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

February 16, 2009

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

Re: ENSC 440 Functional Specification 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 enclosed document, *Functional Specification for a Motorcycle Racer Training Device*, specifies the general, environmental, performance, safety, and usability requirements, the hardware and software interface requirements, standards and regulations our device will meet, and an overall test plan summary.

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 PC concurrently. The deliverable 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.

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 projects we have undertaken previously.

Please do not hesitate to contact us at ensc440-monarch@sfu,ca with any questions or comments about the functional specification.

Sincerely,

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

Enclosure: *Functional Specification for a Motorcycle Racer Training Device*

MONARCH TECHNOLOGIES INC.

Functional Specification for a Motorcycle Racer Training Device

Project Team:

Ted Meredith
Freya Santos
Helia Sharif
Daniel Carter

Contact Person:

Ted Meredith
ted.meredith@gmail.com

Submitted to:

Patrick Leung
Steve Whitmore
School of Engineering Science
Simon Fraser University

Issue Date:

Monday, February 16, 2009

Revision:

1.8

Executive Summary

To date, there are no devices in the motorcycle market that assist a hobbyist rider *and* race team by providing lean information. Our product is uniquely situated to exploit this oversight and provide motorcyclists with this information. Our device will assist the enthusiast rider, providing information in real-time on rider performance. For the race rider, a more sophisticated version of the device will couple GPS tracking capability with lean information and transmit that data to software running on a PC, providing real-time information to a race crew. The crew can then analyze this information to make improvements to machine and rider and increase their chances at achieving victory on the circuit.

The system consists of 2 main sections: onboard module and the base PC module. The onboard module consists of the lean detector, GPS, Atmel microcontroller, and RF transmitter. The base PC module is the RF receiver, laptop or PC, and the PC application. Since the onboard module is mounted on the motorcycle's handle bars and will be used outdoors under rapid speed, it is vital that the module is portable, miniature, durable, and non-obstructive. Throughout this document we specify and detail the functional requirements that the overall system should accomplish.

Some of the requirements are specific to prototype or production phases, and these will be noted explicitly. We foresee the overall design process to contain three main phases: first prototype, later prototype iterations, and production unit.

The completion date of the first prototype is April 2009 and the primary requirements we will focus on delivering are:

- Two functional modes: Motorcycle Trainer mode and Enthusiast mode
    - Mode 1: Motorcycle Trainer Mode
        - Lean and GPS information transmitted wirelessly to a PC with a software application that will be display the data in real-time
    - Mode 2: Motorcycle Enthusiast Mode
        - Sensor for detecting lean angles and a display system for showing sensor output
- Minimum RF transmission range is 100 meters and is within line of sight
- GPS accuracy is 7 meters
- Onboard module will have a LCD display will show the highest angle inclination of rider after a turn
- Onboard module will have LED bars that light up sequentially to indicate lean direction and corresponding lean magnitude

For the production stage, the transmission range should be able to cover more range, GPS reading and RF transmitting will be strong and consistent in different weather conditions, and all components shall be built with environmentally friendly components that satisfy RoHS.

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

Table of Contents

List of Figures

Glossary

ADC	Analog to Digital Convertor
GPS	Global Positioning System
GUI	Graphical user interface
LCD	Liquid Crystal Display
LED	Light emitting diode
MCU	Microcontroller
PC	Personal Computer
RF	Radio Frequency
RXD	Received Data
RoHS	Restriction of Hazardous Substances
UART	Universal Asynchronous Receiver Transmitter

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

1.0 Introduction

Monarch Technologies is working to develop a motorcycle racer training device, using lean angle measurements, GPS and wireless data transmission. This unique solution will allow riders to collect data about how they ride, in order for them to fine tune their performance and provide them with a competitive advantage over other teams and riders. Furthermore, this system will also have a secondary function of only providing the lean information to riders after a turn off track.

