April 15, 2016

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, BC, V5A 1S6

Re: ENSC 305W Post Mortem for OxiTrak-5001

Dear Dr. Rawicz,

Please find attached the Post Mortem document for OxiTrak-5001. Our project aims to revolutionize cardiac and respiratory malfunctions detection in real time using an ear-worn oximeter. Recommended by healthcare professionals to patients with pre-existing respiratory and cardiac conditions, OxiTrak is able to measure a user's heart rate and blood oxygen levels. This product provides analyzed feedback along with an emergency algorithm system implemented on a mobile device.

The enclosed document will provide a detailed overview of the system as whole as well as business plan and marketing of the product. System overview of the product includes hardware, software and mechanical components of the product development. The final prototype is functional and ready to compete with other products.

The motivated OxiTrak team consists of Doasay Igiri, Johnny Chou, Mohammad Ahmad, Shahzada Randhawa and Rasha Abu Alzuluf, five experienced senior engineers in biomedical, electronics, systems and computer fields. This diversity in background ensures a variety in skill set required to cover every aspect of design for successful completion of the project.

Please feel free to contact us at oxitrakteam@gmail.com for further inquiries.

Sincerely,

Johnny Chou
Chief Executive Officer - OxiTrak

Post Mortem for OXITRAK-5001

"Track the Rhythm, Keep it Beating"

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Submitted to: Dr. Andrew Rawicz
Prof. Steve Whitmore

School of Engineering Science
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Executive Summary

This document details a post mortem of the Oxitrak project. The team has worked to create a real-time emergency notification oximeter and will detail a breakdown of challenges and obstacles faced over the past few months.

OxiTrak is a real-time oximeter recommended by healthcare professionals to patients with pre-existing respiratory and cardiac conditions. This device will be able to measure a user's heart rate and blood oxygen levels, and provide analyzed feedback along with an emergency algorithm system implemented on a mobile device. The outlined design document consist of the following main components:

- System Overview
- Business Plan
- Project management
- Problems and challenges
- Group Dynamics
- Personal reflections
- Meeting minutes

The aim of this document is to provide an in-depth review of what went right and what went wrong. More importantly, it highlights the hard lessons learned when bringing a design to market. We are confident that despite the challenges we have developed an easy to use and well-designed device that can help millions of people around the world.

1. Introduction

Numerous brands of efficient oximeters exist in medical technology in our world today, but extensive research has shown that only a select few of these devices cater to home/personal use, and next to none have a built-in emergency notification system. This warranted meticulous efforts by the OxiTrak engineering team to create a real-time heart rate and SPO_2 monitor with an integrated emergency notification system that could help save lives in the long run. Over the past few months, the team has worked judiciously to develop a simple idea into a fully functional proof-of concept.

OxiTrak-5001 is a wearable medical device consisting of a packaged clip-on microprocessor and an ear clip sensor. This device has been successfully designed such that the sensor will take SPO_2 level and heart rate readings from the user's earlobe via infrared LEDs. The obtained signals will be processed using Intel Edison, and displayed on an accompanying app. Should critical readings be detected, the app will request user confirmation that everything is alright; If there is no response after a reasonable time period (~1 minute), the user's caregiver will be notified of the situation along with exact geolocation, in order to ensure that timely emergency response is carried out – if necessary.

The mechanics of our product also allows for easy usage by the consumer, ensuring it can be implemented while carrying out daily routines such as fitness schedules, and even during sleep. Stroke, asthma, hypoxia and sleep apnea are some of the conditions OxiTrak-5001monitors. Sufferers of these conditions can rely on our device to help monitor their heart rate and SPO_2 levels.

2. System Overview

2.1 High-Level Functionality

The main goal of OxiTrak is to provide a real-time notification system that will alert both the user and his/her caregiver in the case of an emergency, via an Android Application.

The application layout has been simplified such that its operation is user-friendly and efficient. It is currently based solely on an android platform, but the OxiTrak team has plans in place to expand to other operating systems, in order to promote cross-functionality. To maximize the efficiency of the application, users will be required to setup accounts consisting of individual profiles that can be updated per discretion, where they will also be able to track blood oxygen level and heart rate components. The application is to be designed in such a way that although healthcare professionals will be able to have access to their patients' data readings in the case of an emergency, all other personal information will only be made available as preauthorized by the account owner. With regards to OxiTrak-5001, an emergency occurs when abnormal health readings occur; alert notifications will be sent out to the user, and in an instance where said user is unresponsive, a geotagged notification will then be sent to his/her registered healthcare professional. The design overview of our system is depicted in the high-level diagram below:

Figure 1: System Block Diagram

2.2 Business Plan

2.2.1 Target Market

Health and Stroke foundation statistics states that cardiac stroke is the third main cause of death, and around 40,000 patients encounter heart attacks and heart failures per year in Canada alone. Which is a big number relative to the total Canadian population. As of 2013, the market value of pulse oximeters was $605.4 million, and is expected to reach $1.3 billion by 2018. This prediction depicts the substantial positive growth and exponentially rising awareness levels within the medical industry.

OxiTrak is targeted primarily towards people with respiratory or cardiac problems, or sleep disorders such as apnea or hypopnea.

