Svasth healthcare
always better

September 22, 2014

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University

Burnaby, British Columbia
V5A 1S6

Re: ENSC 305/440 Project Proposal for *Comfort Mat System (CMS)*

Dear Dr. Rawicz,

In regards to the course requirements of ENSC 305W/440W, enclosed to this letter is *Svasth Healthcare's* proposal for the product - *Comfort Mat System (CMS)*. The objective of this system is to prevent pressure sores from developing by monitoring the condition of the skin of people who are bound to wheelchair and/or bed for prolonged periods of time. Unfavorable conditions which cause the pressure sores will be notified to the user through a friendly graphical user interface (GUI) available via smartphone apps on Android and iOS. A vibration motor inserted into the mat can also be turned on when the alarm goes off or after a certain specified amount of time or whenever the user feels like using it to improve blood circulation in the part of skin which is under pressure.

The following documentation provides an overview of our proposed product design, manufacturing, marketability, timeline, budgeting, and funding aspects of it. This document also contains information about existing solutions available on the market and how this product differs from those solutions.

Svasth Healthcare consists of four talented engineers: Wei Lu, Di Luo, Henson Truong, and JabarJung Sandhu. From now on until the completion of the project, we will work closely to design, manufacture, and test *CMS* product to meet the design and other specifications. If you have any questions or concerns regarding the proposal or product, then please feel free to contact us via email at jss19@sfu.ca or by phone at 604.351.4927.

Sincerely,

JabarJung Sandhu
Svasth Healthcare CEO

Enclosure: Proposal for Comfort Mat System

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Proposal for Comfort Mat System (CMS)

Project team: JabarJung Sandhu **(CEO)**
Wei Lu **(CFO)**
Di Luo **(COO)**
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Contact: JabarJung Sandhu

Submitted to: Dr. Andrew Rawicz - ENSC 440W
Dr. Steve Whitmore - ENSC 305W
School of Engineering Science
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Executive Summary

Pressure sores, also called bed sores, or pressure ulcers are injuries to the skin and underlying tissues near bones when exposed to unfavorable conditions. Some common body parts where bed sores develop are hips, shoulder blades, knees, and heels. Prolonged constant pressure between bones and outside surfaces while in a high temperature and high humidity environment are the major causes of bedsores. Majority hospital patients or disabled persons who are bound to wheelchairs or beds suffer from bed sores. According to *Agency for Healthcare Research and Quality* report, the numbers of patients who suffer from bed sores have increased by more than 80% over the last two decades (Griffin, 2008).

We foresee a growing need and potential market for bedsore related products because most bedsores related products currently on the market are not very affordable. Our objective is to design a *Comfort Mat System (CMS)* to help those who not only have limited mobility, but people who sit on chairs for long periods of time like those who work in offices. The primary function of *CMS* is to detect long lasting high pressure points and visualize them on a user friendly interface in real time. There are some additional features in *CMS* which other products on the market do not have:

- Customized pressure relief mat - for relief of pressure.
- Humidity and temperature sensor- to monitor the conditions of the environment to help keep skin in a cool and dry environment.
- Smartphone app- Process and visualize sensor data's in real time, actuate massager and also making the system portable.
- Massager- Vibration motors inserted into the mat to help improve blood circulation.

Svasth Healthcare has four members right now and each one has been assigned a task or job duty for developing *CMS*. *CMS* is a combination of both hardware and software components. The hardware portion mainly consists of temperature and humidity sensors, an array of pressure sensors, FPGA board, and a Bluetooth add-on board. The software portion of *CMS* consists of processing pressure and other sensors mapping data and controlling the massager from different devices i.e. laptop, touchscreen LCD and a smartphone app. The total cost of the hardware components is around CAD $750, which is explained thoroughly under the budget section. The challenging part of this project is controlling the budget while still creating a product which is attractive and competitive in the market.

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Glossary

1. FPGA - Field-programmable Gate Array
2. FSR - Force Sensitive Resistor
3. GUI - Graphical User Interface
4. CMS - Comfort Mat System
5. LCD – Liquid-crystal Display

Introduction

Pressure sores are defined as the breakdown of the skin under long lasting pressures. This can lead to lack of blood flow and prevent blood from bringing oxygen and nutrients to the skin and underlying tissues. Another factor to consider besides pressure is the temperature and humidity. Increasing temperature and humidity under pressurized skin increases the rate at which the pressure sore is developed. The most common locations where pressure sores emerge are on the back of the heels, the buttocks, the backbone, and the shoulder blades.

