October 6th, 2003

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

Re: ENSC 340 Project *Functional Specifications for a Dynamic Directional System*

Dear Dr. Rawicz:

The attached document, *Functional Specifications for a Dynamic Directional System*, outlines functional requirements of our project for ENSC 340. Our project is to implement a dynamic directional system which provides vocal directions based on the orientation of a visually impaired person.

This document encloses the functional specifications of the two phases of our product. The document also includes a test plan and user documentation and training requirements.

Our team at Sound Directions, is comprised of six talented, enthusiastic, optimistic, and hard-working fourth-year students. Group members include: Farhan Ali, Ted Liu, Chris Chun, Nima Jahedi, Daniel Kim, and Gelareh Parandian. If you have any enquiries or questions feel free to contact us at sd-ensc@sfu.ca. Thank you very much.

Sincerely,

Farhan Ali

Farhan Ali
President and CEO
Sound Directions

Enclosure: *Functional Specifications for a Dynamic Directional System*

Functional Specification for a Dynamic Directional System

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Executive Summary

Sound Directions is currently developing an innovative product that will improve the quality of life for visually impaired individuals. Our product provides directional guidance to visually impaired individuals based on their orientation. Our system would be installed in major public places including universities, airports and malls.

The development of our product is divided into two phases. Phase one encompasses the most basic navigational requirements, which includes determining a user's location and orientation. Our aim is to complete Phase one by mid December 2003. This will provide a proof-of-concept device that will be used as a basis for Phase two.

Phase two will incorporate wireless internet access into the entire system to allow a more manageable, adaptable and scalable product. Phase two will follow immediately after the completion of Phase one and will continue for approximately 6~8 months.

This document outlines the functional specifications for the two phases of the product.

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1 Introduction

The *Dynamic Direction System* is a guidance system for the visually impaired that provides vocal directions to nearby places of importance. The system is comprised of two modules; the user module and the sign module. Each module has sets of functional requirements which are listed throughout this document. The development of the project will be under taken in two phases. Phase one will be a development of a proof of concept device with a completion date set in December 2003. Phase two will follow immediately and is expected to last 6~8 months.

1.1 Scope

This document lists functional and non-functional requirements for *Dynamic Directional System* for the visually impaired. The requirements are divided into Phase one and Phase two requirements. This document will supply a complete set of the requirements for Phase one. On the other hand, the requirements for Phase two are loosely defined since a substantial amount of revisions/modifications are expected during the Phase one development stage.

1.2 Glossary

bps	bits per second
dBm	decibel with respect to 0.001 watt
FCC	Federal Communications Commission
FM	Frequency Modulation
FSK	Frequency Shift Key
Hz	Hertz, cycles per second
IC	Industry Canada
IEEE	Institute of Electrical and Electronics Engineers
mW	0.001 watt
MHz	1,000,000 cycles per second
OS	Operating System
RF	Radio Frequency
RSS	Radio Standards Specification
VDC	Volts, Direct Current
WLAN	Wireless Local Area Network

1.3 Intended Audiences

This document is intended for designers, managers, and marketing personnel. Designers may use this document as a guideline for the development of the system. Managers may use this document as a guide for scheduling and other management activities. Marketing personnel may use this document for promotion of the product.

1.4 Conventions

The functional requirement notations used throughout this document are explained below:

[R#] A functional requirement

Roman numerals at the end of each requirement denote which phase it is confined to. The description of each Roman numeral is shown below:

(I) A functional requirement for only Phase one
(II) A functional requirement for only Phase two
(III) A functional requirement for both Phase one and two

2 System Overview

2.1 Phase One

Figure 1 illustrates the system overview of Phase one. The system consists of two modules: a user module carried by a visually impaired person and a sign module placed on the directional sign. These two modules communicate each other through RF technology.

The sign module transmits RF directional information continuously throughout the air. As a visually impaired person approaches the directional sign, the user module receives a set of pre-recorded directional messages. The user module then determines the orientation of the user and then calculates the resultant directions. The directions are then 'spoken' through the onboard headphone/speaker.