1.1 Scope

This document describes the functional requirements for the first prototype Monarch Technologies is developing, hereafter referred to as the Lean Detector, consisting of one onboard module and one base PC module. The onboard module consists of the inclinometer sensor, MCU, GPS and wireless transmitter, while the base PC consists of a wireless receiver, laptop PC and software.

This functional specification outlines the requirements and operations which need to be standardized for the first prototype. Furthermore, included in this document are requirements that we will incorporate into future iterations of the Lean Detector. These various requirements will be differentiated in this document as follows:

(1) A functional requirement for the first prototype unit
(2) A functional requirement for future prototype units
(3) A functional requirement for production units

Functional requirements will be broken into various sections, and will denote as follows:

[FR#] (X) A description of the particular functional specification,

where [FR#] refers to a single, discrete requirement, (X) refers to (1), (2) or (3) above and is followed by a brief description of the particular specification.

1.2 Intended Audience

This document is intended to act as a reference for the various parties working on this project. For the design team, the requirements are guidelines for design decisions. Management can use this document to assess the current state of the project and determine whether the project is keeping to schedule.

Marketing can use this document to develop marketing materials needed to promote the product in the marketplace. Marketing can also use this document to compare feature sets between this product and competitors' devices, and position the Lean Detector accordingly against those competitors.

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

2.0 System Overview

The Lean Detector is comprised of a number of discrete components, controlled via a central microcontroller. An inclinometer measures the lean angle of the motorcycle and sends this data via a ADC line to the Atmel MCU. The MCU collects this data into a series of sequential values, while collecting a single GPS measurement for this angle set. The MCU then packages this data together and sends it to the XBee wireless transceiver for transmission to the laptop PC base station. Figure 1 below shows this scheme, while Figure 2 shows the module interaction of the Lean Detector.

