

Feb 7, 2019

Craig Scratchley

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Burnaby, BC V5A 1S6



**Re: ENSC 405W/440 Requirements Specification for FoCoS (Forward Collision Warning System) by TRAFEC**

Dear Dr. Scratchley,

The following document contains an overview of the functional specifications of our project for ENSC 405/440: FoCoS. The goal of this project is to make an aftermarket front collision warning system for cars. The system will be designed to alert the driver in case of upcoming collision to prevent or reduce the severity of the crash. FoCoS will be of big advantage in high traffic area or when driver is unconscious which is the reason for most of the front collisions. Due to its object tracking technology, in addition to detecting collisions it can also be used for other applications like detecting pedestrians or other objects that can cause a crash.

This document will provide high level introduction to our product with brief information of the target audience. Then we will go in depth explaining the technology and sensors involved and how they are going to integrate with each other to turn into final product. Product requirements will be laid down in this document for FoCoS alongside their stage of completion i.e. Proof of Concept, Prototype and Production and with level of priority each requirement holds.

Our team consists of 4 individuals who are passionate about finding solutions to traffic problem bringing safe and faster commute to people. Our team has Avneet Kaur, Abhishek Mahajan, Ranbir Makkar (CCO) and Amitoj Singh. If you have any questions or comments, please direct them to [rmakkar@sfu.ca](mailto:rmakkar@sfu.ca).

Sincerely,

A handwritten signature in black ink, appearing to read "Ranbir Makkar". The signature is fluid and cursive, with the first name being more prominent.

Ranbir Makkar

Chief Communications Officer



# REQUIREMENTS SPECIFICATIONS

FoCoS (Forward Collision warning System)

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**Issue Date:**

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## Abstract

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Forward Collision Warning (FCW) systems are quite common in modern cars. In March 2016, the National Highway Traffic Safety Administration (NHTSA) and the Insurance Institute for Highway Safety announced that manufacturers of U.S. automobiles agreed to include automatic emergency braking systems based on Forward Collision Warning as standard on virtually all new cars coming in the U.S. by 2022. In 2012, Europe had a similar agreement about advanced emergency braking system (AEBS) or autonomous emergency braking (AEB) [1]. Any FCW equipped vehicle is less prone to an accident and makes you and others feel safer on the roads but there are still many old cars running on the roads. They don't have such technology in their cars.

The FoCoS by TRAFEC is reliable, affordable, and trustable aftermarket solution for the cars that are not provided with such technology. This document provides the overall specifications and functional requirements of the product. The specifications can be separated into software and hardware functionalities. TRAFEC is determined to the fact that their team will be able to tackle the requirements laid out in this document and intend to follow the relevant engineering standards.



## Glossary

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|                        |  |
|------------------------|--|
| <b>Closing time</b>    | Time required for the collision to occur based on the relative speed of 2 objects and the distance between them              |
| <b>Frontal object</b>  | Any object in front of the car is considered as Frontal object. It could be any vehicle, pedestrian or other stationary body |
| <b>Subject Vehicle</b> | Vehicle equipped with FoCoS  |
| <b>Audio Alert 1</b>   | 600Hz sound at a rate of 1 beep/sec  |
| <b>Audio Alert 2</b>   | 600Hz sound at a rate of 2 beep/sec  |
| <b>User</b>            | Driver of the subject vehicle  |



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# 1 Introduction

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## 1.1 Background

Safety features in the Automotive industry are quickly propagating across the world. Attempts for early warning systems have been made many times in the past but were not successful as they were too costly. As the time passed and technology became more affordable, we started seeing Forward Collision Warning systems (FCW) became very common in the car world. The FCW are an active safety system that warns the drivers in an event of frontal collision and can help in preventing or reducing the severity of a crash.

