ASA CONCEPTS

School of Engineering Science • Burnaby, B.C. • V5A 1S6
ensc440-asaconcepts@sfu.ca

January 19, 2009

Patrick Leung
School of Engineering Science
Simon Fraser University
Burnaby, BC
V5A 1S6

Re: ENSC 440 Project Proposal for a Smart Crutch

Dear Patrick,

Attached is a document, *Project Proposal for a Smart Crutch,* which describes our proposed project for ENSC 440. The proposal outlines our solution to a slipping problem caused by slippery surfaces or mishandling of a crutch on a person using crutches.

The proposal presents the outline of our project, the possible solutions to solve the problem, the proposed solution we came up for the problem, the estimated costs we will incur and the timeline for our project development. Though not in detail, the document also states different approaches with small technical details on how we can come up with an effective means in solving the problem.

ASA Concepts Inc. is made up of a diverse team coming from both systems and electronics engineering background. The team includes system engineers: Ben Lush, Amir Sadeghi and Kyle Lin and electronics engineers: James Guerra and Stan Lin.
For any further information please feel free to contact me through my phone (604) 970 8998, my email, stanl@sfu.ca or our company's email, ensc440-asaconcepts@sfu.ca.

Yours truly,

Ming - Cheng Lin

Ming - Cheng Lin
President and CEO
ASA Concepts Inc.

Enclosure: Project Proposal for a Smart Crutch

Proposal for a

Smart Crutch

***Project Team*:**	Ming-Cheng Lin Amir Sadeghi Ben Lush James Guerra Chien Wen Lin
***Contact Person*:**	Ming-Cheng Lin ensc440-asaconcepts@sfu.ca
***Submitted to*:**	Patrick Leung – ENSC 440 Steve Whitmore – ENSC 305 School of Engineering Science Simon Fraser University

***Issued date*:**	January 19, 2009
***Revision*:**	1.1

Executive Summary

Crutches have been used to assist patients with disabilities usually those who have a severe injury in one leg. One downside of using crutches however is the patient's tendency to fall due to slippery ground or mishandling of the crutch. Even worse is when the patient is incapable of calling for assistance once an accident happens while using the crutch. One of our group members, Ming-Cheng Lin is currently using a crutch and through his current disability, he is able to point the particular problem mentioned above.

Different solutions have been applied to avoid falls using crutches. Crutches were redesigned to have tight gripping heads for stronger friction in contact with the ground, pivotal heads for easier maneuvering and long curved heads for smoother transition of weight. The solutions mentioned however aren't adequate and may just result to the breaking of crutches due to a person being overweight or tight gripping heads not entirely adequate for some special surfaces.

Our proposed solution, the Smart Crutch, will have the ability to sense the friction between the ground and the crutch and warn the user for any possible slipping. We consider three stages on a user's possible fall that we would like to address. On the first stage, a friction sensor detects that the surface in contact with the crutch thus warning the user for a possible slippage. On the second stage, a sudden movement of the crutch or sudden slight slipping of the crutch will activate a support arm that can help prevent the crutch from fully slipping thus preventing the user from completely falling. The last stage is if a user falls, a warning signal will be sent to an alarm device notifying other people that an accident happened.

For our project development, we estimate that we will be able to complete our functional specification for our project by February 16, design specification by March 2, individual module development and testing by March 5 and final integration and testing by April 3. The estimated cost of our project is $450.00 with probable sources of funding from the ESSS, Wighton Engineering Science Fund and our own personal contribution.

ASA Concepts consists of individuals with diverse background suitable for making the Smart Crutch project. We are made up of three systems engineers, namely, Ben Lush, Chien Wen Lin and Amir Sadeghi and two electronics engineers namely James Guerra and Ming Cheng Lin. Our group is driven by the excitement and independence of exercising one's own areas of expertise in developing the project.

TABLE OF CONTENTS

1. Introduction

Crutch is a commonly used medical tool for people who suffer from temporary disability of their lower body. Patients who rely on crutches instead of wheel chair usually have only one injured leg so that they can stand up and walk with the other healthy leg with the assistance from crutches. Crutches usually come in pairs and are used by placing the pad right below the armpit and gripping the handle near the middle of crutch. Once crutch is in position, patients can move by lifting the crutch up and placing it a step forward. Patients then apply their arm strength to the crutch in order to lift their whole body up and finally move their whole body a step forward.

