure 17 also illustrates what generally produced the least consistent results when scanning for tags. However, the situation we experienced once testing actually began was different at times.
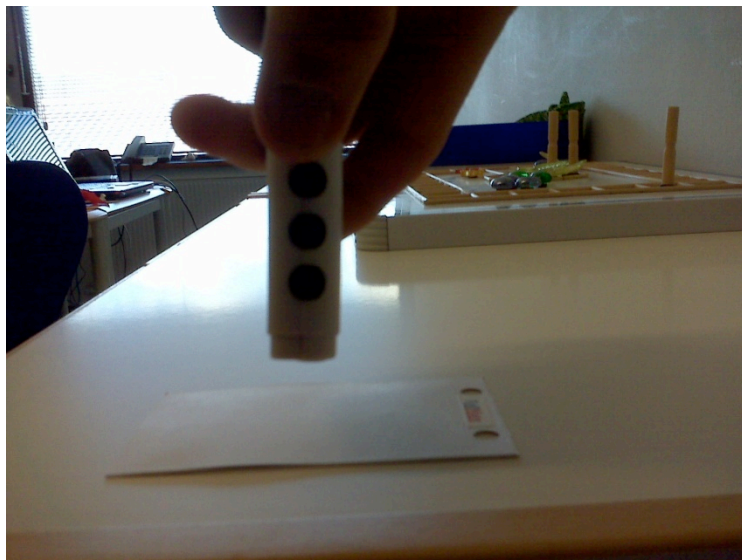
Figure 17: Worst Case Scenario Placement

For the most part, it appeared that parallel placement was the best for both readers once testing actually commenced, although at times, placement at a slight angle seemed fine as well.

Part of the problem with these products is that there is no indication to the user as to what angle the reader should be applied to the tag at when attempting to scan. As testing progressed, we found that a fair amount of our test subjects just assumed automatically that each device had an "eye," referring to the idea that the device might behave like a television remote with an optical interface. This clear disconnect between what the user assumes to be the case and what actually is the case is a definite problem with both the Milestone 312 and the TellMate.

The TellMate has an external speaker and headphone jack. It also has an SD mini memory card slot allowing for the storage of additional data. There are five main buttons on the front of the reader and five other buttons located on the sides. These are used to operate the RFID-related features as well as the many other features incorporated into the device.

Another concern for the TellMate is the small size of the antenna, which restricts the range to a maximum of 5 cm. Because a bigger reader results in a larger range, the size of the reader would need to be increased to allow for a larger antenna. For our intended purposes the range was acceptable, but with a longer range the device could be used in many more applications.

Some of the software and other hardware were not quite as simple and easy to use as we had expected. For most electronic devices, when headphones are plugged into the headphone jack sound no longer comes out of the normal speaker. When headphones are plugged into the TellMate sound comes out of both the headphones and the speaker. Muting the speakers is an advanced feature that occurs by holding down two buttons. It is a nice feature to be able to play from the headphones and speaker in some situation, however it seems most useful if the speaker turned off by default when the headphones are plugged into the device. The clock was also a difficult feature to use. After reading the user manual it is easier to understand how to set the time because it requires you to set the date, time of day, and year during the first use. It would be more suitable if this were a prompt when the user first turns on the device from the packaging. Otherwise they will have to search through the user manual, which is more difficult for someone who is visually impaired. The final hardware issue is the radio feature. It does not have the strength to pick up any radio stations in neither the U.S. nor Denmark. At the moment it would be better to remove this insignificant feature in order to have a cheaper product.

4.1.2 Initial Testing for the Milestone312

The Milestone 312 is a well-developed product to use as an aid for the blind. It is a reliable device when held the correct way and contains the same features as the TellMate, like a radio and the ability to read audio books. Switching between the different features was quicker on the Milestone 312 than the TellMate, because it allows the user to continue to scroll through the menu without having to hear the entire message indicating which feature was active. It also distinguishes itself from the TellMate by having a soft ticking noise to indicate it is searching for tags and the ability to replay messages from the last scanned tag without needing to rescan it. Response time (time between scanning the tag and playing the message recorded for that tag) was also noticeably shorter than the TellMate.

There are some drawbacks, very similar to the ones seen on the TellMate. One of the most noticeable issues was the difficulty in changing the language. To change the language the user must go into an advanced menu, which is explained in the manual. This still required some trial and error on our part. Like the TellMate, the Milestone 312 usually worked best when held in a parallel position in order to scan an RFID tag properly, though individual results varied. The range is noticeably shorter than the advertized 10 cm, and occasionally required that we wave the reader around 1-2 cm above the tag for the best results.

4.2 Interview Results

The two pretesting interviews, previous mentioned in the methodology, that we conducted were each intended to achieve a different goal. Interview A was given prior to testing. The interview consisted of seven short answer questions. It was designed to gain a general background on each test subject pertaining to their blindness and their ability to function with their disability. Interview B was also given before testing but after Interview A. It consisted of six free response questions. The purpose of this interview was to learn specific tasks that are both frequent and challenging. This allowed us to customize our testing to fit these specific needs. The interview was also a way to find out which tasks were not difficult and do not need to be heavily focused on. The following sections are overall responses from the test subjects.

4.2.1 Interview A

The first question of Interview A asked people what motivated them to meet with us for testing. This question was added in after the third test subject, to give us a greater understanding

for the reasons people devote time and energy into advancing this technology. Reasons ranged from curiosity about what this RFID technology is, to wanting to help so that these products can be improved upon and better technology can be created.

The second question allowed us to know which aids for navigation they currently use. Results are shown below in Figure 18. The most technological of the aids listed, GPS, was not widely used, though as stated in the background, GPS has some limitations that may not make it worth the price at this point in time. Walking canes were used universally. Sighted guides were also used by five of the test subjects, though three indicated that they were used only rarely, or for specific situations like clothes shopping.
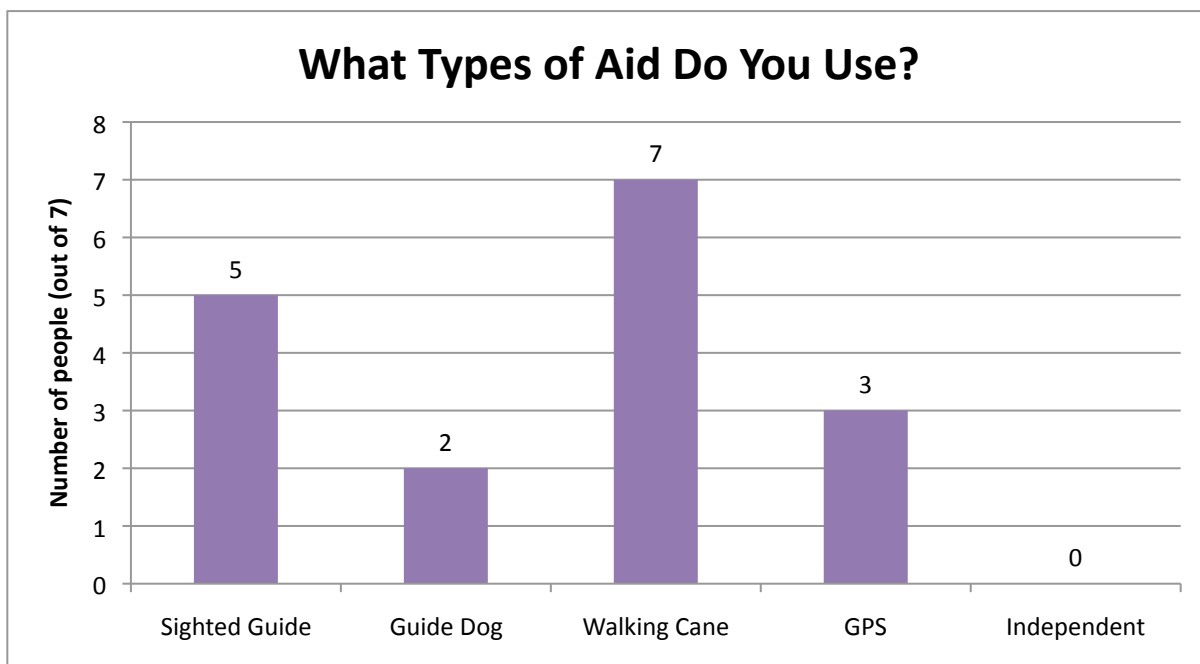
After that, we determined whether the test subject was familiar with RFID technology, and if he/she had ever used it before. Five of the test subjects were not familiar with RFID technology. Only two test subjects had ever used RFID technology before, one stating he had tried the Milestone 312 reader before our testing. This is illustrated in Figure 19 below.
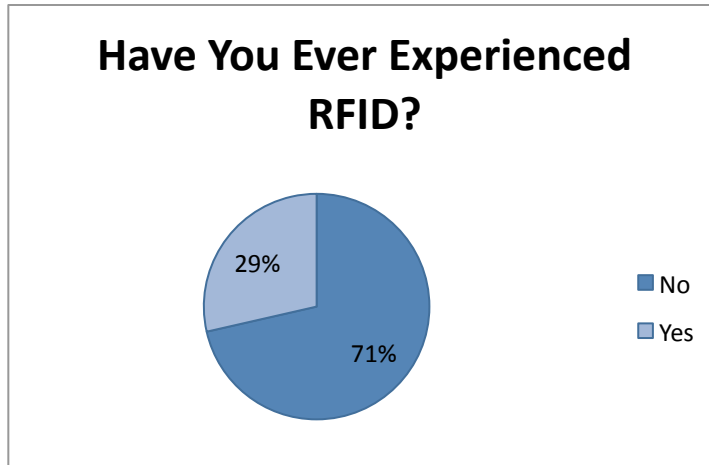
Figure 19: Percentage of Subjects with RFID Experience

The next three questions after that gave a better understanding of the ease and frequency of navigation for a blind person. Most subjects indicated that they travelled through unfamiliar environments on a weekly basis, with some stating they traveled through them on a daily basis. Specific numbers can be seen in Figure 20 below. The one subject who stated that she only navigated through unfamiliar environments on occasion stated that she would more frequently, if she could. While all subjects indicated that navigating in familiar environments was extremely easy (an average of around a 9 on a scale of 1-10, with 10 being the easiest), unfamiliar environments were more challenging, typically falling between a 3-5, though all indicated that it really depends on the situation. Large buildings with complex layouts and many offices are much more difficult than smaller, more simplified buildings.
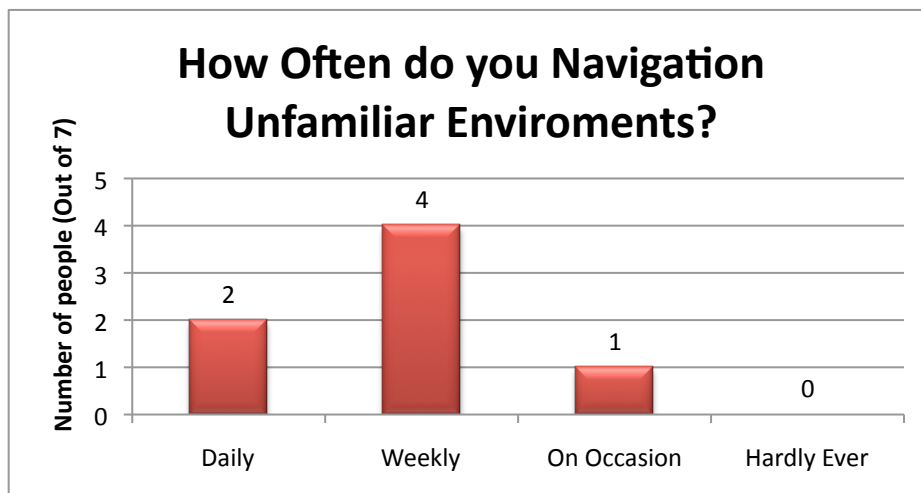
Figure 20: How Often Subjects Navigated Unfamiliar Environment

The last question for Interview A was open ended, to see if there were any other issues with navigation that the subjects would like to elaborate on. Most did not have anything else to add, though one individual stated that orientation was an important factor in navigating, and another indicated that places that are difficult to maneuver are the ones that should be looked at when designing solutions. One test subject also alluded to having difficulty in noisy environments.

