Monarch Technologies Inc.
1234 Boundary Road, Burnaby, BC, V5A 4R9
Email: ensc440-monarch@sfu.ca

April 17, 2009

Mr. Patrick Leung
School of Engineering Science
Simon Fraser University
8888 University Drive
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Post Mortem for a Motorcycle Racer Training Device

Dear Mr. Leung:

Monarch Technologies is committed to designing a motorcycle racer training device that will aid in improving racers' skills on the track and act as an informative device off the track. The training mechanism will be a light, robust, and rider friendly device that will detect and display the lean angle of a turn and track the position of the motorcycle which will be transmitted wirelessly to a base station concurrently. This device will be a small mountable product with a set of LCD and LED displays to show the lean angle of the motorcycle and some keys to power the device and select modes.

The attached document, *Post Mortem for a Motorcycle Racer Training Device*, details the current state of our device, how the scope of this device changed during the development cycle and what future plans our group has for this device. We plan to discuss the topics of budget, timelines, deliverables, group dynamics and what we have learned from this project.

Monarch Technologies is a new engineering firm operating in Vancouver, BC. Our staff has a wide variety of experience ranging from software and hardware programming, and mechanical and electric circuit design. We will complete the duties associated with this project with the same diligence, competence and pride of workmanship as we have displayed on the previous projects that we have undertaken.

Please do not hesitate to contact us with any questions or comments about the post mortem.

Sincerely,

Ted Meredith	*Dan Carter*	*Freya Santos*	*Helia Sharif*
Ted Meredith Chief Executive Officer	Dan Carter Chief Technical Officer	Freya Santos Chief Marketing Officer	Helia Sharif Chief Financial Officer

Enclosure: *Post Mortem for a Motorcycle Racer Training Device*

Post Mortem for a Motorcycle Racer Training Device

Project Team:

Ted Meredith
Helia Sharif
Daniel Carter
Freya Santos

Contact Person:

Ted Meredith
ted.meredith@gmail.com

Submitted to:

Patrick Leung
Steve Whitmore
School of Engineering Science
Simon Fraser University

Issue Date:

Friday, April 17, 2009

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1.12

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1234 Boundary Road, Burnaby, BC, V5A 4R9
Email: ensc440-monarch@sfu.ca

Abstract

The Motorcycle racer training system was developed successfully. There were, however, several important deviations from our functional specifications and an issue with measuring lean angle during a turn. This document outlines the current functionality of the system, indicates where we deviated from our original plan, and demonstrates what would be implemented in future development of the system. The projected and actual budget and milestone timelines are then assessed. The document is concluded by each team member discussing their contributions, issues they faced, and reflect on their experience and what was learned throughout the course.

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Glossary

GPS	Global position system	LED	Light emitting diode
IC	Integrated circuit	MCU	Microcontroller
I/O	Input/output	RF	Radio frequency
LCD	Liquid Crystal display	USB	Universal serial bus

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1.0 Introduction

Monarch Technologies has been working since January 2009, to develop a system that can detect the lean angle of a motorcycle as it moves through a turn, couple that lean information with GPS position data and wirelessly transmit this information to a laptop PC to be processed. We undertook this endeavour so that motorcycle riders, both hobbyists and professional riders, could see how they perform in a turn and improve their handling skills.

1.1 Scope

This document is intended to provide information on the current state of our device and how the scope of this device changed during the development cycle. Furthermore, what future plans our group has for this device will also be discussed. Lastly, we highlight the topics of budget, timelines, deliverables, group dynamics and what we are taking away from this project.

1.2 Intended Audience

This document is intended for those people that have followed along with this project from the beginning of January, 2009, and have familiarized themselves with the basic scope of this project as it was defined in the functional and design specifications of the Motorcycle Racer Training device.

2.0 Current State of the System

As mentioned in the project proposal document, the lean detector system will have 2 modes of operation. In the more basic of the two, it will assist the hobbyist rider by providing a measurement of the bike's lean angle after a turn by displaying the numerical angle value on an LCD display while a series of LED lights communicate the relative severity of the turn. The more sophisticated version of the device will couple GPS tracking capability with lean angle information and transmit that data to software which is running on a PC, providing real-time information to the race crew. The crew can analyze this information to make enhance the performance of the vehicle and the rider on the track.

The lean detector system has five main components: GPS, Inclinometer, Microcontroller (MCU), RF transceivers and PC Data Acquisition software. The onboard module consists of the GPS, Inclinometer, MCU, and RF Transmitter. The base station module contains the RF receiver and PC software for data processing and display. A block diagram of the onboard module's subcomponents and data direction are shown in Figure 1. Figure 2 is the base station module's components and the direction of data involved.

