Software Requirements Specification (SRS)

Lane Management System

Authors: Benjamin Blazy, Ashlee DeLine, Benjamin Frey, Maxwell Miller

Customer: General Motors, Dr. Ramesh S, GM R&D

Instructor: Betty Cheng, TA: Dennis Phillips

1 Introduction

Within this Software Requirements Specification (SRS) document a detailed explanation of the requirements for the Lane Management System (LMS) requested by General Motors will be provided. The following items are included: the LMS’s purpose, scope, functionality, requirements, diagrams relating to the system, and a detailed explanation of the corresponding system model.

1.1 Purpose

The purpose of this SRS document is to give a detailed overview of the requirements for the LMS requested by General Motors. To be absolutely certain that all system requirements are validated and verified, any stakeholders of this LMS and the corresponding software development team should utilize this SRS.

1.2 Scope

The LMS will be classified within the embedded systems domain. The software products produced will be a LMS with several subcomponents. These subcomponents include a Lane Centering System (LCS), a Lane Departure Warning System (LDWS) and a Lane Keeping System (LKS). The LMS will be placed in automobiles as a safety feature. Its purpose is to keep the driver’s vehicle in or near the center of their lane to avoid crashes caused by drivers who become distracted and therefore inattentive to what lane they are in. The LDWS will issue warnings to the driver when the system determines that a lane change was unintentional. The LCS and LKS will work together to take control of the vehicle and adjust to a driver-defined center of the lane. The system will make use of output data from several already-developed subsystems including: Camera Sensing Subsystem, Image Processing Subsystem, Vehicle State Estimation System, Path Prediction Subsystem, Driver Interface Subsystem and a Supervisory Control System.

The LMS will be able to take control of the vehicle’s braking and steering systems; however, the system will not be able to accelerate. The LMS will work at speeds above five miles per hour.
1.3 Definitions, acronyms, and abbreviations

This section is responsible for outlining all terms, acronyms and abbreviations required to comprehend the SRS.

1. **LMS**: Lane Management System, the main system required by GM Customer. The LMS encompasses the following subsystems: LKS, LDWS, and LCS.
2. **LKS**: Lane Keeping System, a subsystem of the LMS; responsible for being able to “intervene and…send commands to steer and adjust the position of the vehicle” [2] when the vehicle leaves the lane.
3. **LDWS**: Lane Departure Warning System, a subsystem of the LMS; responsible for making “use of the Lane sensing feature and issues warnings to the driver when the vehicle leaves a lane” [2].
4. **LCS**: Lane Centering System, a subsystem of the LMS; responsible for returning the vehicle to a driver-defined center of the lane.
5. **SRS**: Software Requirements Specification
6. **Camera Sensing Subsystem**: “Captures images on the sides of the vehicle and sends over to the image processing unit for lane marker detection [2].”
7. **Image Processing Subsystem**: “Processes the raw images coming from the camera and identifies the lane marker [2].”
8. **Vehicle State Estimation System**: “A set of sensors that would periodically determine the speed, steering angle and road curvature [2].”
9. **Path Prediction Subsystem**: “A software subsystem receives information from the Image Processing Subsystem and the Vehicle State Estimation System and tries to predict the path of the vehicle in order to detect, warn and possibly correct any potential lane violations [2].”
10. **Driver Interface System**: “The driver and LMS exchange control and data information through this system [2].”
11. **Supervisory Control Systems**: “Controls all other subsystems, decides when to enable and disable other subsystems and possibly provides diagnostic information [2].”
12. **Lane Departure**: A lane departure occurs when the user intentionally or unintentionally veers out of lane markers. An intentional lane departure is defined as a lane departure when the left or right turn signal is active.
13. **Host Vehicle**: A vehicle that has the LMS installed.
14. **Driver**: This term refers to the current user of the LMS system.
15. **Lane Marker**: Refers to markers that define the boundaries of a lane. These can be any color, and both dashed lines and solid double lines will interact with the system in the same way.
16. **Cruising Area**: Refers to the area that the driver will set via the dashboard. Specifically, when a driver’s host vehicle is in cruising area, will be defined as when the host vehicle is within the boundaries of the extreme left and extreme right positions that are set by the user.
17. **Vehicle Dynamics System**: System that receives information regarding host vehicle and will interface with LMS if steering or braking need to occur to realign vehicle.
1.4 Organization

The remainder of this SRS contains information regarding the LMS requirements requested by General Motors. The following items are included: the system’s purpose, scope, functionality, requirements, diagrams relating to the system, and a detailed explanation of the corresponding system model.