4.2.2 Interview B

The first question in Interview B was asked to directly help us with our test system design. Two predominant responses were that a layout of the building/room, and acoustics would be the most helpful when navigating unfamiliar indoor environments. Five subjects stressed how important the layout of the room is when orienting one's self, which is something RFID could be used to provide. Three subjects also stated that acoustical/sound properties were important.

There were mixed feelings about the effectiveness of technology to aid the blind. Three subjects felt that in a lot of situations it is easier to simply use other methods, and two subjects said that there is still so much room for improvement, and it isn't effective enough at this point. One individual said he thought that technology has been 'revolutionary', using text-to-speech as an example of the improvements that can be made. The overall attitude appeared to be optimistic, though with some hesitance, because technology is not a replacement for their own senses, or simpler methods that have been effective for years. One subject also indicated that technology in other fields, such as refrigerators and DVD players, have become more and more advanced in touch screens, making it increasingly difficult for blind individuals to use them.

The next several questions were devoted to finding out what these individuals had the most difficulty with for specific organizational tasks. Question 3 was reworded from entryways to entrances because this terminology made it easier to understand the intent of the question. There were very mixed responses on the difficulty in identifying transitional parts of buildings. Three test subjects stated that they were not difficult to identify, or it was no more difficult than any other part of the building. Four stated that it was very difficult to identify them, especially staircases and elevators. Packaged food and other similarly shaped items was more consistently a problem for the test subjects, with five indicating that it was difficult, and inconvenient to have to open packages up to see if it is the right item. One individual stated that this difficulty was

troublesome sometimes, because a person with sight can go into a grocery store and become 'inspired' to make something for dinner, while a blind individual has real difficulty finding that inspiration if they cannot know what is available to them. Those that said it was not a problem indicated it was because of specific circumstances, such as not buying many items because he did not have a family, or being married to someone with sight who helps organize these different items. Many of the systems currently in use to discern between these objects were simply mental organization by remembering where different objects were placed. Specifics are listed in Table 3 below.

Current Aids for Organizational Tasks	People
Braille	4
Feel (by touch)	3
Memorization	2
Sighted Guide	5
Barcode Reader	1
Limited Sight	2
Trial and Error	1

Table 3: Current Organizational Aids

A few individuals also stated that because of the European Union regulation, most medicine packages have Braille on them. Most test subjects indicated that either packaged items such as food or cleaning products, or CDs, were the most difficult for them to identify. There was no clear indication of what was the easiest, with a few indicating clothing or furniture, and others stating that not one thing in particular was the easiest for them. Specific results can be seen in Table 4 below.

Most Difficult	People	Least Difficult	People
Marking Different Items	1	Large Items in House	2
CDs	3	Clothes	3
Packaged Food	2	Non-Packaged Food	2
Paper Work	1	Nothing in Particular	1
Shopping	1		

Table 4: Most and Least Difficult Organizational Tasks

4.3 Testing and Analysis of Systems

Our testing began with teaching the test subjects how to use the TellMate. This includes a brief description of each button on the device and its function. Next we told them how to access the RFID feature on the device. Then we provided them with books and pamphlets that

have RFID tags on them which already have a pre-recorded message. We alerted them of the most effective way to hold the TellMate with respect to the tag, based on previous testing. After several attempts all test subjects were able to successfully proceed with the actual testing. This included testing the navigational and organizational systems we had set up. Once the test subjects finish both systems, we proceed with Interview C. Interview C is constructed to determine how the test subjects felt about the system they tested, the TellMate specifically, and how they fell a similar system could be set up in their own homes as well as in any other application. Once the interview is complete, we repeat the entire testing process with the Milestone 312.

4.3.1 System Changes after Feedback

A number of design changes were made throughout the course of the testing process. The first change we implemented was the removal of the Velcro system we had planned on using, and it should be noted that it was in fact never actually used in any of our test sessions. This decision was made primarily due of feedback we received from our liaisons, Daniel Gartmann and Thorkild Olsesen, who each seemed particularly unenthusiastic about the idea. They felt that it was not very practical and could not see themselves or any other blind individual using the system. The second design change we implemented was the removal of canned goods from our organizational testing, since we discovered before our first test session that the metal from the cans interfered significantly with the radio waves used by the RFID readers to communicate with the RFID tags. The third design change that we implemented was to essentially add more information in the form of a basic room layout to the tag that was used to identify the library entrance in our "unfamiliar environment." This decision was made after our third test session due to some specific feedback we had received from our test subjects regarding the helpfulness of a room/building layout when in unfamiliar environments.

4.3.2 Feedback on the System Design: Navigational Segment

Our unfamiliar environment took place in a small library. It consisted specifically of a tag on the doorframe, which gives a basic layout of the room, a tag on the doorframe to the bathroom, and tags placed on various cupboards, which were programmed to tell the user what was inside of them. Once they scanned the tag with the layout, they were intended to explore the library as independently as possible by following the information provided on the tags.

When asked how useful the system was in the library, all test subjects stated that the system was at least somewhat useful, once again with varying responses. One subject indicated after testing the TellMate that directional information would make the system more useful when reading tags, such as in the situation where one might be walking down a hallway, they could receive different signal strengths as they progress down the corridor to alert the user of their location. He also said that, after using the Milestone 312, the newly added message that tells the user the room layout in the library was more helpful. This same test subject also said that there could possibly be a mixture of GPS and RFID given certain situations. Three test subjects specifically mentioned how useful the cupboards were in identifying objects inside them. It should be noted that two subjects found the system gave no added benefit when identifying objects in the unfamiliar cupboard. One subject mentioned how Braille labeling might be just as simple to use for the application, and another said it took just as much time to open the drawer and find out for himself what was inside. When we asked whether or not getting accustomed to the system was worth the hassle, overall, all seven of the test subjects stated that it was in fact worth it. One subject said it was worth the hassle, though the tags should be pre-recorded. Another test subject specifically alluded to the effectiveness of the Swedish, although we assume he meant Swiss, bus system, which was previously mentioned in the background chapter.

4.3.3 Feedback on the System Design: Organizational Segment

To recap, the organizational testing included a set three pairs of items resulting in six items total. Every item contained a RFID tag on the top right corner and had the type of food and expiration date prerecorded. Each pair consisted of two items that were physically identical but contained different types of packaged foods. We told the test subject to find a specific type of food. Once they had located it, we asked them to find another item from a different pair, and continued with the final pair. After they successfully found each item we requested, this part of the testing was over.

We discussed the system after testing, and found that all of the test subjects found it worth the hassle, except one who indicated it wasn't worth the hassle to become accustomed to the Milestone 312. One person felt that the tag should also include information about the manufacturer. It was brought to our attention that to include the nutritional facts and ingredients in the message could be useful information also. By the fifth test subject, one of the tags had become very difficult to scan. We believe that this happened because the tag was on a bag of

chips and therefore became bent and could not perform as well as a normal tag can. It is also possible that it is because it was not on a flat planar surface.

4.3.4 Feedback on the TellMate

We asked each test subject what he or she liked the most about each device. Many test subjects agreed that the size of the device was small and the physical design comfortable to hold. One test subject stated that he enjoyed that the device is very easy to use. Another test subject said that the speaker sound quality was also one of his favorite things. Another test subject stated that just simply being able to obtain the information at hand was his favorite thing about the reader. One test subject said that there is a comfortable fit in either hand and that the ease of use such as with the button placement was his favorite things. Another subject said she liked that the reader was more flexible with required range and angle than a barcode reader. More specific responses can be seen in Table 5 below.

Most liked Features of the TellMate	People
Just being able to get Information	1
Sound quality	1
Easier than a Barcode Scanner	1
Easy to use	3
Size	4

Table 5: Most Liked Features on the TellMate

We asked each subject what they liked the least about the TellMate. Several subjects said that they would prefer if the reader response time was much quicker. After contacting Gaishan Technology about this issue, they said that because of the design of the reader the response time would be at least two seconds. It was also evident that the range of the device is so short that it results in the user having to know exactly where each tag is placed. While tags are easy to find on packaged foods, they can be difficult to locate on doorframes. One test subject did not like the idea of carrying another item with him. He, and one other test subject, suggested integrating the technology into a mobile phone. Another subject stated that he did not like the fact that the information was stored in the reader and not in the tag, although the Milestone 312 works the same way. Because of this, tags have to be recorded for each separate reader. This same test subject stated that the key lock mechanism on the TellMate was his least favorite thing because it seems that it is too easy to be accidentally activated. He also disliked the plastic body, although it should be noted that both the Milestone 312 and the TellMate have plastic bodies. Another test

subject said that determining the angle required for scanning and the amount of time it took for the reader to state that there was a scan failure were his least favorite things. A more detailed list of disliked features can be seen in Table 6 below.

Least liked Features of the TellMate	People
Range	3
Have to Carry Around an Extra Device	1
Response Time	2
Key Lock	1
Plastic Chassis	1
Information is independent of tag	1
Too many buttons	1
Knowing the Correct Orientation of Device	2

Table 6: Least Liked Features on the TellMate

Regarding the reliability of the RFID reader, test subjects generally felt that the reader were acceptable in terms of reliability/consistency. Something that we noticed as testing progressed was that the sensitivity of each reader to the angle at which it was applied to the tag when scanning was relatively inconsistent, which is not surprising given the nature of wireless technology in general. Despite this, however, there were generally few failed scanning attempts.

