Proposal for Indoor Direction Finder for the Visually Impaired

January 21st, 2013

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6 Canada

Re: ENSC 305/440 Project Proposal for Indoor Direction Finder for the Visually Impaired

Dear Dr. Rawicz:

The attached document, "Proposal for Indoor Direction Finder for the Visually Impaired", outlines our endeavour for our capstone project in ENSC 305/440. We seek to design and implement an indoor system of signal beacons that enable the blind and visually impaired to navigate safely and effectively to their destinations with a portable device. We named this system the **WhereTo**.

The purpose of this proposal is to provide insight to our proposed design and evaluate its risks and benefits to society as well as to outline our strategy at funding and budgeting. This document will also illustrate our credible scheduling and better introduce the talents on our team.

Envied Solutions consists of four talented near-graduate engineering students: Alan Fang, Phillip Peach, Shaham Shafiei, and I, Wilson Chen. For any questions or concerns you may have, please contact me by phone at 778.386.3284 or by email at wilson_chen@sfu.ca.

Sincerely,

Wilson J. L. Chen
President and CEO
Envied Solutions

Enclosure: Proposal for Indoor Direction Finder for the Visually Impaired

Proposal for

INDOOR DIRECTION FINDER FOR THE VISUALLY IMPAIRED

Project Team:	Alan Fang Wilson Chen Phillip Peach Shaham Shafiei
Contact:	Wilson Chen (wilson_chen@sfu.ca)
Submitted to:	Dr. Andrew Rawicz – ENSC 440 Steve Whitmore – ENSC 305 School of Engineering Science
Issued Date:	January 21, 2013

Exclusive Summary

Imagine that you have troubles seeing. You have a severe visual impairment that declares you legally blind. You also have a meeting in an unfamiliar building. Your GPS device got you as far as the building's entrance – but now you need to get to the meeting room. You ask for directions but they are half useless but you can only constantly badger people. You can't see the stairs that are halfway down the hall, if no one tells you. You won't notice you've finally found the B-wing unless someone tells you or you've luckily found a sign in Braille. Figuring out which room you want could require some trial or error and a lot of time... NOW, WHAT IF, when you first enter the building, you notice that there is a rack beside the door. Off that rack, you pick up a **WhereTo** *way-finder and after a few seconds of inputting your destination, it directs you turn by turn up the stairs, down the hall, and right through the door of your destination.*

Most buildings provide primarily visual way-finding. Overhead signs, maps, colour-coded walls are some examples. This leaves a gap for those with significant visual impairments when navigating these unfamiliar buildings. Envied Solutions proposes erecting a system that will help visually impaired people navigate through buildings without another person's assistance, the **WhereTo**. The **WhereTo** system would provide the visually impaired user a greater degree of freedom and would drastically improve their standard of living enable them to live a more independent and happy life.

The proposed **WhereTo** system consists of a series of beacons strategically throughout a building paired with handheld way-finders for the users. The users' portable device will use the beacons to figure out where it is and then map a path from wherever the users are to their destinations. Through audible directions, the device would reliably guide the users.

We hope to leverage existing inexpensive technology such as Wi-Fi to speed our design and building processes.

The current forecasted budget including a contingency fund sits at $740. At this time, we have secured $400 funding from the Engineering Student Society Endowment Fund. We are investigating other sources of funding including the Wighton Fund as well as the possibility of borrowing some of the equipment instead of purchasing it. Any shortfall will have to be covered out of the pockets of the members of Envied Solutions. Our schedule calls for assembly to begin in mid-February with a prototype system projected for completion at the beginning of April 2013.

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1. Introduction

Visual impairment can cause great difficulty for a person in a new environment. Common way-finding systems used in buildings can present difficulties for a visually impaired person. There is a market for systems that substitute for this traditional way-finding for visually impaired users.

Currently, to make up for this, those with visual impairment must use second best alternatives. . Their inability to use visual landmarks can interfere with their spatial sense. [1]They may be required to do some combination of navigating by trial and error, creating a mental model without the benefit of traditional signs and maps, or insisting that another person give more precise directions. [2] Each of these workarounds imposes a monetary and/or social cost on the user.