Organizational Structure

2. Overall Description

This section describes the product’s structure and functions. It clarifies the type of user that will be expected to be using the system, and it explains all assumptions made in the usage of the system. It also establishes goals for future versions of the system.

3. Specific Requirements

This section lays out all of the specific requirements for the design of the system.

4. Modeling Requirements

This section includes models describing the functionality and interactions of the system.

5. Prototype

This section describes the interactive prototype of the system and gives some sample scenarios.

6. References

This section is a bibliography.

7. Point of Contact

This section establishes who to contact for more information.

2 Overall Description

Section two will cover the LMS product perspective, product functions, driver characteristics, constraints, assumptions, and dependencies, as well as the apportioning of the requirements.

3 Product Perspective

The product perspective section will give a high-level overview regarding the context of the LMS. In addition, it will include a complete description of the specified product and any constraints. Finally, it will give a pictorial representation of the bigger system.

The LMS is intended to enhance the safety and convenience of the driver and any passengers. The system interface will be responsible for sending direction messages to the Vehicle Dynamics System if a directional change is needed. The driver interface will consist of two components. First, there will be a graphical representation of the vehicle's default position in the lane visible on the dashboard that is adjustable by the driver. The driver will be able to adjust settings through the driver’s interface on the dashboard. These settings include center of lane,
extreme left of lane and extreme right of lane. In addition, there will be a beep to indicate imminent, unintended lane departures as well as a visual depicting which sub-components of the LMS are on or off.

The LMS consists of three subsystems: the LKS, the LCS, and the LWDS. The LKS is responsible for preventing unintended lane departures. The LCS is responsible for keeping the vehicle in the center of the lane. The LDWS is responsible for warning the driver when an unintended lane departure is imminent. There is a central control module that coordinates the actions of the subsystems as well as any action with the driver interface. It also coordinates any action with the driver interface.

The LMS communicates with other vehicle systems, vehicle hardware, and the driver. Those interfaces are as follows:

- **System Interfaces**
  - The Vehicle Dynamics System is notified if a change in direction is called for by one of the LMS's subsystems, such as the vehicle needing to move away from a line and/or towards the center of the lane.
  - The LMS gathers information about the current state of the vehicle, including speed, steering angle, and road curvature, from the Vehicle Estimation System.
  - The LMS uses information from the Path Prediction System to determine if a lane departure might happen given the current vehicle state.

- **Hardware Interfaces**
  - Indirectly, the LMS interfaces with the steering and braking hardware through the Vehicle Dynamics System.
  - Through the Path Prediction System, the LMS interfaces with the cameras and sensors mounted on the vehicle.

- **Driver Interface**
  - Graphical representation of the vehicle's default position in the lane, adjustable by the driver. The driver will be able to adjust settings through driver interface.
  - Beep to indicate imminent unintended lane departure.
4 Product Functions

Within the product functions section, all major functions of the LMS will be defined, along with any other functionality described by the customer.

The LMS will be comprised of three subsections that will each have different functions. The LDWS will identify the lane in which the host vehicle is in and the relative position of the vehicle within the lane [1]. Once this information is obtained, it will issue warnings to the driver if the vehicle leaves a lane through a dashboard interface. These warnings will be both visual and audible warnings. The LKS is an enhancement to the LDWS that will allow the system to directly take control of the steering and brakes of the vehicle in order to make adjustments that will keep the vehicle within the bounds of the lane. The system notifies the driver through an audible beep when this occurs, and the driver can reassert control at any time by resisting the rotation of the steering wheel for at least one second. The LCS is an enhancement to the LKS that will allow the system to take control and make steering adjustments to keep the car at a certain predefined position within the lane. The driver can set their preferred position within the lane at any time via the driver interface settings.