The next thing we asked the subjects to comment on was about the specific attributes of each device, consisting of response time, size, physical interface and layout, and range. The specific question regarding response time was added into the interview process beginning with the third test subject, and the specific question regarding size, physical interface and layout, and range were added into the interview process beginning with the fourth test subject. However, due to the fact that our first two test subjects were only able to test the TellMate the first time they each tested our system, when they later arrived for Milestone 312 specific test sessions, we asked them these specific questions regarding both readers. So ultimately, the question regarding size, physical interface and layout, and range was not asked to the third test subject only. These additions, as well as the way they were implemented, was in part due to the evolutionary nature of our system and interview design as the entire testing process progressed. Six people were satisfied with the current size of the TellMate. Four felt that the response time needs to be improved upon, as it can be very time consuming to scan many items. Two people thought that the design was a little complex but based on the functions they needed to know for the RFID features, it was quite simple. One person also felt that the tactile buttons were too small

to tell the difference. The rest felt the buttons were nicely placed. Concerning the range, six test subjects felt that the range was too short, with one indicating it was fine for packaged foods, but needed to be longer for scanning tags located on doorframe.

4.3.5 Feedback on the Milestone 312

We asked the test subjects the same set of questions concerning the Milestone 312 but asked that they also point out specific details that distinguish the Milestone 312 from the TellMate. We asked each person what his or her favorite thing about the Milestone 312 was. Detailed results from this can be seen in Table 7. Four test subjects noted there was quicker response time than the TellMate. While it could be more difficult than the TellMate to pick up the tag in some cases, once it is within its range the response time is very short. Another shared favorite feature was that the Milestone 312 can replay the message of the last tag scanned without rescanning the tag. This is a useful, timesaving function that is not present in the TellMate. Because two test subjects had prior experience with the Milestone 312, they said their favorite thing about the device was that there were many extra features, such as the ability the read Daisy books and MP3 files. We informed them that the TellMate also has these functions.

Most liked Features of the Milestone 312	People
Quick Response	2
Size	1
Other Features	1
Repeat Message Feature	3
Location of Scan Button	1
Size	1
Lock Function	1
Ability to Stop a Message	1
Buttons	1

Table 7: Most Liked Features on the Milestone 312

Most test subject had similar responses about their least favorite part of the Milestone 312. Like the TellMate, the Milestone 312 had a very short range. Some test subjects said that it was shorter than the range of the TellMate, and therefore took extra time to get used to using the device. Many test subjects thought that the angle of orientation with respect to the tag was quite sensitive and resulted in failed attempts to successfully scan tags. One test subject wanted the ability to delete messages off of tags instead of just overwriting them. Both the Milestone 312 and TellMate are unable to accomplish this task. Two people thought that the scanning button

placement was not nearly as comfortable to use as the TellMate's. This is because the button is on the front of the device and has to be held, whereas the TellMate's scan button is on the side of the device and only needs to be pressed once.   Specific results can be seen in Table 8 below.

Least liked Features of the Milestone 312	People
Range	3
Knowing the Correct Orientation of Device	3
Scanning button	2
No "delete tag" Function	1

Table 8: Least Liked Features on the Milestone 312

We asked the test subjects how they felt about the reliability of the Milestone 312. Four people thought that the Milestone 312 was very reliable when it picks up the tag right away. Occasionally the reader will not pick up a tag for no apparent reason. When comparing all responses gathered from test subjects, the TellMate appears to be slightly more favorable than the Milestone 312 when it comes to reliability/consistency. Six subjects expressed that they were very comfortable with the each reader when using the system. One subject stated he felt 'unsecure' when reading tags, because the failed scans made him feel uncomfortable.

The final question we asked was how they felt about the size, response time, physical design and layout, and range. For the most part, everyone said that the size was appropriate and not much different than the TellMate. However, unlike the TellMate, the response time was much quicker. Some described it as instant. All test subjects liked the size of the device, though two noted it does not fit as nicely in their hand as the TellMate. They also preferred the tactile buttons of the Milestone 312 to that of the TellMate. The main difference is that the buttons on the Milestone are around 3-5 times larger than those on the TellMate. This results in the user having an easier time distinguishing between different buttons. Finally, four people described the range as being very short. One subject said it was about the same as the TellMate, however two people said that it was definitely shorter. One person said that they would have preferred the range being around three meters in the navigational testing. This is because he wishes to know the information a few seconds before he arrives to the actual location of the tag. Another stated that half a meter would be sufficient.

4.3.6 Comparing the Milestone 312 and the TellMate

When we asked each of our test subjects which reader they preferred overall based upon testing each, there was a clear preference for the Milestone 312. It should be noted that this

question was not asked to our third test subject. One test subject said that he preferred the Milestone 312 if he could find a good way to scan tags given the fact that the overall design and functionality worked well for him. Another test subject said that he preferred the TellMate's RFID reading ability, but still overall preferred the Milestone 312 due to its button size and layout. The same test subject said that he had no preference regarding holding or just pressing a button to scan. Another test subject said that he preferred the Milestone 312 because of the quick response time.

Feature	TellMate	Milestone 312
RFID capability	√	√ [Extra Cost]
Radio	√	√ [Extra Cost]
Plays music files	√	√
Reads audio books	√	√
Reads word documents (.doc)	X	√
Reads text files (.txt)	√	√
Text-to-speech	√	√
Voice recording	√	√
Memory expansion slot	√	√
Key lock function	√	√
Headphone jack	√	√
Microphone jack	√	X
Advertised Range	3-5 cm	10 cm
Price	$456	$500
Subjects who preferred it	1	5
Subjects who would buy it	5	4

Table 9: Comparison of the TellMate and Milestone 312

Table 9 shows a comparison of the features available on each device and how many test subjects would prefer buying each reader and which reader they prefer overall.

4.3.7 Feedback on Current and Future Applications of RFID

When asked how useful the system would be in their homes, the test subjects had a wide range of replies, but overall five said it would be useful. This was largely due to the fact that each subject had a different application(s) in mind for home usage, assuming they found it useful at all to begin with. For instance, a number of subjects mentioned how identifying different CD's would be much easier with such a system in place for organizing their collections. Certain

subjects also alluded to how such a system would be useful for organizing and identifying different foods in their own homes, although there appeared to a strong preference for pre-tagged foods. That is, a number of subjects expressed how if the effort were required on their own behalves to tag food items, the system would not be particularly useful to them, whereas if food items were pre-tagged as part of a standardized infrastructure at supermarkets, the system would be very useful. A number of subjects mentioned how the system might be useful for identifying different clothing. One subject in particular mentioned the possibility of usefulness for cleaning products, as well as being able to have the information play back to him audibly while in the kitchen or in front of his refrigerator regarding expiration dates, etc. One subject said when we asked him this question after having tested the TellMate that it might be useful for the home given pre-recorded tags but he might just use Braille labeling instead, although Braille can be worn out. When we asked this same test subject the question after using the Milestone 312, he said that it was pretty useful and also highlighted the fact that it has other features besides the RFID capability.

We asked our test subjects if they would invest in a home system given the costs of each reader. One test subject said that he would buy the TellMate if he could use it in different places such as if it were part of a standardized infrastructure, but he alluded to the speed being an issue and the fact that he probably would not invest if tags had to be programmed by the user. The same test subject said after having tested the Milestone 312 that the price is not a big deal to him as long as the functionality is adequate. A test subject stated that he would consider investing in the TellMate if there were pre-recorded tags, whereas he would have considered investing in the Milestone 312 because of the other features it had compared to the TellMate. When we asked another test subject about investing in the TellMate, he mentioned that he would be more likely to invest if he did not have to record his own messages, along with the fact that his current lifestyle would probably not require such technology in his opinion. This same test subject also alluded to the numerous features that the Milestone 312 had such as the MP3 player, Daisy book reader, and dedicated voice recording. Another test subject highlighted the fact that he would be more inclined to invest in the TellMate and Milestone 312 given prerecorded tags as a purchasable option and different tag shapes. A different test subject said that he would not invest in either the Milestone 312 or TellMate given the small size of his household with limited ways to use the technology at this time. It should first be noted that both readers have the same overall

features regardless of test subject responses, and secondly that cost was not a major determining factor for most if not all of the test subjects when considering investing in either reader. Functionality itself was the more central issue.

When we asked our test subjects about what features they would like to add to the devices, we received a variety of responses, details of which can be seen in Table 10 below. One test subject said that within the context of the TellMate, he would add the ability to connect the device to his computer on a weekly basis to download new tag information, assuming that in the future supermarkets were to adapt such an infrastructure of tagging different items. The same test subject, after having tested with the Milestone 312, said that he would possibly add a color scanner, podcast capability, being able to download the morning newspaper, a light sensor, and Bluetooth® capability. Another test subject said that regarding the TellMate, if it could be integrated into an iPod® or a mobile phone, as well as possibly being a color tester, he might like it more. Another test subject said that in the context of both the TellMate and Milestone 312, as previously mentioned, being able to delete tag information on demand while scanning said tag would be a feature worth adding. Another test subject said that within the context of the TellMate, he would like to be able to know how close he is to a given tag. This same test subject also stated how having more information than just what the item is on packaged goods, such as the manufacturer, would be especially helpful. Another test subject said that within the context of both readers, he would add phone capability. He also stated that within the context of the Milestone 312 specifically, he would add radio capability, though it should be noted that this feature is already available at an extra cost.

What Features would You Add?	People
Distance from tag	1
Range Increase	2
Pre-Recorded Tags	2
Integrated in a Phone	2
Color Reader	2
Delete Information on Tag	1
Download Tag Information from Internet	1
Download Morning Paper	1
Light Sensor	1
Bluetooth®	1

Table 10: Features to be Added

When we asked each of our test subjects how they saw this technology substituting or complementing their current means of organizational and navigational aids, once again, responses widely varied. One test subject said that it would make things easier for him and that it would especially nice to not have to meet someone for help regularly. Another test subject said that it would be nice to have options and that it would complement what he was already used to. A different test subject mentioned that having the information on the tag instead of the reader would be better, and that a downfall of RFID is that it is dependent upon a unique device, since messages are not recorded on the tags themselves. An additional test subject saw the technology possibly aiding him in identifying objects in close proximity. One test subject said that the technology could complement his current aids in some small ways, but it should not be used to replace what could otherwise be done cheaper or more simply, such as using his senses. One person said that it would be useful for organizing his paperwork. Lastly, one subject stated that right now she has more preferred methods, like Braille and barcode readers, however when her barcode reader fails she would like to use RFID instead.