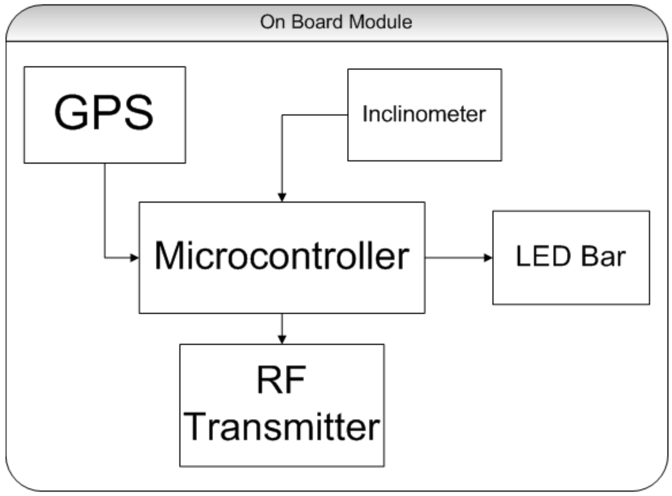

Figure 1: Onboard module

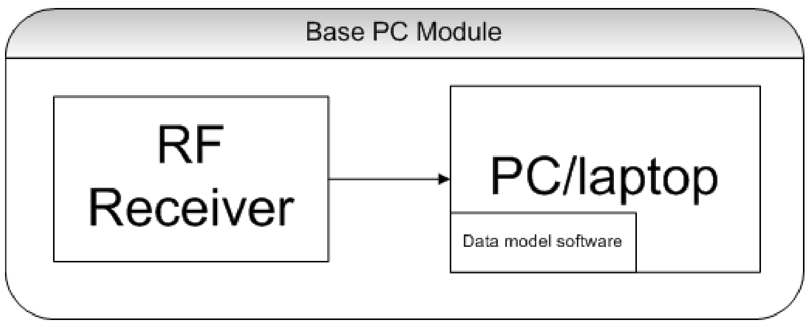

Figure 2: Base station module

As of April 17 2009, we have designed and built a functioning prototype as per the first prototype requirements set forth in both our functional specification and design specification. In other words, we have created:

1. An onboard module consisting of an angle measuring sensor, microcontroller, GPS chip and wireless transmitter
2. A base station module consisting of a wireless receiver and software to interpret the data wirelessly transmitted
3. A small, unobtrusive device that won't interfere with the rider's operation of the motorcycle
4. A wireless trans receiver that successfully sends and receives data up to 500 meters in the line of sight

The system, as illustrated in Figure 1 and Figure 2, contains several key components.   We will describe the components and functionality of the on board module and base station module in the following paragraphs.

The on board module is contained within a plastic enclosure which houses the electrical circuit components soldered to a single piece of protoboard, 4 1.5V AA batteries to power the components, a

1.5V AA battery for GPS memory backup, and a GPS antenna. The enclosure has an on/off switch on the outside, and there are two windows cut into the lid to display the LED bar and the LCD angle display, as shown in Figure 5.

Figure 3: Internal circuitry

Figure 4: The Protobox

Figure 5: Power switch located at side, windows on lid for LED bar and LCD screen

Figure 6: A lean angle displayed and visually through LED bar (note degree is a decimal place)

The inclinometer is connected to the ADC port of the microcontroller. The angle reading on the LCD display is refreshed at a rate of 4Hz. When stationary, it has an error of about ±0.3° for angles between 0-40°. The accuracy decreases as the angles become higher due to the nature of the inclinometer and the equation used to calculate angle from voltage. Around 80°, the error becomes 3.1°; this increase in error is because we are using an Analog to Digital converter with finite precision and an angle conversion equation that uses an arcsine calculation. The result of arcsine becomes very sensitive to variations in its argument near the extremes of its domain. The maximum angle that a competitive racer could ever be expected to reach would not exceed 70°. The error for this angle is approximately 1.2°. The inclinometer unfortunately is inaccurate when it is measuring the lean of a motorcycle during a turn. When the motorcyclist is turning, the motorcycle is not only affected by gravity but also centripetal forces, which influences the reading of the inclinometer dramatically. During a complete system test, we expected lean angles of at least 20 degrees but received small angle values in the average of 5 degrees instead.

To illustrate an example, we will use a pendulum as our 1-D inclinometer. Please note that we do not know how the sensor behaves internally because this information is not provided in the datasheets, so the following is our theory on what could be happening. Assuming rider is turning to the right, he/she will be leaning clockwise. Figure 7 shows a pendulum lean angle due to gravity (left) but when the centripetal force is considered, the pendulum moves back close to the center axis (right). The image to the left is the same as leaning when the rider is stationary (and we have established that the inclinometer is very accurate in static cases), but when turning is involved, our 1-D inclinometer alone is erroneous because of the centripetal force.

