School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, BC V5A 1S6

September, 22, 2014

School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Project Proposal for Smart Abdominal Binder

Dear Dr. Rawicz,

Please accept the following document for the proposal of our Smart Abdominal Binder project. Influx Medical is aiming to design and implement an abdominal binder that will be used for patients whom suffer from low blood pressure due to sitting on a wheelchair for an excessive amount of time. Our design will consist of an abdominal garment that will contract when the blood pressure patient falls below a certain threshold.

The purpose of this document is to present an overall view of our company's goal and to introduce our product, some design considerations, funding and budgeting and its sources and also team organization and project concerns.

Influx Medical consists of six determined and motivated engineering students from various disciplines. Our team members include Hamed Soltanishirazi, Jason Jiang, Simon Cheng, Kevin Liew, Junyang Tao, and Shayan Gaeni. Feel free to contact our group regarding any questions that you may have, or any concerns about our proposal. Please contact Shayan Gaeni at 604-720-4433 or by email at sga60@sfu.ca.

Sincerely,

Shayan Gaeni

Shayan Gaeni
Chief Executive Officer
InFlux Medical

PROJECT PROPOSAL

Smart Abdominal Binder

Company: InFlux Medical

Project Team: Shayan Gaeni

Hamed Soltanishirazi

Christy Tao

Simon Cheng

Kevin Liew

Jason Jiang

Executive Summary

There are many patients worldwide that suffer from complete/incomplete spinal cord injury, which deal with many hardships with everyday situations. They seek the help of health care providers in order to carry out simple and basic tasks that are common for the normal human beings. Injuries to the spinal cord can affect many bodily functions. Thus InFlux Medical purpose is to eliminate one of the many hardships that spinal cord injured patient's deal with on an everyday basis, which is the patient suffering from the effects of low blood pressure. InFlux Medical plans to implement a smart binder that is placed around the abdomen area of the patient suffering from spinal cord injury, in order to disperse blood throughout the circulatory system. Utilizing a blood pressure sensor or a pulse oximeter, once the blood pressure of the patient is below a certain threshold the smart binder starts to contract causing blood that is in high volume in the abdomen area to be pushed throughout the circulatory system. InFlux Medical is planning on designing a loosely fitted garment in which the device can be implemented.

There are solutions available for patients suffering from low blood pressure such as medications; however this may tend to cause autonomic dysreflexia that is a life threatening condition that requires immediate medical attention. Our device unlike medications senses when the blood pressure of a patient is at an optimal level and stops the contraption from pumping. Furthermore, the effects of medications can last for up to eight hours causing side effects and in many cases threatening conditions. There are Anti-G suits that fighter pilots use that can be used for patients suffering from low blood pressure, however they are hard to take on and off, and also are very expensive. InFlux Medical plans on designing a cheaper and well established technology that costs approximately one hundred.

InFlux Medical consists of six dedicated, optimistic, driven, and enthusiastic engineers majoring in electronic, physics, biomedical, and computer. The project we have proposed is estimated to be completed within a semester (12 weeks), with an allocated budget of around five hundred dollars.

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Introduction

According to Spinal Cord Injury Canada, there are 86,000 people who live in Canada with spinal cord injuries (Farry, 2010). It is also estimated that there are over 4,300 new cases of spinal cord injuries in Canada each year (Farry, 2010). The Canadian government estimated annual costs for dealing with patients that have spinal cord injuries are $3.6 billion of which $1.8 billion is being directed to health care costs. Thus there are many patients in Canada alone that suffer from spinal cord injuries.

Spinal cord injured patients have many of their bodily functions affected. Areas in the brain normally control blood pressure and heart rate, where signals from the brain send messages through the spinal cord to constrict or dilate blood vessels. However patients with spinal cord injury have these signals interrupted, and in many cases inactive movement causes low blood pressure requiring medication. The cost of medication for the government can be an economic burden, and our company plans on reducing the government's annual costs by designing a smart binder to be worn around the abdomen. However, using medication can result in autonomic dysreflexia, which occurs most often in spinal cord injured individuals that causes a reaction of the autonomic nervous system to over stimulate (Karlsson). It can be characterized as sudden onset of severe high blood pressure that can cause throbbing headaches, profuse sweating, anxiety, and cognitive impairment (Karlsson).