When we asked our test subjects where else they could see RFID technology playing a role, once again, the responses widely varied. Two test subjects specifically mentioned use in the train and public transportation in general. Another two subjects said that they could see the technology playing a role in street crossing as a means of replacing the sound method currently in place, and in outdoor environments. One test subject specifically mentioned indoor and outdoor signs as a possibility.

4.3.8 Errors in Testing

A final consideration that should be taken into account when evaluating these results is that the interviews and test sessions may have included some degree of bias. This is partly due to the fact that interviews were conducted in a very informal, conversational manner, and at times, we found it beneficial to probe deeper into the thoughts of our test subjects when considering their responses. Also, some of the changes we made to our interviews and system design were improvisational in nature. Another part of this though is simply human error. We are not professional interviewers, and given the limited amount of resources we had to work with, we attempted to obtain results that were not only unbiased, but as complete and informative as possible. Because of this, the prices of the readers were not always accurately stated due to new information obtained as testing went on. Achieving a balance between the two was central

to our investigative process. This is not to say that our results should be disregarded, but rather, that they should be evaluated simply with these factors in mind. Moreover, although these results were not obtained in a perfectly unbiased manner, we feel that they are still a very accurate representation of how our test subjects felt.

Chapter 5: Conclusions and Recommendations

The primary objectives of this project were to explore the current ability of RFID technology, in particular the Milestone 312 and TellMate products, to assist blind individuals in their indoor navigation and organizational tasks and to identify areas where this technology can be improved. To accomplish these objectives we performed tests and conducted interviews with seven visually impaired volunteers at the VIKC.

As a result of this work, we arrived at some conclusions and provided recommendations ranging from different infrastructural implementation ideas for the DAB to specific design modifications that Bones Inc. and Gaishan Technologies should consider for their respective readers, the Milestone 312 and the TellMate.

5.1 Conclusions

After obtaining feedback through direct observation and interviews, it appears RFID is on its way to becoming a viable solution for aiding navigation and organization for the blind and partially sighted. All of the test subjects quickly and easily learned how to use the RFID features on both of the readers. The price of the system did not seem to be a large deterrent for the test subjects. One major concern though was how the messages would be recorded for the tags. Many people indicated that they would not be willing to record their own messages, and that a standardized system would be a more usable option. Overall, based on the results compiled, it is safe to conclude that RFID technology, although possibly viable in the future, is still not a realistic option at this time for the blind and partially sighted to rely upon for aiding navigation and organization. A major reason for this, aside from the lack of standardization currently in place, is simply that the blind and partially sighted can rely on many other methods, which are currently more effective in aiding their everyday tasks.

Overall, the Milestone 312 was the most preferred RFID reader by our test subjects. This result was obtained from specifically asking the test subjects which reader they preferred. This may have been due to the fact that at least some of our test subjects were more familiar with the Milestone 312 prior to testing. The TellMate and the Milestone 312 each offer separate advantages after examining the results, though. With this in mind, the manufacturers could still improve each device, specifically regarding the maximum scanning range.

Ultimately, as was previously mentioned, standardized RFID systems of some sort are going to be absolutely necessary in the future in order for this technology to move forward in terms of actually being useful to the blind and visually impaired on a broad scale. Whether this is achieved by means of government regulation, or simply through private sector innovation is something that is outside of our reach. And although government intervention might play some role in the future, we feel that what private businesses decide to do will be the determining factor in this matter.

5.2 Recommendations for the DAB

One recommendation for future implementation of RFID for the blind would be in places such as grocery or clothing stores. With stores such as Wal-Mart shifting from traditional barcodes to RFID tags, it is beginning to become the standard for companies to put on their products (Brown, 2007). When this becomes the case, a blind individual could work with local stores, and download RFID tag information from their website. This would enable them to go into these stores and scan any of their products to find out more information on them. This information could include what the product is, who makes it, and other pertinent information such as nutritional facts or ingredients.

Regarding the implementation of a standardized infrastructure in retailers, specifically supermarkets, it is highly recommended that this be done or at least considered in the near future. This was a major highlight of our test results in that many of our subjects expressed interest in this idea. It is also very important to note that many test subjects were "on the fence" (undecided) about purchasing readers without such a standardized system already in place. With these factors in mind, the actual costs of implementing such a system can probably only be justified by manufacturers and retailers in the long run given some of the current statistics we came across. Wal-Mart has been in the process of implementing such a system, and as of 2003, AMR Research claimed that such a system could cost Wal-Mart's suppliers at least $2 billion (Collins, 2003). Given the fact that Wal-Mart is such a massively successful business with a wide array of products to choose from, the figure of $2 billion would probably drop to some extent for the average sized retailer in Denmark. There is no guarantee that this is in fact the case though, as cost can only truly be determined on a case-by-case basis. Nonetheless, AMR alluded to the fact that manufacturers would have a very difficult time justifying the costs associated with implementing such an expensive RFID system for their goods. Of course, being

able to do business with an extremely successful retailer is a very strong incentive for any supplier at the end of the day. Implementation would therefore probably have to begin with more successful Danish retailers. From the retailer's perspective, implementing such a system would allow for faster checkouts for all consumers. In this way, the system would not just benefit blind and visually impaired consumers. At the same time, it would give retailers a solid incentive to invest in such a system, at least in the long term.

Another recommendation is one that has already been implemented in Switzerland, and could significantly improve navigation for the blind. RFID tags were placed on Swiss busses and at bus stops, and blind individuals were given Milestone RFID readers to test the system (Neely, 2008). When a user scanned these tags, they could get information such as the bus stops, arrival times and the final destination of the bus. They can also alert to the bus driver that they would like to board with the push of a button. This is a system that could be implemented in Denmark, helping both the blind community by improving ease of navigation, as well as the Danish government by helping it meet the EU regulation stating that more information on public transit must be provided for the blind by 2013.

5.3 Recommendations for Gaishan Technology

Throughout the course of testing, we examined the specific advantages and disadvantages that both readers had to offer. Based on our results, it is safe to say that the TellMate is a very feasible option for every day usage by the blind. In the event that a mainstream, standardized RFID infrastructure is ever implemented in Denmark, the TellMate should definitely be considered an option as a possible standardized reader. With this being said, there are some design improvements that should be made to the TellMate reader on behalf of Gaishan.

The first major design modification that we recommend is to reduce the overall processing time required by the reader to detect a tag, and then subsequently play the corresponding message out loud. This problem was of particular concern to some of our test subjects since, for example, in a situation such as perusing a grocery store, the total amount of time needed to find the necessary item on a shelf might take minutes as opposed to seconds. The consistency/reliability of the reader is something that we also feel needs to be improved upon by Gaishan. Given the fact that so many variables come into play when dealing with wireless technology, many of which lie outside of the domain which the designer has control over, some degree of inconsistency and unreliability is understandable and ultimately unavoidable when

dealing with any wireless system. However, the lack of reliability and consistency specifically associated with the angular orientation of the reader relative to a tag when attempting to scan said tag is so significant that it should be noted as a possible design flaw. Omi-directional RFID antennas should be considered as a viable solution, though there may be an added cost. However, given the fact that the test subjects indicated that function outweighed price, this may not be a significant issue.

In the event that Gaishan does decide to make design modifications in the future, we strongly recommend that the size of the TellMate reader remain unchanged in accordance with the feedback of some of our test subjects. The user interface, consisting of button placement and menu navigation, should also remain unchanged, as certain subjects felt that it was particularly easy to follow.

The last major recommendation we have for Gaishan Technologies is to consider working with phone manufacturers in order to consolidate mobile phone capabilities and the TellMate's capabilities into one device. This was an idea that came up twice throughout the feedback process. As of 2009, a group named Touch has been investigating the usage of RFID in conjunction with the iPhone® (Timo, 2009). Specifically, the integration of an RFID reader which will, once a tag has been scanned, trigger the displaying of specific pre-stored media in an iPhone® has been under investigation. Video footage posted on Touch's website shows significant progress in this endeavor, and an even more promising sign is Touch's claim that based on Apple's patents, there is a very high probability that RFID will be integrated into the iPhone® in the future.

5.4 Recommendations for Bones Inc.

The second part of our testing focused on the Milestone 312. While the TellMate performed well in testing, so did the Milestone 312 and should be considered for further use in developing a future RFID system. While it was overall better than the TellMate in some areas, it was not better in every category that our study focused on. To improve the Milestone 312 so that it performs in the best way possible, we recommend the following to Bones Inc.

The test subjects thought that the Milestone 312 has many reliable and useful features. They overall felt that the device has a very fast response time. This feature is very important because when searching for a specific item it may be necessary to scan many different items, which can be time consuming. Another helpful feature is the ticking noise that allows the user

hears when the device is scanning. During testing the test subject did not have the issue of thinking the device was scanning when it was not. It can also be used as a clear indicator in the event that the device happens to malfunction even though this did not occur in our testing. The next positive feature is that the tactile buttons were very helpful. The test subjects had little or no trouble distinguishing between different buttons, which results in easier use. The Milestone 312 has a very useful feature that is not present in the TellMate. After a tag is scanned, it can replay the message again without having to rescan the tag. Especially because there was a language barrier in our testing, this feature was very useful. The final preferable feature is size of the device. All interview responses stated that the reader was an acceptable size.

Even though the Milestone 312 has many positive features, it still has some features that could be improved upon. First and most importantly, the device has a very short range in practice even though the advertised range is much larger. The short range made it difficult to first learn how to use the device because it was also sensitive to the angle with respect to the tag. Once the test subject got used to how to use the device, it was no longer an issue but they did prefer the longer range of the TellMate. However, from a general overview of our test results, neither reader had a long enough range based on the users' needs. The other major issue was that it is required to press and hold the scan button to scan for tags. Because of the sensitivity to angle of the device with the tags and the location of the button, it was that much more difficult to scan tags. We found that having the scan button on the side of the device, similar to the TellMate design, was easiest to scan.

The current design of the Milestone 312 is quite acceptable but, if Bones considers some of these recommendations, they can develop a better product. While altering the current design to the device can result in a sharp price increase, the ease of use was very important to the test subjects. Most of our test subjects would consider investing in an RFID device if RFID was more widespread at the public level. Because RFID will not reach this level for quite some time, Bones Inc. can thoroughly explore our research and recommendations before they make any adjustments to their product.

In the previous section regarding the TellMate, the recommendation was made that Gaishan Technologies work with phone manufacturers in an effort to consolidate the TellMate's capabilities and mobile phone capabilities into once device. We have the same recommendation for Bones Inc. regarding the Milestone 312. As was previously mentioned, a group named

Touch as of 2009 has been investigating the usage of RFID in conjunction with the iPhone® (Timo, 2009). Specifically, the integration of an RFID reader which will, once a tag has been scanned, trigger the displaying of specific pre-stored media in an iPhone® has been under investigation. Video footage posted on Touch's website shows significant progress in this endeavor, and an even more promising sign is Touch's claim that based on Apple's patents, there is a very high probability that RFID will be integrated into the iPhone® in the future.

