Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1S6

December 16th, 2011

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

Re: Post Mortem Report for Wearable Proximity Detector for the Visually-Impaired

Dear Dr. Rawicz,

Please find enclosed the post-mortem report for PROXIMIview Technologies' Wearable Proximity Detector for the visually-impaired. The purpose of the device is to aid the user in avoiding obstacles via tactile and auditory feedback by utilizing an array of ultrasonic sensors mounted on sunglasses as well as on the handheld enclosure.

The report describes the functionality of our current product, the deviations we have made from the original design, and ideas for some future work to further enhance the product. Also included are details on market analysis, deviations from initial projects costs and project completions timelines. Finally, each member of our team has taken this opportunity to share the experience they gained throughout the semester.

PROXIMIview Technologies is comprised of four talented, dynamic and motivated engineering students namely Renuka Rani, Gary Brykov, Sajith Kulasekare and Marish Lalwani. If you have any questions or concerns, please feel to contact me by phone (778-321-3761) or by e-mail (PROXIMIview@gmail.com).

Thank you very much for your consideration.

Yours sincerely,

Renuka Rani
Chief Executive Officer (CEO)
PROXIMIview Technologies Ltd.

Enclosed: Post Mortem Report for Wearable Proximity Detector for the Visually-Impaired

PROXIMIview Technologies

Post Mortem for a Wearable Proximity Detector to Aid the Visually-Impaired

Contact Person: Gary Brykov
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Submitted To: Andrew Rawicz – ENSC 440
Mike Sjoerdsma – ENSC 305
School of Engineering Science
Simon Fraser University

Issue Date: December 16th, 2011

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PROXIMIview Team

Renuka Rani	CEO
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Marish Lalwani	COO

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GLOSSARY

MCU - Microcontroller

NiMH – Nickel Metal Hydride

NiCd – Nickel Cadmium

SPDT – Single Pole Double Throw

1.0 Introduction

Over the past three and half months, our team at PROXIMIview has been working extensively to create a device to aid visually impaired users in avoiding obstacles while moving, and is ready with a fully functional proof-of-concept device. Our team has successfully been able to accomplish this by mounting an array of ultrasonic sensors on a pair of sunglasses, as well as on the handheld control/feedback box. The information from these sensors is processed by a microcontroller programmed with comprehensively tested software which drives the auditory and tactile feedback components. Each design decision and component has been carefully selected by our team considering that the user of device will be visually impaired. To this end, some deviations have been made from the originally planned design outlined in *Design Specifications for a Wearable Proximity Detector to aid the Visually Impaired* [1], details of which are included in this document.

2.0 Current State of Device

As of now, PROXIMIview Technologies Ltd. has been successful in developing a working prototype of Wearable Proximity Detector for the visually impaired. As mentioned in the Design Specifications, the system contains two main components namely:

- Sunglasses/Sensor unit
- Control Unit

2.1 Sunglasses/Sensor Unit

This is the most important unit of our project. This unit consists of a sunglasses with the three sensors mounted at different positions (Figure 1). The first and the most important sensor that drives the functionality of others is the centre sensor. The other two sensors are mounted on the sides of the sensors, i.e, the left and the right sensors. All the three sensors are connected together with their three pins namely, the Vcc, the signal and the ground to a single piece of shielded wire going down to the control unit. The sensors send the proximity signals to the microcontroller through this connection.

Figure 2.1: Sunglasses Unit

2.2 Control Unit

The control unit (Figure 2) is the unit that drives the entire functionality of our device. This consists of an Arduino Uno microcontroller, a battery pack that supplies 11V to drive the circuit, a vibrating module that is used to send the tactile feedback to the user, a Single Pole Double Throw (SPDT) Rocker switch to toggle between the two states namely, where the microcontroller and the is connected to the sunglasses/sensors unit and the other state is connected to the battery for charging. The control unit also holds a 11V rechargeable battery pack made up of 8 Ni-Cd battery in series. We also have a wall adapter in order to charge the batteries. The outputs from the control unit are Audio Out jack and a battery charging jack to connect the wall charger to it.

