Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

[Instructions: Fill in the date, version and description fields. You can fill out the Editor field with your name if you want to do so. Keep track of your editing as if this were a real world project.

For example, if this were your first draft or first submission, you might say version 1.0. If this is a second submission attempt, then you'd add a second line with a new date and version 2.0]

Date	Version	Editor	Description
3/13/2018	1	Scott Schnelle	First Draft of Function Safety Concept

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Purpose of the Functional Safety Concept

The Functional Safety Concept documents the system's high level requirements. These requirements are allocated to different parts of the system architecture. Technical safety requirements will be derived from these safety concepts. Instruction on how to validate and verify the requirements are presented as well.

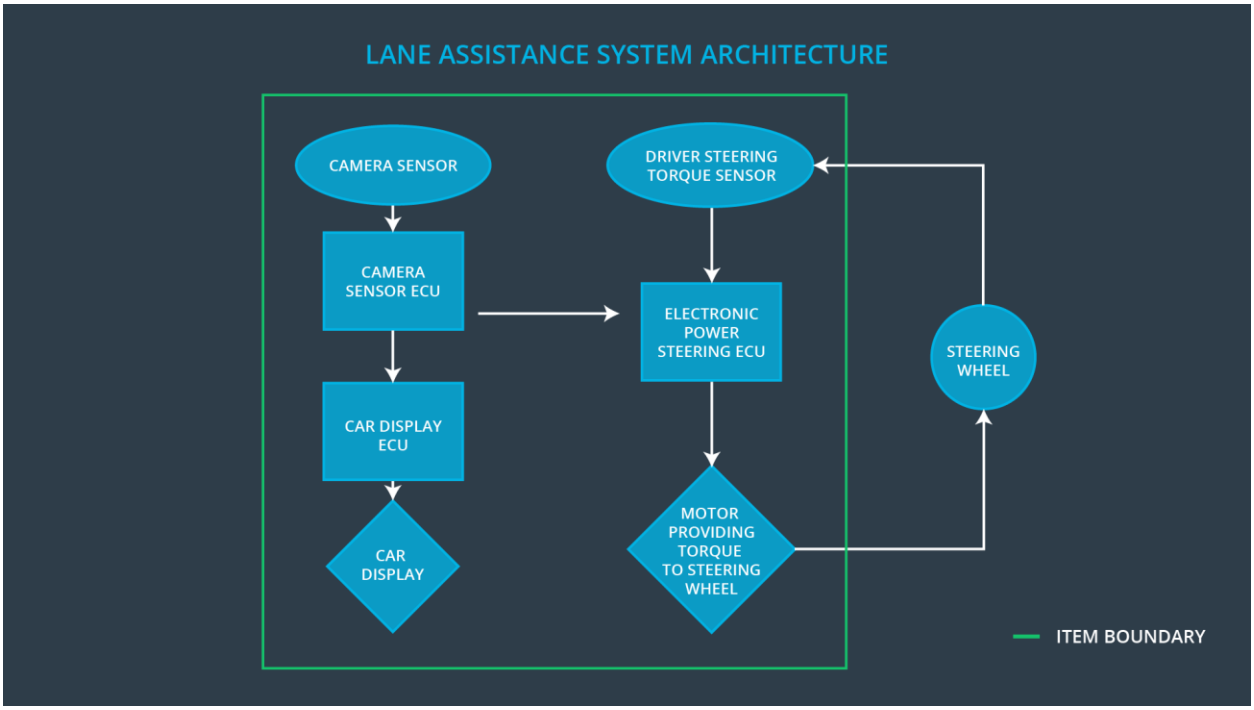
Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	The oscillating steering torque from the Lane Departure Warning function shall be limited.
Safety_Goal_02	The Lane Keeping Assistance function shall be time limited, and additional steering torque shall end after a given time interval so the driver cannot misuse the system for autonomous driving.
Safety_Goal_03	The Lane Departure Warning function shall be deactivated when the camera sensor malfunctions.
Safety_Goal_04	The Lane Keeping Assistance function shall be deactivated when the camera sensor malfunctions.

Preliminary Architecture

The following figure shows the Lane Assistance item architecture:



Description of architecture elements

Element	Description
Camera Sensor	Capture road images
Camera Sensor ECU	Analyze road images for vehicle/lane localization
Car Display	Provide visual feedback to driver
Car Display ECU	Provide the display with what systems are active
Driver Steering Torque Sensor	Measure driver torque input
Electronic Power Steering ECU	Determine how much torque needs to be applied to the steering wheel
Motor	Apply toque to 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

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)	MORE	The Lane Departure Warning function

	function shall apply an oscillating steering torque to provide the driver a haptic feedback		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 function shall be deactivated when the camera sensor malfunctions.	WRONG	The Lane Departure Warning start acting randomly when the camera sensor is malfunctioning
Malfunction_05	The Lane Keeping Assistance function shall be deactivated when the camera sensor malfunctions.	WRONG	The Lane Keeping Assistance start acting randomly when the camera sensor is malfunctioning.

