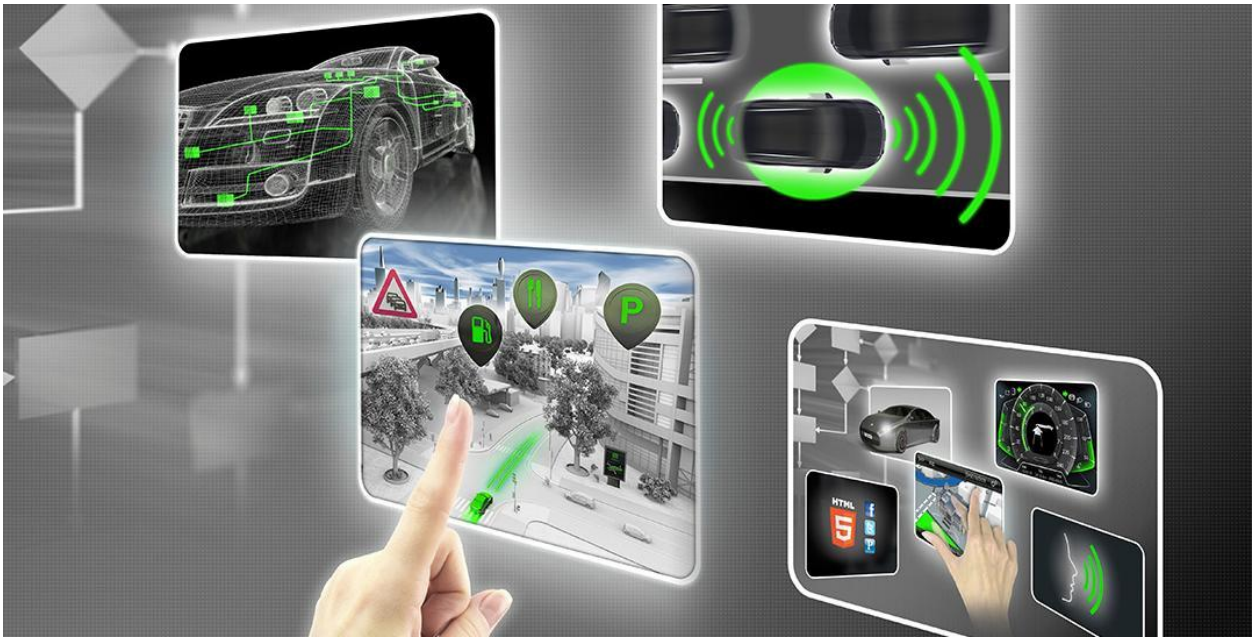
Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

Document Version: 1.0



Document history

Date	Version	Editor	Description
15.08.2018	1.0	Reuss	First version

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Purpose of the Functional Safety Concept

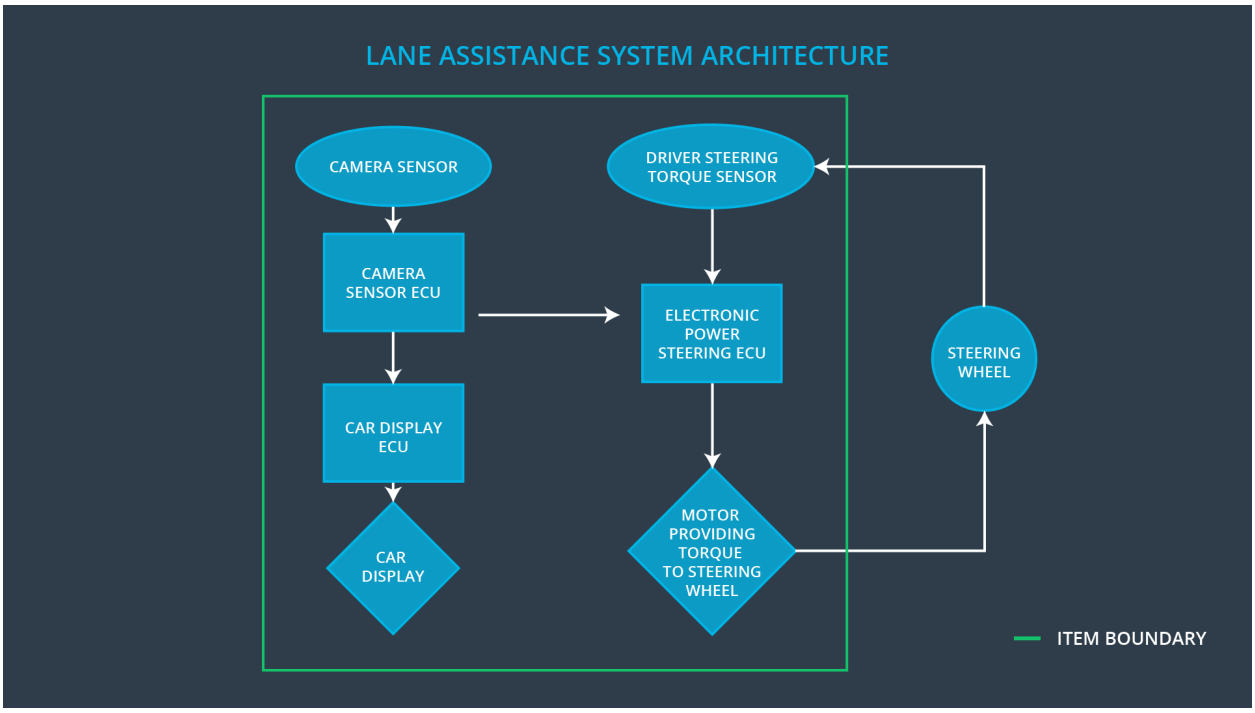
The purpose is to avoid accidents by reducing risk to acceptable levels. The functional safety concept helps contributing to that, by decomposing safety goals into functional safety requirements and allocating them to the corresponding subsystems.

