



Elektrobit



UDACITY

Technical Safety Concept Lane Assistance

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Purpose of the Technical Safety Concept

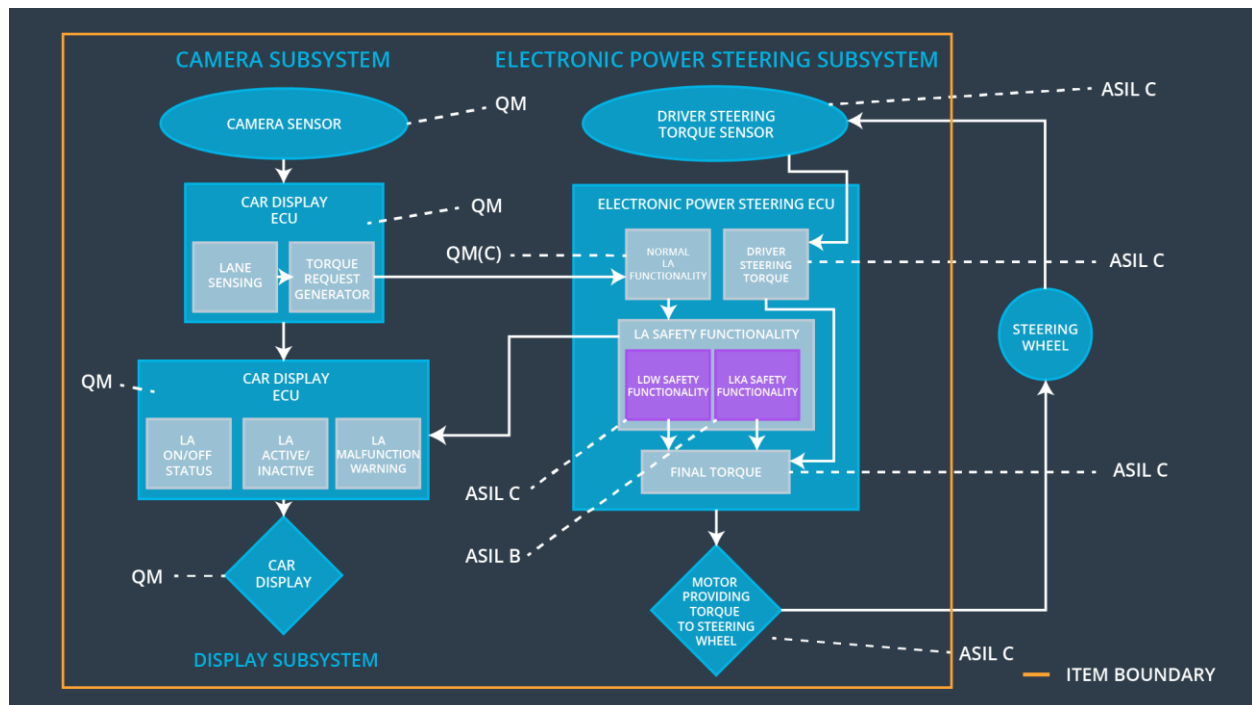
In this document, we examine the technical safety of each subsystem and define a separate safety concept for each subsystem. These requirements are more concrete and gets into details of the item's technology as specified by ISO 26262.

Inputs to the Technical Safety Concept

Functional Safety Requirements

ID	Functional Safety Requirement	A S I L	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 01-01	The Lane keeping item shall ensure that torque is below Max_Torque_Amplitude.	C	50 ms	Set Vibration to zero when fault detected
Functional Safety Requirement 01-02	The Lane keeping item shall ensure that lane departure oscillating torque frequency is below Max_Torque_Frequency.	C	50 ms	Set Vibration to zero when fault detected
Functional Safety Requirement 02-01	LKA function shall be time limited for max_duration	B	500 ms	Set the LKA torque to zero when fault detected

Refined System Architecture from Functional Safety Concept



Functional overview of architecture elements

Element	Description
Camera Sensor	Captures images and provides them to the Camera Sensor ECU.
Camera Sensor ECU - Lane Sensing	Detects lane lines and calculates position of the car with respect to lane
Camera Sensor ECU - Torque request generator	Generates torque request to the car for ECU.
Car Display	Displays status of individual systems.
Car Display ECU - Lane Assistance On/Off Status	Indicates the status of the Lane Assistance functionality (On/Off.)
Car Display ECU - Lane Assistant Active/Inactive	Indicates if the Lane Assistance functionality is properly functioning (Active/Inactive.)
Car Display ECU - Lane Assistance malfunction warning	Indicates a malfunction of the Lane Assistance functionality.