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Appendix A: Interview Results

Test Subject 1 Results

Interview A

1. Of the following, which do you currently use as a form of navigation? (Circle all that apply)

A. Sighted Guide (for shopping)

C. Walking Cane

Are you familiar with Radio Frequency Identification?

No.

2. Have you ever personally experienced this technology? In what way?

No.

3. How often do you need to navigate through unfamiliar environments?

B. Weekly

4. On a scale from one to ten, how easy is it for you to navigate to places that are familiar to you?

9-9.5

5. On a scale from one to ten, how difficult is it for you to navigate to places that are unfamiliar to you?

5

6. Are there any other issues related to navigation that you feel we should be aware of?

One notice, I have a good sense of orientation, so I get around easier than maybe other blind people would.

Interview B

1. When in an unfamiliar indoors environment, what pieces of information would you find to be the most important in order to successfully navigate?

Audible information, acoustical properties, floor textures, information about stairs is very important.

It can depend on building. Work is huge building, so when I have to find a place, it can be difficult to know where room F3321 is. Also, with a lot of open stairways, I can go under them accidentally. Where exits are would be good to know.

Public building – get information like fourth floor, elevator straight ahead, directional (take a right after this, etc)

I wouldn't use it [RFID system] at home.

2. Do you feel that the usage of technology to aid the blind is effective?

There are plenty of situations when it could be easier to use other methods, like small places and frequented places (though it may be nice initially when those places are unfamiliar) but could be great for situations like in the street to get street names, specific shops, looking for specific places or large buildings

3. Do you have difficulty identifying transitional parts of buildings, such as entryways, elevators and/or staircases?

Normally the challenge is to find if it's the right house, right office, right entrance (right button to press to have someone let you in)

Elevators are also quite a challenge – the new ones have touch screen that is helpful

Staircases – It would be nice to know where to find them when you enter the building – to left of right, do you have to go through a door, how many sets of stairs do you go up to reach a certain floor (weird floor numbering and half staircases can make it difficult)

4. Do you have difficulty identifying the different types of packaged food that you have in your cupboard?

Yea, it is one of the real challenges I have. I have four supermarkets around the corner; one I can get help in, but leaves no room for being 'inspired'. What is it, ingredients, and nutritional facts about it, is it ecological or organic

It is still a challenge at home especially with cans, meat products, jars of pesto and Chile – I normally have to stick my nose in them – it's a pain when you are trying to preserve the food

Cleaning products, shoe shine products (whether they are black, clear, brown), etc.

5. What current system do you have to aid you in discerning between different objects such as food, clothing, medicine, etc.?

Right now I am just using my brain and knowledge – no technical tools. Sometimes in the kitchen it can be a problem

Clothing – it would be nice to have more details about the clothes (which type of blue is it) – I know it from touch memory

I don't really use a lot of medication so I know it quite well – all prescription medicine is marked with Braille- but it is limited in information. However If you can't read Braille, you must remember shape of pill and packaging or get help

6. What organizational task(s) would you say you have the most difficulty with on a regular basis? What are the least difficult? Why?

Most difficult-During shopping – like if you go to 7 Eleven for something to drink – there are 50 different bottles – also would be nice to know the price of it before you buy it

Different type of food packaging, sliced meats, nearly all type of groceries, cleaning products

Need someone to come when clothing shopping to say what looks good

Least difficult-clothing once bought it pretty easy. Also discerning between tomato and onion is easy (category of food), but what type of tomato is it? Organic, vine ripened, etc. can be difficult. 60-80% of things can easily be found, such as bread

TellMate Interview C

1. How difficult was it to use the system? Why?

Quite easy- the only thing that was difficult was finding the tag on the product

Say you are standing in the supermarket looking for salmon, there are two different kinds, smoked and not smoked, you need to be sure that when you scan it, it is the right thing – Don't want any interference – want to make sure you don't have to pull the product out every time to scan it

2. How useful would you find the system for your home? Why or why not?

It could be useful especially in the kitchen with the groceries, sometimes when standing in front of the fridge, it would be nice for a computer to say what is actually in the fridge - Say one liter of milk expiring on a certain day

It would be nice for cleaning products, CDs, DVDs, etc.

Clothing identification would be nice with the option – wouldn't do it if you had to make the recording on your own, but would work if information was already provided for you

3. How useful did you find the system in the unfamiliar indoor environment? Why?

It could be great in public buildings if you are looking for certain office – but the challenge is that the system needs more information – like directional information

Scanning tag at the beginning of the hallway or as you walk down the hallway (stronger signal) would be more helpful

Maybe a mixture of GPS or RFID for some situations

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Yes, certainly is a great opportunity – this can't be implemented quickly enough

Swedish bus system idea is really good idea-works very well

5. Would you consider investing in a home system in the future given a typical cost of 350 Euros? Why or why not?

Certainly, if I could use it in different places – though I wouldn't buy it just to tag my own items at home, and the speed is an issue – needs to be quicker or it's just a disadvantage or irritating to use

6. How reliable did you feel the device was? How consistent? Why?

The only thing was it could be good with a clearer indication of how to hold it (he felt parallel was easier given the way you hold it) – gets to be unpractical

Should be incorporated into a smaller object like a bracelet, or mobile phone

7. How comfortable would you say you were when using the system?

Fine – I didn't feel any uncertainty – clear and easy

8. What did you like least about the device? Why?

Speed – the time it takes from pressing a button to telling the message

9. What did you like most about the device? Why?

Pretty small and easy to use

10. What features would you want to add?

On the internet at home – it would be great if it could connect to the computer and select different items, then go into grocery store and find products easier

Should automatically update every week with the supermarket online

11. How do you see this technology complementing or substituting your current methods of organization and navigation?

It would make things easier

It would be nice not to have to arrange to meet people to help you while shopping

12. Is there any other area that you think RFID would be useful in?

In the train – or public transportation in general

Milestone 312 Interview C

1. How difficult was it to use the system? Why?

It is quite easy, and in no way complicated. It was quicker to find information from the tag [than the TellMate].

2. How useful would you find the system for your home? Why or why not?

Answer did not change from the TellMate.

3. How useful did you find the system in the unfamiliar indoor environment? Why?

The new information on the first tag that gives the layout was more helpful than when it did not.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Yes.

5. Would you consider investing in a home system in the future given a typical cost of 350 Euros? Why or why not?

Not a big deal. If the functionality is adequate then the cost isn't an issue.

6. How reliable did you feel the device was? How consistent? Why?

It was unreliable/irritating to orientate it correctly. It is very sensitive to the angle. The Milestone is more difficult than the TellMate.

7. How comfortable would you say you were when using the system?

Fine. Not uncomfortable at all.

8. What did you like least about the device? Why?

Finding the right angle to hold the device with respect to the tag.

9. What did you like most about the device? Why?

The quick response time, being able to replay tags without rescanning and the ability to stop in middle of a message.

10. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

Response time: The TellMate took a long time. The Milestone was very fast.

Size: Same more or less

Layout: The Milestone 312 has a nice simple design and the buttons are well placed. The TellMate is more difficult.

Range: The TellMate was better but still not good enough. The Milestone has almost no range.

11. What features would you want to add?

Color scanner. Podcasts. Downloading the morning paper. Light sensor. Blue tooth.

12. Overall, which reader did you prefer based on today's testing?

The Milestone 312.

13. How do you see this technology complementing or substituting your current methods of organization and navigation?

Answer did not change from the TellMate.

14. Is there any other area that you think RFID would be useful in?

Answer did not change from the TellMate.

Test Subject 2 Results

Interview A

1. Of the following, which do you currently use as a form of navigation? (Circle all that apply)

A. Sighted Guide

C. Walking Cane

D. GPS

Are you familiar with Radio Frequency Identification?

No.

2. Have you ever personally experienced this technology?

No

3. How often do you need to navigate through unfamiliar environments?

B. Weekly

4. On a scale from one to ten, how easy is it for you to navigate to places that are familiar to you?

10

5. On a scale from one to ten, how difficult is it for you to navigate to places that are unfamiliar to you?

3

6. Are there any other issues related to navigation that you feel we should be aware of?

To know where you are, know what's around you is important.

Interview B

1. When in an unfamiliar indoors environment, what pieces of information would you find to be the most important in order to successfully navigate?

Layout of the room, what is in front of me, what kind of room it is (bathroom, etc.) who is in the room with me, what is available (public building? Apartment building? Is there an elevator? Only stairs?)

2. Do you feel that the usage of technology to aid the blind is effective?

Still in its infancy, so it has room for improvement.

3. Do you have difficulty identifying transitional parts of buildings, such as entryways, elevators and/or staircases?

Yea occasionally.

4. Do you have difficulty identifying the different types of packaged food that you have in your cupboard?

Yea.

5. What current system do you have to aid you in discerning between different objects such as food, clothing, medicine, etc.?

Sometimes I put Braille markings on them, discern the colors of clothing; I also use the shapes and material to determine the clothes.

Different kinds of supplies organized separately (one place where beans go, for instance, different place for cleaning supplies)

6. What organizational task(s) would you say you have the most difficulty with on a regular basis? What are the least difficult? Why?

Marking different items buy on a regular basis is the most difficult.

To know where the different things are in your house (appliances, furniture, stationary objects) is the least difficult.

TellMate Interview C

General notes during testing:

Test subject stated that the matter of finding the actual tag is the most difficult part.

Subject had difficulty identifying the tag on doorframe.

Some inconsistency on how to hold the reader against the tag (perpendicular/parallel)

Three tries to get tag scanned effectively on one tag.

1. How difficult was it to use the system? Why?

It wasn't too difficult once you are familiar with the reader, and are familiar with the feel/position of the tag.

2. How useful would you find the system for your home? Why or why not?

Quite useful in my own home, sometimes there was a scan failure though.

It is great that the tags can be reused and recorded over.

3. How useful did you find the system in the unfamiliar indoor environment? Why?

Quite useful, especially in the drawers.

Once I knew where they were located, the doors were useful (longer range would be better though).

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Absolutely, yes.

5. Would you consider investing in a home system in the future given a typical cost of 350 Euros? Why or why not?

Definitely, especially if the tags come in different shapes.

Maybe some pre-recorded tags you could buy in an electronics stores would be helpful.

Subject recommended we check out bar code readers.

6. How reliable did you feel the device was? How consistent? Why?

Overall yes, though I did have to press the button more than once or turn the reader to scan successfully.

7. How comfortable would you say you were when using the system?

Quite comfortable.

8. What did you like least about the device? Why?

It was hard to know which angle to turn the device.

