January 26th, 2010

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

RE: ENSC 440 Capstone Project Proposal for the HeartMon, a cardiovascular diagnostic device

Dear Dr. Rawicz:

Please find attached the Capstone Project Proposal for the product HeartMon, presented by Biomedical Engineering Solutions. We are enthusiastic to design and implement a diagnostic device similar to a Holter monitor that is easily accessible and usable by the general public. The goal of the device is to keep the user aware of their own health, to help doctors save time in making diagnoses, and to save money for healthcare is associated costs.

This proposal will provide an overview of the system, an outline of solutions, our sources of information and funding, a tentative budget, a proposed schedule, and our team organization. These sections will assist in supporting the viability of the product.

Our team is versatile and consists of five innovative and motivated individuals: Amir Kamyabnejad, Bobby Luk, Cheng Zhang, Eric Boyer, and Yash Trivedi. If there are any questions or concerns regarding our proposal, feel free to contact me by phone at 604-617-1478 or by e-mail at aka39@sfu.ca.

Sincerely,

Amir Kamyabnejad
Chief Executive Officer
Biomedical Engineering Solutions

Enclosure: *Proposal for a Heart Monitor System*

Proposal for a

Heart Monitor System

Project Team:	Amir Kamyabnejad Bobby Luk Chen Zhang Eric Boyer Yash Trivedi
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Submitted to:	Dr. Andrew Rawicz – ENSC 440 Michael Sjoerdsma – ENSC 305 School of Engineering Science Simon Fraser University
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EXECUTIVE SUMMARY

Every seven minutes someone in Canada dies from heart disease or stroke. In fact cardiovascular diseases account for 30% of all deaths, and heart disease and stroke are two of the three leading causes of death. It is no surprise then that every year heart disease and stroke costs the Canadian economy more than $22.2 billion in physician services, hospital costs, lost wages, and decreased productivity [1].

Unfortunately, 54% of these cardiovascular deaths are caused by ischemic heart disease (ISHD), which has no noticeable symptoms and can happen to seemingly perfectly healthy individuals [1]. This silent ischemia can lead to sudden death to massive heart attack or fatal arrhythmias, all with no prior warning [2].

Thus, there is clearly a need in the healthcare industry for creating better monitoring, diagnosing, and prevention systems for heart disease and stroke. Biomedical Engineering Solutions (BES) is determined to improve the existing technology for diagnosing ISHD by utilizing better prevention methods and more treatment options. This will then reduce the associated healthcare cost as well as the fatality rate.

An exercise stress test or wearing a Holter monitor are two tests often used to diagnose ISHD [2]. Holter monitor, BodyKom, and Alive Technologies are examined as some of the available heart monitoring systems on the market. Holter monitors don't send heartbeat data to a cell phone or server, don't alert the doctor in case of an emergency, and don't include an accelerometer to correlate the heartbeat accurately with activity. BodyKom doesn't have an accelerometer for accurate data analysis either. This requires that the patient keep a diary of their activities. Lastly, Alive Technologies doesn't analyse the data or notify the doctor.

BES is proposing to take a next step in the evolution of heart monitoring devices by creating a diagnostic device called HeartMon. HeartMon will acquire and send heartbeat data to a cell phone, include an accelerometer for better accuracy of data, analyse data on-site in the cell phone, and alert the doctor in case of an emergency.

A timeline of completion of various stages of this project is outlined in this document, with the delivery date of the functional prototype at April 10, 2011.

A list of required parts and their estimated expenses are presented in this proposal. The total estimated cost of this project is $495. The sources of funding depend on the Engineering Science Student Endowment Fund and the Wighton Development Fund. BES members have agreed to cover any additional costs that may arise, as we believe in BES and its innovations of being capable of making a significant contribution to our society.