To alleviate their troubles, we propose to design and create a direction finding system by installing a series of short range radio beacons at known locations in the building. The user will then utilize a portable handheld unit which will use these beacons to locate and orient itself and thus the user. The handheld's user interface must take into account the user's disability: the interface will have to make use of sound and tactile feedback instead of visuals. For this system to succeed, it will require precision positioning, ease of use, and be reasonably discrete as not all users will want to broadcast their disability by using an obvious aide.

Our proposed system gives the user the benefit of holding the model for the building in the handheld unit instead of their head, and can give them their location even in an unfamiliar place. This allows them to obtain help without feeling socially awkward.

2. Existing Design Solution

GPS is the most commonly used location service. However, it was not designed to work indoors and the results can be erratic and unreliable inside. [3] Indoors, the signal is attenuated and scattered by the building's structure. GPS by itself is thus unsuitable for this application.

There is an emerging market in so called "Indoor Positioning Systems." There are several competing standards and technologies being developed. [4] We have explored some of the different technology choices before arriving at our proposed design in the following section. Industry standardization is expected to come this year for the Indoor Positioning space and it could be beneficial to examine any draft standard both to save research time and to leave open the possibility of making our system compatible with other vendors at some future time.

What differentiates our system from the others is our focus on helping visually impaired users with a user interface design and specialized handheld unit that places their particular needs at the forefront.

3. Design Solution

Our proposed design solution consists of two parts. First, there are the beacons which are placed along the inside perimeter of buildings to ensure sufficient coverage. Each beacon transmits a constant identifiable signal to indicate its position. If generic Wi-Fi signals prove reliable, ubiquitous Wi-Fi routers could make up the beacons to save development time. The second and more complicated part to the system is the handheld way-finder. This handheld unit should receive the signals from the beacons and uses the signal properties, the encoded positions of the beacons, and geometry to estimate the handheld's and thus the user's position.