Also, it took a long time before it said scan failure – too long of a scanning time.

9. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

The response time - took too long

Size – fits in the pocket

Feels ok, smooth

Too short of a range

10. What did you like most about the device? Why?

Just being able to get the information.

11. What features would you want to add?

Possibly knowing how close you are to the tag, like if there is a scan failure.

More information on the tags, and prerecorded tags on packages.

12. How do you see this technology complementing or substituting your current methods of organization and navigation?

It's definitely good for very close range (what is on this shelf, what is in this box, what is in the room).

13. Is there any other area that you think RFID would be useful in?

Close range outdoor navigation (reading signs, house numbers, etc)

Indoor and outdoor signs

Milestone 312 Interview C

General notes during testing:

There was more of a learning curve, and the subject had a harder time correctly scanning a tag. He had a greater difficulty scanning tag in front of library.

Subject noted lack of delete button to erase tag messages, and stated that he liked knowing whether you actually got the tag or not (the ticking noise).

1. How difficult was it to use the system? Why?

Once you got used to it, it was pretty easy.

2. How useful would you find the system for your home? Why or why not?

Quite useful in my own home, but more useful if there were pre-recorded messages on the labels.

3. How useful did you find the system in the library? Why?

Same, quite useful – The new piece of information saying where tags are in the room is very helpful, and makes it easier to find.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Did not change from TellMate answer.

5. How reliable did you feel the device was? How consistent? Why?

Pretty reliable - same as TellMate.

6. How comfortable would you say you were when using the system?

Pretty comfortable.

7. What did you like least about the device? Why?

The range – you have to be so close to the tag.

8. What did you like most about the device? Why?

You quickly get a response whether you picked up a tag or not.

9. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

Pretty quick response time – I liked the clicking noise.

Good size, same as the TellMate.

Familiar interface and layout.

Too short of a range.

10. What features would you want to add?

Range increased and pre-recorded tags.

11. Overall, which reader did you prefer based on today's testing?

I prefer the Milestone because of the quick response time.

12. Would you consider investing in a home system in the future given a typical cost of 380 Euros? Why or why not?

Yea I would consider it.

13. How do you see this technology complementing or substituting your current methods of organization and navigation?

Did not change from TellMate answer.

14. Is there any other area that you think RFID would be useful in?

Did not change from TellMate answer.

Test Subject 3 Results

Interview A

1. Of the following, which do you currently use as a form of navigation? (Circle all that apply)

A. Sighted Guide (rarely)

C. Walking Cane

Are you familiar with Radio Frequency Identification?

No.

2. Have you ever personally experienced this technology?

No.

3. How often do you need to navigate through unfamiliar environments?

B. Weekly

4. On a scale from one to ten, how easy is it for you to navigate to places that are familiar to you?

8

5. On a scale from one to ten, how difficult is it for you to navigate to places that are unfamiliar to you?

3

6. Are there any other issues related to navigation that you feel we should be aware of?

No, not really.

Interview B

1. When in an unfamiliar indoors environment, what pieces of information would you find to be the most important in order to successfully navigate?

How an apartment is arranged – the layout of the room – directional information (go right, second door on the left, etc.)

2. Do you feel that the usage of technology to aid the blind is effective?

Things like speech synthesizers have been revolutionary and very effective.

I've tested different types of things; some technology has become obsolete though.

3. Do you have difficulty identifying transitional parts of buildings, such as entryways, elevators and/or staircases?

Yea if the building is unfamiliar, acoustical environment can trick you sometimes. But it's not really more difficult than finding anything else in the building.

4. Do you have difficulty identifying the different types of packaged food that you have in your cupboard?

Nope, I don't buy many different types of things, but it would be difficult to distinguish them. Limit what you buy. However, if I had a family, the case would be different, there would be many different types of things in the household, such as different types of milk.

5. What current system do you have to aid you in discerning between different objects such as food, clothing, medicine, etc.?

Usually I only wear black clothing, so that's not really an issue. I have more than 300 CDs and I use a trial and error method, or try to list them alphabetically to get a rough idea. It's not a very reliable method, especially if friends mix them up when they come to my home.

6. What organizational task(s) would you say you have the most difficulty with on a regular basis? What are the least difficult? Why?

CD collection is the most difficult.

Food is the least difficult.

TellMate Interview C

General notes during testing:

The test subject liked the placement of the tags on the doorframe, and the navigational directions recorded onto the tag.

There was not a single failed scan attempt when holding it parallel to the tag.

1. How difficult was it to use the system? Why?

Pretty easy.

2. How useful would you find the system for your home? Why or why not?

It would be very useful with CDs, and some shirts, but I don't have a huge use for it.

3. How useful did you find the system in the unfamiliar indoor environment? Why?

Shelves were nearly the same whether opening them or using the reader to find out what was in them. It could be useful for navigating through the building.

There could be universal 'audio signs' which are visual signs for sighted people, but scannable for the visually impaired.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Very easy to learn how to use – yea – the day will come when it could be placed in a mobile phone and there could be signs for ALL public buildings. However, I don't want to walk around with an added device if I only used it once in a while, but if I used it all the time, it would be a different story.

5. Would you consider investing in a home system in the future given a typical cost of 350 Euros? Why or why not?

No, with small household there are not enough ways to use it at the moment.

6. How reliable did you feel the device was? How consistent? Why?

Very consistent, no problems at all.

7. How comfortable would you say you were when using the system?

Comfortable, no problem at all.

8. What did you like least about the device? Why?

Not really a huge problem, but it could be slightly faster.

9. What did you like most about the device? Why?

Quite easy to use (button placement), and natural to hold with either hand.

10. What features would you want to add?

Part of a cell phone, not standalone device.

11. How do you see this technology complementing or substituting your current methods of organization and navigation?

It can compliment in some small ways, but I don't want it to be an excuse to not move forward in some areas, such as not improving the PA system for train stations.

12. Is there any other area that you think RFID would be useful in?

Can't think of any.

Milestone 312 Interview C

General notes during testing:

Subject was quicker to find tags on doorframes the second time around, sometimes took two attempts to get a successful scan.

The response time quicker than Tellmate, the subject noted.

1. How difficult was it to use the system? Why?

Quite easy. – Handling wasn't as easy as on the TellMate though.

2. How useful would you find the system for your home? Why or why not?

Did not change from TellMate answer.

3. How useful did you find the system in the unfamiliar indoor environment? Why?

Did not change from TellMate answer.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Did not change from TellMate answer.

5. Would you consider investing in a home system in the future given a typical cost of 380 Euros? Why or why not?

Did not change from TellMate answer.

6. How reliable did you feel the device was? How consistent? Why?

It is a little less consistent than the TellMate.

I don't like having to hold the button to scan.

7. How comfortable would you say you were when using the system?

Quite comfortable, no real problem.

8. What did you like least about the device? Why?

Having to hold the button while recording/scanning, as well as the design.

9. What did you like most about the device? Why?

Being able to replay a recording without having to rescan was very useful.

Liked having the scan button on the side not the front.

10. What features would you want to add?

A radio and cell phone, or iPhone implementation.

11. How do you see this technology complementing or substituting your current methods of organization and navigation?

Did not change from TellMate answer.

12. Is there any other area that you think RFID would be useful in?

Did not change from TellMate answer.

Test Subject 4 Results

Interview A

What motivated you to show up to testing with us today?

I was interested in seeing what it was.

1. Of the following, which do you currently use as a form of navigation? (Circle all that apply)

A. Sighted Guide

C. Walking Cane

Are you familiar with Radio Frequency Identification?

Yes.

2. Have you ever personally experienced this technology? In what way?

Yes, offices have been tagged in this building.

3. How often do you need to navigate through unfamiliar environments?

A. Almost daily

4. On a scale from one to ten, how easy is it for you to navigate to places that are familiar to you?

10

5. On a scale from one to ten, how difficult is it for you to navigate to places that are unfamiliar to you?

1-6, really depends on the sound in the area, etc.

Like in train stations it's difficult because of all the noise.

6. Are there any other issues related to navigation that you feel we should be aware of?

Look at places where it is difficult to maneuver around when designing solutions.

Interview B

1. When in an unfamiliar indoors environment, what pieces of information would you find to be the most important in order to successfully navigate?

Sound on the walls, structure on the floor, acoustics, sounds like printer, photocopier, or a clock ticking.

2. Do you feel that the usage of technology to aid the blind is effective?

Most important source of information for me when navigating is my ears so technology shouldn't interfere with hearing the environment. I develop an inner picture in my brain when navigating. If there are changes and I don't know, I could run into things.

3. Do you have difficulty identifying transitional parts of buildings, such as entryways, elevators and/or staircases?

No, once I am familiar with a place, I have the mental picture of it, of course you must be aware of it

Doesn't really trouble me

4. Do you have difficulty identifying the different types of packaged food that you have in your cupboard?

Not really, though of course it is somewhat of a challenge because you can't see what it is until you open it. My wife helps out with that stuff.

5. What current system do you have to aid you in discerning between different objects such as food, clothing, medicine, etc.?

I used to put Braille labels on to tell the different colors for shirts.

It will always be a challenge, but my wife helps out when she is around. She puts markings on clothing.

6. What organizational task(s) would you say you have the most difficulty with on a regular basis? What are the least difficult? Why?

Identifying CDs and books, especially CDs because you can't really put Braille on them are the most difficult.

Many things are very easy to do because they are part of daily living – there isn't one thing in particular.

TellMate Interview C

General notes during testing:

One scan failure throughout the testing.

The test subject said that he didn't really know what they should have felt like. For instance, we said find the piecrust, but you instantly think of a box?

1. How difficult was it to use the system? Why?

Not difficult at all

2. How useful would you find the system for your home? Why or why not?

Well, I'm not fond of moving around with too many gadgets.

I would easily be able to implement another solution besides this device.

It can solve many of the problems if I was alone, but I have a wife.

If the tags were pre-recorded on items it would be better. Reusing the tags isn't convenient to do because you have to take it off and store it some place.

3. How useful did you find the system in the unfamiliar indoor environment (library)? Why?

It would be very useful, especially cupboards, but to fill in the info yourself is less useful

Recording the messages yourself still takes time.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Yes, no trouble at all. Most people would have an easy time learning how to use it.

It fits easy in your hand.

I would want it implemented in a cell phone.

5. Would you consider investing in a home system in the future given a typical cost of 350 Euros? Why or why not?

Yes, with all these features I would consider it, but it would be nice not having to record my own messages. However, I would be more likely to use it if I was alone, but right now I have someone at home to help me out with this stuff. Maybe if we had it from the beginning she could have recorded the messages for me to use, but we have organized our lives in a way where my wife takes care of these things.

I like how the Milestone has the MP3 player, voice recorder, daisy book player and other features with the RFID reader. [We informed the test subject that the TellMate had these features as well.