Most pressure sores occur while sitting or lying on bed so wheelchair-bound people or people who are paralyzed are at high risk. It is reported in *Advances in Skin and Wound Care* journal that approx. 36% to 50% of pressure sores are attributed to sitting in a wheelchair (Geyer, Brienza, Karg, Trefler, & Kelsey, 2001). There are increasing number of people studying and working using computers and other electronic devices while sitting for prolonged periods of time. The pressure sore has already become a common skin disease for normal people.

Once the pressure sore appears, it takes a lot of effort, care and time to heal. It also costs ample amount of time and money to get treated, especially for the disabled people who cannot reposition their body by themselves or those who are paralyzed and the nervous system doesn't tell them where there is high pressure developed or developing. To solve this we need to find a way to prevent pressure sores from developing. Hence continuous measuring and monitoring of the pressure and environment is the best approach for preventing pressure sores, which is considered to be beneficial from both health and economic viewpoint.

Svasth Healthcare is designing *Comfort Mat System* (*CMS*) which will be able to collect all monitoring data from sensors (pressure, temperature, and humidity sensors) and processed by a software system displaying the result in user friendly graphical user interface in real time. Another feature is that once the collected data meets some preset threshold value, the system can automatically turn on different vibration motors to increase blood circulation in the affected area and sending an alarm to the user to reposition their body or to the person who is in charge of taking care of that user. The *Comfort Mat System* will also be integrated with Android and iOS which allows people to be able to monitor and control the system by using their own smartphone devices.