During the New Year of 2009, one of our group members, Ming-Cheng Lin, was injured with a swollen left ankle from pushing a neighbor's car which was trapped in the snow. He was on crutches for about a month and he found a couple of flaws with the crutch he used. One time he almost tripped himself in the washroom because the crutch slipped on the floor which was slippery due to the spilled water from shower. Also he found that if he did fell onto the ground, he would need help from other people to get up. However, if his parents or friends were far from where he fell, shouting out loudly would not save him from this trouble.

With his problem proposed in our group meeting, we came up with a solution that can solve his problem. We will design an smart crutch that contains a friction sensor that is installed right under the crutch pad. The friction sensor is able to detect how slippery the ground is and output a calculated static friction coefficient to the central control system. The central control system will then decide if patient is safe to move forward based on parameters including patient's weight, the crutch's angular position corresponding to the ground (measured by the motion sensor). The control system will send out a beeping sound to notify patients if there is a potential to slip. Patients then can decide to move a smaller step to result in a bigger friction for the crutch.

The other feature for this electric crutch is the motion sensor which utilizes the function of accelerometer to calculate the angular position of the crutch with respect to the ground.If accident happens and patients fall onto the ground, the motion sensor is able to detect a sudden drop of the crutch and send the emergency request signal to the central control system. We will design a RF remote control system which will notify a remote device e.g, a RF receiver, if accidents happen. With this feature on the crutch patients can receive an immediate help or treatment instead of crying out loud for help.

The last feature we have for the crutch is an extra mechanical support during a slip motion. The mechanical support will be activated when the crutch slips. With this extra mechanical support, patients have bigger possibility to maintain their body position even when crutch slips in the first place.

This proposal discusses an overview of our product, outlining design guidelines, sources of information, alternate solutions, and financial requirements. The milestone and timeline for each design stage is also provided.

2. System Overview

Considering each crutch as one individual system, the system senses the friction at the bottom of the crutch and also the angle of the crutch. These two parameters help the system to realize how dangerous it is for the user of the crutch to move forward and warn the user in different ways. On the other hand if either one of the crutches fall down, the system warns the nurse by transmitting radio frequency signal to the nurse's receiver. **Figure 1** shows the conceptual overview of the system.

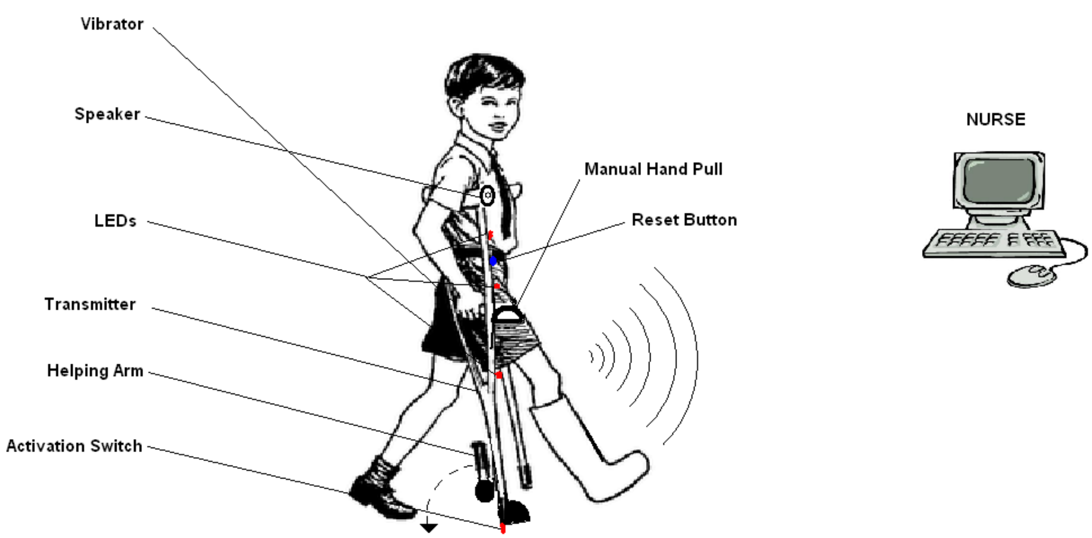

Figure 1- Conceptual Overview of the System

There are three stages of danger, one is when the system determines that the ground might be slippery and the user should be cautious. Second is when the system knows that the user would fall by moving in a way that the crutches are placed and the last stage is when the either one of the crutches or both of them fall on the ground.

