



Elektrobit



UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
28-10-18	1.0	Madhukar	First Draft
03-11-18	2.0	Madhukar	LDW & LKA Safe State Modified

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Purpose of the Functional Safety Concept

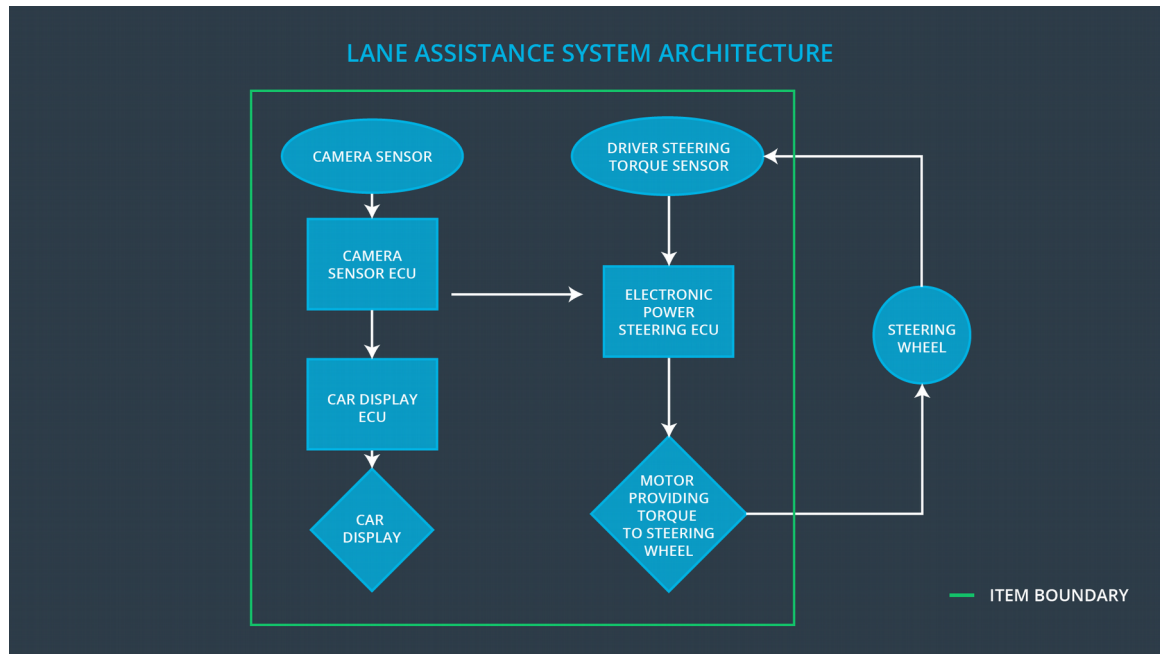
Functional Safety Concept documents identified high level system requirements. These requirements are allocated to different parts of the item architecture. Technical safety requirements will be derived from these safety concepts. Validation and verification of the requirements are also presented here.

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	LKA functionality should take the delay in the sensing and actuation of the actuators in consideration. So that it may take corrective action on time.
Safety_Goal_04	The oscillating steering torque from LDW should be gradually increased till deviation from lane is increasing.

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	Captures road images and provide them to the Camera Sensor ECU.
Camera Sensor ECU	Post processing provided images by camera sensor to analyze car position wrt lanes.
Car Display	Provides feedback to the driver displaying warnings and the Lane Departure Assistance status.
Car Display ECU	Controls the Car Display component to show the Lane Keeping Assistance warning and Lane Departure Assistance status.
Driver Steering Torque Sensor	Senses the torque applied to the steering wheel by the driver.
Electronic Power Steering ECU	Use the information received from the Driver Steering Torque Sensor and the torque requested by the Lane Keeping Assistance and Lane Warning and request the necessary torque to be applied by the Motor actuator.
Motor	Applies the torque indicated by the Electronic Power Steering ECU 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

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	Less	The Lane Departure Warning function applies an oscillating torque with very Less torque frequency (below 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 leads to misuse as an autonomous driving function.

