Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

Document Version: 1.1

Document history

Date	Version	Editor	Description
12.01.2019	1.0	Michael Ikemann	Initial definition of functional safety
13.01.2019	1.1	Michael Ikemann	Refinement

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Purpose of the Functional Safety Concept

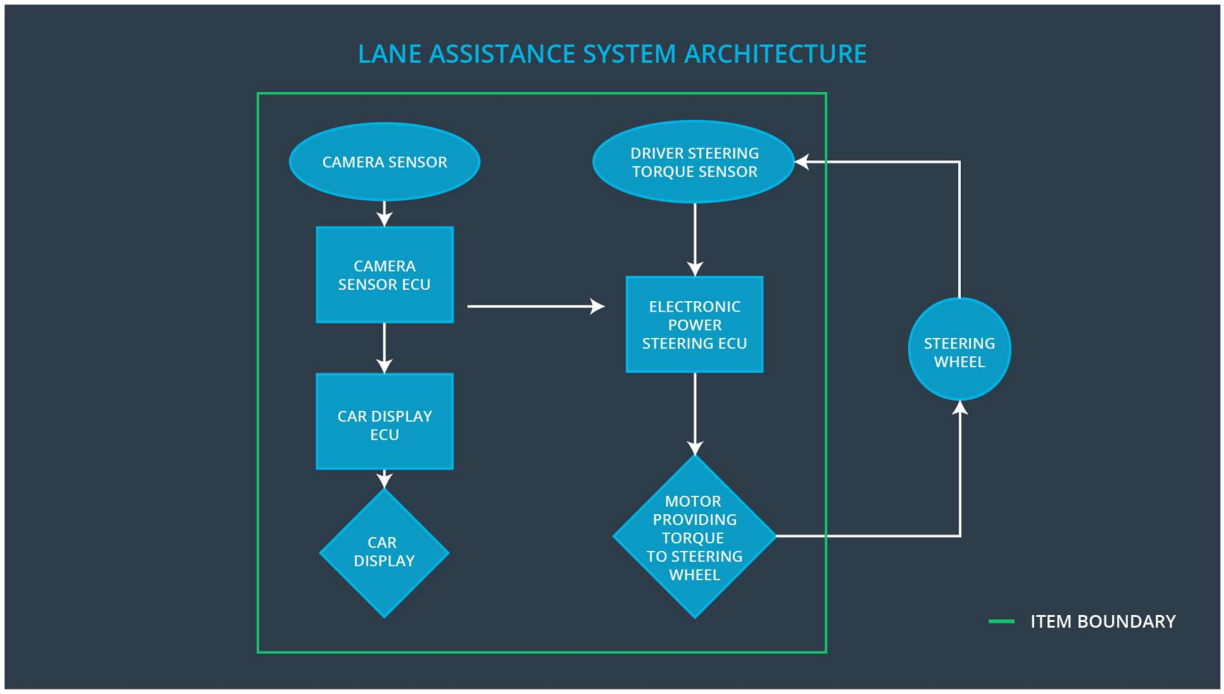
The purpose of the functional safety concept is to define the single functionalities from a high level perspective, how the the safety can be ensured as much as possible for each of it's features and the functionality's ASIL level.

Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	The lane keeping item shall ensure that the lane departure oscillating torque amplitude is below Max_Torque_Amplitude
Safety_Goal_02	Under bad weather conditions the LKA should deny activation to prevent this situation. The driver should be made aware that the LGA is no autonomous system and that majorly road work sites can lead to uncontrollable situations.
Safety_Goal_03	If the user removes the hands from the steering wheel the driver should be informed audiovisual that the lane guidance will be deactivated because the system shall not be used in an autonomous manner.
Safety_Goal_04	It shall be verified that the lane guidance system will be disabled when the vehicle is not driving.

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	Captures the image. Is mounted at the top of the wind screen.
Camera Sensor ECU	Analyses the image – detects the lane and the detection certainty and decides if the user shall be warned about lane departure or follow the center of the lane if lane guidance is activated.
Car Display	Visualizes if lane guidance and departure features are activated and also informs the user when a lane departure occurs.
Car Display ECU	Is responsible for the visualization of the car's dashboard. Needs to be extended for the visualization of LGA related features.
Driver Steering Torque Sensor	Detects with which amount of force the driver tries to steer. In case of the LGA a non-existing steering of the driver in a curve should lead to a warning so the driver will not use the LGA in an autonomous way. Also a

	counter-steering of the driver should be detected and disable the lane guide so the driver will regain control of the vehicle if required.
Electronic Power Steering ECU	The EPS ECU decides by the information provided by the DSTS and CS ECU which amount of torque to apply to the steering wheel.
Motor	Applies the amount of torque provided by the EPS ECU to the steering wheel so that the vehicle will (for example) follow the lane detected.

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	The lane departure warning applies MORE oscillating torque than intended.	A too strong vibration of the steering wheel would distract the driver.
Malfunction_02	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	The computation of the camera ECU arrives too LATE at the EPS ECU.	The driver will be notified too late to still be able to react due to a delayed notification.

