

October 13, 2011

Dr. Andrew Rawicz
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Re: ENSC 440 Functional Specifications for Bluetooth Hearing Aid *HAB-1*

Dear Dr. Rawicz,

Please find enclosed the functional specifications for the Audima HAB-1 Bluetooth hearing aid. Our device will increase the convenience for people hard of hearing while interacting with external devices, particularly cellular phones. Not only will the device eliminate the use of any wires and cables, but will also make the pairing process easy and hassle-free.

The functional specifications outlined in this document provide a set of high-level requirements for the HAB-1's functionality throughout its development, from the proof-of-concept to the working prototype. This document will serve as the base-line requirements for our product, and we will reference it to ensure that the HAB-1 operates as intended.

Audima Inc. consists of four individuals with Systems, Electronics, and Biomedical Engineering background: Jeffrey Lee, Kevin Wong, Eric Zhou, and Ali Pourghadiri. For further inquiries about our company and proposal, please contact Jeffrey Lee via e-mail at jal19@sfu.ca or by phone at (604)765-9428.

Sincerely,



Jeffrey Lee
Chief Executive Officer
Audima Inc.

Enclosure: Proposal for Bluetooth Hearing Aid HAB-1

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Project Proposal for Bluetooth Hearing Aid *HAB-1*

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Submitted To

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Executive Summary

Modern hearing aids have been a topic amongst inventors since the 19th century.^[1] Since then, hearing aids have gradually become smaller, more discrete, and more technologically advanced. At the turn of the 21st century, society is leaning towards a trend with fashion and convenience in mind. Electronic devices are becoming smaller, and developers are aiming to eliminate the essence of wires between devices.

Bluetooth technology is one of the most widely used methods in pairing different devices wirelessly. The most common application people automatically come to when thinking of Bluetooth is the handsfree device that allows them to talk on their cellular phones. Essentially, that is exactly what the HAB-1 is. This marks both another milestone in the development of hearing aids, and another use for Bluetooth technology in the medical field.

The HAB-1 follows the ideas of inventors dating back to the 19th century, in which hearing aids can be “disguised” or “made invisible”.^[2] The prototype to be developed will be disguised as a normal Bluetooth headset. However, this seemingly simple and straightforward device will also have an amplifier built in to function as a hearing aid when the Bluetooth is not actively communicating with a device (such as a cellular phone). The HAB-1 will be intuitive to operate, consisting of two buttons to toggle between the hearing aid and Bluetooth modes.

We will also take society’s trend into consideration by making HAB-1 both fashionable and convenient to use. Its size will be small and discrete, and anyone seeing it in use will only think of it as any other Bluetooth headset, not as a hearing aid. Additionally, the device will be easy to use, making it safe for users to switch between modes and selecting other options without losing concentration while doing other tasks such as driving.

The functional specifications covered in this document are designed for the primary prototype of the HAB-1. Further prototypes and advanced versions of our Bluetooth hearing aid line will continue to reduce size and energy consumption, as well as incorporate new features to make our product even more convenient and safe for our customers.

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Glossary

BJT	-	Bipolar Junction Transistor
CDN	-	Canadian Currency
ENSC	-	Engineering Science
FDA	-	Food and Drug Administration
HAB	-	Audima’s Bluetooth hearing aid line
LED	-	Light-Emitting Diode

1. Introduction

The Audima HAB-1 is a next-generation hearing aid device, which combines both the general amplification in a hearing aid with Bluetooth technology, allowing it to connect wirelessly with other Bluetooth-enabled devices such as most modern cellular phones. The Audima Inc. development team will build a small hearing aid and connect it to an existing Bluetooth headset. A switch will be implemented to make the two components work in conjunction, making the HAB-1 function as one device. This document will outline the functional specifications of this Bluetooth hearing aid proposed by Audima Inc.

1.1 Scope

This document will outline and detail the functional requirements that the Audima HAB-1 must meet. These specifications will fully cover the proof-of-concept and most of the prototype system to be developed. Some functionalities of the end product will also be covered.

1.2 Intended Audience

The functional specification is intended for use by members of Audima Inc. and board members of ENSC 305 and ENSC 440. Its purpose is to act as a guide for all teams and executives working on this project, so the product can be developed as proposed in a timely manner.