In the first stage, the system warns the user by vibrating the handle and the beeping sound of the speaker. In the second stage the system activates the helping arm to prevent the user from falling. This stage also turns on the flashing LEDs, the beeper and the vibrator. In the third stage the system turns on the LEDs and warns another person.

3. Possible Design Solutions

Over the last few thousand years, the design for the crutch has changed very little, but with the help of new technology, possibilities have arisen allowing more problems to be approached and solutions brought forth. Although the original concept of the crutch is very effective, some areas are still left untouched and as a result some people are left in strange situations, even situations that worsen their original condition. Listed below are some existing techniques used today for crutch safety, i.e. preventing users from falling while using crutches.

3.1 Special grip head

One of the issues found with pivotal heads is that once a certain angle is reached the head is no longer able to attain a high enough friction coefficient with the ground leading to further injury of the patient. Also these grip heads are not ideal for dusty floors or extreme environment conditions like mud, loose gravel, and other unstable ground surfaces.

3.2 Pivot head

One problem found in the pivoting head concept is that there is excess noise emitted from the head due to mechanical parts bouncing and rotating. Also, if a patient is of abnormal size the angled head can lead to breaking and a very dangerous fall.

3.3 Long curved head

Although the long curved head design allows for a smooth transition of weight it sacrifices strength and grip, especially near the initial contact surface, and once again large patients can suffer from breaking of the crutch. The fall happens during the beginning of applying pressure to the crutch; the force exerted on the head at perpendicular angles can exceed material strength and cause failure.

4. Proposed Solution

The proposed design solution of the system can be summarized by the way inputs are processed to outputs. Looking at **Figure 2**, we can see that the system consists of five inputs and five outputs.

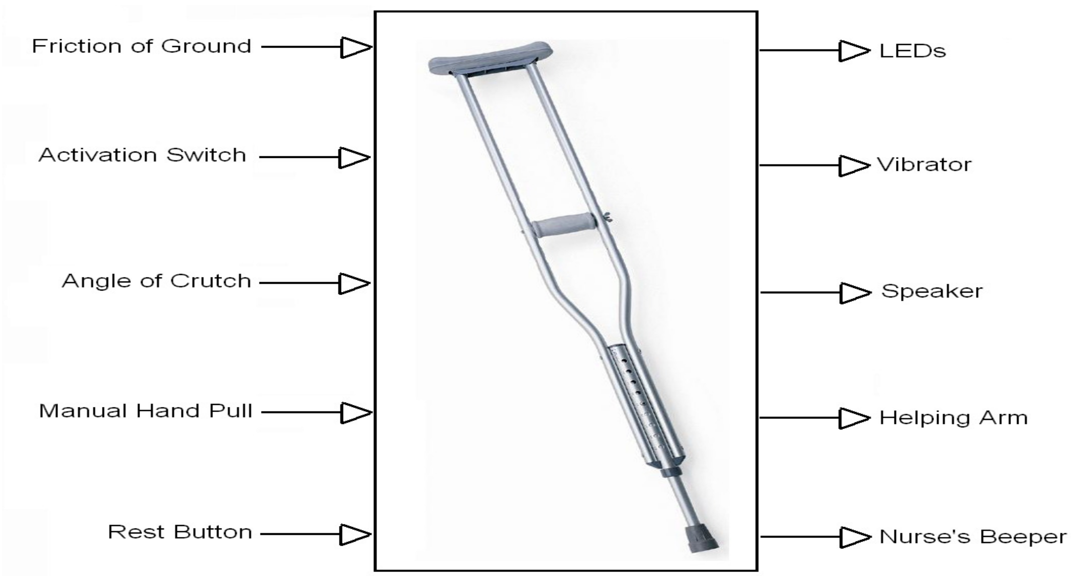

Figure 2 – Inputs and Outputs of the System

The friction at the bottom of each crutch is an input to the system. This input is being sensed by using a motor who's rotating surface touches the ground which detects any change in friction by the intensity of rotation. Fluctuations in the amperage of the motor's current signify changes in motor rotation intensity. The second input to the system is the activation switch placed again at the bottom of the crutch. This switch informs the system that the crutch is now on the ground and the motor should now sense the friction. The third input to the system is the detected angle of the crutch by an accelerometer. And the fourth input to the system is the manual hand pull which mechanically repositions the helping arm and resets the warning outputs. The last input to the system is the reset button which resets the warning outputs in the case that the crutch has felt down but the helping arm is not activated.