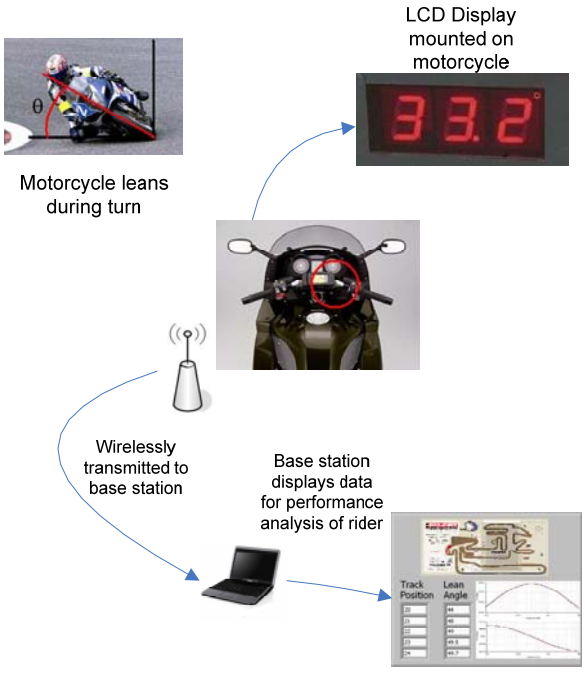

Figure 1 - System overview

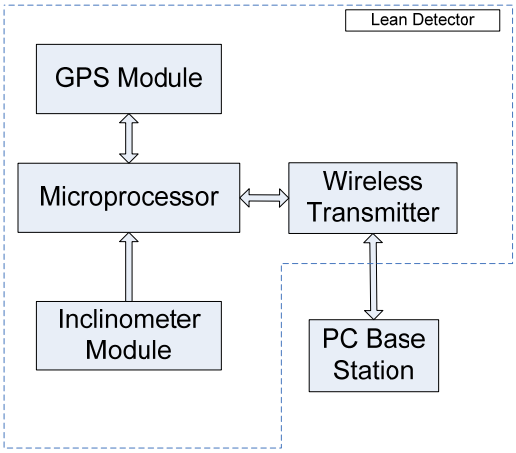

Figure 2 - Lean Detector modules

2.1 General Requirements

[GR1] (1) The onboard module must be mountable onto a Honda CBR1100XX motorcycle's handlebars.
[GR2] (3) The onboard module will have adjustable mounting brackets to enable the onboard module to work with any motorcycle.
[GR3] (2) The onboard module must be simple to operate with one hand.
[GR4] (3) The total weight of the device must be less than 250g.
[GR5] (3) The number of buttons on the device must be minimized.
[GR6] (3) A button's purpose must be straightforward to discern.
[GR7] (3) The onboard module must be housed within a durable, waterproof case.
[GR8] (2) The onboard module must be simple to mount on a motorcycle.
[GR9] (2) It must be easy to distinguish values on the LCD display when viewed from all angles and in varying light conditions.
[GR10] (1) The onboard module must be battery powered.
[GR11] (3) The onboard module must be powered from the motorcycle and be simple to connect to the motorcycle's power supply.
[GR12] (1) The onboard module must be able to transmit data at least 100m.
[GR13] (1) The onboard module must be able to communicate with GPS satellites while outdoors.
[GR14] (1) The PC application must be able to display usable, relevant information on the laptop base station.
[GR15] (1) The Lean Detector must be able to operate accurately at high speed (~300km/h).

2.2 Hardware Interface Requirements

The main hardware interface is the onboard module mounted on the dashboard of the motorcycle. It must be intuitive for the user to operate and display information in a useful way that does not interfere with the normal operation of the vehicle. The interface of the first prototype will have a display for the lean angle, some colored LEDs, and joystick switch. The production unit will likely have several buttons instead of the joystick.

[HIR1] (1) The onboard module will have a visual display mounted on the bike that will show the lean angle of the most previous turn.
[HIR2] (1) The microcontroller will communicate with the GPS and XBee wireless module via a serial data interface at 9600 baud.
[HIR3] (1) GPS and inclinometer data will be wirelessly transmitted to a PC for processing and display.
[HIR4] (2) The lean angle will be updated on the LCD display only after a turn is completed to prevent the rider attempting to read it during a turn (very dangerous activity).
[HIR5](1) There will be LED bars that light up sequentially showing the lean direction and reflecting lean magnitude.

2.3 Software Interface Requirements

The software application will be installable on a PC or laptop. It will be a GUI with wireless drivers to receive data and plot values on a map.

[SIR1] (1) Base PC module will allow user to view the trajectory and lean angle of the device in real-time with a delay of less than 1 second.

[SIR2] (1) PC software will display course trajectory traveled by device with corresponding lean angle reading.

[SIR3](2) Software drivers must incorporate error checking because there is no communication link in the PC to microcontroller direction to request resending of lost data packets.

[SIR4](3) PC software will be compatible with Windows XP, Vista, and Mac OSX operating systems.

2.4 Environmental Requirements

[ER1] (3) The onboard module must be resilient to adverse weather conditions (rain, moisture, cold).

[ER2] (1) The onboard module must be vibration and impact resistant.

[ER3] (3) The Lean Detector must be manufactured with durable components.

[ER4] (1) Operational environment is an outdoor motorcycle racetrack.

[ER5](3) The RF transmitter shall be able to provide adequate RF transmission in weather conditions such as fog, rain, and cloudy.

[ER6](3) On-board module shall be enclosed and resistant to water and other liquid spills.

[ER7](3) Onboard module shall be able to obtain an adequate location acquisition, within the provided margin of error, in all weather conditions.

2.5 Safety & Security

The main reason for creation of this device is to design a safer environment for the rider and others on the road. The product will not only serve as a training device for learners, but also assist professional racers and motorcycle enthusiasts to enhance their quality of skills by minimizing their errors.

[SS1](2) User will not view the exact angle of the inclination during the turn, as it will take away their focus from safe riding. Instead, they will be able to see the maximum lean angle after the turn or view the processed results at a stationary location.