When the vehicle equipped with FCW system comes close to a car or any object (pedestrian or animal), the system will alert the driver with audio and video signals. Below are some of the common situations where FCW can be helpful:

- Car in front of you has stopped at green light due to an obstacle in front of it and you're travelling too fast towards it
- You are looking at your infotainment system and the car ahead accidently pressed brakes
- The vehicle ahead suddenly slows down to turn without giving signal
- You do not notice the car in front pressed brakes due to bad weather low visibility

All the problem listed above have the potentials to put drives at the risk of collision. The National Highway Traffic Safety Administration estimates that sleepy driving was responsible for roughly 72,000 crashes, 44,000 injuries, and 800 deaths in 2013 [2]. FCW uses radar and camera to detect the object ahead and uses cars head's up display or gauge cluster to give visual warning. FCW system also have audio alarms configured which make warning sounds in an event of imminent crash.

FoCoS is purely based on the idea of FCW but this product will be an aftermarket option for the older cars to experience the new technology. FoCoS will be integrated to car's sound system to provide audio warnings and a head's up display will provide the visual warning.

## 1.2 Scope

The following document is meant to provide the full insight of the functional requirements and specifications that we expect FoCoS to meet. All the relevant engineering standards that we will comply to and high-level design will be presented.

## 1.3 Classification

To organize and describe the system requirements, the following format will be used:

**[REQ<Section Number>.<Subsection>-<Priority>-<Type>]**

Example: REQ.2.1.2-H-PoC





**REQ** stands for requirements. **Section Number** refers to the numerical value assigned to each section and **Subsection** points to the number value assigned to the subsection of the Section. **Priority** and **Type** are described in the table below.

| Priority | Description     |
|----------|-----------------|
| H        | High Priority   |
| M        | Medium Priority |
| L        | Low Priority    |

**TABLE 1.1: PRIORITY ENCODING DESCRIPTION**

| Development Stage | Description      |
|-------------------|------------------|
| PoC               | Proof of Concept |
| P                 | Prototype        |
| F                 | Production Ready |

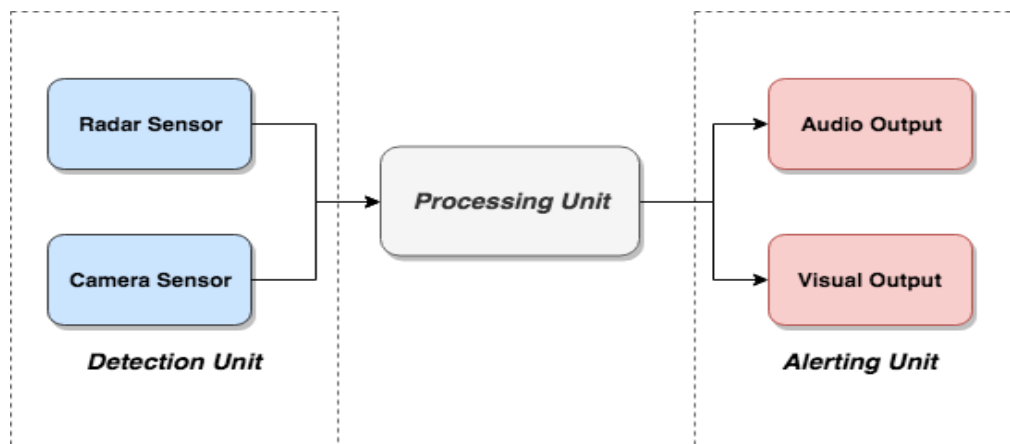
**TABLE 1.2: DEVELOPMENT STAGE DESCRIPTION**