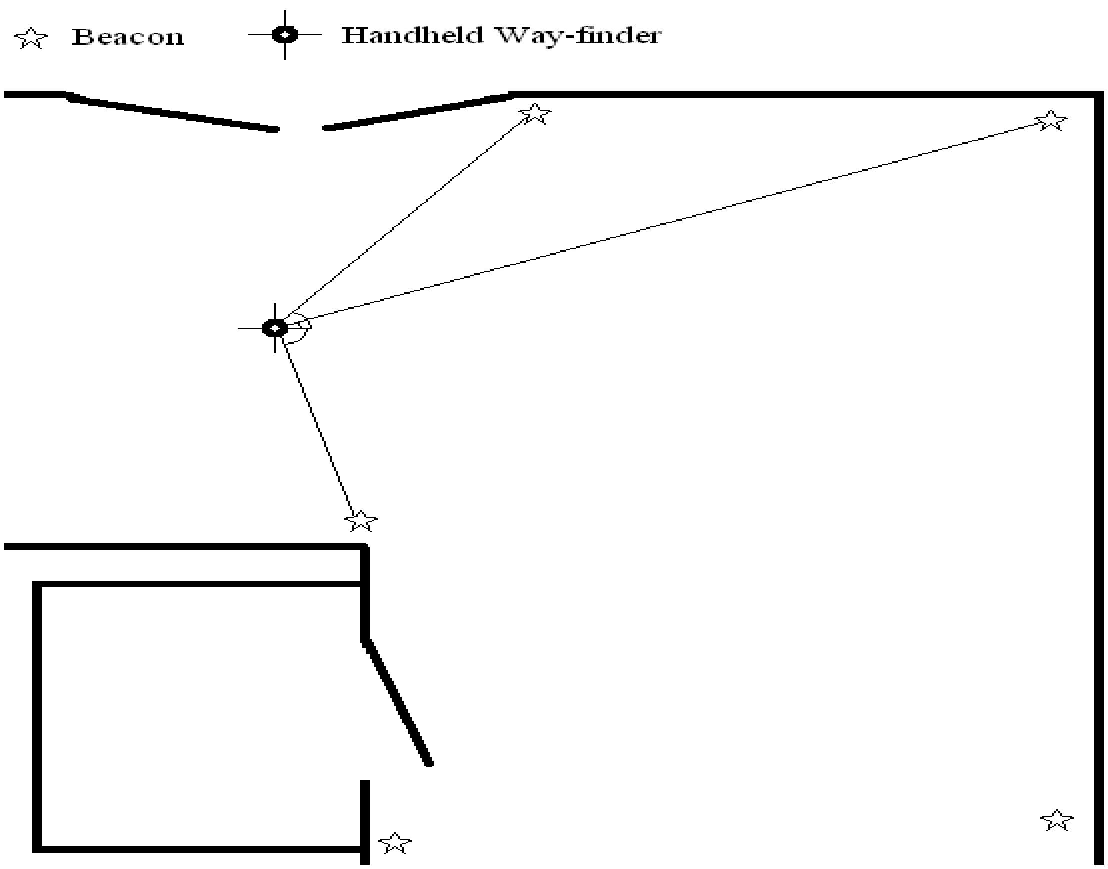

Figure 1: Prospective System Layout

For inputting a destination we are considering a voice recognition system but if that proves infeasible we will fall back on a tree menu structure using a small number of uniquely shaped buttons. Output will be in audio form through a set of headphones. Most of the output will be spoken words such as, “Turn Left”, “Continue Straight”. We are also considering a short range obstacle detection feature so that we can warn the user instead of directing them into an unknown object. However this feature may be dropped in favour of refining the core functionalities if time constraints disallow completing both.

We are considering a few solutions for the handheld unit to locate itself. They all rely on the handheld unit having the positions of the beacons and the building layout in memory. One possibility is using signal strength as proxy for distance and then using the distance to different beacons to calculate its position. Using the signal strength in this way may present precision problems, limiting accuracy to at best 2-3 metres. [5]Another approach is to determine the bearing of multiple beacons. This technique would require the use of directional antennas which, according to early research, seems to be difficult to miniaturize. Finally, we may consider a time-of-flight system where each beacon transmits the current time and the receiver uses the differences in time to accurately fix its position. However we have already been advised by Lakshman One that it may be impractical to implement a sufficiently synchronized and precise clock at low cost.

4. Risks

The part of this project that carries the biggest risk is developing the positioning system. The problem of locating an object using fixed radio transmitters is non-trivial. Different approaches will have differing risks and impose constraints on the design both technically and physically. Given the timeline of the project, if one approach manifests undesirable properties, there could be insufficient time to try another approach. We will do our best to mitigate this risk and will be consulting with experts on choosing a viable approach.

Another risk stems from our plan to use multiple beacons to give coverage to an area. Because there are several (we currently estimate we need five beacons to conduct a demonstration) any unit cost overruns or increases in complexity would be multiplied by the number of beacons.

Related to the risk above, moving from our test environment to a demonstration or full scale implementation could reveal new issues with the interaction between the radio waves and building materials or structure layouts of different buildings and places within buildings.

The user interface will require a greater amount of thought than might otherwise be needed for a similar project so that it is usable by the visually impaired. Visual feedback is a powerful mechanism and not being able to use it will require different design choices. To ensure that the interface is not as frustrating as a telephone menu will be a challenge.

5. Budget and Funding

5.1 Budget

The following table shows the tentative budget which will be used for research and development purposes.

Component	Budget
Wi-Fi Receiver	$30
Wi-Fi Transceiver	$40 x 4
Audio	$50
Battery (rechargeable)	$20
Microcontroller	$50
Sensor	$40
Handle	$40
Magnetometer/Accelerometers	$30
PCB Board	$50 x 4
20% Contingencies	$120
Total	$740

Table 1: Tentative Budget

This is just the estimated budget. The cost information comes from various online retailers. If the project can be successfully done without any failure, such that we do not tap into the contingency pool, actual costs will be lower.