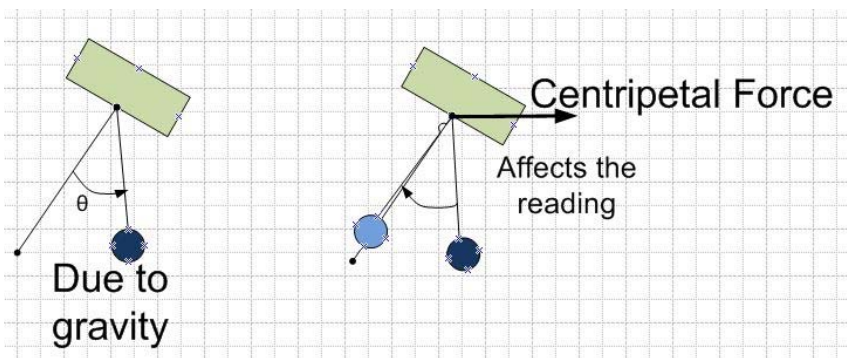

Figure 7: Theory on why inclinometer reading is inaccurate

The GPS is connected to the USART receive interface of the microcontroller. The GPS receives location and time data once every second from satellites orbiting the earth and serially transfers them to the microcontroller. For every GPS time, longitude, and latitude reading that is received, it is transmitted serially to the XBee chip through the USART transmit line along with the current lean angle information. Note that while the LCD lean angle display is refreshed 4 times a second, only one of these readings is sent to the PC for processing.

The XBee is a fairly advanced wireless transmitter, intended for use in ad-hoc wireless sensor networks. We use its most simple functionality - as a transparent serial transmission line. Data sent through one XBee's serial data input port at the correct baud rate will appear at the serial data output port of the receiving XBee. Apart from level converters to make sure the serial signal was at the correct voltage levels, the XBee didn't need to be configured a great deal. In our system, the microcontroller sends GPS time and location data and angle information to the transmitter XBee. The receiving XBee is connected to a PC or laptop which processes the information.

The PC module receives serial data via the XBee. We used MATLAB to process and display the data. MATLAB is set up to read from the serial port until a specific code in the data tells it that a full string of data has been received. It then does three important things with this data:

1. Plots data points on a map to indicate the path the on board module has taken
2. Adds time, location, and lean angle data to a table
3. Indicates current lean angle using a descriptive visual plot

3.0 Implementation Deviations

There were very few implementation deviations in the project. The main reasons for these changes are to decrease the required physical space, so that we can keep the module as compact as possible, and to maintain the simplest design possible.

At first we planned on implementing the LED bar circuit control through circuit components like a few comparators chips and/or an LED driver. However this method will require more hardware (i.e. using additional resistors and IC chips) which will take some space on the overall protoboard and will be another part that will draw additional power.

The AVR butterfly microcontroller has several I/O ports available for external use and we decided to reconsider the idea of using software to control and drive the LED bar circuit and allow the microcontroller to power the LEDs directly. This idea is less challenging, cost effective, requires less power and physical space, and is adaptable since software is easier to modify than hardware.

Similarly, instead of building the RS232/Logic level converter and serial I/O circuit for the XBEE receiver to communicate with the laptop/PC, we decided to purchase an XBee Explorer USB. This is a miniature device that contains the RS232 converter and sockets for the XBEE chip to mount onto. Additionally this device has status LEDs, and connects directly to the PC via mini-USB, which is desirable since the laptops we have for testing only have USB ports and no RS232 serial ports. Going forward with the XBee Explorer USB idea prevented us from complicating the design and the process of XBee receiver to PC communication; thus, saved us time and allowed us to focus on other parts of development.

In our functional spec, we intended to sample GPS and inclinometer data many times a second. We soon realized, however, that the GPS only gathers location data once a second. Because of this we decided to gather and send angle data to the PC once a second as well. It is foreseeable that inclinometer data could be sampled more frequently and the location values could be interpolated for a more accurate analysis, but we chose to keep the data sampling to once a second to match the function of the GPS.

Because a schematic of the LT1081 chip in any of the manufacturer's data sheets doesn't exist, we had used LT1080 model's instead (under the assumption that they are practically the same). Soon after, we realized that the internal circuitry is not quite the same and hence our description of the connections in the functional spec had to be changed in order to have a working wireless module.

The following figure below demonstrates the corrected circuitry between our XBee sender chip and the LT1081 which was connected to the MCU (via the RS232 cable).