5 User Characteristics

The user characteristics section describes the expectations the software development team has regarding any driver utilizing the LMS.

It is expected that the driver will have fulfilled the legal requirements to possess a driver's license. In addition, it is highly recommended that any driver review the vehicle’s manual prior to setting up and utilizing any portion of the LMS.

6 Constraints

The constraints section of the SRS elaborates on all the constraints of the LMS. In addition, it explains any safety-critical properties and the reasons for which the LMS will not correctly function.

- If one of the six subsystems does not give the LMS sufficient or consistent data, then the LMS will fail and automatically be shut off. In other words, the success of the LMS is completely dependent on the successful operation of the subsystems. If the LMS fails, prior to shutting off, it will alert the driver via both audible and visual warnings.
- The driver should always be able to take control of the vehicle. For example, if the LMS attempts to correct an unintentional lane departure, then the wheel will pull in the direction that will correct the departure. However, the driver will be able to pull in the opposite direction for a sustained period of about one second in order to override the system.
7 Assumptions and Dependencies

This section documents all assumptions and dependencies regarding the LMS.

- Hardware assumptions include the following:
  - The hardware (sensors, cameras) must be fully functional for the system to work.
  - The hardware will be mounted and able to detect road markers.
  - The hardware will not interfere with the driver’s choice. In other words, the driver will always have final say regarding the movements and actions of the vehicle.
  - The hardware will interface properly with other devices to allow data collected by the sensors and camera to be used by the software systems.
  - The hardware will include a console in the driver’s field of view. This will allow for driver interaction and information flow through the system.

- Software assumptions include the following:
  - The software’s audible, visual, and tactile cues will not distract the driver from performing tasks that need his or her full attention.
  - The software will be able to differentiate between paint colors and ambiguous roadside symbols.
  - The system will only function under normal circumstances (receiving clear, valid data at regular intervals) to avoid invalid information.
  - The system will turn itself off if the information that is being received is invalid or there is an imminent collision.

- Environmental assumptions include the following:
  - The environment should be considered to have visibility clear enough for the camera to be able to see the lane markers without obstruction.
  - The environment should be considered to be a paved road with visible lane markers on both sides.

- Driver interaction assumptions include the following:
  - The driver will be alerted of lane departures through an image on a dashboard, a beep, and through a tactile response to the wheel in the vehicle.
  - The driver will always have the ultimate decision in controlling the vehicle.
  - The driver will be able to set the desired cruising area in the lane as he or she pleases.

- System dependencies include the following:
The system’s functionality will depend completely upon the functionality of its subsystem elements. These include a Camera Sensing Subsystem, Image Processing Subsystem, Vehicle State Estimation System, Path Prediction Subsystem, a Driver Interface System and a Supervisory Control System.

8 Apportioning of Requirements

This section will describe the requirements that have been agreed to be outside of the scope of this project by Team LMS and our GM Customer, Dr. Ramesh.

Future versions of the LMS system will incorporate a feature that will allow the system to interface with roadside units to gain more information. For example, a sign that indicates that a lane ahead will be shut down due to construction will cause the system to be turned off, as it will not be able to take in lane data under normal conditions in such a situation. However, today’s road signs will not be able to interface with the system in a reliable manner, as driving past them at high speeds will not allow the camera or other sensing systems to read them adequately. Future road signs may provide features that will allow the LMS system to obtain information.

In addition, the current system will simply move into an idle, non-active state if it is no longer receiving data about the lanes. Future versions of the system may be able to fill in some of the gaps in data and make accurate assumptions about the missing pieces.
9 Specific Requirements

This section will describe the specific requirements of the LMS and its three subsystems: LDWS, LKS and LCS.

