October 19th, 2015

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

Re: ENSC 440 Functional Specifications for Local Guidance System

Dear Dr. Rawicz,

The attached document is from LocalSonic entailing the functional specifications for the Local Guidance System (LGS). We are designing and implementing a local positioning system that will assist the visually impaired by informing the user where they are in relation to the closest nodes in the system. Our project consists of ultrasonic beacons and a user device, the NavU. Using time of flight, distance can be measured between the two devices and the user's location can be found. This system will serve as an elementary guidance system to give users audio feedback on their physical location and may be improved on outside of this project course.

The purpose of our functional specifications document is to outline the requirements for the LGS to operate for the proof of concept and future evolutions of this project. This document will be used to guide our research and development of the LGS.

LocalSonic consists of five talented engineering students: Andrew Chan, Justin Crosby, Yihao Zhang, Shuo Yang, and Han Shen. If you have any concerns, or questions about our proposal, please feel free to contact Andrew Chan 604-671-1028 or by email at acc37@sfu.ca.

Sincerely,

Andrew Chan
Chief Executive Officer
LocalSonic

Enclosure: *Functional Specifications for Local Guidance System*

Functional Specification
Local Guidance System (LGS)

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Issued Date: Oct. 19, 2015

Revision: 1.0

Executive Summary

Technology has always been evolving towards providing a better user experience for consumers whether it is through improving a user interface or providing services to help user productivity. Smartphones are a good example; current generation cellphones contain more processing capability than many computers ten years ago. Online services to help with connecting friends globally or ordering goods internationally has never been easier.

However, innovative technology for user accessibility in a physical environment is less prominent compared to the other aspects of technological development. The most common technology of this category would be a GPS system in the form of either Google Maps or Apple Maps. Yet, these technologies do not perform well inside buildings and leave much to be desired for indoor navigation.

At LocalSonic, our goal is to provide a navigation solution for the visually impaired inside a building. Often large public structures such as universities, schools, and shopping malls are difficult to access and maneuver for the visually impaired. We address this problem with a scalable solution that can be applied to any building.

With LocalSonic's Local Guidance System (LGS), users will know where they are inside a building with a press of a button. This system requires small ultrasonic receiver beacons placed throughout a building. The user, carrying an ultrasonic emitter unit called the NavU, will signal these beacons and the response time is then used to triangulate the user's location. The user is then informed by the NavU through audio of how far they are in relation to the closest landmark such as a door, room, or hallway and what that landmark is.

LocalSonic will research, design, test, and implement a proof-of-concept model of the LGS over the next 3 months. LocalSonic will also ensure that the operation of LGS complies with all pertinent standards. Depending on the rate of development and available resources, changes and improvements to the designed system may be made.

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Glossary

LGS	Local Guidance System
NavU	Wearable user device for the LGS
Ultrasound	Sound waves having a frequency above 25kHz
LGS User	A person operating the NavU with the following characteristics: ▪ Is capable of maneuvering in a public indoor environment ▪ Has healthy hearing capabilities ▪ Is not accompanied by animals ▪ May be visually impaired
RSS-102	Industry Canada Standards for Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
RSS-GEN	Industry Canada Standards for General Requirements for Compliance of Radio Apparatus
CAD	The Canadian dollar
Ping	A radio message that elicits a response to the source of the message

1. Introduction

LocalSonic's Local Guidance System (LGS) is a turn-by-turn navigation system for indoor use to aid the visually impaired. Pressing a button on the user device (NavU), a component of the LGS, will make the NavU emit a combination of radio and ultrasonic waves. These waves will be received by nearby beacons with ultrasonic sensors, which will in turn relay the LGS user's distance from the beacon to the NavU. The NavU will then inform the LGS user of their physical position in relation to the closest landmarks inside the building via audio. The requirements for the proof-of-concept and future development models of the LGS will be entailed in this functional specification document.

