



Elektrobit



UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
21-Jun-18	1.0	Nikhil Sinnarkar	Initial Draft

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Purpose of the Functional Safety Concept

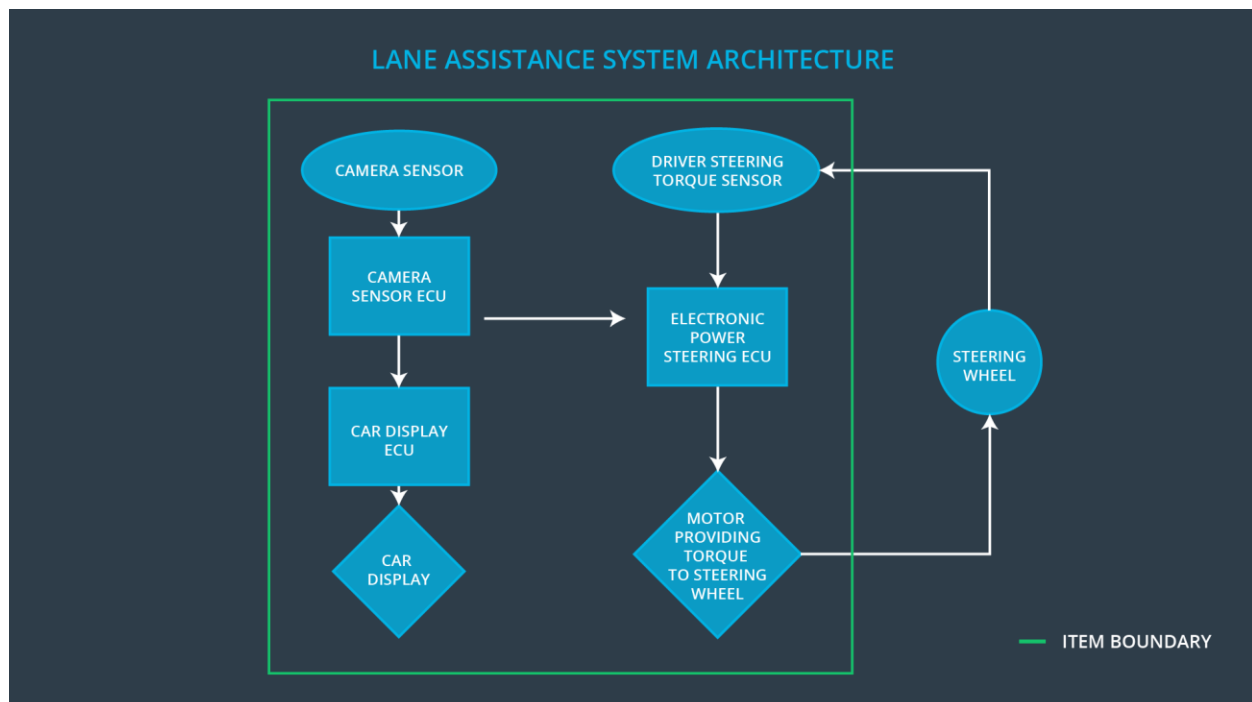
The purpose of functional safety concept is to describe the implementation of the independent safety solutions for a defined item.

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.

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	Capture road images and provide them to the Camera Sensor ECU.

Camera Sensor ECU	Analyze provided images to determine if the car is leaving the lane and if so, send a vibrational torque request to the power steering ECU.
Car Display	Provide feedback to the driver displaying warnings and the Lane Departure Assistance status.
Car Display ECU	An Electronic Control Unit that drives 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	ECU responsible for measuring the torque provided by the driver and adding appropriate amount of torque based on a lane assistance system torque request (LKA) and vibrates the steering wheel when the driver drifts away from the center (LDW).
Motor	Actuator responsible for applying requested torque to the steering column by Electronic Power Steering ECU for either the LKA or LDW functions.

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	MORE	The Lane Departure Warning function applies an oscillating torque with very high

	torque to provide the driver a haptic feedback		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.

