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January 16, 2012

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

Re: ENSC 440 Project Proposal for Multifunction Intelligent Headphone System

Dear Dr. Rawicz,

Enclosed is a proposal for our device Multifunction Intelligent Headphone System which correspond to ENSC 440 project. The project aims to design and implement a system that will detect the surrounding environment in real time and process this information to the user. Some of the main features we want to achieve in our project are word recognition, sound recognition, and voice recognition if time permits.

The objective of the proposal is to present an outline of our project. Below, we will discuss our system overview, design considerations, projected budget, sources of funding, project scheduling, and some background information about our company and its constituents.

Our company, Sound Tec Inc., consists of five talented individuals: Leo Jia Hong Jiang, Simranjit Sidu, Frank Zhu, Xiao Peng He and Afrin Chowdhury. We believe this team is capable of accomplishing the proposed task in a timely fashion.

If you have any questions about our proposal, please do not hesitate to contact us via phone at 778-855-4037 or email at jhj1@sfu.ca.

Sincerely,

Leo Jiang
Chief Executive Officer
Sound Tech Inc.

Enclosure: *Proposal for Sound Tech Inc. Multifunction Intelligent Headphone System*



Project Proposal:

Multifunction Intelligent Headphone System

PROJECT TEAM

Leo Jiang
Simranjit Sidu
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SUBMITTED TO

Dr. Andrew Rawicz – ENSC 440
Steve Whitmore – ENSC 305
School of Engineering Science
Simon Fraser University

ISSUED DATE

January 16, 2012



EXECUTIVE SUMMARY

It can be irritable, lose concentration, and increase stress to user when the noise is excessive when people is listening to music on their headphones. Either for entertainment or for work, to block all the noises, a “high-end” headphone is expected. The headphones in the market nowadays provide great comfort and offer high-quality sound, and the technology has made the “high-end” headphones completely noise proof. Having the noise cancelling headphone is great, however it also brings a range of issues: often it is very inconvenient to use when communicating with other people, and it brings danger to users when using the headphone outside. Recent studies showed that the number of injuries and deaths related to people using headphone on the street have been increasing. The multifunction intelligent headphone system aims to continue providing users the comfort, great sound quality, as well as safety.

The device has three modes: word, sound, and voice recognition modes. In word recognition mode, the system will tune the volume up and down by detecting the keyword ‘up’ or ‘down’. In sound recognition mode, the system will interrupt the headphone volume system and warn the user when danger sound is detected in the surrounding environment. In voice recognition mode, the system will inform the user who is calling them.

Development of the multifunction intelligent headphone is budgeted at approximately \$650. This is a conservative and reasonable estimation given by microcontroller board, debugging chip, and a noise cancelling headphone. Funds have already been sourced from Engineering Student Society Endowment Fund, and we plan on applying for funding from Wighton Fund. In the case the funding does not cover all the costs needed for the development, the members of the team are willing to contribute to the total remaining costs.

Our team assembles a comprehensive technical experience and interests together. Five engineering students involve in this effective team with varying backgrounds in software, hardware, mechanical systems, and project management. Most of us were exposed to a much larger scale projects in our previous cooperation than the one we are proposing. Administrative and technical responsibility will be given in this proposal of the intelligent headphone system. Strengths, personalities, and cooperation will be considered through the entire project. The better division of responsibilities and the reasonable schedule will drive us to the completion of this project.

To ensure the project will be completed before the deadline, the project is divided into many stages and a timeline is implemented to make sure previous stage is completed before moving to the next stage. Also a group meeting will be held every week to discuss the progress made by each team member and to resolve any obstacles that they might have on their tasks.