2.2.2 Current Market Competition

Primitive oximeters have been long present in the industry to obtain measurement of a onetime oxygenated blood levels and heart pulse. Recently, Bluetooth, ear-worn oximeters have been developed by some companies; an example of this is FreeWavz, This earpiece fitness device developed by a surgeon in Orlando provides the user with updates of heart rate and calories burnt. Heart rate and oxygen level is read by shining a light through the thin tissue of ear lobe and calculating the density of light absorbed by the sensor, placed at the back of the ear. The price for this ranges 219USD to 249USD.

The aforementioned product and others like it such as **Biosport,** lack emergency system notifications in the application developed for the device. They mainly target the fitness industry and come in forms of earphones, which can hinder listening. Our device is incorporated to target both industries, provides real-time emergency notification and ensures users with heart problems to confidently carry out their daily life activities by communicating directly with caregivers in case of critical health situations. With the incorporation of a GPS tracker, the patient's geolocation information will be provided to their Emergency contact. This complete emergency system will insure that the user, and if need be, their emergency contact is notified in the occurrence of an emergency and they can be provided immediate help through the geolocation feature.

2.3 Project Management

2.3.1 Financial Overview

Table 1 shows the estimated budget when we first applied for the ESSEF fund. **Table 2** shows our actual expenses for the entire project. We spent more than our estimated budget because our initial approach was too time consuming and unreliable (creating our own sensor), therefore we were required to purchase other hardware. Also, in our estimated budget, we forgot to take shipping fees into consideration, which accounted for ~10% of our actual cost.

Intel Edison and Mini Breakout board	$112.50
Intel Edison Battery Block	$37.50
Intel Edison OLED Block	$37.50
Intel Edison Hardware Pack	$4.50
Intel Edison 9 Degrees of Freedom	$52.00
TI OPT 101 (IC)	$26.00
Different types of red and infrared LEDS	$25.00
Custom PCB quote	$60.00
Filters, resistors and capacitors	$25.00
Total Cost	**$380.00**

Table 1: Finance Estimation

Intel Edison and Mini Breakout board	$110.00
Intel Edison Battery Block	$40.00
TI OPT 101 (transceiver)	$38.00
LED's	$17.00
Capcitors	$10.00
Edison Hardware pack (screws)	$9.00
Intel Edison ADC Block	$30.00
Intel Edison GPIO Block	$25.00
Bi-directional Logic Converter (1V8 and 3V3)	$16.00
Heart Rate Click (with MAX30100)	$35.00
TI AFE4400 Pulse Oximeter IC	$15.00
Intel Edison I2C Block	$30.00
Operational Amplifiers	$10.00
Nellcor Ear Clip SPO2	$35.00
MAX30100 Sensors (x3)	$29.00
Custom PCB (x3)	$77.00
Additional battery and charger	$40.00
Total Cost	**$566.00**

Table 2: Actual Finances cost

Taking a look at **Table 3**, it shows the cost of production for one device. In a mass production, designing custom PCBs for the microcontroller and Bluetooth unit can make budgeting improvements. Intel Edison standalone is already 42% of the total cost, and with the battery and I2C block, it is at 81%. With the experience of designing custom PCB for the sensor, we can custom design a MCU onto the sensor board, bringing down the cost to $39, Table 4. We got this number from an estimate of manufacturing 500 products, where Digikey and Omni Circuit Boards have prices at a cheaper rate for mass orders.

Intel Edison standalone	$74.00
Intel Edison Battery Block	$40.00
Intel Edison I2C Block	$30.00
MAX30100 Sensors	$10.00
Custom PCB	$23.00
Operational Amplifier	$1.00
Total Cost	$178.00

Table 3: Current Cost

Custom PCB integrating MCU, Sensor and BT	$15.00
Integrated Battery	$5.00
LDO, and other passive components	$3.50
MCU IC	$2.50
RFID IC	$8.00
MAX30100 IC	$5.00
Total Cost	$39.00

Table 4: Production Cost

2.3.2 Project Schedule

Figures 2 and 3 below depict the anticipated and actual milestones chart for the overall project development over the course of the semester. It is good to note that with our anticipated schedule, we aimed for a very aggressive timeline of completion, such that we would finish the project a month in advance and be able to cater to unexpected delays and unforeseen hurdles.