This document can be used by project managers to organize the development of this project. Milestones can be set in conjunction with certain specifications listed to ensure that the device includes important functions. Such milestones can also be used to properly manage the time spent on each phase of development, ensuring smooth progress to achieve the desired completion date.

Researchers and developers can refer to the specifications listed in the document as a guideline of the functionalities that must be incorporated in each phase of the project, and also as a checklist to ensure that all functions have been implemented and the device operates as intended.

Additionally, ENSC 305 and ENSC 440 board members can also refer to the document to ensure that the functions of the HAB-1 were implemented as proposed.

1.3 Classification

In this document, the following convention shall be used to denote a functional requirement:

[R##-P] A Functional Requirement

R = Requirement

= Requirement Identification Number

P = Priority level, as explained in table 1 below.

Table 1 – Functional Requirements Priority Level

Priority Level	Priority Description
I	Implies that the requirement applies only to the proof-of-concept system.
II	Implies that the requirement applies to both the proof-of-concept system and the production system.
III	Implies that the requirement applies only to the production system.

2. System Requirements

2.1 System Overview

Audima’s Bluetooth hearing aid shall be a hearing aid with the added capability of connecting to external devices via Bluetooth. Figure 1 illustrates our product’s functionality.

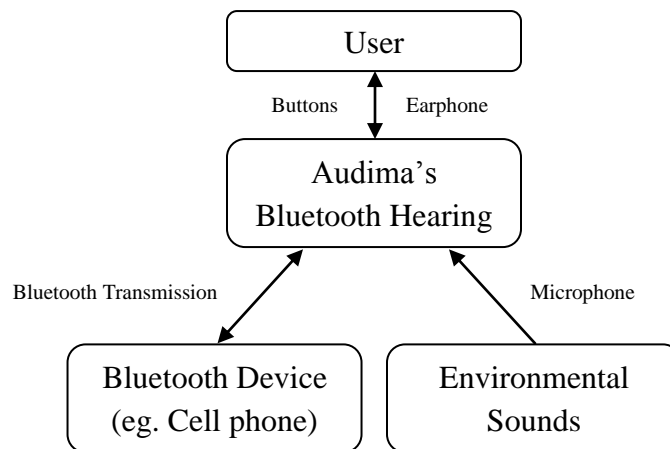


Fig. 1 – Flowchart of HAB-1 System Overview

The hearing aid component of our product is considered the main unit, while the Bluetooth component is considered the secondary unit. There will be at least 4 buttons on our product: one for overall power (on/off button), another for toggling on and off the Bluetooth, and two more for dedicated volume control. Our product shall be powered by a rechargeable lithium polymer battery, which will last at least three to four days on a single charge (under moderate usage). A unique, fitted earpiece will also be available through an audiologist, to properly create a mold that will perfectly seal the user’s middle ear for maximum audio clarity.

On start-up, the regular audio amplifier will be enabled, and the Bluetooth transceiver will be disabled by default. During this mode of operation, the device will function exactly like a regular hearing aid. It will convert sound into an electrical signal using a microphone, amplify the signal, and convert it back into sound using an earphone.

To connect to a Bluetooth device, the user must press the Bluetooth enabling button on the hearing aid to activate the transceiver. The hearing aid will then make itself readily available to nearby devices that are searching for a Bluetooth signal such as, in this case, the user’s cellular phone. Similar to a regular Bluetooth headset, the cell phone will be able to connect to the hearing aid, and even store its information so subsequent connections will be made automatically. While the Bluetooth is enabled, the hearing aid can be in one of two states: “Standby” or “Active”. It is on “Standby” if a Bluetooth connection has been made, but no activity (transfer

of packets) is taking place. The device is “Active” if a signal is actually being transmitted and received. During the “Active” state, the regular audio amplifier will be disabled so that only the Bluetooth signal is heard.

2.2 General Requirements

- [R01-III]** The device shall fit securely in the ear.
- [R02-III]** The device shall be ergonomically correct.
- [R03-II]** The device shall be user-friendly.
- [R04-III]** The retail price of the device shall be under \$500 CDN.