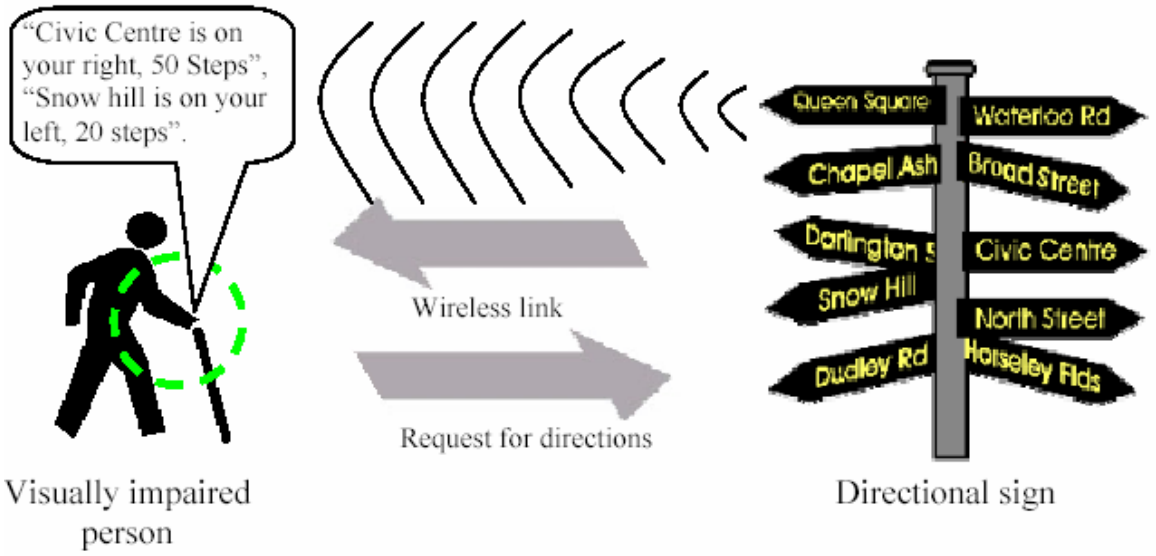

Figure 1 – Overview of Phase One System

2.2 Phase Two

Figure 2 illustrates the system overview of phase two. In phase two, the *Dynamic Directional System* uses both RF and WLAN technologies (Web module). With wireless hotspots popping up in major urban centers we believe that this technology allows us to provide a complete guidance solution to the visually impaired using pre-existing infrastructure. Also the use of the WLAN for data transfer considerably simplifies the design of the sign modules.

In Phase two, the sign module uses RF for continuously transmitting location codes which are specific to each location. As a user approaches a sign module, it receives the location code. The user module then connects to an online database over the WLAN and retrieves the directions specific to that code. The user module then determines the user orientation and calculates resultant the directions. These directions are again 'spoken' through a speaker/headphone.