1. System will be composed of three subsystems: LDWS, LKS and LCS.
2. System-Wide Requirements:
   2.1. System shall never increase speed.
   2.2. System may require braking when the road is curving so that the car can adjust speed to go around the turn without crossing the lane lines. However, the actual mechanical movement of the car is performed by a separate subsystem that is not under the jurisdiction of this system.
   2.3. System will not operate when the vehicle is traveling at speeds below five miles per hour.
   2.4. System shall alert the driver when taking control of vehicle. System alert shall be a distinguishable audio alert and a visual cue on the dashboard.
   2.5. System shall alert driver when the system is shutting off or turning on. System alert shall be a visual icon.
   2.6. Driver shall be able to manually override the system at any time. If system takes control of the vehicle, then the steering wheel will pull in the direction in which the system wants the vehicle to travel. If the driver wishes to override the system, then he or she will pull the wheel in the desired direction for one second.
   2.7. System shall not interfere with the driver’s intentional lane departures. An intentional lane departure is defined as a lane departure during which the turn signal is engaged.
   2.8. System will go into an idle state if any of the following errors occur: lack of lane markers, debris in the road covering lane markers, traveling off road, or if any other error does not allow system to function properly.
   2.9. If the driver is unintentionally changing lanes, then the system will have a driver-defined period in which only warnings are shown before actually taking control. This (deleted) period will be driver-determined and driver-adjustable.
   2.10. The system does not have a specific response to immanent crashes with other vehicles or obstacles. System is only concerned with issues from its own subsystems.
   2.11. System will utilize subsystems described in 3 to poll vehicle information.
       2.11.1. A rate of one measurement per millisecond is considered a normal rate.
       2.11.2. The system should poll the sensors at a low rate (~100 ms) when there are no changes detected and at a higher rate when there are changes detected (~10 ms).
3. System shall interact with the following subsystems already provided with the vehicle:
   3.1. Camera Sensing Subsystem that will “capture images on the sides of [a] vehicle and send over to the image processing [subsystem] for lane marker detection [2].”
3.2. Image Processing Subsystem that will “process the raw images coming from the camera and identify [any] lane markers [2].”

3.3. Vehicle State Estimation system that will consist of “a set of sensors that [will] periodically determine the speed, steering angle and road curvature [2].”

3.4. Path Prediction Subsystem that “will receive information from 3.2 and 3.3 and then try to predict the path of the vehicle in order to detect, warn and possibly correct any potential lane violations [2].”

3.5. Driver Interface System that “the driver and LMS [will] exchange control and data information [through] [2].”

3.6. Supervisory Control Systems that will “control all the other subsystems, decide when to enable and disable other subsystems, and [will] possibly provide diagnostic information [2].”

4. LDWS Requirements:

4.1. System shall receive data inputs from the subsystems described in Section 3 of the requirements to detect whether a vehicle is staying within the boundaries of a lane.

4.1.1. System will use data from camera and sensors to determine the location of the lane markers.

4.1.2. System will use the anticipated path provided by the path prediction subsystem to detect any imminent deviations.

4.1.3. System will display a warning and produce a beep when the vehicle appears to be leaving the lane and departing from the predicted path.

5. LCS Requirements:

5.1. System shall receive data inputs from subsystems described in Section 3 of the requirements to keep a vehicle centered within a lane. The driver shall define the center during a setup process. In addition, the driver will define the extreme left and extreme right during this setup process.

5.2. The LCS is allowed to take direct control of the vehicle.

6. LKS Requirements:

6.1. System shall be able to take control of steering wheel if predicted path commits a lane violation. System shall utilize the Path Prediction Subsystem to know when such a violation has occurred.
10 Modeling Requirements

This section of the SRS will further clarify the previously specified requirements via various modeling techniques. With each model an accompanying description will give details regarding syntax, purpose and other necessary details.