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1. INTRODUCTION

As a modern human, we cannot help to admire the intricate technology in electro - acoustic. In 1877, the greatest invention from Edison, the phonograph, replays the first perfect recording that Mary Had A Little Lamb in the history of mankind. Nowadays, with the rapid development of science and technology, headphones which enable us to be free to experience all kinds of musical instruments and creation and performance of the distinguished singer have advanced tremendously in this aspect. But the world as we know does not treat music lovers well enough, this is due to the rising types of ambient sounds that can interfere with or even block the sounds coming through their headphones. [1]

The age of multifunctional headphones has entered into people's lives. To satisfy music lovers, many of the high-tech companies have designed headphones with significantly improved sound quality and the elimination of surrounding noise. If you look around, you can find these ambient sound cancellation headphones everywhere (from the corner of the streets to homes of individuals). Meanwhile, it also brings some potential danger to us. There are many cases where headphone-wearing pedestrians have been the reason of traffic accidents. The most common scenario involves a pedestrian stepping into the road without looking properly and failing to hear an oncoming vehicle. This can force the approaching driver to brake suddenly, subsequently being hit by the car behind. Therefore, our group will improve headphones using intelligence like an automated robot.

To prove the advantages of the multifunctional intelligent headphone system, we will strive to enhance the quality in music and remove unwanted ambient noises. It can warn users of incoming traffic (e.g. fire engines and ambulances) nearby and surrounding danger. Just like the iPhone 4S, the headphones can be controlled by the user's voice commands; notify the user when someone is calling his/her name or talking to him/her. Furthermore, there are three main features for our design project. Firstly, the headphone detects the keyword, and performs certain actions (Word Recognition). Secondly, interruption of the headphone system to warn the user upon detection of 'danger sound' (Sound Recognition). Lastly, interruption of the headphone system to inform the user of incoming call (Voice Recognition).

This document provides an overview of our design project, as it provides a general outline the steps of design, funding of the project and team management for scheduling. The major challenges that need be overcome during the embedded system design of this project include integrating the interrupt system, testing and debugging.

2. SYSTEM OVERVIEW

The Multifunction Intelligent Headphone System (MIHS) is an intelligent headphone that tells you everything that is around you. Aside from being intelligent, the headphone also provides great comfort and sound quality like most commercial headphones. The headphone system has three main components, the microcontroller board, the noise detection board, and the noise cancelling system. The three main components will be implemented on the headphone as shown in the figure 1.

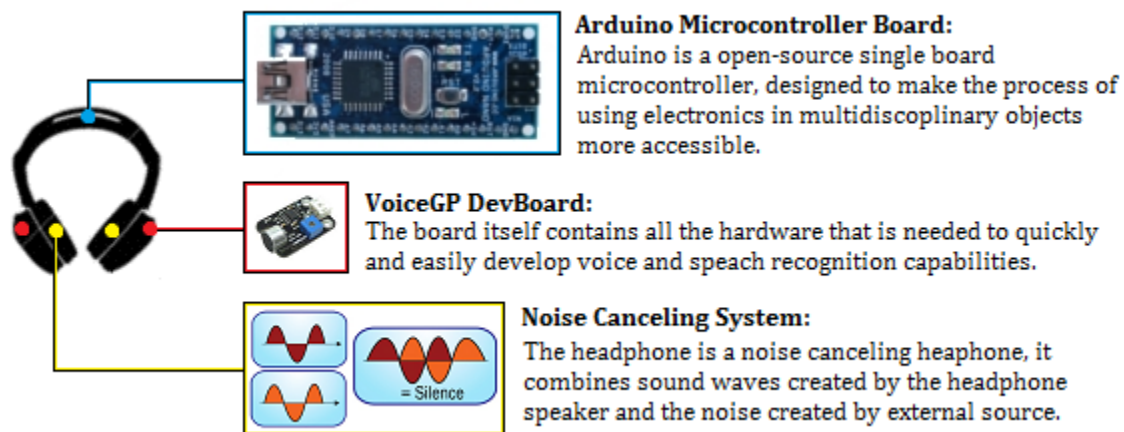


Figure 1: Main components of MIHS

The headphone system uses one of the latest and advanced microcontroller boards, the Arduino Board. The board will be used to control all the basic functions of the headphone, from basic functions such as controlling the volume to more advanced functions such as warning/signalling the user the danger around them. The controlling of the headphone is done through the noise detection board, the VoiceGP development board. The board will pick up signals from the two microphones, one on each side of the headphone, and process the information accordingly. [2]

There are three active modes in the headphone system: each mode corresponds to different type of noise detection, which are word, sound, and voice. Each mode will behave the same, first the headphone will pick up the noise, and then it will process the noise and compare it to the data that is “pre-programmed”. The behavior varies depending on the type of information processed. And in the case that the information is critical or there is an interruption in the headphone system, the headphone will be in idle mode until the user acknowledges the action taken. The flow chart in the next page shows the behavior of the headphone system when it is in active mode.

