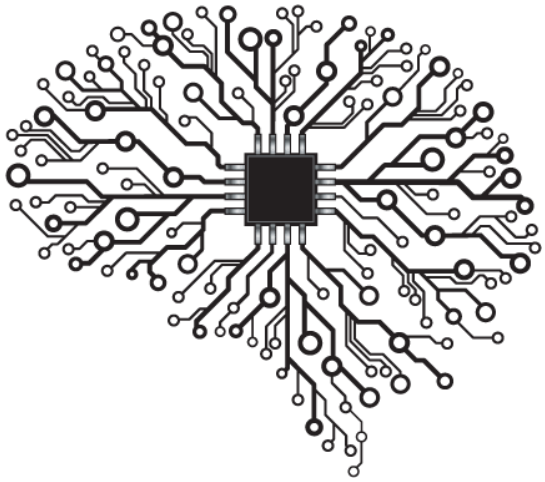
Ollscoil Teicneolaíochta an Oirdheiscirt
South East Technological University

# SafeDrive AI

## Functional Specification

Department of Computing
Bachelor of Science(Hons) in Software Development



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# Introduction

This is a functional specification for a proposed mobile application which will use Machine Learning technology to increase driver safety by warning drivers in cases where the system detects one or more danger signs of some of the foremost contributors to road traffic accidents.

This functional spec will first give a detailed Product Overview which will explain the concept ,motivation, positioning and context of the product. This will be followed by a high level look at the target user base and the use cases that form the value proposition for those users. Finally it will explain the key functionalities the project should contain and the metrics for project success.

This functional specification aims to convey a comprehensive explanation of how this project will deliver value to its users through its core functionalities and its potential position in the market.

# Product Overview

## Problem Statement

WIth an ever increasing number of cars on the roads around the world, the issue of road safety affects drivers of all types, particularly those who frequently use the road at night due to the increased risk due to driver fatigue.

This project's aim is to use the emergent field of machine learning to develop a mobile application capable of detecting driver fatigue and issuing a warning in real time. The impact of such a system in helping prevent road traffic collisions has the potential to save the lives of its users and make the roads a safer place for the public at large.

