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
9/18/2017	1.0	Dr. Martin Pfeifle	First Version of the Functional Safety Concept for

			Lane Assistance

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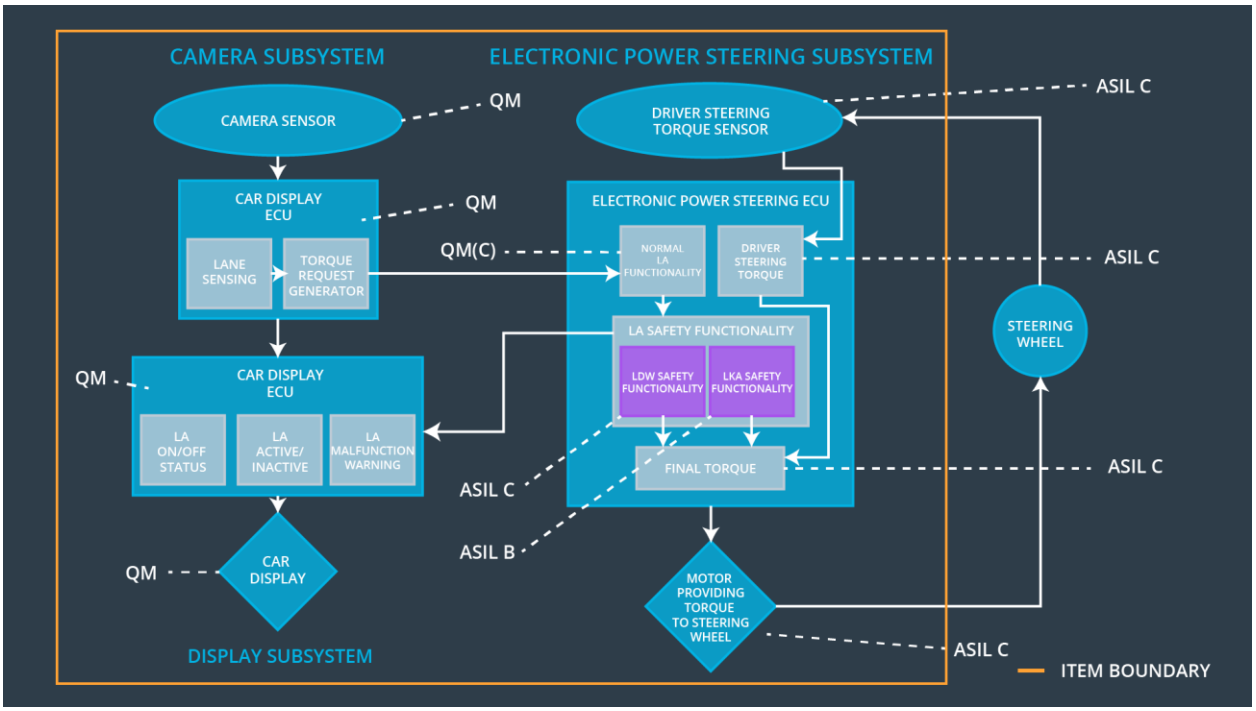


Purpose of the Functional Safety Concept

The functional safety concept describes the high-level safety functionality of the system.

