Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

Document Version: [Version]

Template Version 1.0, Released on 2017-06-21

Document history

Date	Version	Editor	Description

Feb 28, 2019	1.0	Junxun Luo	First submit
Mar 26, 2019	2.0	Junxun Luo	Revised by review comments

Table of Contents

Purpose of the Functional Safety Concept

This document identifies the high-level system safety requirements which are allocated to different parts of the item architecture. Technical safety requirements will be derived from these safety concepts. It also presents instructions on how to validate and verify the requirements.

Inputs to the Functional Safety Concept

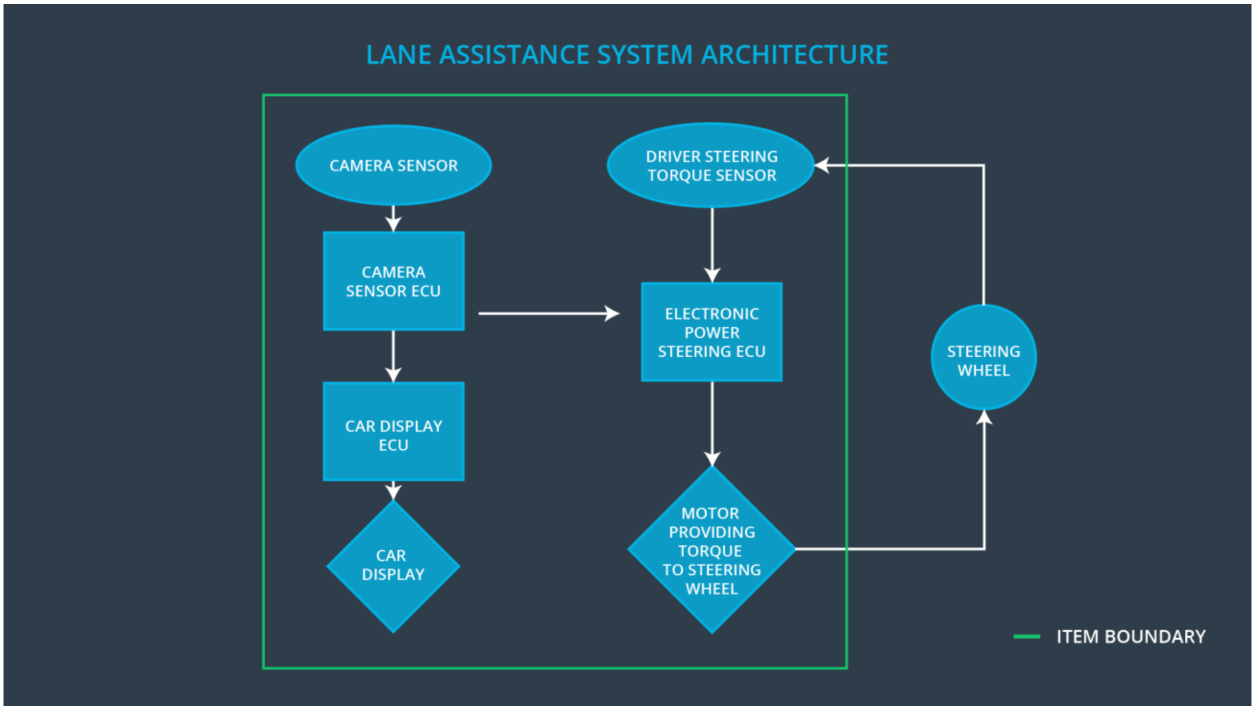
Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	The oscillating steering torque from the Lane Departure Warning (LDW) function shall be limited.
Safety_Goal_02	The Lane Keeping Assistance function shall be time limited. The additional steering torque shall end after a given time interval so that the driver cannot misuse the system for autonomous driving.
Safety_Goal_03	The Lane Keeping Assistance function shall be deactivated when the camera sensor stops working.