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 the additional steering torque shall end after a given time interval so that the driver cannot misuse the system for autonomous driving.
Safety_Goal_03	The steering torque from the lane keep assistance function shall steer the car back to the center of the lane.
Safety_Goal_04	The steering torque from the lane keep assistance function shall be limited.

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	Takes images of the road.
Camera Sensor ECU	Processing images taken by the camera sensor and outputs information to the Electronic Power Steering ECU.
Car Display	Display used to share information with the driver.
Car Display ECU	Responsible ECU to control the car display.
Driver Steering Torque Sensor	Measures torque applied by the driver the steering wheel.
Electronic Power Steering ECU	Processing information from Camera Sensor ECU and Torque Sensor and controls motor to add additional torque to the steering wheel, depending on the situation.
Motor	Adds additional torque to the steering wheel, if requested.

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	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 leads 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 electronic power steering ECU shall ensure that the lane departure oscillating torque amplitude is below Max_Torque_Amplitude.	C	50ms	Set torque to zero and shut off system
Functional Safety Requirement 01-02	The electronic power steering ECU shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency.	C	50ms	Set torque to zero and shut off system

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	Test how drivers react to different torque amplitudes and frequencies to prove that the chosen value is apprpriate	Software test with fault injection
Functional Safety Requirement 01-02	Test how drivers react to different torque amplitudes and frequencies to prove that the chosen value is apprpriate	Software test with fault injection

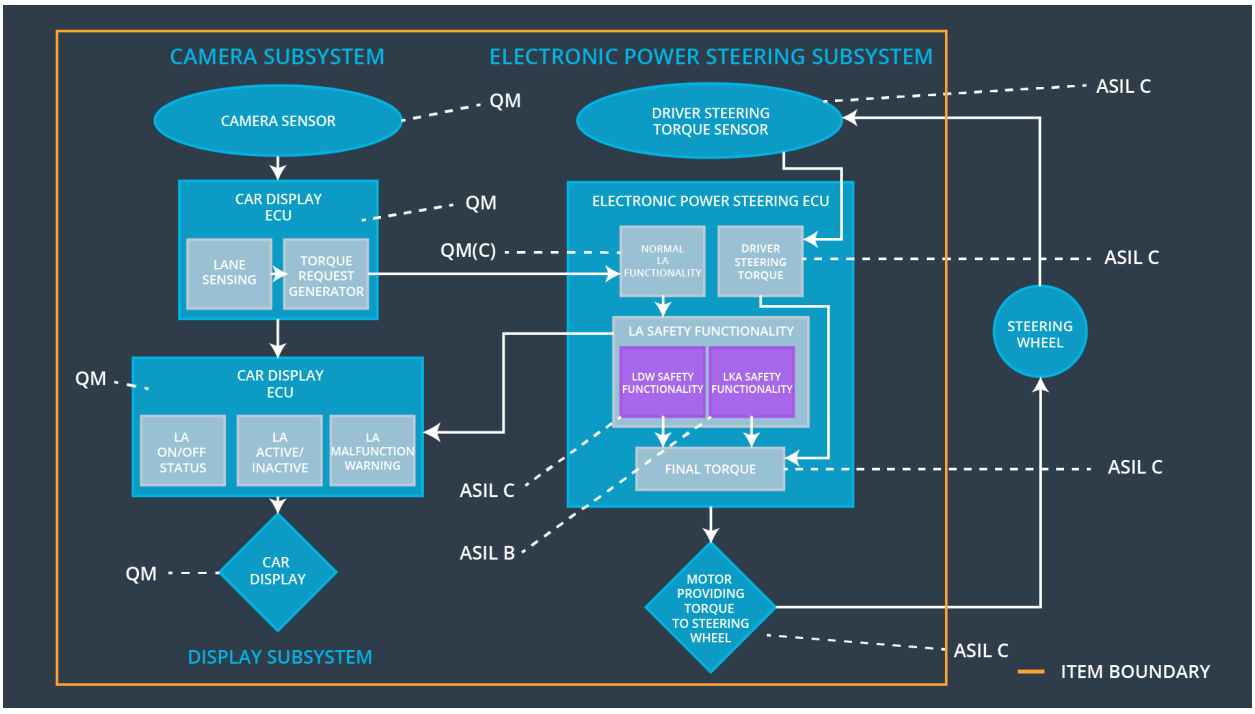
Lane Keeping Assistance (LKA) Requirements:

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	Set torque to zero and shut off system

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 chosen parameter Max_Duration really dissuade drivers from taking their hands off the wheel.	Vehicle test to verify that the system turns off, if the lane keeping assistance has 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 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	Turn off functionality	Torque amplitude over Max_Torque_Amplitude OR Torque frequency over Max_Torque_Frequency	Yes	Play alarm sound. Display warning “Lane assistance system is shut off due to malfunction.”

WDC-02	Turn off functionality	Driver did not put hands on the steering wheel for time longer than Max_Duration	Yes	Display warning “Lane assistance system is not designed for autonomous driving. Driver is responsible to control the car at all times. System is shut off.”