WIRELESS MEDICAL DEVICES

School of Engineering Science Simon Fraser University
Burnaby British Columbia Canada
ensc340-aadej@sfu.ca

September 16, 2002

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Subject: Project Proposal for ENSC 340: Wireless EMG Electrodes

Dear Dr. Rawicz:

The document enclosed with this letter, *Proposal for Wireless EMG Electrodes*, is a general framework for our ENSC 340 project. The goal is to develop a system to sense, acquire and wirelessly transmit muscle activity data from a patient to a computer. Without any wires limiting the patient's freedom of motion, this novel technology could revolutionize many aspects of rehabilitation, diagnosis and research.

This proposal includes several important pieces of information that serve to guide us in our development.

- General introduction to the proposed product
- Outline of design options
- Investigation of market potential
- Analysis of alternatives to our technology
- Sources of available funding
- Tentative project schedule
- Team organization

Wireless Medical Devices was formed in June of 2002 by four highly skilled and motivated Engineering Science students: Eric Chow, Aaron Ridinger, David Press, and Andrew Pruszynski. We look forward to hearing your comments on our proposal. Please feel free to contact me by phone @ (604) 782-7488 or email @ ensc340-aadej@sfu.ca.

Sincerely,

Jedrzej (Andrew) Pruszynski
Chief Executive Officer
Wireless Medical Devices

Enclosure: Proposal for Wireless EMG Electrodes

Executive Summary

Have you ever used Cable FM Radio? Did you even realize that you could plug your radio into your Cable TV outlet and listen to music? Not very many people have. Conventional (Wireless) FM is more convenient, portable and accessible.

An Electromyograph is a recording of muscle activity used for rehabilitation, injury prevention and performance enhancement. Unfortunately, current systems rely on the use of restrictive wires and equipment that result in inaccurate and inconvenient diagnosis. Applying wireless communications principles to Electromyography (EMG) will lead directly to better diagnosis, research and rehabilitation. These advances have far-reaching implications for corporations, insurance agencies, athletes and patients.

Corporations will increase productivity as they reduce injuries occurring in the workplace and speed recovery of those that do occur. Insurance agencies will substantially cut their payment to the injured as the recovery time is minimized. Athletes will have completely unimpeded measurements of their muscle activity and thus increase performance and suffer fewer injuries. Lastly, and most importantly, the injured patient will get better analysis and diagnosis leading to faster rehabilitation.

The Workers Compensation Board of British Columbia reports that the costs associated with rehabilitation of injured employees is above $200 million annually. This is in addition to the payments made while employees are away from the workplace. Each year, employers and insurance agencies lose tens of billions of dollars throughout North America due to lost productivity, rehabilitation costs and payments made to injured employees.

Wireless Medical Devices (WMD) is proposing a cutting-edge wireless solution to create completely independent Surface EMG sensors (iEMGs). These iEMGs will communicate with a personal computer that will capture and analyze muscle activity. Using our solution will yield complete independence and allow for large advances in research, diagnosis and rehabilitation.

At WMD we have a solid team of four senior Engineering Science students with experience in wireless communication, signal processing, biomechanics, systems integration, engineering physics and microelectronics.

This document proposes a 15-week engineering cycle ending early in December of 2002. It outlines a schedule and plan that will yield a working prototype iEMG System for a cost of $700.

Proposal for Wireless EMG Electrodes

Project Team: Eric Chow
Dave Press
Andrew Pruszynski
Aaron Ridinger

Submitted To: Dr. Andrew Rawicz
Mr. Steve Whitmore

Revision Number: 1.2

Revision Date: September 16, 2002

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1 – Introduction

Injury costs everyone. In British Columbia alone, the Worker's Compensation Bureau (WCB) spends $200 million each year on rehabilitation of injured employees and many millions more on supporting them while they are out of work.

EMG is a well-established and commonly used method of rehabilitation, injury prevention and performance enhancement. The two most common techniques of acquiring EMG data are tethered systems and dependent wireless systems. A tethered system connects the each EMG sensor to the Personal Computer (PC) by a wire. This essentially requires that the patient remains nearly stationary due to the restrictive bundle of wires attaching their body to the computer. A dependent wireless system connects each sensor via wire to a bulky communications box. Again, the wires and heavy communications box impede the patient's movement and complicate setup.