Figure 1 depicts a Use Case diagram for the LMS. Use case diagrams are used to display user-visible functionality of a system. The blue box represents the system boundary. In this case, that system boundary is the LMS itself. The stick figures represent actors who interact with the system. The ovals represent the use cases. In addition, our system utilizes an “include” within our use case diagram. An “include” simply splits up a behavior that is reused among other use cases. Detailed descriptions of each use case are found after Figure 1.
Figure 1: LMS Use Case Diagram
**Use Case**: Disable System  
**Actors**: Driver  
**Description**: The system is being turned off because of some scenario such as unable to read road markers, or a subsystem is breaking down.  
**Types**: Primary  
**Cross-refs**: 2.3, 2.4, 2.5, 2.6, 2.8  
**Use Cases**: Subsystem Failure, Collision Imminent, Driver Normally, No Lane Departure

**Use Case**: Enable System  
**Actors**: Driver  
**Description**: The system is turning on and trying to help the driver maintain a straight path, and warn them of incoming dangers.  
**Types**: Primary  
**Cross-refs**: 2.4  
**Use Cases**: Take Control of Vehicle, No Lane Departure, Drive Normally, Display Information, Intended Lane Departure

**Use Case**: Alert Driver  
**Actors**: Driver, Camera System, and Vehicle Control System.  
**Description**: Something has gone wrong and the driver will be alerted of it with a beep.  
**Types**: Primary  
**Cross-refs**: 2.4, 2.9, 4.1.3  
**Use Cases**: All

**Use Case**: Display Information  
**Actors**: Camera System, Vehicle Control System, Driver.  
**Description**: The information that is gathered for the subsystems is being shown to the driver, such as the location in the lane, and current speed.  
**Types**: Primary  
**Cross-refs**: 2.5, 4.1.3  
**Use Cases**: All

**Use Case**: Drive Normally  
**Actors**: Driver, Camera System.  
**Description**: Nothing is going wrong, so the driver has full control and only information is being passed from subsystems to the driver's display to view the information.  
**Types**: Primary  
**Cross-refs**: 2.7  
**Use Cases**: Intended Lane Departure, No Lane Departure
Use Case: Subsystem Failure
Actors: Driver, Camera System, and Vehicle Control System.
Description: Something has broken down and the system is going to shut itself off because of a lack of sufficient information to help the driver with.
Types: Primary
Cross-refs: 2.8
Use Cases: Disable System

Use Case: Subsystem Failure
Actors: Camera System, Vehicle Control System.
Description: There is a collision that is going to occur, so the driver needs to be warned and the system needs to shut itself off to allow the driver to act to mitigate the situation.
Types: Primary
Cross-refs: 2.10
Use Cases: Disable System, Alert Driver, Drive Normally, Take Control of Vehicle

Use Case: Take Control of Vehicle
Actors: Camera System, Vehicle Control System.
Description: The system is trying to move the vehicle towards the center of the lane and help the driver maintain a stable driving path.
Types: Primary
Cross-refs: 5, 5.1, 5.2, 6, 6.1
Use Cases: Collision Imminent, Unintended Lane Departure, Alert Driver, Enable System

Use Case: Unintended Lane Departure
Actors: Camera System, Vehicle Control System
Description: The driver is leaving the lane without intent, through non-indication of the lane transfer. The system should warn the driver of the problem.
Types: Primary
Cross-refs: 4, 4.1, 4.1.1, 4.1.2, 4.1.3
Use Cases: Disable System, Alert Driver, Drive Normally, Take Control of Vehicle

Use Case: Intended Lane Departure
Actors: Camera System
Description: The driver is trying to leave the lane intentionally, by using an indicator. The system should be turned off in this scenario.
Types: Primary
Cross-refs: 2.7
Use Cases: Drive Normally, Display Information, Enable System
**Use Case:** Detect Lane Departure  
**Actors:** Camera System, Vehicle Control System  
**Description:** The cameras are detecting that the lane is being left, and needs to determine if this departure is intended or unintended.  
**Types:** Primary  
**Cross-refs:** 3.1, 3.2, 4, 4.1, 4.1.1, 4.1.2  
**Use Cases:** All

**Use Case:** No Lane Departure  
**Actors:** Camera System, Vehicle Control System.  
**Description:** The driver is going along in a normal fashion, in the center of the lane where they want to be. The system should sit idle and track for any problems to occur.  
**Types:** Primary  
**Cross-refs:** 2.11, 2.11.1, 2.11.2, 4, 4.1, 4.1.1, 4.1.2  
**Use Cases:** All