The five outputs of the system are the flashing LEDs on the two sides of the crutch, the speakers, the vibrator, activation of the helping arm and the beeper of the nurse.

For the overall behavior of the system, i.e. the microcontroller side, the microcontroller programmed to sample on a consistent clock cycle frequency to detect activations. **Figure 3** shows the possible behavior of the system using a flowchart.

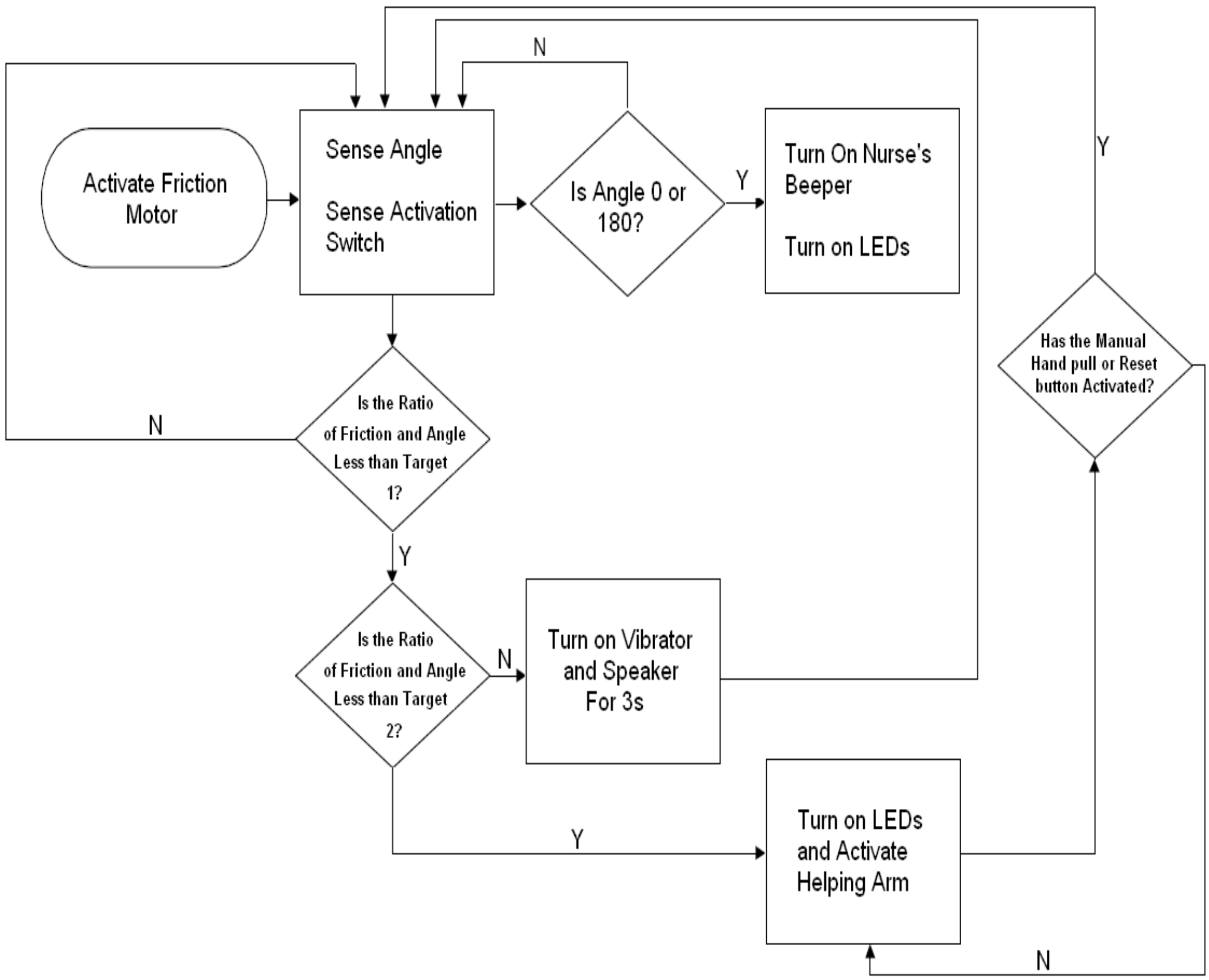

Figure 3- System Block Diagram

5. Sources of Information

To better understand and locate the problem of crutches, we first discuss with our group member, Ming-Cheng Lin, who is a current user of crutches due to injury. Through his daily experience with crutch in places like school, parking lots, and washroom, we are able to observe and outline some difficulties met by daily crutch users.