We are proposing a system of eight independent wireless EMG sensors (iEMGs) that attach to the skin with a small adhesive pad. Each sensor independently transmits the muscle activity data in real time to our Data Receiver Card (DRC) that can be mounted in any PC. Our application software will collect, analyze and display the acquired data. Each sensor will be small and lightweight, minimizing the effect on a patient's movement. It will also be easier to setup as there are no wires that must be carefully routed and attached to the patient's body. The patient will have the freedom to move naturally anywhere within 100 meters of the DRC.

WMD will be using proven EMG sensors and established wireless communications techniques to develop the iEMG solution. Our product will be more portable, easier to use, and more accurate than the current available systems. By eliminating all wires, iEMG can be quickly and easily setup in any environment. For example, it can be setup at a track to monitor a sprinter's performance or brought to the office to investigate the causes of lower back pain. The lack of wires greatly reduces the restriction on the subject's movement which, in turn, leads to more accurate diagnoses.

EMG is the first of many applications that will be pursued by WMD. By applying our proven transmission technology with this product, we will be able to transfer the technology to other medical devices such as Electroencephalograph (EEG), Electrocardiograph (ECG), and Wireless Stethoscope.

This document outlines the proposed iEMG solution, gives an overview of the competition, states sources of resources and funding, defines an initial corporate structure and constructs a timeline of the engineering cycle.

2 – System Overview

The following figure gives an overview of the proposed system structure and operation. In this diagram, each iEMG sensor is acquiring and transmitting muscle activity data to the DRC in the PC. The PC then records and processes the acquired data. The activity of each individual muscle is transmitted to the computer, which recognizes the originating iEMG, decodes the muscle activity data and makes the information available for the user.

