CSC436 Software Engineering Software and Safety Requirements Engineering

Requirements Engineering & Safety Analyses of Super-Duper Secret Car Rear-View Camera with Cross-Traffic Detection, Rear Collision Avoidance System and Smart Trunk Hatch

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Software Requirements Specification

Document

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1. Introduction

1.1 Purpose

The purpose of this document is to present a detailed description of our requirements engineering of Hyundai's Saint Jose 2.0 4WD Sport SUV; specifically the rear-view camera with cross-traffic detection, rear collision avoidance, and smart trunk hatch driver assistance system. We will also conduct safety analyses to ensure that the likelihood of humans and external systems to suffer injury, damage, or death is sufficiently low enough and/or unlikely.

The document will explain the purpose and features of the system. What the system will do, the constraints under which it must operate, and how the system will react to external stimuli in a given environment. This document is intended for stakeholders, developers, and users of the systems within the vehicle.

1.2 Scope

Rear Cross-Traffic Collision System

- The Rear Cross-Traffic Collision Avoidance Assist (RCCW) system uses radar sensors to monitor the approaching cross traffic from the left and right side of the vehicle when your vehicle is in reverse. The blind spot detection range varies relative to the approaching vehicle speed.
- The Rear Cross-Traffic Collision Avoidance Assist (RCCA) system may activate the Electronic Stability Control (ESC) in accordance with a possible collision with an approaching vehicle. It is to lower the possible collision risk or mitigate the possible collision damage
- The RCCW is not entirely reliable and is not a substitute for proper and safe driving.

Rear MoniterView

- view rear view through the screen while driving. the system activates when the engine is on
- the system help in reverse parking as the rear view camera help with guided line in the monitor screen for the driver

Smart Trunk Hatch

- Smart Trunk Hatch system uses a sensor to sense the smart key behind the car for 3 seconds to automatically open the trunk without touching anything but The Smart Liftgate will NOT operate when: Any door is open, or all doors are closed but not locked, The smart key is detected within 15 seconds from when the doors were closed and locked, and if the smart key is in the vehicle.

1.3 Definitions, Acronyms, and Abbreviations.

Glossary

Term	Definition
RCCW	Rear Cross-Traffic Collision Warning
ESC	Electronic Stability Control
RCCA	Rear Cross-Traffic Collision Avoidance Assist
BCW	Blind-Spot Collision Warning
LKA	Lane Keeping Assist
VSM	Vehicle Stability Management
DAW	Driver Attention Warning
TBD	To Be Determined
WIP	Work in Progress
N/A	Not available

1.4 References

- IEEE. *IEEE Std 830-1998 IEEE Recommended Practice for Software Requirements Specifications.* IEEE Computer Society, 1998. Obtained via Blackboard
- HYUNDAI , *OWNER'S MANUAL Operation Maintenance Specifications.* HYUNDAI Santa Fe 2020. Obtained via Hyundai / Blackboard

1.5 Overview

The next(second) section, the overall description section, of this document gives an overview of the functionality of the product. It describes the informal requirements and is used to establish a context for the technical requirements specification in the next chapter. This section concerns users.

The third section, Requirements Specification section, of this document is written primarily for the developers and describes in technical terms the details of the functionality of the product. Both sections of the document describe the same software product in its entirety, but are intended for different audiences and thus use different language

The fourth section explains how customers may go about getting in contact and interact with the requirements engineers as well as developers. This section concerns customers, clients, and anyone interested in speaking to the team about the system.

The fifth section consists of only engineer signatures

The sixth section contains the appendix and extra notes that may be useful to anyone.

2. The Overall Description

2.1 Product Perspective

The system consists of three main components rear Rear Cross-Traffic Collision System
which is supported by a rear monitor system and smart trunk hatch.

Rear Cross-Traffic Collision System is used to help the driver reverse the car in a parking situation where the driver could not see the side of the car due to any cars parked around. Rear monitor system helps the drivers as the driver does not have to constantly keep looking, turning behind or looking at different mirrors to see the back view but rather the rear camera mounted at the rear bumper streams a live video on the screen for the driver. There are also sensors mounted in the tail light and bumper of the car to create a radar sensor to warn the driver where the vehicle is approaching from left or right and alert the driver through screen and audio alert. The sensor system will also apply brakes for vehicles if an approaching vehicle is too close and could cause a crash.

Smart trunk hatch is a feature to help the driver/user to open the trunk without touching it. The smart trunk hatch senses the smart key behind the for 3 seconds after all doors are closed and locked for 10 seconds.

2.1.1 System Interfaces

The rear monitor view uses a camera to stream it on the screen.

Rear cross-traffic collision System interfaces with the sensor to detect the environment, audio system to alert the driver of approaching vehicles, side light in the mirror to alert the driver when looking in the side view, and the ESC to apply brakes for safety if the vehicles are about to crash.
Smart trunk hatch system interfaces with the sensor of the rear to detect the smart key and the door/locks of the car to safely open and close the trunk

2.1.2 Interfaces

There is a screen located on the dashboard which can be used as a means by which the system interacts with the driver by providing warnings and a means of changing the system settings.

2.1.4 Software Interfaces

Rear cross-traffic collision System software interfaces multiple software within the vehicle one it takes the information from the detected sensors to convert them into audio alerts or apply safety breaks for the driver if the vehicle is too close to be crashed. Rear monitor view take the video stream from the camera to upload it on the screen for the user and applies guided line for the driver to see how the vehicle moves back, smart trunk hatch software interfaces with the locking system to make sure and be activated it also interacts with a smart key to open the trunk.

2.1.6 Memory Constraints

No memory constraints, only the software memory is required depending on how big the software is created and uploaded because most data is used for real time.

2.1.7 Operations

If the system needs an update it will show up on the screen on the dashboard with instructions to follow as per the update of a specific component or system for the vehicle.

2.2 Product Functions

- The RCCA system may activate the ESC in accordance with a possible collision with an approaching vehicle. It is to lower the possible collision risk or mitigate the possible collision damage

- The driver can change and switch on/off the system in setting and activation in the dashboard screen.
- The RCCA system shall be able to alert the driver by hearing from the audio system.
- The rear monitor system shall be able to alert the driver by looking on the side view mirror
- The RCCA system shall be able to alert the driver by showing on the dashboard screen the live stream from the camera place behind.
- The RCCA system shall reduce cross traffic accidents.
- The smart trunk hatch system shall help the driver to hand free open the trunk.

2.3 User Characteristics

The owner of car much be able to driver the car with a valid driving license and be able to read and under the alert/warning on the dashboard screen

2.4 Constraints

Since May 1st, 2018, all new cars sold in Canada, weighing 4536 kg or less, must be fitted with a backup camera, says Transport Canada. The law was first put forward back in October 2016 in reaction to some rather alarming statistics.

- https://www.guideautoweb.com/en/articles/46328/

About half of model year 2012 automobiles were equipped with backup cameras. On March 31, 2014, three years past its deadline, the U.S. National Highway Traffic Safety Administration announced that **it would require all automobiles sold in the United States built beginning in May 2018 to include backup cameras and video displays**.

- https://www.autoinsurance.org/are-backup-cameras-required-on-new-vehicles-updated/
-

2.5 Assumptions and Dependencies

- Always be aware of road conditions while driving and be alert for unexpected situations even though the Rear Cross-Traffic Collision Warning system and Rear Cross-Traffic Collision-Avoidance Assist system are operating.
- The Rear Cross-Traffic Collision Warning system and Rear Cross-Traffic CollisionAvoidance Assist system are supplemental systems to assist you. Do not entirely rely on the systems. Always pay attention, while driving, for your safety.
- The Rear Cross-Traffic Collision Warning system and Rear Cross-Traffic CollisionAvoidance Assist system are not substitutes for proper and safe driving. Always drive safely and use caution when backing up the vehicle.

- Drive safely even though the vehicle is equipped with a Rear Cross-Traffic Collision Warning system and Rear Cross-Traffic Collision-Avoidance Assist system. Do not solely rely on the system but check your surroundings when backing the vehicle up.
- The driver is responsible for accurate brake control.
- Always pay extreme caution while driving. The Rear CrossTraffic Collision Warning system and Rear Cross-Traffic Collision-Avoidance Assist system may not operate properly or unnecessarily operate in accordance with your driving situations.
- The Rear Cross-Traffic Collision-Avoidance Assist system is not a substitute for safe driving practices, but a convenience function only. It is the responsibility of the driver to always drive cautiously to prevent unexpected and sudden situations from occurring. Pay attention to the road conditions at all times.
- The system may not work properly when the bumper has been damaged, or if the rear bumper has been replaced or repaired.
- The system may turn off due to strong electromagnetic waves.
- Always keep the sensors clean.
- Never arbitrarily disassemble the sensor component nor apply any impact on the sensor component
- Make certain that you close the liftgate before driving your vehicle.
- Make sure there are no people or objects around the liftgate before opening or closing the liftgate.
- Make sure objects in the rear cargo area do not come out when opening the liftgate, especially if the vehicle is parked on a grade or incline.
- If you keep your vehicle parked and locked on your driveway, you may want to temporarily deactivate the Smart Liftgate system. Otherwise, standing at the rear of the vehicle with the smart key may cause the liftgate to open unintentionally

