THE FIND PROJECT: INTRODUCING AN

OPPORTUNITY FOR INDEPENDENCE

TO THE VISUALLY IMPAIRED

by

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DEDICATION

This thesis is dedicated to my nephew, Joaquin, for showing me how to love; my mother, Teresa, the inspiration for this research, for smiling every day; my father, Jim, for knowing when to be my parent and when to be my friend; my aunts, Ester and Virginia, for putting our family's needs ahead of their own; my sister and brother, Krista and James, for supporting their brother no matter what; Karen, for giving our family love and support; Katie, for being my best friend and love; and all friends and family who helped me.

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ABSTRACT

The number of visually impaired (VI) people is expected to increase to unprecedented proportions in the near future due to an aging population and diabetes, the nation's leading cause of blindness (NFB, 2009). An alternative to braille and embossed signage is needed as a VI person's means of way-finding and indoor navigation. These traditional means of indoor navigation, in conjunction with current mobile assistive technology such as canes or guide dogs, do not provide all of the information a VI person could receive with current technology existing in industries, outside of mobile assistive technology (MAT) for VI people.

This research examines the configuration of existing hardware and software technologies including a mobile application for VI people which interacts with a user's physical environment to facilitate a more effective, independent, indoor navigation experience. The traditional experience of a VI person using braille or embossed signage for indoor navigation is replaced by The Find Project's interactive technologies which guide a user through a physical space with visual and audible commands from a smartphone mobile device or Bluetooth® headset.

Usability testing revealed the prototype's effectiveness at assisting a VI person to independently navigate a physical space by lowering the number of errors the user committed moving through an unfamiliar space.

CHAPTER I

INTRODUCTION

The Find Project's focus is to improve the indoor navigating experience of VI people by supplementing braille and embossed signage with innovative MAT. The Find Project's MAT is integral to this improvement as the technology has shown the ability through usability testing to provide more information to VI users than they are currently receiving through traditional communication (i.e., braille or embossed signage). Lessening the challenges of a VI person improves their indoor navigation experience. Identifying areas of opportunity for technology makes the decision process simpler and more independent for VI people. With the configuration of existing hardware and software technologies in The Find Project (see Figure 1), VI people have the ability to independently navigate indoors. The research describes the process of assessing need, forming a hypothesis, testing the hypothesis, and creating design outcomes based on the research data. For the process to begin, exploration of VI technology and its role in VI people's lives is the first area of research.

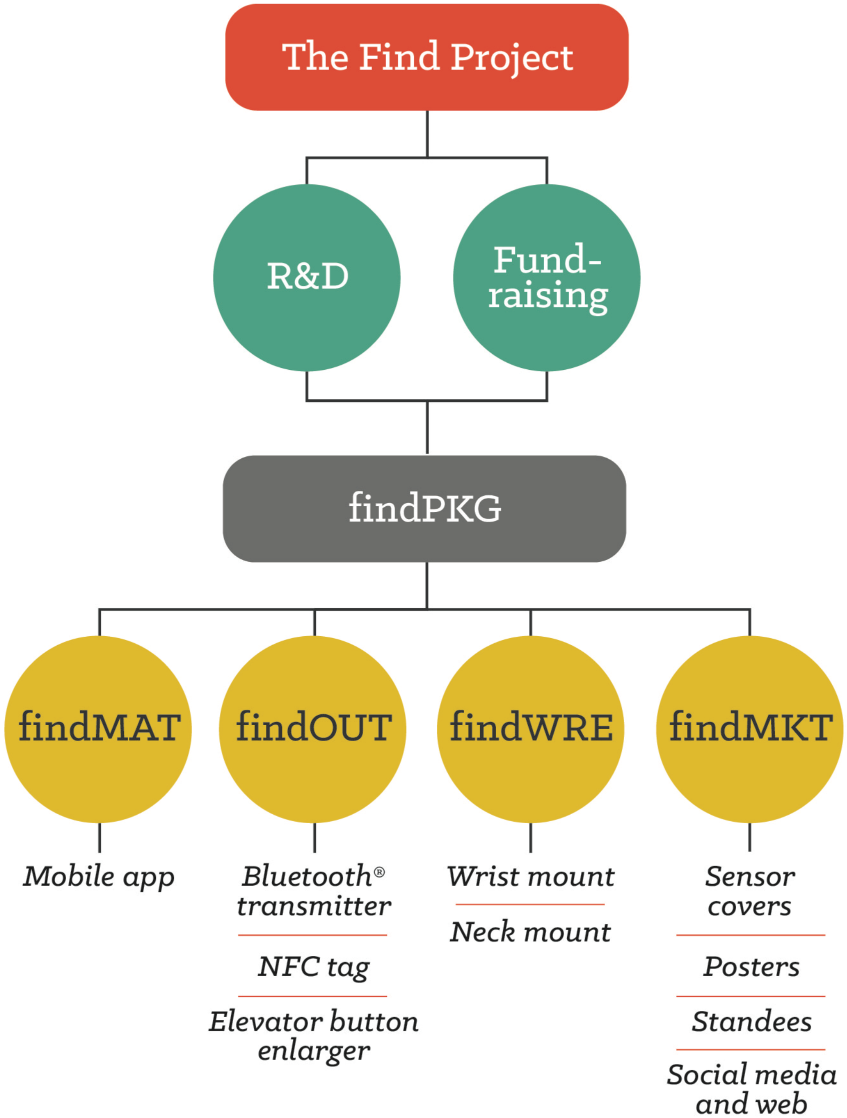


Figure 1. Organizational Chart. This chart illustrates the main deliverable of The Find Project, the findPKG. The findPKG contains hardware, software, and marketing materials to outfit physical spaces of businesses, organizations, and individual customers necessary to assist VI people in indoor navigation.

Defining Assistive Technology

Assistive technology (AT) is defined as "any item, piece of equipment, software or product system that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities," (Assistive Technology Industry Association, 2014).

The disability focus of this thesis is visual impairment (e.g. blindness and low vision). Mobile assistive technology (MAT) includes software native to a mobile device used to operate other applications within the device or perform tasks to assist VI people. MAT include hardware tools (i.e., cane or guide dog). MAT also includes screen reader software (i.e., Apple® Voiceover®). Apple® Voiceover®, native to Apple® devices, assists users through auditory and tactile commands for the purpose of operating mobile applications and features of the device. Voiceover® screen reader functionality came into prominence only in the last few years since about 2011 (Center for Persons with Disabilities, 2012). With an introduction to assistive technology, the next section defines the visual impairments relevant to this research.

Defining Low Vision and Blindness

Low vision is defined as partial vision loss resulting in uncorrectable vision impairment. "A person with low vision has severely reduced visual acuity or contrast sensitivity, a significantly obstructed field of vision – or all three" (Lighthouse International, 2014). Legal blindness is defined by the Social Security Administration as "best corrected visual acuity of 20/200 or less in the better eye, or a visual field limitation such that the widest diameter of the visual field, in the better eye, subtends an angle no greater than 20 degrees, as measured with a Goldmann III4e or equivalent stimulus," (Lighthouse International, 2014). Before the process of assessing need for MAT for VI people begins, an inventory of existing technology intended to assist VI people navigating indoors must be taken.

Current Mobile Assistive Technology

There are three primary tools used as MAT. These tools are: 1). canes, 2). guide dogs, and 3). GPS devices. GPS is “a U.S.-owned utility that provides users with positioning, navigation, and timing services” (GPS, 2014). Canes are primary options for navigation. A person places a cane in front of them as they navigate to tactilely identify changes in topography of the physical space. Although widely used, a cane only provides information of immediate physical surroundings, roughly four feet ahead (Bickford, 1996). In addition, the information provided by a cane is limited to locating an obstruction, not identifying an object. VI people also use guide dogs during navigation.

The benefits and limitations of a guide dog are similar to a cane as the service animal is effective in observing obstructions. A guide dog offers immediate feedback to the user about their surroundings. The guide dog is able to see obstructions farther away than the four-foot limitation of a cane. Although dogs avoid obstacles, not every object in a path is an obstacle (Guide Dogs for the Blind, 2014). Dogs are unable to identify and relay when it is safe to cross the street (Irish Guide Dogs, 2014). The level of information provided by a guide dog is less than what is needed to identify objects in a person’s path. The guide dog alerts their owner to stop proceeding, but the dog cannot determine routes to new destinations (Guide Dogs for the Blind, 2014). Another tool used by VI people, often simultaneously with a guide dog or cane, is global positioning system (GPS) technology.

GPS software is used in map applications on mobile devices to provide directions with auditory or braille commands. The Sendero Group provides BrailleNote GPS 2014, an app which allows for route planning in advance, as well as latitude and longitude coordinate inputs to direct people not navigating in a vehicle (Sendero, 2014). The NavBelt is a hardware technology using ultrasonic sensors to provide information about the user's surroundings. The NavBelt is "worn by the user like a belt and is equipped with an array of ultrasonic sensors," however "it is exceedingly difficult for the user to comprehend the guidance signals in time to allow fast walking (Shoval, 2003). These previously mentioned technologies lead to the review of mobile assistive technology in the form of mobile applications.

Accessibility Applications

CNIB (formerly Canadian National Institute for the Blind) states, "Accessibility refers to the ability for everyone, regardless of disability or special needs, to access, use and benefit from everything in their environment," (CNIB, 2014). Currently, there are a number of mobile accessibility applications to help VI people navigate their physical spaces outdoors such as Ariadne GPS, AbleRoad, BlindSquare, Mapp4All and Blind Navigator (AppleVIS, 2013). Each of these applications rely on GPS technology to provide information to the user. However, GPS navigation is not precise enough to give indoor directions to a user, even if a physical space like a library were digitally mapped. According to GPS.gov, "the official U.S. Government information [site] about the Global Positioning System (GPS) and related topics," the literature states GPS is reliable to provide 3.5 meter horizontal accuracy at best (GPS, 2014). The previously mentioned mobile applications for the visually impaired do not solve the problem of indoor navigation for VI people as the capabilities of GPS end at the entrance of an establishment (see Figure 2). There are, however, technologies commercially available in other industries applicable to the indoor navigation of VI people.

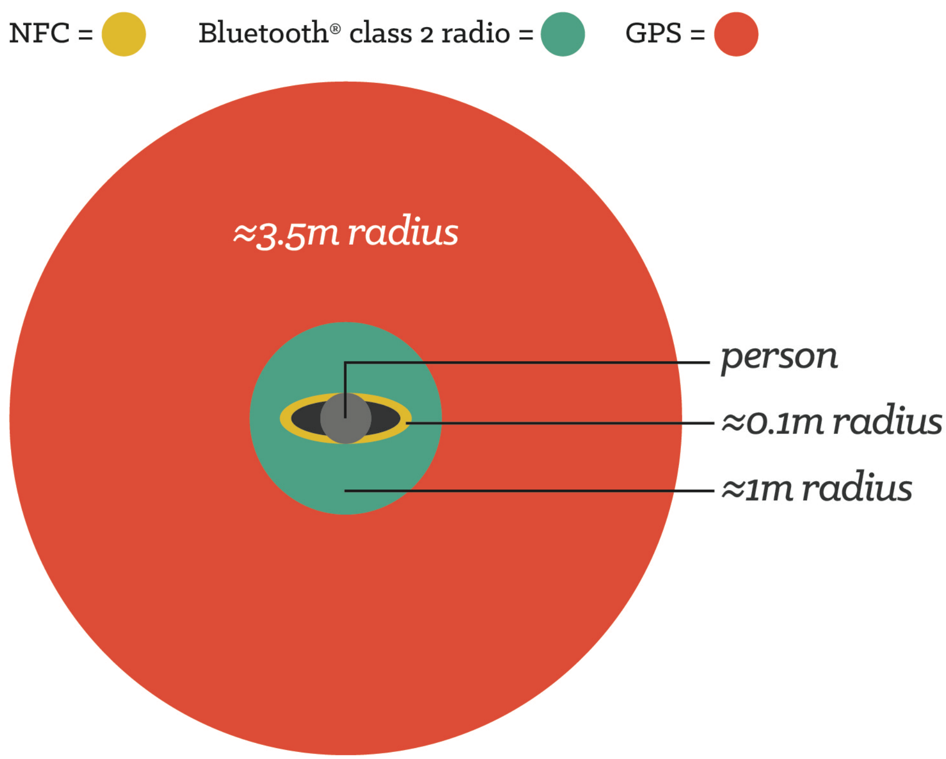


Figure 2. Proximity Distance Accuracy. This illustration shows the level of location accuracy for various technologies, with GPS being the least accurate.

<u>Statement of the Problem</u>

An alternative to braille signage, embossed signage, and human guides is needed as a VI person's means of way-finding and indoor navigation. According to a report published by the National Federation of the Blind called *The Braille Literacy Crisis in America,* "Fewer than 10 percent of the 1.3 million people who are legally blind in the United States are Braille readers. Further, a mere 10 percent of blind children are learning it" (NFB, 2009). In addition, the report stated, "Each year as many as 75,000 people lose all or part of their vision. As the baby-boom generation moves into retirement age and as diabetes (the nation's leading cause of blindness) approaches epidemic proportions, the NFB expects this number to increase dramatically..." With diabetes as the nation's leading cause of blindness, a VI person with diabetes can have hand and foot numbness due to poor blood circulation, making it difficult to read braille or embossed signage (Diabetes, 2014). With an aging population and diabetes, the nation's leading cause of blindness, increasing its margin annually, the number of visually impaired (VI) people is expected to increase to unprecedented proportions in the near future (NFB, 2009). The traditional means of indoor navigation (i.e., braille, embossed signage) in conjunction with current mobile assistive technology (i.e., canes, guide dogs), do not provide all of the information a VI person could receive with current technology existing in industries, outside of mobile assistive technology (MAT) for VI people.

This research describes the configuration of existing hardware and software technologies including a mobile application for VI people which interacts with a user's physical environment to facilitate a more effective, independent, indoor navigation experience. The traditional experience of a VI person using braille or embossed signage for indoor navigation is replaced by findMAT which guides a user through a physical space with visual and audible commands from a smartphone mobile device or Bluetooth® headset.

The following questions about visual impairment led to this research:

1.) How does a VI person, who does not read braille nor has the tactile sensitivity to read embossed signage, know they arrived at their destination without asking another person?

2.) Even if GPS technology was precise enough to track a person's movement using a mobile device indoors, how would GPS be able to inform a VI person of their location in a room of a building?

3.) Is it frustrating for VI people to ask for assistance when they want to perform a task spontaneously?

4.) If VI people could receive indoor navigation information on a mobile device, would they be able to operate their mobile device as well as their traditional MAT (i.e., canes or guide dogs)?

These are a sample of the questions addressed in the research through usability testing which measured a prototype's effectiveness at assisting a VI person to independently navigate a physical space.

Deliverables

The deliverable product of The Find Project is the findPKG (see Figure 3).

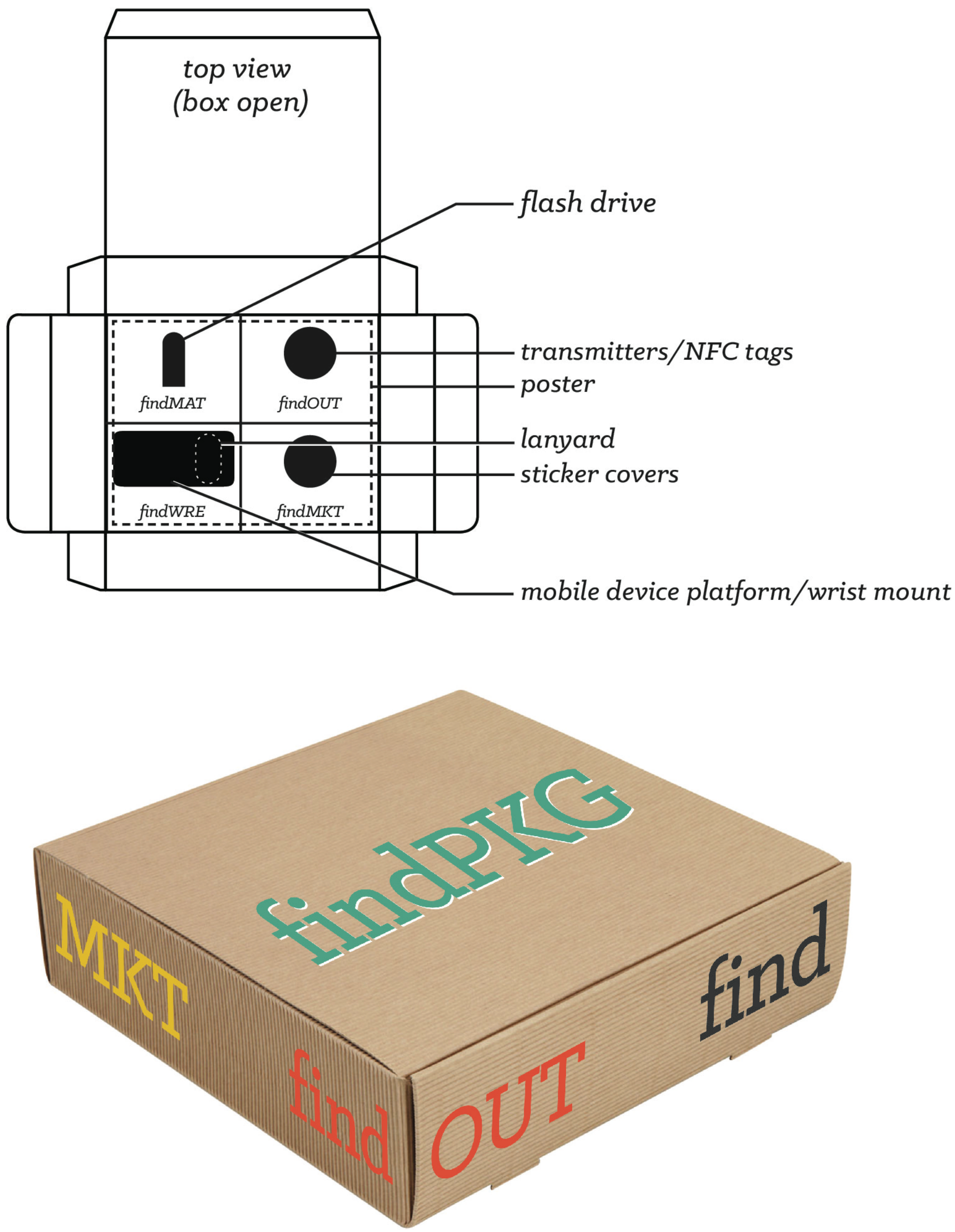


Figure 3. findPKG. The findPKG is the product which can be purchased by component category or whole.