Table of Contents

1. INTRODUCTION

Every seven minutes someone in Canada dies from heart disease or stroke. In fact cardiovascular diseases account for 30% of all deaths, and heart disease and stroke are two of the three leading causes of death. It is no surprise then that every year heart disease and stroke costs the Canadian economy more than $22.2 billion in physician services, hospital costs, lost wages, and decreased productivity [1].

Unfortunately, 54% of these cardiovascular deaths are caused by ischemic heart disease (ISHD), which has no noticeable symptoms and can happen to seemingly perfectly healthy individuals [1]. This silent ischemia can lead to sudden death to massive heart attack or fatal arrhythmias with no prior warning [2]. This certainly calls for innovating better methods of monitoring, diagnosing, and treating patients.

The current methods of diagnosis and prevention of cardiovascular disease in general and ischemic heart disease (ISHD) in particular are exercise stress tests and the Holter monitor. The Holter monitor has the advantage of recording data over a 24 hour period and a better chance of catching an abnormal heart rhythm [3]. Holter monitors and remote heart monitoring devices currently on the market from two other companies are studied in this document: BodyKom and Alive Technologies. Thereafter, Biomedical Engineering Solutions' device is introduced: the HeartMon. Thereafter, a comparison is drawn between HeartMon and the other existing solutions on the market mentioned above.

This document will illustrate the details of the budget required to complete this project. The total estimated price is $495. In terms of funding, BES currently depends on the Engineering Science Student Endowment Fund and the Wighton Development Fund. Any additional cost is agreed to be covered by BES members.

A timeline of completion dates of various parts of the project is illustrated. This is accompanied by a delivery date of the function prototype on April 10, 2011. The proposal is finalized with the portfolio of BES members, as well as references for this document.

Biomedical Engineering Solution strives to find the needs of the medical field, determine what has to happen to improve the well being of humanity, and create solution with its cutting edge innovations. BES's goal is not only to establish itself as a leading biomedical engineering company, but also to contribute, and that's what drives us everyday: "Only those who have learned the power of sincere and selfless contribution experience life's deepest joy: true fulfillment." Anthony Robbins.

2. SYSTEM OVERVIEW

The HeartMon system consists of three parts: electrodes, the main unit, and the mobile device.

Figure 1 below illustrates how this system works. Electrodes are worn by the subject, and heart rate information is relayed to the main unit. The accelerometer on the main unit is used to detect the activity of the subject, such as walking, running, or resting. The heart rate and accelerometer information is transmitted via Bluetooth to a mobile device that contains analysis software that will interpret and manipulate the data. These results are sent in real-time to the patient's doctor, allowing the doctor to know immediately if there is a problem, in which case emergency personnel will be dispatched.