5.2 Funding

Due to the high cost of the project, our group will seek funding to cover the project. Currently, our main source of funding is from the Engineering Student Society Endowment Fund (ESSEF). ESSEF has already approved of $400 to support this project which will cover most of the costs. If the funding is insufficient, we will apply for the Wighton Fund to reimburse us after completing this project.

If all funding do not cover total cost, the extra costs will be equally shared by all of our group members.

6. Schedule

The following is the Gantt Chart displaying the timeline for our project.

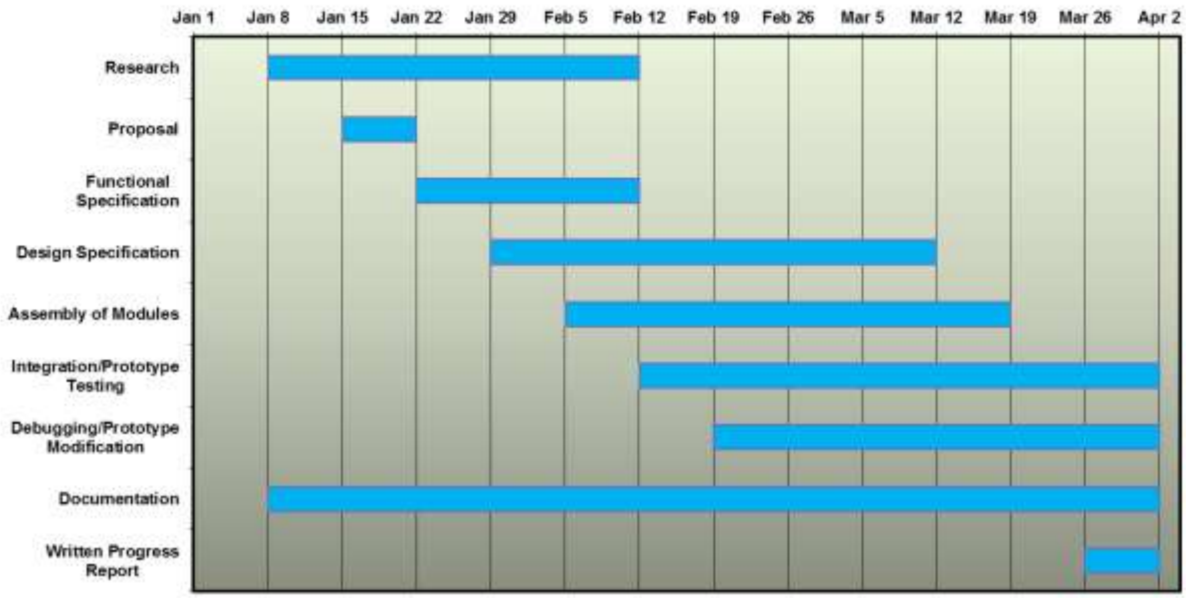

Table 2: Gantt Chart

The following figure shows the milestones along the way to completing our project.

Figure 2: Milestones

7. Conclusion

We at Envied Solutions hope the way-finding system we intend to develop will be installed by building owners all over the world as it will benefit both their visually impaired clientele and themselves by raising their reputation in social responsibility and attract opportunities.

When fully implemented, this system should deliver a large measure of freedom and independence to the visually impaired. It will also be possible to use the existing system as a stepping stone for new products and innovations. These products could range from a separate handheld geared towards users with unimpaired vision to other less cumbersome assistive devices.

The Envied Solutions team is dedicated and driven. We believe that with strict adherence to our Gantt chart presented previously, we can design, prototype, and test the system on schedule. Our ultimate goal is to outfit a portion of the Applied Science Building at Simon Fraser University with a demonstration system by the beginning of April, 2013.

8. Team Organization

Envied Solutions consists of four talented, well-trained, near-graduate engineering students: Wilson Chen, Alan Fang, Phillip Peach, and Shaham Shafiei. We each hold a unique set of expertise that is invaluable to our success. This diversity enables us to analyze problems at hand from multiple perspectives. The Company Profile section, which follows, highlights our individual skills and talents.