The findPKG is the product intended to be shipped directly to businesses and individual customers. The flash drive contained in findPKG contains all instructional information for applying the technology to a physical space. The findPKG is divided into four categories to provide the assistive experience for the physical space equipped with this technology. The four categories are: 1). findMAT, 2). findOUT, 3). findWRE, and 4). findMKT (see page 2, Fig. 1). The findMAT category configures the mobile assistive technology and software present in the findPKG. The findOUT category focuses on hardware technology outfitting physical spaces. The findWRE category addresses wearable technology necessary to effectively assist users. The findMKT category is the marketing component, providing the brand and marketing materials. These categories are described further in Chapter 3 as to why they are the solution to the problem.

Technological advancements made in other industries not considered for inclusion in mobile assistive technology contributes to the problem. As evidenced by the inventory of MAT in previous sections, VI people are largely unaccounted for in mainstream technology. Despite ubiquitous social media outlets connecting people in every way imaginable, VI people want the opportunity for independence to navigate without human assistance, as evidenced by research in the next chapter (SALB, 2014). If AT for VI people mirrored a fraction of the advancements in technology adopted by mainstream society, VI people would be able to interact with people and objects in their world at their discretion. Also, VI people would not be forced to seek out assistance from another person when they need help. To understand the potential growth for MAT and design tools benefitting these people, mainstream technology must be observed, filtered through the lens of accessibility needs, and applied appropriately. This translation of technology requires communication between sighted users and VI users, mainstream and assistive technology designers, and key influencers in both technological industries.

Lack of collaboration between the sighted community and the VI community adds to the problem of inadequate assistive technology (AT). The worlds of these two groups are quite literally divided by vision, a sighted person's physical world is more visually weighted. More than any other sense, this makes the task of sighted people empathizing with blind and low vision people more difficult. Another responsibility of findMKT is to educate the sighted community about the needs of VI people and specifically how VI people interact with their environment, (i.e., physical indoor spaces). Once sighted people understand eliminating barriers to information benefits society as a whole, more of the sighted community will appreciate the merit in providing an opportunity for independence to VI people.

Hypothesis

The mobile assistive technology (MAT) industry benefits from findMAT through the elimination of barriers to information for VI people by collaborating with the sighted community. The findMAT technology provides more detail of a person's physical space, allowing VI people to spend less time navigating and more time doing the action they set out to do, such as reading a book or enjoying a sporting event. As users become increasingly familiar with the functionality of findMAT, their mobile interface, they can develop an emotional connection with it. Established AT like Apple® Voiceover® are used in conjunction with findMAT. Visual information presented in the findMAT interface is relayed to the user through audible information using Apple® Voiceover®. Sighted people using their mobile devices while multitasking is currently not an option for VI people. The majority, if not all, of a VI person's attention when navigating focuses on safety.

Navigation and safety, although clearly important to a person, are not what people want to *focus* on in their daily lives. People want to converse, play, or be spontaneous while navigating, and VI people are no different (SALB, 2014). It is the responsibility of society as a whole to provide for all in regards to public infrastructure. Currently, blind and low vision people are underaccounted for technologically and infrastructurally, unlike sighted people. The findPKG is a solution to providing a more engaging and supportive physical infrastructure benefitting all people in society.

CHAPTER II

PRELIMINARY RESEARCH

Internal and External Influences of Technology Adoption

To gain insight to the environments and daily operations of VI people, observations were imperative components to the research process. These observations were conducted at the San Antonio Lighthouse for the Blind (Lighthouse), a military goods manufacturing company in San Antonio, Texas employing blind and low vision people. The Lighthouse visit had three goals: 1). observe AT utilization, 2). discuss influencers of AT adoption, and 3). present findPKG in theory to get initial feedback of its proposed benefits. A questionnaire used as a survey instrument at the Lighthouse was essential to gaining an understanding of each person's level of proficiency with AT, as well as an introduction to their history with AT (see Figure 4). Questions like, "If used, do you view these [assistive technologies] as efficient, cumbersome, or neither?" are beneficial to ask as they provide information about a person's willingness to adopt new technology. The questionnaire is divided into two sections: 1). current mobility and 2). potential mobility. Current mobility discusses the interviewee's current relationship with MAT, and potential mobility discusses the person's willingness to adopt new technology. A sample of 18 participants and their qualitative data is reviewed in this research.

SAN ANTONIO LIGHTHOUSE FOR THE BLIND QUESTIONNAIRE

The main objective in speaking with the visually-impaired workers at San Antonio Lighthouse for the Blind is to gain insight to their knowledge and use of assistive mobile technology in their work setting and daily lives, in general. In addition, the workers will be asked about their likeliness to incorporate new assistive mobile technology into their daily lives as a supplement for canes, service animals, and human guides.

Current Mobility

1. When walking through your work building, do you navigate using a cane, guide dog, or human guide?
2. When walking through public spaces, do you navigate using a cane, guide dog, or human guide?
3. When walking through your personal spaces, do you navigate using a cane, guide dog, or human guide?
4. If used, do you view these assistances as efficient, cumbersome, or neither?
5. If you do not navigate with any of these assistances, what contributed to this decision?
6. Are there any activities involving walking which you do not participate in due to not being comfortable performing independently or with assistance?

Potential Mobility

1. If your mobile device had a camera and it could see for you as you walk, would you use it with a cane, guide dog, or human guide? If not, please explain.
2. Are there situations in your daily life where you prefer walking with assistance more than other times, for instance, through a crowded mall or down the street?
3. If your mobile device replaces a cane or other aid, you will appear the same as many sighted people walking while using their mobile devices. Is this blending into society beneficial to you?
4. Is there anything which you think would benefit you to have as a feature on a mobile application to improve your life, for instance, your camera phone "reading" a restaurant menu or guiding you to a public bathroom?
5. Based on the description given of the proposed technology, can you envision incorporating it into your daily life?

Figure 4. Lighthouse Questionnaire. This questionnaire was administered to better understand VI people's relationship with MAT.

The purpose of the visit was to observe how the VI workers traversed through the facility spaces, operated machinery, and lived their daily routines with or without AT. In addition to these observations, another goal of the research visit was to gain insight to individual's opinions about AT and its role in their lives, if at all. A majority of the workers observed at Lighthouse did not use a cane inside the facility or in their work spaces, only in the general public. No guide dogs were observed. Through the administration of the questionnaire, many VI people at the Lighthouse expressed initial hesitancy or resistance to using AT, such as canes or screen readers, for personal, professional, or academic purposes until "[they] had to," (SALB, 2014). Similar sentiments expressed were they "did not want to feel different" by using AT but often became "frustrated" trying to function without the sense of sight or technology. Following questions about their current relationship with technology, the interviews shifted to discussing findMAT.

When interviewees were presented the brief description of findMAT as stated in the introduction of Chapter 1, and subsequently asked if they would consider trying the technology, all subjects said they would likely try it but would be more comfortable doing so in certain situations rather than others. The situations they were hesitant about were crowded settings like shopping malls or places requiring high levels of detail to function like finding a hotel room. All interviewees agreed, as familiarity grew with findMAT, they would likely become more confident and use it in more situations.

The subject of technology adoption shifted from external influences, (e.g., technological performance) to internal influences (e.g., self-awareness) when questions were asked about how the interviewees viewed themselves in society. The initial hypothesis was VI people do want to blend more into society by navigating with only a mobile device as opposed to a cane or guide dog, since a person entering a room with a cane generally becomes a focus of attention and care. Some interviewees stated they would be "all for" a supplement to a cane, but many people said they did not mind navigating with a cane due to the increased care people give to them (see page 14, Fig. 4).

A user's adoption of findMAT is directly dependent upon the technology's response time, which refers back to the interviewees' hesitancies in crowded settings, where reaction time is shortened. With findMAT, a person navigates at their own pace allowing their body movement to trigger the sensors providing directional information. The findMAT feature allows the user to determine their speed of navigation which proved advantageous as interviewees stated they did not go places in the past for fear of inconveniencing their accompanying person. In those instances, the VI person did not want to navigate alone in those situations either. As evidenced by the qualitative research from the Lighthouse observation, motivations for or against technology adoption varies based on lifestyle, profession, societal pressures, and technology effectiveness. In addition to technological performance, a personal connection with the technology must be made for successful user adoption.

Psychology of Patient Therapy Adherence with Humanizing Objects

The psychology of patient therapy adherence with humanizing objects plays an important role in users accepting findMAT into their daily lives. Patient therapy adherence is a phrase used in the medical community to describe the effectiveness of a patient to follow prescribed rehabilitation instructions (MIT Media Lab, 2011). The process of a VI person learning how to live and function with technology parallels the possible struggle it can be for a patient to adhere to a therapy regimen. By humanizing the technology, it assists the user in building a connection, especially early in the adoption process when, theoretically, acclimation is most challenging. The time period when the user is most likely to discontinue use of findMAT is early in the acclimation period as initial steps to learning the new technology are most difficult. In the initial stages, users likely have not established a connection with the technology, so deleting the application from their mobile device is easier. VI user frustration with technology is examined in *Determining the Impact of Computer Frustration on the Mood of Blind Users Browsing the Web,* a study which tracked users' emotions and responses to technological problems using the Internet (Lazar, 2006). The study found VI users with more years of experience using screen readers to navigate the Internet became less frustrated with a problem than people who were relatively new users. In addition, the VI users, for the most part, did not react as expected to frustration. Users did not reboot computers or give up on tasks. They took additional time to complete tasks, and the researchers attributed this motivation as pride of task completion.

The findings in the user frustration study are encouraging for findMAT. There is potentially less "giving up" as there is with mainstream technology where people delete applications from their mobile devices with ease. In addition to technological sufficiency, product adoption is aided by VI people forming a relationship with the product (Diana, 2011).

A user making a personal connection with an inanimate object is a goal for every company in business of selling goods and services, not just the assistive technology industry. People build relationships with objects they use in their daily lives. From naming their vehicles to constantly having their mobile devices by their side, personal connections with inanimate objects and the humanization of objects is not a novel idea. This reality makes findMAT more than a navigation app for VI people. The findMAT technology gives users the opportunity to connect to marketing and advertising as well as objects of interest in their physical spaces. Reception of advertising and marketing for VI people becomes a “pull” scenario, meaning VI users request marketing information from only the businesses and organizations they wanted. In the article, “Enchanted Objects: Designing Products to Express Emotion,” the author cited examples of designing human qualities into objects to facilitate the connection between the user and object, such as the power light of a Mac® laptop pulsing from dim to bright to capture the essence of breathing (Diana, 2011). In addition to humanizing AT, gamification plays a role in users adopting findMAT.

The relationship a VI person has with findMAT parallels the experience of a patient adhering to a physical therapy regimen. New Media Medicine describes innovation in patient care with Oovit PT, using gamification in physical therapy to improve patient adherence to doctor-prescribed therapy regimens (MIT Media Lab, 2011). Gamification involves introducing play or challenges to an otherwise straightforward, unengaging action like performing physical therapy. Gamification benefits findMAT by empowering VI people to have fun with the technology. Games can be developed like a virtual hide-and-seek game, allowing users to have fun with family and friends while becoming more familiar with the technology.

Understanding internal and external influences of technology adoption as well as the benefit humanizing objects has on technology acclimation periods serves as a basis of knowledge to compare technologies studied in academic research.

Literature Review

The search terms used to research scholarly journals were: vision impairment, blind, low vision, indoor navigation, and assistive technology. After cursory research through more than a dozen journal entries, three literature articles were selected for discussion in this research: 1). "Indoor Navigation by People with Visual Impairment Using a Digital Sign System", 2). "A Prototype Navigation System for Guiding Blind People Indoor using NXT Mindstorms.", and 3). "Indoor Positioning System based on Sensor Fusion for the Blind and Visually Impaired."

Digital Sign System

The article titled, "Indoor Navigation by People with Visual Impairment Using a Digital Sign System," discusses the development and testing a "Digital Sign System" and "Building Navigator" (Legge, Beckmann, Tjan, Havey, & Kramer, 2013).

Claim

The Digital Sign System (DSS) claims to enhance way-finding for VI people through the distribution of digitally-encoded signs throughout a building. DSS operates with the use of the Building Navigator software which has three modes of functionality: 1). tag browsing, 2). exploration, and 3). route finding.

Methodology

Tag browsing is achieved through the use of a camera-enabled tag reader locating digital tags placed on walls near signage for the entrances to rooms or passageways. Testing of this technology produced favorable results with the lowest median accuracy score for a group equaling 89% of 38 identifiable tags (Legge et al., 2013).

The second function of Building Navigator is exploration. This function allows users to receive information about multiple DSS locations ahead in their path. This technology was tested by "placing subjects at a starting location in an unfamiliar corridor and [asking] them to use the system to find another room on the same corridor." Participants tested this function with and without the DSS tag reader. With the tag reader, participants used the reader to identify rooms they passed on their way to their desired room. Without the tag reader, participants relied on the 2D maps of the Building Navigator software. Without the tag reader, the user did not have location sensing capability, so they relied on traditional means of location identification (i.e., braille and embossed signage). The exploration function proved effective as all participants completed the task of room identification.

The last function of Building Navigator is route finding. The user is provided a series of waypoints and the corresponding instructions to get from waypoint to waypoint. The user keeps track of their progress through the waypoints by identifying the room they are near with the tag reader. Users were able to effectively reach destinations with this function even if they navigated off the intended path by entering a new starting point.

Strengths and Weaknesses

DSS and Building Navigator, collectively, are effective tools for indoor navigation of VI people, but the technology does not function as effectively individually. If a VI person cannot utilize DDS with the tag reader, the user must rely on reading braille or embossed signage for location identification. The technology also requires a piece of hardware (tag reader) in addition to the user's smartphone mobile device to be fully functional. In addition, object identification smaller than architectural scale objects (i.e., elevators and staircases) are not identifiable with this technology.

NXT Mindstorms

The article titled, "A Prototype Navigation System for Guiding Blind People Indoors using NXT Mindstorms," is a robotic system that travels with the VI user.

Claim

The NXT Mindstorms robotic system claims to use "inertial navigation for mapping and ultrasonic sensors for obstacle avoidance" (Alhmiedat, Taleb, & Samara, 2013).

Methodology

A robotic system precedes the navigation path of a VI person using ultrasonic sensors to detect obstacles in the user's path. The robotic system uses inertial navigation (i.e., the physical movement of an object encoded into binary code to determine distance traveled) to provide directional information to the user. The robotic system receives a reference point command from the user, calculates the optimal route based on a weighted map of the area, and relays that information back to the user through auditory commands.

Strengths and Weaknesses

The NXT Mindstorms literature states, “the implemented system works efficiently in small environments, and extra work has to be added in order to expanded the proposed prototype. Second, an extensive effort has to be devoted before using the proposed system in real situations, since a large number of reference points have to be pointed in order to make it possible to convert the infrastructure (environment) to a weighted graph...” (Alhmiedat et al., 2013). The robotic system does not identify objects of interest; it only recognizes obstructions within two meters.

Kalman Filter

The article titled, “Indoor Positioning System based on Sensor Fusion for the Blind and Visually Impaired,” is a software configuration housed on a mobile device to provide indoor positioning (Gallagher et al., 2012).

Claim

The system claims to provide indoor positioning by fusing “information provided by all the smartphone’s sensors (Wi-Fi, accelerometer and magnetic flux sensor)...” (Gallagher et al., 2012). Through estimation of a user’s speed and step size, the system uses map matching and Wi-Fi positioning to locate a user.

Methodology

Indoor positioning is calculated through, “the Wi-Fi positioning engine that feeds the Kalman filter...” (Gallagher et al., 2012). The Wi-Fi positioning method depends on building a database of information based on access points (APs) and signal strengths, along with a positioning phase, which, “uses pattern matching algorithms to match a measurement made by the user’s device to the pre-recorded fingerprint database.”

Strengths and Weaknesses

The Kalman filter positioning system managed a 35% increase compared to positioning performed entirely with Wi-Fi. The literature stated the Kalman filter positioning system is accurate enough to deliver signage and contextual information to VI people. However, point-to-point indoor navigation is not probable with this system due to Wi-Fi measurements varying greatly and being unpredictable (Gallagher et al., 2012).

A review of these scholarly articles related to findMAT shows, while each of the technologies discussed provides useful information VI people, none of the systems provide robust (i.e., non-Wi-Fi dependent) positioning and navigation or allow for small-scale object identification. For these reasons, The Find Project research is innovative in its approach to VI indoor navigation. Following a review of scholarly literature, a comparative market analysis is conducted to determine how the findMAT technologies are positioned with commercially available MAT.