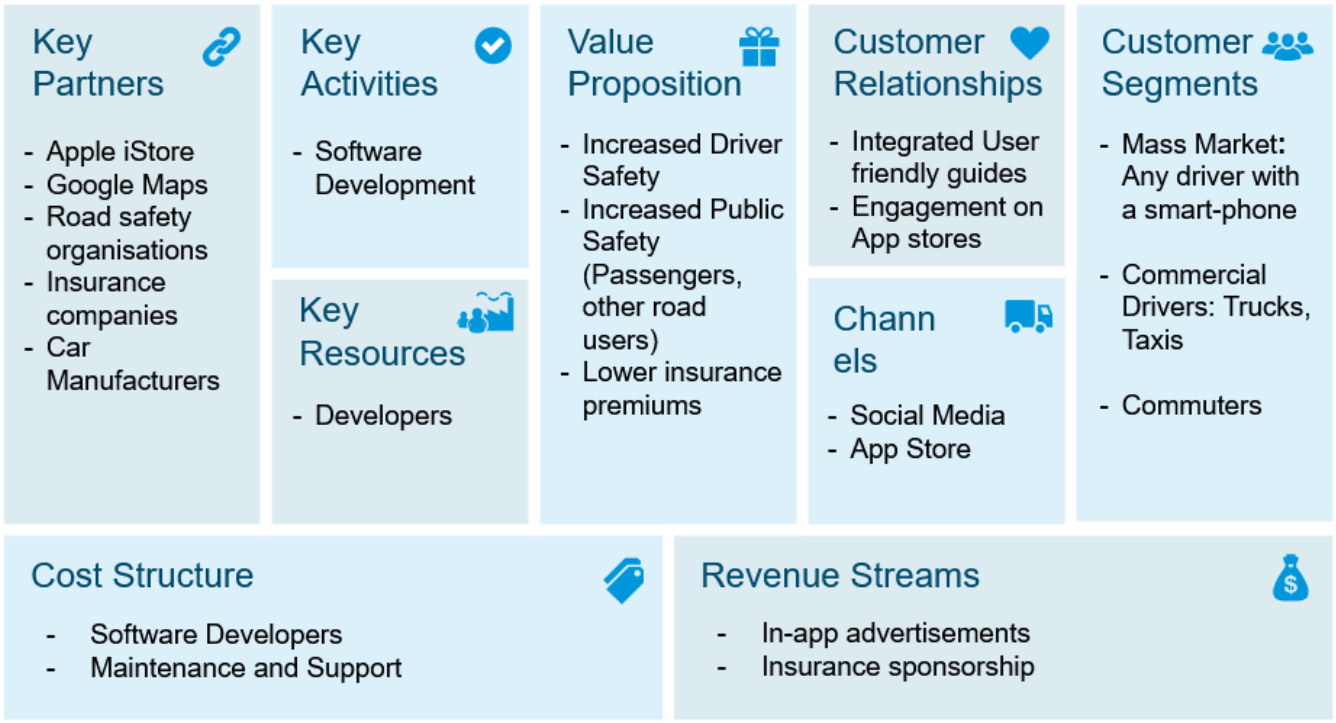
## Motivation

According to Garda figures, road traffic fatalities are on the rise in Ireland with twenty-three young people having lost their lives so far this year [1]. Road traffic fatalities have risen by 10% in real terms from the 2022 figure while almost the same number of 16-25 year olds have been killed in the first half of 2023 as in the same period in 2021 and 2022 combined. These are tragic and preventable deaths and this is not just an Irish issue. Across the world, these tragedies are repeated with around 20,600 people being killed in road traffic accidents in 2022 [2] and 42,765 fatalities in the US [3].

Three of the main contributing factors to the occurrence of road traffic accidents are Driver Fatigue, Driver Distraction and excessive speed [4, 5]. Thus the aim of this project is to create a mobile application which will attempt to utilize Machine Learning technology to detect in real time the danger signs that these factors may be occurring and issue a warning to the driver thereby helping to prevent the transpiration of road traffic collisions. The Road Safety Authority (RSA) has estimated that driver

fatigue is a contributing factor in as many as one in five road traffic accidents in Ireland every year, as such this factor will be the primary target for the first iteration of the application [5].

## Business Model Canvas




# User Descriptions

## Potential User Bases

| User | Use Case |
|---|---|
| Casual Drivers | A 2021 survey of Irish drivers found that 23% used their mobile at least sometimes while driving [6]. So casual drivers can use this application to improve their safe driving practices and practice speed limit awareness. |
| Commuters | Drivers who commute long distances are open to the dangers of driver fatigue and use this application to improve their safety while commuting. |
| Commercial Drivers | Drivers who drive professionally such as Taxi Drivers and Truck Drivers are especially vulnerable to driver fatigue particularly if working nights with 49% of all deaths on the roads occurred at night-time (8pm-8am) [7]. They can use this application to help ensure their safety on the roads from many of the common factors in traffic accidents. |

