URBAN WHEEL
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Feb 11th, 2013

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

RE: ENSC Functional Specifications for Blind Spot Detection System

Dear Dr. Rawicz,

The enclosed document details the functional specifications for the "Blind Spot Detection System". Our system is an upgrade of the current vehicles which will enhance safer driving experience with blind spot detection and warning system, and real-time blind spot video capture.

The functional specifications in this document will be a basis for all future iterations of prototypes and products, and act as a reference when new operational modifications are made. All members of Urban Wheel Inc. will adhere to these specifications in future design and production processes.

The Blind Spot Detection System team is comprised of five fourth-year electronic engineering students; Howard, David Cao, Emmanuel Yeung, and David Zhong. Each member brings unique skill sets and experiences to this project.

Thank you for your time for reading over our functional specification. For any inquiries or comments regarding our project, please contact our team through our contact person, Emmanuel Yeung via email at hhy6@sfu.ca.

Sincerely ,

Howard Sun
Chief Executive Officer
Urban Wheel Inc.

Enclosed: *Function Specification for Blind Spot Detection System*

Functional Specification for

Blind Spot Detection System

Urban Wheel

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Executive summary

Blind spot is a nuisance of everyday driving that causes a significant number of accidents every year. Many drivers get tired while having a long distance driving, and forget to perform shoulder check when changing lane. Car manufacturer has developed a blind spot detection system to prevent blind spot related accident. However, it is only available on luxury branded cars as an additional package for thousands of dollars. The Blind Spot Detection System (BSDS) addresses these issues by implement more features and yet keeping the cost low.

BSDS will be developed in three stages. In the first stage of development, we will be focusing on the warning mechanism. At the end of the first stage, the system shall have the following core functionalities:

- The system should be able to correctly notify the driver if the safe threshold has been breached
- The system shall be able to turned ON/OFF instantly when device is plugged into power source
- The system shall not produce any fire or electrical hazards

For the second stage, the video feedback system will be implemented. It shall be able to capture and display the real-time video from the corresponding side.

For the last stage of BSDS development, we will integrate the video feedback system to the completed warning system. Also, once the proof of concept model is finished, we will continue to improve the performance and the overall design of BSDS. Furthermore, BSDS will comply with correlative standard including AMIS, ISO, IIHS.

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Glossary

ANSI – **A**merican **N**ational **S**tandards **I**nstitute

BSDS - **B**lind **S**pot **D**etection **S**ystem

FPS – **F**rames **p**er **S**econd

ISO - **I**nternational **O**rganization for **S**tandardization

R - Functional **R**equirements

IIHS - **I**nsurance **I**nstitute for **H**ighway **S**afety

MTBF - **M**ean**T**ime **B**etween **F**ailures

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1. Introduction

Urban Wheel Blind spot detection system (BSDS) is a highly accurate electronic driving aid for motor vehicles. The primary objective is to provide customers with safer driving experience in their current vehicles. The BSDS is intended to be capable of detecting obstacle hidden in either side of the vehicle's blind spot, and notify the driver accordingly to avoid accidents. The detailed functional requirements for the BSDS are described in this documentation.

1.1 Scope

This document outlines and details the functional requirements which must be met by the BSDS. The specifications in this document fully describe the functionalities of our proof-of-concept prototype, and will serve as a basis for future iterations of the product. Possible design, modification, and optional features of future implementation will be included in this documentation.

1.2 Intended Audience

The functional specification is intended to be used by all members of Urban Wheel Inc - BSDS branch. The project manager shall refer to the functional requirements as an actual measure of progress throughout the development phase. Design engineers shall refer to the requirements as overall design goals to be kept in mind from product design throughout the implementation. Test engineers shall examine the functionality of the actual system by referencing to this document in order to aid testing.

1.3 Classification

The following classification has been established and shall be used throughout this document.

[R###-p]: Functional Requirement.

Where 'FR' stands for the functional requirements, '##' stands for the requirement number and 'p' is the priority of the functional requirement.

Table 1- Priority Levels of Requirement

Priority Level	Description
I	The requirement applies to the proof-of-concept system only.
II	The requirement applies to both the proof-of-concept and final production system.
III	The requirement applies to the final production system only
IV	Future requirement

2. System requirement

2.1 System overview

Our blind spot detection system can be illustrated in the following high level diagram

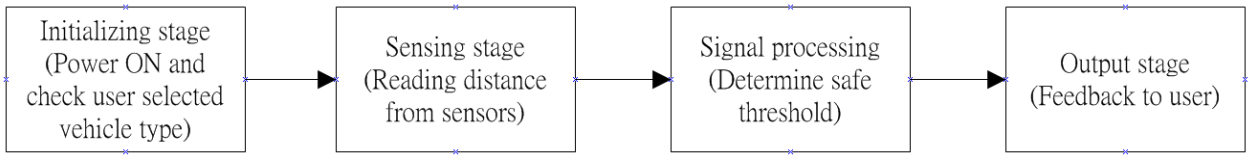

Figure 1 - High-Level Block Diagram

The system consists of microcontroller, ultrasonic distance sensor, night vision camera, LCD display, LED lights, vibration motor, and buzzer. The ultrasonic sensor and night vision camera are sending outputs to the microcontrollers, and the microcontroller will enable the LED, vibration motor and buzzer depending on the situation.