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 keeping 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 Requirement 01-02	The Lane Departure Warning item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency.	C	50 ms	Vibration frequency is below 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 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.

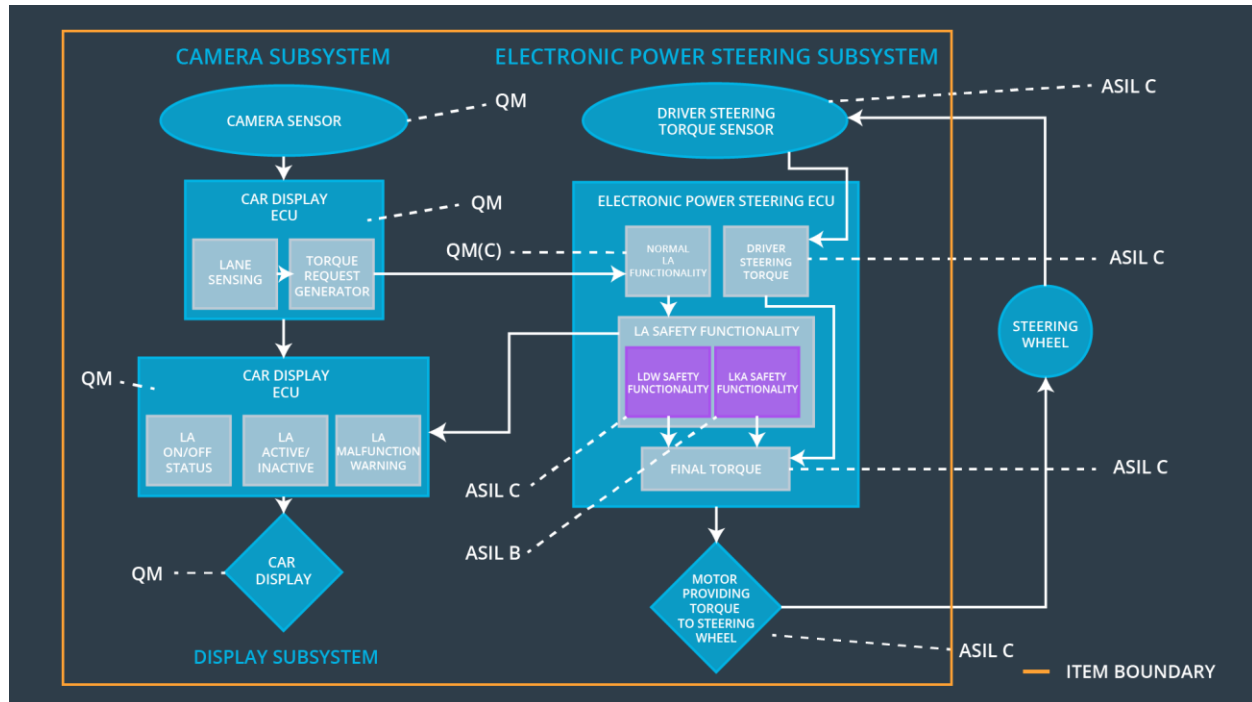
Lane Keeping Assistance (LKA) Requirements:

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 only Max_Duration.	B	500 ms	Lane Keeping Assistance torque is zero.

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	Test and validate that the Max_duration chosen did dissuade drivers from using the car as self-driving car.	Verify that the system really does turn off if the lane keeping assistance ever exceeded 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 Departure Warning item shall ensure that the lane departure oscillating torque amplitude is below 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.	✓		

Functional Safety Requirement 02-01	The electronic power steering ECU shall ensure that the Lane Keeping Assistance torque is applied only Max_Duration.	✓		
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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	Yes	Lane Departure Warning Malfunction Warning on Car Display
WDC-02	Turn off Lane Keeping Assistance functionality	Malfunction_03	Yes	Lane Keeping Assistance Malfunction Warning on Car Display