6. How reliable did you feel the device was? How consistent? Why?

I didn't experience any unreliability, very consistent.

7. How comfortable would you say you were when using the system?

Easy enough to use, but you have to have it with you at all times.

They key lock isn't safe enough for me to put in my pocket.

8. What did you like least about the device? Why?

I don't feel the lock is safe enough, it's too easy to activate, maybe a key combination like a cell phone would be better.

I don't like the feel of the plastic; my fingers sweat while holding it.

I don't like that information is dependent on the device not the tag. [Recording goes with that specific reader, so another reader reading the same tag won't pick up the same message].

9. What did you like most about the device? Why?

It's easy to hold in your hand.

10. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

Could have been faster response time.

Ok size, shouldn't be any bigger, around the size of a cell phone is ok, button size ok, buttons should have better symbols on them.

Layout is ok with the three buttons and the cross, it's easy to memorize button layout

Packaged food range was ok, but the doorframe range could have been bigger.

10. What features would you want to add?

I would like to be able to delete the tag information, so that when you take the tag off an object and put it on another, it comes on as a blank tag. So you can scan a tag and delete the information on it.

11. How do you see this technology complementing or substituting your current methods of organization and navigation?

The main problem is that it is dependent on a unique device, but you could organize which reader is which I guess. It may be easier to have the info on the tag not the reader.

12. Is there any other area that you think RFID would be useful in?

If there was a bigger range (>5M) there could be more possibilities.

Could have RFID on the crossings on streets instead of the beeping noise.

Outdoor environments.

Milestone 312 Interview C

General notes during testing:

The test subject noted how there is no scan failure feature on the Milestone, it just keeps scanning.

Test subject said that the learning curve was a little more with this reader, however that may be because he got used to the other reader first, so he was trying to use it like the other device, and it may have been different had he tried this one first and the other one second.

He also noted that the Milestone 312 works better than the Milestone 311.

1. How difficult was it to use the system? Why?

Did not change from TellMate answer.

2. How useful would you find the system for your home? Why or why not?

Did not change from TellMate answer.

3. How useful did you find the system in the unfamiliar indoor environment (library)? Why?

Did not change from TellMate answer.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Did not change from TellMate answer.

5. Would you consider investing in a home system in the future given a typical cost of 380 Euros? Why or why not?

Did not change from TellMate answer.

6. How reliable did you feel the device was? How consistent? Why?

Did not change from TellMate answer.

7. How comfortable would you say you were when using the system?

Easy enough to use, but you have to have it with you at all times.

8. What did you like least about the device? Why?

Nothing specific.

I still would like to be able to delete a tag.

9. What did you like most about the device? Why?

I like the small design and having so many different functions.

I like the lock function better than the TellMate's.

10. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

It seems like a faster response time and I liked hearing the ticking to know that it was scanning.

It's an ok size.

It's less easy to hold the device when reading [scanning] than the TellMate.

But it is easier to switch between functions.

Range was about the same between both readers.

10. What features would you want to add?

Being able to delete the tag info.

11. How do you see this technology complementing or substituting your current methods of organization and navigation?

Did not change from TellMate answer.

12. Is there any other area that you think RFID would be useful in?

Did not change from TellMate answer.

13. Which reader did you prefer overall?

I prefer the Milestone 312 to the TellMate, but I'm not really well informed on the TellMate.

Test Subject 5 Results

Interview A

What motivated you to show up to testing with us today?

By helping us [The WPI group], it allows us to create better products for the blind.

1. Of the following, which do you currently use as a form of navigation? (Circle all that apply)

A. Sighted Guide (shopping)

B. Guide Dog

C. Walking Cane

D. GPS

Are you familiar with Radio Frequency Identification?

Not too much

2. Have you ever personally experienced this technology? In what way?

I tried it a few times just to try it, the Milestone 311 and 312, and reviewed the 311 a few years ago at an exhibition. I also worked for a company that sold the 312, so I got familiar with it.

3. How often do you need to navigate through unfamiliar environments?

A. Almost daily

4. On a scale from one to ten, how easy is it for you to navigate to places that are familiar to you?

8

5. On a scale from one to ten, how difficult is it for you to navigate to places that are unfamiliar to you?

6-7

6. Are there any other issues related to navigation that you feel we should be aware of?

I am blind accompanied by hearing impairment in one ear.

Interview B

1. When in an unfamiliar indoors environment, what pieces of information would you find to be the most important in order to successfully navigate?

For large buildings – Basic layout information, staircases, elevators, how to navigate from one floor to another, directional (straight corridor, etc.), also tactile information, like leading lines on the floor

2. Do you feel that the usage of technology to aid the blind is effective?

No, but we are getting there. 15 years back people said they could make all these devices to help us, with so many different gadgets, but it didn't work out.

It is getting to the point where we can put everything in the mobile phone, and can add programs into it; maybe we could have a program to recognize intersections, or adding RFID reader into mobile phone.

3. Do you have difficulty identifying transitional parts of buildings, such as entryways, elevators and/or staircases?

Yes sometimes, especially in large buildings like shopping malls.

Doors are very hard to recognize, and dogs can't recognize them either.

4. Do you have difficulty identifying the different types of packaged food that you have in your cupboard?

Yea, like cans and meats.

5. What current system do you have to aid you in discerning between different objects such as food, clothing, medicine, etc.?

Sometimes I shake objects to try to figure it out.

I go with a sighted person to help buy things, then put things away in certain areas, then just memorize the location.

EU regulation – Some medicine has to be marked with Braille, which is nice because I don't need to carry around a device with me to figure it out.

Also, the feel of things, and using my very low vision to see whether it is light or dark.
Tactile recognition.

6. What organizational task(s) would you say you have the most difficulty with on a regular basis? What are the least difficult? Why?

CDs are the most difficult.

Finding my own clothing is the least difficult, I have good organization of my clothes.

General notes during testing:

Expiration date is important to know.

Distance to shelves that is told when entering library has been difficult, they [the test subjects] underestimate the distance.

1. How difficult was it to use the system? Why?

Generally it's not difficult, though the range could be better.

2. How useful would you find the system for your home? Why or why not?

If the tags were already on the product and pre-recorded yes, if I had to do it myself every time, I'm not sure if I would use it, it might be easier to make a Braille label or memorize it [what is on the shelf].

3. How useful did you find the system in the unfamiliar indoor environment (library)? Why?

Useful, but I might use Braille instead, though Braille is subject to wear and tear, and the RFID tags are not.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Yea.

5. Would you consider investing in a home system in the future given a typical cost of 350 Euros? Why or why not?

Yes, though I am more likely to do it if the tag was prerecorded.

6. How reliable did you feel the device was? How consistent? Why?

Pretty reliable as long as you were close to the item.

7. How comfortable would you say you were when using the system?

Pretty comfortable.

8. What did you like least about the device? Why?

It is a separate unit instead of added on to say, a cell phone.

And the range was too short.

9. What did you like most about the device? Why?

The size, the speakers are loud and clear, it would be good for outdoor environments or noisy places.

10. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

The response time was ok, it is to be expected.

Nice size, and it fits nicely in my hand.

Button layout is nice.

The range could be better.

10. What features would you want to add?

It could be in an iPod®, mobile phone or color tester instead of separate device.

11. How do you see this technology complementing or substituting your current methods of organization and navigation?

It compliments what I'm using already, because it is nice to have options.

12. Is there any other area that you think RFID would be useful in?

Yea, like for public transportation, knowing what train was in the station.

Milestone 312 Interview C

General notes during testing:

Subject noted that this device had a much closer range than the TellMate.

1. How difficult was it to use the system? Why?

Generally it was not difficult, though the range could be a lot better – it's a bit more difficult than TellMate.

2. How useful would you find the system for your home? Why or why not?

Pretty useful, because it has other features too.

3. How useful did you find the system in the unfamiliar indoor environment (library)? Why?

Useful, when I got the hang of it, it was pretty smooth.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Yea.

5. Would you consider investing in a home system in the future given a typical cost of 380 Euros? Why or why not?

Yes, because of the other features.

6. How reliable did you feel the device was? How consistent? Why?

Because of the range and mis-scanning [not scanning successfully], it was all right.

7. How comfortable would you say you were when using the system?

Pretty comfortable, it's very easy, even if you're not familiar with the technology. I have been teaching the Milestone 311 to people over 90 and they got the hang of it.

8. What did you like least about the device? Why?

Range.

9. What did you like most about the device? Why?

Size, and I really like all the features.

10. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

The response time was pretty fast.

Good size.

It is a little harder to handle than the TellMate.

Button layout nice and logical and easy to navigate.

Range could be 10 times better.

10. What features would you want to add?

None.

11. How do you see this technology complementing or substituting your current methods of organization and navigation?

Did not change from TellMate answer.

12. Is there any other area that you think RFID would be useful in?

Did not change from TellMate answer.

13. What reader did you prefer overall?

I preferred the TellMate's RFID reading ability. Overall though I still like the Milestone 312 better because of the size, and the button layout (I liked that all of the buttons were on the top, not on the top and the side).

No preference whether I had to hold the button to scan or just press it once.

Note: This test subject had previous experience with the Milestone 312, but not the TellMate. Though it was explained that the TellMate offered very similar features as the Milestone 312, the subject still felt the amount of features on the Milestone 312 made it a superior product.

Test Subject 6 Results

Interview A

1. What motivated you to meet us for testing today?

I was asked by Thorkild to do it. I usually say yes when asked.

2. Of the following, which do you currently use as a form of navigation? (Circle all that apply)

C. Walking Cane

D. GPS

Are you familiar with Radio Frequency Identification?

Yes.

3. Have you ever personally experienced this technology? In what way?

No.

4. How often do you need to navigate through unfamiliar environments?

B. Weekly

5. On a scale from one to ten, how easy is it for you to navigate to places that are familiar to you?

9

6. On a scale from one to ten, how easy is it for you to navigate to places that are unfamiliar to you?

2

7. Are there any other issues related to navigation that you feel we should be aware of?

Reading sign and street names is quite difficult.

Interview B

1. When in an unfamiliar indoors environment, what pieces of information would you find to be the most important in order to successfully navigate?

Indoor environments, it can be signs. It can be difficult to find the steps and which way to go. Finding doors

2. Do you feel that the usage of technology to aid the blind has been effective?

No. We have signs but they are too difficult to manage. Tactile signs take too long to use and are troublesome.

3. Do you have difficulty identifying transitional parts of buildings, such as entrances, elevators and/or staircases?

No, but it is difficult to find the right one.

4. Do you have difficulty identifying the different types of packaged food that you have in your cupboard?

Yes, sometimes. If I have packages I know the colors then I often know what it is. Colors make is easy.