The ultrasonic sensor will be reporting the distance to the SainSmart UNO microcontroller board every 2 microseconds, and the microcontroller board will determine if the distance between the vehicle blind spot is within the predetermined threshold distance. The threshold distance will be determined by vehicle type, for example with sensor mounted to the side of a mid-size sedan, the safe distance will be determined as 3.6 meter, which is calculated based on the average road land width, and assuming both drivers are on the furthest side of the lane.

When the threshold distance is breached, depending on the state of the turn signal, if the turn signal is turned on the left, then the left LED, buzzer and vibration motor will be enabled, the LCD screen will be switched to the video reported by the left camera. If no turn signal is turned on, only LED will be switched on, and the screen will show the video from the front camera.

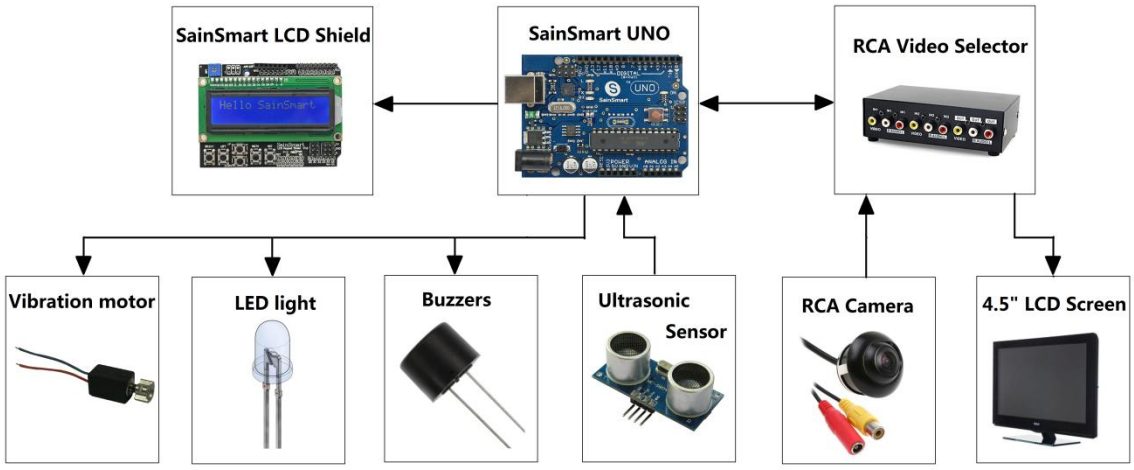

Figure 2 – System Overview Diagram

2.2 General Requirements

[R001-II] The system shall be ON instantly when it is connected to the power supply
[R002-II] The system shall be OFF instantly when it is disconnected to the power supply
[R003-II] The system shall have an indication to the user about the system status
[R004-I] The cost of the proto-type shall be less than $300
[R005-II] The wiring of the system shall be insulated

2.3 Physical Requirements

[R006-III] The system shall not weigh more than 20 pounds
[R007-III] The system shall be easy to install
[R008-III] The system shall be easy to un-install
[R009-III] The system shall not have any sharp edges
[R010-III] The protection shall must have rugged design

2.4 Electrical Requirements

[R011-II] The system shall not draw any current when it is OFF
[R012-II] The system shall not be damaged when it is powered off during its work cycle
[R013-II] The system shall not cause any electrical damage to the vehicle's circuit
[R014-II] The system shall include a fuse and diode protection against any electrical damage
[R015-II] The system shall be able to operate with 12V 500mA generated from a car cigarette lighter power supply

2.5 Standards

[R016-III] The system shall effect to the vehicle's IIHS standard rating
[R017-III] The system shall comply with AMIS standard
[R018-III] The system shall comply with car electronic safety standard ISO 26262-9 [1]

2.6 Reliability and Durability

[R019-II] The camera and sensors shall be resistant to dust, water, wind, extreme weather and shock on daily basis.
[R020-III] The system shall be able to perform multiple installation and un-installation processes and keep the required standard.
[R021-III] The system shall be serviceable by trained technicians.
[R022-II] The system shall be able to keep the system settings without external power.
[R023-II] The system shall be able to work continuously once been powered on.
[R024-II] The MTBF (meantime between failures) of the system shall be no less than 24,000 hours

2.7 Safety Requirements

[R025-II] The system shall not create any shock hazard to users at any part of the system.
[R026-II] The system shall not overheat and spontaneously combust.
[R027-II] The system shall not produce harmful radiation.