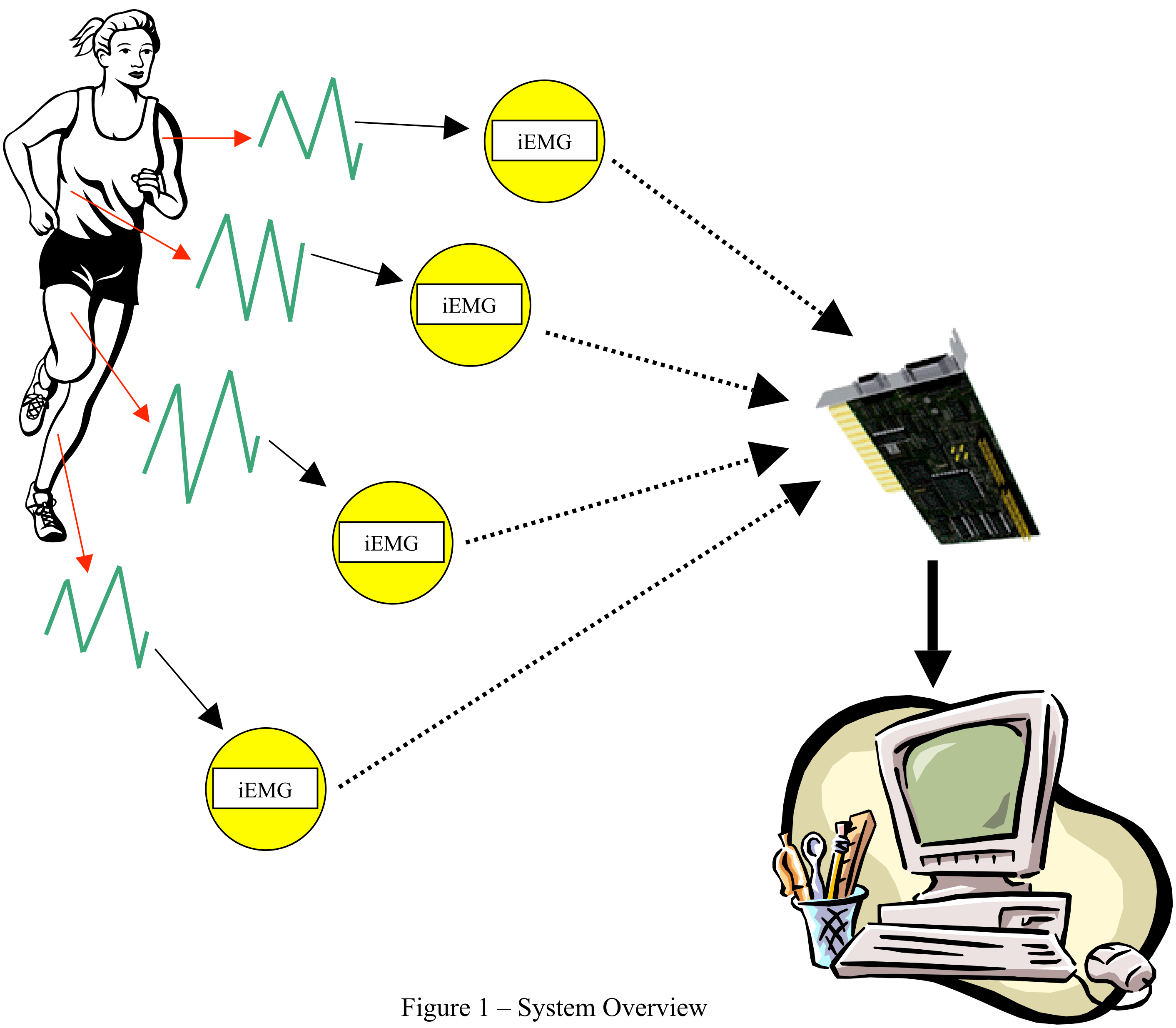


Figure 1 – System Overview

3 – Other Solutions

This section outlines the three other commercially available methods of acquiring EMG data.

3.1 – Tethered Multi-Wired

The *tethered multi-wired* system is the classical EMG solution that connects the sensors directly to the computer by means of insulated copper wire. This is the most commonly used version of EMG and it severely restricts mobility. This places serious limitations on testing options and value of the obtained results. When using hardwired EMG sensors, the tester must ensure that the wires do not physically interfere with the testing. Due to the limitation of being physically tied to the computer, many actions simply cannot be effectively studied. There are also restrictions on the length of wire connecting the sensors to the computer. Extensive effort and time is required to attach and route the wires in the least obstructive positions on the human body and to the computer. All these factors mean that testing of natural motion in an everyday environment becomes cumbersome and nearly impossible.

3.2 – Tethered Single-Wired

The *tethered single wire* system is a newer and uncommon solution. The user is still tethered to the computer but this is via a single wire capable of transferring information from each of the sensors. Each sensor is wired to a box on the body, which then communicates with the computer via a single cable. This system still suffers all the same problems as the multi-wire system with the exception that a single connection point slightly reduces physical obstruction.

3.3 – Dependent Wireless

The *dependent wireless EMG* system is a large step forward in creating a less limited environment for testing. These systems are made of several EMG electrodes that are wired to a body-mounted communications box that interacts with the computer for analysis. This eliminates the restraint of being connected to the computer, which allows the patient to move freely in the natural environment to perform the desired motion. Although it no longer restricts *where* the patient moves, it still restricts *how* they move. The many wires that are still routed on the body together with the heavy communications box impede natural motion. The system is difficult to setup as wires must still be connected and routed along the subject's body.

4 – Proposed Design Solution

Wireless Medical Devices proposes an innovative and exciting advancement in EMG technology. This product, called iEMG, is a completely independent EMG system that gives total freedom to the patient and tester. These EMG sensors are each capable of communicating directly to the computer system and they eliminate the need for wires and bulky communications boxes on the body.

The system is a large step forward from currently available products as it eliminates many barriers associated with evaluating and interpreting muscle activity. iEMG grants the tester the assurance that the system is not interfering with the subject's motion. Our product can be taken anywhere as it is not tethered to a large computer system and can operate on any desktop or notebook PC. iEMG permits more detailed and conclusive on-site studies that help prevent injury, lead to better diagnoses, and speed rehabilitation.