Comparative Market Analysis

There are four companies out of more than ten researched providing technologies and making claims similar to findMAT. These companies are Google™, Sensewhere™, Visus Technology, Inc., and Estimote, Inc. Only one of these companies, Visus Technology, Inc., developed their product specifically for the visually impaired.

For the purpose of this research, six key factors were used to compare among the companies (see Figure 5). The attributes are:

1). The technology has a functional location accuracy less than a 3.5 meter radius.

2.) The technology tracks a user's path progress.

3). The technology provides indoor turn-by-turn directions.

4.) The technology provides vertical orientation tracking.

5.) The technology is GPS and Wi-Fi independent.

6.) The technology can identify objects in a user's path.

Indoor navigation is the main capability claim of findMAT, so the comparative market analysis starts with a company making the same claim.

Companies > Technologies ⌄	Google™ IPS	Sensewhere™	Visus Technology, Inc.	Estimote, Inc.	findMAT
Accuracy *< 3.5m radius*				X	X
Track user's *path progress*			X	X	X
Turn-by-turn *directions indoors*	X				X
Vertical *orientation tracking*		X			X
GPS/Wi-Fi *independent*					X
Identify *objects in path*			X	X	X

Figure 5. Comparative Market Analysis. This chart shows the various key factors analyzed among five companies, including findMAT, to determine if there was a company on the market providing a technological solution similar to The Find Project.

Google™

An emerging technology relevant to findMAT is the Internal Positioning System (IPS) which Google™ made available with Google Maps (ExtremeTech, 2011).

Claim

IPS technology is intended to be what its name describes, a system to locate a user's indoor location, but the technology through Google Maps fails to do more than place a marker in the rough vicinity of the user, much like the 3.5 meter accuracy of GPS. This IPS technology was tested using an iPhone 5 and the Google™ Maps app.

Methodology

Google™ provides digital maps of multilevel buildings, but the specific areas of those buildings are not selectable as destinations. The user must arbitrarily "drop a pin" where they want to go on the map, and the application, in fact, provides directions indoors to the area, starting at the main entrance of the building. However, these directions are a static list for the user to follow; this feature does not track the user through their progression of the direction's path.

Strengths and Weaknesses

Although an effort has been made to digitally map an indoor location, the technology falls short in a few ways. First, directions are provided starting from the main entrance every time a user initiates a request for directions. This potentially discourages for a user who is lost in the middle of a large building like a mall or airport. Having to walk back to the main entrance of a location to get indoor directions from the app may dissuade the person from using the technology, subsequently asking for help. Second, the technology does not take into account any vertical orientation on the map, meaning a user cannot determine which level of a building they are currently on to return back to the main entrance even if they so desired. Third, Google™ Maps does not identify the area of the building the user is in, it only provides a flat, non-selectable map image on which to place a blue marker, the user's approximate location. This is not necessarily a problem for sighted people who view the map and "drop a pin" for directions to the location. For the visually impaired, however, the IPS technology cannot be used. A visually impaired person has no way of knowing where to "drop a pin" on the Google™ map.

Summary

Google™ IPS provides only one of six key attributes for indoor navigation:

1). Google™ IPS cannot locate accurately less than a 3.5 meter radius.

2.) Google™ IPS does not track a user's path progress.

3). Google™ IPS does provide indoor turn-by-turn directions.

4.) Google™ IPS does not provide vertical orientation tracking.

5.) Google™ IPS is not GPS and Wi-Fi independent.

6.) Google™ IPS cannot identify objects in a user's path.

The IPS system is certainly a first step towards truly digital maps, but it is not the current solution for indoor navigation of VI people.

Sensewhere™

Sensewhere™ is a software indoor location technology with retail and social media applications (Sensewhere, 2014). Sensewhere™ was not tested; all information was gathered from the company website.

Claim

Sensewhere™ claims to offer “indoor GPS” which “seamlessly integrates multiple technologies where available e.g., GPS, A-GPS, Wi-Fi, Bluetooth®, NFC, Cell ID, etc.” (Sensewhere, 2014). The phrase “where available” in the previous statement suggests the company’s technology becomes increasingly less reliable the fewer technologies it has to reference. Sensewhere™ also claims to offer an indoor accuracy of less than 10 meters. Finally, Sensewhere™ makes no claim to provide users with directions through a physical space, for instance from one Sensewhere™ user’s position to another Sensewhere™ user’s position. The company’s technology is not interacting with the physical building but rather with radio frequency (RF) sources in and around the building.

Methodology

Sensewhere™ uses A-GPS, assisted GPS, which “describes a system where outside sources, such as an assistance server and reference network, help a GPS receiver perform the tasks required to make range measurements and position solutions” (LaMance, 2002). Sensewhere™ technology “uses a patented hybrid approach to deliver a location fix using the [RF location] database...” (Sensewhere, 2014). Access to this database requires cell service or a Wi-Fi, which can be unreliable.

Strengths and Weaknesses

The "outside sources" mentioned in the "Methodology" section include cell towers and their corresponding cell ID's through which cell phones largely operate. Cell ID's are unreliable sources for location accuracy since this calculation depends on cell-site size which range from 2km-20km, and, naturally, there are fewer base stations in rural areas, making this technology poor in terms of accuracy and consistency (AT&T, 2014). The company's claim of not needing in-building hardware installation seems attractive at first, but the reality is Wi-Fi, Bluetooth® and near-field communication (NFC) are all systems which require hardware. With an indoor accuracy of less than 10 meters, this location range of about is too large to be a reliable source for indoor navigation directions. At a minimum per the *2010 ADA Standards for Accessible Design*, an establishment must provide a "turning space…of 60 inches diameter minimum" (ADA, 2010). Buildings meeting the minimum ADA design standards have pathways too narrow for the Sensewhere™ technology to reliably position a user.

Summary

Sensewhere™ provides only one of six key attributes for indoor navigation:

1.) Sensewhere™ cannot locate accurately less than a 3.5 meter radius.

2.) Sensewhere™ does not track a user's path progress.

3). Sensewhere™ does not provide indoor turn-by-turn directions.

4.) Sensewhere™ provides vertical orientation tracking through Wi-Fi triangulation positioning methods (Sensewhere, 2014).

5.) Sensewhere™ is not GPS and Wi-Fi independent.

6.) Sensewhere™ cannot identify objects in a user's path.

Based on the information provided, Sensewhere™ technology is not the current solution for indoor navigation of VI people.

VelaSense®

VelaSense® is a "smartphone application suite" developed by Visus Technology, Inc. VelaSense® technology was not tested; information was gathered from the company website.

Claim

Partnering with Verizon™, it provides VI users with imaging processing, navigation, and voice command capabilities (VelaSense, 2014). The focus of VelaSense® technology's inclusion in this analysis is in reference to the application's navigation feature.

Methodology

VelaSense® literature states the technology employs the use of GPS for point-to-point navigation. Further review of the company's website, Visus Technology claims to provide solutions for "mobility and navigation through outdoor and indoor environments" using "place recognition and room mapping tools" (VelaSense, 2014). While precisely *how* the application's technology accomplishes these tasks was not explained, clearly the application uses the "[Verizon™] cloud to store video files and other data from previous routes, and then deliver it quickly and easily back to the user" (VelaSense, 2014).

Strengths and Weaknesses

As stated with the previous companies in this comparative analysis, GPS technology is sufficient for point-to-point navigation if those points are location addresses. GPS is not reliable to navigate indoors as it is not precise enough (an accuracy of about 3.5 meters), and there is no standard for providing truly digital, interactive, multi-level maps of locations. Using the Verizon™ cloud to store information means the ability to effectively navigate indoors with the mobile application largely depends on access to the Verizon™ cloud, which can be a security issue with user's potentially mapping their homes and a reliability issue with user's needing to be connected to Wi-Fi or Verizon™ data service to access the cloud information.

Summary

VelaSense® provides only two of six key attributes for indoor navigation:

1). VelaSense® cannot locate accurately less than a 3.5 meter radius.

2.) VelaSense® does track a user's path progress.

3). VelaSense® does not provide indoor turn-by-turn directions.

4.) VelaSense® does not provide vertical orientation tracking.

5.) VelaSense® is not GPS and Wi-Fi independent.

6.) VelaSense® can identify objects in a user's path.

While this application is intended to be an all-inclusive application suite, the one area where it is clear this application can be challenged is with indoor navigation, especially if it is depending on GPS to navigate those spaces. For these reasons, VelaSense® is not the current solution for indoor navigation of VI people.

Estimote, Inc.

Estimote, Inc. (EI) is included in this market analysis due to the company's technology being most closely aligned with the technological needs of findMAT. EI described itself as a “technology start-up building a sensor-based analytics and engagement platform (Estimote, 2014). EI technology was not tested; all information was gathered from the company website.

Claim

EI works off of Bluetooth® and Wi-Fi technologies to operate beacons placed on products and surfaces in a business, which provide an enhanced shopping experience. These beacons are walnut-sized computers communicating with the EI mobile application through Bluetooth® and other wireless sensors, sending marketing information to the user of the app as well as temperature and motion sensor information through radio signals to the business owner. EI claims the beacons are “unlocking micro-location and contextual awareness” (Estimote, 2014).

Methodology

According to EI literature, “unlocking micro-location and contextual awareness” is achieved by placing these beacons around the perimeter of the store space and calibrating the mobile application software to these coordinates. The current construct of the EI technology is structured to fulfill marketing and sales needs for business owners, providing “richer, more personalized experiences” for shoppers (Estimote, 2014). The company’s business model is not to provide an indoor navigation experience for VI people, but, rather, provide marketing information to a user who passes by an EI beacon in or around a store.

Strengths and Weaknesses

The beacon-perimeter process appeared to successfully locate a user within the perimeter of those beacons per the illustrations on the company website. However, this beacon perimeter is far from a digital map of the store space. There is no information provided to the user or application about the layout of the store space as the user moves towards the center of the room.

Summary

EI provides only three of six key attributes for indoor navigation:

1). EI locates accurately less than a 3.5 meter radius.

2.) EI does track a user's path progress.

3). EI does not provide indoor turn-by-turn directions.

4.) EI does not provide vertical orientation tracking.

5.) EI is not GPS and Wi-Fi independent.

6.) EI can identify objects in a user's path.

Although EI beacons, as currently sold, are not the solution for the indoor navigation of the visually impaired, a portion of the technology, specifically Bluetooth® and microcomputer processing, has an application in the assistive technology industry for indoor navigation of VI people.

After a comparative analysis of four companies, it was evident where findMAT is well positioned in regard to technologies currently on the market:

1). The findMAT technology locates users accurately less than a 3.5 meter radius through the use of motion sensors and Bluetooth® technology to locate rather than GPS and Wi-Fi.

2.) The findMAT technology tracks a user's path progress using motion sensors and Bluetooth® technology.

3). The findMAT technology provides indoor turn-by-turn directions stored in Bluetooth® transmitters and NFC tags.

4.) The findMAT technology provides vertical orientation tracking with motion sensors and Bluetooth® technology.

5.) The findMAT technology is GPS and Wi-Fi independent.

6.) The findMAT technology identifies objects in a user's path using NFC technology.

The next chapter discusses these technologies in depth and illustrates their effectiveness through a usability study.

CHAPTER III

RESEARCH METHODS

The Find Project Technology

The purpose of findMAT is to assist VI people with indoor navigation. To do this, a scan of the technological environment was performed in the assistive technology sector as well as the mainstream technology sector. After a review of the current state of assistive technology for VI people presented earlier in this research, attention shifted to mainstream technology. Bluetooth® technology, motion sensors, and near-field communication (NFC) are components of findOUT's technological configuration. The decision to not depend on Wi-Fi or GPS to position and guide a user through indoor spaces is based on Wi-Fi not currently being a universal technology and GPS technology not having the level of accuracy needed for findMAT (Wolpin, 2014).

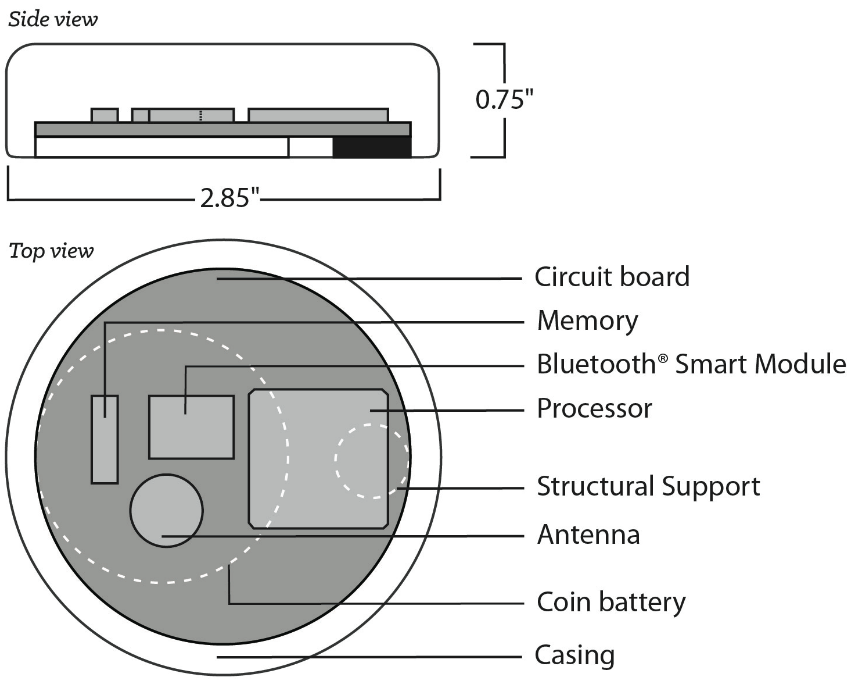
Bluetooth® Technology

Bluetooth® technology is a "wireless communications technology" which "operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHz" (Bluetooth, 2014). This technology uses radio waves at a dedicated frequency, which allows a user to communicate directly with a device while minimizing the potential of signal interference and unreliability as with cellular, data, and Wi-Fi signals. Unlike signal strength divided among users on Wi-Fi, Bluetooth® technology uses "adaptive hopping among 79 frequencies at 1 MHz intervals" (Bluetooth, 2014). Bluetooth® technology is a more robust and precise alternative to Wi-Fi and GPS. This opportunity for improvement was exemplified in the comparative market analysis of the four companies largely depending on those inaccurate and unreliable technologies.

The findPKG's technological suite is configured to accomplish two tasks: 1). guide a person through an indoor pathway and 2). enable a person to identify stationary objects of interest. Safety when navigating continues to depend on the user's existing set of assistive technology such as a cane or guide dog. The findPKG is not replacing these technologies and is intended to enhance the navigation experience of VI people. The first task of guiding a person through a pathway utilizes motion sensors and Bluetooth® technology. The user pairs their Bluetooth®-enabled device with an antenna-enabled Bluetooth® transmitter as they enter the place they want to navigate (see Figure 6). This process is near instantaneous as the user only has to hold their device near the pairing device for seconds. Once the devices are paired, the user receives visual and/or audible confirmation depending on their device type.

Bluetooth® transmitter design

Bluetooth® transmitter diagram[1]



[1]Diagram reference: http://stuffandymakes.com/2013/12/16/maker-review-bluetooth-smart-beacons-apple-ibeacons/

Figure 6. Bluetooth® Transmitter. This is a diagram of technological construct of a findMAT Bluetooth® transmitter, which is activated by a motion sensor which a user passes through. The transmitter sends audio/visual directional information to a user's mobile device or Bluetooth® headset.

Bluetooth® Device Pairing

An innovation in Bluetooth® technology is the core of findOUT. Currently, a person using Bluetooth® technology pairs their mobile device with a headset, for instance. The mobile device is the information transmitter, and the headset is the information receiver, which is called a Bluetooth® peripheral device. The innovation through findOUT in this technological field is a person no longer must pair a headset to a central device like a smartphone to experience Bluetooth® technology (see Figure 7). The user chooses whether to navigate with a mobile device providing visual and audible information or with a headset providing audible information. Allowing a headset to be the central device of a Bluetooth® pairing configuration is not the traditional construct. However, this option potentially reduces the financial cost of implementing findPKG, especially when a person may not be able to fully experience the visual display of the mobile application. While the latest smartphone can cost upwards of US $749, Bluetooth®-enabled headsets from Jabra® like the Jabra Motion for US $129.99 provide users with the ability to receive and end calls by intuitively flipping the microphone boom up and down (Jabra, 2014). Instead of receiving calls using the headset, the user instead receives audible directions about their physical space from the antenna-enabled Bluetooth® transmitters placed on the walls and structures inside a building.