**Use Case:** Driver Defined Settings  
**Actors:** Driver  
**Description:** The driver is changing the thresholds for the extreme left, extreme right, center of the lane, and exit duration for the vehicle’s lane.  
**Types:** Primary  
**Cross-refs:** 5.1  
**Use Cases:** All
Figure 2 displays a class diagram for the LMS. This class diagram describes the objects involved in the LMS, their behavior and their relationships with one another. The class diagram consists of boxes that depict classes, which hold relative attributes and operations within them. In addition, associations (relationships) between the classes are depicted with a line, as well as a description and arrow. Within Figure 2, there are also special associations called aggregations depicted via a diamond. An aggregation is used for showing when a class is a part of another class. Following the class diagram is a data dictionary that will give further details describing each of the classes within the class diagram.
Figure 3: LMS Class Diagram
## Data Dictionary

<table>
<thead>
<tr>
<th>Element Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LaneCenteringSystem</td>
<td>Subsystem that keeps the vehicle in a desired position within the lane.</td>
</tr>
</tbody>
</table>

### Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IsActive:bool</td>
<td>Returns true if LCS is active</td>
</tr>
<tr>
<td>minSpeed:float</td>
<td>Has the minimum speed at which the system will function.</td>
</tr>
<tr>
<td>driverCenter:float</td>
<td>Keeps track of the driver-defined center of the lane.</td>
</tr>
</tbody>
</table>

### Operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TurnOn(): return void</td>
<td>Turns on the LCS</td>
</tr>
<tr>
<td>TurnOff(): return void</td>
<td>Turns off the LCS</td>
</tr>
<tr>
<td>CheckStatus(): return bool</td>
<td>Will return True if the system is receiving data correctly.</td>
</tr>
<tr>
<td>CheckConditions(): return bool</td>
<td>Will return True if the conditions are good enough to obtain meaningful data.</td>
</tr>
</tbody>
</table>

### Relationships

The LaneCenteringSystem class is a part of the LMSSubsystem and it is a feature of the LaneKeepingSystem. The LaneCenteringSystem is activated by the brake or steering systems. The SupervisoryControlSystem controls the LaneCenteringSystem.

### UML Extensions

NA

---

<table>
<thead>
<tr>
<th>Element Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LaneKeepingSystem</td>
<td>Subsystem that keeps vehicle within lane boundaries</td>
</tr>
</tbody>
</table>

### Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IsActive:bool</td>
<td>Returns true if LKS is active</td>
</tr>
<tr>
<td>minSpeed:float</td>
<td>Has the minimum speed at which the system will function.</td>
</tr>
</tbody>
</table>

### Operations

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TurnOn(): return void</td>
<td>Turns on the LKS</td>
</tr>
<tr>
<td>TurnOff(): return void</td>
<td>Turns off the LKS</td>
</tr>
<tr>
<td>CheckStatus(): return bool</td>
<td>Will return True if the system is receiving data correctly.</td>
</tr>
<tr>
<td>CheckConditions(): return bool</td>
<td>Will return True if the conditions are good enough to obtain meaningful data.</td>
</tr>
</tbody>
</table>

### Relationships

The LaneKeepingSystem class is a part of the LMSSubsystem. The LaneDepartureWarningSystem transitions to the LaneKeepingSystem. The LaneKeepingSystem is activated by the brake or steering systems. The SupervisoryControlSystem controls the LaneKeepingSystem.