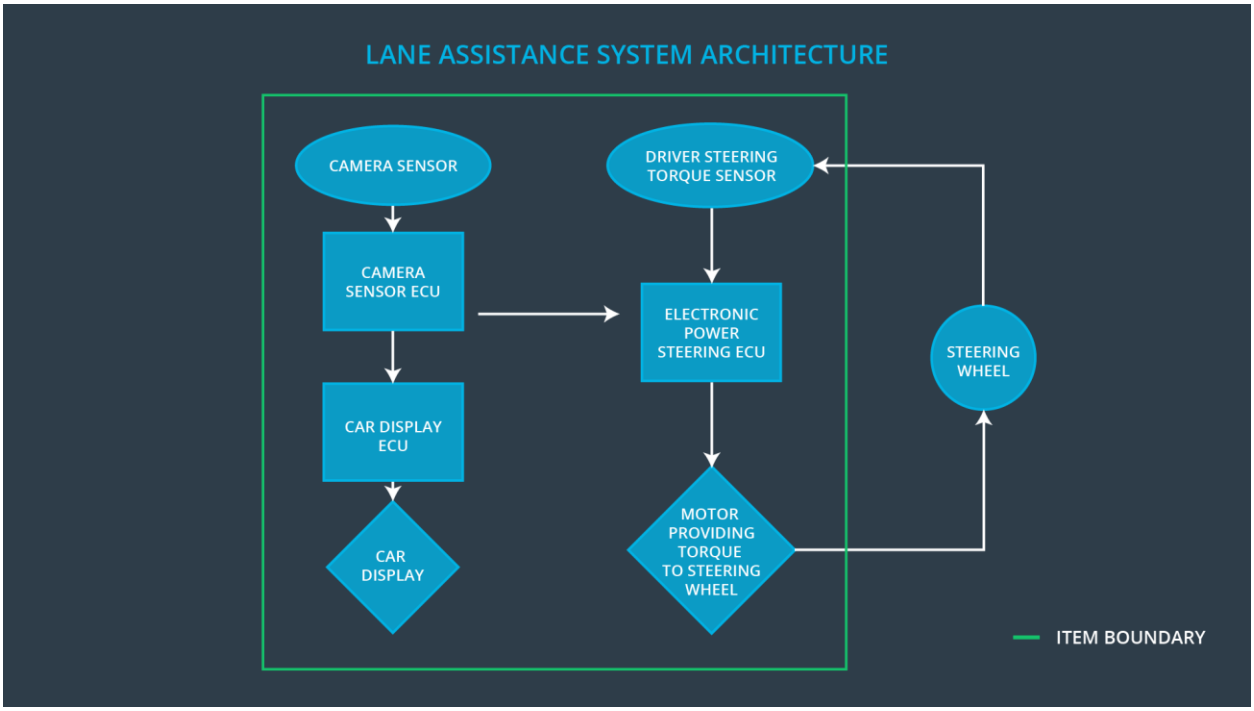
Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	Limit the magnitude and frequency of the oscillating torque
Safety_Goal_02	System must switch off if lanes are not corrected by the camera. Responsibility needs to be passed to the driver.

Safety_Goal_03	System must inform the driver that the sensors are not working properly anymore, slow down and pass the responsibility to the driver
Safety_Goal_04	The controlling unit / execution model needs to publish steering and acceleration values at least values every 30ms

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	The camera sensor reads in images from the road.
Camera Sensor ECU	The Camera Sensor ECU identifies when the vehicle has accidentally departed its lane and sends the appropriate messages to the car display ECU and the Electronic Power Steering ECU.
Car Display	The car display shows information to the driver which reflect the status of the system, i.e. whether it is working normally or whether an error situation occurred and the driver needs to take over.

Car Display ECU	The Car Display ECU does the graphical rendering of the information which are depicted. It activates lamps or other display modules according to the current status of the system. Basically, it prepared the information so that it can be shown on the Car Display element.
Driver Steering Torque Sensor	A sensor that outputs the torque applied by the driver to the steering wheel
Electronic Power Steering ECU	A control module that fuses the driver steering torque signal, requested steering wheel torque from the camera sensor ECU, and the motor information to create an actuator output signal.
Motor	An actuator that adds torque to the steering system in either direction (clockwise or counterclockwise)

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	MORE	The lane departure warning function applies an oscillating

	an oscillating steering torque to provide the driver a haptic feedback		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 applying the steering torque as the lanes are not detected properly by the camera system

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	50ms	Lane keeping item output torque = 0
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque amplitude is below Max_Torque_Frequency	C	50ms	Lane keeping item output torque = 0

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	Acceptance Criteria 100% of drivers are able to regain steering control Event Software produce a torque signal which exceeds the maximum	Criteria Lane_Keep_Torque = 0 within 50ms of event Event Fault injection by RAM address write, requested torque amplitude exceeds limit