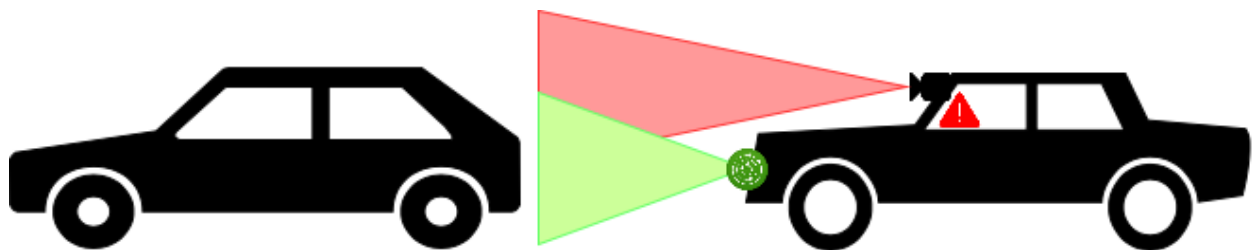
## 2 System Overview

FoCoS is a small device that comes along with a Detection Unit- 1 radar sensor and 1 camera, a Processing unit: 1 microcontroller, and an Alert Unit: heads up display and audio output. The detection unit will be attached to the front of the car which is used to sense the frontal object (car or pedestrian) incase if it's too close to the vehicle. A warning will be sent out to the driver using the heads up display and Subject Car's audio system. The sole purpose of the FoCoS will be to bring the forward collision warning system into the old cars and the new cars that are not equipped with this technology.

The detection unit will have the radar sensor as its primary sensor and a camera as its secondary sensor. Speed of travel and distance from other vehicles will be determined by monitoring changes in the Doppler Shift of the radio wave after it bounces off something and returns to the point where it started. In addition, the camera will continuously monitor changes in distance of the Subject Vehicle from various objects on the road. Based on this data a closing time will be calculated and if that closing time is less than certain threshold a warning will be sent out to the driver. If the driver presses the brake in the span of 3 seconds after the warning has been sent out, the car should stop without colliding with the object.



**FIGURE 1: BLOCK DIAGRAM FOR FoCoS**



**FIGURE 2: CONCEPTUAL DIAGRAM VISUALIZING THE FoCoS**



### 3 General Requirements

This section gives the general requirements of FoCoS as a whole.

#### 3.1 System Requirements

The following table includes the general system requirements for the system.

| Requirement ID | Requirement Description   |
|----------------|---|
| REQ 3.1.1-H-P  | The system shall consist of a microcontroller, a sensor, a camera, a display and a power adapter                        |
| REQ 3.1.2-M-F  | The product shall be small enough to fit in a hidden place in the vehicle   |
| REQ 3.1.3-H-F  | The wires from the sensors to the main unit shall be long enough to reach from the front bumper to the driver's cabinet |
| REQ 3.1.4-H-P  | The product shall be able to identify upcoming collision and warn the user with audio/visual signals                    |
| REQ 3.1.5-L-F  | The product shall have an on/off button   |
| REQ 3.1.6-H-F  | The product shall not cost more than CAD 500  |

**TABLE 3.1: SYSTEM REQUIREMENTS**

#### 3.2 Functional Requirements

The following table includes the general functional requirements for the system.

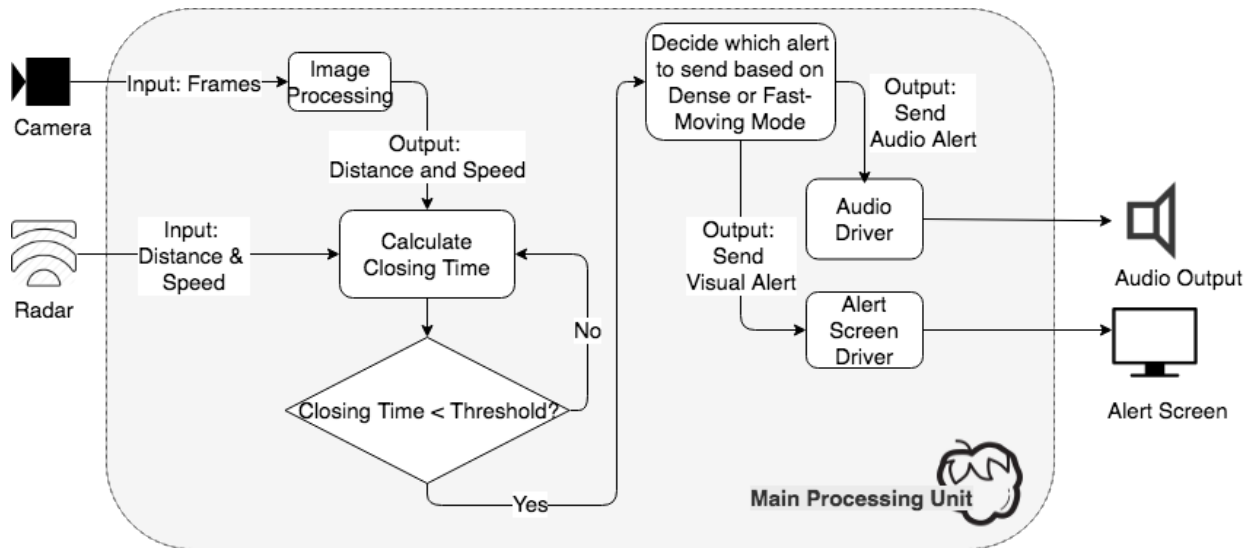
| Requirement ID | Requirement Description  |
|----------------|--|
| REQ 3.2.1-H-P  | Correctly determine the distance and speed of the car in front of microcontroller to process the information |
| REQ 3.2.2-H-P  | The product shall compute the closing time and give the alert in less than 0.5 sec                           |