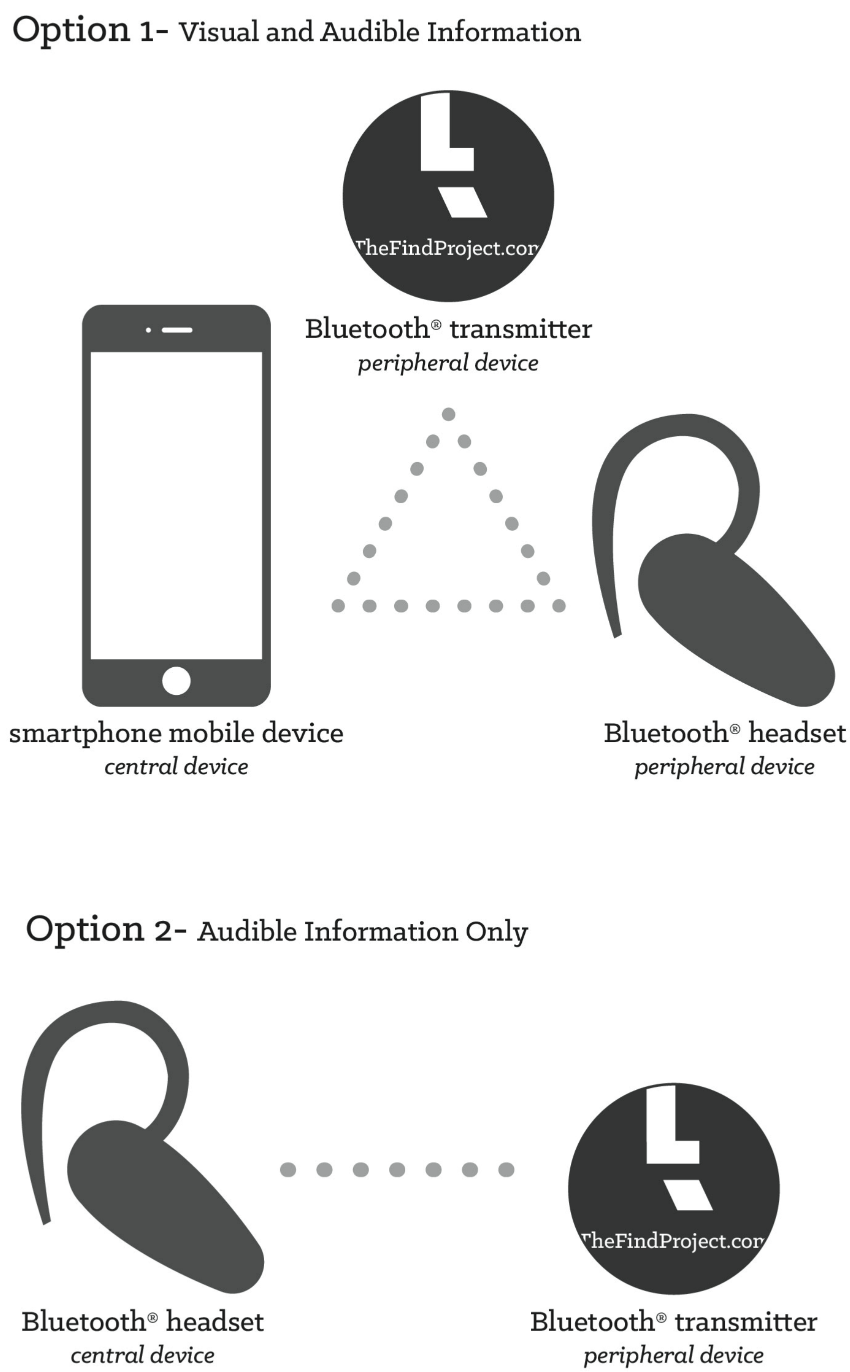


Figure 7. Bluetooth® Device Pairing. Bluetooth® device pairing is a integral component to communication between findMAT and findOUT. With findMAT users have to navigation using only a Bluetooth® headset, which is an innovative use of the hardware.

Navigation with findMAT

To begin this directional process, a motion sensor operates in conjunction with a Bluetooth® transmitter called a “beacon” by the previously mentioned Estimote, Inc. The transmitter is turned on by the motion sensor attached to it, allowing a user to naturally traverse through a pathway without searching for devices while moving. This specific transmitter utilizes a class 2 radio which delivers a signal up to 10 meters (Bluetooth, 2014). The user is seldom 10 meters away from a transmitter, but the class 1 radio signal of up to one meter is too short of a distance and would not be appropriate for the range of pathways intended for findMAT.

Once a user passes through a transmitter, the motion sensor activates the transmitter which begins emitting its stored radio wave signal. The signal is then received and interpreted by the user’s paired device such as a smartphone or headset. The information sent to the paired device is directional information to guide the user to the next transmitter on the path to their destination. This directional information is not turn-by-turn details to get to one, specific location. The directional information is much like the experience of a sighted person looking through a directory. The VI user decides the path they should take to their destination based on location options. These location options provide routes to return to previous sensors, allowing the user to go back through their path if they change their mind. Since users are depending on a progression of location options to make their decisions while moving through pathways, signal interference prevention is crucial. There is a strong possibility a user is physically near multiple transmitters within the signal strength of a single transmitter, 10 meters.

Although Bluetooth® transmitters do power down after a time of inactivity, the specific length of time is unclear on bluetooth.com, so the decision is made to have the transmitters power down seconds after inactivity by motion sensors. This prevents a previous sensor in the user's path from interfering with the next sensor. The process of decision-making through location options continues until the user comes across a stationary object of interest (see Figure 8).

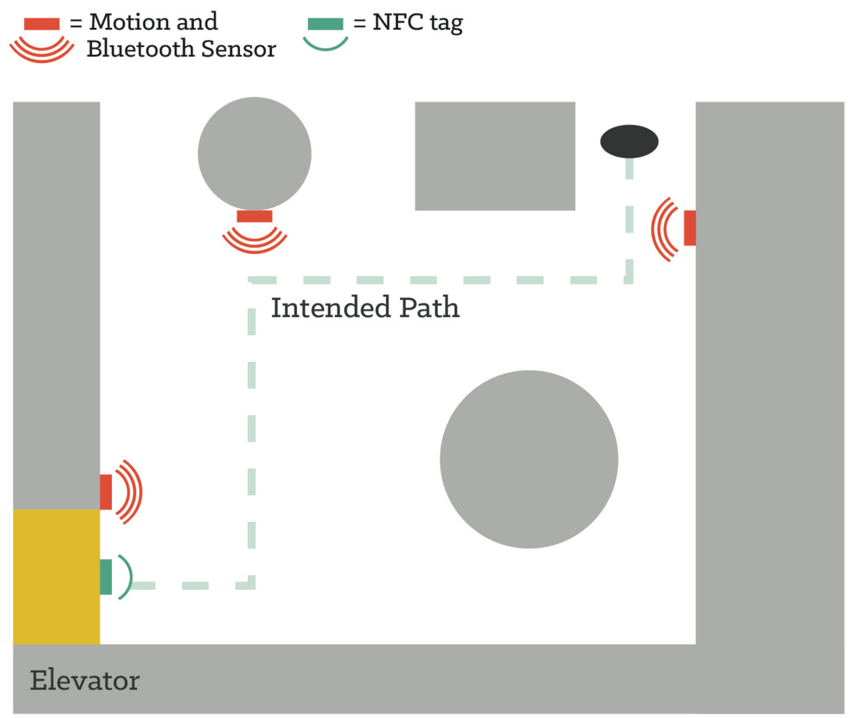


Figure 8. Sensor Diagram. This diagram illustrates where findOUT hardware is placed to direct a user from an entrance of a space to their destination.

<u>NFC Technology in findOUT</u>

Stationary objects of interest are any object a person interacts with while navigating indoors (i.e., an elevator button, book rack, etc.). Since identifying objects of interest require a more precise range of technology, Bluetooth® technology is not applicable for these instances. Near-field communication (NFC) technology is another wireless radio communications standard, like Bluetooth® and Wi-Fi, and it has the appropriate signal range for identifying objects of interest, up to 4 inches (Chandler, 2014). Similar to Bluetooth® transmitters, NFC tags store information received and decoded by an appropriate receiver. These NFC tags are placed on stationary objects of interest so a user can pass their mobile device over the tag to receive information identifying the object. Persons not using a mobile device are not able to identify these tags, since the NFC chips needed to interpret the tags are housed in most smartphone mobile devices. NFC technology is now supported by all three of the major mobile device companies, Apple®, Google™ and Windows®, which means users carrying a mobile device likely have a device capable of reading NFC tags (NFC World, 2014). In addition to hardware technologies in findOUT, other products of The Find Project research are available in findPKG.

The Find Project Components

The main deliverable of the The Find Project's research and development (R&D) is findPKG. A findPKG is the box housing the hardware, software, and marketing materials needed to assist VI people with indoor navigation.

There are four categories comprising a findPKG: 1). findMAT, 2). findOUT, 3). findWRE, and 4). findMKT (see page 2, Fig. 1). As previously stated, the findMAT category configures the mobile assistive technology and software. The findOUT category focuses on the hardware technology outfitting the physical spaces where findMAT is used. The findWRE category addresses wearable technology necessary for findMAT to be effective. The findMKT category is the marketing component of findPKG, managing the brand and marketing materials. This section discusses these components and the next section describes what professions are responsible for those efforts, The Find Project team.

The software required for findMAT is a mobile application intended for the use of VI people. The application's only purpose is to perform the navigation task described in this research. Unlike the VelaSense® application in Chapter 2 which provided a suite of services for VI people, findMAT is targeted at performing the one complex task of assisting a VI person to independently navigate indoors. The application has two features, the navigation function and a section describing how to use the assistive tool (see Figure 9). The instructional section of the app is intended make users more familiar with phrases used in findMAT and actions expected of them while using the app (see Figure 10).

As previously mentioned, there are two aspects to navigating with findMAT. The first is pathway navigation, which is moving through doorways, hallways, and such. The second component is object identification using NFC technology. Unlike with pathway navigation using Bluetooth® technology and motion sensors where the person's body movement activates the technology, object identification requires the user to place their mobile device within four inches of an NFC tag attached to the object identified.
The instructional section first makes users more familiar with phrases used in the app.

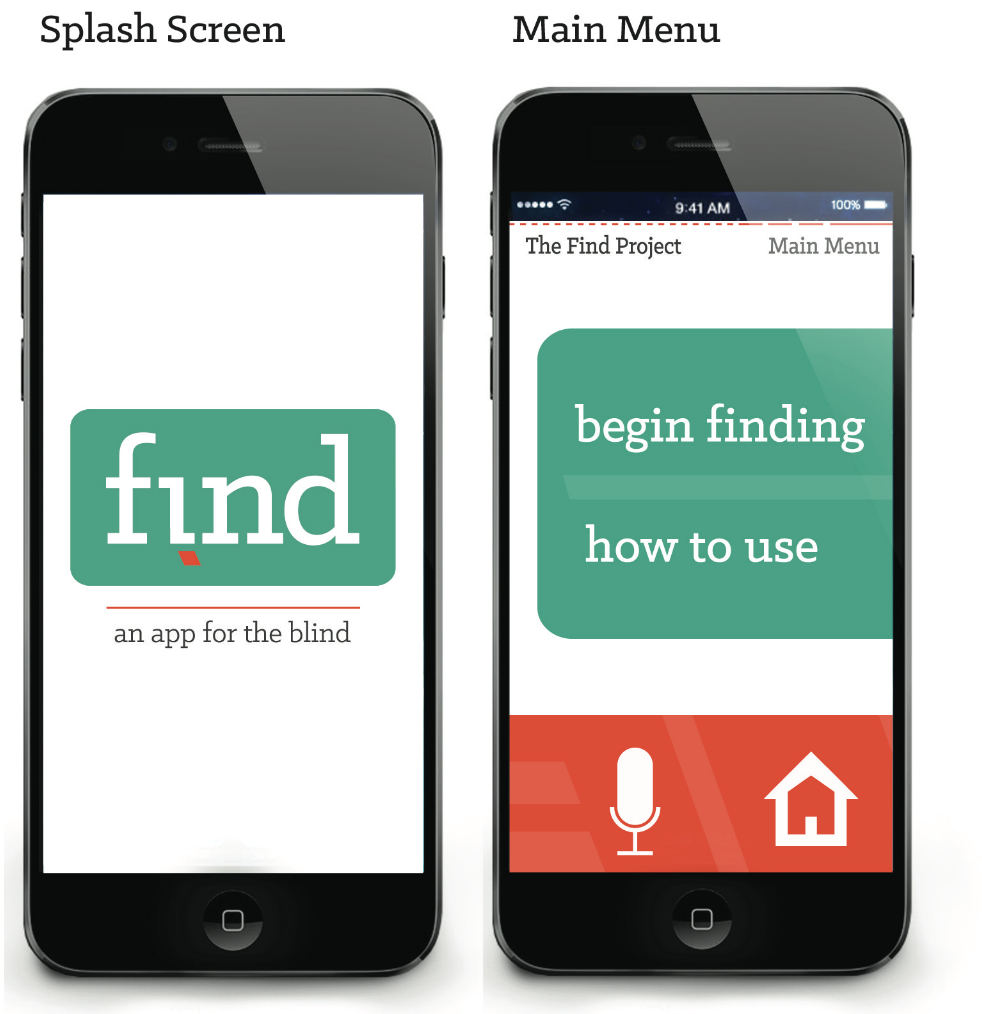


Figure 9. App Interface. The mobile application serves two functions: 1). serve as a navigation tool for VI users and 2). teach users how to operate findMAT through the instructional section of the app.

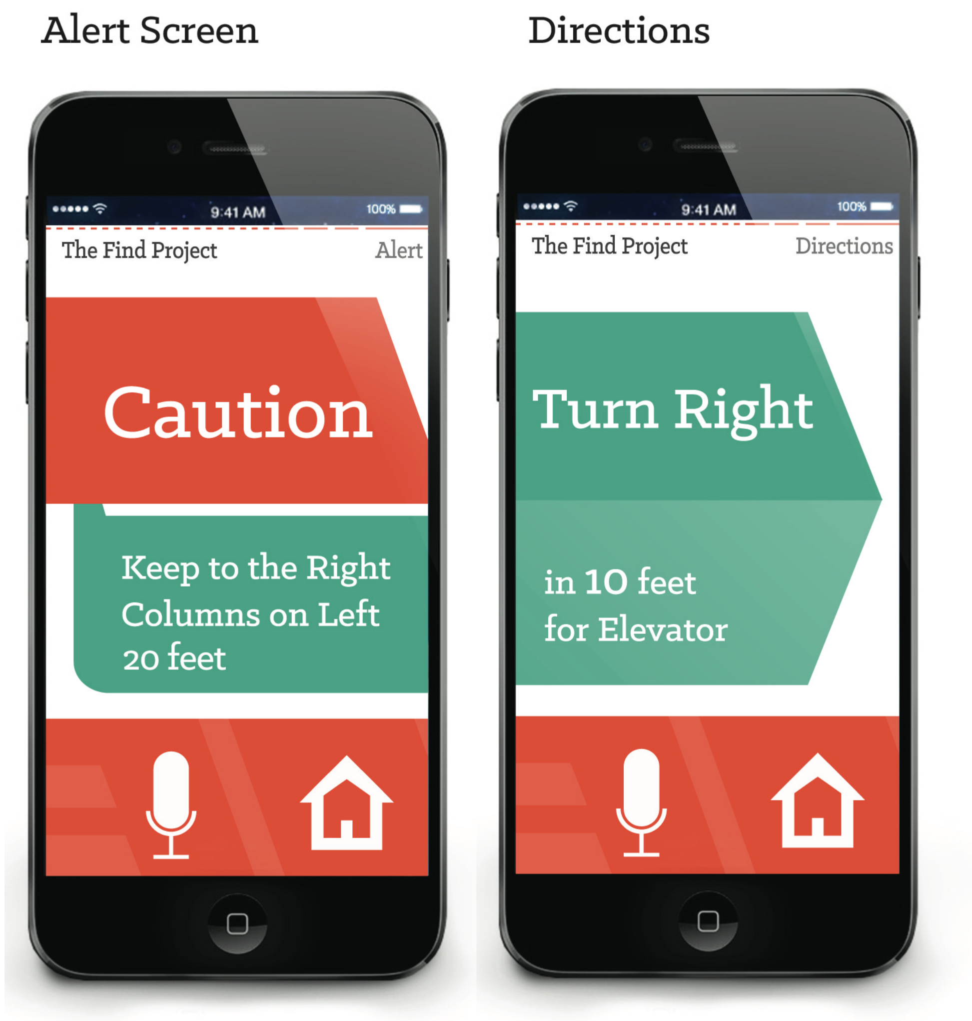


Figure 10. App Interface Continued. Large display graphics and concise messaging are attributes of findMAT facilitating its use as an mobile assistive technology navigation tool.

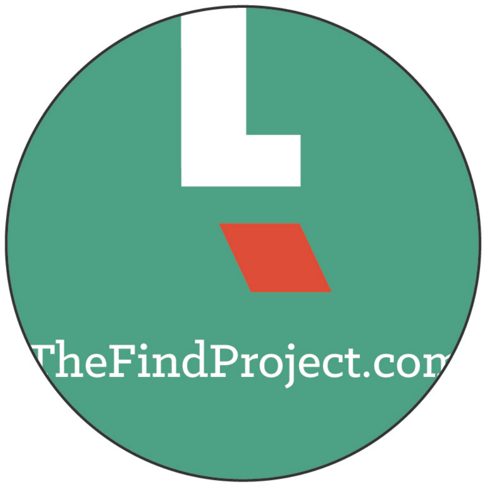
Examples of phrases in the application are "Please choose from these location options" and "Caution: keep right for 20 feet, columns on left." Users are expected to become familiar with directional phrases to make decisions about change of direction after they experience the location options. Warning phrases about known obstructions in a person's path provide information sooner than the person might experience if only using a cane or guide dog. In addition, the technology is more specific than the information received from a cane touching an obstruction. Since a sighted person is tagging stationary objects and placing sensors throughout a physical space, the names of actual items are relayed to the user. When a person's cane contacts an object, they are informed an object is in their path, but they do not know what the object is. With findOUT, the technology is able to identify and caution a person of an obstruction they are approaching. This provides the user more information sooner than they could receive with current assistive technology. The user's effectiveness with findMAT is directly related to how familiar they become with these phrases. In addition to briefing user's on phrases, the instructional section also communicates about the feature of object identification.

The instructional section also explains identifying objects with a mobile device. The user is expected to place their mobile device near objects of interest along the path to their destination. Objects of interest are anything from elevator door buttons to computers in a library, for instance. Now, of course, it is unrealistic to expect every object in a location to be tagged, so it is made clear to the user as they enter which objects are tagged. Objects, like paths, determined most necessary are tagged. If a findMAT user or the general public wants more information about the research, they can visit the website or Twitter. The findMAT category communicates with a number of pieces of hardware in findOUT to assist VI people.