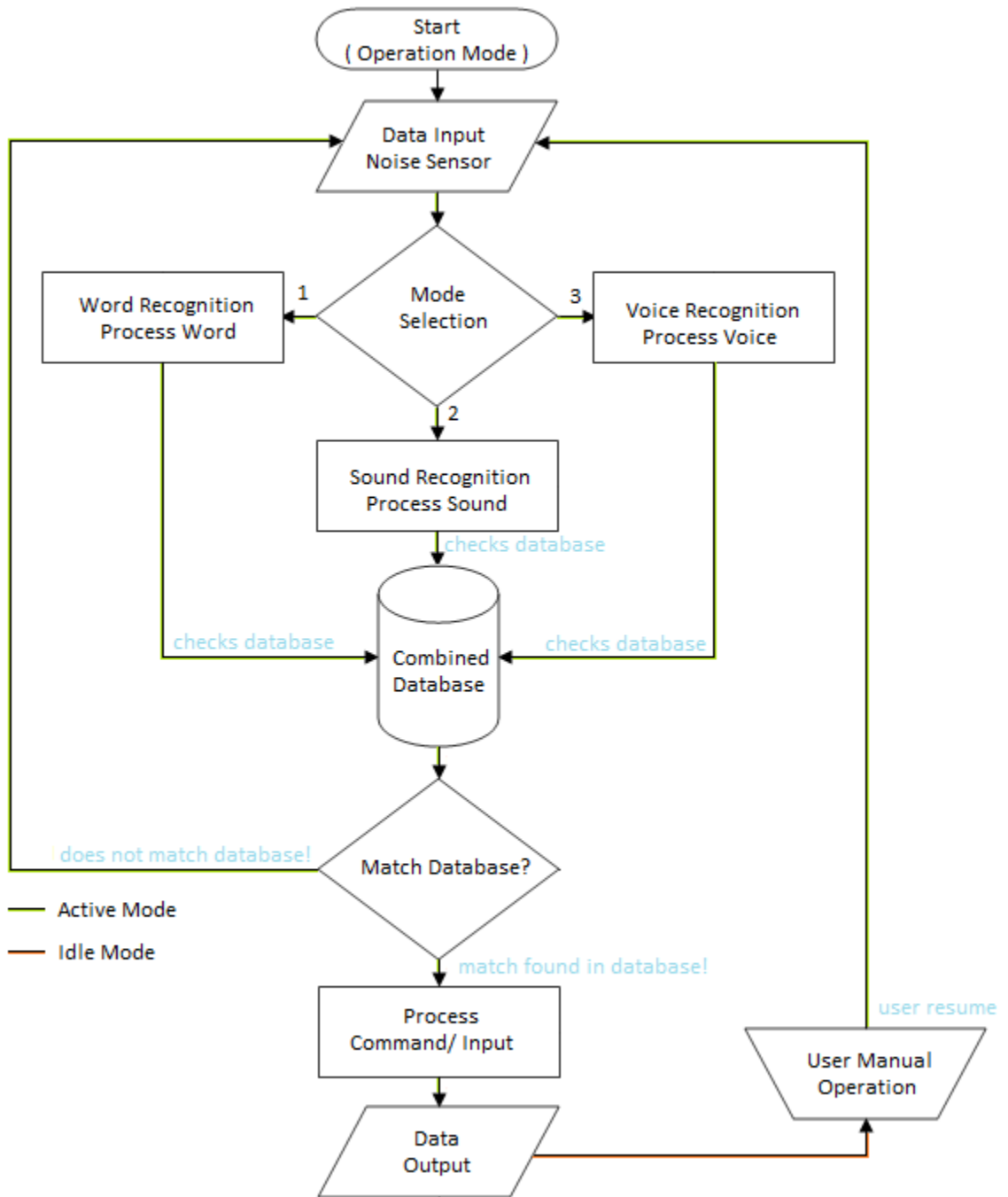


Figure 2: MIHS Flow Chart

3. POSSIBLE DESIGN SOLUTIONS

The functionality of our project includes word recognition, sound recognition and voice recognition. The most complex functionality out of the three is voice recognition because it varies in terms of accent, pronunciation, articulation, roughness, nasality, pitch, volume, and speed. Voice processing real time algorithms require processors with decent processing power. Based on the different cases, the design team had come up with 6 possible design solutions. These are listed in the table below:

Table 1: Design Solutions – Microcontroller Boards

Name Of Board	Price(\$)	Pro	Cons	Misc.
EasyVR with Arudino Board	~ \$100	Cheap, small size of EasyVR as compared to VoiceGP, Lot of support from robotics community, Customaries Arudino board size according to headset, on chip microphone, VRbot GUI	EasyVR is old version of VoiceGP, Arudino instruction set familiarity is required, Microphone customisation, VRgui requires the new command to be typed	http://www.sparkfun.com/products/9753 http://www.youtube.com/watch?v=aUkLd2MncHg http://www.robotshop.com/tigal-easyvr-shield-arduino.html
VoiceGP with Development Kit	~ \$250	On Chip microphone, VRbot GUI, Lot of support from developers, Superior than EasyVR, low development time (as it has quick demo and prototypes), C/C++ language set, Automatic voice training.	Large size, cost	http://www.robotshop.com/ca/productinfo.aspx?pc=rb-tig-03&lang=en-us http://www.veear.eu/Demos/VoiceGPIntroduction.aspx
Standalone VoiceGP	~ \$100	VRbot GUI, small size, cheap	More development time, less flexibility, VRgui require new command to be typed	http://www.robotshop.com/ca/productinfo.aspx?pc=RB-Tig-02&lang=en-US http://wn.com/VRbot_Voice_Recognition_Module
Standalone VoiceGP	~ \$100	VRbot GUI, small size, cheap	More development time, less flexibility, VRgui requires new command to be typed	http://www.robotshop.com/ca/productinfo.aspx?pc=RB-Tig-02&lang=en-US http://wn.com/VRbot_Voice_Recognition_Module