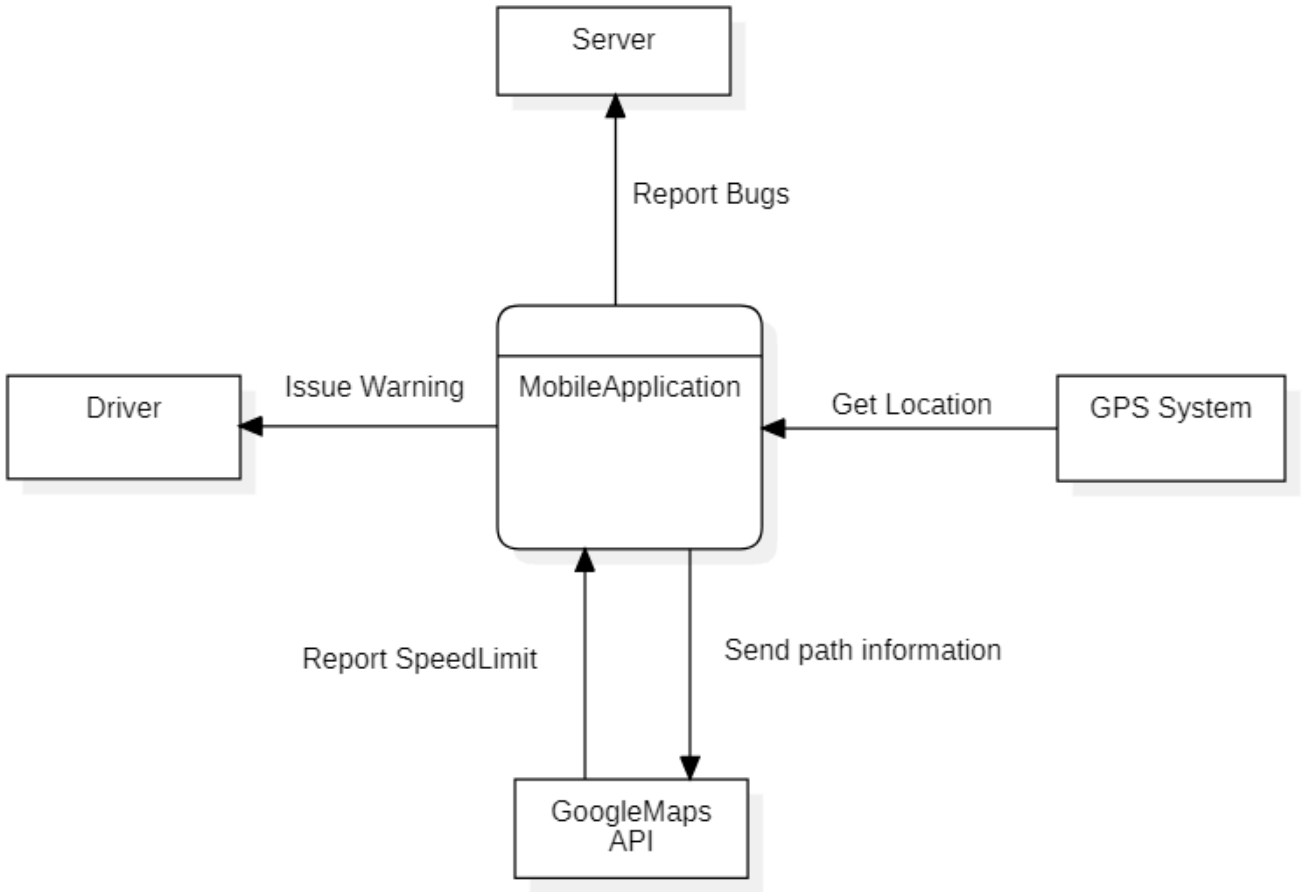
## Driver Environment

This mobile application will run directly on the User's smartphone and be available on both major mobile platforms and require no additional hardware. Smartphone penetration in Ireland for 2023 is estimated to be over 81%, meaning a majority of drivers will be reachable by this application [8].

## Positioning

There are many existing technological solutions on the market which seek to address this problem, however, many of the proposed systems are either invasive (such as wearable technologies), expensive (such as dashcam variants, or some features only available in high end cars) or do not address all of the causes listed above in one non-invasive and user friendly application [9]. These barriers to entry often means only small scale adoption of such technology by the average consumer. The goal of this project is to improve on these existing solutions by creating an easy to use and lightweight mobile application which is cheap to obtain and non-invasive to use, while providing a broader range of protection against the causes of road traffic accident occurrence.

## Context Diagram



## Similar Applications

There are two main classes of competitors which approach solving this problem in a similar way.

### Similar Mobile Applications

After conducting research on the various solutions currently available, the closest example in terms of functionality is the mobile application “Aware Driving App” on Android [10]. This application uses machine learning technology to detect driver fatigue and driver distraction in the same manner that this project is aiming to implement. However, our analysis has shown that these are only two of the causes of road traffic incidents so our application will aim to improve the range of factors which it protects against by also monitoring for excessive speed. A survey of 387 driver fatalities in Ireland from 2013-17 where there is a record of their pre-collision speed showed that in 24.5% of cases, the speed limit had been exceeded [4]. We hope that by extending the range of protection that our application offers to more of the contributing factors to road accidents that we can generate value for users by granting them greater protection against traffic incidents and potential injury or death.

### Integrated Systems

Some manufacturers of high end cars are implementing integrated cameras into their cars which also use machine learning algorithms to detect driver drowsiness and distraction in the same manner [11]. These are currently limited to only expensive and high end cars so such systems are not yet widely available to the general population, Our product will be cheap and uncomplicated to retrofit, making it easy to deploy for users and thus having the possibility of a much broader target audience.