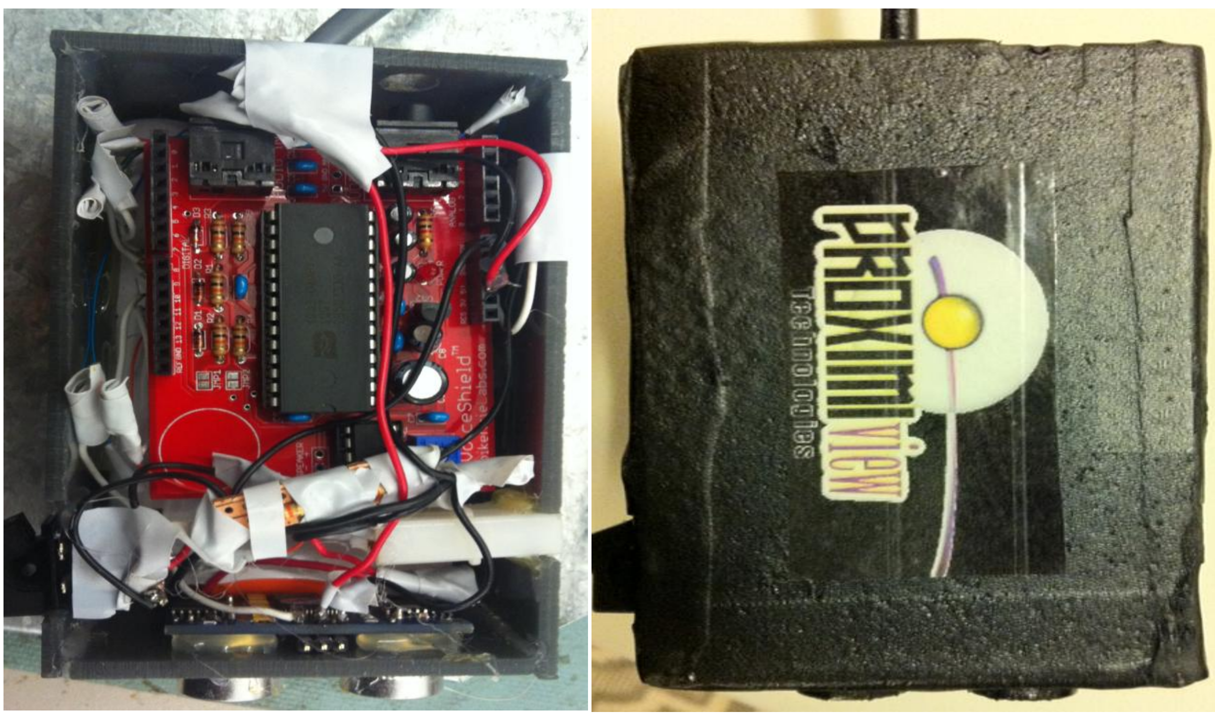

Figure 2.2: Control/Feedback Box

3.0 Deviation From Original Design

From idea generation to idea screening to concept development, our team PROXIMIview has been focussing on developing a product that will benefit the user in its target market with maximum efficiency and ease of use. As such, some adjustments were made as necessary:

1. **An additional (4th) Ultrasonic Sensor**
   Considering input from a few sources, as well as Andrew Rawicz, we decided to mount a 4th ultrasonic sensor in the control/feedback box that will provide information to the user regarding objects in front of the box. This is very useful because it can help the user avoid waist-level objects. Although this addition added extra work and further use cases, it improved the functionality of our product dramatically.

2. **Omission of the Integrated Speaker**
   After much debate, we decided that including speakers with the device would be unnecessary since they would be disruptive to any person but the user, and sometimes, annoying even to the user. Therefore, headphones alone will be used to provide auditory feedback to the user. If speakers are required, portable speakers are easily available that can be plugged into the 3.5mm port of the device.

3. **An additional (2nd) Vibration Motor**
   A 2nd vibration motor was added to the device to increase the intensity of the vibration.