OMAP Processor and Tlesr open-source software (Beagle board)	~ \$150 + Microphone	Lot of flexibility, Beagle community support, TI community support	Size of board, require separate microphone, Need some time to understand all the pipeline of the board, No idea about performance and microphone interface(driver hacks) for real time	https://gforge.ti.com/gf/project/tiesr/
Use DSP chip for Voice recognition	Can range from \$99 - \$1000	Small size, very efficient(application specific)	Less support, audio processing chips are cheap but don't have voice recognition module, voice recognition specific chips are expensive, No idea about the microphone interface	http://www.ti.com/tool/tmdx5535ezdsp?DCMP=c5000-c553x-110830&HQS=c553x-b-tf http://processors.wiki.ti.com/index.php?title=C5000_Connected_Audio_Framework
Com09753 with AxonII	~ \$150	Small Size, VRbot GUI, Com09753 is old version of VoiceGP	Less support, Word recognition not voice recognition, VRgui requires new command to be typed in. Learn Axon II instruction set	http://www.sparkfun.com/products/9753 http://www.youtube.com/watch?v=aUkLd2MncHg



4. PROPOSED DESIGN SOLUTION

The main problem of ambient sound cancelling headphone is it is very risky to wear it while walking down the street. Because this type of headphone does not warn the user if there is any oncoming danger on the busy road. Our proposed design solution is to build a small device which will be attached to an ambient sound cancelling headphone. The ambient sound cancelling headphones are everywhere on the market. But the extra feature of the small device attached to the headphone is an innovative idea. Our modern headphone technology will bring many advantages such as better communication sound system in international meetings, minimizes unwanted background noises to provide improved sound quality, and automatically controls the volume level depends on the noise of the surrounding environment.