# Product Features

## Functional Requirements

### Primary Focus

- The ability to analyze video data of the driver and detect and record signs of driver drowsiness using the criteria of blink duration.
- The creation of a system to issue a warning to the driver if a safety event is recorded.

### Secondary Focus

- The ability to analyze video data of the driver and detect and record signs of driver distraction.
- The application should have the capability to create and manage user profiles with preferred settings.
- The Driver should have the ability to choose which detection systems are activated at any time.
- The application should allow the User to change the detection threshold settings to their preference.
- The ability to utilize GPS tracking to monitor and detect excessive speed and issue a warning to the driver if detected.

- The application should have the ability to record and store statistics on driver performance for each User Profile
- The application must be able to connect by bluetooth to an external GoPro camera and use the image data from that source for its detection algorithms.

# Non-functional Requirements

## Usability

- A new Driver using the mobile application should be able to set up the application and start the drowsiness detection system in less than 3 minutes.
- The mobile application should have clear troubleshooting messages displayed to Drivers to help them handle the most common problems that may occur during setup and operation.

## Reliability

- The mobile application should be robust to runtime errors and have the capability to handle them and not crash for 95% of bugs.
- The ML model should be capable of detecting driver drowsiness by the threshold criteria selected with a minimum of 95% accuracy.
- The ML model should generate false positive events in less than 1 in 100 detection events.

## Performance

- The hardware requirements for the mobile application ability to handle the real-time processing and analysis of video data must be below the current hardware specs of at least 75% of consumer smartphones currently on the market.
- The system should issue a warning to the driver if any driver safety event is detected in less than one second.

## Supportability

- **Portability**
    - The mobile applications code base must be deployable for both the Android and iOS platforms.
- **Maintenance**
    - The mobile application should have the ability to send anonymous crash reports to a server to allow for ease of support for developer teams during release and future development.

## Security

- **Data Privacy**
    - The mobile application should collect no Personal Identifying Information (PII) from Users and fully comply with GDPR regulations regarding user data.

    - The Driver should be able to disable the sending of anonymous crash reports to give them full control of all data processed by the application..

# Risks

## Lack of experience in a key Technology

- **Risk:** Lack of developer experience working with Machine Learning technologies which are a central technology for the success of the project.
- **Management of Risk:** Will have early emphasis within the project on training courses in this area and will engage with all available experts in the field as the project progresses.

## Deployment of Machine Learning onto Mobile Platforms

- **Risk:** The deployment of Machine Learning on a mobile platform must contend with the limited resources that such a platform entails. The application must be effective while also not overly affecting device performance and battery life.
- **Management of Risk:** The development of the Machine Learning algorithm will have a heavy focus on making it as lightweight as possible and extensive testing on a number of mobile platforms will be performed to ensure reliability and performance requirements are satisfied.