3. Specific Requirements

3.0.1 Natural Language Requirements

Natural Language Requirements

ID	Natural Language Requirement	Artifact Type	Requirement Type	Quality Property / Perspective	Source
G1	The system shall activate when both the vehicle speed is below 6 mph (10 km/h) and the shift lever in R (Reverse).	Goal	Functional	Performance	5-84 pg
G2	The system shall on the warning light of outer side view mirror and blink if a	Goal	Quality	Performance	5-85 pg

	vehicle approaches from the rear left/right side				
G3	The system shall display alert on LCD display if a vehicle approaches from the rear left/right side	Goal	Functional	Performance	5-85 pg
G4	The rear view monitor system shall warning the driver by the audio or AVN screen	Goal	Functional	Performance	5-85 pg
G5	The system warning shall stop when the detected vehicle moves out of the sensing area	Goal	Functional	Performance	5-85 pg
G6	The system warning will stop when the vehicle is not approaching your vehicle	Goal	Functional	Performance	5-85 pg
G7	The system warning will stop when the other vehicle slows down	Goal	Functional	Performance	5-85 pg
G8	The system shall have smart hand free liftgate system to open automatically	Goal	Functional	Operability	3-59pg
SC1	1 The user opens the User Settings in the cluster LCD display 2 The user then enables Smart Lift capability for ease of use	Scenario	Functional	Satisfaction	3-59pg
SC2	1 After all the doors are closed and locked for at least 15 seconds 2 Then the Smart Liftgate will activate and be ready for operation	Scenario	Functional	Operability	3-59pg
SC3	The smart key is detected in the area behind the vehicle for 3 seconds Then the Smart Liftgate will open.	Scenario	Functional	Satisfaction	3-59pg
SR1	The car sensors detect other vehicles coming from the back-left and/or back-right The car sensors will then inform the user using a chime sound and displaying BRAKE	SOR	Functional	Operability	5-83

	Only if 'Active Assist' is enabled, and the user fails to brake prior to impact will the vehicle take over and brake for the user.				
G9	The Smart Liftgate must NOT operate when any door is open, or all doors are closed but not locked	(anti)Goal	Functional	Satisfaction	3-60
G10	The Smart Liftgate must NOT operate when The smart key is detected within 15 seconds from when the doors were closed and locked	(anti)Goal	Quality	Satisfaction	3-60
G11	The Smart Liftgate must NOT operate when if the smart key is within 60 inches (1.5m) from the front door handles	(anti)Goal	Quality	Satisfaction	3-60
G12	The Smart Liftgate must NOT operate when the smart key is in the vehicle.	(anti)Goal	Functional	Satisfaction	3-60
G13	The system shall have automatic brake system which depends on sensors	Goal	Functional	Performance	FHA
G14	The system shall have two sensors working independent from each other.	Goal	Quality	Performance	FHA
G15	The system shall have full range of sensor to alert the driver and safely brake	Goal	Functional	Performance	FHA
G16	The system shall be able to change the warning time to a specific limit	Goal	Quality	Performance	FHA
G17	The system shall be able to change the volume to allow for the alert noise to be heard	Goal	Quality	N/A	FHA
G18	The system shall interrupt the driver's actions for safety actions.	Goal	Quality	N/A	FHA
G19	The system shall alert the driver when the system component is broken/ damaged/ not connected	Goal	Functional	Safety	FHA
G20	The system shall be able to alert the driver if the radar systems are blocked or if the BCW system is unable	Goal	Functional	N/A	FHA

G21	The system shall alert the driver about a possible collision	Goal	Functional	Performance	FHA
SC4	1 The system will detects a vehicle from the rear left and/or right side 2 Then the vehicle produces a chime to notify the user that another object is approaching	Scenario	Functional	Satisfaction	FHA
SC5	1 The collision avoidance sensor will detects objects within 20 feet 2 The vehicle plays a chime from the dashboard, alerting the driver	Scenario	Functional	Satisfaction	FHA
SC6	1 The system will detects a vehicle passing from left to right or right to left 2 Then displays a flashing symbol on the backup camera screen on the side the car is passing from.	Scenario	Functional	Satisfaction	FHA
SC7	When a certain threshold distance is reached the system will engage the brakes for exactly 2 seconds	Scenario	Quality	Satisfaction	FHA
G22	The system could have portable sensors that could be attached to the trailer.	Goal	Functional	Goal	FHA
G23	The sensor should sense the road elevation change	Goal	Functional	Goal	FHA

Context Entities

ID	Entity	Subject Facet	IT System Facet	Usage Facet	Development Facet
1	Radar Sensors	x		x	
2	Braking System	x		x	
3	Camera	x		x	
4	Dashboard Display		x	x	

5	Driver / Users			x	
6	Smart Liftgate	x	x	x	
7	RCCW	x	x	x	x
8	ESC	x	x	x	x
9	RCCA	x	x	x	x
10	BCW	x	x	x	x
11	LKA	x	x	x	x
12	VSM	x	x	x	x
13	DAW	x	x	x	x
14	Stakeholders			x	
15	Developers				x
16	Hyundai and other competitors				x
17	Other clients				x
18	Governments				x

3.0.2 Functional Hazard Analysis

CSC436-800 **SUNY Oswego**

This template is based on the template provided in:
Cliffton Ericson III: Hazard Analysis Techniques for System Safety, 1st Ed., Wiley, 2005, p. 276.

Software & Safety Requirements Engineering Spring 2022

Functional Hazard Analysis							
Version:	*1.1*	**Safety Engineers:**	*Anubhav Sigdel , Sven Keppler, Tyler West, Umang Patel*				
System:	Hyundai's Saint Jose 2.0 4WD Sport SUV			**Subsystem:**	*The rear-view camera with cross-traffic detection, rear collision avoidance, and smart trunk hatch*		
Hazard ID	**Functional Requirement**	**Hazard Description**	**Effect (Accident)**	**Trigger Conditions**	**IMRI**	**Safety Goal**	**FMRI**
H 1.1	SC 6	Camera failure	Rear-end collision leading to human death, injury,	Rear-view camera feed not played in screen to the driver RCCW warning may not display on camera screen	3D	The system shall have automatic brake system which depends on sensors	4E
H 1.2	SC 6	Inclement weather conditions or dirt impacting camera's ability to see	Poor visibility causing the driver to engage in risky behavior and/or have a collision (without Active Assist)	Rear-view camera is obfuscated by objects or inclement weather covering it	2D	Operability of camera and systems must be able to persist through partial obfuscation to maintain safety of driver	4E
H 2	G 14	Sensor failure	See H1.1	Audio to alert driver is not working and system does not display alert	3D	The system shall have two sensors working independent from each other.	4E
H 3	G 15	Blind Spot in Sensing Capabilities	Collision to approaching vehicle in speed	The car does not have a full radar covering the whole back	2D	The system shall have full range of sensor to alert the driver and safely brake	4E

H 4.1	G 16	changing warning time	See H1.1	If you change the warning timing, the warning time of other systems may change.	3E	The system shall be able to change the warning time to a specific limit	4E
H 4.2	G 17	Changing warning volume	rear collision and the driver does not hear the sound alert	If you change the warning volume, the warning volume of other systems may change.	3E	The system shall be able to change the volume to a specific limit	4E
H 5	SC 7	The brake activation by the system lasts for about 2 seconds	Driver mistakenly keeps accelerating the car without knowing the system is braking	The user keeps their foot on the accelerator while and after the 2 second of automatic braking is over	3B	The system shall be able to alert the driver of its braking and the car control will be given over back.	4E
H 6	SC6	The system might be turned off due to strong electromagnetic waves.	RCCW fails leading to rear collision, human death or injury	sensor failure and RCCW error	1D	Rear camera could have a system that could predict the distance/ sense object through image recognition to alert the driver of the surrounds	4E
H 7	SR 1	Damaged Sensor	The system would not be able to warn the driver leading to collision	The sensor might not be connected to the system or could be physically broken	3D	The system shall alert the driver when the system component is broken/ damaged/ not connected	4E

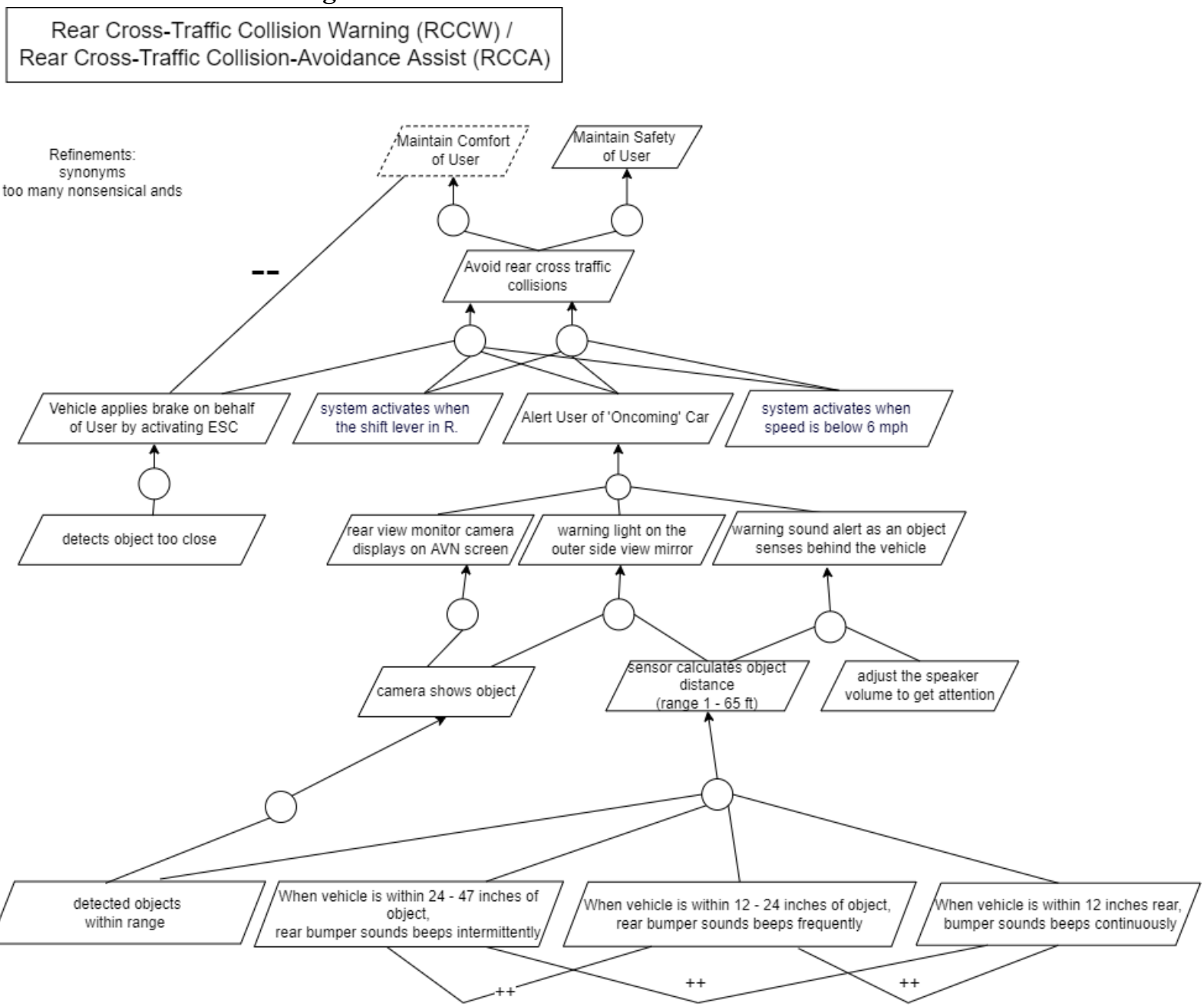
H 8	G18	System disabled/ radar blocked	BCW would not be able to alert the driver of the blind spot leading to collision	blind spot collision/ not detected	3D	The system shall be able to alert the driver if the radar systems are blocked or if the BCW system is unable	4E
H 9	G22	A trailer is attached to the back of the car	RCCA failed and the trailer crashed	RCCA system sensor would be turned off as the sensor wouldn't be able to detect behind the trailer	2D	The system could have portable sensors that could be attached to the trailer.	4E
H 10	G 20	When the sensors are blocked by other vehicles, walls or parking-lot pillars	The system might send alert to the driver while the car is parked nearby an object	The driver might turn off the system due to sensors reading the object near which are not in the path of the driver	3A	The sensor should be trimmed to a specific setting that driver don't get annoyed with the alerts/warning	3E
H 11.1	G23	The entire RCCA system is rendered useless due to elevation differences	The RCCA fails and the driver is involved in a side-on collision	Car is approaching from an incline causing the sensor to not be able to sense the others car's presence	1D	The sensor should sense the the road and if there's a severe enough elevation change, informs the user that the RCCA is unable to work in the current conditions	3D

