Elektrobit

UDACITY

Technical Safety Concept Lane Assistance

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Document history

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25-05-2018	1.0	Srigandhan	First Submission

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Purpose of the Technical Safety Concept

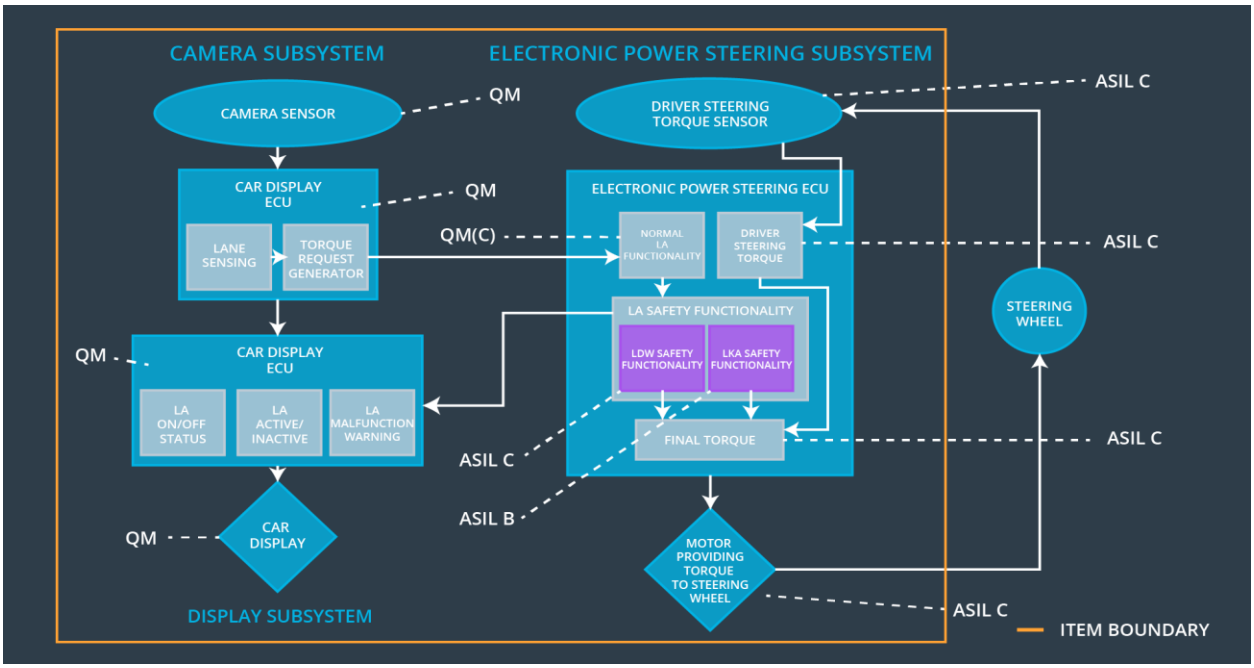
The purpose of the technical safety concept is to refine the functional safety requirements established in the functional safety concept into technical safety requirement. These new requirements are more concrete and gets into details of the item's technology as specified by ISO 26262.

Inputs to the Technical Safety Concept

Functional Safety Requirements

ID	Functional Safety Requirement	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	50 ms	Turn Off System
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency	C	50 ms	Turn Off System
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	500 ms	Turn Off System
Functional Safety Requirement 02-02	The electronic power steering ECU shall be deactivated when the electronic power steering ECU detects the camera sensor is not working.	B	50 ms	Turn Off System