Some important design consideration needs to be examined while designing the multifunction intelligent headphone:

- **Word Recognition:** For entertainment and user friendly purpose, word recognition system in headphone will allow user to control the headphone at their comfort. The headphone will automatically tune the volume up and down by detects the keyword, and performs certain action such as mute the headphone when the user's name is called.
- **Sound Recognition:** The sound recognition system will detect surrounding high level sound and alert the user by interrupting the headphone system. The headphone will tune the volume down or mute if it detects any High level sound such as siren of ambulance, police cars or blaring horn. This will eventually reduce the number of injuries and deaths on the street as nowadays many people on the street with the headphone are not aware of danger around them.
- **Voice Recognition:** The voice recognition system will inform the user if anyone is calling user's name by interrupting the system and lessees chances of missing important conversations.

We have to finish the project in a limited timeline and funding. The time to complete the initial design concept to the functioning prototype of our project is one semester, which is thirteen weeks. Although the timeline is very short, we will be able to design and construct a simple multifunction headphone.

With a sufficient time and money, we aim to finish the multifunction intelligent headphone system. We would improve the device's accuracy of recognizing specific word and surrounding high level sound; furthermore the accuracy of selected area would be worked on. Moreover, the size of the product would be considered to improve on since it is to be attached to the headphone for usage on a day-to-day basis.



5. SOURCES OF INFORMATION

Several sources of information will be used for the design of the multifunction intelligent headphone system. In order to complete this project, we will take advantage of various sources of information such as the Internet, research articles, datasheets and specification documents of electronic and mechanical components. Also, we will research and study of Sound, Word recognition technology, Analog-to-Digital (ADC), statistics and other features of Headphone and their circuit diagrams to assist us in building this new technology.

Before identifying the final design implementation, preliminary research will be used to determine the functional design of our intelligent headphone.

To obtain expert advices in engineering field, we will consult with faculty members and graduate students at SFU. Their advice will help us with the key concepts and also might reduce the cost of our project as predicted previously.

6. BUDGET

The table below contains the tentative development budget for the Multifunction Intelligent Headphone System. The price of all parts and components for the development of the prototype are sourced from various reputable online vendors and electronics shops. Since the price listed is the retail price and it is per component, in the case of mass production the cost of each component would much lower. For mass production, we would be contacting the manufacturer companies for better pricing.

Table 2: Price Listing for Equipment

Equipment	Estimated Cost (CAD)
Microcontroller Board (Arduino or Beagle Board)	~ \$ 150
Voice Recognition Module and Sensors	~ \$ 100
Noise Cancelling Headphone	~ \$ 150
Debugging Chip	~ \$ 100
Miscellaneous Electrical Components	~ \$ 50
Power Supply and Batteries	~ \$ 50
Shipping and Handling	~ \$ 50
Total Cost	~ \$ 650

The two main cost of the project is the Microcontroller Board and the Noise Cancelling Headphone, these accounts for approximately 50% of the development cost. It is important that we get the parts needed as they are the “heart” of our project. The microcontroller board provides the necessary functions needed to control the whole system, and the noise cancelling headphone is needed to properly give the user the experience and for us to demonstration of our product. [3]

7. FUNDING

We have considered different funding sources for our project such as Simon Fraser Engineering Science Student Endowment Fund (ESSEF) and Wighton Fund. By far, Sound Tech Inc. has obtained funding from the Engineering Science Student Endowment Fund in the amount of \$500 CAD, which accounts for 77% of the total cost for the development stage of our product. We will try to get the remaining funding from the Wighton Fund. In the case that we are not eligible for the Wighton Fund, each team members are willing to contribute an even amount to cover the remaining cost of the project development.

8. SCHEDULE

The figure below shows the timeline for the Multifunction Intelligent Headphone System. All group members will be contributing their time and effort to the individual tasks. Most of the time will be allocated for research; we believe research is one of the most important steps of the project because we want to have the system to work as proposed, and for our product to be unique. There will be other tasks that are working parallel to the research. We aim to complete the project in the second week of April of 2012 by following these time schedules.