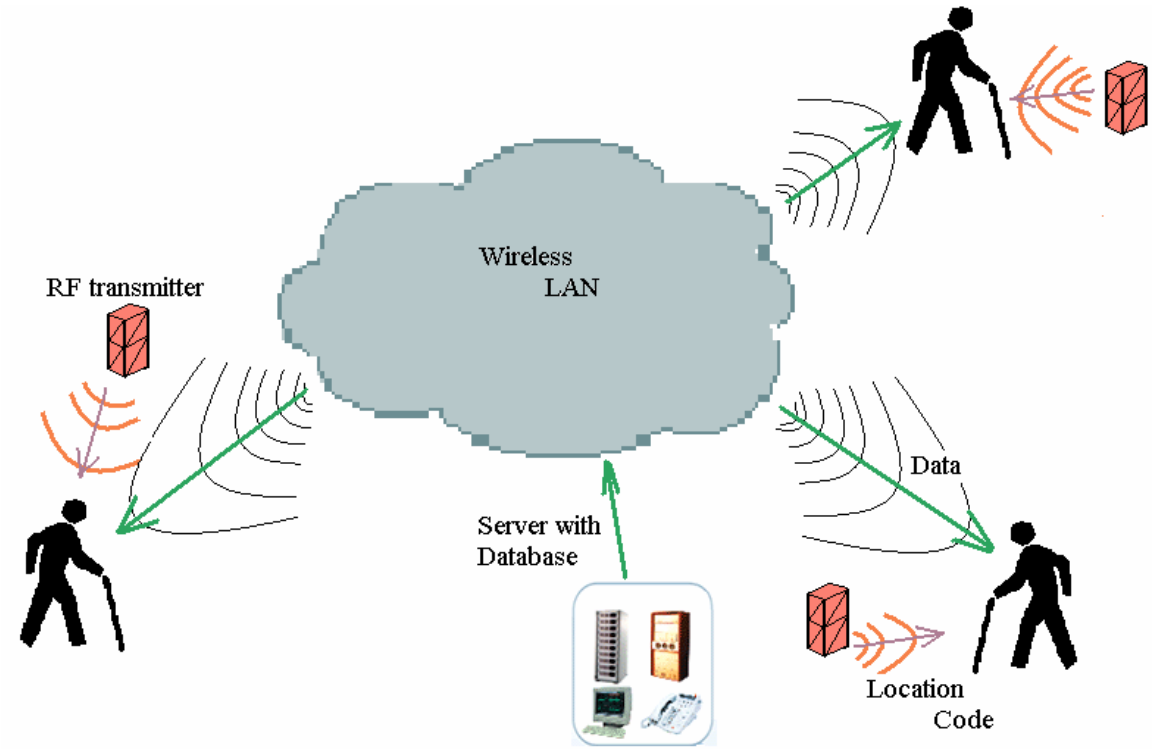

Figure 2 – Overview of Phase Two System

3 Usage Scenarios

In order to further improve the understanding of our system operation, we have included some possible usage scenarios. Note that these are just possible instances of events, thus may not represent the whole functionalities of the system.

3.1 Scenario 1

1) Scenario name: Finding a washroom in a mall
2) Participating actors: Susan - visually impaired
3) Flow of Events:
   i. Susan wishes to find a washroom in a mall.
   ii. Susan approaches a sign with a sign module implemented.
   iii. Vocal direction is played through the speaker on the user module.
   iv. Susan hears directional information about a washroom.
   v. Susan follows the direction to find the washroom.

3.2 Scenario 2

1) Scenario name: Finding a gate at the airport
2) Participating actors: John - visually impaired
3) Flow of Events:
   i. John wishes to find gate I to get to Singapore Airline.
   ii. John approaches a sign with a sign module implemented.
   iii. A vocal direction to different gates begins to play on a speaker.
   iv. John hears directional information about gate I.
   v. John unfortunately forgets the direction to gate I shortly after.
   vi. John pushes a small button to re-play the message again.
   vii. This time, John correctly remembers the direction.
   viii. John follows the directions to find gate I.

3.3 Scenario 3

1. Scenario name: Finding the right bus
2. Participating actors: Frank - visually impaired
3. Flow of Events:
   i. Frank wishes to get a #135 bus to go to SFU. He is already in downtown.
   ii. Frank is walking in the sidewalk; he hears directional information about presence of a bus stop for #135, #10 and #15.
   iii. Frank waits in the stop till the first bus gets there.
   iv. As the bus is getting close to stop he hears that “This is bus #10 to Burrard Street”.
   v. Frank waits more and second bus gets there.
   vi. Frank hears “This is bus #135 to SFU”.
   vii. Frank gets inside the bus #135.

4 System Requirement

4.1 General/Overall System Requirements

This section lists the requirements of the system as a whole.

3.3.1 Reliability

[R1] The system shall have a mean time between failures of 10,000 hours **(II)**
[R2] The system shall be able to recover from errors upon reset **(III)**
[R3] The system must be able to operate in crowded environments **(III)**
[R4] The system service intervals shall not be less than 1 month **(III)**
[R5] The system will not work properly in areas with abnormal magnetic field levels **(III)**
[R6] The system must be installed after thorough investigation of the environment **(III)**

3.3.2 Performance

[R7] The system must provide correct directional information to user in any situation **(III)**
[R8] The system shall not interfere with other devices **(III)**
[R9] The system must not be harmful to any living beings **(III)**
[R10] The system shall function properly under different environments exclusive of places with heavy or fluctuating magnetic interferences **(II)**

4.2 User Module

This section lists requirements specific to the user module.

