Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
09/10/2017	0.1	Gustavo Espindola	First draft
11/10/2017	1	Gustavo Espindola	Release candidate

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Inhalt

Purpose of the Functional Safety Concept

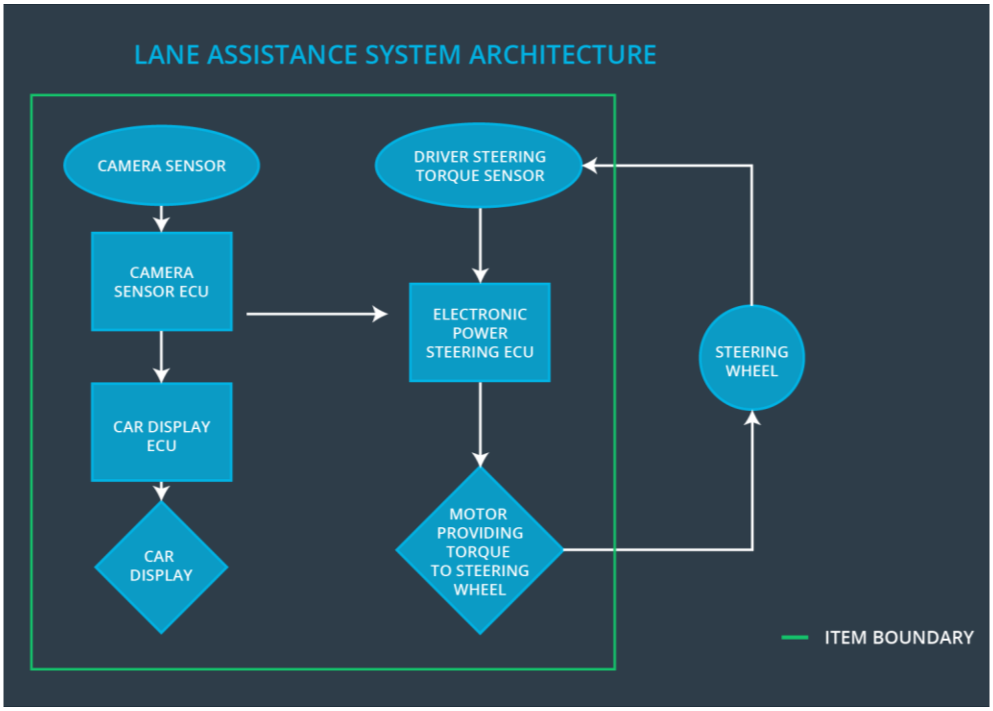
This document is intended to map the safety goals to a specific ECU, sub-system or system.

Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	The vibration applied to the steering wheel shall be limited.
Safety_Goal_02	The function lane keep assistance shall be limited in time. The additional torque shall end after the configured time.

Preliminary Architecture


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

Description of architecture elements

Element	Description
Camera Sensor	Obtains the image as raw data.
Camera Sensor ECU	Processes the image and extracts the lines of the lane. With that information requests the correction torque needed to stay on the lane.
Car Display	Shows information about the state of the system
Car Display ECU	Interprets the signals from other ECU's and sends the command to the Car display to show them.
Driver Steering Torque Sensor	This sensor gives feedback on the force applied to the steering wheel, either by the driver or by the LKA system.
Electronic Power Steering ECU	This ECU is responsible of controlling the signals sent to the motor and its correct behavior.
Motor	Is the actuator which applies the torque to steering wheel which finally corrects the trajectory of the vehicle.

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	MORE	The LDW applies an oscillating torque which amplitude is

	an oscillating steering torque to provide the driver a haptic feedback		above the limit and thus very high.
Malfunction_02	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	MORE	The LDW warning applies an oscillating torque at a frequency above the limit and thus very high.
Malfunction_03	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	NO	The LKA functionality is not limited in duration, this leads to abuse from the user which uses it as a full autonomous car.

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 electronic power steering ECU shall limit the alert for the LDW, so the amplitude of the oscillating torque is less than Max_Torque_Amplitude	C	50ms	LDW requested torque is set to zero. The failure is shown in the car display and recorded.
Functional Safety Requirement 01-02	The electronic power steering ECU shall limit the alert for the LDW, so the frequency of the oscillating torque is less than Max_Torque_Frequency	C	50ms	LDW requested torque is set to zero. The failure is shown in the car display and recorded.