[SS2](1) The LED bar on the device will light up providing a rough estimate of the lean for the rider.

[SS3](3) To reduce theft mishaps, the portable device is designed to fit in the trunk of the bike while not in use.

[SS4](3) The wireless data transmission will be password protected such that only the intended audience will be able to gain access to the personal information.

[SS5](3) While the motorcycle is at rest, the device can be used as an alarm system to notify the owner in case of accidents (i.e. if the bike has been tipped over or is being moved).

2.6 Performance Requirements

2.6.1 Onboard module

[PR1](1) Onboard module shall acquire the GPS location in less than 50 seconds of initial power up outdoors [1].

[PR2](1) Onboard module shall have a GPS accuracy of at least 7 meters for proof of concept [1].

[PR3](1) Onboard module shall have a maximum inclinometer error of ±0.23 degrees [2].

[PR4](2) Onboard module shall operate at maximum power to maximize the RF transmission range.

[PR5](1) The base station and the motorcycle shall have minimum range of approximately 100m and maximum range of 500m to demonstrate a proof of concept.

[PR6](2) Onboard module shall acquire an accurate position (within the margin of allowable error) at any speed of the motorcycle.

[PR7](2) Wireless transmission shall have a maximum Packet Error Rate (PER) of 1%.

[PR8](2) The RF transmission will not interfere with the GPS transmission on the board module.

2.6.2 Base PC module

[PR9](2) Base PC module shall process the received data from onboard module in under 2 seconds.

[PR10](1) PC application will display the data acquisition in a visual manner and/or a table of values.

2.7 Usability Requirements

[UR1](1) Simple on and off switch with green LED shall be used to indicate the operation status of the onboard module.

[UR2](2) To choose the first (default) mode, user simply has to press the joystick switch to the left and “MODE 1” will scroll once on the LCD screen right after.

[UR3](2) To use the second mode, user simply has to press the joystick switch to the right and “MODE 2” will scroll once on the LCD screen right after.

[UR4](1) The PC application will have a straightforward GUI to enable the user to view the GPS and inclinometer data.

[UR5](2) Onboard module shall not obstruct rider’s view or use of the handle bars.

[UR6](2) Onboard module’s LCD display will be tinted to optimize viewing from the angle of the rider’s eye sight.

2.8 User Documentation and Training Requirements

Since our product is one of the first of its kind in the market, our documentation and quality of customer support is extremely important to succeed!

[UDTR1](2) The documentation will consist of pictures, diagrams, and simplified terminology to provide an efficient and easy instruction that will suit the target audience.

[UDTR2](2) The user manual included with the device will explain the functionality of the product in detail.

[UDTR3](3) An installation manual will be provided for registration and set-up of the device.

[UDTR4](3) Although the documentation will offer a section designed for Frequently Asked Questions, Monarch Technologies plans to provide 24/7 customer support via a 1-800 number to assist its customers.

[UDTR5](3) To better support our global audience, multi-language versions of all documents will be available. The languages provided would depend on the location that the product is being sold at.

[UDTR6](3) To ensure quality assurance, a copy of detailed description of the warranty will be provided along with the device.

[UDTR7](2) Monarch Technologies will also be providing a copy of all documentations on the company website for easy access.

2.9 Standards and Regulations Requirements

This device will meet the following standards and regulations:

[SRR1](3) CSA standardCAN/CSA-C108.4-M92 (R2003)—Limits and methods of measurement of radio interference characteristics of vehicles, motorboats, and spark-ignited engine-driven devices.

[SRR2](3) CAN/CSA-C108.6-M91 (R2003)—Limits and methods of measurement of electromagnetic disturbance characteristics of industrial, scientific, and medical (ISM) radio-frequency equipment

[SRR3](3) FCC CFR 47 Part 15 Subsection 247 - RADIO FREQUENCY DEVICES Radiated Emission Limits

[SRR4](3) General Requirements for All Electronic Products which Emit Radiation (21 CFR § 1000 - 1005)

[SRR5](3) All components shall be built with environmentally friendly components that satisfy RoHS.