Wilson Chen, the President and Chief Executive Officer (CEO), drives progress and lays out the full roadmap to project completion. Alan Fang, the Chief Financial Officer (CFO), manages our budget and works to minimize costs. Phillip Peach, the Chief Operating Officer (COO), oversees the technical design and is our consultant on feasibility. Shaham Shafiei, the Vice President of Marketing, works closely with Phillip to ensure that the product thrives in the market of improving accessibility for the blind or visually impaired.

Our company structure closely resembles that of a start-up company. While we each have our primary responsibilities, we maintain constant communication and we cover for each other whenever it is necessary. We share most of our work and encourage collaboration because, again, we want to leverage the diversity of our team as much as possible.

To ensure that we are constantly making progress, we hold weekly hour-long meetings to identify what stage in the project we are in and to delegate work. We divide work into portions that require two people to oversee each one's completion to alleviate contingencies. We also schedule follow-up meetings on the fly as necessary to maximize productivity. We believe that as long as we adhere to our company's structure, we will triumph in the months to come.

9. Company Profile

Wilson Chen – Chief Executive Officer (CEO)

Wilson is in his last year of study in Systems Engineering at Simon Fraser University. He brings hardware design and prototype building experience from school projects as well as extensive software engineering and project management skills from his co-op internships at Research In Motion Ltd. in Waterloo as well as at Darelle Media Inc., an e-commerce start-up based in Vancouver. With a keen eye for usability enhancements, he is crucial in driving the team to success.

Alan Fang – Chief Financial Officer (CFO)

Alan is in his last year of studying Electronic Engineering at Simon Fraser University. He has developed a strong background in analog circuits and has working knowledge of RF circuit and digital system design. Alan is extremely proficient with DMMs, oscilloscopes, power supplies, and function generators in the lab. His last co-op role is an Audio Electronic Associate at Research In Motion at Waterloo. He has contributed to the most advanced audio electronic design technology for current BlackBerry smartphones. He assisted in testing noise, crosstalk and THD, and headphone detection for devices. He also developed strong soldering skills by modifying PCB component. Alan is an exceptionally quick learner in schematic design and he is hardworking as well as patient. Of course, he is amongst the best in problem solving within the team.

Phillip Peach – Chief Operating Officer (COO)

Phillip Peach is a senior student in Simon Fraser University's System Engineering program. He is talented at writing, testing, and debugging software systems, a skill-set he has put to use during multiple co-ops at the NetApp Vancouver Technology Centre performing automated functional and regression testing.

Shaham Shafiei – Vice President of Marketing (VP Marketing)

Shaham is a fourth year Systems Engineering student at Simon Fraser University with experience in a variety of fields in both software and hardware. In past few years he had taken courses in circuits, microelectronics, real time embedded systems, linear systems, feedback control systems, as well as sensors and actuators, just to name a few. His focus is on hardware more so than software. In previous terms, he had done projects such as VHDL programming and assembly language programming on the 68HC11 microcontroller board but he enjoyed designing and building a hockey-playing robot more. Shaham has extensive experience with most of the workshop machines as well as generic electronics laboratory equipment. Besides his technical skills, he is very easy going, a great team player, and a natural leader.

10. References

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[2] Reginald G. Golledge, "Geography and the Disabled: A Survey with Special Reference to Vision Impaired and Blind Populations," *Transactions of the Institute of British Geographers*, vol. 18, no. 1, pp. 63-85, October 1992.

[3] Richard Klukas, Gerard Lachapelle, and Robert Watson, "investigating GPS Signals Indoors with Extreme High-Sensitivity Detection Techniques," *NAVIGATION*, vol. 52, no. 4, pp. 199-214, Winter 2005.

[4] (2012, December) The Economist. [Online]. http://www.economist.com/news/technology-quarterly/21567197-navigation-technology-using-satellites-determine-your-position-only-works

[5] P. Canalda, P. Chatonnay, D. Charlet, F. Lassabe, and F. Spies, "Refining WiFi Indoor Positioning Renders Pertinent Deploying Location-Based Multimedia Guide," in *Advanced Information Networking and Applications, 2006. AINA 2006. 20th International Conference on*, 2006, pp. 126-132.