Preliminary Architecture

[Instructions: Provide a preliminary architecture for the lane assistance item. Hint: See Lesson 3: Item Definition]

The following figure shows the architecture of the Lane Assistance item:


LANE ASSISTANCE SYSTEM ARCHITECTURE
CAMERA SENSOR
DRIVER STEERING TORQUE SENSOR
CAMERA SENSOR ECU
ELECTRONIC POWER STEERING ECU
STEERING WHEEL
CAR DISPLAY ECU
CAR DISPLAY
MOTOR PROVIDING TORQUE TO STEERING WHEEL
ITEM BOUNDARY

Description of architecture elements

Element	Description
Camera Sensor	Capture rod images and provide them to the Camera Sensor ECU
Camera Sensor ECU	Analyze provided images to calculate the vehicle position on the lane
Car Display	Provide warnings and the Lane Departure Assistance status to the driver
Car Display ECU	Drive the Car Display component to show the Lane Keeping Assistance warning and Lane Departure Assistance status
Driver Steering Torque Sensor	Measure the torque applied to the steering wheel by the driver
Electronic Power Steering ECU	Analyze how hard the driver is turning the steering wheel. When it receives a warning from Camera Sensor ECU, it decides the vibration required to alert the driver, and output a torque value to the motor
Motor	Applies the torque to the steering wheel

Functional Safety Concept

The functional safety concept consists of:

- Functional safety analysis
- Functional safety requirements
- Functional safety architecture
- Warning and degradation concept

Functional Safety Analysis

[Instructions: Fill in the functional safety analysis table below.]

Malfunction ID	**Main Function of the Item Related to Safety Goal Violations**	**Guidewords (NO, WRONG, EARLY, LATE, MORE, LESS)**	**Resulting Malfunction**
Malfunction_01	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	MORE	The Lane Departure Warning function applies an oscillating torque with very high torque amplitude (above limit)
Malfunction_02	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	MORE	The Lane Departure Warning function applies an oscillating torque with very high torque frequency (above limit)
Malfunction_03	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	NO	The Lane Keeping Assistance function is not limited in time duration which lead to misuse as an autonomous driving function.
Malfunction_04	The Lane Departure Warning (LDW)	WRONG	The Lane Departure Warning start acting

	function shall be deactivated when the camera sensor stop working.		randomly when the camera sensor is not working.
Malfunction_05	The Lane Departure Warning (LDW) function shall be deactivated when the camera sensor stop working.	WRONG	The Lane Keeping Assistance start acting randomly when the camera sensor is not working.

Functional Safety Requirements

Lane Departure Warning (LDW) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 01-01	The Lane Departure Warning item shall ensure that the lane departure oscillating torque amplitude is below Max_Torque_Amplitude.	C	50ms (Diagnostic Test Interval + Fault Reaction Time + Time in Safe State)	LDW torque request amplitude is set to zero
Functional Safety Requirement 01-02	The Lane Departure Warning item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency.	C	50ms (Diagnostic Test Interval + Fault Reaction Time + Time in Safe State)	LDW torque request frequency is set to zero
Functional Safety Requirement 01-03	The Lane Departure Warning function shall be deactivated when the camera sensor stops working.	C	10ms (Diagnostic Test Interval + Fault Reaction Time + Time in Safe State)	Switch Off Lane Assistance System

Lane Departure Warning (LDW) Verification and Validation Acceptance Criteria:

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Functional	Validate Max_Torque_Amplitude	when the torque amplitude crosses the

Safety Requirement 01-01	chosen is high enough to be detected by a driver while low enough not to cause loss of steering	limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval.
Functional Safety Requirement 01-02	Validate Max_Torque_Frequency chosen is adequate to be detected by the driver and not cause the loss of steering.	when the torque frequency crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval.
Functional Safety Requirement 01-03	Validate Lane Departure Warning is off when the camera sensor is not working.	Verify the Lane Departure Warning is never on when the camera sensor is not working.

[Instructions: Fill in the functional safety requirements for the lane keeping assistance]

Lane Keeping Assistance (LKA) Requirements:

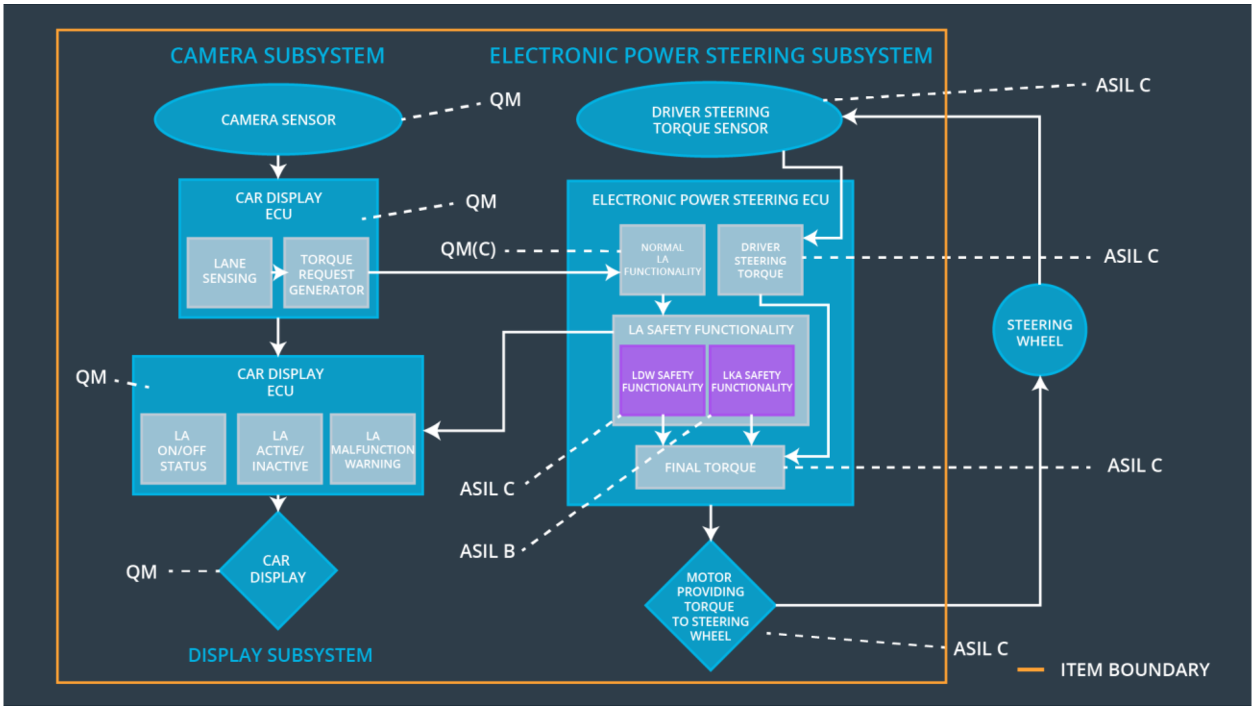
ID	**Functional Safety Requirement**	**ASIL**	**Fault Tolerant Time Interval**	**Safe State**
Functional Safety Requirement 02-01	The lane keeping item shall ensure that the lane keeping assistance torque is applied for only Max_Duration	B	500 ms	LKA torque request amplitude and frequency is set to zero
Functional Safety Requirement 02-02	The Lane Keeping assistance shall be deactivated when the electronic power steering ECU detects the camera sensor is not working.	C	100 ms	Switch Off Lane Assistance System

Lane Keeping Assistance (LKA) Verification and Validation Acceptance Criteria:

ID	**Validation Acceptance Criteria and Method**	**Verification Acceptance Criteria and Method**
Functional Safety Requirement	Validate the Max_Duration chosen not allows the driver to use the car as self-driving car.	Verify the system does deactivate if the Lane Keeping Assistance torque application exceeded Max_Duration.

02-01		
Functional Safety Requirement 02-02	Validate the Lane Keeping assistance shall be deactivated when the camera sensor stops working.	Verify the system does deactivate the Lane Keeping Assistance if the camera sensor is not working.

Refinement of the System Architecture



Allocation of Functional Safety Requirements to Architecture Elements

ID	Functional Safety Requirement	Electronic Power Steering ECU	Camera ECU	Car Display ECU
Functional Safety Requirement 01-01	The Lane Departure Warning item shall ensure that the lane departure oscillating torque amplitude is below	X		

	Max_Torque_Amplitude.			
Functional Safety Requirement 01-02	The Lane Departure Warning item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency.	**X**		
Functional Safety Requirement 01-03	The Lane Departure Warning function shall be deactivated when the camera sensor stops working.	**X**		
Functional Safety Requirement 02-01	The lane keeping item shall ensure that the lane keeping assistance torque is applied for only Max_Duration	**X**		
Functional Safety Requirement 02-02	The Lane Keeping assistance shall be deactivated when the electronic power steering ECU detects the camera sensor is not working.	**X**		

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn off Lane Departure Warning functionality	Malfunction_01, Malfunction_02, Malfunction_04	Yes	Lane Departure Warning Malfunction Warning on Car Display
WDC-02	Turn off Lane Keeping Assistance functionality	Malfunction_03, Malfunction_05	Yes	Lane Keeping Assistance Malfunction Warning on Car Display