H 11.2	G23	The vehicle height gets lower or higher due to heavy loading in a trunk, abnormal tire pressure	System might give error due to sensor not align in the specified height	The system will not give accurate safety directions	4C	The car should have a system on the suspension of the car to alert the driver the sensor are too low of too high	4E
H 12	G13	Small objects don't get sensed by the car sensor	The car would crash in the small object such as shopping carts or a baby stroller	RCCA can't see an object and the RCCW is not raised.	2D	The system sensor should be very sensitive to detect any small object on the rear	4E
H 13	SC6	ESC (Electronic Stability Control) malfunctions	See H1.1	ESC fails to apply brakes on the car	1D	The system be able to alert the driver that the ESC system is malfunctioning so that the driver pays attention to the roads	4D
H 14	SC4	When pulling out diagonally from a parking space, the system may not detect the vehicle approaching from the rear left/right	See H1.1	ESC does not apply brakes	2C	RCCW should be able to warn the driver that the angle of the sensor is being blocked	4E
H 15	G11	When opening and closing, if the power liftgate is blocked by an object or body part, the power liftgate will detect the resistance and the liftgate will stop and move in the	It might injure the person while closing and opening	Object is too near the smart liftgate door and safety release	3D	The smart trunk should detect if someone is on the way before closing and opening	4E

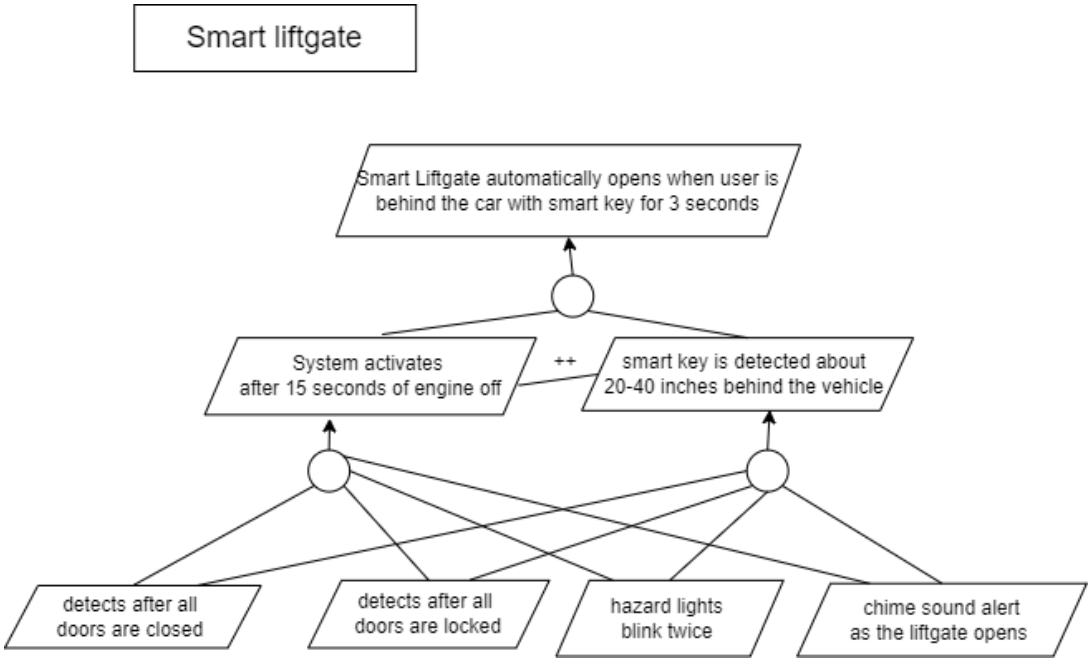
		opposite direction.					

