Technical Safety Concept Lane Assistance

Document Version: 1.1

Document history

Date	Version	Editor	Description
12.01.2019	1.0	Michael Ikemann	Initial technical safety conception
13.0.1.2019	1.1	Michael Ikemann	Refinement

Table of Contents

Purpose of the Technical Safety Concept

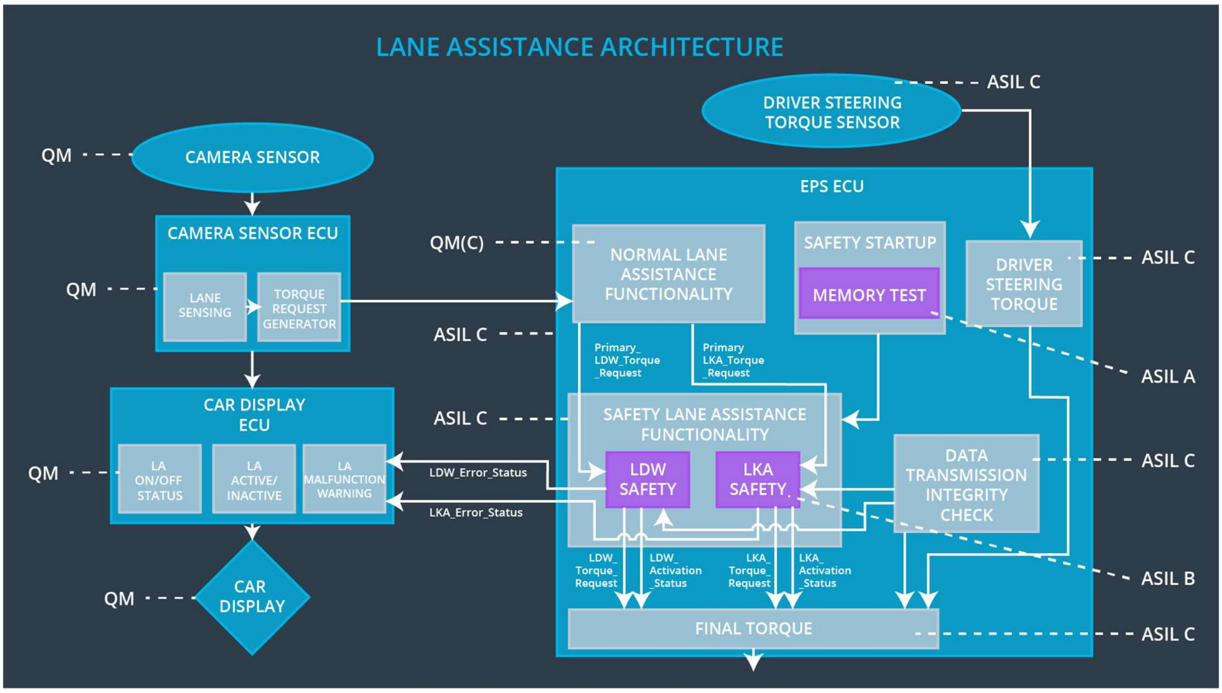
The technical safety concept describes in detail and from a low level, technical perspective how the requirements can be satisfied on the technical sight and which architectural requirements need to be fulfilled to do so.

Inputs to the Technical Safety Concept

Functional Safety Requirements

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 01-01	Bad weather conditions and incorrectly working sensors are detected and the user will be informed.	B	0.1s	The system will be disabled and the user informed via dashboard.
Functional Safety Requirement 01-02	The detection data is provided in intervals of 10 Hz. In case of lost messages the system will automatically be disabled.	B	0.1s	The system will be disabled and the user informed via dashboard.
Functional Safety Requirement 02-01	If the current situation can be detected reliably anymore the system should slow down the car and instantly inform the driver.	B	0.1s	The system will temporarily disabled until the situation normalized.

Refined System Architecture from Functional Safety Concept



Functional overview of architecture elements

Element	Description
Camera Sensor	Is located behind the wind shield, captures images and sends them as stream to the CS ECU.
Camera Sensor ECU - Lane Sensing	Detects lanes by analysing the camera image and applying edge detection filters. Forwards the information of the detect lanes and the confidence to the torque request generator.
Camera Sensor ECU - Torque request generator	If the LKA is enabled and the lanes could confidentially be identified it will create torque requests so the vehicle will stay in the lane's center. If the situation is unsafe it will disable the LKA temporarily and inform the user about this state by sending the status to the CD ECU.
Car Display	Visualizes the vehicle's current state.
Car Display ECU - Lane Assistance On/Off Status	Visualizes if the lane assistance is currently enabled using a symbolic light.