The initial stages of this product are confined to a fifteen-week period that must end before the close of Simon Fraser University's Fall 2002 semester. There are also limitations associated with the funding for this project. This limits the development work to eight prototype iEMGs, a DRC and basic data analysis software. These prototypes will prove our concept of completely independent EMG sensors, but may lack sufficient miniaturization and broadcast range (due to funding limitations and not available technology). Thus, the prototype may be physically larger than the final, marketable product and may not reach the desired 100-meter range. A longer development cycle and larger budget would allow us to create a complete system of eight or more miniaturized, long-range iEMG sensors.

This is a very exciting product with a large potential market including insurance companies, government agencies, doctors, researchers, employers, and trainers. iEMG will allow better diagnosis, more accurate research and faster rehabilitation. Everybody wins with iEMG.

5 – Sources of Support and Information

Wireless Medical Devices has concentrated on developing a wide network of support and information. These sources of information include academic contacts, industry expertise, published research, and internet searches.

We have close contact with Professors and Researchers at Simon Fraser University. Dr. Ted Milner of Kinesiology is principally concerned with understanding how the central nervous system controls limb mechanics. He is an expert user of EMG systems. Dr. Jacques Vaisey of Engineering Science has a great deal of experience with wireless communications and DSP. Lastly, Dr. Andrew Rawicz of Engineering Science works in the field of Biomedical Engineering and can provide general technical and entrepreneurial expertise.

We have also developed close technical links with industry that allow us to take advantage of their unique perspective. VTech Engineering provides wireless communication support and access to components. Contacts at Nortel Networks and Brooks Automation may also provide useful sources of electrical and systems engineering support.

WMD has taken great advantage of the published papers in rehabilitation engineering and biomechanics journals. We are also able to consult textbooks containing well-established DSP and wireless communications techniques. Other extremely useful sources of information are the web sites and product specifications of EMG competitors.

In addition to technical sources of information, WMD has made great steps in building a network of business support. The marketing and business building advice gained from contacts at Brooks Automation and Embedded Automation have been critical in our corporate development. WMD has created and is continuing to develop a large and diverse network of technical and business support.

6 – Budget and Funding

6.1 – Budget

A preliminary budget for the prototype iEMG system is shown in Table 1. The table presents costs for building eight iEMGs and 1 DRC. There is no cost associated with the software development. We have already acquired 8 EMG sensors, valued at $300 each. Miscellaneous components include items such as op-amps, resistors, capacitors and switches. Each cost has been over-estimated by 10% to deal with contingency.

Table 1 – Budget

Item	Estimated Cost
EMG Electrodes	$0
Wireless Transmitters	$300
Wireless Receiver	$100
A/D Converter Card	$100
Batteries	$100
Miscellaneous Components	$50
Enclosure	$30
Adhesive Pads	$20
Total	**$700**

6.2 – Funding

WMD is considering several sources of funding for this project. We are applying to the Wighton Development Fund, the Engineering Science Student Endowment Fund and the University Industry Liaison Office. We have already secured a donation of EMG electrodes valued at $2400 from Dr. Ted Milner. WMD is also approaching members of provincial and federal government for nominal donations. We also have personal contacts with several Vancouver-area angel investors.