## Effects of low light conditions on reliability of detection

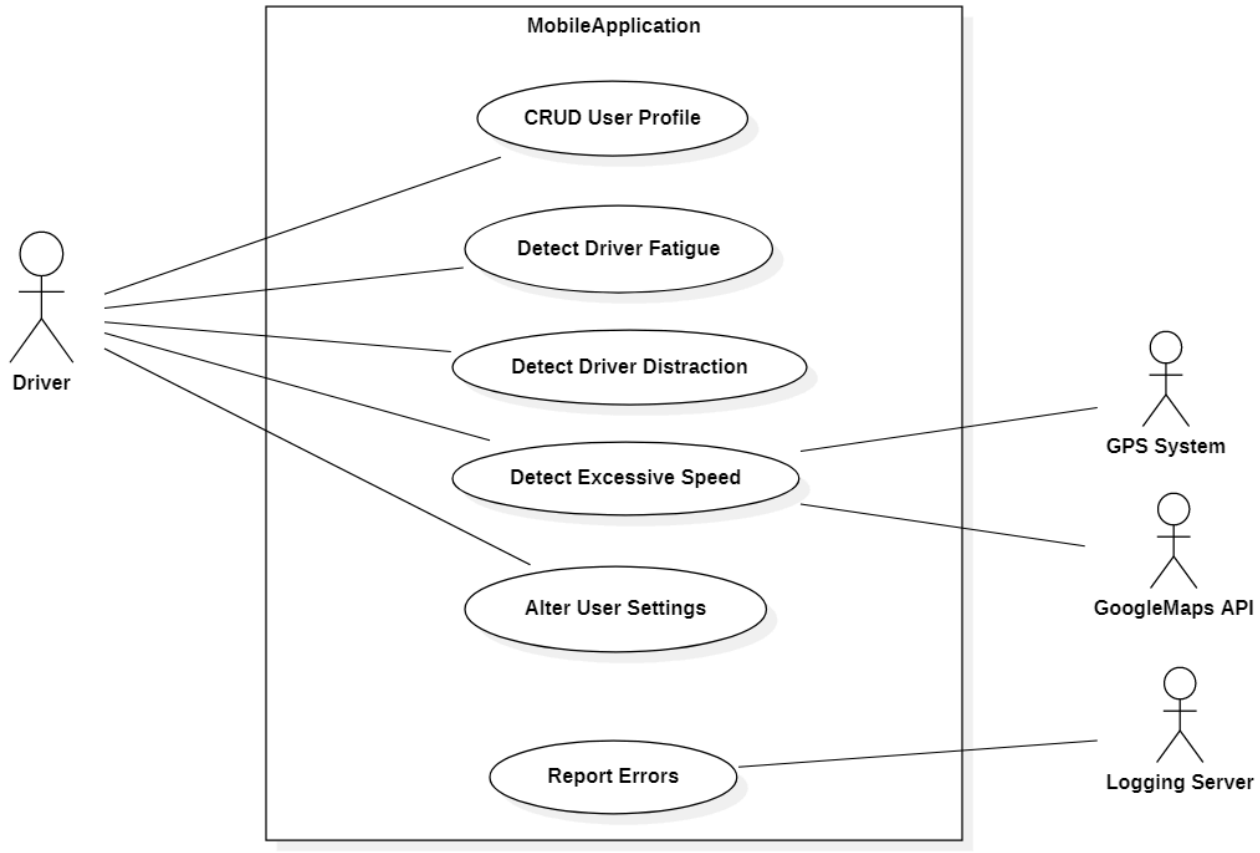
- **Risk:** The detection functionality will have to be able to perform under all driving conditions the most problematic of which is under low light conditions. Such conditions will impact the reliability of the detection rate.
- **Management of Risk:** Will focus on creating an adaptive algorithm which can operate under all conditions and conduct testing to determine how serious the problem is. If necessary, can deploy additional steps such as additional sensors or lighting sources.

## Legal Liability concerns

- **Risk:** Deployment of a safety system with a focus on the protection of human life has additional legal and ethical concerns. In terms of both safety and data privacy legal liability is a risk that must be managed.
- **Management of Risk:** The application must have clear safety warnings that inform the Driver that the system is not to be used when the driver is fatigued and they should instead take a break. The application must have clear terms and conditions that any Driver must accept before using the application. The application should also comply with all GDPR regulations regarding Driver data.

# Use Cases

## Use Case Diagram




## Brief Use Cases

### CRUD Driver Profile

| |
|---|
| **Use Case Name:** CRUD Driver Profile |
| **Actor(s):** Driver |
| **Description:** This Use Case begins when a Driver wants to create, modify or delete a Driver Profile used to store their settings.To create a Driver Profile, the driver must fill in the required fields and the system will create the new profile. |

### Detect Driver Fatigue

| |
|---|
| **Use Case Name:** Detect Driver Fatigue |
| **Actor(s):** Driver |

| |
|---|
| **Description:** This Use Case begins when a Driver activates the Driver Fatigue Monitoring Process. The system activates the specified monitoring process and begins analyzing camera data to determine if a driving fatigue safety event is detected. When a safety event is detected the system will issue a warning to the Driver. |

### Alter User Settings

| |
|---|
| **Use Case Name:** Alter User Settings |
| **Actor(s):** Driver |
| **Description:** This Use Case begins when a Driver wishes to alter the system setting for their Driver profile. The System prompts the Driver to edit their settings as desired. Once the settings have been altered the Driver then submits their preferences and the system updates the system settings as specified. |

### Detect Driver Distraction

| |
|---|
| **Use Case Name:** Detect Driver Distraction |
| **Actor(s):** Driver |
| **Description:** This Use Case begins when a Driver activates the Driver Distraction Monitoring Process. The system activates the specified monitoring process and begins analyzing camera data to determine if a driving distraction safety event is detected. When a safety event is detected the system will issue a warning to the Driver. |