Our company, InFlux Medical, has been founded in order to relieve spinal cord injured patients of autonomic dysreflexia, which promises to be socially beneficial and profitable. Our purpose is to make our garment easy fitted, not tight so that it does not interrupt breathing patterns, easy to put on and take off, be made of breathable material, and also to fit the individual without having him looking socially awkward. With an increase each year in spinal cord injured patients, it is time to think of an innovative approach to ease these individuals of their hardships. InFlux Medical is motivated to take on such a challenge in order to help shape a brighter future.

System Overview

Hardware Stage

According to a biology fact that about 80% of human body blood is gathering around abdomen, InFlux Medical focuses on designing a comfortable and convenient device that can exert a controllable pressure to human body's abdomen thereby to promote the blood circulation. The hardware device of InFlux Medical involves a blood pressure monitor that detects current blood-pressure of patients, an air pump and air chambers that work

cooperatively and operationally to exert an inflation air pressure to user's abdomen. Additionally, a Bluetooth port will be attached to the device in order to pass signals of user's current value of blood-pressure to a Smartphone application.

Users of InFlux Medical device can view their current blood-pressure from the monitor and then decide to press the air pump to generate the inflation pressure to abdomen; meantime, an attached pressure sensor will deliver the blood-pressure conditions to the monitor and InFlux Medical smart phone application simultaneously via Bluetooth port. Therefore, it is a sequential operating system and further operations can be determined depending on current blood-pressure values. A mechanism block diagram of the designed system is shown as following:

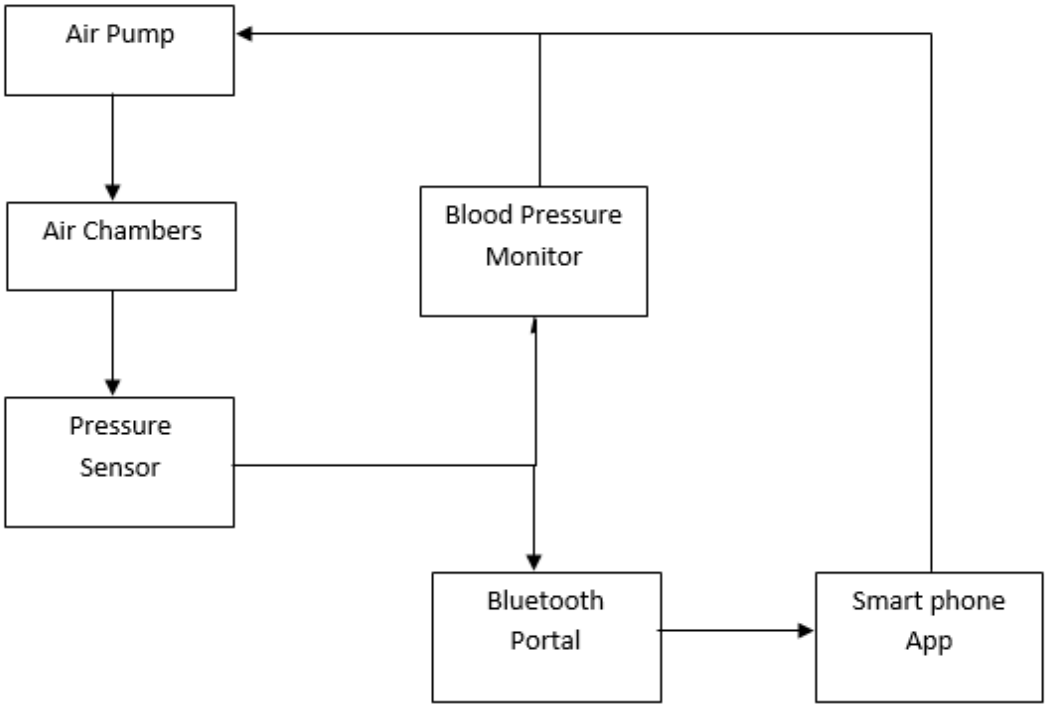

Figure 1: Hardware Block Diagram

Considering the comfort ability of the design, InFlux Medical device is applied as a bottom part of a shirt. In the other words, the air chambers which deliver inflation pressure to abdomen will be incorporated with the shirt. As the result, the designed shirt can be conveniently dressed, taken off and carried.