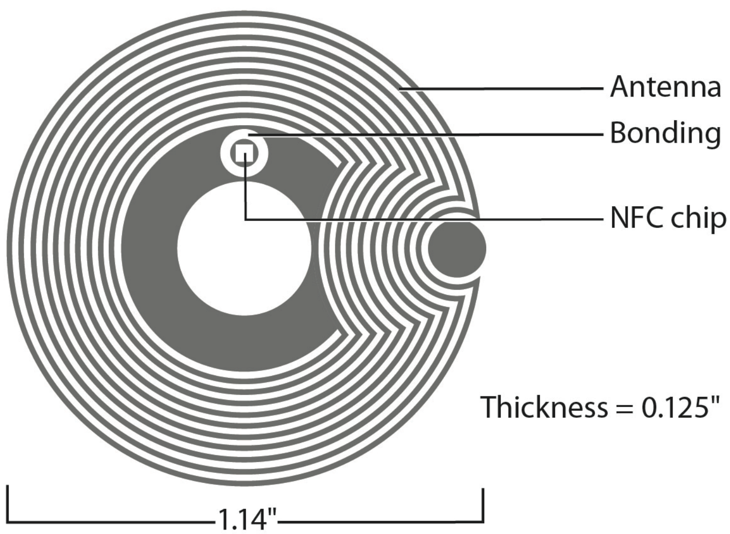
A mobile device is used as the main interface for the findMAT user due to the amount of standard technology in current smartphones. Bluetooth® and NFC technology are supported by the latest smartphones of Apple®, Google™, and Windows® (NFC World, 2014). These technologies are essential to the effectiveness of findOUT, so it is advantageous to leverage existing technology rather than manufacture a new device. If a person chooses to experience findMAT through auditory communication, a Bluetooth® headset is all a person needs, not a smartphone. The Bluetooth® headset receives the same information from the Bluetooth® transmitters as the smartphone does, but it receives and decodes the information as audio, not visual and audible information like a mobile device. The one capability Bluetooth® headsets currently on the market do not have is NFC technology as they are not created with NFC chips. Despite this lack of technology, a user with a headset can still receive more information about their surroundings using Bluetooth® technology through findMAT than with their existing technology like canes and guide dogs alone.

Bluetooth® transmitters and NFC tags are the hardware technology which stores information sent to users through the smartphones and headsets to help guide them through their physical spaces (see page 36, Fig. 6). The transmitters are adhered to hard surfaces along the navigation path at the height of three feet or lower when necessary so users in wheelchairs pass through the motion sensors (see Figure 11). The NFC tags are placed along the user's path as well, but, unlike the transmitters, the tags give the user information about a specific object, not their path.

NFC tag cover design



NFC tag diagram[1]



[1]Diagram reference: http://rapidnfc.com/nfc_tag_antennas

Figure 11. NFC Tag. NFC tags are used to identify stationary objects of interest along the path of a VI person using findMAT. These tags are adhered to objects and identifiable using NFC chip-enabled mobile devices.

The last piece of findOUT hardware is a button surface area enlarger (see Figure 12).

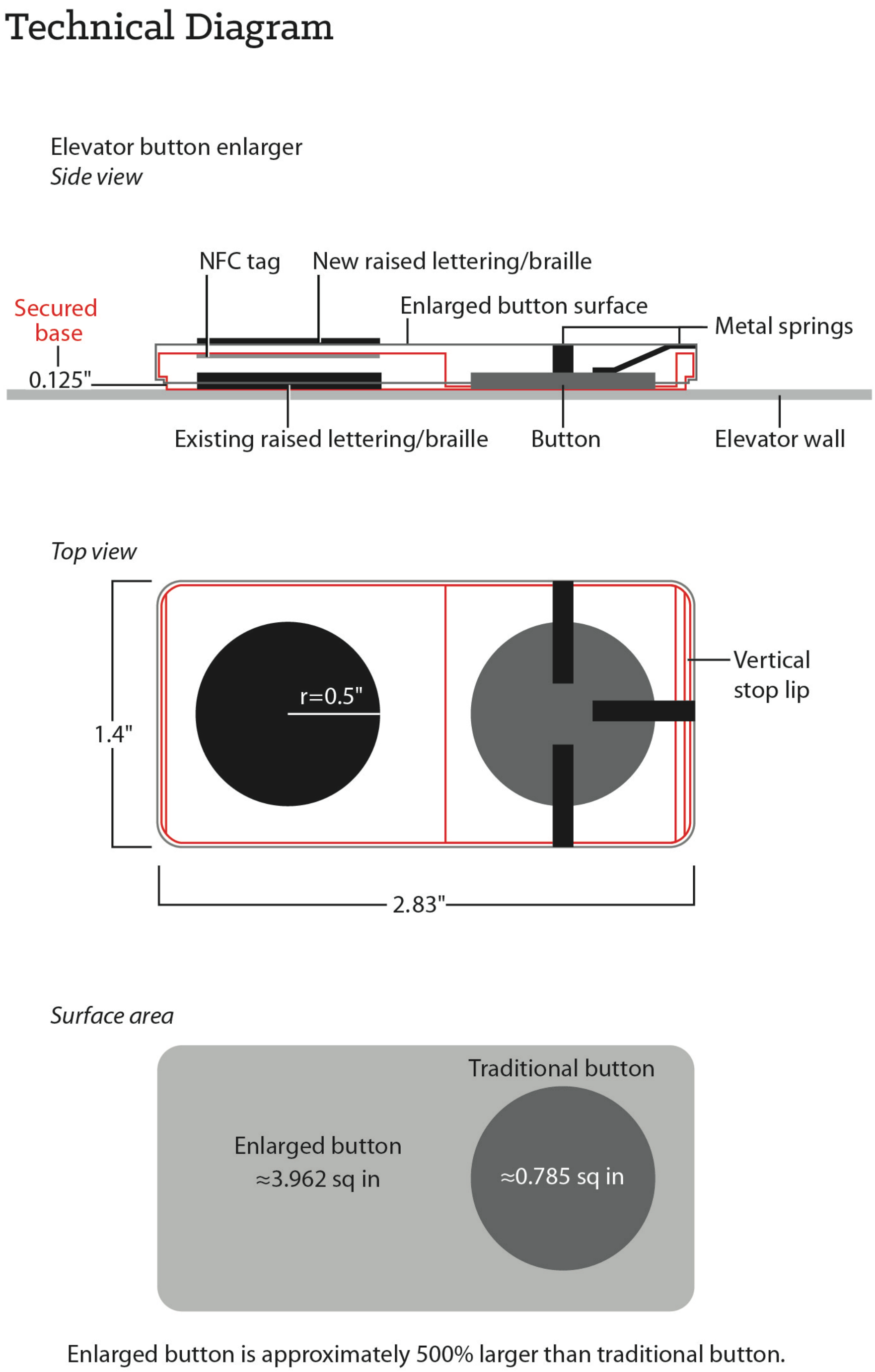


Figure 12. Button Surface Area Enlarger. The button surface area enlarger assists VI users scanning for stationary objects of interest equipped with NFC tags using their NFC-enabled mobile device.

This device was developed by The Find Project team, so there is no current model of this on the market. The purpose of the device is to enlarge the scannable surface area of buttons, like elevator buttons, for VI people. This device is used when scanning for NFC tags. The theory is when the scannable surface area of a button is enlarged there is an increased probability of the user correctly pressing the button they scanned. Scanning NFC-enabled signage and buttons (i.e., elevator buttons due to their small surface area) is an alternative to braille and embossed signage which is needed. With fewer than 10 percent of the legally blind population in the United States reading braille, and a mere 10 percent of blind children being taught to read it in school, NFC-enabled signage and surface area enlargers are necessary (NFB, 2009). With diabetes as the nation's leading cause of blindness, a visually impaired person with diabetes can have hand and feet numbness due to poor blood circulation, which makes it difficult to read embossed signage either (Diabetes, 2014). To read digital signage, the mobile device is held while experiencing findOUT hardware, but it is recommended users employ a wearable mount to hold the smartphone, freeing their hands.

The findWRE category recommends two types of wearable mounts for the smartphone mobile device: a neck-supported mount or a wrist-supported mount (see Figures 13 and 14).

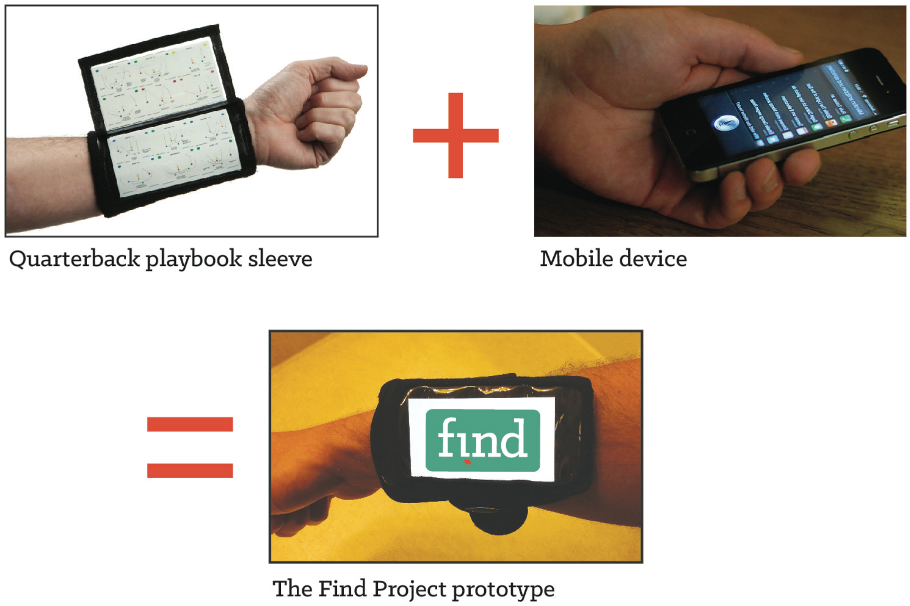


Figure 13. Wearable: Wrist-supported Mount. This findWRE device is intended to keep the hands of a VI person free while using the technology.

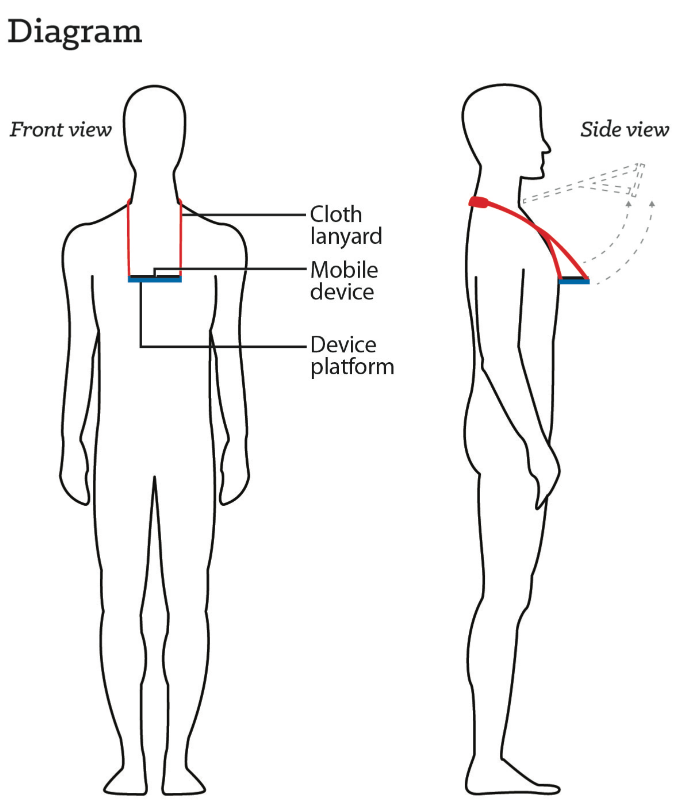


Figure 14. Wearable: Neck-supported Mount. This findWRE device is intended to keep the hands of a VI person free while using the technology.

Wearable Technology

The wrist-supported mount is similar to an arm band which a runner places on their bicep to hold their mobile device, only the VI person wears it on their forearm. The neck-supported mount is essentially a platform for the mobile device to securely rest while attached to a lanyard around the neck. Neither of these mounts currently exist; they are designed specifically for findWRE. The mobile device in the neck-supported mount is placed at a person's chest with the device screen facing up. Since the screen is always facing up, the user can raise their device to eye level, and be confident the device is oriented correctly. This neck-supported mount construct is also advantageous for people with hearing impairments as they can keep the phone closer to their ears for audio, if they do not have or want earphones. The second wearable device is a wrist mount for the smartphone. With the smartphone mounted to a user's wrist, this gives VI people the accessible ease of turning their wrist to the view the device screen the same way a person would use a wrist watch. Product benefit information of findMAT and findWRE are points of messaging communicated though findMKT.

The findMKT category is distributed into three sections: informational and marketing signage, hardware covers, and a social media/web platform. The informational signage of findMKT communicates the benefits and applications the findMAT technology (see Figure 15).

Standee poster

Figure 15. Marketing Materials: Location-specific Signage. Marketing materials such as this poster illustrate the benefits and technological innovations of findMAT and findOUT for VI people.

Informational and marketing signage are wall posters and self-standing posters placed in locations equipped with findOUT or locations determined to potentially benefit from findOUT, possibly near businesses, public services buildings, and schools for VI people. Most marketing signage is intended for all people to experience, but some signage, like the poster in Figure 15 (see page 52), is created for the sighted community to experience, which illustrates findOUT technology operating for VI person navigation. In addition to posters intended for all people (see Figure 16), covers on the transmitters and tags inside of locations equipped with findOUT are intended to reach the sighted community.

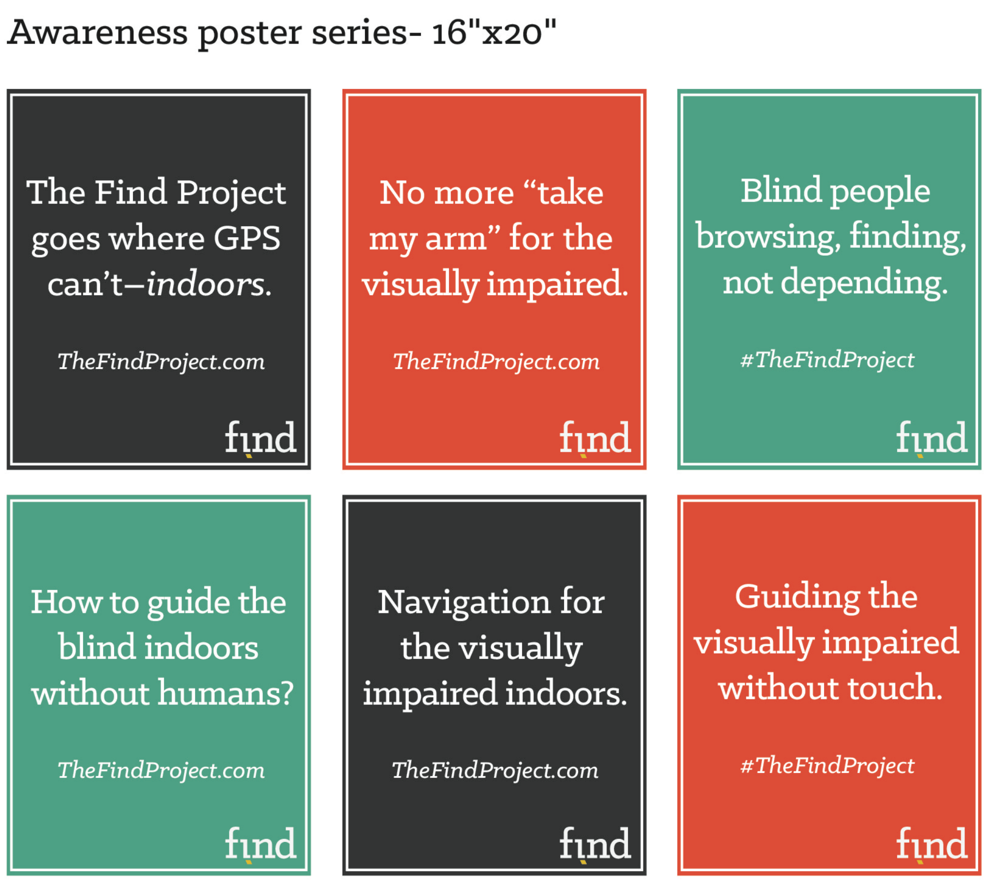


Figure 16. Marketing Materials: Poster Series. The purpose is to raise project awareness to all people.

Hardware Covers and Marketing Materials

Covers are adhesive stickers placed on the Bluetooth® transmitters and NFC tags in the paths VI people navigate (see page 36, Fig. 6 and page 47, Fig. 11). These covers have the website or Twitter hashtag printed on them so sighted people interested in the technology attached to the wall of a building can perform research. The decision to have a standalone website provide findMKT information as opposed to including the information in the application was made to provide the sighted community immediate access to findMKT information without the need of downloading the application. Sighted people who refer findMAT to a VI person are not likely to download the application or read the app description in a mobile application store. Therefore, calls to action (i.e., web address and hashtag) are placed on findMKT materials (i.e., signage and NFC tag covers) for immediate access to information. In addition to the website housing information about findMAT, Twitter is the resource used to communicate with people around the world about potential places findOUT can exist. Once the purpose of findMAT is communicated to the public, all people (sighted and visually impaired) are expected to identify intended and unintended uses for technology in their community, allowing Twitter to be an effective source to map where people can potentially experience findMAT. To develop the components discussed in this section, an interdisciplinary team of professionals is assembled to collaborate and define the research of The Find Project.