### Detect Excessive Speed

| |
|---|
| **Use Case Name:** Detect Excessive Speed |
| **Actor(s):** Driver |
| **Description:** This Use Case begins when a Driver activates the Speed Monitoring Process. The system activates the specified monitoring process and begins analyzing GPS data to determine if a driving speed safety event is detected. When a safety event is detected the system will issue a warning to the Driver. |

## Detailed Use Cases

### CRUD Driver Profile

| | |
|---|---|
| **Use Case Name:** | CRUD Driver Profile |
| **Actor(s):** | Driver |
| **Brief Description:** | This Use Case describes the process by which a Driver may create a Driver Profile. |

| **Steps performed (main path):** |
|---|
| 1. This Use Case is triggered when a Driver opens the mobile application.<br>2. The system will retrieve the saved Driver Profiles and ask the User to either select an existing Profile, or create a new Profile.<br>3. The Driver chooses to create a new Profile.<br>4. The system prompts the Driver to create a Profile Name and Password.<br>5. The system checks that a Profile of that name does not exist and if it does not, the system creates and stores the new Profile. |
| **Alternatives:** |
| 5a. The system detects that a Profile with the same name already exists.<br>1. The system asks the Driver to choose a new Profile name.<br>2. The Driver enters a new Profile Name.<br>3. The system then checks if that Profile Name already exists and if it does not creates and stores the new Profile. |

## Detect Driver Fatigue

| **Use Case Name:** | Detect Driver Fatigue |
|---|---|
| **Actor(s):** | Driver |
| **Brief Description:** | This Use Case describes the process by which the system monitors and detects driver fatigue safety events. |
| **Steps performed (main path):** | |
| 1. This Use Case is triggered when a Driver activates the Driver Fatigue monitoring process.<br>2. The system periodically processes image data and the Machine Learning model watches for potential Driver fatigue safety events.<br>3. The system detects a Driver fatigue safety event.<br>4. The system issues a warning to the Driver.<br>5. The Driver must deactivate the alarm and monitoring then resumes.<br>6. The use case ends when the Driver deactivates the Driver Fatigue monitoring process. | |
| **Alternatives:** | |
| 2a. The system detects that required data is not being detected for processing.<br>1. The system issues a warning to the Driver that a problem has occurred and deactivates the system. | |

## Detect Driver Distraction

| **Use Case Name:** | Detect Driver Distraction |
|---|---|

| **Actor(s):** | Driver |
|---|---|
| **Brief Description:** | This Use Case describes the process by which the system monitors and detects driver distraction safety events. |
| **Steps performed (main path):** | |
| 1. This Use Case is triggered when a Driver activates the Driver Distraction monitoring process.<br>2. The system periodically processes image data and the Machine Learning model watches for potential Driver distraction safety events.<br>3. The system detects a Driver distraction safety event.<br>4. The system issues a warning to the Driver.<br>5. The Driver must deactivate the alarm and monitoring then resumes.<br>6. The use case ends when the Driver deactivates the Driver Distraction monitoring process. | |
| **Alternatives:** | |
| 1a. The system detects that required data is not being detected for processing.<br>1. The system issues a warning to the Driver that a problem has occurred and deactivates the system. | |

## Detect Excessive Speed

| **Use Case Name:** | Detect Excessive Speed |
|---|---|
| **Actor(s):** | Driver |
| **Brief Description:** | This Use Case describes the process by which the system monitors and detects driver distraction speeding events. |
| **Steps performed (main path):** | |
| 1. This Use Case is triggered when a Driver activates the Driver Speeding monitoring process.<br>2. The system periodically processes GPS data, combined with Speed Limit data and the mobile application monitors for instances of speeds over the Speed Limit.<br>3. The system detects a Driver speeding safety event.<br>4. The system issues a warning to the Driver.<br>5. The Driver must deactivate the alarm and monitoring then resumes.<br>6. The use case ends when the Driver deactivates the Driver Speeding monitoring process. | |
| **Alternatives:** | |
| 2a. The system detects that GPS data is not being detected for processing.<br>1. The system issues a warning to the Driver that a problem has occurred and deactivates the system. | |

2a. The system detects that Speed Limit data can not be calculated.
1. The system issues a warning to the Driver that a problem has occurred and deactivates the system.

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