Software Stage

The software side of the system is based on a Smartphone application for the android operating system. It involves retrieving output data via Bluetooth from the pulse or blood pressure device and provide through a microcontroller to have the contraption occur. The

software side will also involve a graphical interface in which the user and 3rd party viewers can access. The software is a major part of the system as it will control the contraption of the strap at the abdomen for the wearer. The software monitors the input data from the pulse or blood pressure monitor and once the data drops below a certain threshold, the software will alert the user via visual and sound on the android device and send an output to have the abdomen contraction offer. The user side of the software will interface with the input and output devices of the system via Bluetooth. The user cannot interact with the application; its primary purpose is to display information and alert. For safety, consistency and reliability, it does not allow the user to change of any behavior of the system.

The application will also provide information for 3rd party viewing and thus a Wi-Fi or data connection for the user's android device will be necessary to upload the data to a database. Another possible solution for viewing is to build a PHP based website where the device can be viewed on any browser providing mobile and desktop flexibility since it removes device dependency.

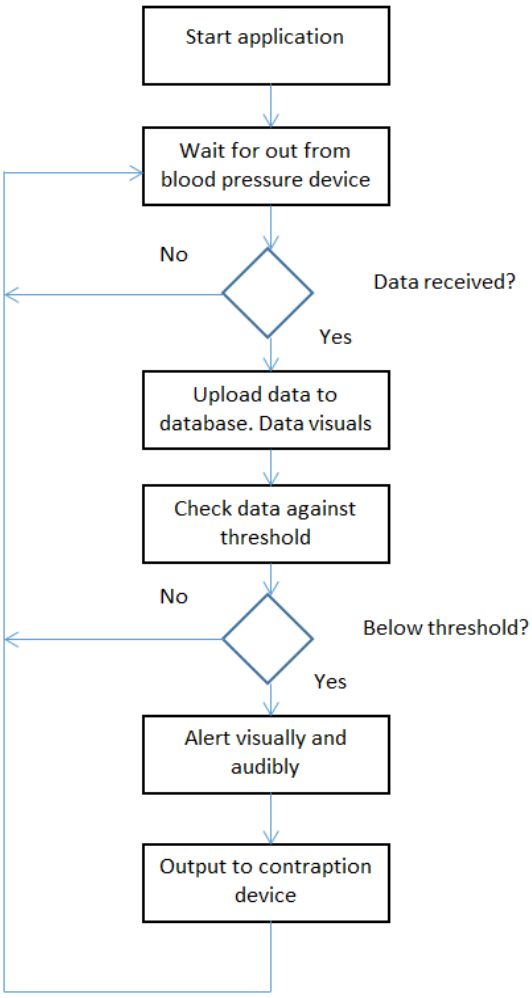

Figure 2: Software Flow Diagram

Project Benefits

The heart pumps blood into the body, and if there is not enough volume of it, the pressure drops. The nervous system senses and responses to regulate the blood pressure in the body and also the blood vessels can squeeze to raise blood pressure, and if this system is working properly and if the nervous system is paralyzed then the blood pressure may fall. (Timothy C.Hain)

Orthostatic hypotension is a type of hypotension that the blood pressure falls suddenly after a physical activity such as standing up or stretching. In medical terms, it is defined as a fall in systolic blood pressure of at least 20 mm Hg or diastolic blood pressure of at least 10 mm Hg when someone is in standing position.

One of the many different problems caused by spinal cord injury is the circulatory problem such as orthostatic hypotension (Low blood pressure) and Autonomic Dysreflexia. (High blood pressure) The cause of this is the interruption of the signals sent by the brain to the heart through the spinal cord to control the blood pressure. (Rosner)

We will be trying to tackle the orthostatic hypotension for people with the spinal cord injury. Some of the symptoms caused by this problem are such as dizziness, dimmed vision, generalized numbness and tingling and fainting, distortions in hearing, lightheadedness, nausea and headaches. If we would be able to tackle this issue for the people with spinal cord injuries it could benefit many people with their daily life condition. (Michele L. Wagner)

Project Risks

One of the other main problems caused by spinal cord injuries is the Autonomic Dysreflexia. This common problem can be lead to by one of the following conditions; full bladder, constipation or a full bowel, pain, infection, skin breakdown and a sudden temperature change. The symptoms of this problem may include high blood pressure, low heart rate, anxiety, and severe pounding headache, sweating above the level of injury and nasal stuffiness. (Webmd)