Due to time constraints, the functionality of the LGS has been greatly reduced from the initial conception of the idea for the project which is why there has been no consideration for a production model of this version of the LGS.

1.1. Scope

The function requirements that must be met for an operational LGS are entailed in this document. These functional specifications will full cover the requirements of the proof-of-concept model and partially cover the requirements of future evolutions of the LGS.

1.2. Intended Audience

This functional specification document is intended for use by all members of LocalSonic and any party desiring to recreate the LGS. This document will be referred throughout the development of the LGS and will be used to measure progress and accuracy of desired results. Any design changes and additions to the proof-of-concept model of the LGS will refer to this document. Any testing required of the LGS will also refer to this document to assess proper functionality. Any party desiring to assess compliance of standards may refer to this document.

1.3. Requirements Classification

The following convention will be used throughout the document to denote functional requirements:

[Req.n.p] A functional requirement.

Where **n** refers to the functional requirement number, and **p** refers to one of the following priority values:

- **I** The requirement applies to the proof-of concept model only.
- **II** The requirement applies to both the proof-of-concept and future evolutions of the project.

2. System Requirements

This section of the document covers the general functional requirements of the LGS.

2.1. System Overview

LocalSonic's Local Guidance System consists of two main components that handles user input and provides feedback as shown in Figure 1.

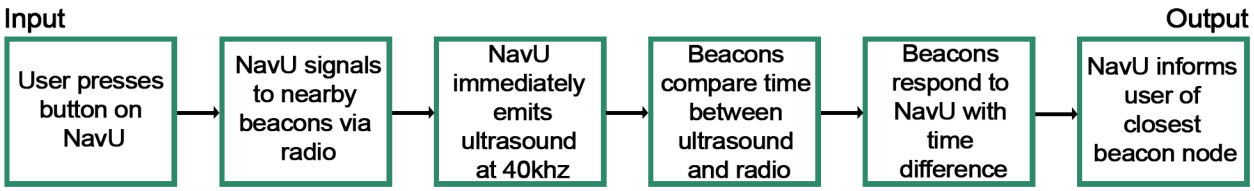

Figure 1: System Response Diagram

The Local Guidance System (LGS) is a local positioning system that informs users via audio of the closest landmarks at the press of a button. It uses a combination of wireless technologies, radio and ultrasound, to triangulate the user. The LGS is designed to work indoors, in public and multi-level buildings such as libraries and schools. The LGS is not designed to work out of the box, however. Although the LGS can be used in most public buildings, each building is different and therefore the number of beacons and beacon placement has to be recorded and stored in the NavU for accurate triangulation of the user.

The LGS requires adequate line-of-sight between the NavU and beacons to function accurately. To guarantee line-of-sight from the user, the NavU has to be worn in a way such that the emitters can emit ultrasound without obstruction from the user's body. Beacon nodes will be spaced out and placed over main landmarks such as doors in a way that will have little obstruction and line-of-sight to the user can be established.

The LGS involves two main components, the NavU and the beacon(s). The NavU consists of 5 emitters: a radio transceiver, a microcontroller, and a battery pack. Of the 5 emitters, there are 4 on the horizontal plane and 1 on the vertical plane for a near complete hemispheric coverage as seen in Figure 2. The radio transceiver must operate on a frequency that is not commercially licensed and must not interfere with other radio devices in its environment.