4. **Battery type**
   Instead of using a Ni-MH battery pack, we opted to use a Ni-Cd battery pack instead due to its low self-discharge rate. Ni-MH also cannot handle high rates of charges and discharges.

4.0 Future Plans

The wearable proximity detector developed by the PROXIMIview group can be accurately used to assist a visually impaired person to manoeuvre around concrete eyelevel objects, as well as waist level objects. Due to time constraints and limitations of the hardware, a number of concerns were not addressed in the final product. These concerns and limitations will be mentioned in this section with the intention that the device can be improved further to provide accurate assistance of a real life environment for the visually impaired.

Motion Detection

The PING))) ultrasonic sensors used in the final device emit a 40kHz ultrasonic burst and uses the echo to calculate the distance from the object (1). The strength of the echo clearly depends on the size of the objects providing accurate feedback for large objects (walls) and less accurate feedback for comparatively small objects (humans, chairs, etc). Furthermore due to the use of the ultrasonic sensors, the device in incapable of differentiating between stationary objects opposed to mobile objects. These shortcomings can be countered in the future by using motion sensors and using image processing to provide a realistic replication of the environment.

Power Supply

The device is powered by a custom rechargeable battery pack which uses 8 AA NiCd batteries to provide 10.4V and 6 hours of battery life. Although the unit provides a straight forward means of recharging while the battery remains in the device, the weight of the handheld control unit is significantly increased by the use of the AA NiCD battery pack. The weight of the power supply can be significantly improved in the future by using Lithium batteries which can provide greater capacity and less weight.

On/Off switch for the 4th sensor

The PROXIMIview proximity detector currently uses a single pole double throw switch to toggle between power to the Arduino and the battery charging mode. In the future, a single pole triple throw switch can be used to provide the capability of turning the 4th sensors on/off which can provide more flexibility to the user.

Wireless data transmission from sunglass unit to the handheld device

The device currently uses a shielded wire from the Arduino Uno board to the glasses to provide signal wires, ground wires and power supply wires to the sensors. The functionality and aesthetic appeal of the device can be significantly improved in the future by providing a separate power supply for the glasses and wirelessly transmitting the sensor signals to the handheld Arduino.

Detection of Potholes/Stairs

Another limitation of the PROXIMIview proximity detector is the incapability to distinguish very low level objects such as stairs and obstacles such as potholes. In the future the device can be extended from a handheld device to a wearable unit which can be worn around an individual's waist or legs which will provide the ability to detect ground level objects.

Miniature Sensors

The size of proximity detectors increase with the detections range. The device currently uses ultrasonic sensors the size of 22mm height x 46mm width x 16mm depth. In the future aesthetic appeal and functionality of the sensors can be significantly improved by using custom made miniature ultrasonic sensors with a larger detection range. Furthermore miniaturising sensors will provide the ability to make the device weather proof and robust.

5.0 Business Aspects

5.1 Cost Breakdown

PROXIMIview Technologies' project was to be funded by the Engineering Science Student Endowment Fund (ESSEF), which was obtained in the amount of $500 CAD. As noted in our project proposal, this funding grant was conditional on our company returning - upon completion of the project - any and all components that the Engineering Science Student Society (ESSS) deems valuable and useful enough to be used in future student projects at Simon Fraser University. Any costs exceeding the $500 CAD granted by the ESSEF were covered by the four members of PROXIMIview Technologies. Due to unforeseen circumstances, our team experienced a severe setback approximately one week prior to the final project deadline. This setback destroyed all four of the PING))) sensors as well as the Arduino Microcontroller. Our team had to re-order and pay for these five components, as well as pay for expedited shipping in order to obtain these parts in time for final assembly so the deadline could be met.

The following table compares our projected project costs with the actual costs incurred by PROXIMIview Technologies.