Driver Steering Torque Sensor	Measures the torque applied to the steering wheel by the driver.
Electronic Power Steering (EPS) ECU - Driver Steering Torque	Receives the driver's torque request from the steering wheel.
EPS ECU - Normal Lane Assistance Functionality	Receives the Camera Sensor ECU torque request.
EPS ECU - Lane Departure Warning Safety Functionality	Ensures the torque amplitude is below Max_Torque_Amplitude and torque frequency is below Max_Torque_Frequency.
EPS ECU - Lane Keeping Assistant Safety Functionality	Ensures the Lane Keeping Assistance functionality application is not activate more than Max_duration time.
EPS ECU - Final Torque	Combines the torque request from the Lane Keeping and Lane Departure Warning functionalities and sends them to the Motor.
Motor	Applies the required torque to the steering wheels.

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 01-01-01	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 element	Lane departure Warning torque to zero.
Technical Safety Requirement 01-01-02	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 element	Lane departure Warning torque to zero.
Technical Safety Requirement 01-01-03	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 element	Lane departure Warning torque to zero.
Technical Safety Requirement 01-01-04	The validity and integrity of the data transmission for 'LDW_Torque_Request' signal shall be ensured.	C	50ms	Data Transmission Integrity Check	Lane departure Warning torque to zero.
Technical Safety Requirement 01-01-05	Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition cycle	Memory Test	Lane departure Warning torque to zero.

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

ID	Functional Safety Requirement	Electronic Power	Camera ECU	Car Display ECU
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		Steering 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	A S I L	Fault Tolerant Time Interval	Architecture Allocation	Safe State
Technical Safety Requirement 01-02-01	The Lane Departure Warning safety component shall ensure the frequency of the 'LDW_Torque_Reques' sent to the 'Final electronic power steering Torque' component is below 'Max_Torque_Frequency.'	C	50ms	LDW Safety software element	Lane departure Warning torque to zero.
Technical Safety Requirement 01-02-02	The validity and integrity of the data transmission for 'Max_Torque_Frequency' signal shall be ensured.	C	50ms	LDW Safety software element	Lane departure Warning torque to zero.
Technical Safety Requirement 01-02-03	As soon as a failure is detected by the LDW function, it shall deactivate the LDW feature and the 'Max_Torque_Frequency' shall be set to zero.	C	50ms	LDW Safety software element	Lane departure Warning torque to zero.
Technical Safety Requirement 01-02-04	As soon as the LDW function deactivates the LDW feature, the LDW Safety software block shall send a signal to the car display	C	50ms	Data Transmission Integrity Check	Lane departure

	ECU to turn on a warning light.				Warning torque to zero.
Technical Safety Requirement 01-02-05	Memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition cycle	Memory Test	Lane departure Warning torque to zero.

Lane Departure Warning (LDW) Verification and Validation Acceptance Criteria:

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Technical Safety Requirement 01-01-01	Validate the Max_Torque_Amplitude is the chosen from the Lane Departure Warning Validation	Verify the Lane Departure Warning functionality is turned off.
Technical Safety Requirement 01-01-02	Validate the 'TORQUE_LIMITER' sends the error_status_torque_limiter signal to the LDW_SAFETY_ACTIVATION.	Verify the Car Display ECU displays the Lane Departure Warning malfunction warning signal.
Technical Safety Requirement 01-01-03	Validate the 'TORQUE_LIMITER' sends 'LDW_Torque_Request' with zero.	Verify the Final EPS Torque generator receives a LDW_Torque_Request of zero.
Technical Safety Requirement 01-01-04	Validate the 'TORQUE_LIMITER' calculate and sends the correct cyclic redundancy check (CRC) and Alive counter for data transmission validity and integrity.	Verify the functionality is turn off if there is a CRC or Alive counter discrepancy.
Technical Safety Requirement 01-01-05	Validate the Safety Startup Memory test to check memory faults catch memory faults.	Verify the Lane Departure Warning is turned off when the Safety Startup Memory fails.
Technical Safety	Validate the Max_Torque_Frequency set is the chosen from the Lane	Verify the functionality is turned off if the 'LDW_Torque_Request' frequency