Car Display ECU - Lane Assistant Active/Inactive	Visualizes if the lane assistance is currently active using a symbolic light.
Car Display ECU - Lane Assistance malfunction warning	Notifies the user if there is any malfunction, for example because of internal system errors or a blocked sensor, for example caused due to weather conditions.
Driver Steering Torque Sensor	Detects the driver's steering torque. The torque is then sent to the EPS and amplified there.
Electronic Power Steering (EPS) ECU - Driver Steering Torque	Calculated the factor by which the driver's torque shall be scaled such as current speed and forwards it to the final torque system.
EPS ECU - Normal Lane Assistance Functionality	Receives the computed values from the Torque Request Generator and forwards it to the Lane Keeping Assistant Safety Functionality for verification.
EPS ECU - Lane Departure Warning Safety Functionality	Verifies that the torque requested by the NLF is within given bounds of up to MAX_TORQUE and limits it if required. Zeroes the torque in case of detected functional errors.
EPS ECU - Lane Keeping Assistant Safety Functionality	Verifies that the torque requested by the NLF is within given bounds of up to MAX_TORQUE and limits it if required. Zeroes the torque in case of detected functional errors.
EPS ECU - Final Torque	Receives the final torque and forwards it to the steering motor.
Motor	Applies the torque to the steering mechanically to turn the car's wheel left or right.

Technical Safety Concept

Technical Safety Requirements

Lane Departure Warning (LDW) Requirements:

Functional Safety Requirement 01-01 with its associated system elements
(derived in the functional safety concept)

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 amplitude is below Max_Torque_Amplitude	X		

Technical Safety Requirements related to Functional Safety Requirement 01-01 are:

ID	Technical Safety Requirement	ASIL	Fault Tolerant Time Interval	Architecture Allocation	Safe State
Technical Safety Requirement 01	The LDW safety component shall ensure that the amplitude of the 'LDW_Torque_Request' sent to the 'Final electronic power steering Torque' component is below 'Max_Torque_Amplitude.	C	50ms	LDW_SAFETY Software	The LDW torque amplitude request shall be set to zero
Technical Safety Requirement 02	As soon as the LDW function deactivates the LDW feature, the 'LDW Safety' software block shall send a signal to the car display ECU to turn on a warning light.	C	50ms	LDW_SAFETY Software	The LDW torque amplitude request shall be set to zero
Technical Safety Requirem	As soon as a failure is detected by the LDW function, it shall deactivate the LDW feature and	C	50ms	LDW_SAFETY Software	The LDW torque amplitude

ent 03	the 'LDW_Torque_Request' shall be set to zero.				request shall be set to zero
Technical Safety Requirem ent 04	The validity and integrity of the data transmission for 'LDW_Torque_Request' signal shall be ensured.	C	50ms	Data Transmission Integrity Check	The LDW torque amplitude request shall be set to zero
Technical Safety Requirem ent 05	Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition cycle	Safety Startup	The LDW torque amplitude request shall be set to zero

Functional Safety Requirement 01-2 with its associated system elements
(derived in the functional safety concept)

ID	**Functional Safety Requirement**	**Electronic Power Steering ECU**	**Camera ECU**	**Car Display ECU**
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency	X		

Technical Safety Requirements related to Functional Safety Requirement 01-02 are:

ID	**Technical Safety Requirement**	**ASIL**	**Fault Tolerant Time Interval**	**Architecture Allocation**	**Safe State**
Technical Safety Requirement 01	The LDW safety component shall ensure that the frequency of the 'LDW_Torque_Request' sent to the 'Final electronic power steering Torque' component is below	C	50ms	LDW_SAFETY Software	The LDW torque amplitude request shall be set to zero

	'Max_Torque_Amplitude				
Technical Safety Requirement 02	As soon as the LDW function deactivates the LDW feature, the 'LDW Safety' software block shall send a signal to the car display ECU to turn on a warning light.	C	50ms	LDW_SAFETY Software	The LDW torque amplitude request shall be set to zero
Technical Safety Requirement 03	As soon as a failure is detected by the LDW function, it shall deactivate the LDW feature and the 'LDW_Torque_Request' shall be set to zero.	C	50ms	LDW_SAFETY Software	The LDW torque amplitude request shall be set to zero
Technical Safety Requirement 04	The validity and integrity of the data transmission for 'LDW_Torque_Request' signal shall be ensured.	C	50ms	Data Transmission Integrity Check	The LDW torque amplitude request shall be set to zero
Technical Safety Requirement 05	Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition cycle	Safety Startup	The LDW torque amplitude request shall be set to zero