The Find Project Team

The Find Project team gathers expertise from the fields of communication design, architecture, mechanical engineering, social anthropology and mobile application development. These professions are brought into process at multiple points during the research process (see Figure 17).

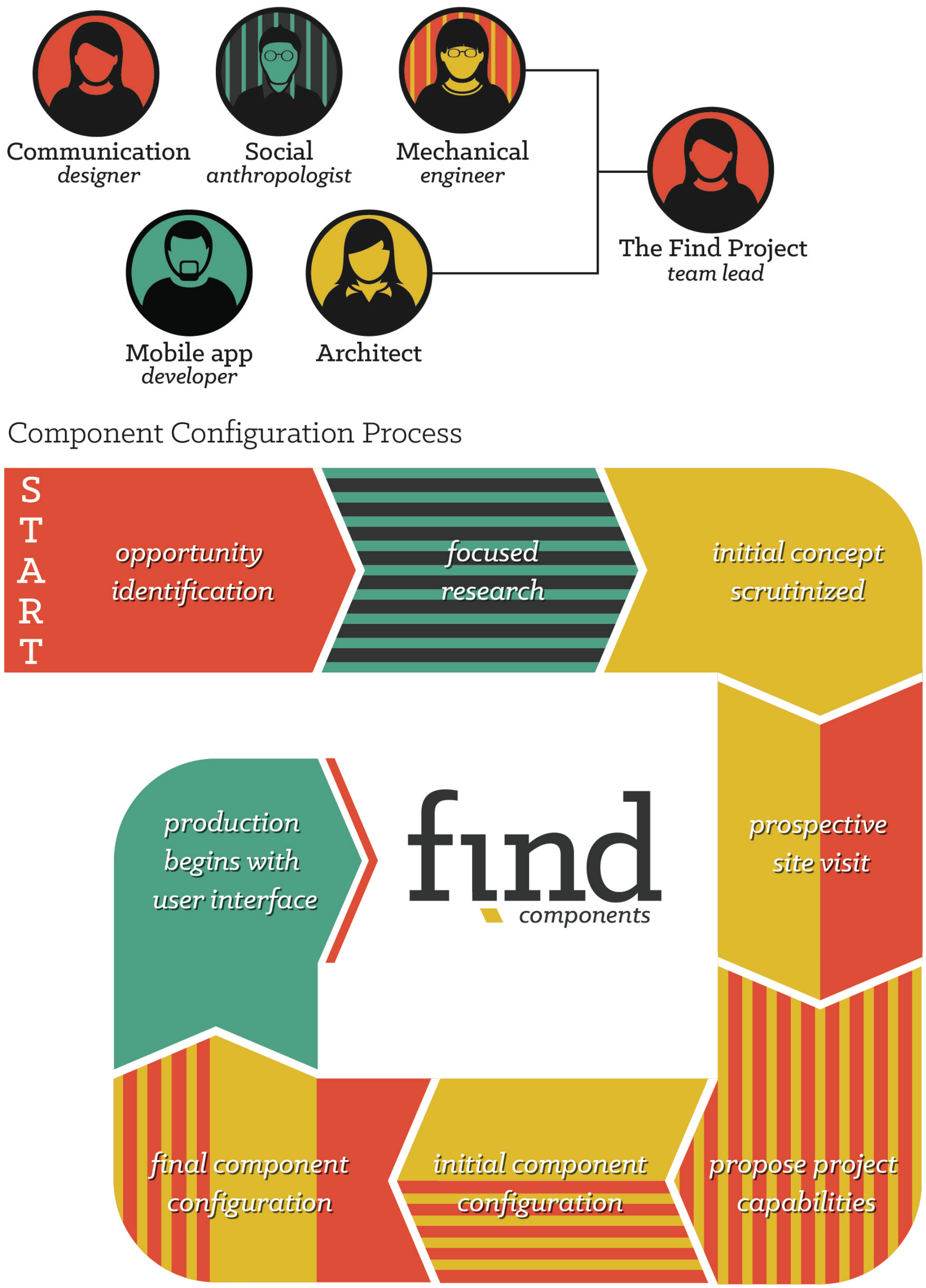


Figure 17. The Find Project Team. The Find Project team is an interdisciplinary team focused on identifying locations where findOUT is applicable and people who can benefit from findMAT.

Communication designers with expertise in environmental graphic design (EGD), brand management, user experience (UX) design, and user interface (UI) design are the initiators of The Find Project research. EGD is defined in *Signage and Wayfinding Design* as "the graphic communication of information in the built environment" (Calori, 2007) These are the observers responsible for surveying physical spaces and identifying opportunities to improve the navigation experience of VI people. Once an opportunity is identified, which in this case is a need to provide more effective mobile assistive technology to VI people for indoor navigation, these designers conceptualize through initial research how the problem is solved. After the hypothesis is set, the proposal is presented to a social anthropologist who then reviews the existing research and performs their own research to ensure all sensitivities of VI people are acknowledged and appropriately addressed. Social anthropology is defined by the University of Cambridge as "the study of all peoples everywhere – what they make, what they do, what they think and how they organise their social relationships and societies" (Cambridge, 2014). An example of a social anthropologist's expertise is referring to the device a visually impaired person uses to traverse physical paths as a "cane" not "walking stick." This word choice, as explained by VI people at the San Antonio Lighthouse for the Blind, respects the tool as a medical device not as a walking stick used by non-VI people.

Initial Concept

Following the due diligence of these experts, the initial concept and plan for the project is presented to an architect collaborating with an EGD professional to ensure the project meets the basic requirements needed to outfit a building with findOUT.

The architect also considers if the project should pursue LEED certification, specifically an Innovation in Design Credit. LEED is an acronym meaning, “Leadership in Energy & Environmental Design,” (LEED, 2013). “Innovation in Design credits for innovative performance are awarded for comprehensive strategies which demonstrate quantifiable environmental benefits not specifically addressed by current LEED Rating Systems,” (USGBC, 2008). The purpose of acquiring these certifications is to benefit all stakeholders (i.e., investors, designers, government agencies, employees, building managers, and tenants) in addition to VI people by exemplifying the innovative measures taken and resources expended to provide for VI people. The findMAT navigation system is potentially applicable to the general public and can be communicated as such to pursue these certifications. Detail about findOUT as a potential requirement for LEED certification is discussed in Chapter 5. The *Reference Guide for Building Design and Construction* states, “the purpose of [the Innovation] LEED category is to recognize projects for innovative building features and sustainable building practices and strategies (LEED, 2013). To gain a sense if the project is appropriate for these certifications, it is critical for the EGD designer and architect to survey a prospective location space to discuss the architectural best practices of making technological additions to the existing building. The scope of findOUT is determined at this point in the process considering current technological capabilities, such as GPS and Wi-Fi versus findMAT for indoor positioning and navigation. Subsequently, a mechanical engineer, with a specialty in wireless technology integration (i.e., Wi-Fi, GPS, etc.) is brought into the collaborative process.

Capabilities of findMAT

A mechanical engineer's role on The Find Project team is to determine which proposed capabilities of findMAT are realistically producible. Technological and financial parameters are set here (i.e., manufacturing capability and cost) for the production of prototypes and mass-produced findPKG deliverables. Once the mechanical engineer and EGD designer determine a collection of producible technologies for findMAT, the communication design (CD) team in collaboration with the anthropologist lead must review the configuration to decide if the scope of the technology is still in line with the intended focus of findMAT.

After the mechanical engineer (ME), architect, and CD team agree on the final deliverables, the process of developing a prototype begins by determining the software and hardware needed. A critical piece of the software is the mobile application which is created by a mobile application developer who is collaborating with the CD team creating the app user interface (UI) and app user experience (UX). The informational website is created by the CD team, as well as marketing materials for findMKT (i.e., posters and covers for the sensor technology hardware). The wrist- and neck-supported mounts for the mobile device are designed by the CD team in collaboration with the ME. The ME & CD team collaborate to develop the button surface area enlarger used in the elevator (see Figure 18) as well as the battery-powered, Bluetooth® transmitters with antennae (beacons) and the NFC tags.

Elevator poster

Figure 18. Marketing Materials: Elevator Signage. This location-specific signage provides all people an introduction to the findOUT efforts of identifying opportunities where the technology can benefit people.

This section described findOUT and findMKT in theory, and the next section describes those technology in relation to the findMAT prototype created for usability testing.

Usability Metrics

The findMAT prototype was created to perform usability testing. The prototype focuses on testing usability based on the International Organization for Standardization (ISO) 9241-11 standard and ISO/IEC 9126-2 standard for external usability metrics, which centers around quality management and a guidance on usability (Bevan, 2000).

ISO 9241-11 Standard

The ISO 9241-11 standard describes three metrics by which to test the usability of a product: 1). effectiveness, 2). efficiency, and 3). satisfaction. Effectiveness is defined as "the accuracy and completeness with which users achieve specified goals." Efficiency is defined as "the resources expended in relation to the accuracy and completeness with which users achieve goals." Satisfaction is defined as "the comfort and acceptability of use." The ISO standard goes on to state, "For each chosen task and user type, estimate: 1). the acceptable task time and the optimum target, 2). how to score effectiveness by agreeing what errors the user might make, 3). the effectiveness target, and 4). the satisfaction target," (Bevan, 2000).

ISO/IEC 9126-2 Standard

The ISO/IEC 9126-2 standard tests four metrics: 1). understandability, 2.) learnability, 3.) operability, and 4.) attractiveness. The ISO/IEC 9126-2 standard states, "Understandability metrics assess whether new users can understand: 1.) whether the software is suitable and 2.) how it can be used for particular tasks." Learnability metrics “assess how long it takes users to learn to use particular functions, and the effectiveness of help systems and documentation.” Operability metrics “assess whether users can operate and control the software.” Lastly, attractiveness metrics “assess the appearance of the software, and will be influenced by factors such as screen design and color.” The usability study conducted for findMAT based its methodology on these two ISO standards.

Usability Study Metrics

In reference to the ISO 9241-11 standard, effectiveness, which measures accuracy, was scored based on the number of instances a user asked for help or was so far off task, meaning a physical pathway, their safety was compromised or user recovery was unlikely. Efficiency, which measures resources expended to achieve the goal, was measured by recording the user’s time on task (ToT), with time being the resource expended. Satisfaction, which measures user comfort, was qualitatively recorded through the post-test survey and debrief (see Figure 19). In reference to the ISO/IEC 9126-2 standard, a tutorial similar to the demonstrations found in the instructional section of findMAT were administered before the testing. Quantitative data was not recorded to measure understandability, rather verbal confirmation of understanding as well as a signed consent form were received to fulfill this metric. In future research, understandability is quantitatively measured. Learnability was observed qualitatively as user’s progressed through the usability test. However, since users did not perform the test more than once, learnability was not qualitatively recorded. Future usability tests provide for users to perform tests multiple times to record learnability metrics. Operability was measured based on level of task completion, while observing user's ability to correct their errors while using findMAT. Lastly, attractiveness in regards to the visual interface design of the prototype was not recorded. Future research is intended to test various app interfaces.

Exit Interview (post-experiment interview and debriefing)
Interview questions: What was the most challenging or enjoyable part of the testing? Are there any changes for improvement you can suggest for the app? Could you envision yourself using this app on a daily basis if more places were mapped like this? Yes, No, Maybe **Debriefing:** Thank you for completing the testing. How are you doing right now? If positive, proceed. You are truly a pioneer in the field of mobile application testing! I will be going through the research you provided today to improve the application. Once the process is finished, I will send an update to you and the progress of our study. Please don't hesitate to contact me with or concerns about the study at pl1089@txstate.edu. Or if you have pertinent questions or concerns about the research, research participants' rights, and/or research-related injuries to participants should be directed to the IRB chair, Dr. Jon Lasser (512-245-3413 - lasser@txstate.edu) and to Becky Northcut, Director, Research Integrity & Compliance (512-245-2314 - bnorthcut@txstate.edu). Thank you and have a great day.

Figure 19. Usability Post-test Survey. The interview and debrief were administered immediately following the usability test in order to monitor and record the well-being of the test participant.

Usability Testing

The testing conducted at San Antonio Public Library's Central Library spanned two days. The purpose of the testing was to determine the viability of findMAT as a supplement to current assistive technology for VI people. To determine this, a simulation of findMAT was designed at the library. The simulation defined a path to navigate through the library ending at a desired location and object. Participants were asked to locate the closed-circuit televisions (CCTVs) on the sixth floor of the library. The study participants were only people with severe visual impairment. This was a critical factor to the study. In addition to testing the functionality of the application, the application was examined for its ability to supplement a VI person's current set of MAT. Participants ranged between the ages of thirty and sixty-two years.

Before the testing began, participants were briefed on the technology being simulated. The motion sensors a person using findMAT interacts with were simulated by providing visual and audible directions to the user through a Keynote® presentation. The participants wore an iPhone® 5 in an arm band (see page 50, Fig. 13) or held the mobile device in their hand throughout the study. Each screen of the presentation transitioned remotely through an iPad® synced with the iPhone® as the data collector trailed the participant by three feet to observe their actions and provide safety in the event of a potentially dangerous situation. As participants received location options from the prototype, they were trained before the testing to speak to the device saying 'yes' or 'no' depending if the location offered was the desired location. Participants were also asked to use their mobile device as they would if they were actually scanning for NFC tags attached to objects of interest. In the testing, there were three instances where the users had to perform the motion of scanning for NFC tags, the external elevator buttons, the internal elevator buttons and the CCTV. When a user was prompted to use their device to scan for objects, they were expected to pass the device within at least four inches of the object of interest. This distance, inside of the signal range of the NFC tag located on the object, allows the object to be identified.

A survey and debrief was administered immediately following each test (see page 62, Fig. 19). In the survey, the participant is asked about their experience using the prototype as well as their willingness to use the technology on a daily basis if more places they frequented were mapped. These questions were designed to give insight to the effectiveness of the application as a supplement to their existing technology, as well as qualitatively measure satisfaction as defined in the ISO standard. To better understand if severity of VI was a significant factor in the ability of a user to engage with findMAT, participants were placed in two groups based on their severity of VI.

Blind participants were placed in one group and people with low vision in another. Subsequently, people in each group were placed in subgroups labeled "control" and "variable" (see Figure 20). The control group were the participants not testing the application; they were navigating the path using only verbal instructions given before the beginning of the test. The participants could hear the directions as many times as they liked but only before they began testing. This simulated the experience of a person receiving directions to a place in a building rather than someone escorting them to their destination.

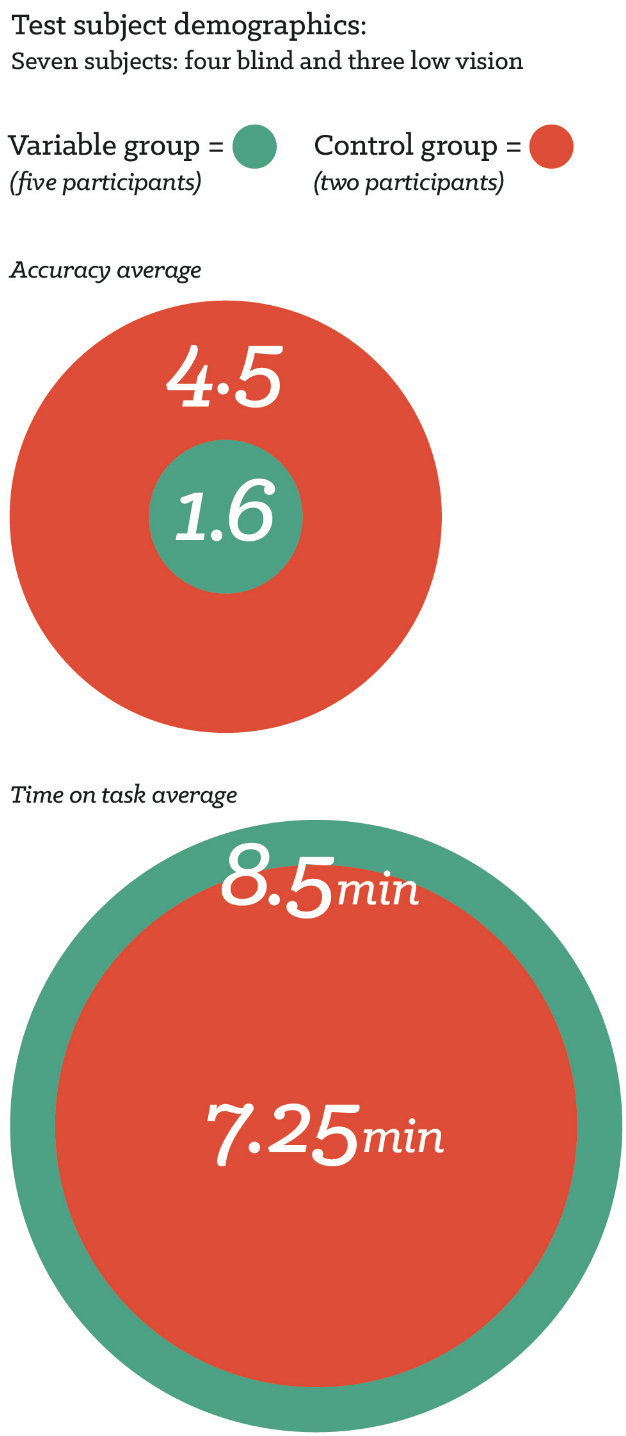


Figure 20. Usability Results. Time on task (ToT) and accuracy were the two quantitatively measurable metrics of the findMAT usability testing.