System Overview

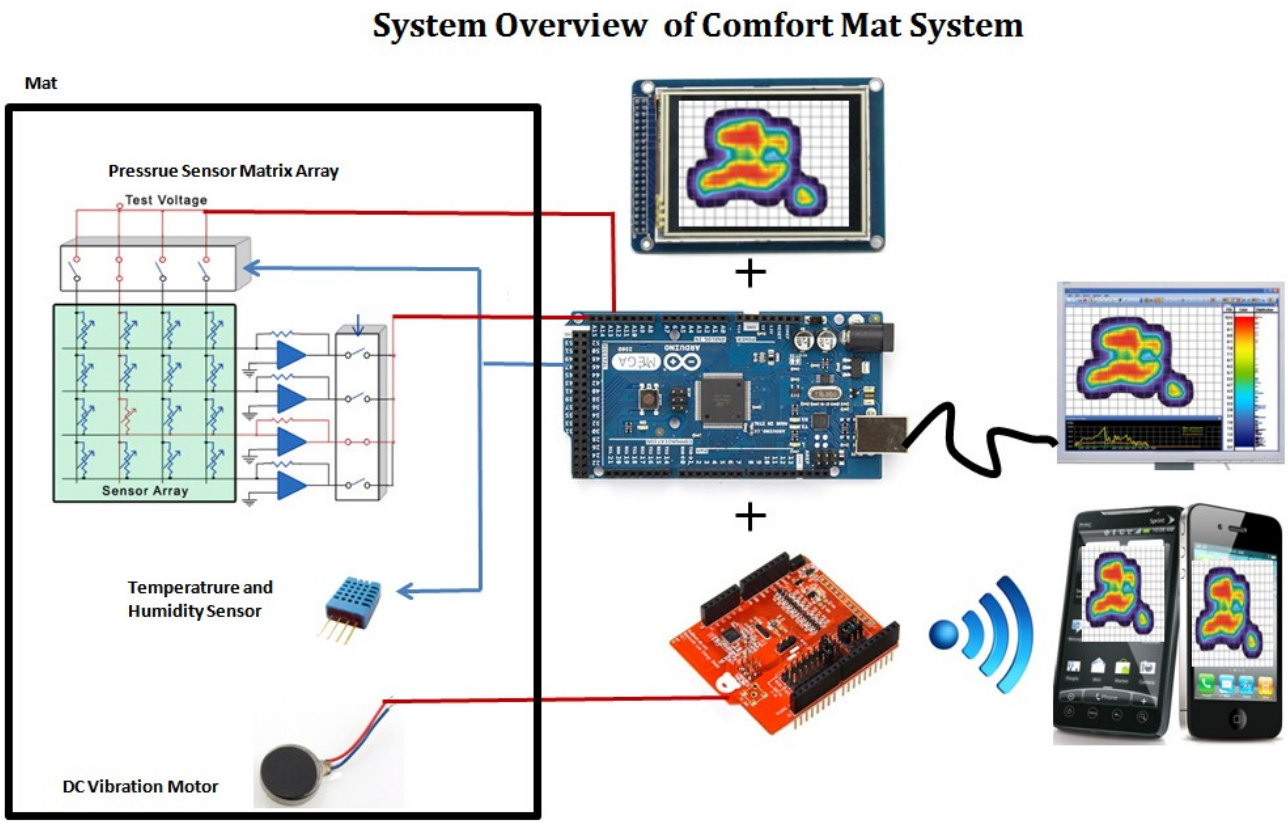


Figure 1: System Overview of Comfort Mat System

Figure 1 illustrates the overview of *CMS*. It consists of a pressure sensitive mat, a smartphone, and a microcontroller. When the user is sitting on the mat, the mat outputs the pressure sensors, temperature sensors, and humidity sensor's data to the microcontroller. There are three options we can use to display the data – either on a small LCD screen or on a computer, or on a smartphone. We will start with the computer first, move on to the small LCD display, then finally to the smartphone once we know everything is working. The vibration motors can be set to vibrate whenever the alarm goes off or whenever set off by the user.

Figure 2: FSR sensor series and model of FSR matrix array

1. **Pressure Sensor**: We will be building our own array of pressure sensors (**Figure 2**) using force sensitive resistors (FSR series) on a flexible piece of plastic. FSRs are two-wire devices which exhibit a decrease in resistance with an increase in force applied to the surface of the sensor. We plan to build an 8x8 array of pressure sensors using FSRs which will give us a dynamic pressure distribution mapping over the desired area. Our pressure sensor matrix will be placed inside a waterproof sealed seat mat. The more sensors we put in the matrix, the better the resolution of the dynamic pressure image will be when it gets mapped to the smartphone GUI.

Figure 3: Humidity and Temperature Sensor

2. **Humidity and Temperature Sensor**: Temperature and humidity are two other factors causing pressure sores. The temperature and humidity sensor (**Figure 3**) can continuously monitor temperature and humidity of the environment. Many types of sensors are available in the market and RHT22 is one of them. An advantage of this sensor is that it comes in a plastic enclosure which can protect the sensor in case of damage by body pressure. It is good for 0-

100% humidity readings with 2-5% accuracy and -40° to 80°C temperature readings with ±0.5°C accuracy.

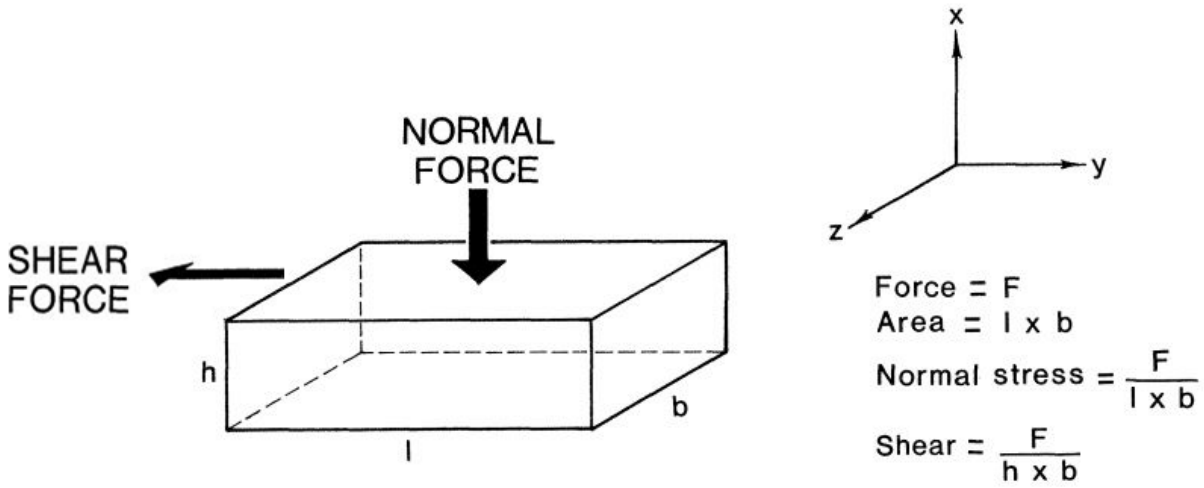


Figure 4: Force that acts perpendicular to the surface causes pressure and force that acts parallel to the surface causes shear

3. **Pressure Relief Mat**: The pressure relief mat is a customized mat that is placed on top of the pressure sensor matrix array. The mat is designed for comfortable sitting along with pressure relief, temperature & humidity reduction, and improved air circulation. As a result, the pressure relief mat can decrease the likelihood of pressure sores developing.

   Pressure is formed by two individual forces: Normal force and Shear force. The Normal force is the compression between bone and skin when there is an external force applied. The Shear force is when the skin and its underlying tissue move in different directions. Pressure has a proportional relationship with the normal force and shear force individually, which is shown in **Figure 4**. The friction between skin and mat, environmental temperature, and humidity play important roles in pressure sore formation.