For the technology details of our solution, we have consulted Patrick Leung, who is the professor for this course and also the professor for course ENSC 387- Sensor and Actuators, for suggestion on the design of our motion sensor as well as the friction sensor. Three of our member are from the systems option and have exposed to a few mechanical design project using accelerometer and actuators from the course they have taken in the past. Their experience in mechanical design also helped the team find the solution.

Lastly, the Internet and engineering textbooks are a great source of information for this project. We can search on the internet for other studies made on crutch users and their safety concerns. We will also consult engineering literature for issues with the design of our proposed device.

6. Budget and Funding

6.1 Budget

As mentioned in the previous sections, there are three main functions for our Smart Crutch project. To minimize the cost of the project, we planned to use the Atmel AVR Butterfly board for the control system and the 3 axis accelerometer for the motion sensor. For the un-finalized design of the friction sensor and the support arm system, we planned to use simple mechanical design with motors and springs to achieve our goal so we only have a very rough estimate on how much the components cost. The total budget is estimated as the table below.

Equipment List	**Estimated Unit Cost**
2 Atmel AVR Butterfly board	80
2 Ming TX-99 V3.0 RF Transmitter	24.00
2 Ming RE-99 V3.0A RF Receiver	24.00
2 3 axis accelerometer	~90.00
Circuit components (op amps, capacitors)	30.0
Full wave rectifier	~40.00
Friction sensor and preventing system	150.00
Total Cost	~450.00

Table 1 – Equipment List and Cost

6.2 Funding

Our probable main source of funding is from the Engineering Student Endowment Fund (ESSEF) which can cover up to 60% of our proposed budget. We will also try to apply to different organizations for other sources of funding like the Wighton Engineering Development Fund. We are also aiming to get free circuit components from ENSC lab staff to eliminate the circuit components part of cost. Finally, personal contributions might be deemed necessary when funding is insufficient.

7. Schedule

Figure 4 shows our projected group milestones while Figure 5 shows the corresponding document related milestones.