Refined System Architecture from Functional Safety Concept

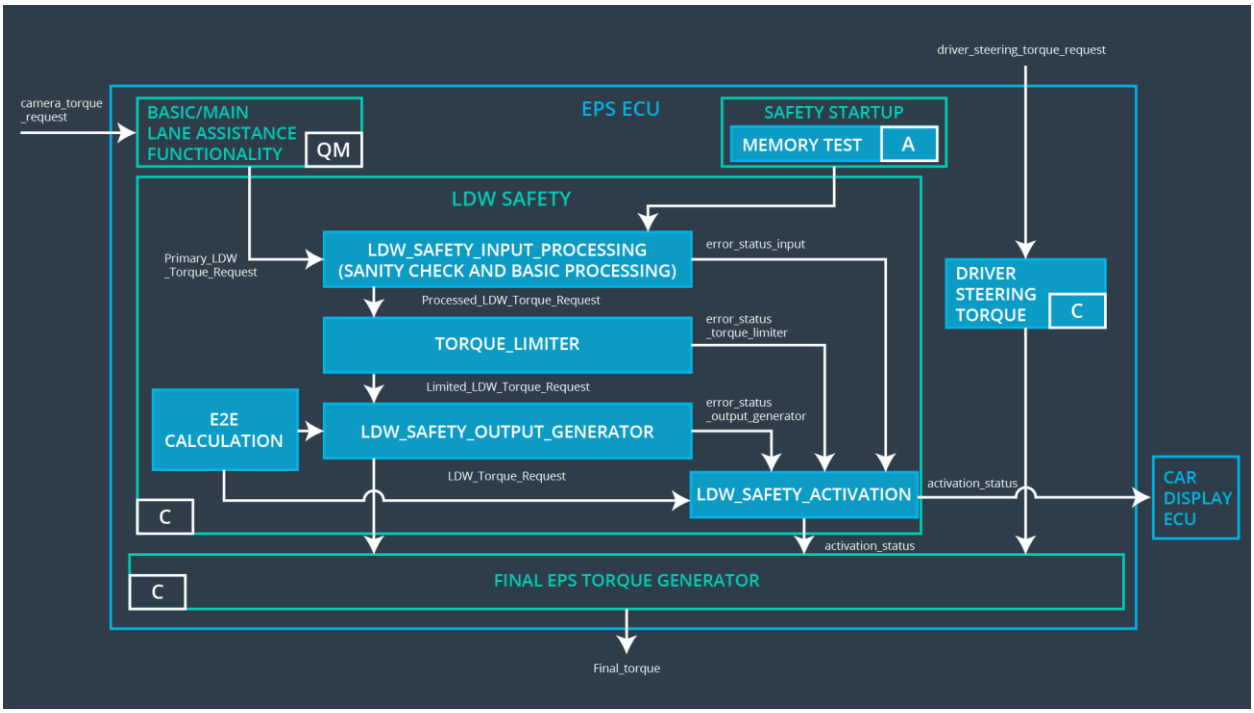


Functional overview of architecture elements

Element	Description
Camera Sensor	Provides camera images to the Camera Sensor ECU.
Camera Sensor ECU - Lane Sensing	Detects lane line positions from camera images.
Camera Sensor ECU - Torque request generator	Generates a torque request to the Electronic Power Steering ECU.
Car Display	Car Display is responsible for providing feedback to the driver about the status of lane assistant system
Car Display ECU - Lane Assistance On/Off Status	Software module responsible for displaying **On/Off** status of LDW & LKA functions.
Car Display ECU - Lane Assistant Active/Inactive	Software module responsible for displaying **Active/Inactive** status of LDW & LKA function.
Car Display ECU - Lane Assistance malfunction warning	Indicates malfunctions on the Lane Assistance functionality.
Driver Steering Torque Sensor	Measure the torque applied to the steering wheel by the driver.

Electronic Power Steering (EPS) ECU - Driver Steering Torque	Software module receiving the driver's torque request from the steering wheel.
EPS ECU - Normal Lane Assistance Functionality	Receives torque request from Camera Sensor ECU and transfers it to Safety Lane Assistance Functionality.
EPS ECU - Lane Departure Warning Safety Functionality	Checks for malfunction of Lane Departure Warning and translates torque request into final torque output.
EPS ECU - Lane Keeping Assistant Safety Functionality	Checks for malfunction of Lane Keeping Assistant and transfers torque request to final torque output.
EPS ECU - Final Torque	Combine the torque request from the LKA safety and LDW safety functionalities and sends them to the Motor.
Motor	An electric motor that applies the torque indicated by the Electronic Power Steering ECU to the steering wheel.

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	50 ms	LDW safety block	LDW_Torque_Output is set 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	50 ms	LDW safety block	LDW_Torque_Output is set 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	50 ms	LDW safety block	LDW_Torque_Output is set to zero
Technical	The validity and integrity of the	C	50 ms	Data	LDW_Torque

Safety Requirement 01-01-04	data transmission for 'LDW_Torque_Request' signal shall be ensured.			Transmission Integrity Check	_Output is set to zero
Technical Safety Requirement 01-01-05	Memory test shall be conducted at startup of the EPS ECU to check for any faults in memory.	A	Ignition cycle	Memory Test	LDW_Torque _Output is 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 01-02-01	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 'Max_Torque_Frequency.	C	50 ms	LDW safety block	LDW_Torque_ Output is set to zero
Technical Safety Requirement 02	As soon as a failure is detected by the LDW function, it shall deactivate the LDW feature and the ‘LDW_Torque_Request’ shall e set to zero.	C	50 ms	LDW Safety	LDW_Torque_ Output is set to zero
Technical	As soon as the LDW function	C	50 ms	LDW Safety	LDW_T

Safety Requirement 03	deactivates the LDW feature, the 'LDW Safety' software block shall send a signal to the car display ECU to turn on a warning light.				orque_ Output is set to zero
Technical Safety Requirement 04	The validity and integrity of the data transmission for 'LDW_Torque_Request' signal shall be ensured.	C	50 ms	Data Transmission Integrity Check	LDW_T orque_ Output is set to zero
Technical Safety Requirement 05	Memory test shall be conducted at startup of the EPS ECU to check for any faults in memory.	A	ignition cycle	Memory Test	LDW_T orque_ Output is set 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 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	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.