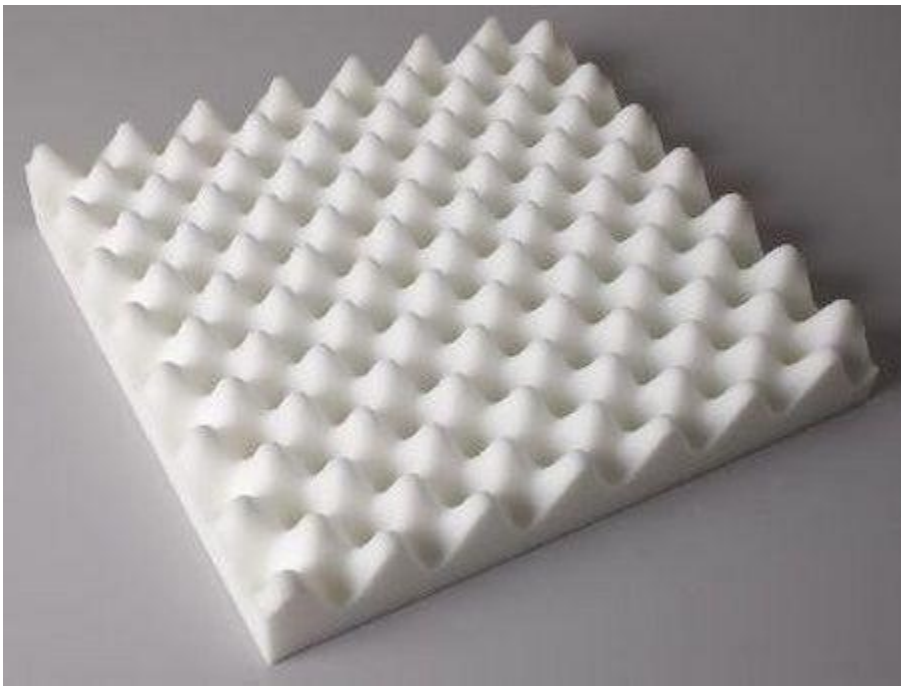


Figure 5: Egg-tray shape cushion

To conclude, the material used for the pressure relief mat should be one of the most critical parts for the *CMS*. Sweating is more likely to occur as the temperature rises. When someone is sweating, moisture accumulation will cause the deformation of soft tissues (Ferguson-Pell, 2014). Therefore we picked a material which is porous so it is able to dry quickly when the sweat appears and to distribute the pressure evenly. Some materials such as gel have good heat conductivity and heat capacity which can dissipate heat on skin quickly but it is not comfortable and easy to customize.

Because of those factors we have decided to use foam to make the mat and bamboo fiber as the mat's exterior cover. The advantages of using foam are that it is lightweight, easy to customize, flexible, and waterproof. The reason why we use bamboo fiber as cover is because it has a higher thermal conductivity (0.121W/m-K) rate than foam (0.03W/m.K) at room temperature (Kiran, Nandanwar, Naidu, & Rajulu, 2012). We plan to customize shape of the cushion to egg-tray shape (**Figure 5**) because this shape can ease pressure by reducing the area that is in touch with the skin while at the same time having circulation of air.

Figure 6: Vibration motor

4. **Vibration Motor**: Microcirculation of the skin has been widely investigated and various methods to promote blood flow have been developed. Applying vibration to the skin improves blood circulation while reducing the likelihood of pressure sores appearing. The vibration with the help of Vibration motor (**Figure 6**) will increase blood flow for a short-term. Although vibration cannot prevent pressure sores from happening but it can be used as an alarm to remind the user who is sitting on the mat for a long time period to adjust his position.