	1.5 * Max_Torque_Amplitude Method Vehicle on test track with test driver	Method Hardware-in-the-loop verification
Functional Safety Requirement 01-02	Acceptance Criteria 100% of drivers are able to regain steering control Event Software produce a torque signal which exceeds the maximum 1.5 * Max_Torque_Frequency Method Vehicle on test track with test driver	Criteria Lane_Keep_Torque = 0 within 50ms of event Event Fault injection by RAM address write, requested torque frequency exceeds limit Method Hardware-in-the-loop verification

Lane Keeping Assistance (LKA) Requirements:

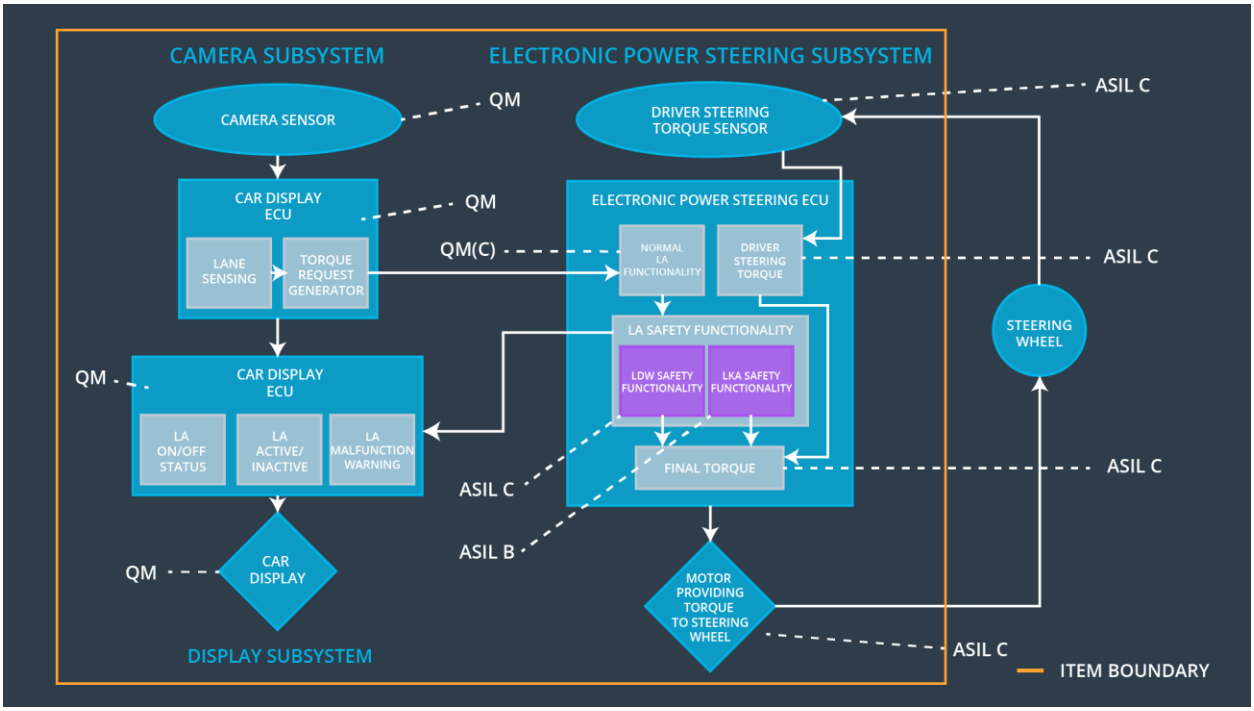
ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	The electronic power steering ECU shall ensure that the lane keeping assistance torque is applied for only Max_Duration	B	500ms	Lane keeping item output torque = 0

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	Criteria 100% of drivers are able to regain steering control Event Driver removes hands from wheel with system active, retakes control after system is	Criteria Lane_Keep_Torque = 0 within 500ms of event Event Fault injection by RAM address write, requested lane keep assistance torque remains active indefinitely Method

	disabled by functional safety feature Method Vehicle on test track with driving coaches and various drivers	Hardware-in-the-loop verification

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 keeping item shall ensure that the 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 amplitude 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	Functionality is turned off	Malfunction_01	Yes, immediately	audible warning signal combined with a pop-up message on instrument cluster
WDC-02	Functionality is turned off	Malfunction_02	Yes, immediately	audible warning signal combined with a pop-up message on instrument cluster