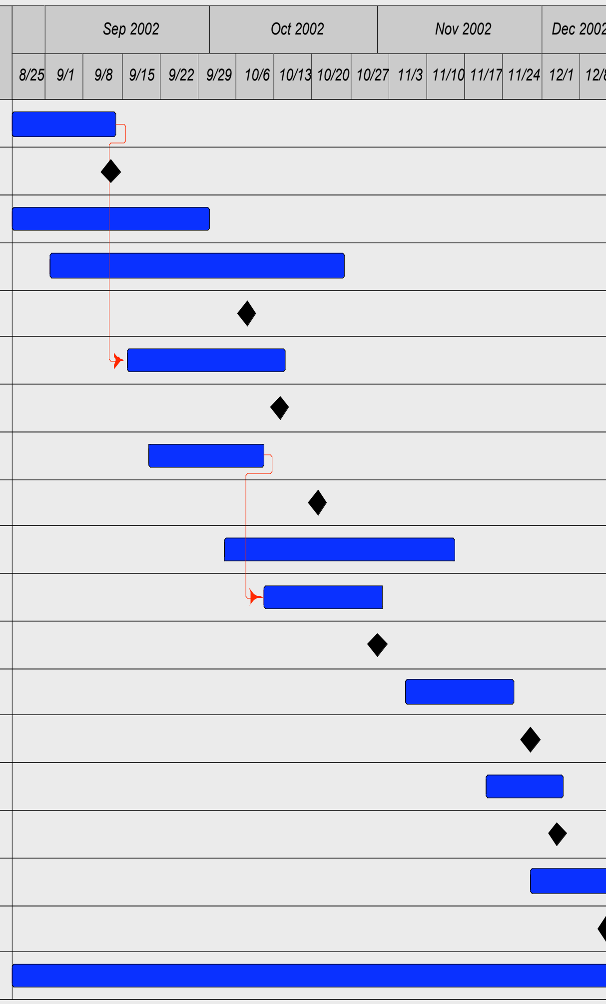
In the event that sufficient capital cannot be raised, our budget can easily be scaled down by reducing the number of iEMG sensors produced. As a final resort, the company members are willing to contribute personal capital to the project. We will be using a single credit card to track expenses and assure fair reimbursement.

7 – Schedule

With such a tight engineering cycle, it is extremely critical to plan, create and maintain an accurate and reasonable schedule. Table 2 shows a Gantt chart explaining the timing and duration of the major development stages. This figure also outlines the major milestones that identify several critical days during the engineering cycle to ensure achievable goals throughout the semester.

Table 2 – Gantt Chart

ID	Task Name	Start	End
1	Proposal	26/08/2002	13/09/2002
2	Proposal Completed	13/09/2002	13/09/2002
3	Research	26/08/2002	30/09/2002
4	Material Collection	02/09/2002	25/10/2002
5	1st Progress Report Completed	08/10/2002	08/10/2002
6	Functional Specification	16/09/2002	14/10/2002
7	Functional Specification Completed	14/10/2002	14/10/2002
8	Initial Design Specification	20/09/2002	10/10/2002
9	Design Specifications Finalized	21/10/2002	21/10/2002
10	Initial Prototype Build	04/10/2002	14/11/2002
11	Design Specification	11/10/2002	01/11/2002
12	Design Specification Completed	01/11/2002	01/11/2002
13	Prototype Testing	06/11/2002	25/11/2002
14	2nd Progress Report Completed	29/11/2002	29/11/2002
15	Prototype Revision	21/11/2002	04/12/2002
16	Product Prototype Completed	04/12/2002	04/12/2002
17	Post Mortem Report	29/11/2002	16/12/2002
18	Final Documentation Completed	13/12/2002	13/12/2002
19	Document and Website Maintanance	26/08/2002	13/12/2002



8 – Organization

Each member of WMD contributes a unique and diverse base of knowledge and experience. This ensures that our technical and business development will have the support of a wide range of ideas. Diversity is critical to our success and it has played a large role in the organization of Wireless Medical Devices.

A specific role within the organization has been assigned to each team member. These roles are in place to ensure continual movement towards the goal of a working prototype within the specified engineering cycle. However, since the bulk of this project is focused on technical development, each team member will contribute their time and skills to this area. Specifically, David Press and Eric Chow will focus on developing the wireless communications link between the iEMG and DRC. Andrew Pruszynski and Aaron Ridinger will focus on hardware and DSP development. As the project evolves, group members will shift their focuses to the technical areas that need the most development.

As Chief Executive Officer (CEO), Andrew Pruszynski manages fundraising efforts and is the main contact person at WMD. Aaron Ridinger, as Chief Financial Officer (CFO), is in charge of the company's bookkeeping and budgeting. Our Chief Technical Officer (CTO), David Press, plays a critical role in directing the company's technical development. Finally, Eric Chow, as Chief Operations Officer (COO), is in charge of daily management issues and keeping minutes and action items at meetings.