These control participants performed the task as independently as possible; they only time they were interfered with was if they were in potential danger or so far off the path it was unlikely they would find their way back. If a participant received assistance due to an error of their own, it was noted in their accuracy score for the test. The test variable group navigated the path independently as well while using the prototype. As previously mentioned, participants had the option of wearing the mobile device on their arm as a sleeve, much like a football quarterback has plays listed on a card on an arm sleeve (see page 50, Fig. 13). The arm sleeve is a common runner's arm band adjustable enough to fit the forearm. Wearing the device in a sleeve on the forearm is advantageous for a user as it keeps their hands free to operate a cane or guide dog or hold other objects like groceries. Since the device is placed on the forearm, it is close enough to comfortably hear the audible commands and see the visual information on the screen by turning their wrist.

The hypothesis for the testing was participants using the prototype and simulation of findMAT to navigate the physical space would accomplish the task with a shorter ToT and with more accuracy than the control group relying on memorization of directions and their current MAT.

Usability Testing Results

A total of seven tests were conducted, two control participants and five variable participants. Four of the participants were blind and three had low vision. The variable group had an average accuracy score of 1.6, meaning 1.6 errors per test. The control group had an average accuracy score of 4.5 (see page 65, Fig. 20). The variable group performed better than the control group in terms of accuracy. Control group participants consistently had problems in accurately navigating the correct distances to make the appropriate decisions along the path. The variable group benefited from findMAT prototype alerting the participant to the precise point in the path the user had to make a decision (see page 44, Fig. 10). There was no significant difference in the accuracy performance of blind and low vision participants.

Time on Task

In terms of time on task (ToT), the control and variable groups performed similarly. The variable group average time was 8.5 minutes, while the average time for the control group was 7.25 minutes (see page 65, Fig. 20). There was not a significant difference in the performance of blind and low vision participants with test results within the same groups spanning as much as a 7.5 minute difference. One possible reason for the slightly better average time by the control group was these participants tended to move relatively quickly as they did not have to pause and pay attention to location options from the prototype. However, this faster pace led to more mistakes, raising the error total for the control group. Most errors from both groups occurred when the participant was prompted to scan their immediate environment for NFC tags in order to locate their object of interest. This sequence of actions was consistently problematic for the variable participants. Following directions from the prototype to navigate through pathways was observed as a more intuitive action than using the device to scan for tags attached to physical objects. Although, users generally became more familiar with the request by the third instance of it during the test when locating the final object of interest, the CCTV.

After quantitative data was recorded following each test, the data collector sat down with participants to ensure their safety and comfortability, as well as administer the survey (see page 62, Fig. 19). Feedback from participants was overwhelmingly positive in regards to the prototype and testing. Some participants admitted to being "very nervous" when starting the test, but, as they got into the task and more familiar with the application, calmed themselves to enjoy the experience. One participant stated, "It was wonderful," and "I would be more independent [using findMAT]." Participants also provided locations in their lives where they would welcome findMAT, such as department stores, their homes, convenient stores, and grocery stores.

The quantitative data supported findMAT as an improvement to the effectiveness of blind and low vision users navigating independently, and the qualitative data gathered showed users welcomed the concept of this technology in their daily lives. Based on this data, the hypothesis is supported by the experiment. Following the administration of the prototype during usability testing, findOUT hardware and findWRE wearables were informed by observations made during the testing. The next chapter discusses these design outcomes and their support of The Find Project mission.

CHAPTER IV

DESIGN OUTCOMES

The Find Project's brand is designed around the typeface used for the identity (see Figure 21). The identity communicates stability and tangible structure through its slab serif characters. These are qualities sought by VI people. Often, these people are traversing through unfamiliar spaces without the ability to see, so relying on information such as consistently know the topography of the ground is vital.

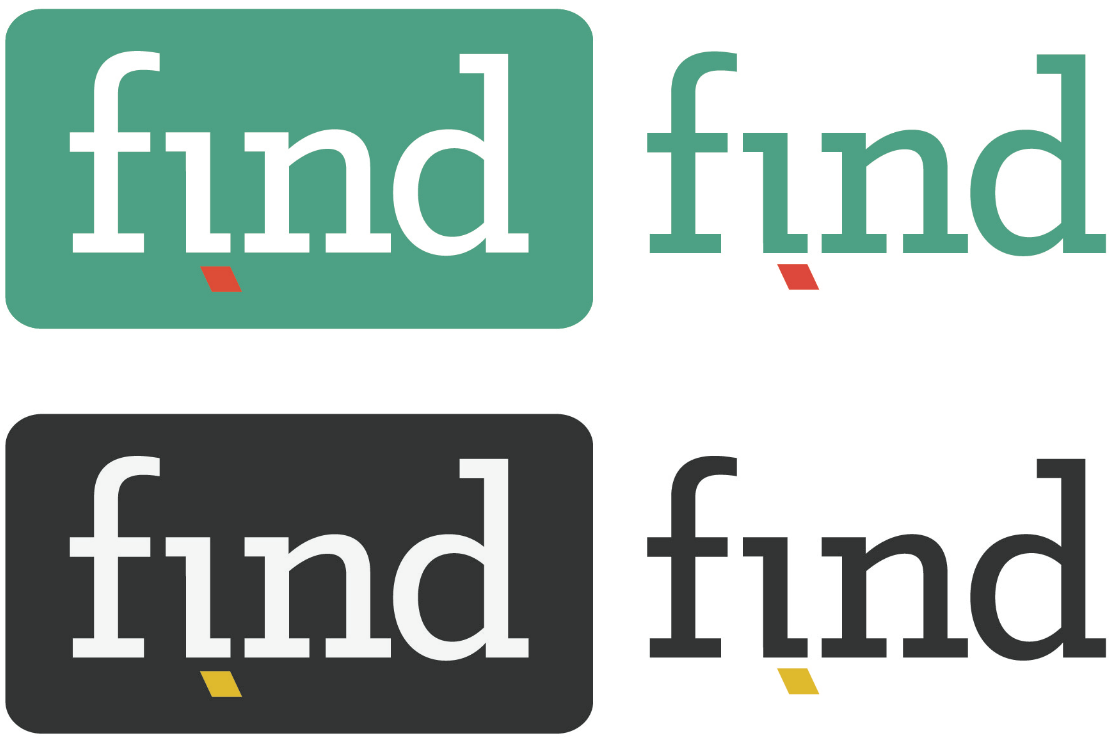


Figure 21. The Find Project Identity System. The identity for The Find Project is a logotype.

Stability is paramount to a VI person navigating as it eases their mind to know they can move at their own pace without overly worrying about their environment changing spontaneously. A mood board was created to visualize the intended character of the brand (see Figure 22).

Figure 22. Mood Board. The contents of the mood board informed design decisions for the brand.

These qualities are what they receive from their current assistive technology (i.e., canes, guide dogs). Gaining trust is a central focus findMAT to earn a place in the daily mobile assistive technology suite of VI people. From typographic choices to the curation of photographic imagery associated with findPKG, every design decision is made to be a reflection of the mission to provide increased independence to the lives of VI people. Here are the design outcomes for findPKG.

Mobile Application Interface

The purpose of the mobile application interface is to function as a platform on which the user receives directions. The application has no other purpose than this, so the interface is designed to accomplish only one task (see page 43, Fig. 9 and page 44, Fig. 10). The interface is designed minimally so, much like space between type characters, VI users have less visual information to process allowing them to focus on their navigation task. The mobile application interface employs the concept of gestalt, meaning the whole is more than the sum of the parts, to inform the design decisions. Elements of The Find Project identity are broken apart and reassembled into the application interface and icon (see Figure 23). The color palette is also leveraged at appropriate situations throughout the design. For instance, the tangerine color assumed the visual role of the color red when communicating the need to stop or use caution, as exemplified on the "Alert Screen."

App icon

App icon on screen

Figure 23. App Icon. The findMAT icon represents the movement and navigation associated with the app.

Messaging (e.g., turning directions) are provided to the user in multiple ways to present the best possible chance of the user receiving the information. On the “Directions” screen, the user receives the information to turn right through the screen text, the right-facing arrow, as well as the audible alert to turn right. All of these considerations are an attempt to make findMAT an addition to a VI person’s assistive technology suite. As previously mentioned, The Find Project brand is built upon its type choices.

Typography

The Find Project identity is a type solution with type manipulated to communicate the product benefit (see Figure 24). The typeface used for the identity is Klinic Slab Medium, a serif typeface which meets the ADA requirements of visual characters for directional, information and regulatory signs in terms on stroke thickness, character spacing, and type size (APCO, 2014).

Headings
Klinic Slab Medium
ABCDEFGHIJKLMNOPQUSTUVWXYZ
abcdefghijklmonpqrstuvwxyz
0123456789?!@#$%&()

Subheadings
Klinic Slab Medium
ABCDEFGHIJKLMNOPQUSTUVWXYZ
abcdefghijklmonpqrstuvwxyz
0123456789?!@#$%&()

Body text
Museo 300
ABCDEFGHIJKLMNOPQUSTUVWXYZ
abcdefghijklmonpqrstuvwxyz
0123456789?!@#$%&()

Figure 24. Typography. Klinic Slab is the typeface for heading use; Museo 300 is used for body text.

A slab serif typeface is selected for the identity to communicate stability to the findMAT user. The slab serifs in the lettering communicate a structural and tangible building quality, which fit the scope of this project. Since the findPKG is not only a mobile application, rather, a virtual mapping of physical locations, the typeface, when viewed in the mobile application, must suggest more than the app is a software program solely housed in a mobile device. This particular slab serif was selected for the identity in consideration of the generous counter spaces throughout the typeface, particularly in the bowl of the "d." According to the American Printing House for the Blind, "the font should be wide-bodied with space between each letter. Letter which have a bubble inside them, such as o, d, g, and others should have plenty of space inside the bubble (Kitchel, 2014). The identity must not be represented with a smaller capital height than three inches when the medium in which the identity is placed is intended for a VI audience, per the ADA Accessibility Guidelines (ADAAG, 2014).

Typography for print and digital purposes is handled by Klinic Slab Medium in heading and subheading instances, while Museo 300 is the typeface for body text (see page 73, Fig. 24). Museo 300, the typeface for body text, is a wide-based typeface and a hybrid between serif and sans serif typefaces. Generally, characters with serifs have a serif at every letter stem, making for a visually heavier typeface like Klinic Slab. Since Klinic Slab is only used for headings and subheadings, which are short lengths of text, the typeface is appropriate. For body text, the lengths of text are longer which means it should be easier for a person to read those typefaces. Museo 300 is a wide-based typeface with serifs generally at the upper-leftmost and lower-rightmost stems of the character. This makes for a visually spacious typeface appropriate for body text.

Contrast and Color

The parameters for selecting a color palette for The Find Project began with considering established practices in color selection for the visually impaired. ADA Accessibility Guidelines states, “The greatest readability is usually achieved through the use of light-colored characters or symbols on a dark background” (ADAAG, 2014). The ADA Accessibility Guidelines also provides information about the level of contrast required on signage for the visually impaired. “Research indicates that signs are more legible for persons with low vision when characters contrast with their background by at least 70 percent. Contrast in percent shall be determined by:

Contrast = $[(B_1 - B_2)/B_1] \times 100$

where B_1 = light reflectance value (LRV) of the lighter area and B_2 = light reflectance value (LRV) of the darker area” (ADAAG, 2014).

The color palette selected for The Find Project are P 7473C, sea green, P 1788C, tangerine, P 446C, charcoal, P 123C, ochre, and white (see Figure 25). Using the identity as a reference for color contrast, the LRV of the sea green is 35; this value is retrieved from a color matrix calling the color P 7473C “Erin Isle” (MPC, 2014). Using the contrast calculation above with the LRV of white at 100, the result is the contrast of white type contrasts the green background by 65%, approaching the 70% recommendation. The white type on the charcoal background (LRV 4) provides a 96% contrast.

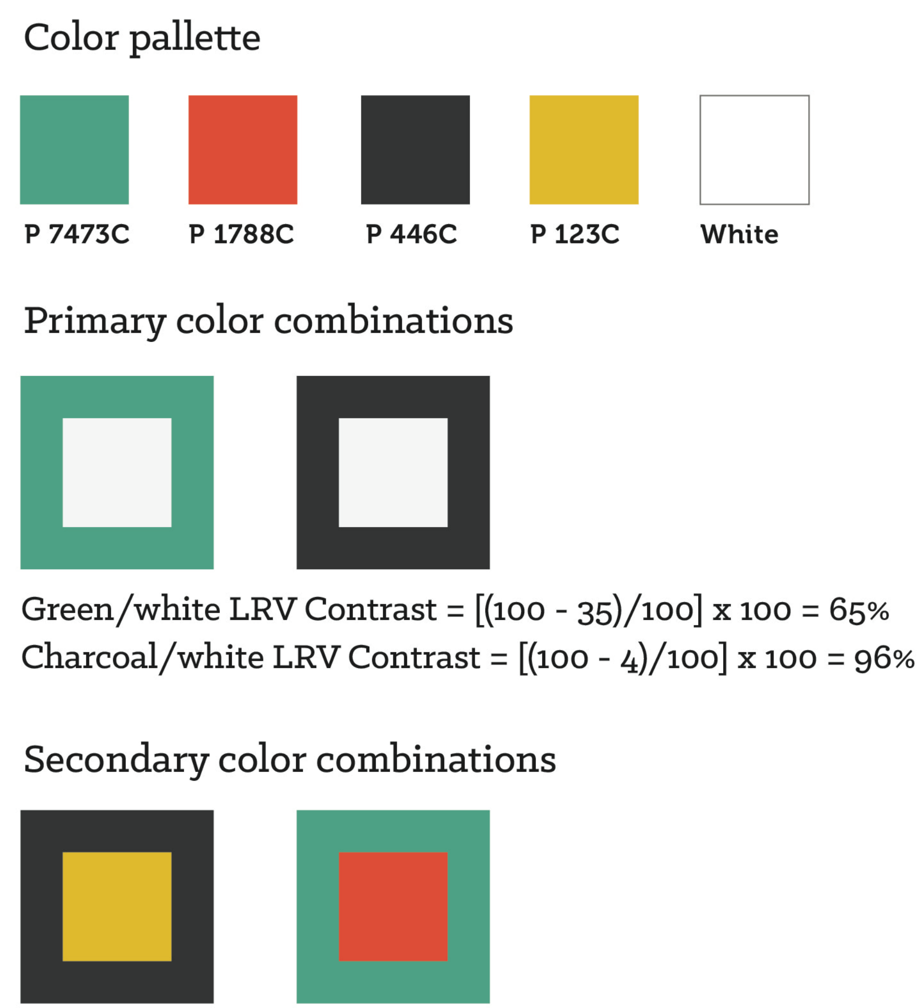


Figure 25. Contrast and Color. The primary color combinations of The Find Project consider contrast requirements set forth by the ADA.

The accent colors of tangerine and ochre intentionally do not produce enough contrast to be used for VI people. These colors are sparingly used not for the purposes of presenting crucial information to VI people. These colors are only intended to enhance the design aesthetic for the sighted community.

<u>Brand Function</u>

David Haigh, CEO Brand Finance, states in *Designing Brand Identity*, “Brands have three primary functions: 1.) Navigation- Brands help consumers choose from a bewildering array of choices, 2.) Reassurance- Brands communicate the intrinsic quality of the product or service and reassure customers that they have made the right choice, and 3.) Engagement- Brands use distinctive imagery, language, and associations to encourage customers to identify with the brand" (Wheeler, 2009). The Find Project brand strives towards these three functions by positioning its differentiating benefits to their VI market and stakeholders. The poster series (see page 53, Fig. 16) in findMKT is an example of the navigation function. The messaging in this series communicates to all people the unique benefit of independent, indoor navigation. The second brand function, reassurance, is provided to VI people and stakeholders through the collaboration of the sighted and non-sighted communities on social media as well as attaining LEED certification. Collaboration on social media between stakeholders, the sighted community, and VI people means people are recognizing the validity of findMAT and identifying additional uses for it. This social media presence of sharing ideas and applications provides reassurance to customers, communicating they made the right choice in purchasing findPKG. Engagement is the third and final function of a brand, as described by Haigh, which discusses the use of "distinctive imagery, language, and associations to encourage customers to identify with the brand. An element of The Find Project is the reoccurring use of the word "find" is the naming schema (e.g., findPKG, findMAT, findOUT, findWRE, and findMKT). This repetition aids in engagement for the audience who being to recognize the reoccurrence of "find" throughout the brand. In addition, a three-letter suffix for each of the previously mentioned component names (e.g. findPKG, findMAT, findOUT, findWRE, and findMKT) engages the user to figure out what the suffix represents (i.e., PKG means package and WRE means wear).

In addition to discussing brand as a whole, *Designing Brand Identity* narrows its focus in “Designing Identity” to provide best practices for design in terms of color and brand guidelines.

Some questions proposed by *Designing Brand Identity* in regards to color were: “Does the color work on white?”, “Can you reverse out of black and still maintain the original content?” and “What background values are necessary?” (Wheeler, 2009). The brand guidelines consider the questions proposed by Wheeler and delineate the proper placement of the identity to ensure sufficient contrast and legibility for VI people per ADA Accessibility Guidelines such as maintaining an LVR contrast value of 70 percent.

Sufficient contrast for identity placement is dependent on which identity version is used in relationship with a particular background (see Figure 26).