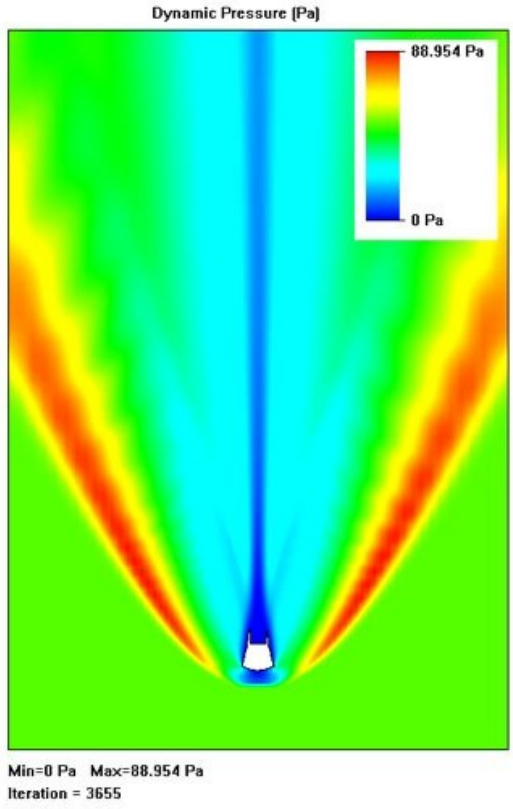


Figure 7: Dynamic Pressure Image

5. **Smartphone app (Android and iOS)**: End user of the *CMS* will be accessing, monitoring and controlling the system via GUI of a smartphone app which particularly will be based on Android and iOS. Development on the other platforms mainly BlackBerry and Windows can also be an option in foreseeable future. A smartphone app will be having the following features:
   a. **Dynamic Pressure Images (DPI):** Displaying dynamic pressure images (**Figure 7**) of the area under pressure. A sample DPI is shown in Figure 7 above. A bar displaying the pressure values in SI unit 'Pa' will also be shown on the screen. As in this example the red color corresponds to high pressure and blue corresponds to low pressure respectively.
   b. **Data transfer to other devices**: Data can also be transferred to other portable devices, medical instruments, and computers via USB connection or over the Bluetooth.
   c. **Fast Sensor Scanning**: DPI will be refreshed at a rate of 100 Hz (optimal) so system will deliver fast sensor scanning.
   d. **Real-time display**: Data will be displayed via DPI's in real-time which will be refreshed periodically.
   e. **Recording and playback of DPIs**: DPI information will be stored on to the device on which the app is installed and can be played back for up to 24 hours prior. Actual playback and recording times might vary depending on the memory available on the device.
   f. **Warning messages**: App can issue a warning to the user of the *CMS* if high pressure sustains for a longer period of time at a particular place. User can preset the high pressure time limits and app will send warning messages based on that.
   g. **Portable:** Because of the use of the smartphone app, it will be easy to connect and update and most importantly portable.
   h. **Humidity and Temperature sensor measurements:** App will also show on separate screens the real-time humidity and temperature sensor measurements. Temperature values can be displayed in C° or F°. Humidity can be displayed in relative, specific or absolute values.
   i. **Control of vibration motor and reminders:** Vibration motor can also be controlled via app. It can either be turned completely off or user can manually turn it on if he or she wants to. Vibration motors can also be controlled automatically by the app based on the pressure values during that specific time.
      If the high pressure sustains for a long interval of time then the app can issue a reminder to the user that vibration motors will be turned on after this much interval of time and then turned off after running for this much period of time.