Since the Autonomic Dysreflexia can be caused by very numerous and different conditions and it is very common in people with spinal cord injuries, it can be one of our main risks at this project. Other main problems caused by spinal cord injury are problems with breathing because of the weakened muscles used for breathing and coughing, altered temperature regulation, which causes the lost of the ability to sweat or to make goose bumps and bladder control issue. (Mayo Clinic)

By trying to increase the blood pressure by increasing the pressure around the abdominal we have to take in to account the cause of all the risks explained above.
We have to look very closely into the different conditions, which cause these problems in order to prevent them from accruing while using the device.

Some of the conditions that needs to be prevented are as such; high temperature, uncontrolled increase of blood pressure, sweating, too much pressure, heat or wetness on the skin, pressure on the bladder, pressure on the muscles used for breathing, coughing and swallowing and also sudden temperature change.

Market/Competition/Research Rationale

This part of the proposal describes the market for a commercial project and details the current competition. For a research project, the need for the system or device is outlined and current solutions are detailed.

Patients in wheelchairs with spinal cord injury are at risk of suffering from orthostatic hypotension (OH) (Claydon et al. 2006). Even Paralympic athletes experience orthostatic hypotension (Claydon et al. 2006). Our device will be applicable to many patients, promoting blood circulation in the legs of the wheelchair-bound.

Current solutions for wheelchair bound sufferers of OH include mechanical and pharmacological methods. Reclining wheelchairs are often employed as a mechanical solution. However, the patient is required to take time off from their routine activities to recline until their pressure normalizes. Compression stockings are non-intrusive on a patient's activities, but they are uncomfortable and not dynamic. Compression pumps also exist; while these can be dynamic, they are bulky and uncomfortable to use. Patient-performed pressure-relief maneuvers also provide relief from OH, but they rely heavily on the diligence of the patient who may not notice OH until it has already set in (Sharon E. et. al, 2014). Health care providers will prefer a more robust method of prevention and treatment.

Pharmacological solutions have varying degrees of success, and include Pseudoephedrine, Fludrocortisones, Ergotamine, Metoclopramide and Domperidone, Clonidine, and Midodrine (Blackmere J, 1997). These solutions carry side effects which the patient may find unacceptable.

Currently existing solutions may not appeal to patients due to operational constraints and side effects. Consequently, our device will attempt to capture this market by providing an effective solution to orthostatic hypotension with minimal side effects.

Budget

The following table outlines major parts of the materials needed to purchase in order to build this product. Please note that the number of battery may vary as the electricity it powers the hardware and software depends on actual use. Contingency cost and failure cost are also included for emergency.

Equipments(contingency included)	Estimated Cost
Microprocessor arduino (Bluetooth capable)	$60.00
Shirt(breathable & customerizable)	$50.00
Belt material	$20.00
Rechargeable battery	$30.00
Blood pressure monitor(Bluetooth capable)	$75.00
Pulse oximeter(Bluetooth capable)	$50.00
Medical Air pump	$30.00
Contingency	$50.00
Failure Cost	$50.00
Total Cost	$415.00

Table 1: Project Budget for Smart Abdominal Binder

Funding

There are several funding options that are group is currently considering. We will be sending in our application to the Wighton Engineering Development Fund and also the Engineering Science Student Endowment Fund. With the contribution of these services and also the parts provided by the School of Engineering Science at Simon Fraser University, approximately half of our estimated cost should be covered.

Furthermore, since we are working with Dr. Carlo Menon on this project, he will be contributing to the funding of the project as well. With Dr. Menon's help we should be able to cover our project costs and also be able to get additional funding as requested. In the case where the amount allocated from these sources are insufficient to cover the total expenses of the project, our team members have all agreed to share the remaining costs equally.

Schedule

The expected dates of when each stage should be finished are all labeled clearly in the Figure 3 below, though in practical process the dates may be adjusted. This chart is a simple but useful way to help to keep the project in control, so that problems about procrastination or time management will not appear. It is also a nice to supervise work efficiency.