3.0.3 Analysis Models

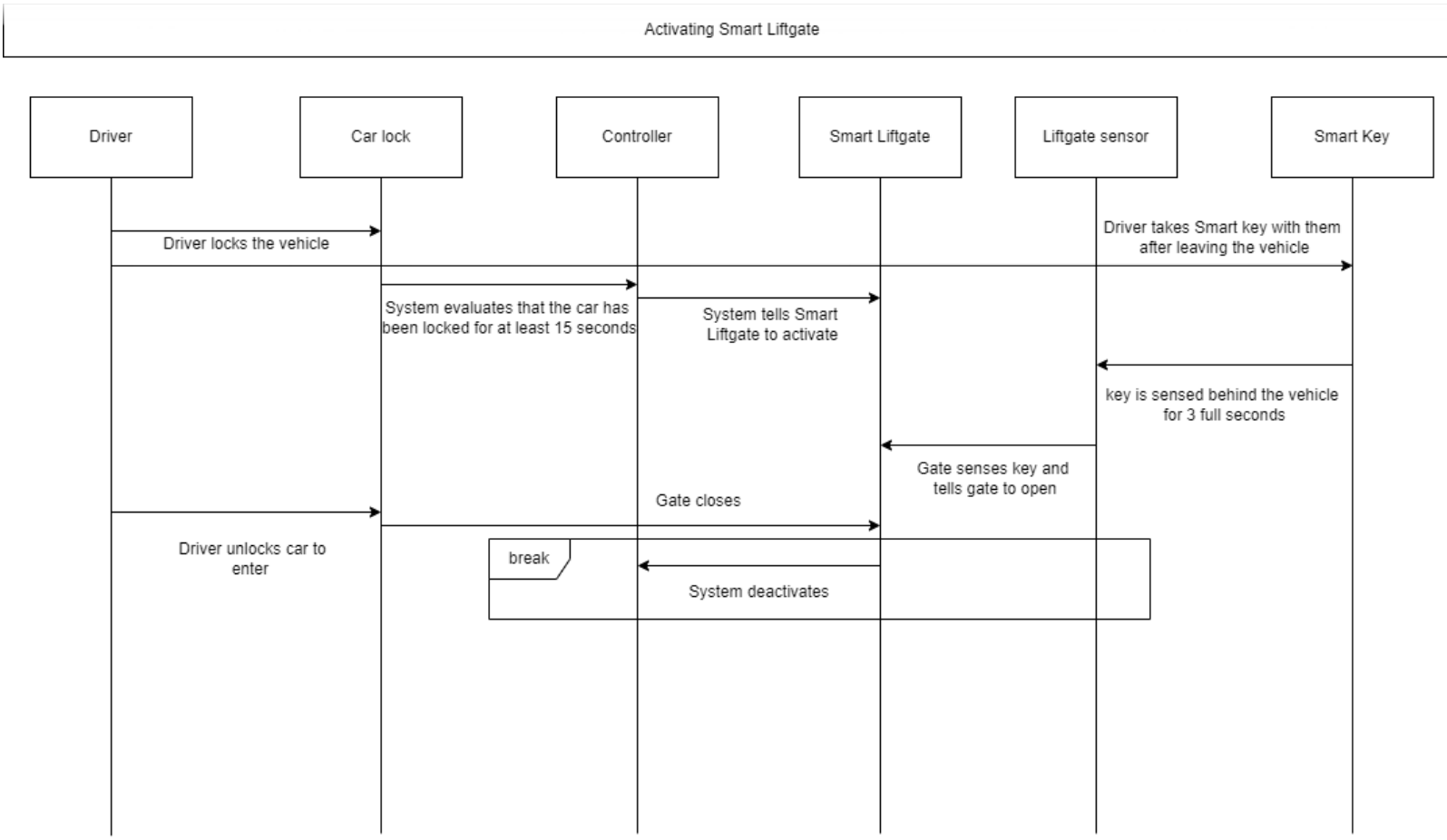
RCCA KAOS diagram

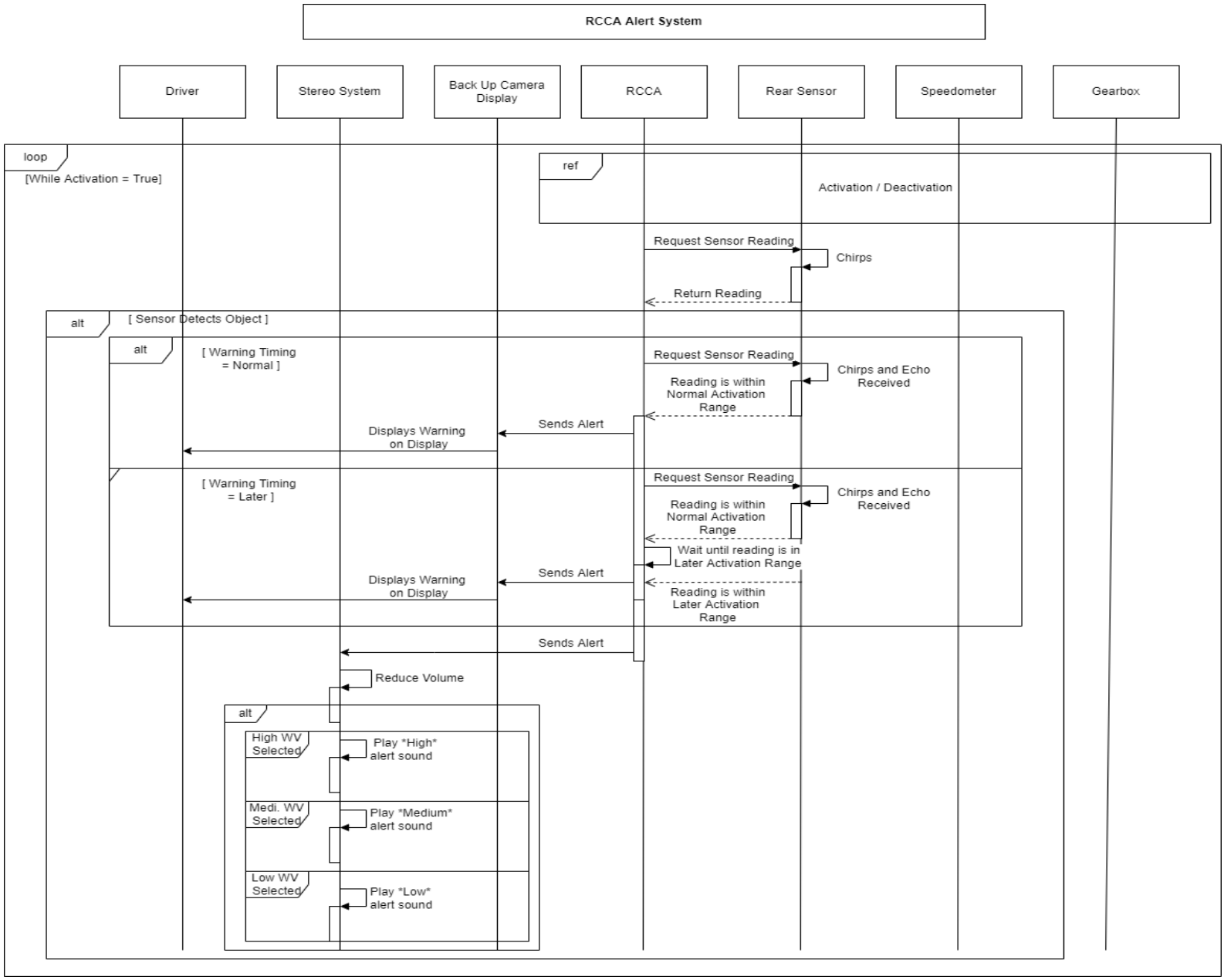


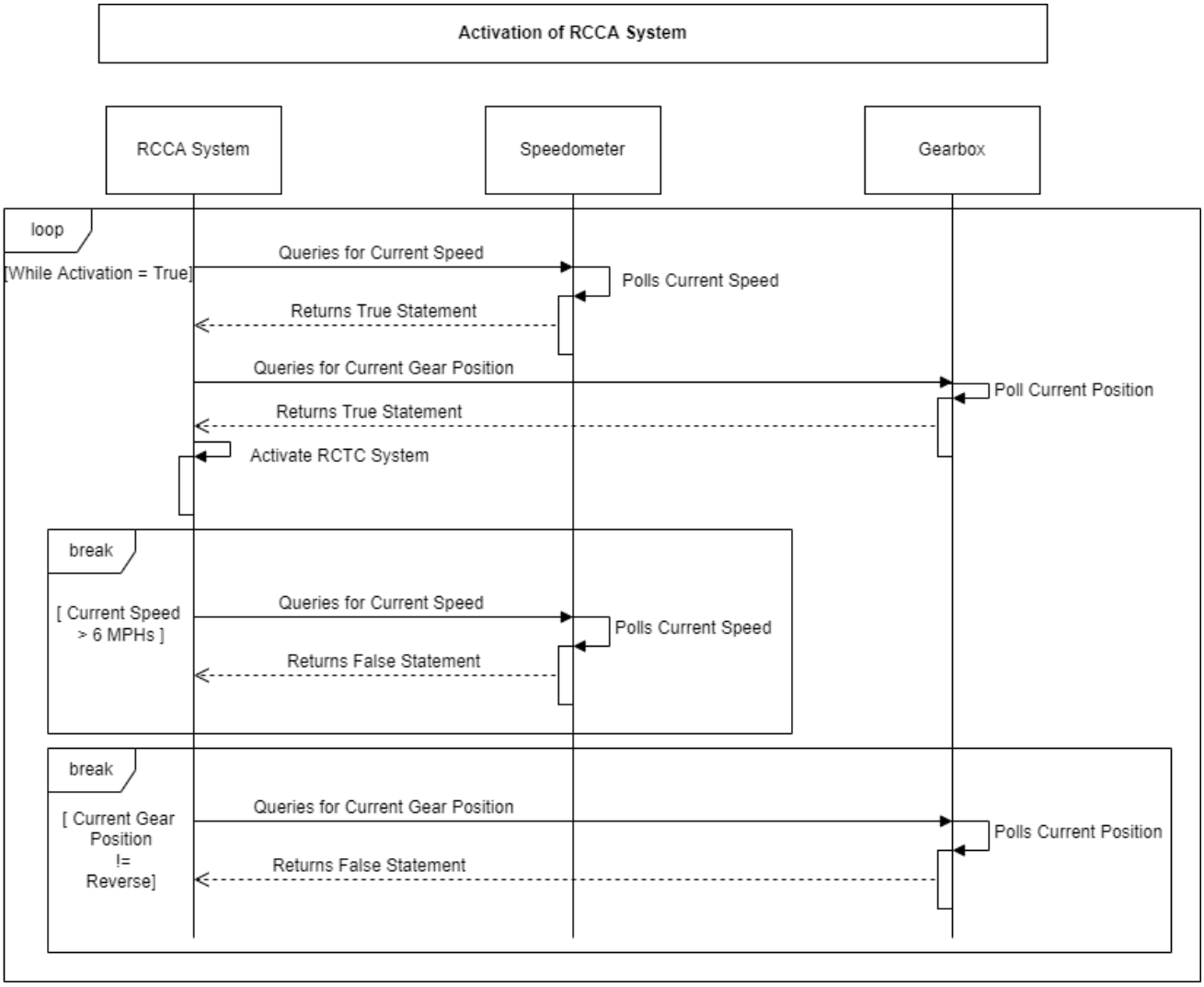
Smart Liftgate KAOS diagram



Sequences diagrams

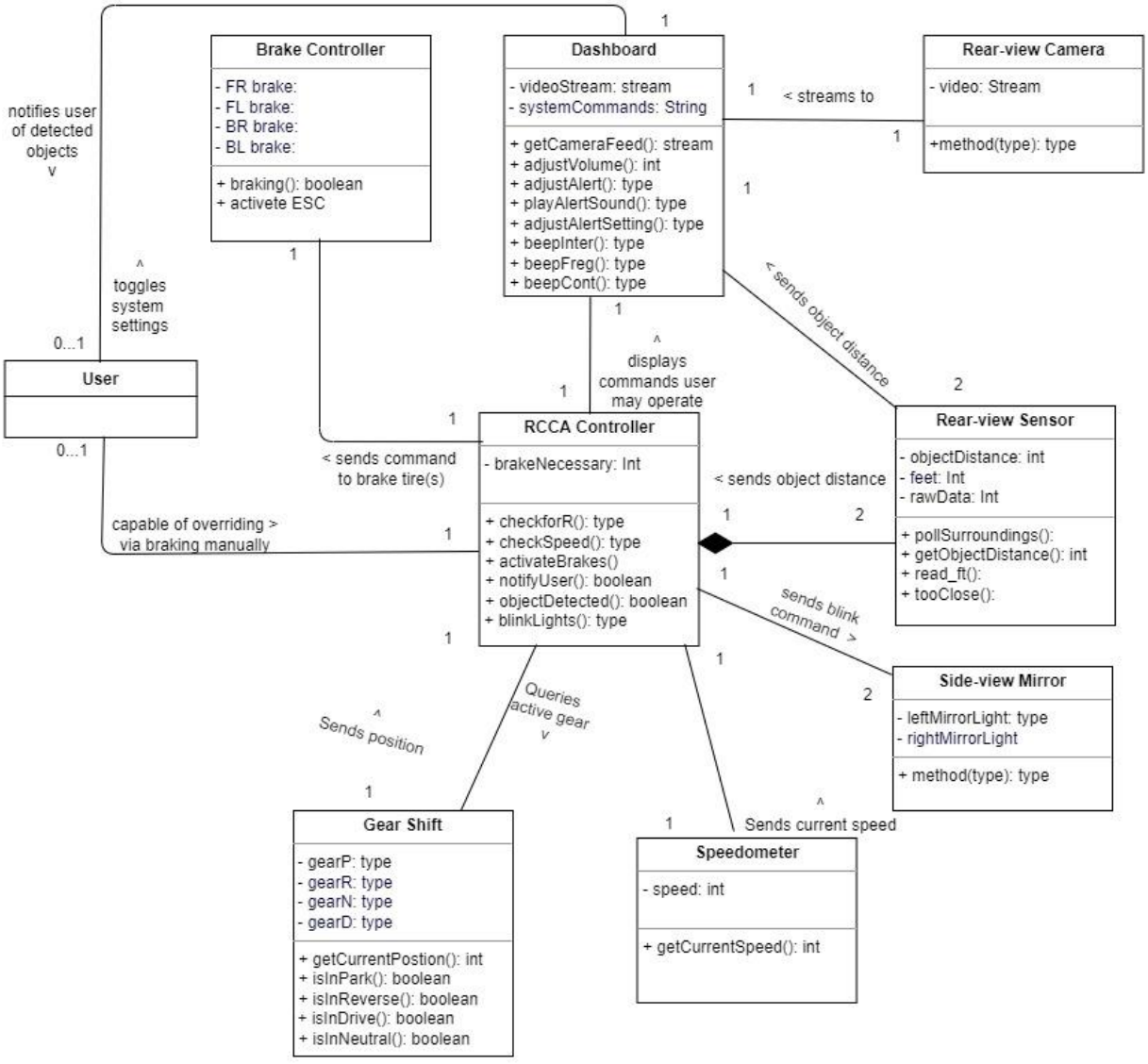

Activating Smart Liftgate
Driver
Car lock
Controller
Smart Liftgate
Liftgate sensor
Smart Key
Driver locks the vehicle
Driver takes Smart key with them after leaving the vehicle
System evaluates that the car has been locked for at least 15 seconds
System tells Smart Liftgate to activate
key is sensed behind the vehicle for 3 full seconds
Gate senses key and tells gate to open
Gate closes
Driver unlocks car to enter
break
System deactivates


RCCA Alert System
Driver
Stereo System
Back Up Camera Display
RCCA
Rear Sensor
Speedometer
Gearbox
loop
[While Activation = True]
ref
Activation / Deactivation
Request Sensor Reading
Chirps
Return Reading
alt
[Sensor Detects Object]
alt
[Warning Timing = Normal]
Request Sensor Reading
Chirps and Echo Received
Reading is within Normal Activation Range
Sends Alert
Displays Warning on Display
[Warning Timing = Later]
Request Sensor Reading
Chirps and Echo Received
Reading is within Normal Activation Range
Wait until reading is in Later Activation Range
Sends Alert
Displays Warning on Display
Reading is within Later Activation Range
Sends Alert
Reduce Volume
alt
High WV Selected
Play *High* alert sound
Medi. WV Selected
Play *Medium* alert sound
Low WV Selected
Play *Low* alert sound