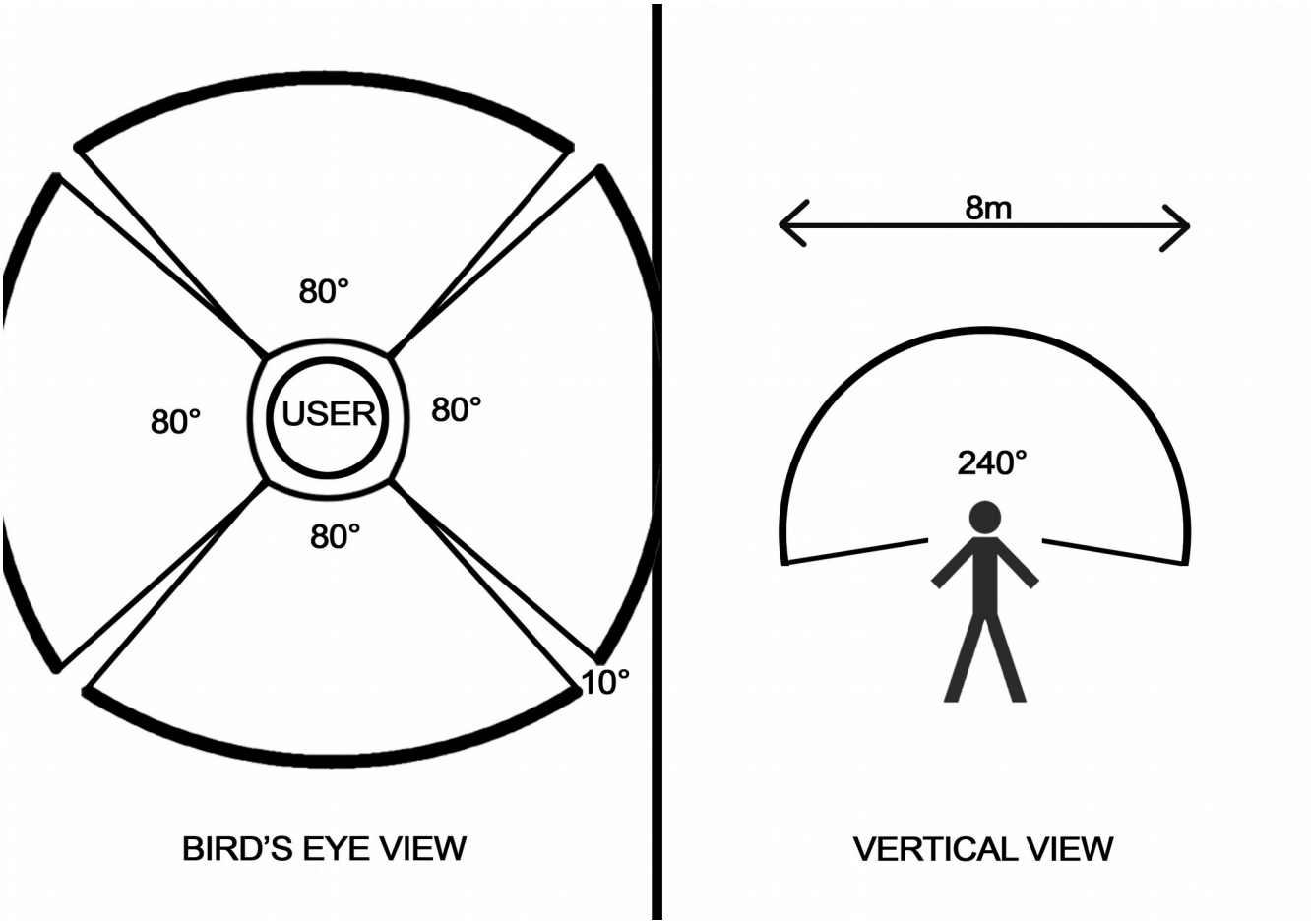

Figure 2: Emitter Coverage

The beacon consists of a microcontroller, a radio transceiver, and 2 receiver nodes spaced 4m apart as shown in Figure 3. Additional nodes can be added to the microcontroller as long as they are mapped correctly in the NavU. Each node will have a specific ID that is used for triangulation purposes.

Figure 3: Beacon Setup

The LGS must accommodate the LGS user as defined in the glossary, which will be referred to as the user from this point on.

2.2. General Requirements

[Req.1.II] The LGS shall have an idle/off state where no ultrasound is emitted and no audio is outputted.

[Req.2.II] The LGS will not guide the user into known hazards.