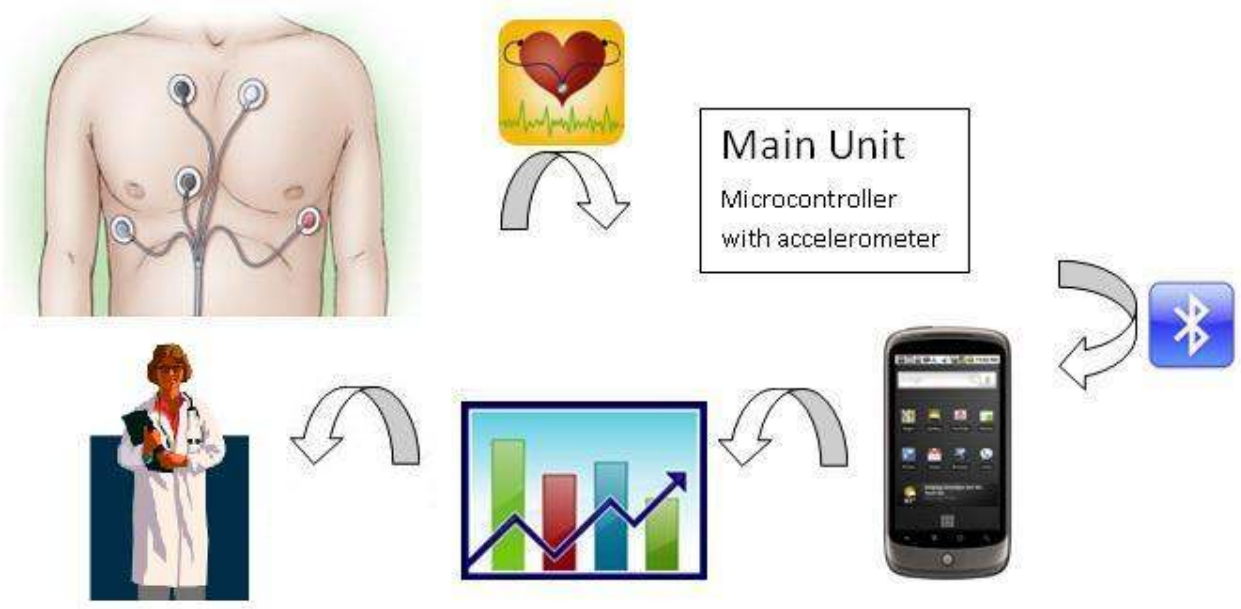

Figure 1: System Overview [4-8]

The HeartMon application begins in an idle state where it waits to receive information from the main unit. When information is received, the application will begin analyzing the data and comparing it against a preset database containing recommended stable values. If the values are outside the stable range, a warning message or emergency call would occur depending on the severity. This data will be sent to the patient's doctor, after which the application will return to the idle state.

The block diagram found in Figure 2 on the following page illustrates how the application on the mobile device works.