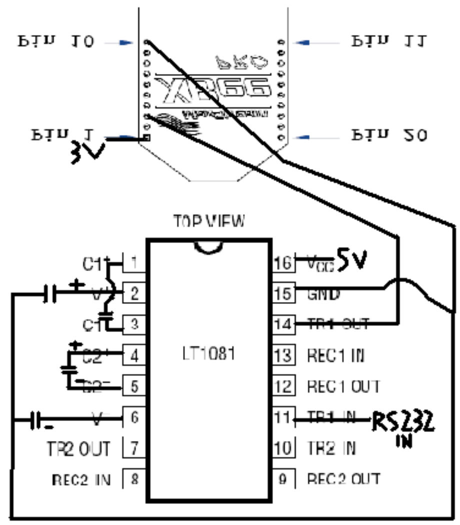

Figure 8: Modified XBee and LT1081 circuitry

4.0 Future Improvements

In the future versions of the product, we plan to expand our wireless coverage by investing in a much more expensive but more promising unit that will allow us to communicate with the base station without direct line of sight, and increase data resolution by using a GPS unit with higher transmission rate and/or sending more samples to the base station. Another important feature that should be implemented is error checking in the wireless transmission; currently our system communicates one way and there is no handshaking between the transmitter and receiver to check for errors and/or retrieve missing or incomplete data. Of course, future iterations of this project should aim to minimize the onboard module dimensions to a smaller form factor, consider using a microcontroller with at least 2 USART ports for 2 way communications with the wireless controller and GPS.

We have confirmed that the current Inclinometer is not an ideal component for our purposes since it is affected by 2 forces while turning (which is when the motorcycle is leaning): gravity and centripetal forces. The presence of the centripetal force affects the output of the inclinometer and so the lean detector system requires another way to measure the lean. . We propose to implement a sonar method in our future designs where the orientation of the handlebars relative to the centre of the bike which is with reference to the road, can measure the lean angle and essentially replace the current inclinometer.

Presently the user is unable to view the LCD screen in low lighting due to the minimum visibility, so a LCD screen with backlight should be added to future designs. It might be desirable to measure the temperature of the components or at least use heat sinks in the hardware to ensure that the device is not overheated when it is used for long durations and/or under hot weather conditions. Also the protobox should be sealed properly in order to decrease the deterioration and fully satisfy the CSA standard.

For user friendliness, our future model will have a longer or much more reachable joystick for operating the device. Also, we'd like to indicate the amount of battery's life on the LCD screen so that the user is aware of when he/she should pursue a change of batteries.

5.0 Project Timeline and budget

In the Project Proposal we highlighted the projected prototype schedule and development milestones. The first Gantt chart below in Figure 9 contains the project management tasks and displays the projected and actual amount of time each task took to complete. The prototype development milestones are shown in the second Gantt chart (Figure 10) and detail the projected and actual time of completion.

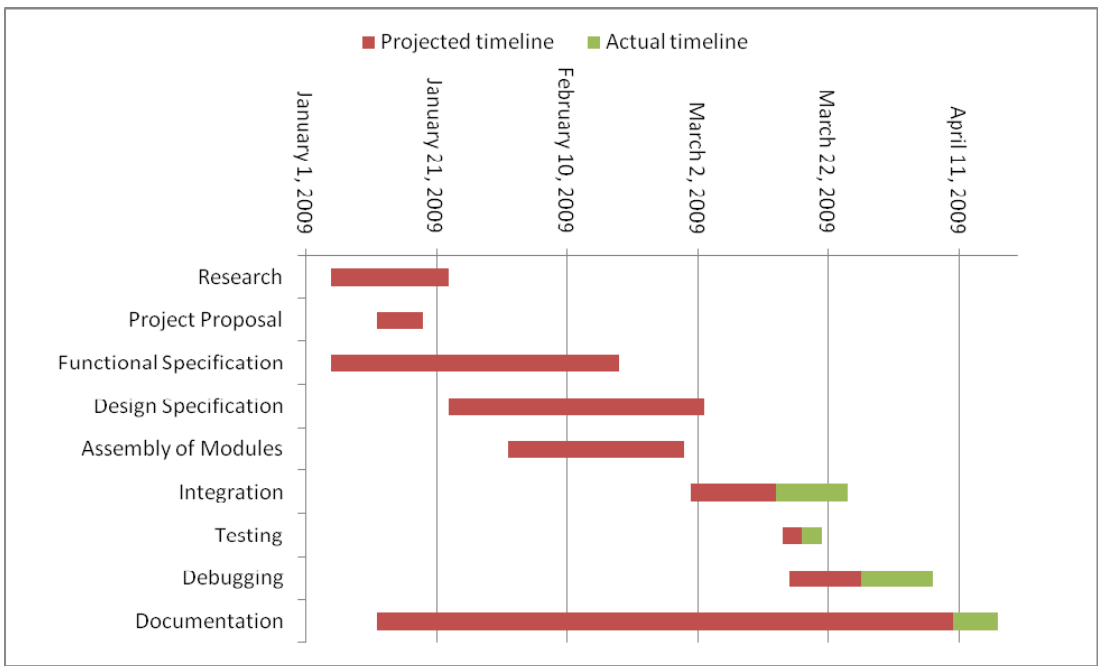

Figure 9: Gantt chart of project management tasks (planned and actual timelines)