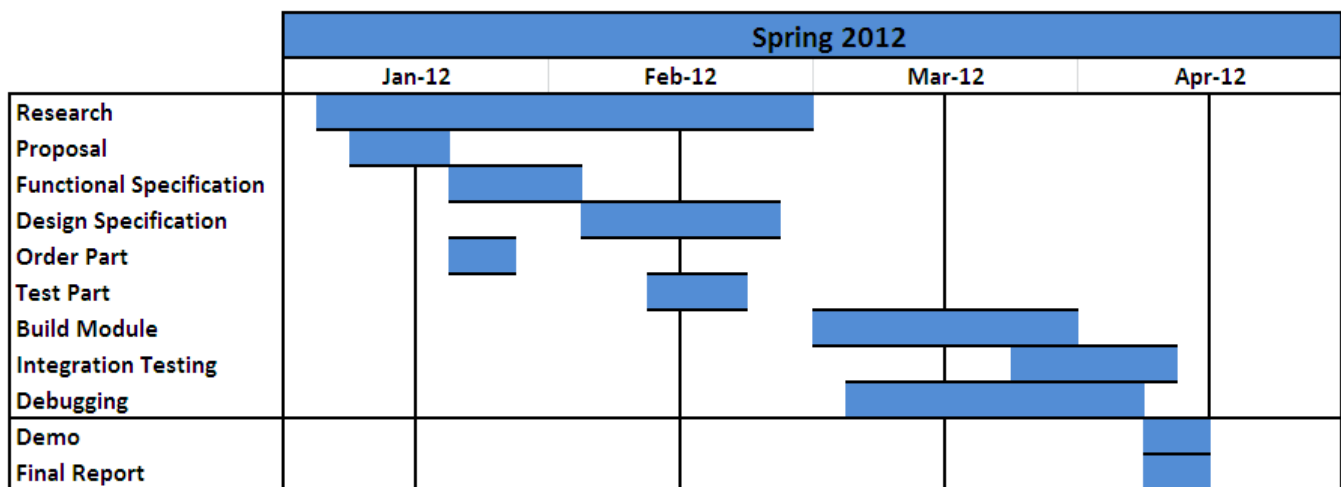


Figure 3: Timeline for MIHS

The project will be divided into eight different stages, figure 4 shows the milestones for the different stages, which include:

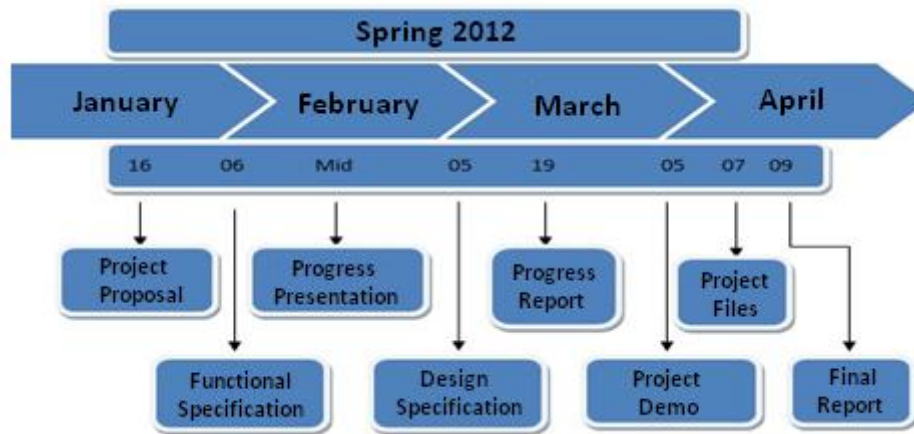


Figure 4: Milestones for MIHS

Project Proposal – Introduction to company, project, strategies, resources, budget, and timeline.

Functional Specification – Documentation on the project in detail, the behavior, design input and outputs.

Progress Presentation – Presentation of the project, listing accomplishments and obstacles.

Design Specification – Documentation on requirements for the project, specification and designs.