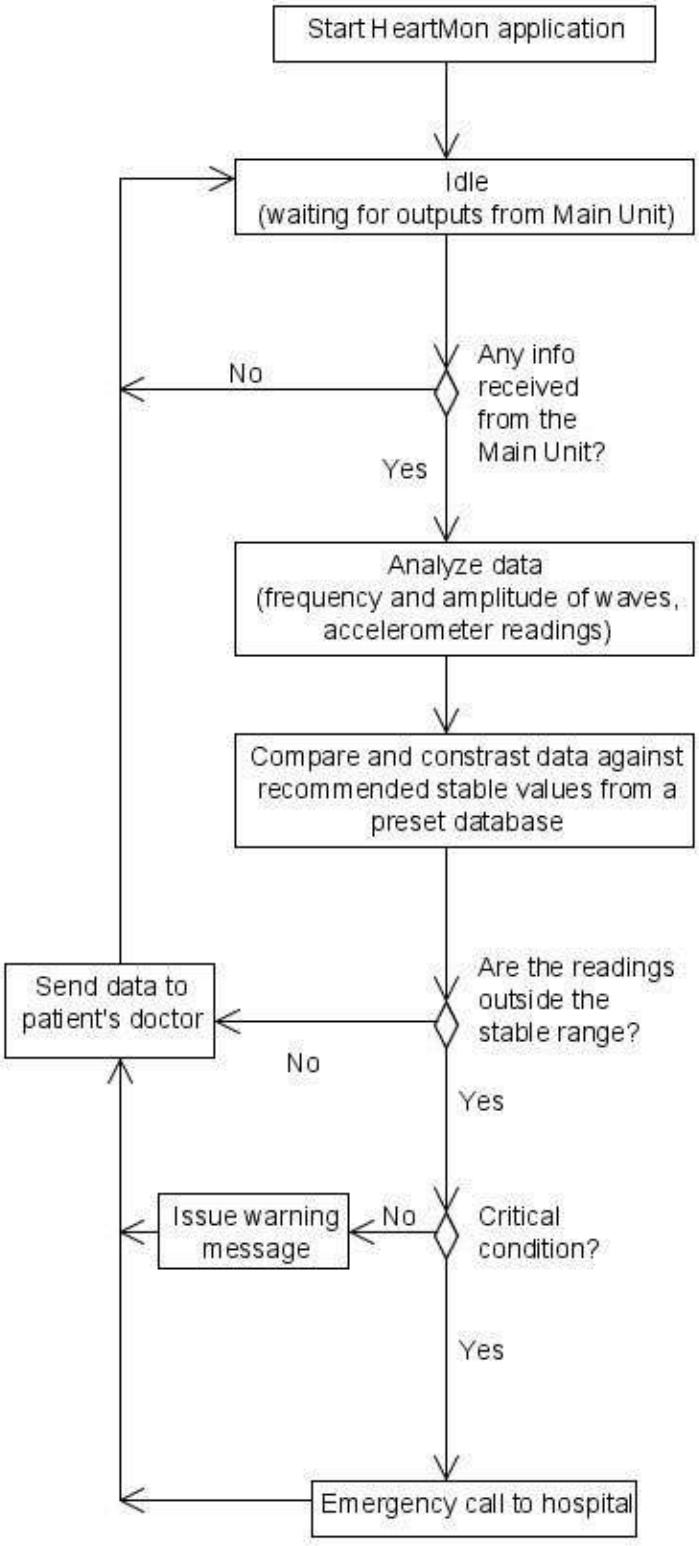

Figure 2: Block Diagram of the Software Application

3. EXISTING SOLUTIONS

There are several commercial products currently available that have similar functionality to BES's HeartMon, some of which are listed below. All of the products listed here include some of the features that HeartMon will include, but none include all of them. As previously mentioned, the lack of a commercially available product with this full feature set is the main motivation for this project. The following is an overview of these existing solutions. Pricing information could not be found for any of these products.

3.1. The Holter Monitor

One of the most commonly used mobile ECG monitors is a class of products called Holter Monitors (sold under various brands) [9, 10]. These devices record a patient's heartbeat for approximately 24 hours using several ECG electrodes. After recording, the patient brings the monitor to their doctor for analysis. To make the results meaningful, the patient must also record a diary to explain events in their heartbeat. For example, walking and sitting produce different levels of heart activity, so the doctor will need to know when the patient was doing either of these in order to make sense of the ECG record. These monitors lack the accelerometer and wireless link via a cell phone that the HeartMon will include.

3.2. BodyKom

The BodyKom (www.kiwok.se) [11] is a wireless monitor that transmits ECG data to a patient's doctor via a cell phone. However, it lacks an accelerometer to correlate this ECG data with the patient's movements, thus making analysis of the ECG data difficult.

3.3. Alive Technologies

One of Alive Technologies' main products, its Heart an Activity Monitor (www.alivetec.com) [12], records ECG and accelerometer data and transmits this data via Bluetooth to a cell phone. However, it lacks the software capabilities to automatically alert the patient's doctor when an issue is found, a feature that the BES project will include.

4. PROPOSED SOLUTIONS

The project will be split up into modules based on their function and application. At present, the following three modules have been agreed upon:

1) Hardware
2) Software
3) System Integration

The Hardware module is responsible for the all of the hardware elements to be used for the project which include the necessary sensors and a microcontroller to manipulate and convert analog signals from the sensors into a digitalized output to be processed by the software.

The Software module includes manipulating the output signals from the microcontroller and using algorithms to extract the desired information and perform any necessary functions based on the information received. The Software module is also in charge of the GUI interface to be used on the handheld platform.

The System Integration module will overlap into both of the first two modules and will act as a bridge between Hardware and Software.

The overall system works as follows:

The ECG sensors and accelerometer send the patient's information in the form of analog signals to the microcontroller. The microcontroller then converts them to digital outputs and sends them to the handheld device via Bluetooth. The device then uses the developed software application to process the data and provide feedback to the patient, as well as send the data to the doctor in real-time for analysis.