4.2.1 Physical

[R11] Shall be small and portable **(III)**
[R12] Shall be contained in a chassis made up of non-toxic materials **(II)**
[R13] The chassis shall be rigid, sturdy, and withstand compression stress **(II)**
[R14] Shall be weatherproof **(II)**
[R15] The chassis shall be tapered at one end in order to ensure that the device is held properly and the right side up **(II)**
[R16] The chassis shall not have sharp edges **(II)**
[R17] The module must not weigh more than 2 pounds **(II)**
[R18] The speaker/headphone will be at least 10~12 inches away from the module **(III)**

4.2.2 Power

[R19] Module shall be powered by 9V batteries **(III)**
[R20] When the user module is no where near any sign module, the power shall be minimized (sleep mode) **(III)**

[R21] Shall have an acoustical power depletion warning when the power supply is low **(II)**
[R22] The module shall not dissipate any heat during its operation **(III)**
[R23] Unit shall operate 10 days before needing a change of batteries **(II)**

4.2.3 Performance

[R24] The module must be able to detect the user's orientation within a range of $\pm$ 5º **(III)**
[R25] The module must operate properly when tilted to angles of $\pm$ 45º **(II)**
[R26] The module must operate within a temperature range of –10º to 40º C **(III)**
[R27] The module shall be able to calculate resultant directions with a relative error of 5º **(III)**
[R28] The module shall be able to complete calculations on the fly **(III)**
[R29] The user module shall not interfere with other user modules **(III)**

4.2.4 Sound Quality

[R30] The directions provided by the speaker/headphone must be clear and understandable **(III)**
[R31] The volume of the directions must be controllable **(II)**

4.2.5 User Interface

[R32] All the device buttons will have a duty cycle of at least 1,000,000 cycles **(III)**
[R33] All the modules buttons will have Braille lettering **(II)**
[R34] All buttons would be laid out in a manner that requires only one hand to access all of the module's functions **(II)**

4.2.6 Serviceability

[R35] The module will not be serviceable by the user **(III)**

4.2.7 Communication

[R36] All data transfers shall be made using RF only **(I)**
[R37] The module will communicate with the sign module through RF, but the data transfers are going to take place over WLAN **(II)**
[R38] All data transfers shall not last for more than 1 second **(III)**
[R39] The module will only act as a receiver **(I)**
[R40] The module will act as both receiver and transmitter **(II)**
[R41] The module will only start communicating with the sign module when it is within 8m **(III)**

4.2.8 Storage

[R42] The user module will only hold one set of directions at a time **(III)**
[R43] The module shall be able to store directions of up to 100 characters in length **(I)**
[R44] The module shall be able to store directions of up to 1,000 characters in length **(II)**

4.3 Sign Module

This section lists the requirements specific to the sign module

4.3.1 Physical

[R45] Shall be sufficiently small so as to not obscure normal signs **(II)**
[R46] Shall be small enough so attachment to a foreign object is possible **(II)**
[R47] Shall be weatherproof **(II)**
[R48] Antenna shall be of sufficient length while been able to transmit within a certain distance **(III)**

4.3.2 Power

[R49] Shall operate from a 5V power supply **(I)**
[R50] Shall operate with conventional 120V 60Hz AC power outlet or any other portable sources of power **(II)**

4.3.3 Performance

[R51] The module shall be able to operate in crowded environments **(III)**
[R52] The module must be able to communicate with multiple user modules **(III)**

4.3.4 User interface

[R53] The module shall only have a power switch **(I)**
[R54] The module shall contain switches for power and to set the location code **(II)**
[R55] All directional information must be programmed via the firmware **(I)**

4.3.5 Serviceability

[R56] The sign module shall be installed and serviced by trained personnel **(II)**
[R57] The firmware shall be upgradeable by the end user **(III)**

4.3.6 Communication

[R58] The sign module shall transmit directions continuously **(I)**
[R59] The sign module shall only transmit the location code continuously **(II)**

4.3.7 Storage

[R60] The module should preserve its data if power is lost **(II)**
[R61] The module should be able to store directions up to 100 characters long **(I)**
[R62] The module shall only store an 8-bit position code **(II)**

4.4 Web Module (Phase Two)

The web module is to only be implemented in Phase two. It consists of a WLAN infrastructure along with a website which stores all the directions. This section lists the requirements specific to the website. (Please refer to Section 5 regarding WLAN requirements)

4.4.1 Performance

[R63] Must be able to handle multiple requests for directions **(II)**

4.4.2 Storage

[R64] Must contain a database of all directions, indexed by the location codes for easy retrieval **(II)**

4.4.3 Security

[R65] Must allow access only by the user modules and the administrators **(II)**

4.4.4 User Interface

[R66] The administrators shall be able to edit, add, delete and update instructions and location codes **(II)**

[R67] The users will only be able to access the directions **(II)**

5 Communication Requirements

This section outlines the wireless communication requirements for the modules.