**TABLE 3.2: FUNCTIONAL REQUIREMENTS**



## 4 Software requirements

This section gives the software requirements of FoCoS. The system shall use the Raspberry Pi microcontroller to define its behavior. The system will run on Raspbian OS and the software will be coded in Python. The system software shall work in two modes- Dense Traffic and Fast-Moving Traffic.



**FIGURE 3: HIGH-LEVEL SOFTWARE OVERVIEW**

### 4.1 General Software Requirements

The following table includes the general software requirements for the system.

| Requirement ID | Requirement Description  |
|----------------|--|
| REQ 4.1.1-H-P  | The system software shall accept data from the radar sensor at least once every 0.1 second |
| REQ 4.1.2-H-P  | The system software shall calculate closing time from the radar data                       |
| REQ 4.1.3-H-P  | The system software shall use the closing time to decide which state the system is in      |
| REQ 4.1.4-M-P  | The system software shall send the output as needed to Audio Output                        |
| REQ 4.1.5-H-P  | The system software shall send output as needed to Alert Screen                            |
| REQ 4.1.6-H-P  | The system software shall run on Raspbian Operating System and shall need Python support   |
| REQ 4.1.7-L-F  | Any failures should be communicated to the user  |



|               |   |
|---------------|---|
| REQ 4.1.8-H-F | The system software shall use multithreading to run sensor data analysis, main processing and feedback control parallelly |
|---------------|---|

**TABLE 4.1: GENERAL SOFTWARE REQUIREMENTS**

## 4.2 Dense Traffic Mode

The following table gives the software requirements for the system when in Dense Traffic Mode.

| Requirement ID | Requirement Description   |
|----------------|---|
| REQ 4.2.1-H-P  | The system software shall enter Dense Traffic Mode when Subject Vehicle and Frontal Vehicle are both moving at a speed less than or equal to 30 km/h and are at a distance of less than 2.5 m apart |
| REQ 4.2.2-M-P  | The system software shall send a warning symbol to the alert screen when the system enters the Dense Traffic Mode   |
| REQ 4.2.3-L-P  | The system software shall send the Frontal Vehicle speed to the alert screen when the system enters the Dense Traffic Mode  |
| REQ 4.2.4-H-P  | The system software shall send Audio Alert 1 to the Audio Output when system is in Dense Traffic Mode and the closing time is less than 4.5 seconds   |

**TABLE 4.2: DENSE TRAFFIC MODE REQUIREMENTS**

## 4.3 Fast-Moving Traffic Mode

The following table gives the software requirements for the system when in Fast-Moving Traffic Mode.