Table 5.1: Project Costs – Projected versus Incurred			
Projected Component Costs		**Incurred Component Costs**	
Arduino Microcontroller Starter Kit	$39.95	Arduino Microcontroller Starter Kit	$34.08
Arduino VoiceShield	$55.95	Four (4) PING))) Sensors	$185.16
PING))) 28015Ultrasonic Sensor	$63.76	VoiceShield and Associated Parts	$149.67
HX40TRC Ultrasonic Sensor	$42.00	Auxiliary Cable	$16.79
Mini Speaker 15mm	$7.00	Two (2) Vibrator Motors	$16.00
LilyPad Vibe Board	$14.95	Custom Ni-Cd Battery	$50.55
LM7805 +5 Volt Regulator	$3.00	Custom Battery Charger	$20.24
Weatherproof Enclosure	$50.00	Charger Adapter Jack	$4.76
Battery	$40.00	Glue Gun for Assembly	$12.31
PCB Fabrication	$200.00	Re-order of four (4) PING))) Sensors	185.16
Miscellaneous Electrical Components	$50.00	Re-order of Arduino MCU	34.08
Shipping Costs	$50.00	Expedited Shipping	$4.95
Contingency Fund	$142.00		
Total Projected Budget	$758.61	Total Incurred	$713.75
Over/Under Budget		**$44.86 under budget**	

It is apparent from the cost analysis that PROXIMIview Technologies completed the project while staying $44.86 CAD under budget, even while experiencing a setback which cost the company a total of $224.19 CAD. Had we not had this near-catastrophic setback, the project would have been completed while staying $269.05 CAD under budget.

5.2 Market Analysis

PROXIMIview Technologies aims to equip blind people with a low-cost assistive technology to support mobility, navigation and productivity.

In recent decades, many promising efforts to develop low-cost assistive technologies for the blind have either stalled or produced devices too costly to address global need. Designers and manufacturers regularly overlook the needs of blind individuals residing in developing countries, who make up about 90% of potential beneficiaries worldwide. Meanwhile, rates of illiteracy, unemployment, and poverty among the blind far exceed those of sighted peers, which propagates a cycle of social marginalization and commercial neglect.

PROXIMIview Technologies strives to develop and disseminate an essential low-cost assistive device in a sustainable, scalable manner. This can be achieved by incorporating the production and development processes into the fabric of the diffuse blind community. Higher performance, lighter, and smaller PROXIMIview low-cost devices for the blind can be released through an international network of blind-accessible institutes such as the Canadian National Institute for the Blind (CNIB) and the American Foundation for the Blind (AFB). These facilities can then serve as platforms for continued refinement and development of the PROXIMIview assistive device.

Current assistive devices for the blind include but are not limited to:

- talking clocks and watches/calculators/pedometers/scales/thermostats/thermometers/glucometers
- magnifiers
- Braille paper
- tactile measuring cups
- audible water level indicators
- large print keyboard inlays
- low vision lamps
- recording devices
- large print calendars
- Braille watches
- tactile games
- bump dots
- Braille rulers
- bold lined paper
- white canes
- guide dogs

These devices are considered part of the market that PROXIMIview Technologies is trying to penetrate with the PROXIMIview Assistive Device. Our product combines various parts of these existing devices and packages it in an easy-to-use, accessible, and inexpensive device. With further refinement, miniaturization, and endorsement from relevant organizations, our device has the potential to become *the* leading assistive device for the blind and visually-impaired population.

5.3 Project Timeline

The expected/actual durations of the individual stages of the project are shown below.