5.1 RF Transmission

This section specifies the desired functional specification for the RF transmission that is predominately used by the sign module.

5.1.1 Transmission Characteristics

[R68] Must be continuous transmission **(I)**
[R69] Shall only operate in 916.48MHz frequency band **(I)**
[R70] Shall transmit using only FM/FSK modulation **(I)**
[R71] Shall transmit at the rate of 200 to 56,000bps **(I)**
[R72] Shall support multiple users transmission **(II)**

5.1.2 Transmission Power

[R73] Shall be no more than 1mW (0dBm) nominal **(I)**
[R74] Shall be at least –3dBm **(I)**
[R75] Shall be adjustable with a mean deviation of $\pm$1dBm **(I)**
[R76] Transmission radiation shall not be harmful to the user and the surrounding **(I)**

5.1.3 Transmission Range and Radius

[R77] Maximum allowable transmission range shall be no more than 10m **(I)**
[R78] Allowable transmission range shall be adjustable **(I)**

5.1.4 Interference Requirement

[R79] Shall minimize co-channel interfere **(I)**
[R80] Shall mitigate effect of multipath **(I)**
[R81] Shall maintain harmonics and spurious emissions within legal limit **(I)**
[R82] Shall not interfere with internal module component, such as switching power supplies, crystals **(II)**
[R83] Shall not interfere with external equipment, such as motors **(II)**

5.2 RF Reception

This section specifies the desired functional specification for the RF reception that is predominately used by the user module.

5.2.1 Receiver Characteristics

[R84] Shall periodically detect the presence of the sign module **(I)**
[R85] Shall only operate in 916.48MHz frequency band **(I)**
[R86] Shall operate with only FM/FSK modulation scheme **(I)**

[R87] Shall download data at a rate of 200 to 56,000bps **(II)**
[R88] Shall be powered by 5VDC **(I)**

5.2.2 Receiver Power

[R89] Shall be no more than 1mW (0dBm) nominal **(I)**
[R90] Shall be at least –3dBm **(I)**
[R91] Shall be adjustable with a mean deviation of $\pm$1dBm **(I)**

5.2.3 Interference Requirement

[R92] Shall mitigate effect of multipath **(I)**
[R93] Shall not disrupt operation of other nearby user modules **(II)**
[R94] Shall not be disrupted during regular operation **(I)**

5.3 RF Communication Regulations

The *Dynamic Direction System* will adhere to the following telecommunications standards. This will give us additional capabilities on both the expansion and upgrading the module.

5.3.1 Wireless Communications Standards

[R95] FCC CFR 47 Part 15 and 18 **(II)**
[R96] IC RSS 139 **(II)**
[R97] IC RSS 212 **(II)**
[R98] IEC-60950 **(II)**
[R99] UL-1950 **(II)**

5.3.2 Electromagnetic Compatibility Standards

[R100] EN 55011:1991/CISPR 11:1992 +A2:1992 (Group 1, Class A) – RE/CE **(II)**
[R101] EN 50082-1:1997 – Radiated, EFT/Burst, ESD Surge, Conducted, Voltage dips/interrupts **(II)**

5.4 WLAN communication protocol

Phase two of the project involves the integration of IEEE 802.11b WLAN standards onto the user module thereby allow maximum data transmission through the internet. This section discusses the functional specification regarding the use of WLAN.

5.4.1 User Module requirement

[R102] The user module shall sign onto the internet whenever it detects the existence of the internet connection **(II)**
[R103] Communication shall only exist between the server and the user module **(II)**
[R104] The user module shall block all other unwanted transmission that is not for the sole purpose of this system **(II)**

6 Documentation and User Training

The Dynamic Directional System has two main user groups. First are the institutions and establishments which would be responsible for installing the system on their premises and the second are the visually impaired users. Because of this group division, we are planning to incorporate two different sets of training and documentation, each specifically targeting its respective user groups.