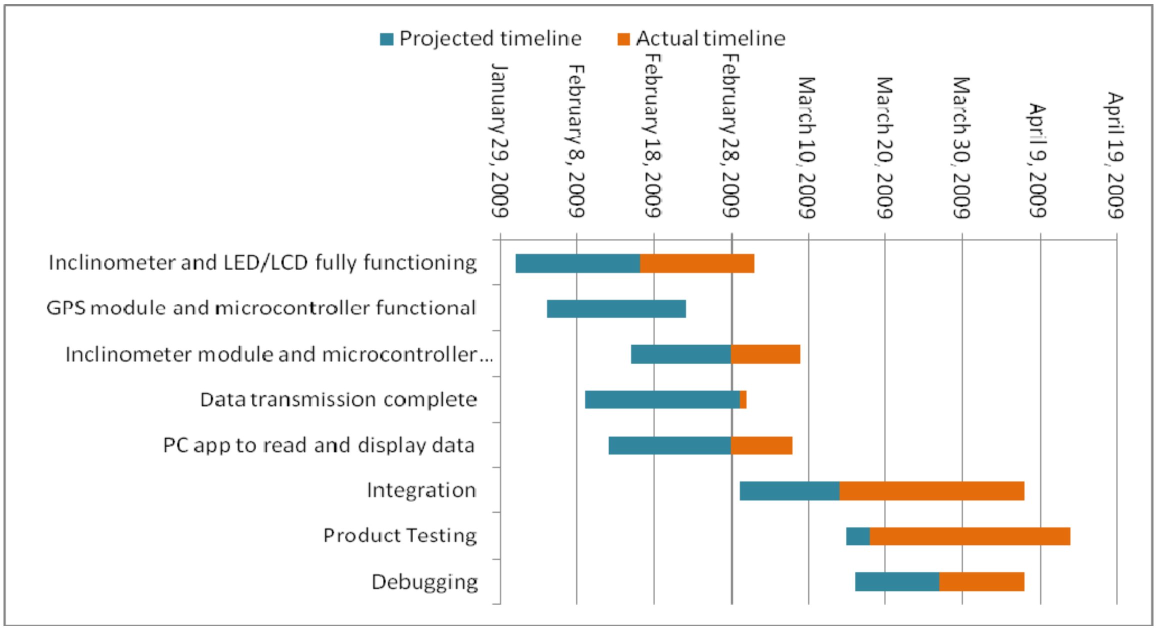

Figure 10: Prototype development Gantt chart (shows projected and actual timelines)

As one can see, the projected timelines for documentation and project management tasks were achieved on time, whereas the prototype development timeline had varying differences between the planned and actual timelines. Some reasons for this are design reconsiderations in the LED bar circuit, later orders of hardware (such as the Inclinometer replacement and XBEE PRO breakout boards), integration of the physical onboard system proved to be challenging and required much more planning than anticipated, software code debugging, and product testing was affected by weather conditions also. The most time-consuming task was integration, which affected other milestones such as product testing and debugging. This is further seen in the detailed list of the development milestones and the planned and actual completion dates are included in Table 1.

Table 1: Development milestones completion dates

Milestone	Target Date of Completion	Actual Date of Completion
Project Proposal	January 19, 2009	January 19, 2009
First Progress Report	February 4, 2009	February 4, 2009
Functional Specification	February 18, 2009	February 18, 2009
Design Specification	March 3, 2009	March 3, 2009
Inclinometer and LED/LCD fully functioning	February 15, 2009	April 2, 2009
GPS module and microcontroller functional	February 22, 2009	February 20, 2009
Inclinometer module and microcontroller functional	February 28, 2009	March 9, 2009
Data transmission complete	March 1, 2009	March 2, 2009
PC app to read and display data	February 28, 2009	March 8, 2009
Integration	March 14, 2009	April 7, 2009
Product Testing	March 18, 2009	April 13, 2009
Debugging	March 27, 2009	April 7, 2009

In the start of the project, we projected the total costs of the first prototype to be close to $1000, and we applied for funding from the ESSS Engineering Fund. We were granted $650 and in the end, to our pleasure, $650 was sufficient to fund our first prototype. Table 2 details and compares the projected and actual costs of our project.