### UML Extensions

NA

---

Template based on IEEE Std 830-1998 for SRS. Modifications (content and ordering of information) have been made by Betty H.C. Cheng, Michigan State University (chengb at chengb.cse.msu.edu)
<table>
<thead>
<tr>
<th><strong>Element Name</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>LaneDepartureWarningSystem</td>
<td>Subsystem that monitors lane position and issues warnings</td>
</tr>
<tr>
<td><strong>Attributes</strong></td>
<td></td>
</tr>
<tr>
<td>IsActive:bool</td>
<td>Returns true if LDWS is active</td>
</tr>
<tr>
<td>minSpeed:float</td>
<td>Has the minimum speed at which the system will function.</td>
</tr>
<tr>
<td><strong>Operations</strong></td>
<td></td>
</tr>
<tr>
<td>TurnOn(): return void</td>
<td>Turns on the LDWS</td>
</tr>
<tr>
<td>TurnOff(): return void</td>
<td>Turns off the LDWS</td>
</tr>
<tr>
<td>CheckStatus(): return bool</td>
<td>Will return True if the system is receiving data correctly.</td>
</tr>
<tr>
<td>CheckConditions(): return bool</td>
<td>Will return True if the conditions are good enough to obtain meaningful data.</td>
</tr>
<tr>
<td><strong>Relationships</strong></td>
<td>The LaneDepartureWarningSystem class is a part of the LMSSubsystem. The LaneDepartureWarningSystem transitions to the LaneKeepingSystem. The LaneDepartureWarningSystem activates the alarm. The SupervisoryControlSystem controls the LaneDepartureWarningSystem.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Element Name</strong></th>
<th><strong>Description</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>LMSSubsystem</td>
<td>Base class that the LMS subsystems are derived from</td>
</tr>
<tr>
<td><strong>Attributes</strong></td>
<td></td>
</tr>
<tr>
<td>IsActive:bool</td>
<td>Returns true if any subsystem of the LMS is on</td>
</tr>
<tr>
<td><strong>Operations</strong></td>
<td></td>
</tr>
<tr>
<td>TurnOn(): return void</td>
<td>Turns on the LMS</td>
</tr>
<tr>
<td>TurnOff(): return void</td>
<td>Turns off the LMS</td>
</tr>
<tr>
<td><strong>Relationships</strong></td>
<td>The LMSSubsystem has three parts: the LaneDepartureWarningSystem, the LanekeepingSystem and the LaneCenteringSystem.</td>
</tr>
<tr>
<td><strong>UML Extensions</strong></td>
<td>NA</td>
</tr>
<tr>
<td>Element Name</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>LMSSystem</td>
<td>Base class that aggregates SupervisoryControlSystem and LMSSubsystem together.</td>
</tr>
</tbody>
</table>

| Attributes           |                                                                  |
|----------------------|                                                                  |
| Operations           |                                                                  |
| Relationships        | The LMSSystem has two parts: the SupervisoryControlSystem and the LMSSubsystem. |
| UML Extensions       | NA                                                                  |

<table>
<thead>
<tr>
<th>Element Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SupervisoryControlSystem</td>
<td>A central control system that manages all of the subsystems of the LMS</td>
</tr>
</tbody>
</table>

| Attributes           |                                                                  |
|----------------------|                                                                  |
| IsActive:bool        | Returns true if SupervisoryControlSystem is active               |
| Operations           |                                                                  |
| TurnOn(): return void| Turns on the SupervisoryControlSystem                            |
| OkLightOn(): return bool| Will return True if Ok light is on                             |
| OkLightOff(): return bool| Will return True if Ok light is off                           |
| ComparePaths(): return bool| Will compare paths                                              |
| WarningIndicatorOn(): return void| Turns on warning indicator if no data is being received |
| Relationships        | The SupervisoryControlSystem controls the LaneCenteringSystem, the LaneKeepingSystem and the LaneDepartureWarningSystem. In addition, the SupervisoryControlSystem activates the Alarm. Finally, the DriverInterface sends input to the SupervisoryControlSystem |
| UML Extensions       | NA                                                                  |
Below are the representative scenarios of the LMS. Following the scenarios are corresponding sequence diagrams for each scenario. Sequence diagrams are used to emphasize the interactions between objects within a system. Sequence diagrams have a series of boxes at the top of the image that depicts objects. From these boxes are dashed lines. Between the dashed lines are synchronous messages and responses that occur between the objects.

Figure 3 depicts the FailureState Scenario, as taken from [2], this scenario depicts how the system handles failure. For example, lane information may be missing or a subsystem may have failed.

Figure 4 depicts the LeftCurve Scenario as taken from [2], this scenario depicts how the system handles non-zero curvature.