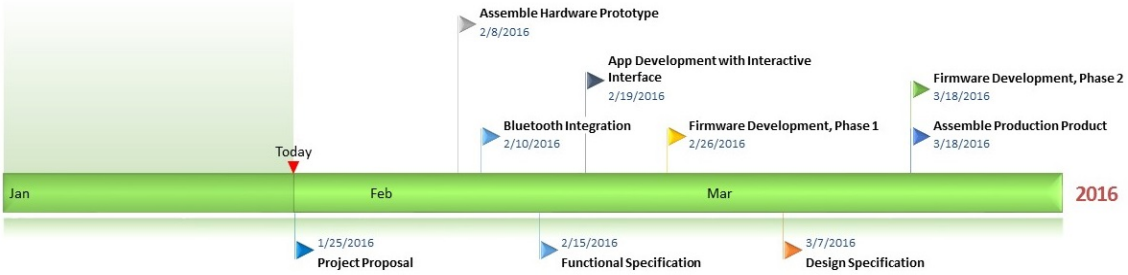


Figure 2: Anticipated Milestone Chart for Project Development

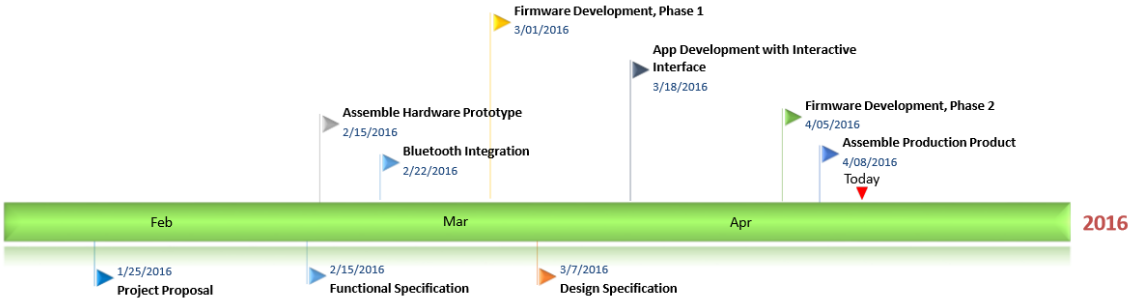
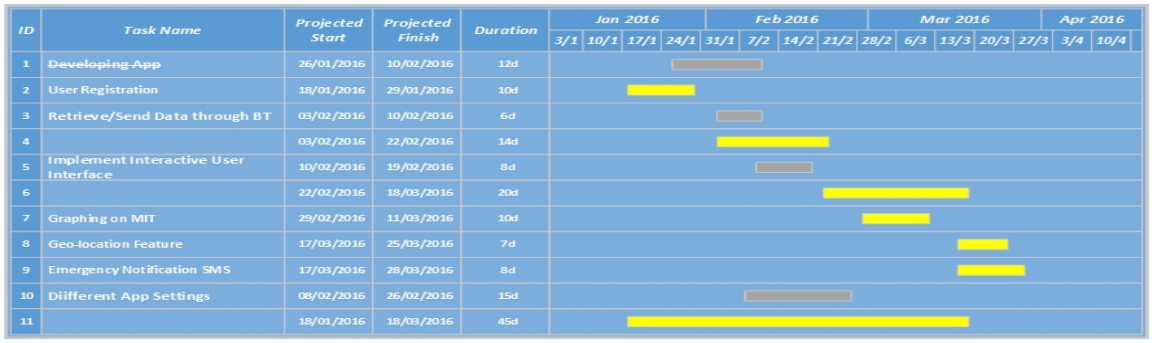


Figure 3: Actual Milestone Chart for Project Development

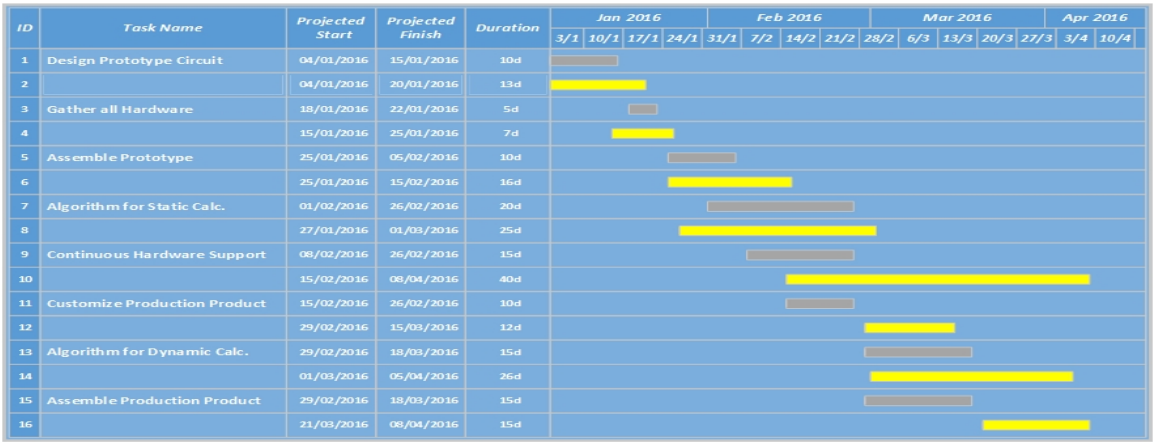
Tables 5 and 6 below show a side-by-side comparison of the initial hardware/software development plan, and the actual plan that was eventually followed. For the hardware section, major changes in the schedule were mainly due to component failures and shipment delays. This caused continuous hardware support, for example, to go on for about 40 days as opposed to the projected 15 days.

One major change in the software development timeline was including specific details of features to be added to the application, such as geolocation and emergency notification SMS.