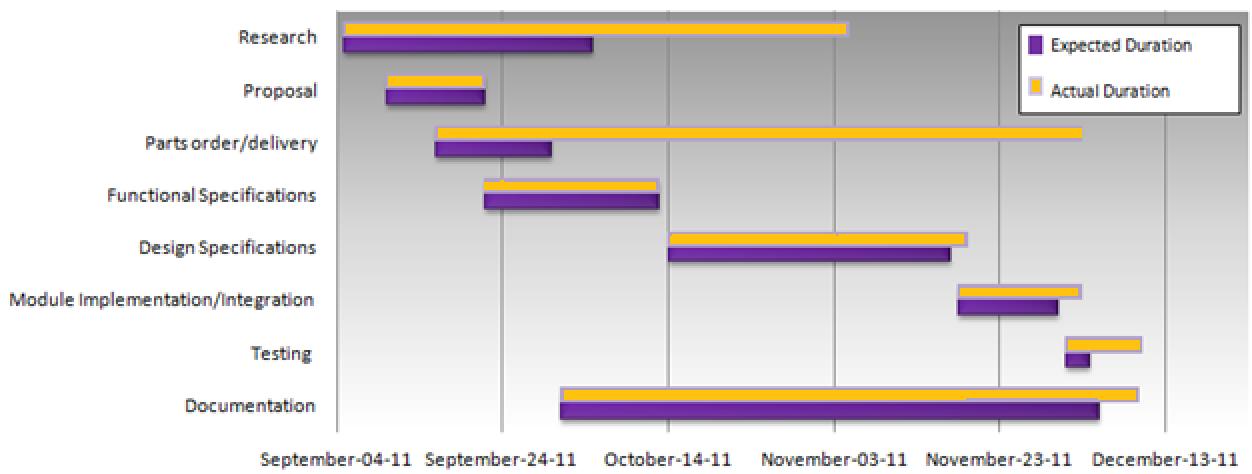

Figure 5.1: Actual/Expected Duration of Stages

Table 5.2: Actual/Expected completion dates

Stage	Proposed Date	Actual Date
Research	October 1st	November 5th
Proposal	September 22nd	September 22nd
Part Order/Delivery	October 1st	December 10th
Functional Specifications	October 13th	October 13th
Design Specifications	November 17th	November 20th
Module Implementation/integration	December 1st	December 10th
Testing	December 5th	December 14th
Documentation	December 5th	December 15th

6.0 INDIVIDUAL CONTRIBUTIONS/EXPERIENCES

6.1 Renuka Rani – *Chief Executive Officer*

Since ENSC 440/305 is one of the only courses that allows students to work on all stages of product development – from idea generation to product testing and revision – it can safely be said that each student completes this course with scores of valuable insights.

As the CEO of the company, I was largely responsible for four main things: distributing our tasks efficiently, making high-level decisions, presiding over the team's day-to-day operations, and ensuring effective collaboration, whether it be within the team, with professors, or outside sources. The first was easy to manage as I learned the strengths of each of my team members, and the second required quite a bit of research and input from my team. I accomplished the third by working closely with all aspects of the project, from research and development to integration to testing. The last required keeping track of all operations within the team. In this capacity, I believe I learned a lot about sourcing information, and most important of all, what to do when you have no idea what you are doing: talk to experts. SFU is full of Professors, teaching assistants, and research students with expert knowledge who are more than happy to help students with any questions they may have, and I would like to thank them for their assistance.

From the beginning, I was very impressed with my team's dedication to ENSC 440/305. This dedication and initiative can be shown by the fact that we met various times before the semester even started to discuss possible project ideas. Each one of us had one goal in mind: to create a product that aimed to help society. We discussed idea upon idea, and at that point, I realized the benefits of working in a well put-together team – since everyone brings together points about technical feasibilities, as well as possible solutions and issues, all the work required for the course does not seem as daunting as before. I am also proud to note that the dedication and work ethic shown at the beginning of the project remained strong during the entire semester. On the whole, I am quite pleased about the goals we accomplished and the results we achieved.

6.2 Sajith Kulasekare – *Chief Technical Officer*

ENSC 440/305 is by far one of the most valuable courses I have encountered in my undergraduate degree. The course made a significant impact not only on my technical knowledge but also on other areas such as team management, time management and documentation.

As the Chief Technical Officer, I was mostly in charge of the hardware aspect of the project, but constantly worked together with Marish and Renuka who were in charge of the software aspect and Gary who was in charge of the mechanical side of the project.

At the start of the project a significant amount of time was spent on figuring out the operation of individual components such as the microcontroller, VoiceShield and the PING))) sensors. After design specifications were finalized all components were accounted for and power calculations were carried out to figure out the power requirement for the device. After purchasing the power supply (AA battery pack) from Polar Batteries, a significant amount of time was spent on the integration stage where meticulous soldering consumed a significant amount of time.