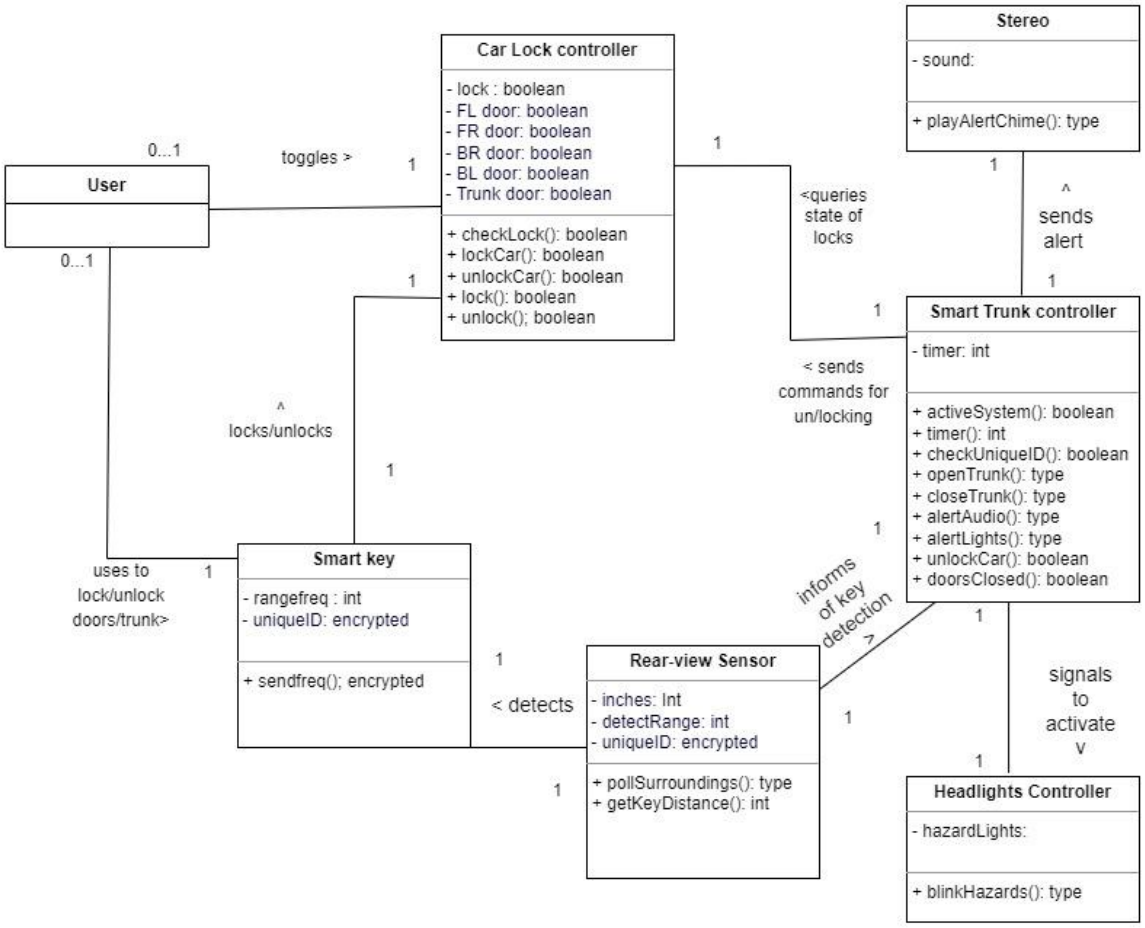


3.0.4 Class Diagrams

RCCA/RCCW Class Diagram

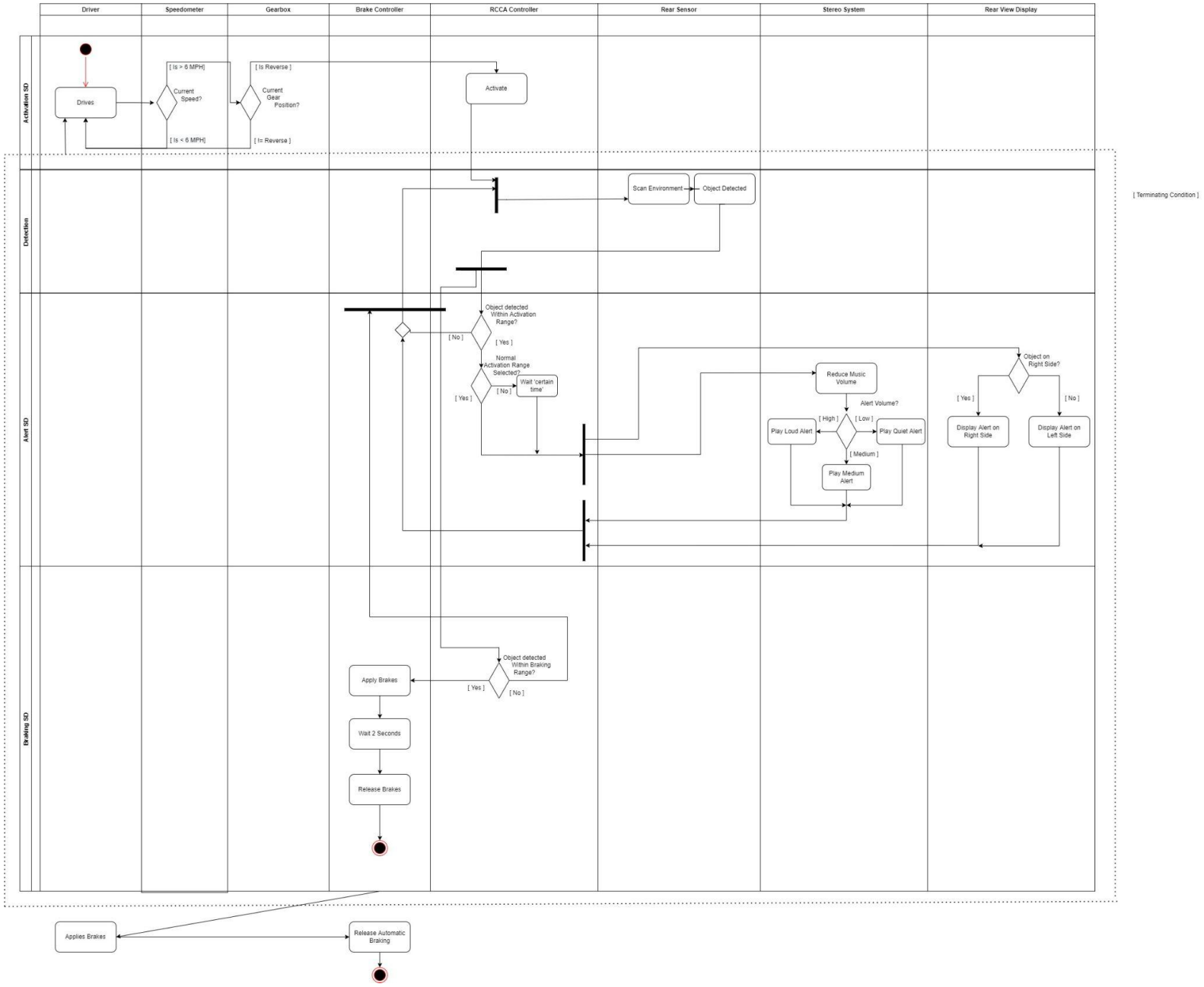


Smart Trunk Class Diagram

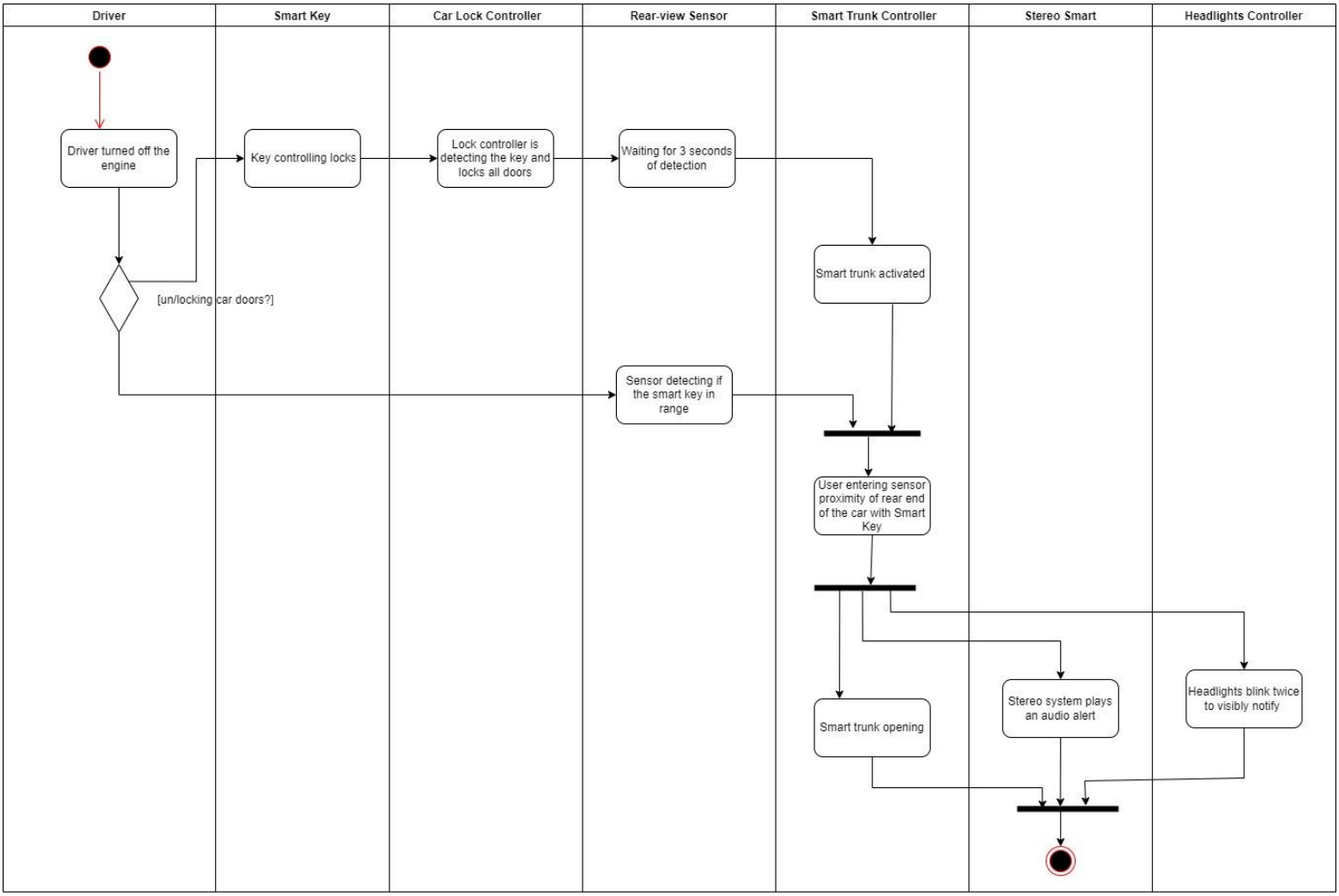


3.0.5 Activity Diagrams

RCCA Activity Diagram

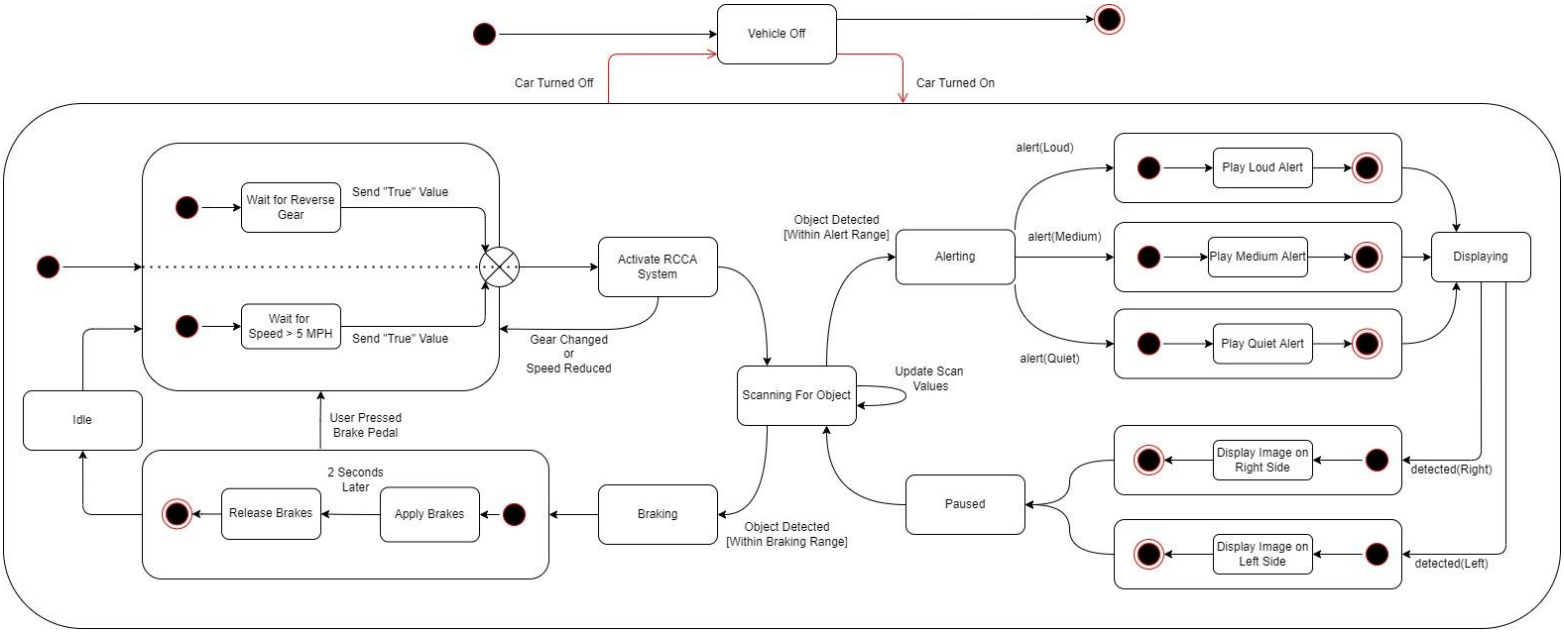


Smart Trunk Activity Diagram

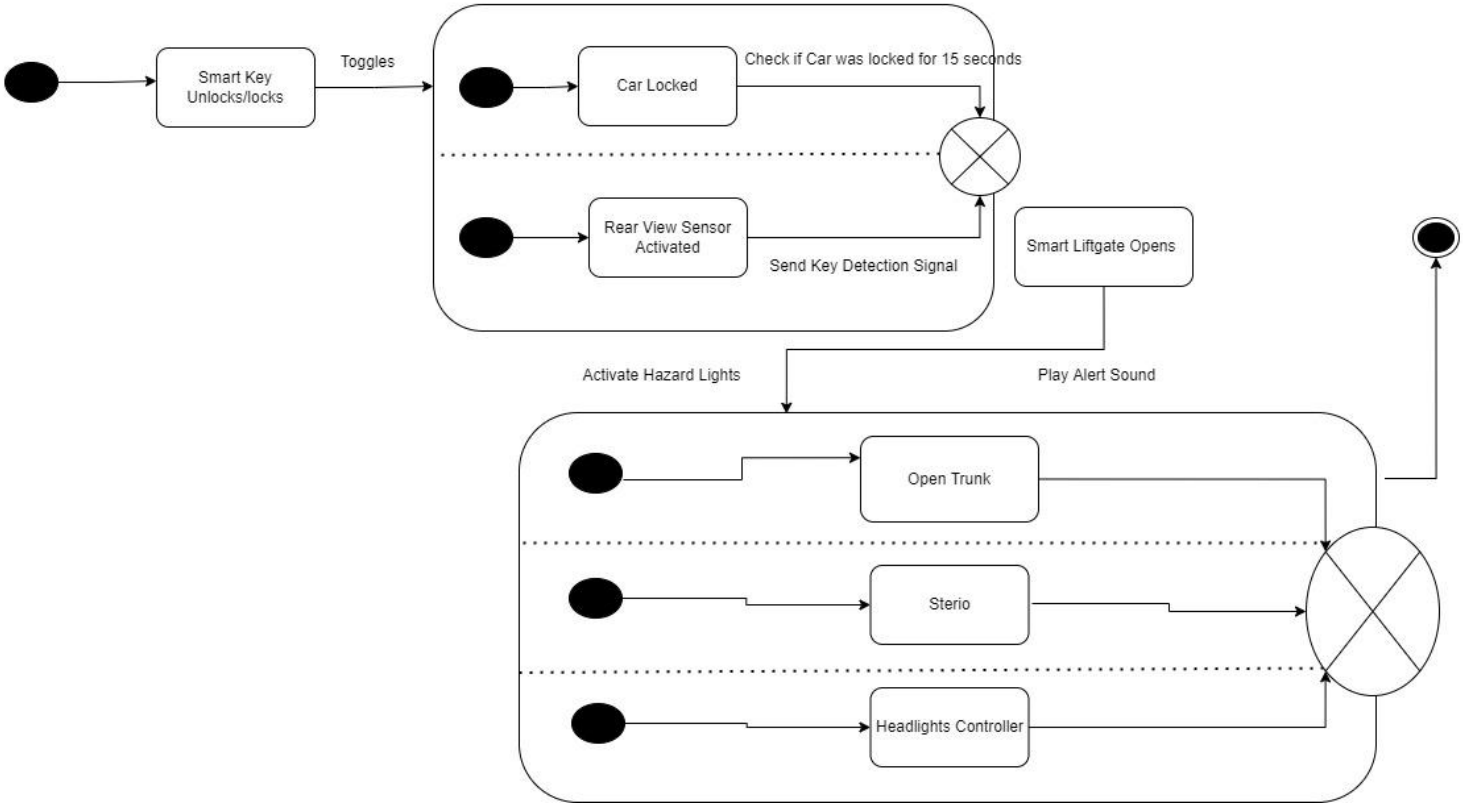


3.0.6 State Machine Diagrams

RCCA State Machine Diagram



Smart Trunk State Machine Diagram



3.0.7 Failure Mode and Effects Analysis

Failure Mode and Effects Analysis										
Version:		1	**Safety Engineers:**	Tyler West, Sven Kappeler, Anubhav Sigdel, Umang Patel						
System		Hyundai's Saint Jose 2.0 4WD Sport SUV	**Subsystem:**	The rear-view camera with cross-traffic detection, rear collision avoidance, and smart trunk hatch						
ID Number	**Function**	**Failure Mode**	**Trigger Conditions**	**Immediate Effect**	**System Effect**	**Method of Detection**	**Current Controls**	**Hazard**	**Risk**	**Safety Goal**
1	Camera Failure	Not streaming	Rear-view camera feed not played in screen to the driver RCCW warning may not display on camera screen	User can't get the feed of the rear view	no warning	None	None	Rear-end collision leading to human death, injury,	3D	The system shall have automatic brake system which depends on sensors
2	Camera Clearity	Dust on camera	Rear-view camera is obfuscated by objects or inclement weather covering it	User can't clear see the rear view	no warning	Display on the dash shows unclear view	None	poor visibility causing the driver to engage in risky behavior and/or have a collision (without Active Assist)	2D	Operability of camera and systems must be able to persist through partial obfuscation to maintain safety of driver
3	Sensor Failure	Not detecting	Audio to alert driver is not working and system does not display alert	User will not be able to receive alert on the surrounding	unable to sense and no warning	None	None	Rear-end collision leading to human	3D	The system shall have two sensors working independent

								death, injury,		from each other.