Table 2: Projected and Actual costs of materials

Part	Estimated Cost	Actual costs
VTI Inclinometer x 2	$150	$153.80
Microcontroller	$100	$119.83
GPS module	$250	$0 (donated by Enlightenment Solutions Corp.)
Wireless controller (transmitter and receiver)	$300	$84.94
Mounting brackets, headers, enclosures	$50	$44.26
Misc. items – batteries, voltage regulators, protoboards, work order	$150	$185.8
Total	**$1000**	**$588.63**

As shown above in Table 2, the overall material cost of the prototype is almost half of what we budgeted for despite getting a replacement inclinometer and building a second integration prototype. The main discrepancies are the estimated and actual costs of the wireless controller for transmitter and receiver and the GPS module. At first we approximated the whole wireless controller to cost $300, since initially we assumed we'll be creating and using our own wireless network. The XBEE Pro chips are RF transceivers that meet the functional specs we require and totaled to $85. Generally, GPS chipsets are in the price range of $50 to $110 (price is proportional to accuracy of the GPS), and fortunately we did not have to purchase a GPS module because a partner company, Enlightenment Solutions Corporation, donated their GPS engine board for the first prototype.

6.0 Group Dynamics and Personal Experiences

When the four of us began preparing for this project in December 2008, it quickly became clear where the roles would fall. Dan was in computer engineering, so the responsibility of programming the microcontroller fell to him. Freya, Helia and Ted were in systems engineering, and so were naturally inclined towards the hardware aspects of the project. Ted took on the responsibility of researching and designing the sensor and power systems, Freya took on the GPS system and Helia researched the wireless system. Additionally, Ted and Freya began investigating possible options the PC application that would manage and display the data sent from the lean detector.

Significant research had to be undertaken in each area. Dan had to learn how the AVR Butterfly operated, what ports would be required and how the MCU would be programmed. Freya had to understand how the GPS chip communicated and via which pins, how the data was encapsulated, how satellite information was acquired and how quickly location information could be generated. Helia had one of the most difficult tasks: what wireless transmission format should be selected for the project for transmitting the data from microcontroller to PC and, thus, what chipset should be selected. Ted had to research numerous sensors to determine which would best suit the needs of a hostile environment (vibration, shock and heat resistant, suitable degrees of freedom, low cost) and investigate how the overall system would be powered. Finally, he had to plan how the entire system would be integrated.

For the most part, the dynamics of the group were very good. All members have known each other for at least three years, and many had worked with each other in previous courses and labs. But like most things, nothing runs perfectly. There always seems to come a point in any group dynamic where the group is tested under stress and our group was no different. In the end, despite what seemed like a serious fracture in the group dynamic, all members were able to pull together for the monumental task of creating a second version of our prototype in only four days, and just three weeks before our demo. If anything, the fracture only served to show that the group dynamic displayed by us was in fact much stronger than we had originally believed.

6.1 Ted Meredith

My contributions to this project were the idea for a lean detector itself and many of its requirements, designing the power and inclinometer circuits, planning the overall hardware integration and assisting with the overall case design. There are many things I will take away from this project. What I liked the most about this project was that it gave me the opportunity to learn without the narrow scope of a set curriculum. As we started down the road to completing the various stages of our project, I had to research and learn many new concepts and figure out solutions to problems as they arose. This free-form learning process allowed for maximum flexibility, while at the same time maximizing the knowledge acquired. All of us would take on whatever we were required to so that we could achieve the next milestone in our project. This form of learning I can excel at.

Another aspect of this project that I think is important is to plan, plan, and plan some more. Someone I feel I fell short with on the hardware side was not putting enough planning into little things like case design. In our engineering lab classes we spend so much time focusing on getting the proper output from an oscilloscope that we often overlook many other things. This really came back to haunt us near the end of March. We had all worked quite diligently, juggling this project with our other academic and extra-curricular activities, to build a functioning prototype by the middle of March. However, I had put little to no real thought into the appearance of our prototype. While we had paid plenty of attention to function, little was paid to form. Thus, when we were required to remake our prototype with roughly 3 weeks until our demonstration, we became quite panicked. In true engineering fashion though, we rose to the challenge presented to us and within 4 days had a second, functioning prototype with a vastly superior form factor.

The last concept I will take away from this project is really more of a reminder to me than new knowledge: always communicate! Two-thirds of the way through this project, the situation was becoming tense and I was feeling the stress of it. There is nothing inherently wrong with this, we all feel stress and manage it in different ways. What is important in these times, though, is to make certain you communicate well with your partners and don't internalize all the stress. Conversely, when they are under stress, keep those lines of communication open with them – it will help out everyone in the group, not only you or that other member.

All in all, I am really proud of what we have accomplished in the timeline we were given and under the constraints of the requirements that were set forth. That four of us could take a complicated idea and make it into a real device in less than four months is nothing short of remarkable. I feel fortunate to have been accepted as a member of this group and I'm happy with what I was able to contribute.