ID	Task Name	Projected Start	Projected Finish	Duration
1	~~Developing App~~	26/01/2016	10/02/2016	12d
2	User Registration	18/01/2016	29/01/2016	10d
3	Retrieve/Send Data through BT	03/02/2016	10/02/2016	6d
4		03/02/2016	22/02/2016	14d
5	Implement Interactive User Interface	10/02/2016	19/02/2016	8d
6		22/02/2016	18/03/2016	20d
7	Graphing on MIT	29/02/2016	11/03/2016	10d
8	Geo-location Feature	17/03/2016	25/03/2016	7d
9	Emergency Notification SMS	17/03/2016	28/03/2016	8d
10	Diifferent App Settings	08/02/2016	26/02/2016	15d
11		18/01/2016	18/03/2016	45d

Table 5: Software Development Timeline Comparison



ID	Task Name	Projected Start	Projected Finish	Duration
1	Design Prototype Circuit	04/01/2016	15/01/2016	10d
2		04/01/2016	20/01/2016	13d
3	Gather all Hardware	18/01/2016	22/01/2016	5d
4		15/01/2016	25/01/2016	7d
5	Assemble Prototype	25/01/2016	05/02/2016	10d
6		25/01/2016	15/02/2016	16d
7	Algorithm for Static Calc.	01/02/2016	26/02/2016	20d
8		27/01/2016	01/03/2016	25d
9	Continuous Hardware Support	08/02/2016	26/02/2016	15d
10		15/02/2016	08/04/2016	40d
11	Customize Production Product	15/02/2016	26/02/2016	10d
12		29/02/2016	15/03/2016	12d
13	Algorithm for Dynamic Calc.	29/02/2016	18/03/2016	15d
14		01/03/2016	05/04/2016	26d
15	Assemble Production Product	29/02/2016	18/03/2016	15d
16		21/03/2016	08/04/2016	15d

Table 6: Hardware Development Timeline Comparison

2.3.3 Product Materials

One main goal for the OxiTrak team was to build an eco-friendly product whose materials would be durable yet recyclable. PCBs and ICs among other components made this difficult to achieve, due to various company specifications but in the long run, we hope to obtain device parts from companies who incorporate a 100% recyclable material policy for their products.

The table below shows a list of our current products and the materials consisting:

Component	Material
Intel Edison and Blocks	PCB, Silicon
Battery	Lithium-Ion
MAX30100 Sensor	Silicon
Custom PCB	Copper, Tin-lead
Ear Clip	Plastic
Device Casing	ABS Plastic

Table 7: Components and Materials

3. Problems and Challenges

This section will revisit the features to be developed as stated at the start of the project, discuss the progress made so far, including any changes that have been implemented along the way, and the challenges the team faced at the different stages of development.

Task 1

Build a pulse oximeter to optically detect blood oxygen and pulse rate.

- Infrared LED circuit will be used to detect raw signal
- Electronic processing circuit will be used to extract accurate readings from detection circuit, by using Band pass Filters in conjunction with instrumentation amplifiers

Progress Made and Challenges Faced

We initially tried to build a sensor from scratch, and soon realized that the values we received were unreliable due to excessive amount of noise. We later came across MAX30100, which has a prebuilt integrated sensor with ambient light cancellation. The setup was easy and all we needed were the SDA and SCL signals connected to Intel Edison. This allowed us to start validating our firmware process as soon as possible since we were already behind schedule.

Task 2

Intel Edison Microprocessor to sample signal and convert analog signals to transmittable binary data

- Microprocessor will be fed a stabilized signal and output processed data to a Bluetooth module
- The Bluetooth Module block of Intel Edison will transmit this data to a paired smartphone

Progress Made and Challenges Faced

For a significant period of time, we had no sensor. This made it difficult to do some complete testing. To make some progress, we created a test app coupled with a test script running on the Edison. The app would pair with the Edison and query it every second, the script would read this generate a random number and respond back. This laid down the framework for the overall protocol our system used as well as chance to debug any future issues we will face during the final integration.

Task 3

Analytic Software

- Android application that will process incoming Bluetooth data
- Data will be sampled and processed in real time and presented to the user in a creative and natural manner. Features Include:
  - History Graph
  - Trend Notification:
    - ❖ User typically experiences drops in oxygen levels at these times
    - ❖ Alert user when sudden drops or spikes occur
    - ❖ Emergency algorithm as an optional setting to automatically contact the caregiver in case of hazardous pulse level or drop of blood oxygen levels.

Progress and Challenges Faced

The software team of OxiTrak had minimal exposure to application development. Learning a new language and using new tools for app development was quite a challenge at the beginning of the development stage. Another challenge the software team has faced is plotting heart rate and oxygen levels in real-time the moment the data is retrieved from Bluetooth. This challenge was overcome by using canvas to plot real-time data.

The software team was highly ambitious when they stated the software requirements. One of the features was to include Google voice to prompt the user of their state and receive voice feedback. However, this is quite challenging and was replaced with a pop-up notification to inquire the user's state. Another requirement was to have a settings button that lists additional features and allows the user to turn the desired setting on/off. Due to shortage of time, the optional disability of features was not implemented and instead displayed on separate app pages.

Task 4

Build a stable, portable casing for the Intel Edison microprocessor, as well as a durable (waterproof and weather resistant) accompanying ear clip.

Progress and Challenges Faced

The packaging for the prototype was produced using a 3-D printer. However, getting the correct fitting and thickness of casing was challenging and required trial and error approach. At first, the design had measurement of 1 mm thickness, which turned out to be very fragile and thin after being 3-D printed. The case had the exact measurement of Intel edition; therefore, bottom and top parts did not form an enclosed box. Alternation of measurement and thickness were made to overcome encountered issues.