5. What current system do you have to aid you in discerning between different objects such as food, clothing, medicine, etc.?

I have a little sight. Reading close to my eyes. "Reading with my nose." [Holding text up to one's nose so that it can be read].

6. What organizational task(s), such as some of the tasks previously mentioned, would you say you have the most difficulty with on a regular basis? What are the least difficult? Why?

Deciphering between paperwork pertaining to politics is the most difficult. This is an area in which I would use RFID for.
Finding clothes is the least difficult.

TellMate Interview C

General notes during testing:
Subject had little difficulty to scan the tags, though some difficulty finding the location of the doorframe tag. No difficulty identifying food packages or location of tags.

1. How difficult was it to use the system? Why?
It was very easy.

2. How useful would you find the system for your home? Why or why not?

It is easy enough but it is too slow. I would not benefit much from it.

3. How useful did you find the system in the library? Why?

85

The cupboard system was useful. Otherwise we use small text, which is very difficult to read.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Yes.

5. How reliable did you feel the device was? How consistent? Why?

It is easy to use and has a reasonable weight. Maybe it has to be too close to the tag. I would like a larger range. Yes, it was consistent.

6. How comfortable would you say you were when using the system?

It was an awkward situation. If I used it more, I would feel more comfortable if I used it more.

7. What did you like least about the device? Why?

There are too many buttons. This wasn't an issue with this testing, but it could be a problem. Want the orientation to be omni-directional.

8. What did you like most about the device? Why?

Weight, fairly light.

9. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

Response time: too slow.
Size: It was ok. It fits nice in my hand.
Layout: too many buttons. Just using for scanning it was very easy though.
Range: It is too short. I would prefer 3 m for a range.

10. What features would you want to add?

None.
It can be used to replace sound devices at intersections [this could be seen as another area RFID would be useful in].

11. Would you consider investing in a home system in the future given a typical cost of 350 Euros? Why or why not?

I would buy it for the other features.

12. How do you see this technology complementing or substituting your current methods of organization and navigation?

I could use it in the streets if it was possible to activate different information systems. It would be useful to organize my paperwork with boxes and use tags to identify these boxes.

13. Is there any other area that you think RFID would be useful in?

Not as far as I see it but I do not know enough about it.

Milestone 312 Interview C

1. How difficult was it to use the system? Why?

This is not accurate enough. It is easy to use the device but there are too many flaws reading. The device is ok. It had better buttons than the TellMate.

2. How useful would you find the system for your home? Why or why not?

Same answer. It is easy enough but it is too slow. I would not benefit much from it. Too difficult to read the tags. Too many flaws.

3. How useful did you find the system in the unfamiliar indoor environment (library)? Why?

It worked in the library pretty well. In that case it was as useful as the other reader.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

No.

5. Would you consider investing in a home system in the future given a typical cost of 400-420 Euros? Why or why not?

No.

6. How reliable did you feel the device was? How consistent? Why?

No. I don't know if it's the surface [This may refer to the surface of the objects he was scanning. We were unable to get clarification]. To many flaws.

7. How comfortable would you say you were when using the system?

It is fine to hold it but I don't feel comfortable when it fails to read tags. I feel unsecure reading tags.

8. What did you like least about the device? Why?

I like the device as it is but there's too many flaws.

9. What did you like most about the device? Why?

Buttons. Well placed and good tactile feel.

10. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

Response time: Awful because of flaws. Sometimes it was quick.

Size: Same as the TellMate.

Layout: Better than the TellMate.

Range: Too small.

11. What features would you want to add?

Answer did not change from the TellMate.

12. Overall, which reader did you prefer based on today's testing?

The TellMate.

13. How do you see this technology complementing or substituting your current methods of organization and navigation?

Answer did not change from the TellMate.

14. Is there any other area that you think RFID would be useful in?

Answer did not change from the TellMate.

Test Subject 7 Results

Interview A

1. What motivated you to meet us for testing today?

Curiosity, and wishing to contribute to improving the possibilities for blind people.

2. Of the following, which do you currently use as a form of navigation? (Circle all that apply)

B. Guide Dog

C. Walking Cane

I tried GPS but it is not correct enough for my taste.

Are you familiar with Radio Frequency Identification?

I only heard a little about it, basically just that it could be used in the future.

3. Have you ever personally experienced this technology? In what way?

No.

4. How often do you need to navigate through unfamiliar environments?

C. On occasion

I would do it more, if I could.

5. On a scale from one to ten, how easy is it for you to navigate to places that are familiar to you?

It depends on the area, it's an 8 on average with the guide dog, a 6 without it. It is more difficult in the city, with all the traffic and noise, and easier in the countryside.

6. On a scale from one to ten, how easy is it for you to navigate to places that are unfamiliar to you?

4

7. Are there any other issues related to navigation that you feel we should be aware of?

GPS can tell me I am at an intersection, but not what type or any other specific information. I have a dream that the traffic lights that beep would be standardized – there would be something like that but only it would also tell me whether the light was red or green ALL over the country, and what direction it is.

1. When in an unfamiliar indoors environment, what pieces of information would you find to be the most important in order to successfully navigate?

Where things are. It depends what I am going to do there, for instance if it was a public office, it would be nice to know where the counter is, where the other information centers are, etc. Directional information would be important.

2. Do you feel that the usage of technology to aid the blind has been effective?

It has made a lot of progress, but you really have to be careful when you buy new things like stoves and refrigerators because if you don't consider the blind, it will be more and more difficult for them to use these products. For instance, CD players and DVD players have all their menus on the screen; so many people have difficulty with them.

3. Do you have difficulty identifying transitional parts of buildings, such as entrances, elevators and/or staircases?

Yes. If I have the dog with me, I can tell her to find the door, but you have to be really close to the door for her to see it, and sometimes she can't tell it's a door, for instance glass sliding doors. With a walking cane it is impossible.

4. Do you have difficulty identifying the different types of packaged food that you have in your cupboard?

Yes. I have a barcode reader. The barcode reader plays recorded messages, but I have to have someone tell me what it is first and other information about it before I can record the message onto it.

5. What current system do you have to aid you in discerning between different objects such as food, clothing, medicine, etc.?

The barcode reader, Braille for spices and CDs.

I have partial sight, so if I put my clothing very close to my face, then I can see what color it is. I know some people use Braille tags designed for clothing, or bar code readers. The barcode tags however are quite expensive.

6. What organizational task(s), such as some of the tasks previously mentioned, would you say you have the most difficulty with on a regular basis? What are the least difficult? Why?

The food is the most difficult. To find new places or trying to get from A to B, or intersections (including traffic light information, special traffic lights for bikes than for cars, etc.) is also difficult. Also which train that is coming, like the S trains, you have to constantly find someone to ask if it is going the right direction. Same with busses, sometimes there are three busses in a row that are all going to different places. I have to run around asking people what bus is going where.

Stationary objects, objects that are constant, never change are the least difficult.

I know people who are much more afraid at finding their way around than I am. The guide dog is a huge help.

TellMate Interview C

General notes during testing:

Subject had little difficulty to scan the tags, though some difficulty finding the location of the doorframe tag. No difficulty identifying food packages or location of tags.

1. How difficult was it to use the system? Why?

It was very easy.

2. How useful would you find the system for your home? Why or why not?

It depends on if the tags were prerecorded, if they were I would find it very useful.

If I have to record my own messages, then I already have a system that works [barcode reader, etc.].

3. How useful did you find the system in the library? Why?

Very useful if I was often going to find something in there.

When asked if she would find it useful if you could connect the device to your computer, go to a grocery store website, and download tag information so that any item in the market could be scanned and a message played:

I would find it useful to download the recordings from say a grocery store website, but others wouldn't because not everyone uses a computer.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

Yes. Tags should be pre-recorded.

5. How reliable did you feel the device was? How consistent? Why?

Quite reliable. If you couldn't feel the tags it would be a lot more difficult though.

Half a meter would be a great range for the tags.

6. How comfortable would you say you were when using the system?

Comfortable, no problem.

7. What did you like least about the device? Why?

The range. Also it would be nice to know when you scanned successfully, like a vibration or beep telling you the scan finished.

8. What did you like most about the device? Why?

It's easy to use, and easy to scan. It is a little more flexible with range and angle than say a barcode reader.

9. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

Very good response time, but could be faster. I didn't get impatient though.

I like the size of the device.

Very nice layout, it is easy to find the buttons. The key lock is nice.

The range isn't bad, but maybe a half meter or 30 cm range would be better.

10. What features would you want to add?

A longer range and the capability to have prerecorded tags.

11. Would you consider investing in a home system in the future given a typical cost of (350-380 euros)? Why or why not?

No, because I have a system that works, but if I didn't I would invest in that system. Also when my barcode reader dies, I would replace it with this.

12. How do you see this technology complementing or substituting your current methods of organization and navigation?

RFID does have some advantage over the barcode readers, but it would not fit in with my current methods.

13. Is there any other area that you think RFID would be useful in?

No.

Milestone 312 Interview C

General notes during testing:

Subject noted that it is a little more difficult for her to handle because you have to hold it down, but quicker than the TellMate.

1. How difficult was it to use the system? Why?

It is a little more difficult than the TellMate because it was difficult to press the button down. After a short while though, it was easy.

2. How useful would you find the system for your home? Why or why not?

Answer did not change from the TellMate.

3. How useful did you find the system in the unfamiliar indoor environment (library)? Why?

Answer did not change from the TellMate.

4. Was learning how to use the system and getting used to it worth the hassle? Why or why not?

It was a little more difficult than the TellMate but still worth it.

5. Would you consider investing in a home system in the future given a typical cost of 380 Euros? Why or why not?

For just the RFID feature, it is not worth it. Same response as TellMate.

It's also a little more expensive.

6. How reliable did you feel the device was? How consistent? Why?

Answer did not change from the TellMate.

7. How comfortable would you say you were when using the system?

Answer did not change from the TellMate.

8. What did you like least about the device? Why?

It is difficult to scan at first because of the way you have to hold it.

9. What did you like most about the device? Why?

Repeat function [Being able to repeat a recording after scanning the tag]. The lanyard.

10. Specifically, how did you feel about the device's response time? Size? Physical interface and layout? Menu design? Range?

Response time: It is faster than TellMate

Size: Very good size. Comparable to the TellMate

Layout: It is easy to find buttons; no problem.

Range: Is too short. A little more difficult to scan the tag than the TellMate.

11. What features would you want to add?

Answer did not change from the TellMate.

12. Overall, which reader did you prefer based on today's testing?

I prefer the Milestone because it can play word files.

13. How do you see this technology complementing or substituting your current methods of organization and navigation?

Answer did not change from the TellMate.

14. Is there any other area that you think RFID would be useful in?

Answer did not change from the TellMate.