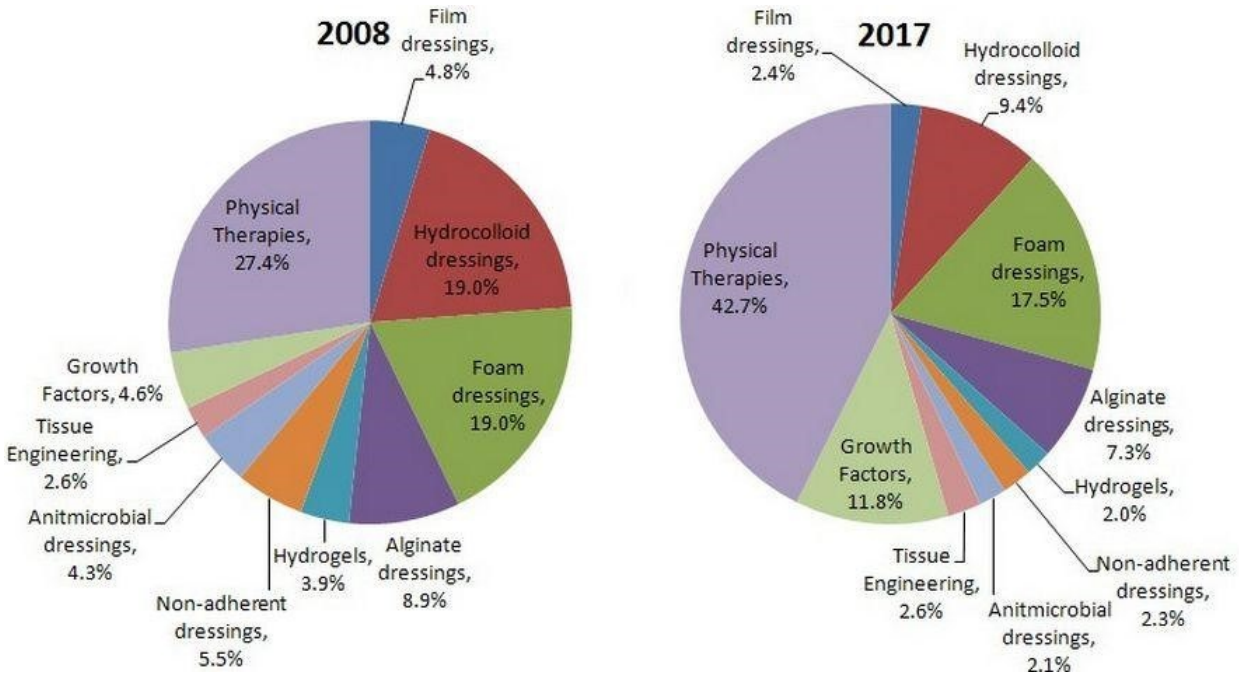


Figure 8: Structure of wound care management market (Advanced Medical Technologies).

The market of wound care management has a huge potential. This market is expected to grow rapidly in the foreseeable future. In 2006, the total cost for treating pressure sores was $11 billion. This cost has increased to $14 billion in 2009 and is expected to increase to $19.6 billion in 2016 (Vittal, 2010). **Figure 8** shows the structure of this market (Worldwide Advanced Wound Management Market, by Segment, 2008 & 2017, 2014). In Canada about 25% of people in Hospital-based acute inpatient care develop pressure sores. In non-acute care settings (e.g. nursing homes) the prevalence of pressure sores is even higher; this is about 30% (The Facts on Bedsores, 2014). There is a huge potential demand and need arising from these outstanding numbers.

Let us take a look at another wound care company in order to have a better understanding of how big the market is: *ConvaTec* is the leading player in the wound care market with a total market share of 7%. In 2008, its holding company *Bristol-Myers Squibb Co.* sold *ConvaTec* for $4.1 billion. *ConvaTec* had earned $290 million in the first quarter of the same year (Bristol-Myers Squibb Completes Sell-off of ConvaTec to PE Firms News, 2014).

The market is out there so our challenge now is figure out how to design *Comfort Mat System* to be more user-friendly and more competitive. We have found similar products on the market such as the LX100, 200 from *XSENSOR*, and the FSA Seating Assessment from *Vista Medical*. Both products are

good but *Comfort Mat System* (*CMS*) has several advantages over these. First, *CMS* takes environmental conditions into account such as temperature and humidity besides pressure. Secondly, all of the components and software included in *CMS* are sold as all-in-one package compared to other companies who sell them separately. Finally, *CMS* has more GUI options for the users to choose from, they can either use the phone application or a computer and an embedded LCD screen to monitor their skin conditions in real time.

Proposed Design Solution

The proposed solution is to build *Comfort Mat System* that incorporates a pressure sensitive mattress to be placed on the seat. Temperature and humidity sensors will also be incorporated into this system. This system will send sensor's data to the user's smartphone via Bluetooth technology. The user would then be able to get real time data of the pressure mapping, temperature, and humidity of the surroundings. Vibration motor will also be placed on the mat. It allows the user to turn on the vibration motors when the pressure at various parts of the seat has been high for a specified amount interval of time. These vibration motors will also have an auto setting, which will repeatedly turn on after a preset time set by the user via the smartphone app. The current pressure sensing mats available in the market are all for bed use, nothing for the chairs. *CMS* can help prevent pressure sores.

The main constraints in implementing this project is the tight schedule given and funding. We have to design, build, and test this product within thirteen weeks of time frame. Given these constraints we will be building a prototype working on the Android mobile platform and then on iOS.

With more funding and time, we can develop another app that would also work on other mobile platforms like BlackBerry and Windows and the apps would have more robust interface. The mat can be configured with increased number of pressure sensors to increase the output resolution level of DPIs and *CMS* can also be installed with more vibration motors as well.

Budget and Funding

Our goal is to minimize the product's development and manufacturing cost in order to compete with existing bed sores related products already available in the market. Here is the list of our expense:

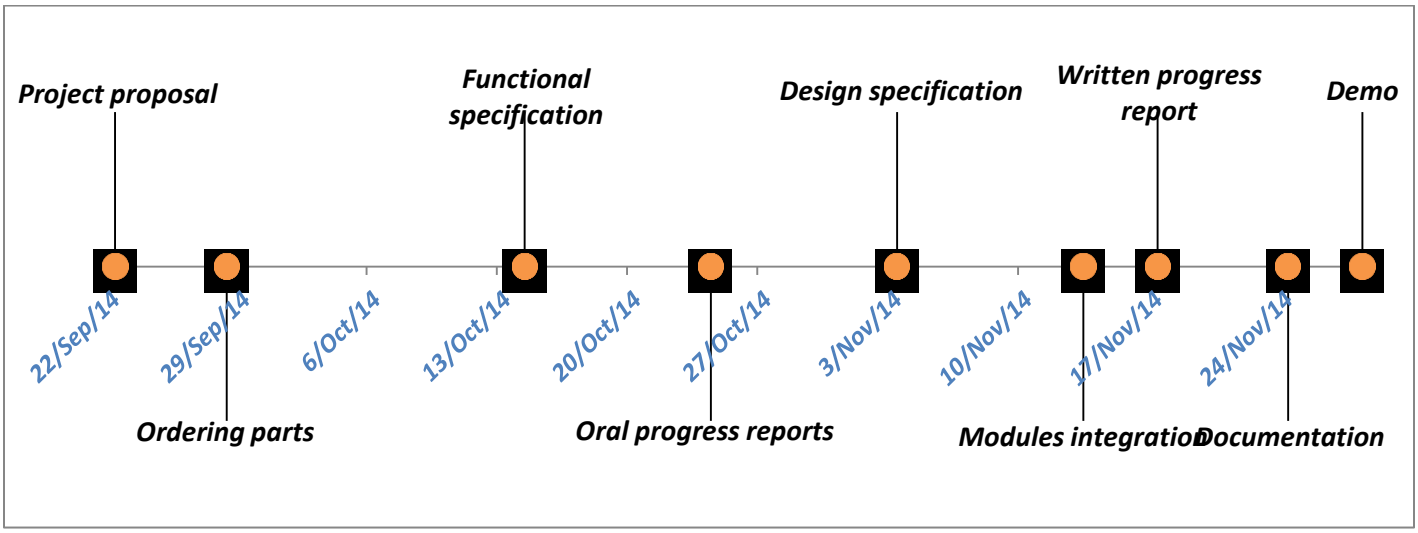
Component	Unit Price (CAN $)	Quantity	Total Price (CAN $)
Mega 2560 R3 board	80	1	80
Temp. and Humidity Sensor	15	1	15
Copper Foil Tape	12	1	12
Vibration motor	5	6	30
Multiplexer 4051N	0.3	5	1.5
Shift register 74HCT595N	0.3	5	1.5
Bluetooth 4.0 low energy – BLE Shield	30	1	30
DMI Med Convoluted Foam Chair Pad (Blue)	20	1	20
FSR 402 .5" or .2"	5/6	64	320/384
Jump wire (Male and Female)	40	1	40
Conductive wire	30	1	30
Resistor	Almost free		N.A.
Battery Connector	5	1	5
Plexiglass Sheet	20	1	20
Touchscreen LCD	75	1	75
		Total Cost	**750**