4. Group Dynamics/Work Distribution Chart

The table below shows the work distribution among team members throughout the course of the project:

	Mohammad	Doasay	Rasha	Shahzada	Johnny
Documentation	xx	xx	xx	xx	xx
Research	xx	xx	xx	xx	xx
Electronics				x	xx
Firmware				xx	x
Android Application	xx	xx	xx		
Enclosure/Assembly		xx		x	x
Financial Budgeting					xx

Table 8: Work Breakdown Table

The notation used in the table is explained as follows:

XX – This person contributed a lot to the section during the course of the project, and any questions or problems that came up would initially be directed to this person before seeking other solutions.
X – This person(s) made contributions to this section during the course of the project. But this person would not be the first point of contact if any questions or problems came up.

5. Conclusions

This document encloses the final progress of OxiTrak medical product that was developed by a team of five engineers with different expertise and fields. This term has been a challenging and rewarding experience for OxiTrak team members. The team has fully developed a prototype that consists of a pulse oximeter, Intel Edison microprocessor and a developed Android user application. Challenges were encountered during implementation and testing phases, however, the team was able to work together and solve encountered challenges. Group dynamics have made this work experience more enjoyable and valuable. Moreover, further work will be conducted on OxiTrak by the team with the hope of attracting sponsors and further market the product.

6. References

[1] "Functional Specifications for OxiTrak-5001" [Online]. Available at: http://www2.ensc.sfu.ca/~whitmore/courses/ensc305/projects/2016/23func.pdf. [Accessed: 9-Mar-2016].

[2] "Design Specifications for OxiTrak-5001" [Online]. Available at: http://www2.ensc.sfu.ca/~whitmore/courses/ensc305/projects/2016/23desi.pdf. [Accessed: 10-Mar-2016].

[3] "Proposal for OxiTrak-5001" [Online]. Available at: http://www2.ensc.sfu.ca/~whitmore/courses/ensc305/projects/2016/23prop.pdf. [Accessed: 15-Feb-2016].

[4]"Statistics - - Heart and Stroke Foundation of Quebec." [Online]. Available: http://www.heartandstroke.qc.ca/site/c.pkI0L7MMJrE/b.3660197/k.358C/Statistics.htm. [Accessed: 25-Jan-2016].

[5]"FreeWavz." [Online]. Available: http://www.freewavz.com/about/. [Accessed: 25-Jan-2016].

[6]"BioSport*—Smart Earbuds with an Integrated Heart Monitor." [Online]. Available: http://www.intel.com/content/www/us/en/wearables/biosport-smart-earbuds.html. [Accessed: 25-Jan-2016].

[7] "DigiKey Electronics - Electronic Components Distributor." [Online]. Available: http://www.digikey.com/. [Accessed: 25-Jan-2016].

[8] "Prototype Estimator." [Online]. Available: http://www.omnicircuitboards.com/prototype-estimator?__hssc=&__hstc=&__hsfp=&hsCtaTracking=10a08456-58f8-4db9-96df-df118ad31bf6|737c068b-a1e1-4100-a69b-e90add641b12.

[9] “Resources - Cradle to Cradle Products Innovation Institute,” *Resources - Cradle to Cradle Products Innovation Institute*. [Online]. Available at: http://www.c2ccertified.org/resources/collection-page/cradle-to-cradle-certified-resources. [Accessed: 29-Jan-2016].

[10] “Recycling 3D Printing Materials: 4 Possible Solutions” [Online]. Available at: https://i.materialise.com/blog/recycling-3d-printing-materials-4-possible-solutions. [Accessed: 10-Mar-2016].

Appendix A (Personal Reflections)

Mohammad Ahmad

Initially, for the first two weeks, it was hard going. At the start of the term I found out that the person that I was supposed to be in a group with had withdrew from the class, which only left me and another member. With some prompt communication with Professor Whitmore, who e-mailed the class asking if they need more members, I got a few replies very quickly. OxiTrak team was the first to respond. After making sure that my qualifications would be of use to their team, and that their project aligns with my interests, I joined them.

Once I was in the team I caught up with the work that had already been done. I was able to identify which aspect of the project I can contribute most to and I took up the tasks for those areas. I took up the responsibilities to manage the connection with Edison, data handling, and graphing of the incoming data. One of the challenges that I faced initially was learning to develop an app for Android, which was something I had not done before. It required a lot of research on different types of development environment and learning those environments. Added to that was knowing beforehand if the app would be compatible with our hardware. This gave me a chance to break down all the aspects of hardware and software and analyze them for their effectiveness in future development.

This project has made this semester one of the most enjoyable ones that I've had at SFU, because I got to develop a product from a concept to a prototype that combined various engineering disciplines. This meant that I got to see how different parts of the system interact with each other. What made this even more of an enthralling experience was that our team consisted of members from different backgrounds, all working in tandem to reach one unified objective.

Since everyone had a different academic background, for us to work effectively it required that we communicate our work and concerns clearly and precisely. That, we achieved through efficient documentation and always trying to be available to help each other out in case something was ambiguous. We all took initiative to complete tasks that arose as we progressed through our project, which allowed everyone a lot of freedom to work in the areas that they were most comfortable with. Also, the team overall was very understanding

of other people's difficult schedules and was willing to help each other out in time of necessity.