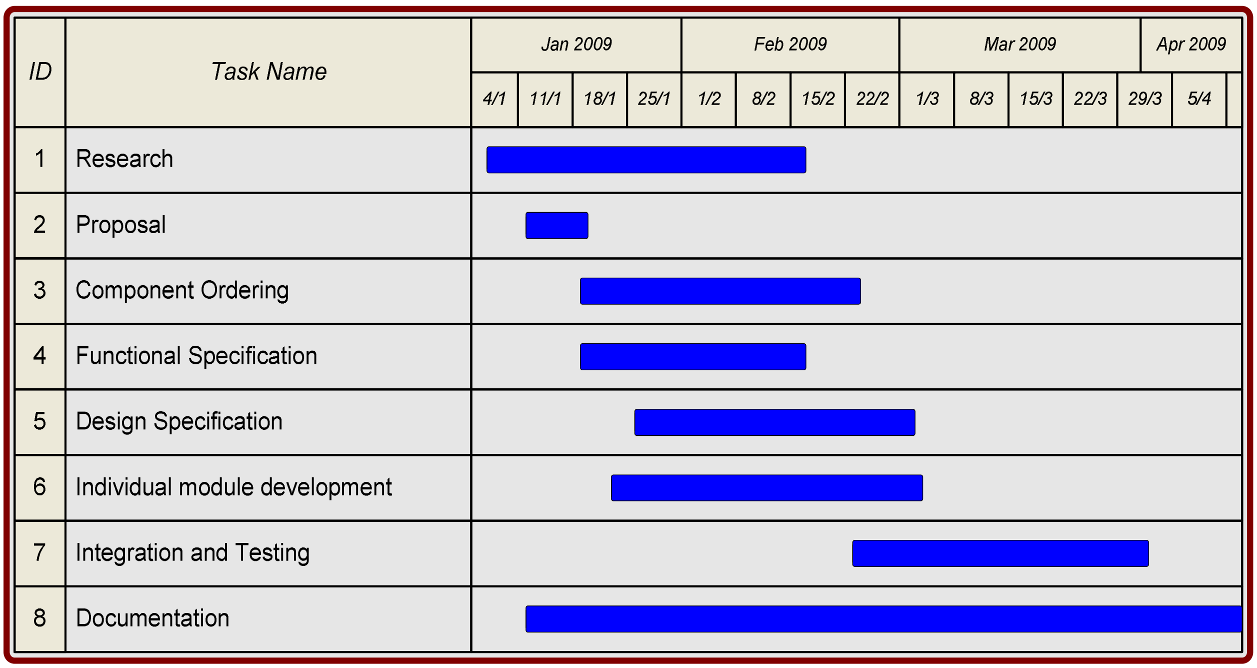

Figure 4- Projected Group Milestones

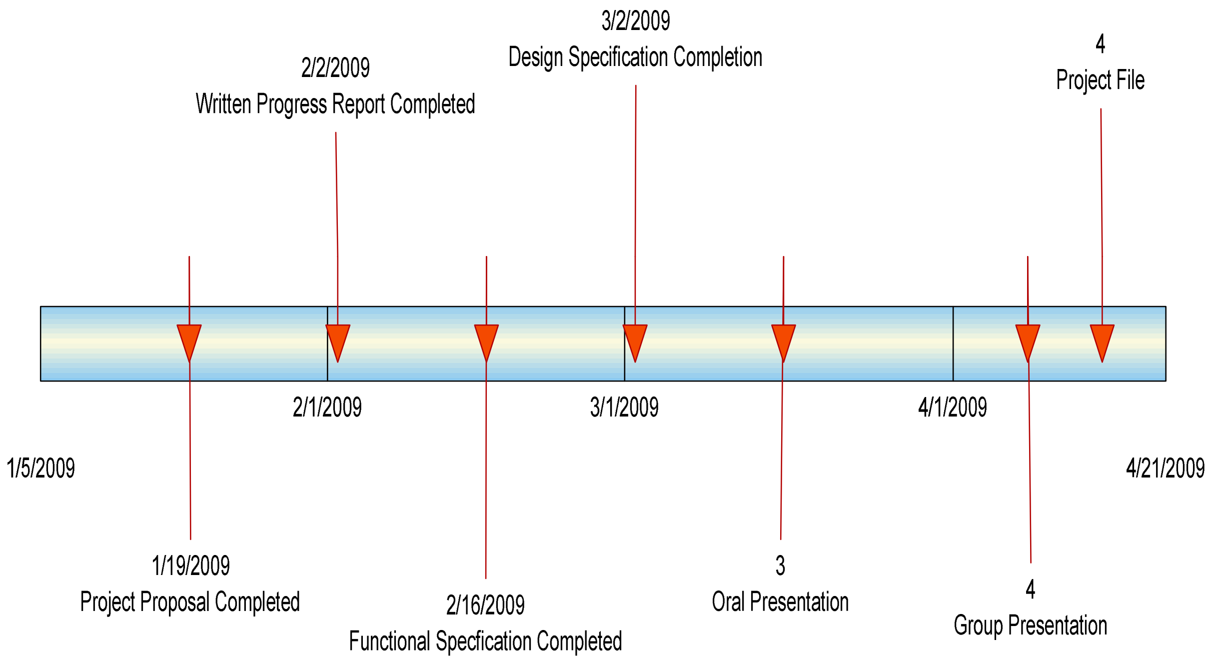

Figure 5 – Projected Document-Related Milestones

8. Team organization

Our team will consist of 5 engineers: 3 systems engineers and 2 electronics engineers. The systems engineers will focus on all mechanical aspects of the device while the electronics engineers will focus on the hardware and software aspects of the device. As a group of 5, we will exercise an *interactive type* of organization where one can express and exercise his ideas fully and the leadership position is only necessary for managing the group. After tasks or the design features are assigned to the group members, the person with the assigned feature has the final right to the design approach or design details he wishes to pursue in order to avoid conflicts with other group members. The other members of the group, however, are free to express their ideas on another person's design.

To assess our group's performance and the project development, weekly meetings are going to be scheduled every Thursday afternoon. While we do have a group milestone to give us structure for our project development, we will also have individual milestones presented to one another with specifics on how to develop our assigned device features. We also created our own mailing list, ensc440-asaconcepts@sfu.ca, for easy notification and exclusive communication between members. Lastly, we decided to make ourselves available to one another as often as we can by designating ENSC Lab 4 as our home base during the semester.