Functional Safety Requirements

Lane Departure Warning (LDW) Requirements:

ID	Functional Safety Requirement	A S I L	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 01-01	The lane keeping item shall ensure that the C 50 mS lane departure oscillating torque amplitude is below Max_Torque_Amplitude.	C	50 ms	Vibration Torque Amplitude < Max_Torque_Amplitude
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency.	C	50 ms	Vibration Torque Frequency < Max_Torque_Frequency

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 that the Max_Torque_Amplitude chosen is low enough that the driver does not loose control over the car.	Verify that the system does turn off if LDW Max_Torque_Amplitude is exceeded
Functional Safety Requirement 01-02	Validate that the Max_Torque_Frequency chosen is low enough that the driver does not loose control over the car.	Verify that the system does turn off if the LDW exceeded Max_Torque_Frequency.

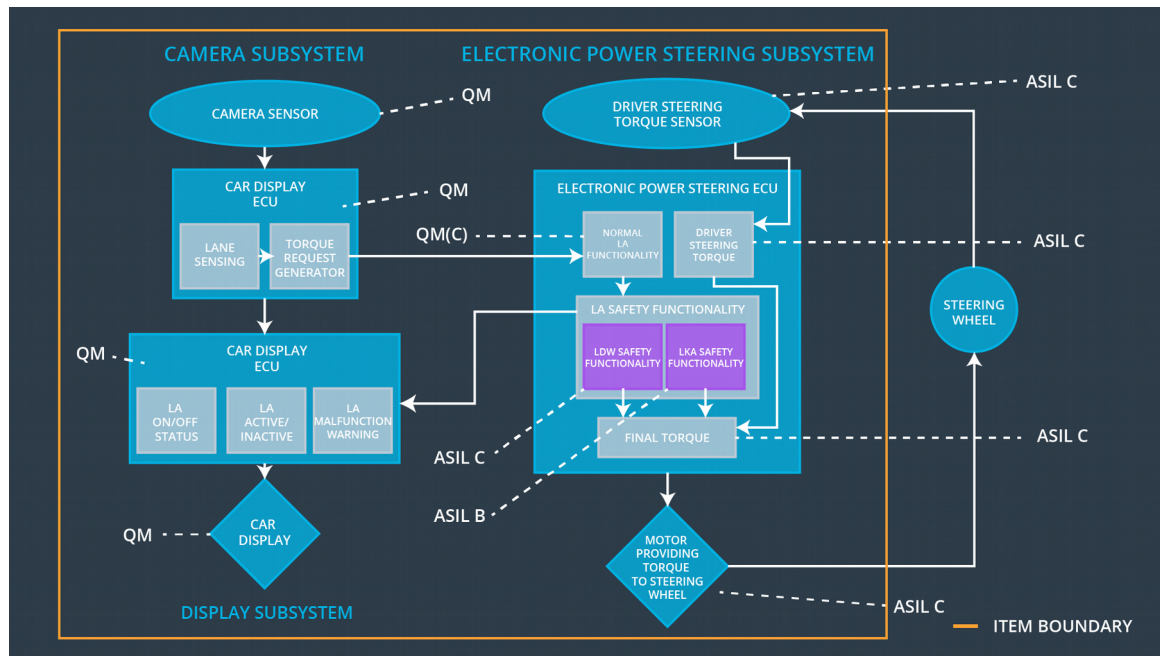
Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	A S I L	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	Electronic power steering ECU will ensure that the lane keeping assistance torque is applied for only Max_Duration.	B	500 ms	LKA_Torque = 0

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 that the max_duration chosen does not encourage drivers from taking their hands off the steering wheel.	Verify that the system deactivate the lane keeping assistance after it exceed max_duration.

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 keeping item shall ensure that the C 50 mS lane departure oscillating torque amplitude is below Max_Torque_Amplitude.	X		
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency.	X		
Functional Safety Requirement 02-01	Electronic power steering ECU will ensure that the lane keeping assistance torque is applied for only Max_Duration.	X		

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Deactivate System	Malfunction_01 Malfunction_02	YES	YES (Display)
WDC-02	Deactivate System	Malfunction_03	YES	YES (Display)