The proposed platform to be tested upon has been selected as the Android OS by Google because it is open source software. Another reason for the choice of this particular OS is that it provides ease in portability when transitioning to other platforms.

The distinguishing feature of the HeartMon compared to current market offerings is the diagnostic algorithm used to process the information obtained from the sensors. Whereas existing products only monitor and store the subject's data, HeartMon actually provides feedback and suggestions to the subject in real time. This feature will ideally save the subject and the government approximately $1000-$2000 per person per hospital trip since physically checking into a hospital will not be necessary in most cases. The application is also capable of the placing an emergency phone call to request an ambulance if the subject displays any critical

signs. Existing solutions on the market lack any of these capabilities. The total cost of the HeartMon project is approximate $495.

The diagnostic algorithm will be implemented within the application. Based on the outputs received from the microcontroller, the algorithm will analyze and monitor signal characteristics such as the frequency and amplitude of the waves in synchronization with the accelerometer readings to assess the subject's condition in real time. This data will then be compared against the recommended stable values from a preset database. If the subject's readings are found to be outside of the stability criteria, different forms of feedback will be delivered. For example a warning message advising the subject to refrain from any exhausting activities for a certain amount of time will be displayed. Under critical conditions, an automated emergency phone call to the hospital will be made.

5. SOURCES OF INFORMATION

The sources of information for our project can be divided into the following three categories:

1) Electronics
2) Science
3) Software

To make the overall system function, individual team members' experiences and skill sets will be utilized. Amongst the five members, various backgrounds have been covered which include electronics, systems design, biology, kinesiology, and software programming.

Besides the members' own knowledge base, other sources of information can be classified based on the previously mentioned categories

1) Electronics: Various electronic manufacturing websites have been identified to obtain information about the required components. Datasheets for every component have been scrutinized to ensure optimality and compatibility during integration.

2) Science: For this category, various professors from different universities and SFU faculty members with a medical background have been approached and will be contacted as required during various stages of development to implement the self-diagnostic characteristics of the device.

3) Software: A development community for the Android OS platform has been selected to assist the members with their software needs. The community provides a wide range of self-learning tutorials, guides, examples and forums for direct questions and additional help.

6. BUDGET AND FUNDING

6.1 Budget

The following table lists estimated expenses for the health monitoring system. Since this project is a biomedical diagnostic tool, the reliability and accuracy of the parts are a priority. Thus, we have chosen components of superior quality, despite being more costly. The costs also include expedited shipping fees due to the time constraints placed on this project.

Table 1: Budget Plan

CATEGORY	ESTIMATED AMOUNT
Microcontroller including Bluetooth (Arduino BT) [13-15]	$168.00 ($150 for the equipment and $18 for shipping)
Accelerometer [16, 17]	$52.00 ($25 for the equipment and $27 for shipping)
Power Control (DC-DC converters and batteries)	$20.00
Project Case for Arduino	$10.00
ECG electrodes	$65.00 ($45 for the sensors and $20 for shipping)
ECG circuit components	$50.00
PCB Supplies	$30.00
Contingency fund	$100.00
EXPENSE SUBTOTAL	**$495.00**

6.2 Funding

The sources of funding mainly depend on the Engineering Science Student Endowment Fund and the Wighton Development Fund. Applications for both funds are currently being processed. Team members' personal funds will be considered for contingencies in case of underestimated expenses or accident component failure. In case of insufficient funding, team members have agreed to cover any additional costs between themselves.

7. SCHEDULE

Figure 3 shows our team's semester schedule by means of a Gantt chart. This is the schedule we expect to follow, based on the experiences of past ENSC 440 groups as well as the experiences of BES's members. Figure 4 shows our schedule in the alternate form of a milestone chart.