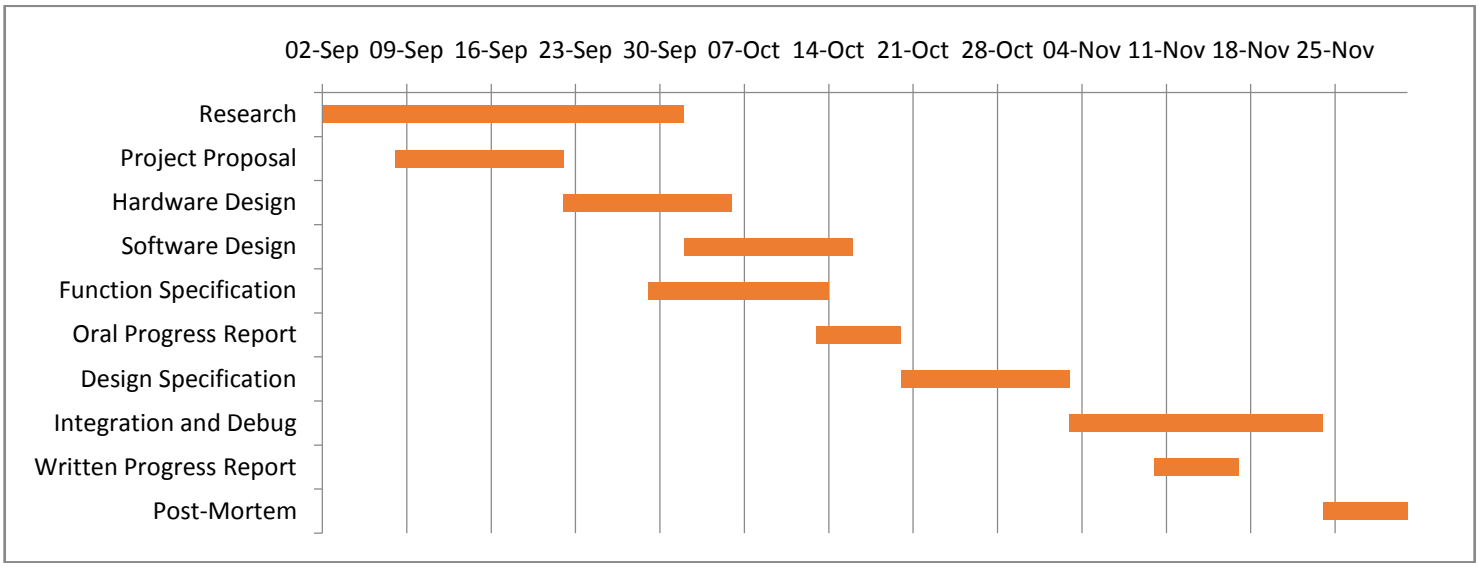

Figure 3: Gantt chart for planned project schedule

The milestones are also demonstrated in the way of another chart below in Figure 4. It indicates the completion dates for several important phases throughout the project.

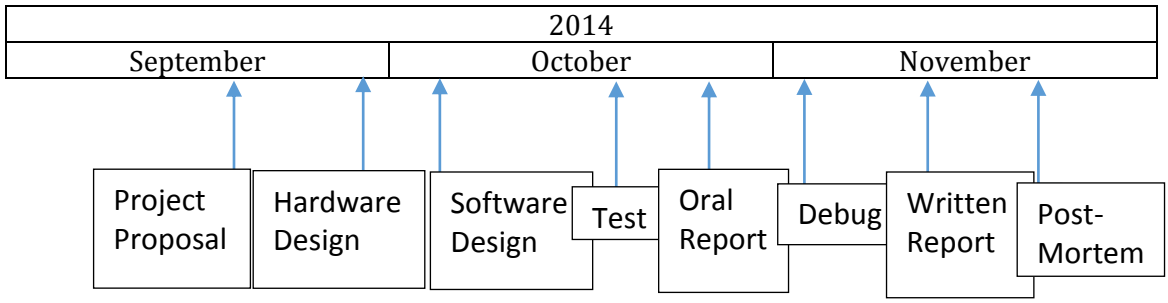

Figure 4: Milestone Chart

Company Description

InFlux Medical is a collaboration of six talented engineers from Simon Fraser University ranging from computer engineering, electronics and biomedical as well as specialization in physics. Biomedical, physics and electronic engineers will focus on the hardware aspects of the project. The computer engineers will concentrate on developing the software aspect of the project which includes developing a mobile application and interfacing with Bluetooth. A summary of each engineer's background is highlighted in the team profile section.