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 if a driver is capable of perceive the torque at the nominal amplitude.	Verify that the torque goes to zero after requesting a value above the limit, and the lamp goes on, This within 50ms after the failure.
Functional Safety Requirement 01-02	Validate if a driver is capable of perceive the torque at the nominal frequency.	Verify that the torque goes to zero after requesting a value above the limit, and the lamp goes on, This within 50ms after the failure.

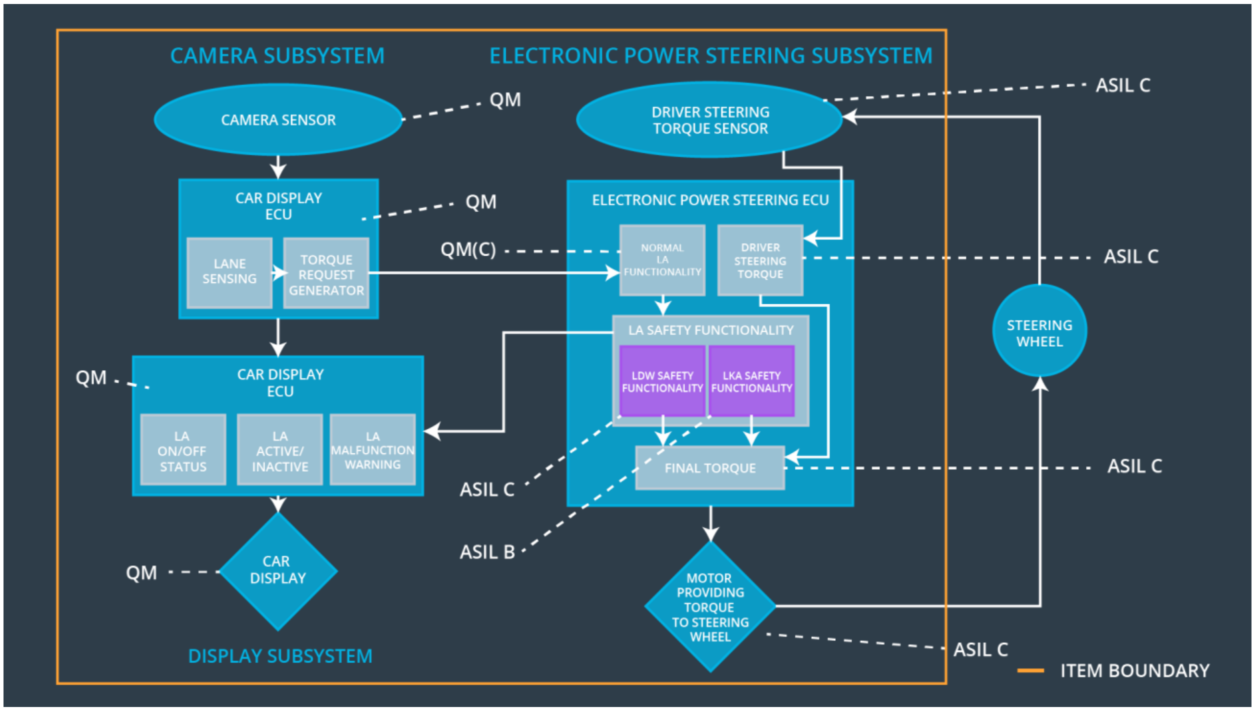
Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	The power steering ECU shall limit the duration of the functionality up to a period of Max_Duration	B	500ms	LKA requested 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	Validate that the active period for the functionality is short enough to make the driver alert.	Verify the deactivation of the system after Max_duraton.

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 electronic power steering ECU shall ensure that the lane departure oscillating torque amplitude is below Max_Torque_Amplitude	X		
Functional Safety Requirement 01-02	The electronic power steering ECU shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency	X		
Functional Safety Requirement 02-01	The electronic power steering ECU shall 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	LDW functionality is deactivated and lamp turned on.	Requested oscillation amplitude is > Max_Torque_Amplitude OR Requested oscillation frequency is > Max_Torque_Frequency	Yes	Yes, through lamp in the dash board.
WDC-02	LKA functionality is deactivated and lamp turned on.	LKA functionality is active after Max_Duration	Yes	Yes, through lamp in the dash board.