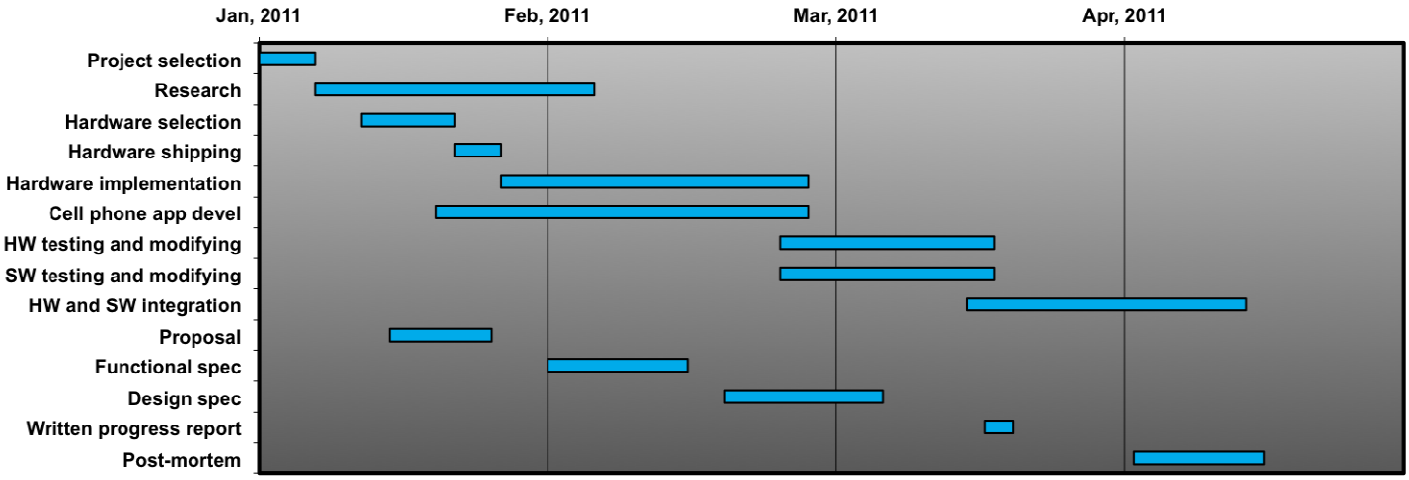

Figure 3: Gantt Chart

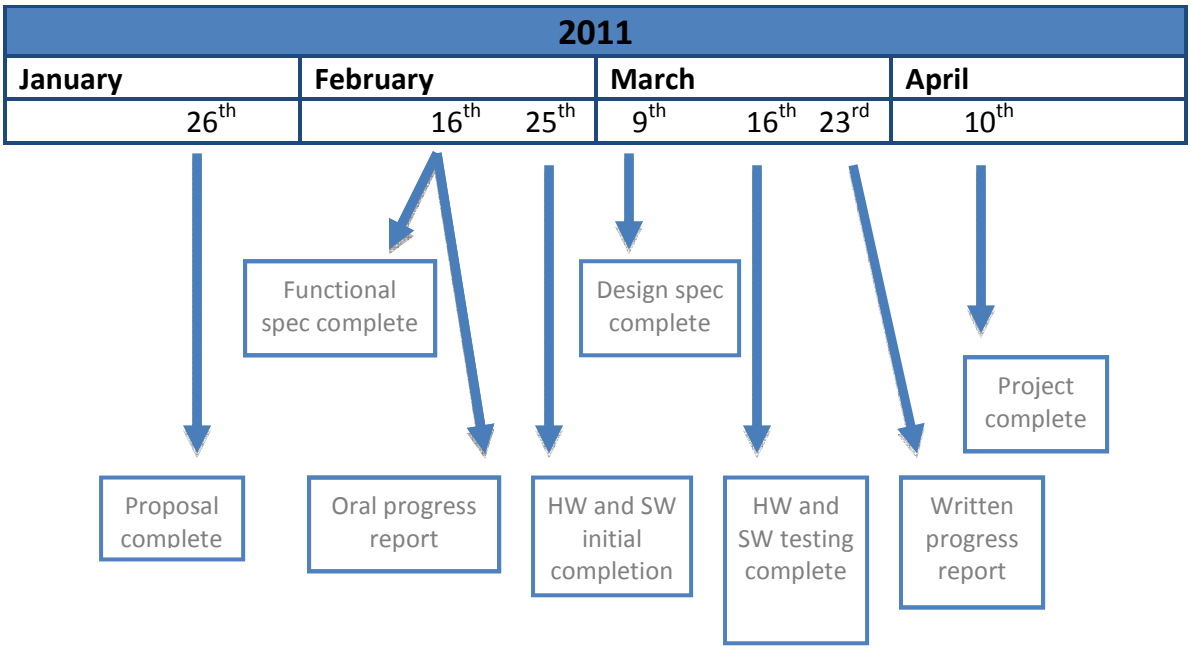

Figure 4: Milestone chart

8. TEAM ORGANIZATION

Biomedical Engineering Solutions (BES) is comprised of five undergraduate fifth-year engineering students: Amir Kamyabnejad, Bobby Luk, Chen Zhang, Eric Boyer, and Yash Trivedi. Each member possesses many unique skills and experiences in their respective field of engineering, allowing BES to develop a project with a wide variety of requirements. The diversity of skill at BES also means that work can be divided evenly, with each member contributing wherever they can most effectively. The following is an overview of each member's area of expertise and the overall corporate organization of BES.

The general structure of BES is divided into hardware and software departments. Amir Kamyabnejad and Eric Boyer, with their strong background in hardware design and integration, constitute the hardware department. Chen Zhang and Bobby Luk, with their industry experience in software, constitute the software department. Yash Trivedi, a systems engineer who specializes in project integration, is responsible for synchronizing work between these two departments and helping either department as needed. This division of responsibilities allows our team to work on both hardware and software in parallel, resulting in a quick completion of our project.

The official titles of the members of BES are as follows. Amir Kamyabnejad, Chief Executive Officer (CEO), is responsible for the overall management of the team, and is also responsible for researching the biomedical and scientific aspects of the project. Bobby Luk, Chief Financial Officer (CFO), is responsible for obtaining sources of funding and for developing software. Chen Zhang, Chief Software Officer (CSO), is team lead for the software department. Eric Boyer, Chief Hardware Officer (CHO), is team lead for the hardware department. Yash Trivedi, Chief Technology Officer (CTO), is responsible for interdepartmental relations and will work to synchronize the hardware and software teams.