2.3 Physical Requirements

- [R05-II]** The dimensions of the device shall not exceed 7.0 x 2.0 x 1.0 cm (Excluding earpiece).
- [R06-III]** The weight of the device shall be less than 20 grams.
- [R07-II]** The device shall resemble a regular Bluetooth headset.
- [R08-II]** The device shall not have more than 5 buttons.
- [R09-III]** The shape of the earpiece shall be a unique mold, to be obtained from an audiologist.
- [R10-II]** The internal components shall be concealed under a case.

2.4 Electrical Requirements

- [R11-II]** The device shall use a rechargeable lithium polymer battery.
- [R12-III]** The device shall not take more than 5 hours to charge.
- [R13-II]** The device shall be easy to recharge.
- [R14-II]** The device shall last for 3-4 days on a single charge under moderate usage.

2.5 Mechanical Requirements

- [R15-I]** All buttons shall have appropriate feedback.
- [R16-I]** At least one LED shall be used to provide feedback.
- [R17-II]** A beeping sound will be used to provide feedback for battery status.

2.6 Environmental Requirements

- [R18-I]** The device must operate as expected within a temperature range of 0°C to 35°C.

2.7 Standards

[R19-III] The device shall receive FDA approval.

2.8 Reliability and Durability

[R20-II] The device shall not be protected against any abnormal physical shock.

[R21-III] The system firmware shall be configurable by an Audiologist.

[R22-II] The system shall resist breakage under normal operating conditions.

2.9 Safety Requirements

[R23-I] The device shall be kept out of water.

[R24-II] In the case of device failure, it shall not harm the user.

[R25-II] The device shall not overheat.

[R26-II] The device components shall be enclosed.

[R27-II] The LED shall flash if the rechargeable battery is low on power.

2.10 Performance Requirements

[R28-I] The device shall have two separate buttons for a combination of three operating modes: “On”, “Bluetooth”, and “Off”.

[R29-II] “On” mode shall enable the amplifier, allowing the user to easily hear his surroundings.

[R30-II] “Bluetooth” mode shall enable the Bluetooth transceiver, allowing the device to connect to any Bluetooth-compatible device.

[R31-III] An earpiece unique to the user’s ear shall be obtainable from an audiologist, and shall be attached to the device to transmit sound to the eardrum.

2.11 Usability Requirements

[R32-II] The device shall be intuitive and easy to use.

[R33-II] The device shall be simple to control by using buttons to select different modes and control the volume.

[R34-II] The device shall be able to transmit and receive sounds with another Bluetooth-enabled device, once connected.

[R35-II] The user will be notified with a “beeping” sound when the battery requires recharging.

[R36-III] The device will have different “beeps” to notify the user when it changes modes.

2.12 Luxury Function

- [R37-II] The casing shall enclose all of the components of the device except for the ear mold.

3. Hearing Aid Requirements

The hearing aid component allows the user to clearly and accurately hear his surroundings. It consists of a sound amplifier, a microphone, an earpiece, as well as some capacitors and transistors.

3.1 General Requirements

- [R38-II] The hearing aid shall receive the surrounding sounds through its microphone.
[R39-II] The hearing aid shall transmit sound to the user's eardrum through the earpiece.
[R40-II] The hearing aid shall be turned on when the "On" button is pressed.

3.2 Physical Requirements

- [R41-I] The hearing aid shall not be waterproof.

4. Bluetooth Transceiver

The Bluetooth transceiver will be implemented as one device with the hearing aid. This will allow a user with hearing deficiencies to connect his hearing aid wirelessly with any Bluetooth-enabled device, such as most modern cellular phones.

4.1 General Requirements

- [R42-II] The Bluetooth transceiver shall be compatible with all Bluetooth-compatible cellular phones.
[R43-II] The Bluetooth transceiver shall be able to connect to all Bluetooth-enabled devices, with all subsequent connections to the same device done automatically.
[R44-II] The Bluetooth transceiver shall be able to maintain a steady connection with its device.
[R45-II] The Bluetooth transceiver's range shall be at least 5 metres.