4	Blind Spot in Sensing Capabilities	Sensor blocked	The car does not have a full radar covering the whole back	User will not be able to receive alert on the surrounding	Unable to sense and no warning	None	None	Collision to approaching vehicle in speed	4E	The system shall have full range of sensor to alert the driver and safely brake
5	Changing warning volume	Option muted	If you change the warning volume, the warning volume of other systems may change.	User will not be able to hear alert	Unable to send sound output	Sensor	None	rear collision and the driver does not hear the sound alert	3E	The system shall be able to change the volume to a specific limit
6	The brake activation by the system lasts for about 2 seconds	Occurs erroneously	The user keeps their foot on the accelerator while and after the 2 second of automatic braking is over	User unable to receive alert on ESC	No warning	Sensor/alert	None	Driver mistakenly keeps accelerating the car without knowing the system is braking	3B	The system shall be able to alert the driver of its braking and the car control will be given over back.
7	The system might be turned off due to strong electrom	Fails 10 issue	Sensor failure and RCCW error	User will not be able to receive alert on the surrounding	Unable to sense and no warning	None	None	RCCW fails leading to rear collision, human death or	1D	Rear camera could have a system that could predict the distance/ sense object through

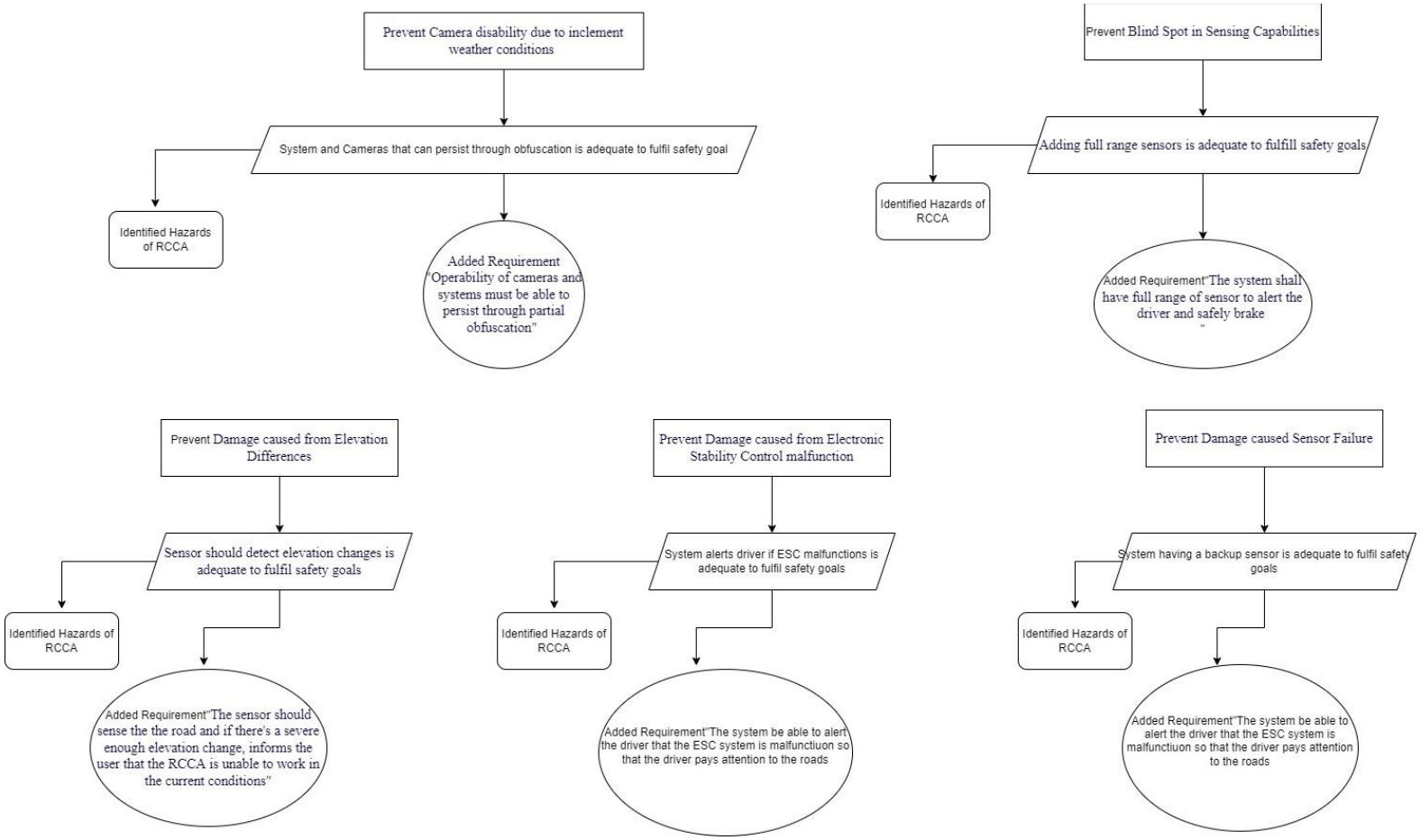
	agnetic waves.							injury		image recognition to alert the driver of the surrounds
8	Damaged Sensor	Not detecting	The sensor might not be connected to the system or could be physically broken	User will not be able to receive alert on the surrounding	Unable to sense and no warning	None	None	The system would not be able to warn the driver leading to collision	3D	The system shall alert the driver when the system component is broken/ damaged/ not connected