To maintain proper communication among members and to ensure that all members share an equal workload, team meetings are scheduled twice per week. The team's primary meeting occurs Monday evenings immediately after the ENSC 440 class and is typically one hour in length. During these meetings each member discusses their work progress, new ideas, and any concerns related to the project. The opinions of all members are respected during meetings, which allow for open dialogue and encourage new ideas. Each member takes turns recording the minutes of the meetings, which are promptly e-mailed to the group later that evening to ensure there is no ambiguity in the decisions of the meeting. The team's other weekly meeting occurs Wednesday evenings immediately following the ENSC 305 class. This meeting is only five minutes long, and is merely meant to be a quick review of each member's progress. This meeting ensures that if any member is behind in their work progress then it will be immediately obvious to the whole group, which encourages all members to maintain acceptable progress in their work.

By splitting the workload based on each member's strengths and by conducting regular team meetings, BES is hoping to maintain positive group dynamics throughout the semester. This will ensure efficient usage of time, allowing everyone enough time to work on other course work, and maintain professional and social relationships after the project is finished.

9. COMPANY PROFILE

Amir Kamyabnejad – Chief Executive Officer (CEO)

I am a 5th-year Electronics Engineering student. My work experience includes a one-year term for ST Ericsson, Belgium; four months in a research assistance position in SFU Biomedical Engineering Labs under Marinko Sarunic's supervision, as well as a consulting position in this field; and four months at Argus Technologies in hardware electronics. I'm certified by National Instrument for LabView Core I and II, as well as TestStand. I have knowledge of C, C++, Java, VHDL, and ARM assembly language. I also have strong working knowledge with lab equipment from my experience with STE. Moreover, I am competent with my interpersonal and communication skills, and flexibility is one of my greatest skills.