| Requirement ID | Requirement Description   |
|----------------|---|
| REQ 4.3.1-H-F  | The system software shall define Fast Moving Traffic Mode when Subject Vehicle is moving faster than 30 km/h  |
| REQ 4.3.2-H-F  | The system software shall send the Frontal Vehicle speed to the alert screen when the system is in Fast-Moving Traffic Mode and the closing time is less than 4.5 seconds |
| REQ 4.3.3-H-F  | The system software shall send Audio Alert 2 to the Audio Output when system is in Fast Moving Traffic Mode and the closing time is less than 3 seconds                   |

**TABLE 4.3: FAST-MOVING TRAFFIC MODE REQUIREMENTS**

## 4.4 Image Processing

The following table gives the software requirements for the system software's Image Processing software component.



| Requirement ID | Requirement Description  |
|----------------|--|
| REQ 4.4.1-H-P  | The image processing software shall accept frames from the camera at least every 0.1 seconds |
| REQ 4.4.2-H-P  | The image processing software shall detect obstacles from the received frames                |
| REQ 4.4.3-M-F  | The image processing software shall identify obstacles as vehicles, pedestrians or objects   |
| REQ 4.4.4-H-P  | The image processing software shall detect distance and/or speed of obstacle                 |
| REQ 4.4.5-H-P  | The image processing software shall send all information to the main processing software     |

**TABLE 4.4: IMAGE PROCESSING SOFTWARE REQUIREMENTS**



## 5 Hardware and Electrical Requirements

Hardware is the integral part of our product, as all the data and alert are being sent and received by it. Our hardware should meet the requirement components listed below.

### 5.1 Radar Sensor

The system will have radar sensor as its primary sensor. The following table includes the radar sensor requirements for the system's hardware and electronics.

| Requirement ID  | Requirement Description  |
|-----------------|--|
| REQ 5.1.1-H-PoC | Radar Sensor shall calculate the front vehicle's distance in less than 0.2 sec |
| REQ 5.1.2-M-F   | Radar Sensor shall be able to able to work in rainy weather                    |
| REQ 5.1.3-H-F   | Radar Sensor shall be able identify only front vehicle from 25m                |

**TABLE 5.1: RADAR SENSOR REQUIREMENTS**

### 5.2 Camera Sensor

The system will have a camera as its secondary sensor. The following table includes the camera sensor requirements for the system's hardware and electronics.

| Requirement ID | Requirement Description   |
|----------------|---|
| REQ 5.2.1-H-P  | Camera sensor shall calculate the front vehicle's distance in less than 0.2 sec       |
| REQ 5.2.2-H-F  | Camera sensor shall be able to work in rainy, cloudy and foggy weather conditions     |
| REQ 5.2.3-H-F  | Camera sensor shall be able to differentiate between vehicle, pedestrian or an object |
| REQ 5.2.4-M-P  | Camera sensor shall be able to detect an obstacle at a maximum distance of 25 m       |
| REQ 5.2.5-H-F  | Camera sensor shall have infrared to work in low light conditions                     |

**TABLE 5.2: CAMERA SENSOR REQUIREMENTS**



### 5.3 Visual Output

The following table includes the visual requirements for the system's hardware and electronics.

| Requirement ID  | Requirement Description   |
|-----------------|---|
| REQ 5.3.1-M-F   | The alert screen shall display front vehicle's speed updated every 1 second     |
| REQ 5.3.2-M-PoC | The alert screen shall have its display in red                                  |
| REQ 5.3.3-H-F   | Alert screen shall always be on in dense traffic area and in critical situation |
| REQ 5.3.4-M-F   | Alert screen shall be in driver's field of view                                 |

**TABLE 5.3: VISUAL OUTPUT REQUIREMENTS**

### 5.4 Audio Output

The following table includes the audio requirements for the system's hardware and electronics.

| Requirement ID | Requirement Description   |
|----------------|---|
| REQ 5.4.1-H-P  | Output sound shall not exceed the limits specified for the Raspberry Pi GPIO pins                     |
| REQ 5.4.2-M-F  | Output sound shall be clear, without any noise  |
| REQ 5.4.3-H-F  | Output sound shall be loud enough to alert the driver   |
| REQ 5.4.4-H-F  | Output sound shall only be given when you are less than the threshold closing time (i.e. 4.5 seconds) |
| REQ 5.4.5-M-F  | Output sound shall have beeps and the beeps will increase as you move closer to the vehicle in front  |

