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February 17, 2004

Lakshman One and Mike Sjoerdsma
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
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RE: ENSC 440/305 – Functional Specification for the Driver Health Monitor

Dear Mr. One and Mr. Sjoerdsma,

The following attached document, *Function Specification for a Driver Health Monitor*, has described the functional requirements of our project for ENSC 440/305.

We are currently developing a car system that will monitor and analyzes a driver's health condition and deliver warning to the driver before any accident happens. Also, this system can be potentially expanded further to wireless communication system that allows remote locations such as local hospital, to obtain the driver's health data.

Our functional specification provides details of the functionality which will be provided by the complete version of our Driver Health Monitor. It also describes the expected functionality that will be done by the project deadline of April 2004 and the functionality that can be implemented in the future.

SLiK Devices Ltd. Engineering team consists of four creative and self-motivated engineering students from Simon Fraser University. These team members are Reza Sanaie, Behroz Sabet, Vedran Karamani, and Gary Lu. If you have any questions or comments about our project or the proposal, please contact us by email at slik-440@sfu.ca or by phone to contact our team leader Reza Sanaie (604) 338-4244.

Sincerely,

Reza Sanaie
President and CEO
SLiK Devices Ltd.

Enclosure: SLiK Functional Specification

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Functional Specification for Driver Health Monitor

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Executive Summary

Less than a month ago on Highway 99 north of Squamish a southbound sedan carrying five hotel workers crossed the centre line and collided, head-on with a northbound SUV carrying two passengers. All seven people involved died at the scene of the accidents. Coroner Jody Doll said driver fatigue may have been a factor since the young man at the wheel of a sedan that crossed the centre line had just finished working a night shift in a Whistler hotel.

Driver fatigue is an area of transportation research that deserves much more attention than the current efforts put into detecting it. Patients with obstructive sleep apnea (OSA), narcolepsy patients, night-shift workers, adolescents, and individuals suffering from acute or chronic sleep deprivation are all at risk for drowsy driving car crashes. Driver drowsiness represents an important risk on the roads, given that it is one of the main factors leading to accidents or near-missed accidents. This fact has been proven by many studies that have established links between driver drowsiness and road accidents. An important drawback of current studies is the fact that they have been performed either on a driving-simulator, or by using non-transparent sensors, which might affect the driving task, and therefore, the behavior of the drivers in a drowsy condition.

The Driver Health Monitor Module makes use of highly accurate and sensitive sensors to detect the drowsiness of the driver. The module will be self-contained, robust and able to calibrate itself to different drivers' characteristics. The parameters that are being monitored are heart rate, reaction time, temperature, and respiratory rate. The past research on the correspondence of these parameters to human drowsiness is well defined and available for comparison.

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1 Introduction

Detecting drowsiness of a driver has been attempted by many institutes and research program due to the high risk of car incidents occurrence that have been fatal in most cases.

Drowsiness in combination with alcohol and/or drug usage can put the life of the driver and the passengers in extreme risk. As a result, acknowledging the problem of detecting this risk is on demand and essential. Enforcing law in regards to sleepiness is almost impossible from the legal point of view. In addition, many work patterns of individuals involved in late night or just simply long shifts of duties make sleepiness an inevitable factor to avoid.

This document outlines the functional specification of the driver Health Monitor Module, the parameters that need to be monitored, and the factors that make this module convenient in terms of use and stability. The description begins with defining the interface specifications, the sensor requirement followed by the system defined specifications and wireless transmission requirements and flowchart.

2 Functional Requirements

2.1 *System Overview*

The following block diagram has shown the basic functionality of the Driver Health Monitor.