[R028-II] The system power connections shall be enclosed.
[R029-II] The system shall not cause any interference with other devices.
[R030-II] The system must notify the users if an error has occurred.
[R031-II] Upon start-up, the system will run through a diagnostic routine to check if the system is safe for operation.
[R032-II] Upon start-up, the system will notify the users the previous system settings

2.8 Usability Requirements

[R033-II] The system shall perform adjustments assuming that the user has correctly selected the system setting.
[R034-II] The system shall perform adjustments assuming that the system has been correctly installed.
[R035-IV] The system's firmware shall be upgradeable by a service person.
[R036-II] The system shall have an interface for external connection with a PC for upgrading or diagnostic purposes.

2.9 Performance Requirements

[R037-II] The system shall respond to manual adjustment for system selection at anytime.
[R038-II] The system shall indicate that it is on after plugged in.
[R039-III] The system shall respond to mode changes within 1 second.

3. Sensors

3.1 General Requirements

[R040-II] The sensor must have range of up to 400cm [4]
[R041-II] The sensor must work in any weather conditions (fog, snow, night etc)
[R042-II] The sensor low current only 15mA, use less power, minimizing heat damage [4]
[R043-II] The sensor shall have high detection precision: up to 0.3cm
[R044-II] The sensor must fully cover all blind spot area
[R045-II] The sensor shall have high refresh rate of 10 microseconds [4]
[R046-II] The sound wave generated by the sensor shall not be audible by the user when it is active [2]

3.2 Physical Requirements

[R047-III] The sensor shall be easy to install
[R048-III] The sensor shall be easy to uninstall and reinstall
[R049-II] The sensor shall be waterproof and shock resistant
[R050-III] The sensor must have rugged design
[R051-II] The sensor must not dismount unintentionally
[R052-II] The sensor must be able to operate in temperature ranging -40 to 50 degree Celsius
[R053-III] The sensor shall not significantly affect the car's aerodynamic [3]

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4. Microcontroller

4.1 General Requirements

[R054-II] The microcontroller must be able to handle high real-time refresh rate 10 microseconds
[R055-II] The microcontroller must have low power consumption[R056-II]The microcontroller must have fast boot up time less than 0.5 second when powered
[R057-II] The microcontroller shall have a failsafe mechanism when system error occurs
[R058-II] The microcontroller shall be able to be re-programmed for special vehicles
[R059-II] The microcontroller shall be able to be restore to factory settings
[R060-II] The microcontroller must be able to handle at least 6 proximity sensors
[R061-II] The microcontroller's firmware must be bug-free
[R062-II] The microcontroller module shall be easy to install
[R063-III] The microcontroller must be able to mount inside the trunk of the car

4.2 Physical Requirements

[R064-III] The microcontroller must have rugged design and shock resistant
[R065-II] The microcontroller must have operating temperature ranging -40 degree Celsius to 85 degree Celsius
[R066-IV] The microcontroller should be have compact design

5. LCD display

5.1 General Requirements

[R067-II] The LCD display must be able to turned on instantly when powered
[R068-II] The LCD display must display and update real-time distance at high refresh rate
[R069-II] The LCD display must be visible at night
[R070-II] The LCD display must be able to display videos of no less than 60 fps
[R071-II] The LCD display shall not have static image noises
[R072-II] The LCD display must be able to mount inside the car
[R073-II] The mounting mechanism of the LCD display must be secured

5.2 Physical Requirements

[R074-II] The LCD display must be able to operate in temperature ranging -40 to 85 degrees Celsius
[R075-II] The LCD display must be shock resistant
[R076-II] The LCD display's dimension must be reasonable without obstructing the wind screen

6. Indicator (vibrate & LED lights & buzzer)

6.1 General Requirements

[R077-II] The indicators must be able to mount inside the car
[R078-II] The indicator mounting must be secured
[R079-II] The buzzers shall warn the driver accordingly and must be able to activate in an instant
[R080-II] The buzzers shall not generate any unnecessary noises when inactive
[R081-II] The buzzers shall generate only necessary noises when active
[R082-II] The LED warnings must be able to activate instantly
[R083-II] The LED lights must be visible under bright light
[R084-II] The LED lights must not be too bright at night
[R085-II] The vibrators must be able to activate in an instant
[R086-II] The vibrators must not generate any unnecessary vibrations when inactive
[R087-II] The indicators must be easily understood