Doasay Igiri

Coming into the Spring 2016 semester, I felt prepared, excited and somewhat anxious. Prepared because I was part of a Capstone group that had been formed almost 8 months prior to the start of the project, meaning that we had met up quite a few times, had a few great ideas going and even started some preliminary documentation. The excitement was as a result of being in my last semester of my undergraduate degree and finally being able to see the light at the end of the tunnel. Due to unforeseen circumstances, we had to change our idea completely, lose one team member and were on the verge of losing another – all barely 2 weeks into the semester. Needless to say, Capstone wasn't going to be such a breeze like we initially thought.

Once the dust had settled regarding team member logistics, it was easier to focus on qualitative research to buttress our Real-time Emergency Oximeter idea. As a team, we all naturally gravitated towards coming up with a device that would help improve the medical industry in some way, so the real challenge there was coming up with an idea that was completely unique and not out on the market already. After some deliberation, we opted for modification of an already existing device i.e. taking the device as it, and adding a few key features to it that would potentially give it its competitive edge.

Having taken a liking to software development over the course of my degree, I was excited to be able to work on creating a companion application for our device. This was not something I had done before, so it was as challenging as it was intriguing. From deciding what language to program the app in and what platform to run it on, to minor details such as laying out the app in a logical manner, there was a lot to consider. We decided to use the MIT App Inventor 2 program, so I was tasked with learning the programming language from scratch. I was also able to apply valuable skills from courses I had taken during my degree, such as Computer Aided Design, to help with the successful completion of the project.

Technical skills aside, I have gained a lot. I've always been able to manage my time well, but taking this course forced me to be an even more dedicated scheduler, to take initiative and to think outside the box. I learned the importance of team dynamics, constant communication, and that teamwork really does make the dream work. I'm glad I took it upon myself to step out of my comfort zone and team up with individuals who I had never

worked closely with throughout my five years at SFU. While this could have turned out to be a big disaster, I'm thankful for the motivated, driven and diverse group of people I was privileged to work with made it all worth my while!

Johnny Chou

During this capstone experience, I've been unmotivated at times and even close to quitting due to the fact that I was not getting credits for my work. This semester I was on co-op for the second half of an 8-month term as a Hardware Engineer. Having known several friends who have previously taken co-op and capstone at the same time, it was the least of my worries of getting the approval. We started forming our group and brain storming a whole semester before (so around August/September 2015). Now fast-forward to the second week of the semester, I was told that I was not approved to take the course. I continued trying to get in the class, while working on the ESSEFF funding proposal, and Proposal document. Around mid-third week, that is when I finally found out that there was no way I was going to get my approval. At this time, I had the option to just completely quit, or continue to stay on the team and do it as a 'side project'. With the support of my team, I was motivated to stay on and complete the tasks we had already assigned the group members. I can say with confidence that I am glad to have stayed on and I am thankful for my teammates. Communication was key to our success and I believe we were able to portray our thoughts in a mature manner.

Having to work fairly hands-on in both my previous co-ops, I have chosen to be involved in the hardware/firmware design of our project, alongside Shahzada. Initially, no firmware work was required until we designed our schematic and built it, so we put in equal amounts of efforts into the hardware. When we decided to change to a prebuilt integrated sensor, I started to take on more of the hardware while Shahzada focused on the firmware. This worked out great because we both were able to master at our respective fields. The most enjoyable experience was having to design a custom PCB where I get to design the schematic and layout. This is a valuable skill and applicable to the industry as I have seen at Broadcom.

This course really goes to show that as engineers, we can easily have an idea and make that become a reality. In my opinion, I feel that every year in the engineering curriculum, there should be a similar course to capstone. Just being able to brainstorm an idea, research, designing and then finally executing on it, is a truly wonderful experience. For my future

capstone course, I would like to take on a bigger challenge and design a more complex schematic and layout.

Shahzada Randhawa

The capstone course puts you through a roller coaster of emotions. From being overly confident with your design to questioning if it will even work was stressful to say the least. Thankfully I was surrounded by talented and very hardworking individuals. Every member was fully committed to making this semester a success, and aiming for this project to be a true capstone jewel in our engineering crowns. This keen attitude had us meeting almost 4 months in advance to plan out our project. However, having lost a member and pushed in a new direction by our professor in the first few weeks of classes, had us feeling catch up once again. For me personally, I had to balance the stresses of this course with a full time co-op. This meant that I had to ensure I pulled my weight in the course while making sure my performance in workplace did not suffer, which proved to be extremely difficult given the long hours of time this course requires. I frequently found myself in the depths of lab 1 in the wee hours of the morning with my groupmates (who were also on co-op), and spent many weekends over the past few months immersed in our design

Given the short 4 month period, the iterative design process proved to be difficult. Tyipically we design a product build it and improve upon it. The initial sensor we had designed form scratch was not reliable at all. This forced us to scrap the design altogether and go a different route. We ordered an integrated sensor built specifically for oximeter purposes. However this was a relatively new product and finding source code, examples online proved to be fruitless. It became apparent that I needed to write a driver for sensor from scratch. The challenge became learning the I2C protocol the device used as well understanding the register maps and the bit strings required to get the behaviour we wanted.