The documentation for the installer group would contain complete instructions regarding the troubleshooting, maintenance and general installation of the device. Meanwhile, the visually impaired group would receive much simpler instructions in both verbal and Braille formats.

6.1 Documentation and Training for the Installer Group

[R105] Documentation of the device shall consist of two different sets of user manuals: one for the technicians who install the system (a hardware manual) and the second for the person who is working with the software and Internet database at the server end (a software manual) **(II)**

[R106] The hardware manual shall consist of all hardware installation instructions for RF transmitter and IEEE 802.11b transmitter **(II)**

[R107] The hardware manual shall include a troubleshooting section and a device characteristics list **(II)**

[R108] The software manual shall contain the complete instruction to the Internet interface and online database **(II)**

[R109] The hardware manual shall be written for technicians with minimal experience in networking and communication theory **(II)**

[R110] Software manual shall contain information on software copyright and warranty while it will also list the minimum requirements of the OS and hardware **(II)**

[R111] The user manuals shall be provided in different languages including but not limited to English, Spanish, and French **(II)**

[R112] Initial training shall be given at the time of purchase **(II)**

[R113] Additional training shall be provided upon requests **(II)**

[R114] Users of the proof-of-concept device will be trained by the project developers **(I)**

6.2 Documentation and Training for the Visually Impaired Consumers

[R115] Brief instructions on how to use the system shall be provided in Braille for the visually impaired **(II)**

[R116] Audio tapes of instructions shall also be provided with a written document that anyone can read for the visually impaired **(II)**

[R117] The tape and document shall also contain contact information on how to reach Sound Directions **(II)**

[R118] User training will be provided by people with experience in dealing with visually impaired individuals **(III)**

7 Test Plan

The product shall be divided and tested in individual subsystems before integration. In addition, further testing shall be performed during integration of components to ensure proper communication between the subsystems.

Since the actual test procedures will be complex and technology-specific, we will only present a brief overview of each test procedure. The eventual product shall also be verified on the conformity of existing safety standards.

7.1 Phase One Test Plan

7.1.1 Power Supply

The power supply test will be done by observing the voltages under all extreme conditions such as temperature variation, and in the presence of magnetic fields.

7.1.2 Text-to-speech synthesizer

The ability of the synthesizer to perform properly under extreme environments shall be tested and verified. In addition, the ability of the synthesizer to output proper speech of composite words shall be tested and verified. The sound quality of the synthesizer shall also be tested.

7.1.3 Digital Compass

The compass shall be tested to work under different weather conditions. Accuracy of the true north data will be tested under different tilting angles in all dimensions. The most challenging test will be in the presence of another magnetic field such as the speaker or any other external magnetic interference.

7.1.4 RF

The antenna length will be changed to accommodate the testing of short range RF capabilities. The RF modules shall be tested for data recovery by transferring 100 characters and measuring the transfer duration. Performance in the presence of noise is very important and shall be tested together in different weather conditions, and environments. The RF transmitter module is to have a non-volatile storage capability and be able to interact with multiple receiving modules.

7.2 Phase Two Test Plan

7.2.1 IEEE 802.11b WLAN

Testing for WLAN will focus mainly on the data recovery and the download speed. Several pre-recorded voice samples will be loaded onto the server for WLAN transmission. Recovery capabilities of the receiver will then be tested in a noisy, high traffic environment so as to imitate major infrastructures. Interaction between multiple receiver modules will also be a key test factor. Multiple downloading will also be tested to ensure equal resource allocation on each subject.

8 Conclusion

This document has outlined the functional requirements for the two phases of *Dynamic Directional System for visually impaired*. The requirements given in this document is tentative and shall be modified as necessary during the course of our development. This document, nevertheless, will provide a clear guideline to the completion of our product.

We aim for completion of the Phase one by mid December, 2003. If time permits, we plan to incorporate some features of Phase two into our prototype. If this happens, the functional requirements will be carefully reviewed and modified as necessary.

We hope these functional specifications will provide with essential insights into the product to our intended audiences.

References

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