6.2 Physical Requirements

[R088-III] The indicators shall have compact design
[R089-II] The indicators must be able to operating in temperature ranging from -40 to 85 degree Celsius

7. Camera

7.1 General Requirements

[R090-II] The cameras shall be able to be turned ON/OFF instantly
[R091-II] The cameras shall have high enough resolution
[R092-II] The cameras shall be able to capture in no less than 24 fps
[R093-II] The cameras shall have night vision
[R094-II] The cameras must fully cover all blind spot area
[R095-III] The cameras must be able to mount outside of the car
[R096-II] The mounting mechanism of the camera must be secured
[R097-II] The cameras mounting must not cause damage to the vehicle's structure and paintjob

7.2 Physical Requirements

[R098-II] The cameras must not dismount unintentionally
[R099-III] The cameras shall have compact design
[R100-II] The cameras must be able to operating in temperature ranging from -40 to 50 degree Celsius

8. User Interface

[R101-II] Indicators must be reasonable and easily understood
[R102-II] Display error message when there's a system failure
[R103-III] Language and unit shall be variable.

9. User Documentation

[R101-III] The user manual shall have easy to understand installation instruction for qualified technician
[R101-III] The user manual will be written in English and French
[R101-III] The user manual shall include the warranty, terms and condition, and contact information
[R101-III] The user manual shall include a company website which will include a FAQ help section

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10. System Test Plan

The general approach to system testing consists of separately testing the individual modules comprising the blind spot detection system, groups of combined modules, and finally the complete unit. Once development of the proof-of-concept has reached the final stages, we will conduct detailed user trials of the system. Testing procedures will be discussed to various degrees with an emphasis on the requirements of the proof-of-concept. More specific testing procedures will be developed during the design and implementation stages.

There are many requirements on the physical dimensions of the entire installed system and on the various parts of the sensors. These will be verified in the design drawings and of the complete system. Once the system has been assembled and installed, the requirements will be verified by measuring the dimensions of the installed system and the individual parts with different settings.

The system test plan can be generalized into 3 main steps: first testing the individual's modules, then testing combined modules and finally testing the whole unit together. Detailed testing procedures for individual modules to be followed throughout implementation

and design periods are as follows:

10.1 Individual modules testing plan

LED:
Color LED lights will be tested to see if it is function correctly according to different input levels.

Photoresistor:
This sensor will be tested to see if its resistance varies with respect to light density levels.

Ultrasonic sensor:
This sensor will be tested to see if it is function correctly to different distances within the required measuring angle.

LCD screen:
The screen will be tested to see if it can display correctly under required operation environment.

Vibration motor:
The motor will be tested to see if it is generating enough vibration.

Buzzer:
The Buzzer will be tested to see if it can produce enough noise to notify the user.

10.2 Combined modules testing plan

Camera + LCD:
This module will be tested to see if the LCD screen can produce the image captured by the camera.

Arduino + Ultrasonic sensor + LCD:
This module will be tested to see if the readings from the ultrasonic sensor can be displayed correctly on the LCD screen.

Photoresistor + LED:
This module will be tested to see if the LED will respond to different resistance produced by the photoresistor.

Arduino + Vibration motor:
This module will be tested to see if the motor is responding correctly to the signal produced by Arduino.

Arduino + Buzzer:
This module will be tested to see if the buzzer is responding correctly to the signal produced by Arduino.

10.3 Whole unit testing plan

The whole unit will be installed on a actual vehicle which will be driven in slow speed in a safe area by qualified driver. A second vehicle will be driven into the blind spots of the first vehicle and provide various stimulations to the system. Feedback from the system will be recorded and analyzed by our technical team to ensure accuracy. Any necessary modifications and justifications will be applied to ensure performance.

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11. Conclusion

This document states the function specifications, outlining the fundamental requirements for the proof-of-concept, prototype, and the final retail product. The proof-of-concept and prototype device are currently under development. The requirements for each stage are arranged with set priorities, and the requirements will be met with professional works and team contribution. The prototype is expected to be completed by 12th April, 2013.

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12. References

[1] International Organization for Standardization, ISO 26262-9 - Road vehicles - *Functional safety Part 9: Automotive Safety Integrity Level.* International Organization for Standardization: 2011.

[2] Gotfrit, M (1995). *Range of human hearing*. Zen Audio Project.

[3] Automobile Aerodynamics, *Background Research.*[Online] Available: http://web-aerodynamics.webs.com/backgroundresearch.htm 18 May 2009

[4] Elecfreaks, *Ultrasonic Ranging Module HC – SR04* [Online] Available FTP: http://elecfreaks.com/store/download/HC-SR04.pdf 10 May, 2011