Once this was understood I had to write python scripts to test the implementation we derived for the datasheet and integrate into the system. Now we had to find a solution to seamlessly link this driver to the Bluetooth interface, and the application. The solution I came up with was to have the smart phone trigger the sampling process as opposed to having the Edison running autonomously. This helped because we weren't running the sensor unnecessarily and allowed a more real time data transfer. The smartphone was programmed to send query, reset, and disable commands with gave the smartphone direct control of the device. I was proud of the fact we were able to develop a complete protocol that worked well within the system.

I had an amazing experience in this course and would like to extend my thanks to all the TAs and professors for their support. More importantly I'd like to thank my group my members for their resilient attitude coupled with a 'get it done' work ethic.

Rasha Abu Alzuluf

Throughout the course of the project, I have solidified my software development skills and gained new software skills such as Android application development which is not acquired in any taken engineering courses. User app interface was also acquired for the first time. Every aspect of user interface was well-researched and implemented for a user friendly app. Data base development and element storage was self-taught and used through-out app development. The essential usage of data storage to store and retrieve user information as well as validate user entry was implemented. The acquired skills are essential for any future software job that acquires application development.

One of the challenging parts was to come up with a unique idea. Many ideas that we came up with were already out in the market or formed a challenge to implement. I have learnt excessive research skills when it comes to choosing an idea for further development. Aspects such as originality, market and development plans need to be considered when intending to produce a prototype. A challenging part of developing of a medical device is the human involvement and excessive product testing to ensure the safety of the user. As a biomedical engineering, this experience will enforce the future design of a safe product that ensures every aspect of user convenience is covered.

Scheduling was an important part of the whole process. I have enforced short term deadlines for every developed app element I have worked on. I have also learnt the importance of consistent scheduling and team meeting as well as integration of different work submitted by each member. The challenge was to keep track of every developed aspect of the project and integrate your own work with the dependency of other developed parts. For example, when we first started implementing the project, the software team could not further proceed with app development until the hardware was ready and data was retrieved from the Intel Edison. Meanwhile, our focus was on user registration and planning until we were able to retrieve the data from the hardware components.

Appendix B (Meeting Minutes)

Date	September 7th , 2015
Meeting Duration	12:00pm – 2:30pm @ SFU Downtown
Members Present	Doasay Igiri, Johnny Chou, Shahzada Randhawa and Rasha Abu Alzuluf
Regrets	Mohammad Ahmad (Joined in January 2016)
Agenda	• Brainstorming Ideas for Capstone
Minutes	• Glove/bracelet for sensing hand waving motions and muscle flexing • Medical shirt with several inputs to display patients status • Color scanner • NFC technology to transfer small amounts of data (ring to unlock phone/automated text) • Medical device to stimulate muscles for long duration of sitting • Portable IoT SPO2 and heart rate monitor • **Before next meeting:** Further research for all the topics discussed above to help decide which idea to go with

Date	January 15th, 2016
Meeting Duration	10:30am – 12:30pm
Members Present	Doasay Igiri, Johnny Chou, Mohammad Ahmad, Shahzada Randhawa, Rasha Abu Alzuluf
Regrets	None
Agenda	• Proposal Documentation • Member Role Definition • ESSEF Funding Application & Presentation

Minutes	• Meeting with whole team following ENSC 305 lecture
	• Set up skeleton for Proposal documentation; **due date – Jan 25th, 2016**
	• Split documentation into sections allocated to each team member
	• Discussed briefly about software development
	  ○ What language to use
	  ○ What features the app should have
	  ○ Layout/design?
	• Team member roles
	  ○ Software Developers – Rasha, Doasay, Mohammad
	  ○ Hardware & Electrical – Johnny, Shahzada
	  ○ Founder, CEO
	  ○ CFO
	  ○ CTO
	  ○ Mechanical (Packaging?)
	• Finalised Funding application
	• Need to create PowerPoint for presentation to ESSEF board
	• **Before next meeting:** Finish proposal section write-ups & start merging/editing

Date	January 22nd, 2016
Meeting Duration	10:30am – 12:30pm
Members Present	Doasay Igiri, Mohammad Ahmad, Rasha Abu Alzuluf
Agenda	• Proposal update • Software requirements • App Research

Minutes	• Meeting with software app team
	• Progress update on proposal document
	• Brainstorm app requirements
	• Discussed briefly about
	• Software development
	  ○ What language to use
	  ○ What features the app should have
	  ○ Layout/Design
	• Discussed possible development environments
	  ○ Android Studio
	  ○ MIT App Inventor 2 (AI2)
	• Before next meeting: Research pros and cons of environment

Date	January 31st , 2015
Meeting Duration	12:00pm – 2:30pm @ SFU Downtown
Members Present	Mohammad Ahmad, Doasay Igiri, Johnny Chou, Shahzada Randhawa and Rasha Abu Alzuluf
Agenda	• Discussion of software requirements
Minutes	• GUI Requirements: • Designed app intuitive and interactive • User registration (through a unique username and secure password) • Validate user credentials and notify user of incorrect input • Landing page layout consists of settings button, heart rate and oxygen levels plot, welcoming user banner, logout button and a marketing logo • Plotted data in landing page is real-time • The user is given the option of turning desired settings on/off • Settings button access geolocation and emergency contact feautures

Date	February 2nd, 2016
Meeting Duration	7:00pm – 9:00pm @ SFU Burnaby, Lab 1
Members Present	Mohammad Ahmad, Doasay Igiri, Johnny Chou, Shahzada Randhawa and Rasha Abu Alzuluf
Agenda	• Working on Functional Specification Document • Discussing the hardware problems
Minutes	• Excessive amount of noise from creating own sensor • Email professor for approval to change design • Research into other solutions such as AFE4400 and MAX30100 • Splitting the functional specification document accordingly • Set deadlines for first, second and third drafts of functional spec.