Progress report – Written report for the project, listing accomplishments and obstacles.

Project Demo – Demonstration of product to faculty staff and professors.

Project Files – Final version of all project files: functional specs, design specs, and all related documents.

Final report – Complete and combined report on the final product.

9. TEAM ORGANIZATION

Sound Tech Inc. is a young research and development company. The company consists of five talented and highly-motivated engineering students: Afrin Chowdhury, Frank Zhu, Leo Jiang, Ray He and Simranjit Sidu. Afrin and Ray are majored in Electronic Option, specialized in microelectronics and its applications in communications, control and computing. Frank and Leo are majored in System Option, specialized in design and integration of computer-controlled machines, and main focus on mechanical structures and mechanisms as well as mechanical sensors and actuators. Simranjit Sidu is majored in Biomedical Option, specialized in medical electronics that are concerning medical and surgical treatments, rehabilitation procedures and assistive devices.

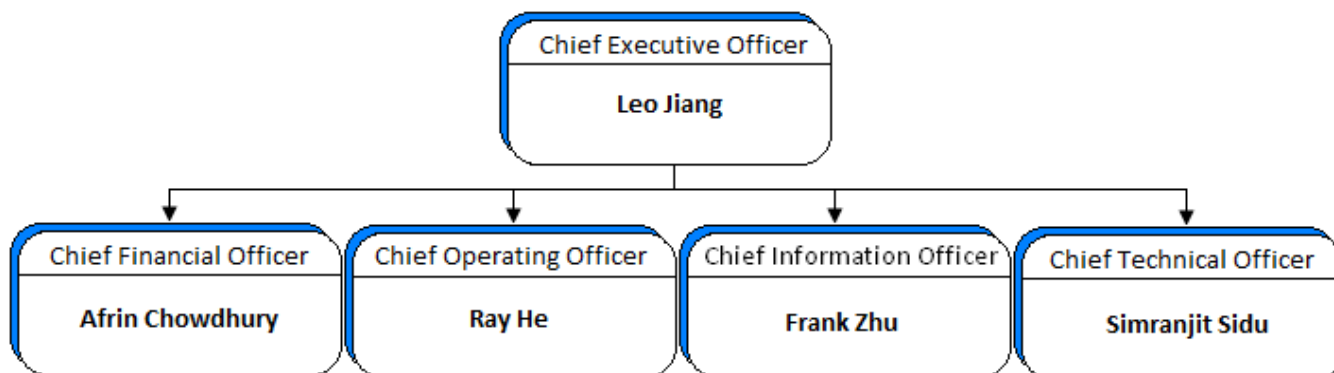


Figure 5: MIHS Team Organization

Leo Jiang, Chief Executive Officer (CEO) of Sound Tech Inc. He is in charge of total management of the company. Leo's past Co-op experience as a software developer in RIM and as an assistant manager at Starbucks will give him necessary management and decision making skills to manage the company. Under Leo's leadership and management skills, the team will drive toward the project milestones as planned.

Afrin Chowdhury, Chief Financial Officer (CFO), is in charge of budget and funding management. Her most recent internship with HSBC Canada as reporting and development support gives her the skills that are needed for project finance and reporting for our company.

Ray He, Chief Operating Officer (COO), is responsible for daily operation of the company. Ray's main role will be maintaining and monitoring staffing and routinely reporting to the CEO. Ray is an expertise in analog circuit and has a strong background in software languages including C and C++ will perform the technical support for the whole team.

Frank Zhu, Chief Information Officer (CIO), is responsible for information technology and computer systems. He will be managing the implementation of the useful technology to increase information accessibility and integrated systems management.

Simranjit Sidu, Chief Technical Officer (CTO), is in charges of product design and software development. From his previous Co-Op experience in Broadcom, he gained variety of skills in software and hardware language which enables him to be competent and overcome difficulties during the project development.