**TABLE 5.4: AUDIO OUTPUT REQUIREMENTS**

### 5.5 Power Supply

The following table includes the power requirements for the system's hardware and electronics.

| Requirement ID  | Requirement Description   |
|-----------------|---|
| REQ 5.5.1-H-PoC | A minimum of 500mA of current shall be supplied by the supply circuit |
| REQ 5.5.2-H-PoC | Raspberry Pi shall need 5V – 3.3V to operate                          |
| REQ 5.5.3-H-F   | Product shall only withdraw power if the vehicle is on                |

**TABLE 5.5: POWER SUPPLY REQUIREMENTS**





## 6 Environment

Our product is made with various materials like plastic and metal, so we have to ensure that our product is not harmful for the environment and can withstand extreme environmental conditions.

The following table includes the environmental requirements for the system.

| Requirement ID | Requirement Description   |
|----------------|---|
| REQ 6.1-H-F    | System hardware and electronics must be able to withstand temperature conditions from -15 <sup>o</sup> C to 45 <sup>o</sup> C |
| REQ 6.2-H-F    | Product shall be water resistant  |
| REQ 6.3-H-F    | Product shall be able to withstand the wind gusts when the vehicle is at higher speeds i.e. 160km/h                           |
| REQ 6.4-M-F    | Product shall not have any harmful consequences on the environment  |
| REQ 6.5-M-F    | Product shall be able to work in bad visibility conditions (e.g. – rain, fog etc.)  |
| REQ 6.6-M-F    | Product shall not emit any harmful radiations that are harmful to the environment   |

**TABLE 6.1: ENVIRONMENTAL REQUIREMENTS**



## 7 Safety and Sustainability Requirements

Our product is made up of electronic components, which may result in an electrical hazard if the user meets any of the electronic components. Due to this, our final product will be covered properly to prevent the user from encountering the circuitry.

The following table includes the safety and sustainability requirements for the system.

| Requirement ID | Requirement Description  |
|----------------|--|
| REQ 7.1-H-P    | Audio output shall be within the frequency range of 20 Hz – 20 kHz                         |
| REQ 7.2-H-F    | Alert screen shall not distract the driver from the road                                   |
| REQ 7.3-M-F    | Alert screen shall not be too bright for the driver  |
| REQ 7.4-M-F    | Product shall not have sharp edges that may hurt the user                                  |
| REQ 7.5-M-F    | Product's electronics shall not pose any electrical hazard under normal working conditions |
| REQ 7.5-M-F    | Product shall not pose any fire or explosion hazard under normal environmental conditions  |

**TABLE 7.1: SAFETY AND SUSTAINABILITY REQUIREMENTS**



## 8 Engineering Standards

### 8.1 Electrical

FoCoS will be using car's 12V power supply to power up the processing unit and the processing unit will be used as a power source for the head's up display, camera, and the radar sensor. Except the sensor, all other parts of the FoCoS will be inside the car. So, it quite important that the sensor is resistant to different weather conditions. The following table includes the electrical standards relevant to our product.

| Standard ID                                | Description   |
|--|---|
| CAN/CSA-C22.2 NO. 61508-1:17               | Functional safety of electrical/electronic/programmable electronic safety related systems - Part 1: General requirements [3]                        |
| CAN/CSA-C22.2 NO. 0-10                     | General requirements - Canadian electrical code, part II [3]  |
| CAN/CSA-C22.2 NO. 60065:16 (home attender) | Audio, video and similar electronic apparatus - Safety requirements (Adopted IEC 60065:2014, eighth edition, 2014-06, with Canadian deviations) [3] |

**TABLE 8.1: ELECTRICAL STANDARDS**

### 8.2 Environmental

Since we'll be having a radar sensor attached to the front of the door, so environment is big concern for our project. The following table addresses the environment standards that will be considered to make sure the product doesn't have any bad effect on the environment.