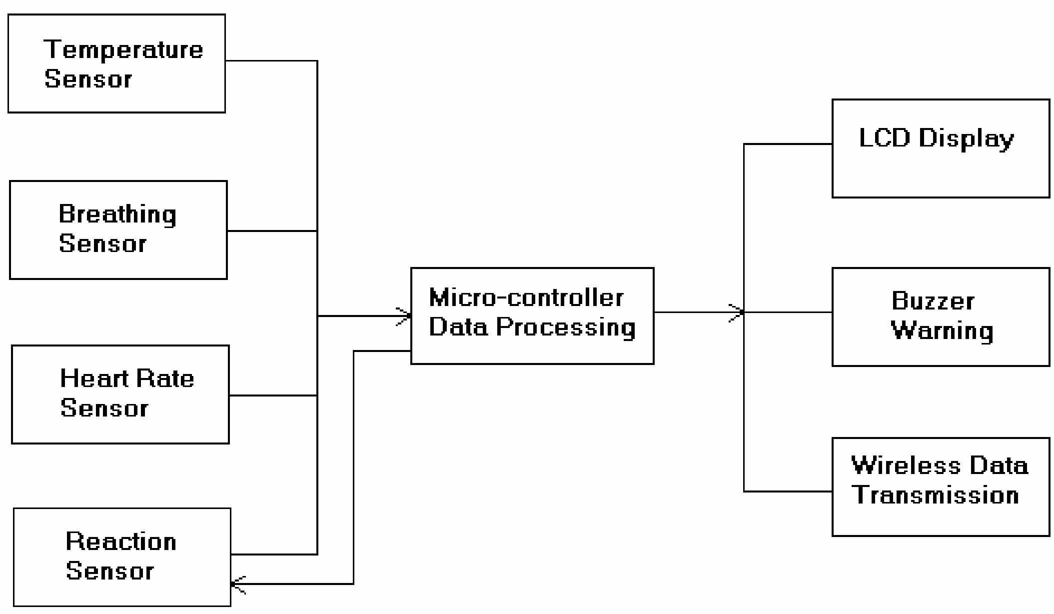

Figure 1: Basic Functionality of Driver Health Monitor

As we can see from Figure 1, all sensor data have to be processed within the Micro-controller. This defines our system architecture. The inputs to the system are analog data frames generated by the sensors according to the appropriate health parameter measurements. As one of the outputs the LCD display would provide the feedback to the user. As the other output the buzzer would only go off if the micro-controller has made a decision that the driver is suffering of fatigue. Similarly, the wireless data transmitter would send out signal for help once the micro-controller has decided that the driver is in a medical life-threatening situation.

2.2 *System Interfacing and I/O Requirements*

1. Sensors shall robust. In other words, sensor signals shall be relatively stable due to driver's movements, vehicle operation, or other physical interference.
   - ✓ As physical disturbances are simulated system must remain in proper operation.

2. Sensors shall have high resistance to any external electric interference, such as magnetic wave, radio signal, and any other kinds of noise.
   - ✓ As electrical disturbances are simulated system must remain in proper operation.

3. Sensors must be calibrated to match actual parameters, and analog data packets must be in format calibrated to the actual measurements.
   - ✓ System feedback must truly correspond to known physical inputs.

4. Sensors shall have high consistency, i.e. they should perform in the same way and have the same result from repeating a same set of measurements.

5. Reaction sensor must successfully log users driving reaction times.
   - ✓ Driving wheel mechanism will be implemented through PC driving wheel simulator.
   - ✓ Force feedback motor provides for test reaction vectors and simulates for the final product in-car implementation of similar reaction test vector motor generator.
   - ✓ Successful test reaction responses digitally fed from a PC to the microcontroller.

6. Real time, intelligent output control
   - ✓ Microprocessor must appropriately control reaction sensor simulator in order to obtain correct user's driving reaction response times.
   - ✓ Microprocessor must correctly and timely control the LCD, Buzzer, and Wireless Component.

7. System will operate in real time.
   - ✓ Temperature sensor must keep up with the rate of change of human temperature.
   - ✓ Breathing sensor must keep up with the human respiratory rate.
   - ✓ Heart rate sensor must keep up with the human pulse.
   - ✓ A/D converter shall handle at least 1500 conversions per second.
   - ✓ Processing of data and activation of outputs must be done with acceptable latency.