5. User Interface Unit

The user interface unit allows the user to control, operate, and receive feedback from the device through the use of buttons. These buttons will be connected to the processing unit. The user interface unit will drive the amplified sound as output.

5.1 General Requirements

- [R46-II] The primary means of user input shall be through buttons on the device.
- [R47-II] The user interface unit shall consist of a flashing LED to indicate low battery.

5.2 Usability Requirements

- [R48-II] The user shall be able to select “On”, “Bluetooth”, and “Off” modes using two of the buttons on the device.
- [R49-II] The user shall be able to change the level of amplification using two dedicated buttons for volume control.

5.3 Physical Requirements

- [R50-III] The interface unit shall resemble the appearance of a Bluetooth headset.
- [R51-II] The unit shall weight less than 20g.

6. User Documentation

- [R52-III] The user documentation shall consist of a user manual and a quick start guide.
- [R53-III] The user manual and the quick start guide shall be written in English, French, Spanish, Chinese, and Japanese language for international marketability.
- [R54-III] The user manual and the quick start guide shall be written for an audience with minimal knowledge of hearing aids and Bluetooth technology.

7. System Test Plan

The general approach to system testing consists of separately testing the individual components comprising of the hearing aid and Bluetooth, before testing the complete unit. The end-users will be conducted to the trials of the final product.

7.1 Individual Component Testing

Components will be assigned to different developers for testing to ensure all the individual components work properly under normal operating conditions before any integration takes place. Once the testing of individual components is passed, the developers will start assembling the components and building the hearing aid on a breadboard. The hearing aid performance will be evaluated by our developers to ensure that the circuit operates as specified in the design.

Here is the sample test case for hearing aid:

Description:

The hearing aid must be able to amplify the sound with minimum noise from a 3V power supply, and the volume control of the device can be easily adjusted by sliding the contact on a potentiometer.

Equipment:

3V power supply
Breadboard
Resistors
Capacitor
Audio Amplifier IC TDA2822M
BJT BC547
Microphone
Earphone

Procedure:

- Build the pre-amplification stage of the circuit and ensure the electrical signal from the microphone has been amplified to the desired value.
- Build the medium-power amplifier section and ensure the amplified sound is driven through the earphone as output.
- **Pass/Fail**

Other Comments:

A volume control must be present, as well as an LED that indicates power status. The LED should also flash to indicate when the device is low on battery. The audio output of the circuit is 10 to 15mW and the quiescent current drain is below 1mA.

7.2 Integration of Hearing Aid and Bluetooth Testing

After all components have passed individual testing, they will be combined into the proposed device and integrated testing will begin. Details on the development stages will be discussed amongst Audima Inc. developers.

Final implementation tests must be performed on the end-product before sending it to users for trials. Developers will ensure that any hardware or technical failures will be minimized before the product is given for user trial.

7.3 Typical Usage Scenario

The device will be operated by a typical user in the following manner:

1. User turns on the device by pressing and holding onto button 1 (power button). This will power on the hearing aid component of the device, amplifying the surroundings for a hearing-deficient person.
2. User connects the device to his cellular phone by pressing and holding onto button 2 (Bluetooth button). This will enable the Bluetooth transceiver in the device, allowing external devices such as cellular phones to pair up with the device.
3. User turns off the device by pressing and holding onto button 1 (power button) once more.
4. User changes amplification volume of the device using the dedicated volume buttons (buttons 3 and 4).

8. Conclusion

This functional specification document clearly defines the features and requirements of the Audima HAB-1, but is not final and will be continuously revised after continuous research and testing to provide a highly satisfactory end product. The development of the device shall be performed in two separate stages. The first stage is already in progress which will prove the concept of creating a functioning, affordable Bluetooth hearing aid. Afterwards, the prototype with requirement priorities I and II will be completed by the target date, December 12, 2011. Finally, priority III requirements will be pursued if time permits.

9. *References*

- [1] From Discovery Health (n.d). *Hearing Aid History*. Retrieved from <http://health.howstuffworks.com/medicine/modern/hearing-aid6.htm>
- [2] From Deafness in Disguise (n.d). *Concealed Hearing Devices of the 19th Century*. Retrieved from <http://beckerexhibits.wustl.edu/did/19thcent/index.htm>