[Req.3.II] Each beacon shall cost less than $60 CAD.

[Req.4.II] The NavU shall cost less than $200 CAD.

2.3. Physical Requirements

[Req.5.II] The LGS should not obstruct the user in daily activities.

[Req.6.II] The LGS shall be minimally intrusive to the user and anyone in the environment.

[Req.7.II] The LGS components shall withstand 30 N

2.4. Electrical Requirements

[Req.8.II] Power supplied to the LGS components should be sufficient for function and will not cause LGS components to overheat.

[Req.9.I] The LGS shall enter a state of energy conversation when not in use after 5 seconds of inactivity.

[Req.10.I] All microcontrollers in the system are to be powered separately via micro-USB capable battery packs.

[Req.11.I] Standard 5V/1A micro-USB power adapters will be used to charge the battery packs.

[Req.12.II] Power sources should be easily accessible for replacement.

2.5. Mechanical Requirements

[Req.13.II] The button on the NavU should be easily accessible and not intrusive

2.6. Environmental Requirements

[Req.14.II] The LGS shall perform normally at temperatures from 10-40 degrees centigrade.

[Req.15.II] The LGS shall operate indoors only.

[Req.16.II] The LGS shall perform normally at elevations from 0 to 2000 m above sea level.

2.7. Standards

[Req.17.II] The LGS shall conform to RSS-102 standards[1].

[Req.18.II] The LGS shall conform to RSS-GEN standards[2].

[Req.19.II] The LGS shall follow Health Canada's ultrasonic safety guidelines[3].

2.8. Reliability and Durability

[Req.20.II] The beacons will run on their own backup power for at least 1 hour before they must be connected to power.

[Req.21.II] The beacons shall have LED lights indicating power levels.

[Req.22.II] The NavU will run on battery power for at least 8 hours before the user must charge the device.

[Req.23.II] The NavU shall alert the user via when it is low on power.

[Req.24.I] Gain circuits in both the beacons and NavU are to be battery powered and should last at least a month before changing.

[Req.25.II] Beacons should be able to be unplugged from the base such that they are easily replaceable.

[Req.26.II] The system should be able to withstand normal usage in indoor locations.

2.9. Safety

[Req.27.II] Ultrasonic emitters must produce sound at a maximum of 100dB so as to not cause harm to animals and humans around the device[4].

[Req.28.II] The NavU will remain a comfortable temperature of a maximum 30°C while being used.

[Req.29.II] All electronic components shall be isolated from the user to prevent scratching and electric shock.

[Req.30.II] The system shall not interfere with any existing radio and ultrasonic devices

2.10. Performance

[Req.31.II] The NavU shall acknowledge user commands within 1s and start routing the user within 2 s.

[Req.32.II] The system shall be accurate to within at least 1 m.

[Req.33.II] The beacons shall respond to pings within 1 ms.

2.11. Usability

[Req.34.II] The NavU shall be comfortable for the user to wear.

[Req.35.II] The system shall interface with a PC for diagnostic and upgrade purposes.

3. NavU

The NavU is the user component of the LGS consisting of ultrasonic emitters, a radio transceiver, and a microcontroller. It is vital for giving user audio feedback about the user's location and is the component that begins the triangulation process.

The NavU can be separated into two semi-components: the emitters and the microcontroller. Because the emitters need line-of-sight to operate but also need to be comfortable for the user, they may be adjusted to be worn as an accessory such as a hat or necklace. Line of sight directly above the user is required in the scenario the user is directly under a beacon. For the proof-of-concept, the wearable accessory option may not be pursued due to time constraints.

3.1. General Requirements

[Req.36.II] The NavU shall provide audio feedback to user regarding location.

[Req.37.II] The NavU shall have audio control.

[Req.38.I] The NavU shall have emitters positioned such that ultrasound emission range covers an upward facing hemisphere with radius of at least 4m around the user.

[Req.39.I] The NavU shall contain an idle state that has low power consumption.