3.0 System Test Plan

The overall testing of the Lean Detector composes of three main phases: individual component testing, integration testing and prototype test. The individual component testing determined if the individual elements are functioning as expected. The integration testing focuses on the intermediate connections between components to certify data collection and transmission is sufficient. Lastly, the overall prototype test will examine the complete system's performance, and allow us to warrant that the prototype meets the proof of concept requirements outlined earlier.

3.1 Individual Component Testing

1. VTI Inclinometer module function test
    - Ensure that the lean angle and direction corresponds to a voltage value as expected
        - When leaning to the left, the voltage range should be between 0 V and 2.5 V, 0 V corresponding to 90 degrees counter-clockwise
        - When leaning to the right, the voltage range should be between 2.5 V and 5.0 V; 5 volts corresponding to 90 degrees clockwise
2. GPS ZX4120 module test
    - Ensure GPS start up is within 50 seconds
    - Test the accuracy of the GPS outdoors and ensure it is within 7 meters of accuracy
    - GPS is able to interface with a PC using HyperTerminal using a serial converter
3. Atmel Microcontroller test
    - Ensure that microcontroller LCD display is operations by programming and running provided LCD demo code onto the MCU
    - Ensure that LED ports are operational by programming and running provided Blinky demo code onto the MCU

3.2 Integration Testing

1. VTI Inclinometer and microcontroller test
    - Inclinometer analog output is properly converted to its digital states using the microcontroller's ADC
    - Microcontroller is able to process the digital reading and properly output the LED sequence to reflect the lean direction and extreme of the lean
    - Microcontroller can shift this digital reading, along with the GPS data to the UART port for transmission
2. GPS and microcontroller test
    - GPS serial output is properly detected and read through the microcontroller's UART RXD pin
    - Microcontroller can shift the GPS reading and an inclinometer value to the UART port for transmission
3. XBee Transmitter and microcontroller test
    - Confirm that XBee can communicate with the MCU or vice versa through the UART port
    - Ensure RF transmitter transmits the GPS and lean data to the RF Receiver
4. XBee Receiver and PC
    - Ensure that RF Receiver is able to interface with a PC through a serial to USB converter
    - Be able to distinguish if data received is complete or missing information
    - PC should be able to process the data received and display the data in a visual or table format for user to view

3.3 Prototype Testing

Prototype testing will be achieved by testing our onboard module on a motorcycle, collecting data from a few runs, and using our PC application to view the data. The base PC will be about 60 to 100 meters from the motorcycle route with line of sight since we want to simulate a wide, open spaced motorcycle track. From the results, we will analyze any issues, compare the expected performance versus actual performance and debug any problems. The solutions to any issues and any additional requirements will be incorporated to later prototype iterations.

4.0 Conclusion

This document outlines the functions, requirements, and standards of the Lean Detector system. We will follow the specifications to provide a convenient unit that can sense the lean angle and GPS data of its motorcycle host during a turn and then wirelessly transmit this data to a base PC in real time. The first prototype system is in the progress of development and is projected to be completed by April 2009.

As the population and the number of motorcycle enthusiasts increases, so does the number of fatalities and accidents for riders. The safety of motorists is an important issue in our fast growing society. Our system can help create a safer environment because it can be used by beginners and racers to enhance their riding skills like the method of turning in sharp corners.

References

[1] VTI Technologies, "SCA61T Inclinometer Series Datasheet", 13 Feb 2009. [Online]. Available http://www.vti.fi/midcom-serveattachmentguid-53b766f2850a127b88947edbf1de536f/SCA61T_inclinometer_datasheet_8261900A.pdf.

[2] Crownhill Associates, "GPS Engine Board: WD-G-ZX4120 User's Manual", 13 Feb 2009. [Online]. Available http://www.crownhill.co.uk/product.php?prod=1474.