6.2 Freya Santos

Being an integral part of the Monarch Technologies team and undertaking this project has been a fulfilling venture. I assumed the role of project manager to gain practical experience in leading and planning meetings, organizing and shaping the project schedule and budget, and keeping the team up to date regarding any upcoming milestones and issues.

The main parts I worked on were the GPS and the MATLAB program to receive and display the data from the moving unit. I also worked a great deal with Dan when programming and testing the AVR Butterfly microcontroller with the LED bar circuit, GPS, and XBee transmitter. To become a sufficient GPS lead of the team, I investigated other GPS applications, learned about the NMEA output functions and its interpretations, and understood the basic functional and power requirements of the GPS chip. Through this role, I was able to learn about how GPS works and thus broaden my technical understanding.

I provided software support to the team in 2 main parts: creating the PC application that will read and process the incoming data from the onboard module, and producing a LED bar function in the microcontroller program. Before taking on this project, I have never programmed in MATLAB before! Through extensive research and using programming knowledge from previous programming courses, I was able to design a MATLAB GUI application that creates a serial connection to the XBee Receiver chip, while the serial connection is maintained, it reads the incoming data from this chip, parses the string to extract the time, position and lean angle values, then plot the position on an axes, display the lean angle visually on the GUI and display these values to a data table, and then reads for incoming data again, etc.

I am impressed that I stepped outside my comfort zone of non-programming and pleased to see that I ended up becoming one of the main software contributors to the team.

Integration was definitely the most challenging milestone. The two main issues were lack of planning in putting the physical onboard module together and software bugs appeared as more incorporations of parts were done, affecting overall performance. Since we didn't put a lot of planning into integration at first, our first version of the prototype had a lot of wires between the lid components and the bottom protoboards and so there was a lot of pulling and loosening of wires as the lid was opened and moved around. This obviously affected the function of the module because loose wires mean missing connections and thus more debugging. It was very frustrating because at times we didn't know if the issues we were seeing where hardware or software! We decided to clean up the board and basically to start from scratch and getting a new protoboard, and enclosure for the onboard module but this time with planning before soldering anything down which I helped facilitate in planning. The second time worked A LOT better! We used the thin wires, kept all wires under the board (unless this was a connection between the top and base layer), soldered all base components onto one board, and used nuts and bolts to keep the board and top components (microcontroller and LED bar board) rigid. This was a key team accomplishment, since we pulled this off in 3 days.

Two main integration software bugs were program resets and freezes. The first issue was due to an interrupt flag being enabled by the bootloader, and was fixed by disabling that flag. The program freeze issue was due to the timer counter not being properly set after the counter interrupt occurred, which Dan figured out. A false alarm issue was not getting a satellite fix with the GPS after the 2nd version prototype integration. This frustrated the team because we weren't sure if we connected wires wrong or the GPS engine was damaged. In the end, it turned out that we just didn't have a good view of the satellites. Dan and I tested it out at the Terry Fox Field one night and were able to get a fix within 10 minutes (this is from not having any ephemeris or almanac data at all) as expected. The point is, in the end, we were able to get through the numerous debugging and integration woes, because we acted as a team, supported each other when others were down, and well, didn't gave up.

6.3 Helia Sharif

The motorcycle lean indicator device has been a very valuable experience for me. Working as the Chief Financial Officer and the Wireless Team Lead, I've had the privilege of overseeing both the technical and non-technical aspects of the project. Applying my expertise from my recent internship as the Beta Program Coordinator at Research In Motion, I was able to create a series of extensive test cases to ensure that all components are tested to their full extent. Wanting a challenge, I took over the responsibility of finances which involved funding and budgeting of the equipments for the prototype and testing purposes.

Initially, having consulted with a group of former ENSC 440 students (including Jason our TA) and Digikey's technical support, I was expecting the XBee Pro module to require extensive programming in order to have the two wireless chips to communicate with each other. Luckily, the default settings were sufficient for our purposes and that I was able to set up the module much faster than I had anticipated. Striving for perfection, I spent the majority of my time on integration and installation of the components. In order to ensure that the product retains its safety requirements, I took over the responsibility of the layout design which included the design of the protobox. By choosing a waterproof, light but durable box, not only will the components remain weather protected, but they will also be presented much more professionally.

Some of the issues that I was facing throughout the project were mainly due to the low funding as a result of economic crisis. The XBee Pro module's coverage is only within the line of sight which limits our test cases; had we gone with a more advanced option, we wouldn't have been able to afford the costs but the results would have been much more desirable. Our initial protobox consisted of a Ziploc topper ware box that was selected because it was inexpensive, durable, water resistant, and easy to cut through. We had to borrow our GPS unit from a former ENSC 440 team to cut down on the costs; but because the GPS components didn't belong to us, we weren't allowed t o modify their board in order to create the most compact design possible. During our testing, our Inclinometer module blew up which put a strain on our finances and also delayed the integration and the overall testing.