10. COMPANY PROFILE

Leo Jiang – Chief Executive Officer

Leo is a fifth year System Engineering student, during his study at Simon Fraser University; he has gained knowledge and experience in both hardware and software. Leo has gained experience in communication and prioritization skills through his internship working as a service desk student at Environment Canada, he also adapted new programming skills and decision making through his internship working as a software developer at Research In Motion. Aside from the internships, Leo also worked as an assistant manager at Starbucks, where he works alongside with the store manager and acted as a coach and mentor, he also ensured the company's policies are implemented and maintained in a consistent manner. Leo was appointed by the group to take charge of the company because his rich skills in management and leadership.

Afrin Chowdhury – Chief Financial Officer

Afrin is a fifth year Electronics Engineering student. She has developed a strong understanding of the fundamental principles of electronics and efficient in circuit design. She had worked on many different projects like Video conferencing in Wimax network, Video Codec, Motion detector for blind, Metal detector, AM Radio-Electric Circuit etc. During her most recent eight months of internship as a Reporting and Development Support with HSBC Canada (Software house), she effectively managed broad areas of Project finance and reporting. With a strong background in electronics and project management, she has assigned a task on hardware and financial issues in the project.

Ray He – Chief Operating Officer

Ray is in his last year of studying Electronic Engineering at Simon Fraser University. He has developed practical problem solving skill, principles of electronics and computer skills (Microsoft office and C++) through the academic study. The intensive teamwork of high level engineering projects and labs honed his interpersonal skills and engineering expertise. During his previous co-op work as an embedded system developer in Ciber Lab, he made significant contribution to convert Dynamic Time Warp Algorithm in Matlab to C and implement this algorithm on the AVR evaluation board. Ray believes that with his academic background and sufficient experience in working in lab, he will be an independent and creative engineer.

Frank Zhu - Chief Information Officer

Frank is a fourth year System Engineering student at Simon Fraser University. He is a dedicated and passionate learner who commits to his best effort in every task. Over the course of his education, he had acquired a profound understanding of various analogs and digital electronics circuits/components. Furthermore, he had performed various labs and executed projects which consisted of complex



electrical circuits and theories regarding communication engineering. Frank is proficient in using Microsoft Office programs, MATLAB, Logic works, Audacity, CodeWarrior and has an excellent understanding of programming languages such as C++ and assembly programming.

Simranjit Sidhu – Chief Technical Officer

Simranjit is in his final year as a Biomedical Engineering student. He is efficient in circuit design and software development. He has done one research Co-Op term at SFU and two industrial Co-Op terms at Broadcom. He has worked on many different projects like Face detection and emotion detection in the video, Optimization of the h.264 codec, fast and more efficient decoding of JPEG, and has built compiler for language similar to C++. With a strong background in image processing and embedded systems, he is assigned a task to focus on resolving the scientific and technological issues faced in the project.

11. CONCLUSION

The headphone design aims to provide users comfort, great sound quality, and safety. With all the functions that are implemented on the headphone: users can now control their headphone with their voice command, enjoy their favorite music or watch their favorite movie with their headphones without any outside disturbance, they don't need to worry about the danger around them because the noise was cancelled out by the headphone, and they don't need to miss any important conversation from the special someone. The multifunction intelligent headphone will pick up all the noise around the user and will warn them if they are in danger, and will notify them if their special someone is talking to them.

Sound Tech Inc. is comprised of talented engineering students that demonstrate good teamwork. Each team members will try their hardest and will combine all their knowledge and skills on the project. Group members will encourage and help each other towards the completion of the different stages of the project, and won't let any obstacles block the path to each of the scheduled Milestones. We can conclude with confidence that this project will be completed by mid-April 2012.



12. SOURCE AND REFERENCE

- [1] "Voice Recognition and Speech using Arduino," 06 December 2009. [Online]. Available: http://www.societyofrobots.com/member_tutorials/node/346. [Accessed 15 January 2012].
- [2] "How Noise-canceling Headphones Work," [Online]. Available: <http://electronics.howstuffworks.com/gadgets/audio-music/noise-canceling-headphone.htm>. [Accessed 14 January 2012].
- [3] "Getting Started with Arduino," [Online]. Available: <http://arduino.cc/en/Guide/HomePage>. [Accessed 10 January 2012].
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