| Standard ID                     | Description  |
|---------------------------------|--|
| CAN/CSA-ISO/TR 14062-03 (R2013) | Environmental Management - Integrating Environmental Aspects into Product Design and Development (Adopted ISO/TR 14062:2002, first edition, 2002-11- 01) [4] |
| CAN/CSA-ISO 14040- 06 (R2016)   | Environmental Management - Life Cycle Assessment - Principles and Framework (Adopted ISO 14040:2006, second edition, 2006-07-01) [4]                         |
| CAN/CSA-ISO 14044-06 (R2016)    | Environmental Management - Life Cycle Assessment - Requirements and Guidelines [4]   |

**TABLE 8.2: ENVIRONMENTAL STANDARDS**



### 8.3 Optics

We'll be using a LED display to alert the user visually. The standards to be followed for LED are as follows:

| Standard ID   | Description   |
|---------------|---|
| IEC 62471     | LED Lighting Products [5]   |
| IEEE Std 1789 | IEEE Recommended Practices for Modulating Current in High- Brightness LEDs for Mitigating Health Risks to Viewers [6] |

**TABLE 8.3: OPTICS STANDARDS**



## 9 References

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- [1] "NHTSA-IIHS Announcement on AEB," National Highway Traffic Safety Administration, 21 12 2017. [Online]. Available: <https://www.nhtsa.gov/press-releases/nhtsa-iihs-announcement-aeb>.
- [2] C. f. D. C. a. Prevention, "Drowsy Driving: Asleep at the Wheel," Centers for Disease Control and Prevention, 7 11 2018. [Online]. Available: <https://www.cdc.gov/features/dsdrowsydriving/index.html>.
- [3] "CAN/CSA-C22.2 No. 61508-1:17," 01 02 2017. [Online]. Available: <https://www.scc.ca/en/standardsdb/standards/28870>.
- [4] C. Group, "CAN/CSA-ISO/TR 14062-03 (R2013) - Environmental Management - Integrating Environmental Aspects into Product Design and Development (Adopted ISO/TR 14062:2002, first edition, 2002-11-01)," CSA, Mississauga, 2013.
- [5] "IEC 62471:2006," Internation Electronical Commision, 26 7 2006. [Online]. Available: <https://webstore.iec.ch/publication/7076>.
- [6] "IEEE 1789-2015 - IEEE Recommended Practices for Modulating Current in High-Brightness LEDs for Mitigating Health Risks to Viewers," IEEE Standards Association, 26 3 2015. [Online]. Available: <https://standards.ieee.org/standard/1789-2015.html>.



## 10 Appendix

### Sample Acceptance Test Plan Sheet

Team 2

|                   |
|-------------------|
| <b>Test Sheet</b> |
|-------------------|

|              |
|--------------|
| <b>Date:</b> |
|--------------|

| Electrical Parts  |                  |
|---|------------------|
| <b>1. Sensor Output:</b>  | <b>Comments:</b> |
| Range: X m    Yes <input type="checkbox"/> No <input type="checkbox"/>                    |                  |
| Detection of Object in front:    Yes <input type="checkbox"/> No <input type="checkbox"/> |                  |
| <b>2. Camera:</b>   | <b>Comments:</b> |
| Able to Detect Object:    Yes <input type="checkbox"/> No <input type="checkbox"/>        |                  |
| <b>3. Speaker Output:</b>   | <b>Comments:</b> |
| Able to Output 600 Hz:    Yes <input type="checkbox"/> No <input type="checkbox"/>        |                  |
| Produce Multiple Beeps in 1 sec: Yes <input type="checkbox"/> No <input type="checkbox"/> |                  |
| <b>4. Alert Screen Output:</b>  | <b>Comments:</b> |
| Output Relative Speed:    Yes <input type="checkbox"/> No <input type="checkbox"/>        |                  |
| Blink screen for warning:    Yes <input type="checkbox"/> No <input type="checkbox"/>     |                  |