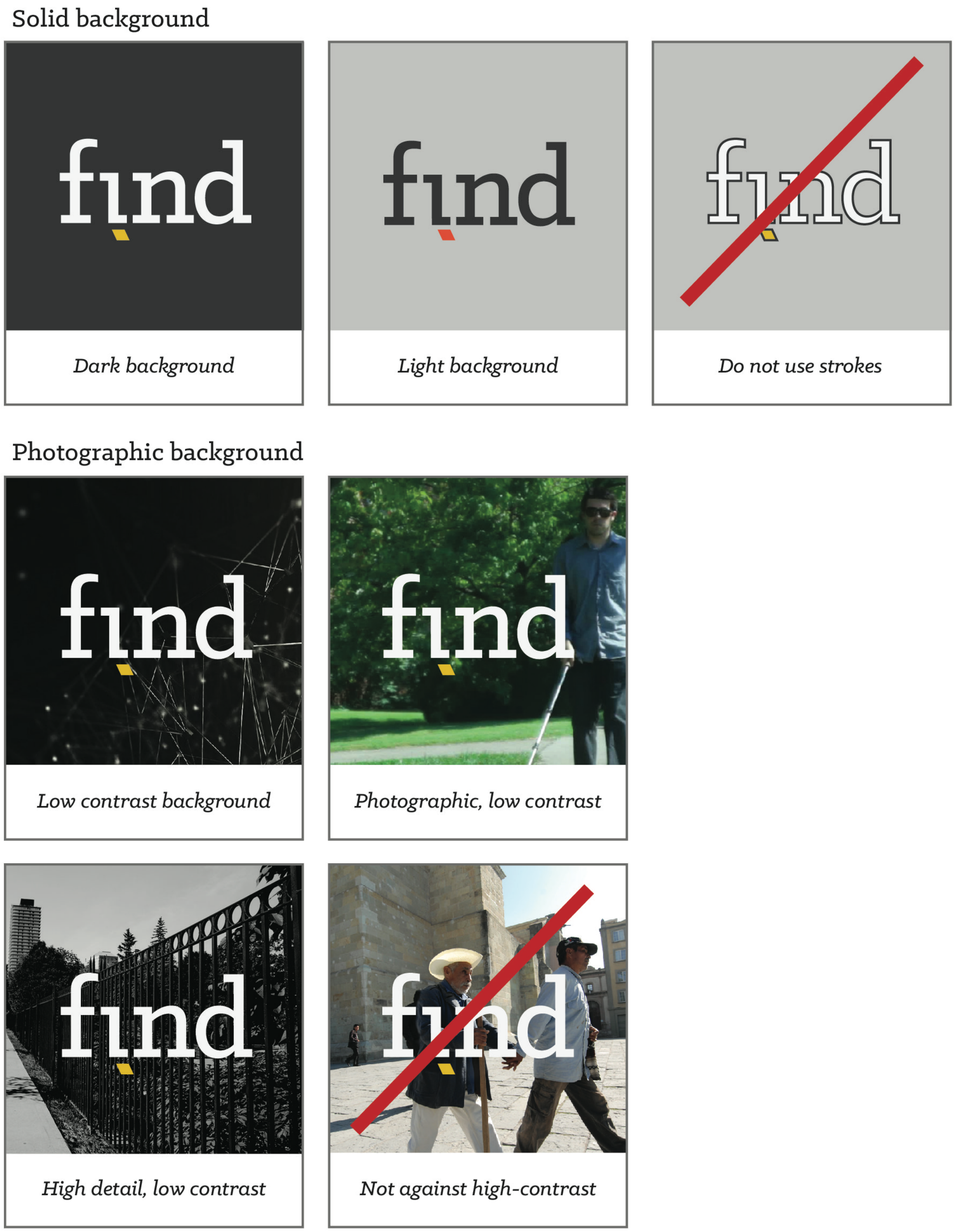


Figure 26. Brand Guidelines. The Find Project brand guidelines were created to maintain brand standards.

Maintaining brand standards and legibility for VI people does not limit the CD team to placing the identity on solid backgrounds. Sufficient contrast is achievable through the effective photographic curation.

To assist the CD team maintaining The Find Project brand, guidelines were created to manage the brand and maintain consistency as work is created by people joining or collaborating with the CD team (see page 79, Fig. 26). Just as the brand guidelines for The Find Project inform collaborators about the brand's standards, the next chapter describes future research of a different collaboration, including growth into mainstream commercial applications with further testing necessary to precisely develop the technological configuration of findMAT and findOUT.

CHAPTER V

CONCLUSION

Limitations of Research

Limitations were evident during the usability testing. The understandability, learnability, and attractiveness metrics of the ISO/IEC 9126-11 standard were not directly tested. Qualitative data was recorded during the consent process in regards to understandability and attractiveness was discussed during the post-test debriefing. However, these metrics can be quantitatively recorded (i.e., directly asking users to identifying buttons and their perceived functionality in findMAT). In addition, with increased sample sizes, multiple routes can be developed to test learnability by having participants navigate through two similar, yet different paths. These expanded paths for testing will also contain scenarios to test failures in the findOUT and findMAT technology as well as emergency situations (i.e., power outages).

Pursuing a more calculated variety of test subject for these usability scenarios is discussed by Ben Shneiderman in “Universal Usability.” He states there are three challenges to achieving universal usability (UU). UU “can be defined as having more than 90% of all households as successful users of information and communications services at least once a week” (Shneiderman, 2000). He continues by explaining three challenges in attaining UU for Web-based, digital, and interactive services:

1.) Technology variety is the support of variety of hardware, software, and network accesses.

2.) User diversity is the accommodation of users with varying attributes (i.e., skill- and knowledge level, age, gender, disabilities, literacy, etc.).

3.) Gaps in user knowledge are the disparities between a user's current and desired technological proficiency.

The Find Project will continue research to broaden the spectrum of collaborative hardware, software, and network accesses (i.e., utilizing NFC technology which is supported by all major mobile providers) (NFC World, 2014). The Find Project will address user diversity by performing a more calculated approach to acquiring test subjects, in addition to the criteria for the usability testing in this research which only regarded visual impairment, age, and mobility. Continuing research will also record gaps in user knowledge to better understand the level of proficiency desired by certain demographics of the population. To continue researching and spreading information about findMAT, funding is required to maintain the findMKT presence as well as develop advancements in findMAT, findOUT, and findWRE.

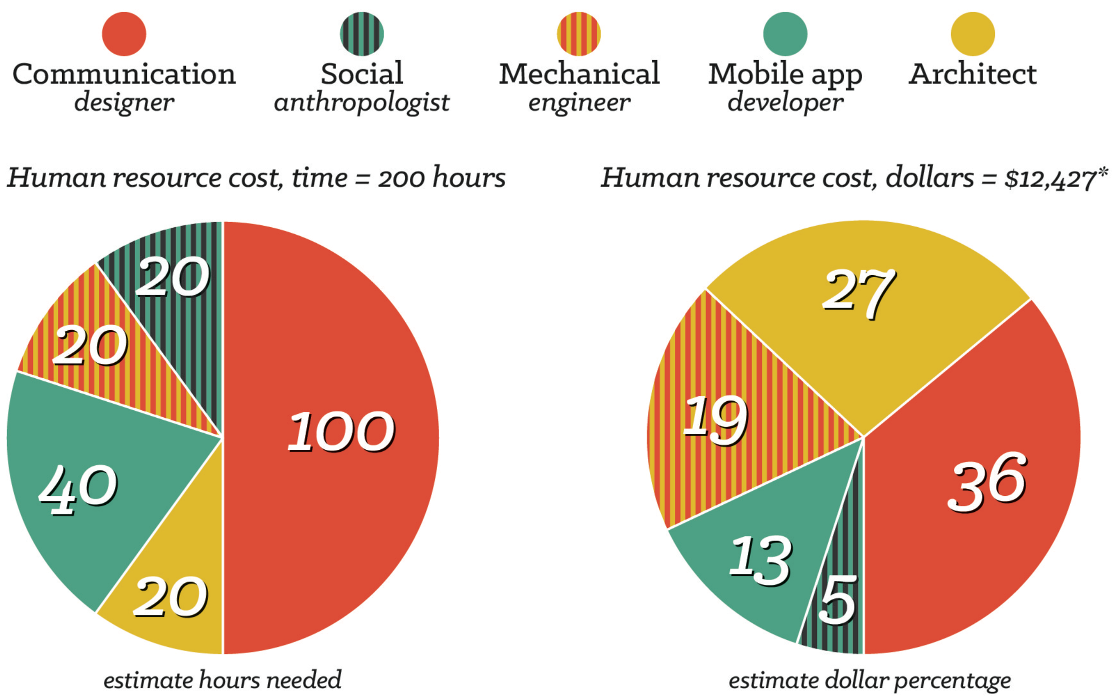
Future Investigations

Determining the amount of funding needed to develop the next prototype begins with an inventory of deliverables needed to continue research. Six components are needed for the high-fidelity prototype: 1). findMAT app, 2). Bluetooth® beacons, 3). NFC tags, 4). mobile device, 5). Bluetooth® headset, and 6). wrist mount.

Deliverable Costs

All deliverable costs are based on a time frame for developing the second prototype. Human resource costs are the largest expense to develop the prototype (see Figure 27). Costs are derived from time requirement estimations of each member of The Find Project team. The cost of hosting the findMAT app is US $149/month for 10 servers through Bitnami® cloud hosting (Bitnami, 2014). For six months, the total cost of hosting is US $894. Bluetooth® beacons are not manufactured for this stage of the prototype process, only the findMAT software. Commercially available beacons are such as Estimote Beacons cost US $99 for 3 beacons (Estimote, 2014). Twelve beacons are needed for the prototyping process, making the cost of beacons total US $396. NFC tags are needed for stationary object of interest identification, and the Broadcom Topaz 512 NFC tag is the correct size (29mm) and memory (512 bytes) to function as needed for the prototyping process. The Broadcom Topaz 512 NFC tag is sold at US $0.67 per tag when 100 or more are purchased through RapidNFC, totaling US $67 for 100 tags (RapidNFC, 2014). The Apple iPhone 6 Plus is the mobile device used for the second prototype, which costs US $749 for the 16GB model (Apple, 2014). Bluetooth® headsets (e.g., Jabra® Motion) are available for US $129.99 (Jabra, 2014). Lastly, the wrist mount is simulated by a runner’s arm band which retails on the order of US $39.99 (BestBuy, 2014). Including the US $12,427 human resource cost, the total deliverable cost for the six-month prototype process is approximately US $14,703. This is the target figure for fundraising to begin the prototype process.

Prototype costs, time and dollars



*Human resource cost, dollars = $12,427
(Freelance hourly charges calculated using latest available median salary of each profession based on 40-hour work week and multiplied by 150% for freelance mark-up)

Communication Designer:
Median salary $62,000[1]/2,080 hours *(annual work avg.)* = $29.8/hr
29.8/hr x 100 hours worked = $2,980 x 1.5 *(freelance mark-up)* = $4,470

Architect:
Median freelance hourly rate: $170[2]/hr x 20 hours = $3,400

Mechanical engineer:
Median salary: $80,580[3]/2,080 hours *(annual work avg.)* = 38.7/hr
38.7/hr x 40 hours = $1,548 x 1.5 *(freelance mark-up)* = $2,322

Mobile app developer:
Median salary: $88,000[1]/2,080 hours *(annual work avg.)* = $42.3/hr
42.3/hr x 20 hours worked = $1,058 x 1.5 *(freelance mark-up)* = $1,587

Social anthropologist:
Median salary: $45,000[4]/2,080 hours *(annual work avg.)* = $21.6/hr
21.6/hr x 20 hours worked = $432 x 1.5 *(freelance mark-up)* = $648

[1] *http://work.chron.com/much-visual-communication-designer-make-8221.html*

[2] *http://www.brickunderground.com/blog/2013/01/the_real_scoop_on_architectural_fees_they_can_be_negotiated*

[3] *http://money.usnews.com/careers/best-jobs/mechanical-engineer/salary*

[4] *http://www.simplyhired.com/salaries-k-social-anthropologist-jobs.html*

Figure 27. Human Resource Costs. This illustration shows the six-month human resource cost of prototype development.

Fundraising

Fundraising efforts begin online through crowdfunding sites like GoFundMe® and Kickstarter®. Crowdfunding is a online tool where a host company allows the creator of an account to post information about an endeavor which requires funding. People view this request for funding through the site and securely donate or lend to the endeavor, with the host company usually receiving a fee from the transaction. The crowdfunding process likely does not begin until patents and trademarks are filed for all proprietary information associated with The Find Project. In addition, The Find Project should become a limited liability company to apply for research grants through the U.S. Small Business Administration (SBA, 2014). Since The Find Project is "engaged in scientific research and development," federal grants may be available under the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programs (SBA, 2014). Future research is what is necessitating the funding, and this research focuses on improving findMATt for VI people as well as identifying new opportunities for the technology.

Retail Industry

Future research is required for findMAT to progress in the four areas: 1). the retail industry, 2). sighted pedestrian navigation, 3). organized sports, and 4). LEED certification. Through the universality of findMAT, VI people can become more independent, resulting in mainstream society and the VI community moving closer together in lifestyle, interactivity and collaboration. An opportunity for findMAT is in the retail industry to benefit all people.

The retail industry benefits from findMAT by having products equipped with findOUT NFC technology. This allows for identification of products as well as additional product information. A person navigating into proximity of a product they have predetermined as desirable can receive personalized information about the product. This retail opportunity for findMAT also has the ability to eliminate customers from searching throughout multiple aisles of a store for a particular item. The customer, instead, could head to the appropriate aisle as soon as they enter the store, even if they are not familiar with the store layout. The same way the retail application of findMAT is useful for all people, the navigational application of findMAT is just as relevant to sighted people.

Sighted Navigation

When a sighted person multitasks by navigating and looking at their mobile device, the sighted person is less aware of their surroundings; their attention is not focused on safety nor is their eyesight fully dedicated to their surroundings. This makes the sighted pedestrian's vision partially impaired through multitasking. If the person's sight is compromised due to multitasking, the person can benefit from findMAT as an additional source of information about their physical surroundings. A sighted person can receive an alert on their device about a popular destination in the building up ahead or alert the user of a predetermined or frequented location of their own. The Find Project focuses on research to eliminate barriers to information for all people, including VI people, so they can spend more time doing what they love, even if their love is sports.

Organized Sports

VI people can use findMAT to effectively participate in competitive sports. For instance, a long snapper in football needs to be able to run onto the field at the appropriate time, locate the football, placeholder, and snap the ball. VI people are independently capable of all of the tasks using their sense of hearing, except for one: locating the football. If the long snapper on the field locates the football, they know the general organization of the players on the field: four teammates to the right of the football, four teammates to the left, the placeholder seven yards behind the football slightly to the right, and the kicker nine yards behind the ball for a place kick. The VI long snapper can locate the football using findMAT since the technology has the ability to identify his position on the field to determine the distance needed to locate the ball. The information he needs to know is what yardage marker the ball is placed at. The long snapper is not expected to play football while holding a mobile device, which is why a thin Bluetooth® transmitter in this scenario functions best. The player has a Bluetooth® -enabled ear piece secured in the helmet to receive verbal messages of the ball's location. Bluetooth® -enabled helmets are commonplace in professional football, so players can receive play calls directly into their helmets. Much in the way findMAT eliminates barriers to entering mainstream sports for VI people, pursuing LEED certifications for findMAT and findOUT benefit all people.

LEED Certification

The *Reference Guide for Building Design and Construction* provides an overview of the rating system by which projects are evaluated (LEED, 2013). The findMAT and findOUT systems of hardware and software technologies are the logical next step in the progression of ADA compliancy. NFC tags in findOUT are placed on ADA compliant signage throughout a building to leverage previous way-finding efforts. LEED certifications strengthen the argument for findMAT's and findOUT's inclusion in ADA Accessibility Guidelines. Once findMAT and findOUT are standards for accessibility, the technology can also be a benchmark for Building Design and Construction LEED certification, including Innovation in Design Credits.

An Innovation in Design credit as part of LEED certification is the first step to communicating to the general public, businesses and government the need for digital, selectable, interactive maps. The progress Google™ IPS began of multilevel maps must be continued and improved upon from multiple directions and companies. The Find Project team is an organization of professionals suited for the task. LEED certification plays the role of adding legitimacy to a test market of findOUT. Once the benefits findOUT are realized as beneficial to all, the movement for multilevel, digitized maps begins in earnest as companies see opportunities to provide the best experience to their customer.

Questions to Guide Future Research

The following questions have arisen from usability testing and design outcomes

1.) If findOUT becomes ADA legislation requiring businesses to comply, can the government provide findMAT and findWRE technologies to VI people?
2.) To what extent will NFC tags be used on stationary objects? Will they remain on static objects or do they have applications with dynamic moving objects (i.e., luggage on a moving baggage claim terminal)?

3.) Does findOUT have applications in homes or a VI person's familiar spaces where stationary objects are memorizable?

4.) What will be the level of involvement for the section of the sighted community who has no affiliation with VI or does not know a VI person? What can be done to identify and communicate to those people directly?

Growth of findMAT

This research is intended to determine if findMAT is a viable supplement to a VI person's current MAT (e.g., canes and guide dogs) for indoor navigation. The purpose of creating a product for VI person indoor navigation is to facilitate an easier, independent, and more enjoyable indoor navigation experience at a time when visual impairment related to an aging population and rise in diabetes is at all-time high (Diabetes, 2014). The research presents a solution through the use of mobile devices, Bluetooth® and NFC technology, and social media interactive mapping. As cases of visual impairment increase, the need for an alternative to braille signage, embossed signage, and human guides will increase as well.

The growth and applicability of findMAT is the solution to this need, which is directly dependent upon user involvement. VI people who identify an aspect of their life where findMAT is useful should share their experience through social media. The sighted community also has the ability to spread awareness of findMAT through social media by sharing how increased independence of blind and low vision people has benefitted *their* life and society as a whole. Undiscovered applications for findMAT can gather people in once disparate societies together for ideation and creation.

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VITA

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