9	System disabled/ radar blocked	Sensor blocked	Blind spot collision/ not detected	User will not be able to receive alert on the surrounding	Unable to sense and no warning	Sensor/ alert	None	BCW would not be able to alert the driver of the blind spot leading to collision	3D	The system shall be able to alert the driver if the radar systems are blocked or if the BCW system is unable
10	A trailer is attached to the back of the car	Sensor blocked	RCCA system sensor would be turned off as the sensor wouldn't be able to detect behind the trailer	User will not be able to receive alert on the surrounding	Unable to sense and no warning	None	None	RCCA failed and the trailer crashed	2D	The system could have portable sensors that could be attached to the trailer.
11	When the sensors are blocked	Sensor blocked	The driver might turn off the system due to sensors reading	User will not be able to receive alert on the	Unable to sense and no warning	None	None	The system might send	3A	The sensor should be trimmed to a specific

	by other vehicles, walls or parking-lot pillars		the object near which are not in the path of the driver	surroundings				alert to the driver while the car is parked nearby an object		setting that driver don't get annoyed with the alerts/warning
12	The entire RCCA system is rendered useless due to elevation differences	Not detecting	Car is approaching from an incline causing the sensor to not be able to sense the others car's presence	User will not be able to receive alert on the surrounding	Unable to sense and no warning	None	None	The RCCA fails and the driver is involved in a side-on collision	1D	The sensor should sense the the road and if there's a severe enough elevation change, informs the user that the RCCA is unable to work in the current conditions
13	The vehicle height gets lower or higher due to heavy loading in a trunk, abnormal tire pressure	Not detecting	The system will not give accurate safety directions	User will not be able to receive alert on the surrounding	Unable to sense and no warning	Sensor	None	System might give error due to sensor not align in the specified height	4C	The car should have a system on the suspension of the car to alert the driver the sensor are too low of too high