8. Sensors shall have high sensitivity.
   - ✓ Temperature sensor shall be able to detect 0.5°C change in temperature.
   - ✓ Heart rate sensor shall detect even weak pulses.
   - ✓ Breathing sensor shall be able to sense shallow and deep breathes.
   - ✓ Reaction sensor shall sense the exact reaction time from the driver.

9. Sensors shall have high accuracy and tolerance.

- ✓ Temperature sensor shall have error within ±0.5°C at operating temperature rang from -55°C to 150°C.
- ✓ Heart rate sensor shall have error within ±3 pulses per minute at the operating temperature range of -50°C to 100°C.
- ✓ Breathing sensor shall have error within ±2 breaths per minute at the operating temperature range of -30°C to 100°C.
- ✓ Reaction sensor shall have a very accuracy of ±0.01 second.

2.3 Reaction Sensor Requirements

Reaction sensor mechanism will consist of force feedback motor attached to the vehicle's steering control. Microcontroller will interface with the force feedback mechanism in order to periodically induce test driving vectors to the user. The test vector specification is fairly simple:

- ✓ Test reaction vector should successfully correspond to subtle driving interference requiring natural, appropriate and timely driver response.

Obviously the test vector will be applied solely to the steering control not the actual vehicle's steering mechanism. This will allow for testing the users reaction time as if the imposed test driving condition was real.

For the functional project demo we will simulate the above described system through a PC steering wheel simulator with force feedback capability.

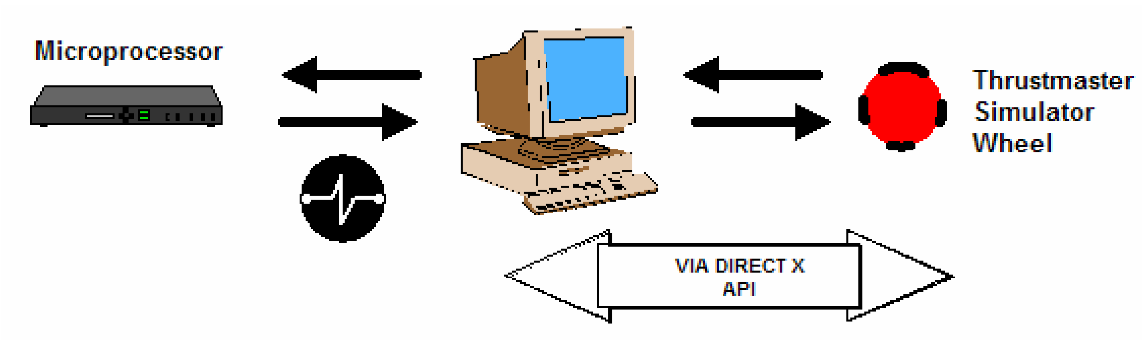

Figure 2: Simulation of the Reaction Sensor Mechanism

Therefore we will:

- ✓ Establish interface and communication between microcontroller and the PC.
- ✓ Establish channel of control to the simulator wheel through Direct X API.
- ✓ Be able to directly control the simulator wheel with the microcontroller by triggering the imposition of test vectors.
- ✓ Successfully obtain driver's reaction times back to the microcontroller.

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2.4 Data Analysis Requirements

1. Microprocessor must successfully organize and maintain complete health parameter frames.
   - ✓ Analysis and update of known parameter settings.

2. Microprocessor must properly analyze the frames in real time.
   - ✓ Processor must hold critical parameter criteria in order to successfully identify critical user states.

3. Processor must display user feedback through the LCD.

4. Processor must sound the Buzzer when parameters match the critical criteria.

5. Processor must activate the Wireless Component if the critical state calls for it

6. Microcontroller has to successfully interface with and control the Reaction Sensor mechanism through a PC.
   - ✓ Establish connection via RS232 PC port.
   - ✓ Successfully implement communication channel through Direct X API.