The company will hold weekly meetings at a designated time and location that is convenient to all the group members. Andrew Pruszynski heads the weekly meeting to ensure that it is kept brief and on topic. This meeting will set corporate activities for the next week, discuss outcomes of the previous week and review long-term progress. Following each meeting, Eric Chow will email the group a detailed listing of minutes and action items.

Our team members have all worked together on other time-consuming and stressful projects and have always succeeded. We feel that our experiences and mutual understanding will help us through the engineering cycle.

Past students of Engineering Science 340 have faced large problems with time management. By delegating responsibility to those who can best handle it and remaining dynamic as the project progresses, WMD ensures results.

9 – Members

Andrew Pruszynski – Chief Executive Officer (CEO)

I am a fourth-year Systems Engineering major and Political Science minor at Simon Fraser University. My areas of expertise are systems integration and control theory. I have also taken part in several large-scale systems integration projects in robotics and communications. I have worked in the field of biomechnics and have been exposed to EMGs and their applications and problems. In addition to my technical skills, my Political Science background has given me the oral and written communications skills that will allow me to support Wireless Medical Devices with internal management support and external business development.

Aaron Ridinger – Chief Financial Officer (CFO)

I am a fourth year Electronics Engineering student at Simon Fraser University. My past experience includes a co-op term at HeatWave Technologies Inc. where I researched and prepared a business plan outlining expansion opportunities for the company. Other projects include a website, corporate logo design, and other graphic layout applications. Through past courses and projects I have experience with real-time, embedded systems and signal processing.

David Press – Chief Technical Officer (CTO)

I am a fourth year Engineering Physics student at Simon Fraser University. My previous co-op experience focused on digital optical communications at Luxtera, Galian Photonics, and Nortel Networks. I have programming experience in C/C++ and Motorola Assembly language. I am also experienced in application building with Visual Basic. My primary strengths are excellent problem solving abilities and a proven track record of academic and project success.

Eric Chow – Chief Operations Officer (COO)

I am a fourth year Electronics Engineering Student at Simon Fraser University. All of my previous co-op work terms have been related to the wireless communications industry. At Philips Semiconductors I was a test engineer for CDMA Cellular Phones. I also spent coop terms as an RF Hardware engineer at VTech Engineering and Norsat International. In addition, I have taken leadership roles in several organizations. My experience in the wireless communications field along with my interpersonal skills will allow me to support Wireless Medical Devices in a number of areas.

10 – Conclusion

Wireless Medical Devices is committed to applying standard wireless communications principles to the science of electromyography (EMG). Our product, the iEMG, will lead directly to better diagnosis, research and rehabilitation. It will reduce costs to insurance agencies, governments, employers, and employees by reducing injuries in the workplace and returning injured subjects to work sooner. iEMG is superior to existing EMG technology, granting complete freedom and no obstruction so tests can be done anywhere, anytime with any motion.

We have provided a thorough Gantt chart that lists and sets a schedule and establishes milestone dates throughout the engineering cycle. This document presents diversified sources of support and information that will help our technical and business development. We have identified and are pursuing potential sources of funding. We have also set out an organizational scheme that maximizes our corporate advantages of diversity, experience, and knowledge. The combination of a very novel product and a thorough plan will lead to meeting our objective of creating a working prototype of the iEMG before the end of the planned engineering cycle.

Wireless Medical Devices has an exciting product, a good plan, and a talented group of people. All this leads to one place: SUCCESS.

11 – Sources and References

- Dr. Ted Milner, School of Kinesiology, Simon Fraser University
- Dr. Jacques Vaisey, School of Engineering Science, Simon Fraser University
- Dr. Andrew Rawicz, School of Engineering Science, Simon Fraser University
- Mr. Alakkatt Sajeev, Senior RF Engineer, Vtech Engineering

- DelSys Inc. Electromyography – www.delsys.com
- Philips Semiconductor – www.philips.com

- Journal of Biomechanics
- RF Prototyping Techniques – University of California, Santa Barbara