01-01-05		
Technical Safety Requirement 01-02-01	Validate the Max_Torque_Frequency set is the chosen from the Lane Departure Warning Acceptance Criteria.	Verify the functionality is turned off if the 'LDW_Torque_Request' frequency exceeds Max_Torque_Request.

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:

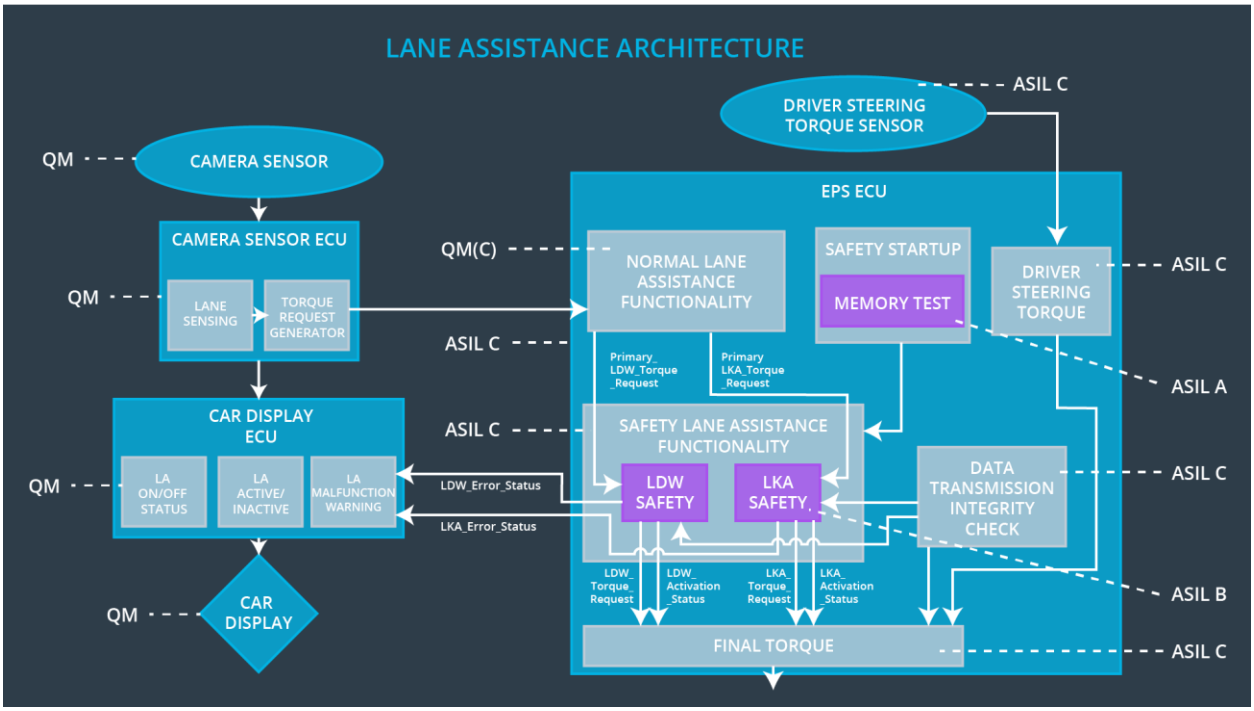
ID	Technical Safety Requirement	ASIL	Fault Tolerant Time Interval	Allocation to Architecture	Safe State
Technical Safety Requirement 02-01-01	The Lane Keeping Assistance safety component shall ensure the duration of the lane keeping assistance torque is applied for less than Max_Duration	B	500 ms	LKA Safety	Lane Keeping Assistance torque to zero.
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.	B	500 ms	LKA Safety	Lane Keeping Assistance torque to zero.
Technical	When a failure is detected, the	B	500 ms	LKA Safety	Lane

Safety Requirement 02-01-03	Lane Keeping Assistance function shall deactivate and the 'LKA_Torque_Request' shall be zero.				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.	B	500 ms	LKA Safety	Lane Keeping Assistance torque to zero.
Technical Safety Requirement 02-01-05	Memory test shall be conducted at startup of the EPS ECU to check for any memory problems	A	Ignition cycle	Data Transmission Integrity Check	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 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

For the Lane Assistance item, all technical safety requirements are allocated to the Electronic Power Steering ECU. For the exact allocation within EPS ECU, please refer to the technical safety requirements tables above.

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn off LDW functionality	Malfunction_01, Malfunction_02	Yes	Turn on warning light of the LDW functionality
WDC-02	Turn off LKA functionality	Malfunction_03, Malfunction_04	Yes	Turn on warning light of the LKA functionality