2.5 *Wireless Communication Requirements*

Initial project prototype can omit this extendable component. Finalized version of the product will successfully implement long range feedback capability where location of the vehicle and operator state will be communicated to the appropriate response party. Location of the vehicle will be obtained via the GPS module while long range communication medium to be used will be first available GSM network. Alarm signal package containing the vehicle location will be transmitted in efficient SMS message format ensuring fast, secure, and robust transmission. Initial wireless testing must be successfully implemented through simulation short range RF transmitter/receiver module.

2.5.1 RF Requirements

2.5.1.1 Frequency spectrum requirements

1. The transmitter and receiver shall transmit and receive data in the 916.48 Mhz frequency band.
2. The signal will have a bandwidth of 28Khz.

2.5.1.2 Data bandwidth requirements

1. The transmitter and receiver shall exchange data at 52,000 bits per second.
2. The transmitter will send digital sensor data to the base station.
3. The base station will send back and acknowledgement when data has been received.

2.5.1.3 Data integrity/reliability

1. The RF system shall have an average BER of 10^{-6}.
2. The RF communications subsystem shall have a maximum of 1% packet loss.
3. Accurate data analysis shall not be affected by the maximum RF data loss.

2.5.1.4 Range

1. The roaming range of the shirt from the base station will be 30m, with line of sight.
2. The roaming range of the shirt from the base station will be 100m, with line of sight.