Bobby Luk – Chief Finance Officer (CFO)

I am a 5th-year Computer Engineering major at Simon Fraser University. I am strong in software languages such as Java, C++, Perl, MATLAB, and VHDL. I have completed a 4 month work term at Environment Canada as a HelpDesk analyst and an 8 month work term at Polycom working in Quality Assurance. My responsibilities at Polycom included writing and maintaining scripts in Perl that test Polycom telephony products such as handsets, conference phones, and video phones. I am a team player, and can take different roles depending on the situation to get the job done.

Chen Zhang – Chief Software Officer (CSO)

I am a 5th-year Electronics Engineering student. I have done my 12-month co-op at BC Genome Science Centre as a system technician, which involved supporting and maintaining servers and other computer systems, and responding to service outages and other problems. During my co-op I also finished an individual project related to virtualization technology. I virtualized some servers built based on old Linux distributions such as Red Hat 8, 9 and SUSE 9 while there is little software support for Linux virtualization. I have experience programming in different languages on various platforms, such as Microsoft Visual C++, and Perl on Linux. Besides the working experiences of software, I have knowledge of hardware such as circuit design and PCB design.

Eric Boyer – Chief Hardware Officer (CHO)

I am a 5th-year student at Simon Fraser University working towards an honours degree in Electronics Engineering and a minor in mathematics. I have completed two co-op work terms in the software industry, but also have a strong background in hardware. I am strong in C, C++, and Java, and have experience with many other high- and low-level programming languages

such as MATLAB, VHDL, and several forms of assembly. In terms of hardware I am experienced with analog circuit design, FPGA programming with VHDL, digital circuit block-level design, and the operation of lab equipment such as oscilloscopes, function generators, and spectrum analyzers. I am also an electronics hobbyist with a strong interest in audio circuit design, and am currently building a 400-watt portable stereo as a hobby.

Yash Trivedi – Chief Technology Officer (CTO)

I am a 5th-year Systems Engineering Student. My hardware technical work experience includes 12 months of designing and building tube amplifiers for guitars. This involved biasing tubes and constructing amplifier circuits. I also had to come up with a multiple input switching circuit. My software work experience includes 8 months at Research In Motion as a Software Developer for the BlackBerry Enterprise Server. This position involved setting up and maintaining build cycles for the Continuous Integration team. It also came with additional responsibilities such as developing the CI toolset and revamping the overall architecture. My hobbies include music, electronics, computers, and reading.

10. CONCLUSION

Biomedical Engineering Solutions (BES) is determined to make a significant improvement to the healthcare industry. This will be done through our innovations of biomedical engineering devices used for monitoring, diagnosing, and treating patients. We clearly observe a need for the application of our expertise and innovation in a time when we have an aging population, increasing healthcare costs, and the burden of it being on the shoulder of taxpayers.

BES's proposed HeartMon monitoring and diagnosing device will enable physicians to have more accurate and diverse data, enabling them to make better diagnoses, as well as having more prevention and treatment options. HeartMon will add to the quality of lives, save lives, and save a lot of money for both public and private healthcare.

The Gantt and milestone charts in the schedule section illustrate the feasibility, flexibility, and well-thought plan for the development of HeartMon. This is complemented by the affordable budget required to complete this project, as well as BES's sources of funding.

With our well thought-out strategy we will attain our company goals to achieve a sound foundation for Biomedical Engineering Solutions. We can then grow and prosper over the years, and allow humanity to enjoy the fruits of our labour. For contribution is the highest value in our company that has endless rewards far beyond wealth, recognition, and fame.

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