Requirement 01-02-01	Departure Warning Acceptance Criteria.	exceeds Max_Torque_Request.
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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:

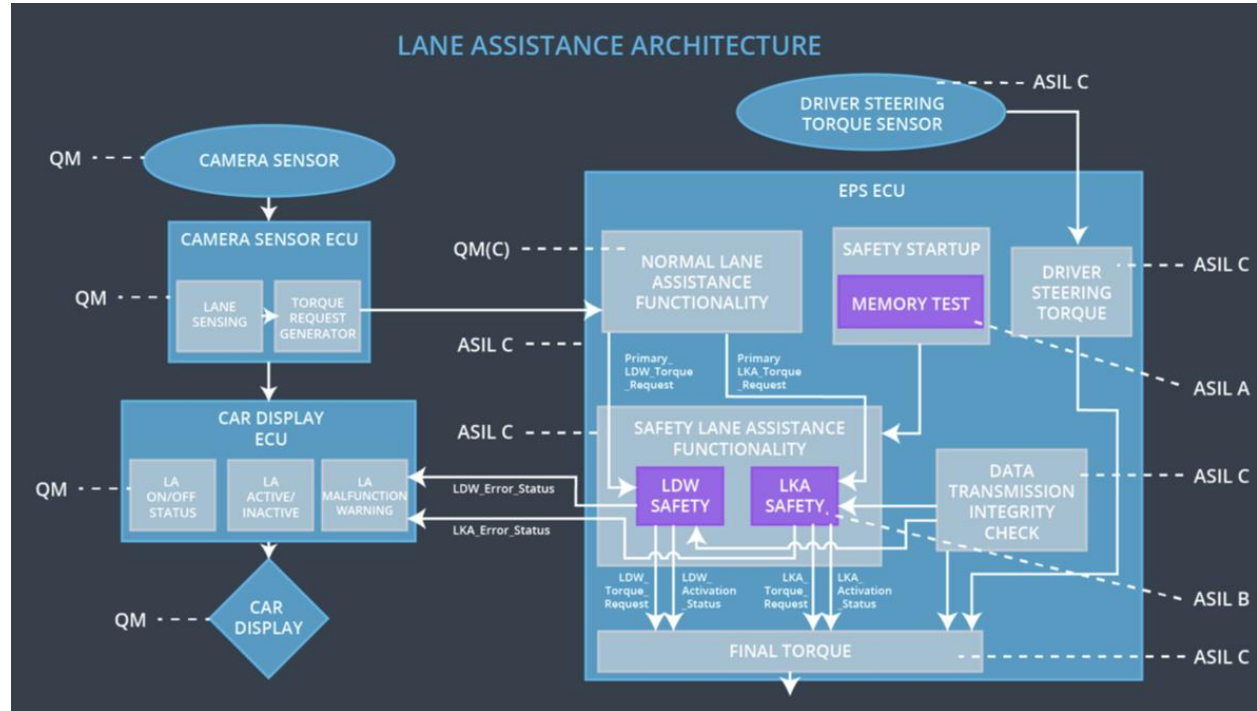
ID	Technical Safety Requirement	A S I L	Fault Tolerant Time Interval	Allocation to Architecture	Safe State
Technical Safety Requireme nt 02-01-01	The Lane Keeping Assistance safety component shall ensure lane keeping assistance torque is not applied for more than Max_Duration	C	500 ms	LDW Safety software element	Lane Keeping Assistance torque to zero.
Technical Safety Requireme nt 02-01-02	When the Lane Keeping Assistance function deactivates, the 'LKA Safety' shall send a signal to the Car Display ECU to turn on a warning light.	C	500 ms	LDW Safety software element	Lane Keeping Assistance torque to zero.
Technical Safety Requireme nt 02-01-03	When a failure is detected, the Lane Keeping Assistance function shall deactivate and the 'LKA_Torque_Request' shall be zero.	C	500 ms	LDW Safety software element	Lane Keeping Assistance torque to zero.