Overall the experience with my team mates was remarkable. Everyone carried out their assigned individual work to precision. And everyone pitched in when working as a group in our team meetings, hardware integration, testing and mechanical design. And I would like to take this opportunity to thank all my amazing team mates on their hard work and dedication in completing this project successfully.

6.3 Gary Brykov – *Chief Financial Officer*

As a member of PROXIMIview Technologies, I had a very positive experience working with my teammates. As the semester went on, the project slowly started to take over many aspects of my life. I found myself constantly imagining what it was like to be visually-impaired and what it would take to create a device that a blind person would appreciate and find useful. I also brainstormed with a personal friend of mine who is severely visually impaired about what he looks for in an assistive device. I then used these ideas in the design of our product.

I was very impressed by my group's ability to write functional and design specifications in a manner that corresponded to my vision of the product from the very start. Through working with my group, I greatly improved my team communication, documentation, and planning abilities. Because our device uses a relatively large amount of components, determining which sensors to use for our intended purpose while staying within size and cost constraints was a challenge that I was satisfied in overcoming with the assistance of my team. Since our device is meant to be worn, it had to remain lightweight enough to not impede mobility while maintaining some level of aesthetic appeal. This aspect of our device was mainly my responsibility and I believe I learned a lot about how to design and fabricate products in a way that the end user will enjoy using them. I gained experience cutting and fabricating a plastic enclosure, modified a standard pair of sunglasses to accommodate our sensors and wiring, installed and soldered many components, and provided constructive feedback to every group member as well as to myself. Finally, as the Chief Financial Officer, I was in charge of keeping our spending within budget, documenting our expenditures, and ordering components, and applying for ESSEF funding. Overall, I greatly enjoyed collaborating with the individuals in my group and would definitely work with them again if given the opportunity in the future.

6.4 Marish Lalwani – *Chief Operations Officer*

During the past 13 weeks, I have been exposed to various aspects of a startup company. These include everything from market research to product development, to product testing and to future works. This course also helped me gaining various team dynamics and helped me learn that working in a team always proves to be fruitful in the end as each and every group member feeds off each other's energy for the betterment of the product.

My role in the team was of a Chief Operations Officer and that of the lead Software Engineer. I was involved in the market research, bringing effective solutions of the product development. Also I was involved in the Software development of the product. The software development involved embedded systems and programming the microcontroller in C. Using the Software Development Kit that came with the microcontroller unit, I was able to program the Ping Sensors and get the distance values. I used these values to effectively and efficiently get the directions working according to our project's functionality. Also I had programmed the vibrator module and set its vibration intensity according to the proximity of the user to the object.

I was involved in the circuit designing of our project which has provided me with various skills required to gather various components, analyze schematic and the build the circuit using those schematics. I have applied all the knowledge gained by me in the entire course of my engineering , especially the microelectronics, electric circuits and the electronic system design.

Due to all my co-op experiences being in the Software Development and my avid interest in the field, I was involved in the entire Software Development with valuable contributions from my team-mates. Also I was involved in the managerial aspects of the company whereby keeping check of the project management and also kept a check of the various roadblocks, technical difficulties encountered during the course of the entire project development. This experience made me realize the various minute details and cumbersome tasks a company has to face to stay alive in this dynamic and rapidly evolving economy.

Finally, I would like to thank my team members, all the TA's, Mike and Andrew for their diligent and continual support and their approving our project. Without you guys, it wouldn't have been possible. I would like to take a moment and say that our sole purpose of this project was the betterment of our society.

7.0 CONCLUSION

The Post Mortem demonstrates the current state of the device as well as the future considerations about the Wearable Proximity Detector for the visually impaired. The current functionality of the product is in accordance with the test plan as mentioned in the design specifications. This document would clearly address various future works for this project as it would definitely help evolve this product into a useful and marketable everyday device for the visually impaired. The demo on the 16th December, 2011 would ensure that the device works as suggested in the documentation.

8.0 REFERENCES

[1] PROXIMIview Technologies, "Design Specifications for a Wearable Proximity Detector to Aid the Visually Impaired", Nov. 2011