14	Small objects don't get sensed by the car sensor	Not detecting	RCCA can't see an object and the RCCW is not raised.	User will not be able to receive alert on the surrounding	Unable to sense and no warning	None	None	The car would crash in the small object such as shopping carts or a baby stroller	2D	The system sensor should be very sensitive to detect any small object on the rear
15	ESC (Electronic Stability Control) malfunctions	Oecurs erroneously	ESC fails to apply brakes on the car	User unable to receive alert on ESC	No warning	Sensor	None	Rear-end collision leading to human death, injury,	1D	The system be able to alert the driver that the ESC system is malfunctioning so that the driver pays attention to the roads
16	When pulling out diagonally from a parking space, the system may not detect the vehicle approaching from the rear left/right	Not detecting	ESC does not apply brakes	User will not be able to receive alert on the surrounding	Unable to sense and no warning	None	None	Rear-end collision leading to human death, injury,	2C	RCCW should be able to warn the driver that the angle of the sensor is being blocked

17	When opening and closing, if the power liftgate is blocked by an object or body part, the power liftgate will detect the resistance and the liftgate will stop and move in the opposite direction.	Sensor Blocked	Object is too near the smart liftgate door and safety release	Will close automatically	No warning	None	None	It might injure the person while closing and opening	3D	The smart trunk should detect if someone is on the way before closing and opening

3.0.8 Safety Cases with Goal Structuring Notation



3.1 External Interfaces

RCCA controller

- wait for all component to say activate to safely activate to help the user
- speedometer, gear position, notify user through lights and dash display,control brakes and let the user change setting according to different features

Speedometer

- help activate the RCCA as soon as the speed is reduce below 10 MPH

Gearbox

- activates the RCCA controller as soon as the gear position is place at Reverse (R)

Stereo System

- gets alert from smart liftgate to play sound

Rear Camera

- camera stream come directly from the camera in the rear bumper it display to the user on the dashboard

Side view mirror light

- As soon as the sensor sense a incoming call on the right side it blinks to alert the user and same happens when a car come from left it blinks in the left mirror

Dashboard

- camera stream from the rear camera is display to the user
- setting options are display here to change volume
- setting options are display here to change to activate different system
- setting of multiple option are shown to the user in GUI format for easy understanding with instruction

Rear Sensor

- sense a rader on the rear of the car and and send alert polled to the dash
- send a radar reading to the RCCA for analyzing the rear incoming car and to give the user a better option and idea of the view that can't be seen behind.

Brake Controller

- brake controls for each wheel
- activate ESC for emergency safely

Head light controller

- gets alert from smart liftgate controller to link the hazard lights

Car lock controller

- senses car locked and send signal to the smart liftgate controller to activate
- locks and unlocks the car with a smart key.

Smart Liftgate controller

- send alert to headlight controller to blink as the door open
- sends alert to stereo system to lay sound as the door open
- wait for signal from car lock controller to activate
- open smart truck as soon as the smart key is sensed in the surrounding
- it also wait for the 15 seconds after the car engine is turned off

Liftgate sensor

- reads the smart keys encrypted frequency to open the trunk
- scans the surrounding for the key frequency

Smart Key

- sends encrypted frequencies to the rear season to open the smart trunk, the frequency is read about 20-40 inches behind the car near the trunk

3.2 Functions

See Natural Language Requirements in section 3.0.1 which contains all ‘shall’ statements of the system.

- The system shall activate when both the vehicle speed is below 6 mph (10 km/h) and the shift lever in R (Reverse)
- The system shall on the warning light of outer side view mirror and blink if a vehicle approaches from the rear left/right side
- The system shall display alert on LCD display if a vehicle approaches from the rear left/right side
- The rear view monitor system shall warning the driver by the audio or AVN screen
- The system shall have smart hand free liftgate system to open automatically
- The system shall have automatic brake system which depends on sensors
- The system shall have two sensors working independent from each other
- The system shall have full range of sensor to alert the driver and safely brake
- The system shall be able to change the warning time to a specific limit
- The system shall be able to change the volume to allow for the alert noise to be heard
- The system shall interrupt the driver’s actions for safety actions
- The system shall alert the driver when the system component is broken/ damaged/ not connected
- The system shall be able to alert the driver if the radar systems are blocked or if the BCW system is unable
- The system shall alert the driver about a possible collision

3.3 Performance Requirements

Supports a maximum of one user despite multiple persons residing within the vehicle at any given moment while it is on as only one person can be in the driver’s seat at a time.

Sensors in the rear can sense multiple vehicles and raise multiple alerts depending on the surroundings. The sensor detects and sends the alert in real time in milliseconds and the camera stream is also live.

3.4 Logical Database Requirements

Speed, proximity, and angles are all calculated via sensors and fed back to the main system software within the vehicle which connects all subsystems.

3.5 Design Constraints

The design constraints of the system are theoretically unbinded by things like cost and materials.

3.5.1 Standards Compliance

All cars built after 2018 in the United States and Canada must have a rear-view camera with video feed built in. - see 2.4

3.6 Software System Attributes

Some of the non-functional / quality attributes include the esthetic of items included in our sub-system such as the Smart Liftgate, headlights, and the Smart key.

3.6.1 Reliability

Reliability depends on the qualitative state in which the subsystems are in. Unless collision or some sort of power cycle malfunction occurs to impair the system. It should maintain high reliability

3.6.2 Availability

System is always available when turned on and settings can be configured in the system settings of the vehicle in the dash.

3.6.3 Security

Security in regards to the rear view camera, collision avoidance system, and smart trunk is relatively high overall. The cameras and sensors impact the security of the system aside from detecting objects which may approach the vehicle and the smart trunk

3.6.4 Maintainability

System remains in quality condition without regular maintenance unless otherwise damaged.

3.6.5 Portability

If necessary, the system can be ported to other machines to simulate detection of objects from behind.

ID	Characteristic	H/M/L	1	2	3	4	5	6	7	8	9	10	11	12

1	Correctness													
2	Efficiency													
3	Flexibility													
4	Integrity/Security													
5	Interoperability													
6	Maintainability													
7	Portability													
8	Reliability													
9	Reusability													
10	Testability													
11	Usability													
12	Availability													

3.7 Organizing the Specific Requirements

For anything but trivial systems the detailed requirements tend to be extensive. For this reason, it is recommended that careful consideration be given to organizing these in a manner optimal for understanding. There is no one optimal organization for all systems. Different classes of systems lend themselves to different organizations of requirements in section 3. Some of these organizations are described in the following subclasses.

3.7.1 System Mode

System contains an Active Assist and Warning only mode where the car can brake on the user's behalf as well as give auditory and visual warning for the former and the car only makes

3.7.2 User Class

All users are synonymous so long as they have the correct key.

3.7.3 Objects

People are included within object detection. All possible objects are included in its detection radius.

3.7.4 Feature

Features include inputs to the sensors and continuously updating the driver's screen display with information from the rear camera and all sensors..

3.7.5 Stimulus

Objects detected are the only stimuli for the sensors relating to collision avoidance. Key proximity to the back of the vehicle is the only stimuli for the smart liftgate.

3. 7.6 Response

N/A

3.7.7 Functional Hierarchy

N/A

3.8 Additional Comments

N/A

4. Change Management Process

We are using srs documents in google drive working in a team of four. We can check who changes which section in the history log and we update each other on discord.

If a customer wants changes to be made to the safety systems and has new requirements, they'll have to address the government first to appeal to its necessity. If the customer completes that, they will have to make an appointment to meet all four developers. A formal written descriptive document detailing what they would like added shall be submitted while making the appointment. Only then will the customer's demands be heard and an evaluation on if they can be implemented will occur. We will have to double check if there are any other government constraints and if the feature is possible and compatible with the system.

5. Document Approvals

Approver Name	**Signature**	**Date**
Anubhav Sigdel,	*Anubhav*	5/6/2022

Sven Keppler	*Sven*	3/3/2022
Tyler West	*Tyler West*	03/01/2022
Umang Patel	*Umang*	3/2/2022

6. Supporting Information

- 2020 Santa Fe Owner's Manual: https://oswego.open.suny.edu/bbcswebdav/pid-2108797-dt-content-rid-14732500_1/courses/202201-12833-CSC436/2020%20Santa%20Fe%20Owner%27s%20Manual.pdf

7. Team Reflection

As a team we thought that the design of the project was very minimal yet efficient. It contains two separate systems which both rely on the rear-end of the vehicle's sensors to activate: the rear collision and crash avoidance system as well as the Smart Liftgate. Our design process relied on us all having the same conceptual idea before creating diagrams and laying out the goals, scenarios, and solution-oriented/neutral requirements. We were able to get on the same page by each of us creating a model how we would imagine it and then having other members contribute and comment on each other's work until we were all satisfied. The context entities were identified by simply reading over our provided document. Requirements which were solution-oriented seemed to be relatively sparse for our specific systems.

The most difficult part of our implementation was initially in our KAOS diagrams as we struggled to gain footing on separating goals from anti-goals and transitions. Afterward, state machine diagrams seemed to provide some challenge as we foud it difficult to differentiate them accurately from our activity diagrams. The document also helped us understand the problem space of the Rear Cross-Traffic Collision Avoidance System.

We enjoyed doing the UML diagrams and given the ample amount of time it was all going through at a steady pace. After learning more about the system and performing all the safety and security analysis we came to the conclusion that the system is somewhat safe because we are unlikely to run into an error from our sensors or other components which would impair the system and result in an accident. We would be comfortable betting our life on it.

We worked together on the milestone with a specific component of a larger system. This helped us learn and sharpen our skills in natural language requirement and implementation of UML diagrams felt like we gained a deeper understanding after CSC 380.