Technical Safety Requirement 02-01-04	The validity and integrity of the data transmission for 'LKA_Torque_Request' signal shall be ensured.	C	500 ms	Data Transmission Integrity Check	Lane Keeping Assistance torque to zero.
Technical Safety Requirement 02-01-05	Memory test shall be conducted at start up of the EPS ECU to check for any memory problems	A	Ignition cycle	Memory Test	Lane Departure Warning torque to zero.

Lane Keeping Assistance (LKA) Verification and Validation Acceptance Criteria:

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Technical Safety Requirement 02-01-01	Validate the Max_Duration is set to the chosen value from LKA Validation Assistance Criteria	Verify the functionality is turned off after it is applied for Max_Duration.
Technical Safety Requirement 02-01-02	Validate the 'TORQUE_LIMITER' sends the error_status_torque_limiter signal to the LKA_SAFETY_ACTIVATION.	Verify the Car Display ECU displays the Lane Keeping Assistance malfunction warning signal.
Technical Safety Requirement 02-01-03	Validate the 'TORQUE_LIMITER' sends 'LKA_Torque_Request' with zero.	Verify the Final EPS Torque generator receives a LKA_Torque_Request of zero.
Technical Safety Requirement 02-01-04	Validate the 'TORQUE_LIMITER' calculate and sends the correct cyclic redundancy check (CRC) and Alive counter for data transmission validity and integrity.	Verify the functionality is turn off if there is a CRC or Alive counter discrepancy.
Technical Safety Requirement 02-01-05	Validate the Safety Startup Memory test to check memory faults catch memory faults.	Verify the Lane Keeping Assistance is turned off when the Safety Startup Memory fails.

Refinement of the System Architecture



Allocation of Technical Safety Requirements to Architecture Elements

Technical Safety Requirement 01-01-01	The Lane Departure Warning 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.'	X	-	-
Technical Safety Requirement 01-01-02	When the Lane Departure Warning is deactivated, the 'LDW Safety' software module shall send a signal to the Car Display ECU to turn on a warning signal.	X	-	-
Technical Safety Requirement 01-01-03	When a failure is detected by the Lane Departure Warning functionality, it shall deactivate the Lane Departure Warning	X	-	-

	feature and set 'LDW_Torque_Request' to zero.			
Technical Safety Requirement 01-01-04	The validity and integrity of the data transmission for 'LDW_Torque_Request' signal shall be ensured.	X	-	-
Technical Safety Requirement 01-01-05	Memory test shall be conducted at start up of the EPS ECU to check for any memory problems	X	-	-
Technical Safety Requirement 01-02-01	The Lane Departure Warning safety component shall ensure the frequency of the 'LDW_Torque_Reques' sent to the 'Final electronic power steering Torque' component is below 'Max_Torque_Frequency.'	X	-	-
Technical Safety Requirement 02-01-01	The Lane Keeping Assistance safety component shall ensure the duration of the lane keeping assistance torque is applied for less than Max_Duration	X	-	-
Technical Safety Requirement 02-01-02	When the Lane Keeping Assistance function deactivates, the 'LKA Safety' shall send a signal to the Car Display ECU to turn on a warning light.	X	-	-
Technical Safety Requirement 02-01-03	When a failure is detected, the Lane Keeping Assistance function shall deactivate and the 'LKA_Torque_Request' shall be zero.	X	-	-
Technical Safety Requirement 02-01-04	The validity and integrity of the data transmission for 'LKA_Torque_Request' signal shall be ensured.	X	-	-
Technical Safety	Memory test shall be conducted at start up of the EPS ECU to	X	-	-

Requirement 02-01-05	check for any memory problems			
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Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn off Warning functionality	Malfunction_01, Malfunction_02	Yes	Light displayed on dashboard and on car as warnings
WDC-02	Turn off Assistance functionality	Malfunction_03	Yes	Light displayed on dashboard and on car as warnings