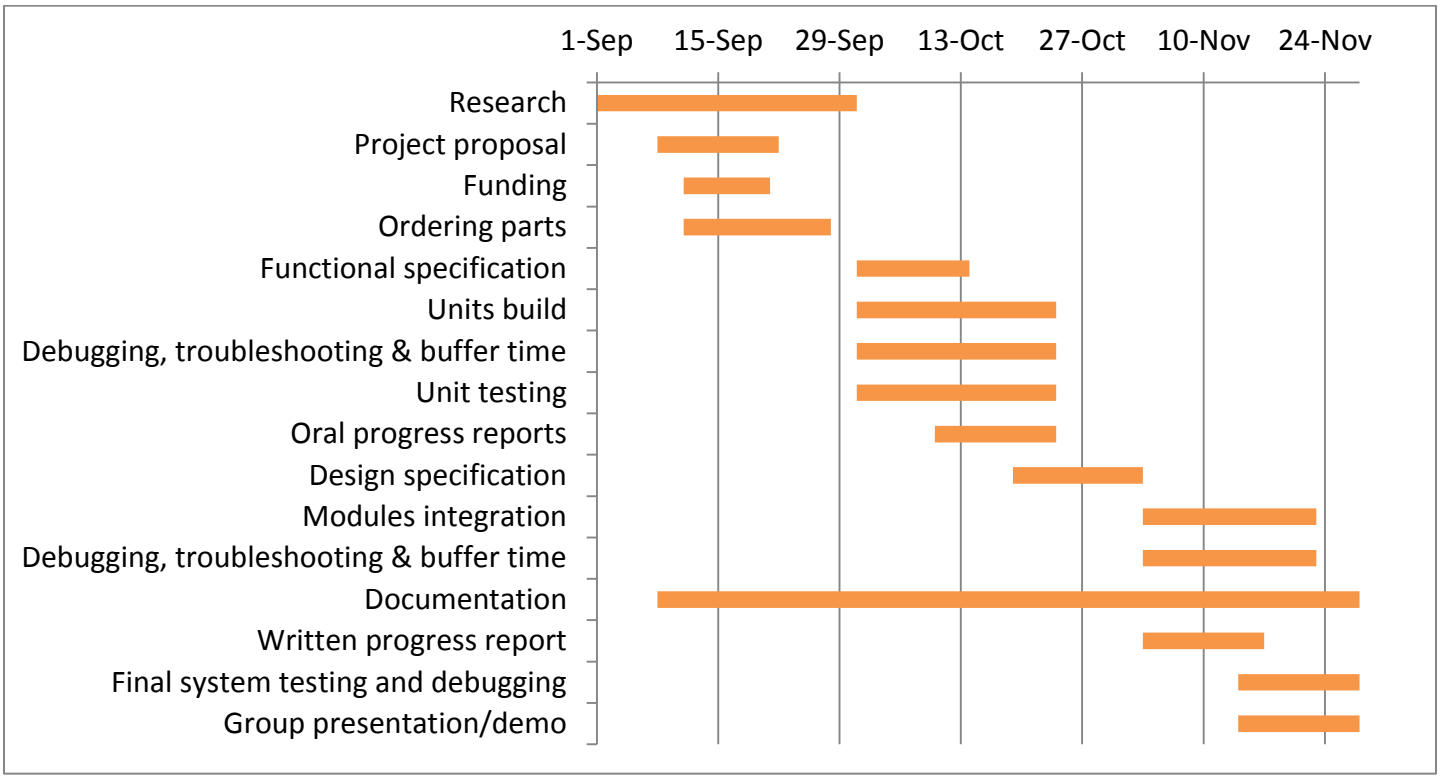
Table 1: Budget and Funding table

This cost does not reflect the actual expense of the final product. In order to bring down the budget we have applied for funding from ESSEF.

Project Schedule

Figure 9: Milestone chart & Gantt chart





Company Profile

At *Svasth Healthcare* we believe having a pressure sore relief system for chairs and mattresses is a life transforming product for people who are bound to bed, chair, or wheelchair most of their time. *Svasth Healthcare* is founded by four engineers from Simon Fraser University namely Wei Lu, Di Luo, Henson Truong, and JabarJung Sandhu. The combination of a large array of skill sets gives us an essential toolkit to develop *Comfort Mat System*.

JabarJung Sandhu
JabarJung is a 5th year Computer Engineering student here at Simon Fraser University and is in his last year of studies. He has completed co-op terms at BC Cancer Agency and at BlackBerry. In addition to that he has two years of experience working as a technician and is currently working as a part-time technician at SFU IT Client Services. He has strong programming, debugging skills in Python, Java, C/C++, Matlab, Assembly and VHDL. He seeks to use his acquaintance, expertise, and proficiency in pursuing a vocation in software development and project management.

Wei Lu
Wei is a fourth year Electronics Engineering student at Simon Fraser University and is in the last semester of his studies. He has completed 16 months of co-op term at Netgear as Hardware Designer. He has strong ability in working in team to perform hardware design and verification procedures. Having strong attention to detail and tendency to see the higher level view, Wei aspires to use his knowledge and experience in pursuing a career in hardware design and project management in engineering field.

Henson Truong
Henson is a 5th year Electronics engineering student at Simon Fraser University and is in the 2nd last semester of his studies. He has completed one year co-op term at BlackBerry. From this, he has gained experience regarding software quality assurance and hardware troubleshooting. Throughout his academic career, he gained a strong background in analog and digital circuit design, SolidWorks design, and programming in C++, Python, Matlab, and Assembly. Henson enjoys playing badminton and going for bike rides during his free time.

Di Luo
Di is a 4th year Electronics engineering student at Simon Fraser University. He has worked as a co-op student at Blackberry. He is familiar with telecommunication technologies such as GSM, UMTS, and LTE and so on. He has experience with lab equipment such as Agilent, Spirent, CMW and Anritsu network simulator. Beside the knowledge from work, he has also gained knowledge and insight in programming skills (C, VHDL, and C++) and circuit design.

Conclusion

The goal of *Svasth Healthcare* is to help people prevent pressure sores from developing by creating a *Comfort Mat System* which informs the user about how much pressure is exerted in a specific area. Our proposed *Comfort Mat System* also incorporates vibration motors which would relieve pressure without even moving. This is especially useful for people who are paralyzed and cannot move on their own. Currently there is nothing in the market for chairs involving pressure sensitive mattresses. People who are bound to wheelchairs is the main target for this product but it can also be used by anyone who uses chair or similar structure for prolong periods of time. Our team strongly believes that this *Comfort Mat System* will greatly improve current wheelchair technologies. It will be an easy to adopt solution because this *Comfort Mat System* is just another add-on to their existing chair or wheelchair.

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