3.2. Physical Requirements

[Req.40.II] The NavU shall not weigh more than 1kg.

[Req.41.II] The NavU shall be easily transportable and storable.

[Req.42.II] The NavU shall have at least one tactile button that is easily accessible by the user.

4. Beacon

Beacon placement is vital for triangulating the user since the degree of accuracy in triangulation is increased depending on the density of beacon nodes around the user. Beacons will be installed throughout a building and active only during the triangulation process. As described in the system overview, beacons will have at least 2 nodes attached that contain 2 ultrasonic receivers. Each node will be powered separately because of the power requirements to amplify the received signal.

4.1. General Requirements

[Req.43.II] The beacon will have an idle state that draws substantially less power than its active state

[Req.44.I] 2 additional nodes can be installed along with the existing 2 nodes.

[Req.45.II] The beacon installation will not damage the building.

[Req.46.II] The beacons shall be easily installable and removable.

[Req.47.II] The beacons shall be easily accessible for component replacement.

[Req.48.II] The beacons shall be placed in locations that are easily mapped on the NavU.

[Req.49.II] The beacons shall be placed in locations that guarantee strong line-of-sight with users in 4 meter radius.

4.2. Physical Requirements

[Req.50.I] Beacon nodes should have 2 ultrasonic receivers angled downwards of 20° vertically and spaced 60° horizontally from the wall.

5. User Documentation

[Req.51.I] User documentation shall be presented in the form of a manual written in both the user's local language and braille.

[Req.52.I] Documentation shall be readable by those with basic technical knowledge and a high school reading comprehension.

[Req.53.I] Technical documentation shall be provided to maintainers and installers of the system.

6. Safety and Sustainability

As outlined in sections 2.7 and 2.9, safety and standards are carefully taken in to consideration in the construction of the LGS. Standards in both radio and ultrasonic technologies are especially important in the design of this product. Additionally, special care is taken to ensure the NavU will be able to be safely worn. All wires and electronics will be enclosed and the device will remain cool.

The cradle to cradle design process was an important part of the development of the LGS. Each component of the prototype will be reusable in future projects or recyclable in the case that they are not needed. Moreover, some components of the prototype (such as microcontrollers, resistors, and operational amplifiers) were reused from previous projects.

In the final product, the number of components used will be minimized and the components themselves will be replaceable or rechargeable. Instead of the entire device being disposed when a component fails, the device will be easily repairable. For example, each of the ultrasonic emitters will be removable such that, if one of the emitters fails, it can be removed and a new one substituted in its place. In the event that the entire device must be disposed of, most of the device will be recyclable. The housing will be made of recyclable plastic and the electronic components can easily be taken to an electronics recycler.

7. Conclusion

The LGS provides a simple way for visually impaired people to navigate public spaces. The proof-of-concept version of this product is a scaled down version of the envisioned final product, only including distance measurement and triangulation functionalities. This functional specification defines the goals of the LGS project and its requirements to be successful for both the proof-of-concept and the final product. Using this document as a guide, LocalSonic will complete a prototype by early December, 2015.

References

[1] Industry Canada. (2015, March). *Radio Frequency (RF) Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)* [Online]. Available: http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf01904.html

[2] Industry Canada. (2014, November). *General Requirements for Compliance of Radio Apparatus* [Online]. Available: http://www.ic.gc.ca/eic/site/smt-gst.nsf/eng/sf08449.html

[3] Health Canada. (1991). *Guidelines for the Safe Use of Ultrasound: Part II - Industrial and Commercial Applications* [Online]. Available: http://www.hc-sc.gc.ca/ewh-semt/pubs/radiation/safety-code_24-securite/index-eng.php

[4] NIOSH and CDC. (2002). *Intensity Comparisons with NIOSH Recommended Permissible Exposure Time* [Online]. Available: http://www.cdc.gov/niosh/topics/noise/chart-lookatnoise.html