Once all components had been verified and tested separately, I was able to come up with a layout that would allow our GPS, Inclinometer, voltage regulator and XBee protoboards to be mounted on the bottom as the base layer followed by the MCU butterfly and the LED bar protoboards mounted on top of them. The design would allow for airflow between the boards while being compact. When Dr. Leung expressed dissatisfaction with the layout of our protobox, because we didn't have sufficient money left over to purchase backups and rebuild the circuitry, we had to take a tremendous risk and reuse our existing chips. Luckily we were granted permission to modify the circuitry of the GPS unit to an extent, so we were able to create a much more condensed and slicker design.

I'm very lucky to have had the opportunity to work with such dynamic group. Every individual in the team has brought a different background and expertise to the table, providing us with an endless sea of solutions to every aspect of the project. Walking away from this diversified team, I know that I can handle almost anything in my future endeavors. Having gone through all stages of this project (from the creation of the proposal to the final marketable design), I am confident that I can approach any problem and reach a solution by myself.

6.4 Dan Carter

I came into this course expecting and expected to be the "software guy", but luckily I got a lot more than that. I took on the role of head software developer and was responsible for programming the microcontroller. In the research phase, I looked into many different choices for wireless chips, but I have to credit the rest of my team with just about everything else from looking up parts and ordering them in.

My main contribution to software development was interrupt service routines for parsing GPS data and LCD display timers. I shared a great deal of the programming responsibility with Freya, having spent several afternoons and nights in the lab just the two of us working on code issues. It was great to work alongside her can-do-it attitude and a huge asset to have her as out team leader as well. There was a lot of problem solving involved that taught me to always question my original assumptions and not hesitate to go back and read data sheets even if you feel like you understand everything perfectly. At one point in the final days of software coding, we went back to read the datasheets to solve a problem that had been plaguing us for several weeks. The fix took one line of code.

Like I said earlier, I came into this expecting to be the software guy, and I was happy to leave hardware to the other members. During our project redesign later in the semester, however, I got to work directly with hardware and I am very glad I got this opportunity. I designed the component layout for the main protoboard in our new design and got some experience desoldering and soldering chips. I literally hadn't soldering in years! Ted and Helia did a great job designing and putting together the rest of the new design. As a result of my new experiences with hardware, I feel a lot more confident in these areas. I definitely recommend trying new areas that you're not totally comfortable with. Anyone who's an expert at anything had to start out knowing absolutely nothing. Don't sweat it and ask lots of questions.

Later in the semester there was some conflict between members of the team. I will take away a very important lesson from that. If you are having problems with another team member, the worst thing you can ever do is to keep it to yourself and let it seep out in emotional bursts or in your behavior towards that person. It can be hard to confront someone you have an issue with, but I think when you try to be totally honest and objective, they appreciate that more than anything. It's easy to say and hard to practice, but say what's on your mind and let others know how you're feeling. It creates a great, open atmosphere as opposed to a closed one with silent resentment towards the issues.

I also learned the important of being reliable and doing what you say you're going to do. If you're not going to do it, then don't promise you will to artificially reassure others. Early in the semester, I had problems getting to meetings on time and being dependable to the team. As time went on, I realized how that was negatively affecting how I was perceived by other members and also my ability to contribute.

Personally, I never felt at any time during the semester that things were hopeless and that there was no end in sight. The entire team had a great can-do-it proactive attitude that easily led us through any difficulty, including redesigning our entire physical layout in only 3 days. This semester will be a 4 months I will never forget and look back on as one of the most important periods of my time here at SFU.

7.0 Conclusion

What started out as an idea a couple of years into engineering here at SFU was finally realized in April 2009. In less than four months, four engineers took that idea and turned it into a working prototype. Not only did they build a device, but they met nearly all the functional and design specifications they set for the prototype. This was no simple feat.

However, looking back over what we learned designing and building this prototype, knowing what we now know of the parts that are available for such a device and the information collected from industry research, we realize that the target audience that we were aiming for doesn't quite have the interest that we need. Throughout the project we have discovered a whole new untapped market which is just starting to grow and would be an ideal candidate for our design.

As we move forward, the population and consequently interest in this sport of motorcycling is gradually increasing; as a result, safety is becoming a primary concern of all riders and motorists alike on the road. We recognize that companies such as On-Star* and airbag manufacturing companies will be our main consumers.

This project has been a very valuable experience for us all, as the learning opportunity it provided us was immense. These kinds of projects are perfect to talk about to potential employers in an interview situation, as they show the independent learning that all of us in this group have undertaken and highlight the initiative drive we all possess to see a project through to successful completion.