Lane Keeping Assistance (LKA) Requirements:

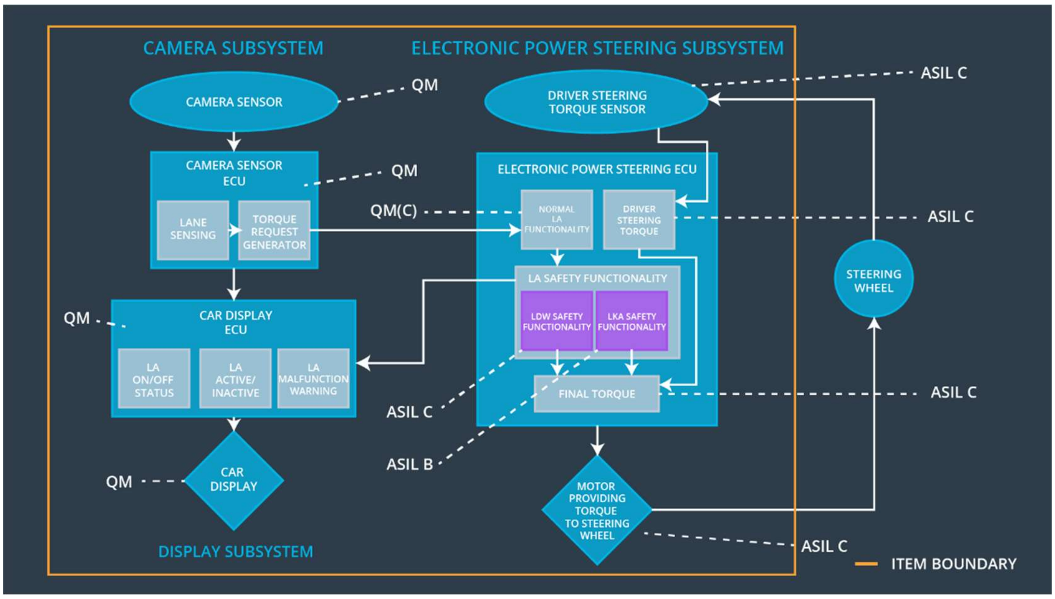
Functional Safety Requirement 02-1 with its associated system elements
(derived in the functional safety concept)

ID	Functional Safety Requirement	Electronic Power Steering ECU	Camera ECU	Car Display ECU
Functional Safety Requirement 02-01	The lane keeping item shall ensure that the lane keeping assistance torque is applied for only Max_Duration	X		

Technical Safety Requirements related to Functional Safety Requirement 02-01 are:

ID	Technical Safety Requirement	ASIL	Fault Tolerant Time Interval	Allocation to Architecture	Safe State
Technical Safety Requirement 01	The LKA needs to ensure that the LKA_Torque signal is only send to the FINAL TORQUE unit above a given threshold for a limited amount of time	C	500ms	LKA_SAFETY Software	The LDW torque amplitude request shall be set to zero
Technical Safety Requirement 02	As soon as the LKA function deactivates the LKA feature, the 'LKA Safety' software block shall send a signal to the car display ECU to turn on a warning light.	C	500ms	LKA_SAFETY Software	The LDW torque amplitude request shall be set to zero
Technical Safety Requirement 03	As soon as a failure is detected by the LKA function, it shall deactivate the LKA feature and the 'LKA_Torque_Request' shall be set to zero.	C	500ms	LKA_SAFETY Software	The LDW torque amplitude request shall be set to zero
Technical Safety Requirement 04	The validity and integrity of the data transmission for 'LKA_Torque_Request' signal shall be ensured.	C	500ms	Data Transmission Integrity Check	The LDW torque amplitude request shall be set to zero
Technical Safety Requirement 05	Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition cycle	Safety Startup	The LDW torque amplitude request shall be set to zero

Refinement of the System Architecture



Allocation of Technical Safety Requirements to Architecture Elements

All technical safety requirements are allocated in the Electronic Power Steering Unit.

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Disabled until next motor start.	CRC checksum errors in communication and or no data provided at 10 Hz rate as required.	LDW disabled.	Error light in dashboard.
WDC-02	Disabled temporarily till situation is safe again.	Too many, none or contradictionary lanes detected.	LKA temporarily disabled.	Inactivity visualized in dashboard.