Date	March 22nd, 2015
Meeting Duration	1.30 pm – 9.00 pm @ SFU Burnaby
Members Present	Mohammad Ahmad, DoasayIgiri, Johnny Chou, ShahzadaRandhawa and Rasha Abu Alzuluf
Agenda	• Test of hardware/software overall functionality and planning of mechanical packaging
Minutes	• Checked code connection with Intel Edison (completed a regression test) • Checked addition of graphs displacement code on OxiTrak app • Checked loop added to automatically connect with intel Edison (connect automatically every minute) • Discussion of mechanical packaging of ear-piece • Package board up to the ear sensor to allow sensor to physically contact earlobe. Attach earing clip to the other side of earlobe (front side) by either gluing of soldering ear clip to the board. • Other possible options: obtain a smaller sensor and have a different packaging design

Date	March 26th, 2015
Meeting Duration	9 am – 11am @ SFU Surrey
Members Present	Mohammad Ahmad and Shahzada Randhawa
Agenda	• Test of hardware/software integration • Timer test • Data handling
Minutes	• Checked code connection with Intel Edison (completed a regression test) • Checked addition of graphs displacement code on OxiTrak app • Separating SPO2 and Pulse rate data • Discussion of geo-location integration • Calculation of heart rate • Timer function and Bluetooth communication • Clearing of data • Planning of mal data alert handling

Date	April 3rd, 2016
Meeting Duration	3:00pm – 4:30pm @ SFU Downtown
Members Present	Doasay Igiri, Johnny Chou, Shahzada Randhawa and Rasha Abu Alzuluf, Mohammad Ahmad
Regrets	None
Agenda	• Brainstorming Ideas for Final Demo Presentation • Post-Mortem Document • Product/Company Video • Task completion for final stretch

Minutes	• Post-Mortem Document
	  ○ 10 pages documentation
	  ○ At least 10 agendas & 10 minutes for Appendix B, so we need to collate these
	  ○ 1 page (~300 word) reflection for each person for Appendix A
	  ○ Johnny will post up a documentation layout and we can all work from there
	  ○ For the document, we can use things from our earlier documents and compare then vs. now
	• Final Demo Presentation
	  ○ PowerPoint MUST be completed by Monday, April 11th, leaving at least two days to meet up and practice the presentation as a group
	  ○ Look into printing a simple brochure to hand out during demo, with company member names, photos and blurb (position, contribution, etc)
	  ○ How can we make the demo stand out? Incorporate some physical activity, audience participation
	  ○ Prepare a list of questions to anticipate and know how to answer them
	• Product/Company video ideas
	  ○ Animated Video
	  ○ White board video
	  ○ Will we be in the video – how? Interview form or just working with device?
	• General Task Completion
	  ○ Need to redo solidworks design; Gary Shum said current design is too thin and will break easily (increase wall thickness to ~3mm)

- Pick up parts from Gary
- Before next meeting
  - Find out cost of creating brochure – Doasay
  - Talk to videographer – Rasha
  - Start working on post-mortem document & demo for powerpoint
- **Next team meeting: Thursday, April 7th**

Date	April 7th, 2016
Meeting Duration	6:00pm – 8:30pm @ Lab 1
Members Present	Doasay Igiri, Johnny Chou, Shahzada Randhawa and Rasha Abu Alzuluf, Mohammad Ahmad
Regrets	None
Agenda	• Brainstorming Ideas for Final Demo Presentation • Post-Mortem Document • Final Demo Powerpoint • Product/Company Video • Task completion for final stretch

Minutes	• Post-Mortem Document underway
	  ○ Need to collate minutes and agendas
	  ○ Business Plan section needs work
	• Final Demo Presentation
	  ○ Powerpoint is now underway
	  ○ Use lecture notes as guideline – quite detailed
	  ○ Need at least 2 days to practice presentation
	• Product/Company video
	  ○ Videographer has ben contacted
	  ○ Filming will be at SFU Burnaby either Saturday or Sunday
	• Miscellaneous
	  ○ Parts are back; everything fits great!
	  ○ Need to modify slightly to fit ear clip
	  ○ Going ahead with brochure idea; will print a few copies at cornerstone for under $10
	• **Next team meeting: Saturday or Sunday for Filming**

Date	April 13th, 2016
Meeting Duration	3:00pm – 12:00am @ SFU Burnaby
Members Present	Doasay Igiri, Johnny Chou, Shahzada Randhawa and Rasha Abu Alzuluf, Mohammad Ahmad
Regrets	None
Agenda	• Finalize Powerpoint Presentation • Practice Presentation for Demo

Minutes	• Spent the first few hours of the meeting working individual parts of the demo
	• Ran through Presentation about 5 times
	  ○ First run-through was about 40 minutes. Way too long!
	  ○ Need to cut down on hardware and software explanation
	  ○ Make things as high-level as possible
	• Picked up brochures
	• **Demo Day: Tomorrow April 14th, 2016**