Figure 5 depicts the DrivingStraight Scenario as taken from [2], this scenario depicts how the system handles driving straight. For example, with this scenario it is assumed that the vehicle will be traveling in a straight line with zero road curvature, valid and conforming sequence of images from the subsystems and vehicle speed is uniform.

Figure 6 depicts the SystemOn Scenario as taken from [2], this scenario depicts how the system handles being on, with no communication between the system and the driver or the system and the systems subsystems.
Figure 3: Sequence Diagram 1, FailureState
Figure 4: Sequence Diagram 2, LeftCurve
Figure 5: Sequence Diagram 3, Driving Straight
In the following pages are depictions of the respective state diagrams for the LMS and its subsystems. A state diagram portrays the behavior of a system. It is made up of states (circles) and events (lines between states). Figure 7 depicts the overall LMS, Figure 8 depicts the LDWS, Figure 9 depicts the LKS, and Figure 10 depicts the LCS.
Figure 7: LMS State Diagram
Figure 8: LDWS State Diagram

Figure 9: LKS State Diagram

Figure 10: LCS State Diagram
11 Prototype

The LMS prototype below (Figure 11) shows how the system should function under various sets of conditions. It allows the user of the prototype to set conditions such as the lane thresholds, current vehicle position, road curvature, vehicle direction, and the current left and right thresholds of the lane (as values) and see on a visual and auditory level how the LDWS, LKS, and LCS should respond to the given case. The driver can also shut off any of the systems at any time, and can use buttons to simulate turning on the vehicle’s turn signal.

![Prototype Interface](image)

**Figure 11: Prototype Interface**

12 How to Run Prototype

The prototype is available on our team webpage, found at the link provided here (http://www.cse.msu.edu/~cse435/Projects/F2014/Groups/LMS/web/prototype/LMS_Prototype_Web_v1.0.html). The program can be run after installing the necessary Unity plugin.

13 Sample Scenarios

Within this section, various sample scenarios will be described and then screenshots (along with their explanations) will be displayed. Screenshots will be available when prototype is complete.
• Figure 12 depicts a situation where the road conditions are clear and the lane markers are visible on a normal road, the system is active. This is considered a normal scenario. All of the subsystems should be functioning and the system should alert the driver if the vehicle is about to leave the lane.

Figure 12: Scenario 1 - Normal, System Active
Figure 13 and 14 depict a scenario where the road conditions are clear and the lane markers are visible on a normal road, the system is inactive. This is considered a normal scenario. The system should have no effect on the driver and give no indication of a lane departure.

![Figure 13: Scenario 2 - Normal, System Inactive, Part 1](image1)

![Figure 14: Scenario 2 - Normal, System Inactive, Part 2](image2)
Figure 15 and 16 depict a scenario where the road conditions are clear and the lane markers are visible on a normal road, the system is active, and the indicator is on. This is considered a normal scenario. The system should have no effect on the driver and give no indication of a lane departure.

**Figure 15: Scenario 3 - Normal, Good Road Conditions, Part 1**

**Figure 16: Scenario 3 - Normal, Good Road Conditions, Part 2**
• Figure 17 depicts a scenario where the road conditions are unclear and the system is active. This is considered an abnormal scenario. The system should not interfere with anything that the driver does under any circumstances incase of flawed information.

Figure 17: Scenario 4 - Abnormal, Poor Road Conditions
• Figure 18 depicts a scenario where the road conditions are clear and the system is active. The left turn signal is activated. This is considered a normal scenario. The system should not interfere with anything that the driver does under any circumstances incase of flawed information.

Figure 18: Scenario 5 - Normal, Turn Signal Activated
14 References

Below, you will find the references used in compiling this LMS SRS.


[7] MSU CSE 435 LMS Team Homepage:
http://www.cse.msu.edu/~cse435/Projects/F2014/Groups/LMS/web/

15 Point of Contact

For further information regarding this document and project, please contact Prof. Betty H.C. Cheng at Michigan State University (chengb at cse.msu.edu). All materials in this document have been sanitized for proprietary data. The students and the instructor gratefully acknowledge the participation of our industrial collaborators.