InFlux Medical is organized in by the follow roles for each individual. Shayan Gaeni is elected as the Chief Executive Officer (CEO) and he will be responsible for group meetings and will oversee the progress of the project. Hamed Soltanishirazi is the Chief Operations Officer (COO) and will be managing the hardware development. Kevin Liew is the Chief Information Officer (CIO) and will be addressing the use of any existing or new technologies the team could use and propose solutions to hardware and software development. Jason Jiang is the Chief Technical Officer (CTO) and because of his flexibility in software and hardware development, he will be responsible for integration of both hardware and software aspects of the project. Christy Tao is the Chief Financial Officer (CFO) and will be managing the funding and is also in charge of assessing resources availability such as components and any parts needed for the project. Simon Cheng is the Chief Risk Officer (CRO) and will be responsible for assessing any major risks that may occur and resolutions of any team conflicts. He will also make sure the team is communicating well amongst each other in an effective and respectable manner. In summary Shayan, Hamed and Jason are expected to handle the hardware aspects of the project while Kevin, Christy and Simon, the three computer engineers in the team, will engage in the software development portion.

Although each member is assigned a role, everyone will be working closely together incorporating both hardware and software parts to make sure integration is flawless. Tasks will be assigning to each individual's strengths or interest.

Aside from skills, an important aspect of team work is having meetings to voice our agreements and disagreements while being open and transparent as well as exploring creativity. Communication within the team is critical to the overall team success; without communication there will be confusion and misdirection and an unguided team is not desirable in any scenario. Team meetings will be held weekly as communication is essential in any project to make sure progress is on pace towards the milestones and to discuss about any difficulties that may arise in the research and development of the product. To have effective meetings, the meetings should have time constraints to insure that the meetings are productive. Many tasks will require input from other team members via e-mail and is encouraged to make sure everyone has sufficient support. As email is the primary form of communication, frequent inbox checks are very important and prompt

responses are crucial to ensure every member is up to date. Conflict resolution and problem solving will be essential to ensure the performance of the team is on track.

Our versatile engineering group understands the important elements of team work. We have a team experienced in many aspects and specializations. It is everyone's goal to see the project completed and to make sure we each feel motivated to contribute and drive this product to market. We are excited and look forward to the challenges we will face as a team.

Company Profile

Shayan Gaeni is a 5th year biomedical engineering student and is the Chief Executive Officer (CEO) of InFlux Medical. He has experience in instrumentation techniques for measuring common physiological signals. Also he has practical knowledge of electronic design issues such as electrical safety and signal conditioning. Furthermore, throughout his undergraduate degree he has obtained knowledge in designing analog circuitry which focuses on biomedical instrumentation. He has completed Radio Frequency Hardware design at Alcatel Lucent, which has improved his knowledge of hardware design while taking into consideration design aspects and regulations.

Hamed Soltanishirazi is a senior student at the Simon Fraser University in the field of engineering physics, electronic option and also the Chief Financial Officer (CFO) of InFlux Medical. He has been mostly involved in physics, electronics, microelectronics, micro fabrication, and nanotechnology. He has also taken courses in numerous related topics such as; linear and control feedback systems, communication systems, and computer architecture. He also enhanced my software experience with C++ programming, Solid Works and Lab view software by taking the real time and embedded systems course and in my previous co-op terms. He has been developing his knowledge in the physics of electro dynamics, electromagnetic waves, thermal physics, quantum mechanics and semiconductor devices, which have helped him, understand the physics behind engineering at a deeper level and depth.

Christy Tao is a 4th year computing engineering student whose minor is in computing science. The various courses she has taken make her a multi-tasker of hardware, software and also internet. She has huge enthusiasm in software development and networking. In her previous coop, she worked as a software engineer help to build an online educational platform for students, teachers and also parents. Now she is studying at the same time working as a product manager in a website company. The academic knowledge along with these experiences makes her outstanding and versatile.

Jason Jiang is a 4th year electronics engineering student with experience in AutoCAD, Solidworks and Embedded Systems. He has an eight month work experience as electrical engineering assistant and is familiar with hardware design by using VHDL program language.