Malfunction_03	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	The LKA steers WRONG within a road work site due to crossing lane markers which irritated the CS ESU.	The vehicle drives into a wrong direction and potentially causes an accident.

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 is amplitude is below Max_Torque_Amplitude.	C	50ms	Disable LDW functionality
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque is oscillating frequency is below Max_Torque_Frequency.	C	50ms	Disable LDW functionality

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: Vibration amplitude is clearly detectable by the driver while not being too intense to be annoying. Method: Vehicle testing	Acceptance: Requested amplitude does not exceed defined maximum of Max_Torque_Amplitude. Method: Fault test with measurement device
Functional Safety Requirement 01-02	Acceptance: Vibration frequency is clearly detectable by the driver while not being too intense to be annoying.	Acceptance: Requested amplitude does not exceed defined maximum of Max_Torque_Frequency

	Method: Vehicle testing	Method: Fault test with measurement device

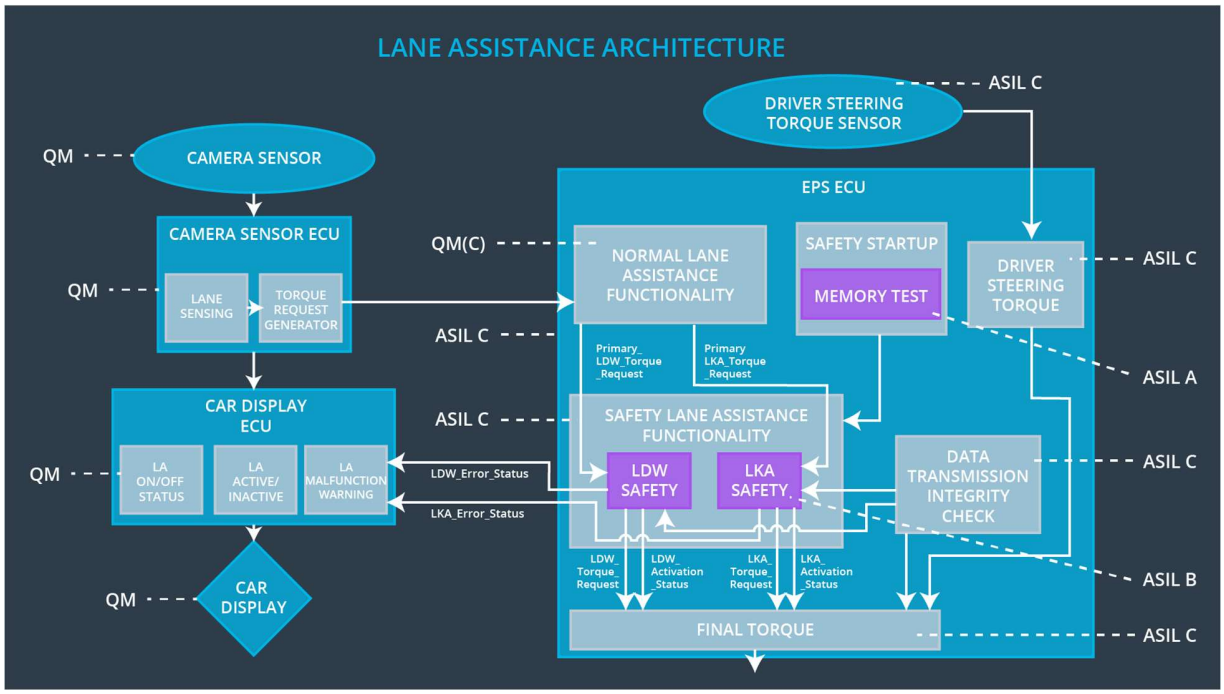
Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	The lane keeping item shall ensure that the torque requested by the lane keeping assistant shall not exceed a given threshold (caused by a non-steering driver) for time span longer than Max_Duration	B	500ms	Disable LKA functionality

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	Validation: The LKA automatically switches off when it detects that the driver did not steer at all for longer than Max_Duration. Method: Vehicle testing	Validation: LKA systems switches off if no activity of the driver, so no noteworthy level from the steering sensor could be received for Max_Duration. Method: Fault test by verifying that the torque applied will be zeroed if the steering sensor does not send any signal above a minimum threshold for 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 lane departure oscillating torque is amplitude is below Max_Torque_Amplitude.	**X**		
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque is oscillating frequency is below Max_Torque_Frequency.	**X**		
Functional Safety Requirement	The lane keeping item shall ensure that the torque requested by the lane keeping assistant	**X**		

02-01	shall not exceed a given threshold (caused by a non-steering driver) for time span longer than Max_Duration.			

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Disabled until next motor start.	When safety requirements for FSR 01-01 or FSR-01-02 are not met.	Yes	Error light in dashboard enabled and an acoustic warning sound played.
WDC-02	Disabled temporarily till situation is safe again.	When safety requirements for FSR-01-01 are not met.	Yes	Error light in dashboard enabled and an acoustic warning sound played.