2.6 *User Interface Requirements*

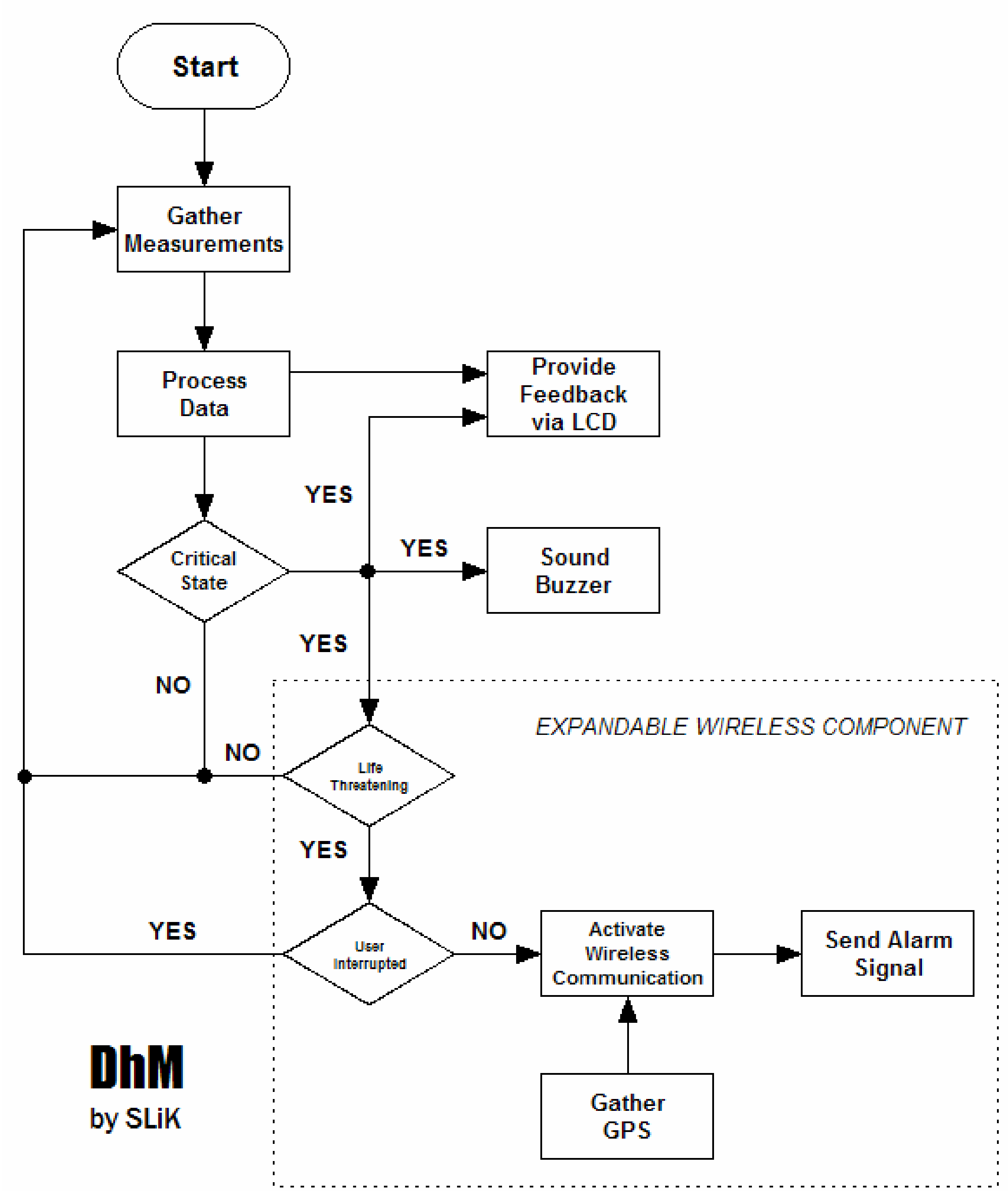

Figure 3: System Flowchart

As mentioned earlier, the system shall be on as soon as the driver starts the vehicle. What the driver should do to get all sensors standby is described as in the following:

- Put on the seatbelt, which has a built-in breathing sensor, and then strap the belt around the back.
- Strap the band around his/her hand. This band has a built-in temperature sensor and a velcro to adjust for different hand size.
- Put on the small finger-stabilizer over his pinky. This little device is simply a heart-rate sensor, which has built-in photo transistor, inferred transmitter and other circuitry.

Emergency wireless data transmission can be manually enabled and disabled by the driver. Once the microcontroller has decided the driver is suffering in fatal medical condition (such as heart-attack), this system would automatically send out the data to local authority in the next 10 second unless the driver disables it within the time frame.

If GPS system is integrated with this system, then the driver can manually enable the data transmission to central authority for help in the case the driver gets lost or encountering any unusually event like hijacking.

*2.7 **Physical System Requirements***

1. The health monitoring system shall be meticulous, i.e. the system shall not create any physical inconvenience/constrain to the driver or the passengers.

2. The health monitoring system shall be on as soon as the driver starts the vehicle.

3. The health monitoring system shall be long lasting due to any physical wearing.

4. The health monitoring system shall operates properly even in a harsh environment, such as dramatic change in temperature.

5. The system electronics should produce very low radiation.

6. The system components shall be easy to replace. For instance, a simple battery replacement can be done by the driver.

7. The health monitoring system shall be waterproof, i.e. the system components can withstand being defected caused by moisture.

8. Sensor components shall be integrated with existing car component, so the driver would not forget to put on. For example, breathing sensor shall be integrated with the seat-belt.

2.8 *Power Requirements*

1. All batteries for our system shall be rechargeable, so that the car-battery can constantly recharge these batteries. Therefore, no frequent power replacements are required.

2. All sensors and other components are required only low power supply, so typically 5-V batteries are sufficient for the system.

3. Charger circuit is required to recharge the batteries.

4. The locations of the batteries shall be obvious for replacements.

3 Test Procedures

Verification of our passing functionality tasks (indicated by ✓) will complete prototype functionality test. Following the ordered gradient of implementation of required functionality requirements will ensure further development of the system. These developments and additions will be reflected in this document in its further revisions and will follow derivation of the product to completion.

4 Conclusion

The functional descriptions mentioned in this document are to ensure the ease of use of the Health Monitor System and the definition and implementation of parameters of interest. These specifications are outlined so that the product can be easily understood in term of its sensitivity and reliability to different situations of driving and drowsiness. Lastly, the outlined functional description of the wireless transmission of the gathered data are to inform the exact data acquisition method used and the different options that could be considered by the user in using wireless compunctions options.