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	50 ms	Vibration torque amplitude below Max_Torque_Amplitude.
Functional Safety	The Lane Departure Warning item shall ensure that the lane departure oscillating	C	50 ms	Vibration frequency is

Requirement 01-02	torque frequency is below Max_Torque_Frequency.			below Max_Torque_Frequency.
Functional Safety Requirement 01-03	The Lane Departure Warning function shall be deactivated when the camera sensor malfunctions.	B	10 ms	Function is deactivated.

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

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Functional Safety Requirement 01-01	Validate Max_Torque_Amplitude chosen is high enough to be detected by a driver while low enough not to cause loss of steering	Verify the system does turn off if the Lane Departure Warning exceeded Max_Torque_Amplitude.
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.	Verify the system does turn off if the Lane Departure Warning exceeded Max_Torque_Frequency.
Functional Safety Requirement 01-03	Validate Lane Departure Warning is off when the camera sensor malfunctions.	Verify the Lane Departure Warning is never on when the camera sensor malfunctions.

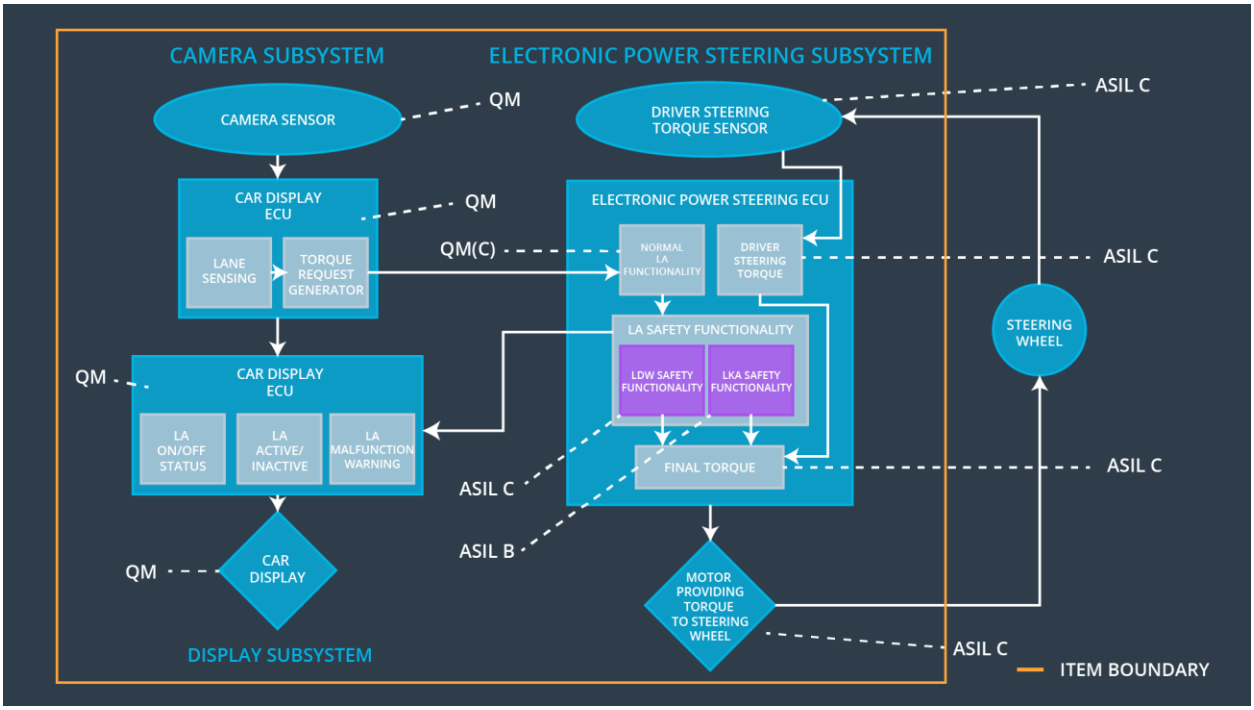
Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	The electronic power steering ECU shall ensure that the Lane Keeping Assistance torque is applied only for Max_Duration.	B	500 ms	LKA torque is zero
Functional Safety Requirement 02-02	The LKA shall be deactivated when the electric power steering ECU detects the camera sensor has malfunctioned.	C	10 ms	Function is deactivated

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

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Functional Safety Requirement 02-01	Validate the Max_Duration chosen not to allow 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.
Functional Safety Requirement 02-02	Validate the Lane Keeping assistance shall be deactivated when the camera sensor malfunctions.	Verify the system does deactivate the Lane Keeping Assistance if the camera sensor malfunctions.

Refinement of the System Architecture



Allocation of Functional Safety Requirements to Architecture Elements

ID	Functional Safety Requirement	Electronic Power Steering	Camera ECU	Car Display ECU

		ECU		
Functional Safety Requirement 01-01	The Lane Departure Warning item shall ensure that the lane departure oscillating torque amplitude is below Max_Torque_Amplitude.	**X**		
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 malfunctions.	**X**		
Functional Safety Requirement 02-01	The electronic power steering ECU shall ensure that the Lane Keeping Assistance torque is applied only for 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 malfunctions.	**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