Simon Cheng is a 5th year Computer Engineering student. His strengths are in software and he was worked with C++, C, Java and MATLAB. He has completed a 1 year work term at BlackBerry as a Systems Implementation Specialist. He handled submitting but reports for mobile devices reported by T-Mobile for BlackBerry and communicated with developers to resolve issues. He is currently working part-time remotely as a Quality Assurance analyst at Blackwell Astor. His responsibilities include writing test cases as well as performing unit testing and usability test on the website. His most recent major completed project involved himself in a team writing a Windows based application in C++ for an academic streamlined grading system

Conclusion

InFlux Medical is a medical corporation dedicated to assisting people suffering from spinal cord injury. Our goal is to relieve patients from low blood pressure problems, and also help their relatives to supervise the patients' situations stably and frequently.

The product guarantees patients' blood pressure and heart beating rate staying in a secure range or the patient could use the pump near his hand to stimulate himself to pump much blood into his brain so that the patient does not feel dizzy even though he may need to stay in wheelchairs for hours. Considering the patient's physical condition, the pressure will be controlled into a safe value. The blood pressure monitor would inform the patient and also the careers around him the current status of his blood pressure at any time. In order to make this product easy to put on and take off, we designed the embedded hardware between two layers of cloth so that patients would feel comfortable using it.

The documentation provides an overview of the product and also our ideas and approach used throughout the whole project. Our product is by far the most cost effective compared to the similar existed products in the market, and we have enhanced the functions to avoid potential problems to comfort our patients.
The Gantt attached in this documentation along with the planning schedule reveals our project process and expected finishing dates of each stage in the following four months. The budget and funding demonstrates the potential cost we expect overall. The hardware and software instructions of the product offer detailed information on how the product is designed, built, tested and used. The highlighted source of the information and research materials are also presented, showing how we managed to propose the strategy to achieve the objective.

References:

1. Blackmer J. Orthostatic hypotension in spinal cord injured patients. *Journal of Spinal Cord Medicine* 1997 20(2):212-217 Apr.

2. Farry, Angela. "The incidence and prevalence of Spinal cord Injury in Canada: Overview and Estimates based on Current Evidence". Urban Futures Institute. December 2010.

3. Karlsson, A K. "Autonomic Dysreflexia." Spinal Cord 37.6 (1999): 383. Academic Search Premier. Web. 22 Sept. 2014.

4. Mayo Clinic. Spinal cord injury. 22 Oct 2011. 20 Sept 2014 <http://www.mayoclinic.org/diseases-conditions/spinal-cord-injury/basics/complications/con-20023837>.

5. Michele L. Wagner, Janet A. Stewart ,Karen M. Stenger. How do Spinal Cord Injuries Affect the Body? 24 2 2007. 21 September 2014 <http://uiortho.com/index.php/how-do-spinal-cord-injuries-affect-the-body.html>.

6. Michael G. Ziegler, M.D., C. Raymond Lake, M.D., Ph.D., and Irwin J. Kopin, M.D.N Engl J Med 1977; 296:293-297

7. Sharon E. Sonenblum, Teddie E. Vonk, Thomas W. Janssen, Stephen H. Sprigle, Effects of Wheelchair Cushions and Pressure Relief Maneuvers on Ischial Interface Pressure and Blood Flow in People With Spinal Cord Injury, Archives of Physical Medicine and Rehabilitation, Volume 95, Issue 7, July 2014, Pages 1350-1357, ISSN 0003-9993.

8. Rosner, Jochanan E Naschitz and Itzhak. "Orthostatic hypotension : framework of the syndrome ." The Fellowship of Postgraduate Medicine (2007): 20-24.

9. Timothy C.Hain, MD. Orthostatic . 13 April 2014. 20 September 2014 <http://www.dizziness-and-balance.com/disorders/medical/orthostatic.html>.

10. Victoria E. Claydon and Andrei V. Krassioukov. Journal of Neurotrauma. December 2006, 23(12): 1713-1725. doi:10.1089/neu.2006.23.1713.

11. Webmd. Spinal Cord Injury: Autonomic Dysreflexia - Topic Overview. 15 Feberary 2013. 20 September 2014 <http://www.webmd.com/hypertension-high-blood-pressure/tc/spinal-cord-injury-autonomic-dysreflexia-topic-overview>.