ASA Concepts is headed by Ming Cheng Lin, our Chief Executive Officer and President and the first person to conceptualize our product, the Smart Crutch. He will organize group meetings and assess individual and group performance. Our Chief Financial Officer, Ben Lush will manage our sources of funding and possible equipment and component supply. Our Chief Technical Officer, Amir Sadeghi who has a diverse background in mechanical and controls systems will be a great source of information for the mechanical aspects of the design. Chien Wen Lin is our Vice President of Marketing who will be in charge of group presentations and product promotions. Lastly, I, James Guerra, am the Vice President of Operations who will help the CEO in managing the group by being concerned with technical details of operation such as source control and procurement of equipments.

With our diverse backgrounds, we are confident that each member can contribute significantly to the project. We are driven by the excitement and independence to exercise our own areas of expertise during project development. Overall, we can say that our group has the right set of skills for this particular project.

9. Team Profile

Ming-Cheng Lin (Chief Executive Officer)

I am a 5th year student in Electronics Engineering at Simon Fraser University. I had two internship experiences both as a Hardware System Engineer in Equustek Solution and Broadcom Canada. My job task was involved with Hardware system design and PCB assembling. In addition to my strong hardware experience, I experienced C++ and VHDL programming in several FPGA and Embedded system school project. I am very interested in the communication system and have achieved good grades in communication related course. Aside from my academic skills, I also gained my leadership skills and spirit by leading a youth group in my church.

Amir Sadeghi (Chief Technical Officer)

I am a final year Systems Engineering student at Simon Fraser University with a previous Co-op term placement at Corporate Images. I have implemented many projects both in software and hardware designs. My skills are more focused in Robotics, Systems and Control. I have designed multiple robots in various courses and in Corporate Images. I have a deep understanding of hands on work and besides theory, during my Engineering practice time both at school and at work I have gain a lot of hands on experience on Mechanics and Electronics. Moreover, I have managed various groups and I have a deep understanding of business side of every project. Team management and communications are two strong abilities of mine.

Ben Lush (Chief Financial Officer)

I am a 4th year Systems Engineering Student at Simon Fraser University with a previous COOP self assessed placement at RP Electronics. My skill set is composed of interpersonal skills, hardware design, and software development. Through university studies and personal activities I have programmed C++, Java, Matlab, Watt analysis, and PSpice. Also I have designed and handcrafted PCB's using Eagle and Photoshop and lab materials.

James Guerra (Vice President of Operations)

I am a 5th year Electronics engineering student at Simon Fraser Univeristy with extensive COOP experience in software development particularly related to communications systems. My strengths include software development and digital design. I have learned how to program in C/C++ and Python, designed digital circuits using VHDL and modeled control systems using Matlab.

Chien Wen Lin (Vice President of Marketing)

I am a 5-th year system engineer student at Simon Fraser University with Specialties with software programming and mechanical design. From the pervious working experience, I am familiar with software testing and minor program for embedded system device by using C language. For the mechanical design, my strengths is on the function with CAD program like Solidwork, and also familiar with the mechanical device such as sensors and motors.

10. Conclusion

Providing a safety mechanism for a biomedical device is the ultimate goal of our company, ASA Concepts. With different approaches to solving the slipping problem while using a crutch, our approach tries to solve the problem by identifying its main causes, the friction between the rubber pads and the ground and the unpreventable instances that the user falls. Our solution provides successive means of solving or lessening the impact of the problem which includes warning the user before a slip or fall can occur, supporting the user when a slip or fall possibly occurs and warning the necessary people in case of a slip or fall of the user.

ASA Concepts is composed of motivated individuals coming from diverse backgrounds and experiences in engineering. We are driven by the excitement on working with our areas of expertise during the project development. We will do our best to follow the milestones we set for ourselves and for the group while constraining as much as possible the costs we might incur. Overall, the experiences and background of each group member is adequate for our proposed project.

11. References

1) January 18, 2009, “A Leg Up for Crutch Design”
http://www.businessweek.com/innovate/content/mar2006/id20060323_308523.htm
© 2009 by The McGraw-Hill Companies Inc.

2) January 18, 2009, “Innovative Crutch Designs: More Gain, Much Less Pain”
http://www.oandp.com/edge/issues/articles/2008-04_06.asp

3) January 19, 2009, “http://www.digikey.com” © 2009, Digi-Key Corporation

4) RP Electronics (Burnaby)