Elektrobit

UDACITY

Technical Safety Concept Lane Assistance

Document Version: 1.0

Document history

Date	Version	Editor	Description
3/24/2018	1.0	Taketo Kobayashi	First attempt

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Purpose of the Technical Safety Concept

The purpose of the technical safety concept is to identify new requirements and allocate these high level hardware and software requirements to system diagrams for the lane assistance functional safety project as pertain to the potential malfunctions of the electrical and electronic systems as defined by **ISO 26262** standard, tailored.

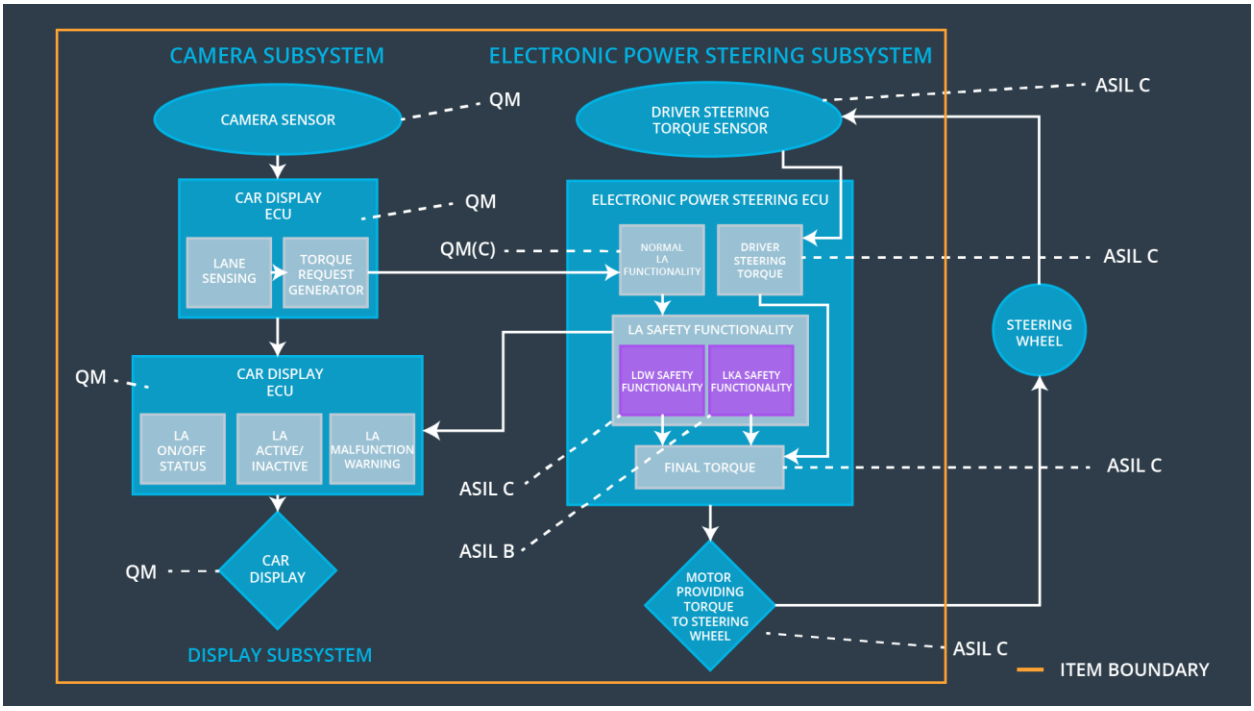
Inputs to the Technical Safety Concept

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	Set vibration torque amplitude to zero
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	Set vibration torque frequency to zero.
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	Set lane keeping assistance torque to zero
Functional Safety Requirement 02-02	The electronic power steering ECU shall ensure that the lane keeping assistance torque is set to zero when the camera sensor ECU stops detecting road markings and shall send its off status to the Car Display.	B	500 ms	Set lane keeping assistance torque to zero

Refined System Architecture from Functional Safety Concept

Description of architecture elements



Functional overview of architecture elements

Element	Description
Camera Sensor	Sensor responsible for capturing vehicle driving condition including detectable lane lines.
Camera Sensor ECU - Lane Sensing	Software Module in the Camera Sensor ECU responsible for detecting lane lines and determining when the vehicle leaves the lane by mistake.
Camera Sensor ECU - Torque request generator	Software Module in the Camera Sensor ECU responsible for calculating and sending the additional torque for the LDW and LKA functions.
Car Display	Visual display responsible to displaying warning of lane departures and LKA and LDW activation and deactivations.
Car Display ECU - Lane Assistance On/Off Status	Visual display responsible to displaying LKA and LDW ON/OFF status.

Car Display ECU - Lane Assistant Active/Inactive	Visual display responsible to displaying displaying warning of lane departures, LKA and LDW activation and deactivations.
Car Display ECU - Lane Assistance malfunction warning	Visual display responsible to displaying warning of LKA and LDW malfunctions.
Driver Steering Torque Sensor	Sensor responsible for measuring how much force (steering torque) the driver is applying to the steering wheel.
Electronic Power Steering (EPS) ECU - Driver Steering Torque	Software Module in the electronic power steering ECU responsible for receiving the Camera Sensor ECU torque requests.
EPS ECU - Normal Lane Assistance Functionality	Software Module in the electronic power steering ECU responsible for receiving the Driver Steering torque sensor input from the steering wheel.
EPS ECU - Lane Departure Warning Safety Functionality	Software Module in the electronic power steering ECU responsible for keeping the lane departure oscillating torque amplitude and frequence below MAX_Torque_Amplitude and MAX_Torque_Fequency respectively.
EPS ECU - Lane Keeping Assistant Safety Functionality	Software Module in the electronic power steering ECU responsible for ensuring the application of the lane keeping assistance torque does not ever exceeded Max_Duration and if lane detection is lost, the LKA function is deactivated.
EPS ECU - Final Torque	Software Module in the electronic power steering ECU responsible for ensuring the LDW, LKA and the driver’s steering torque requests are combined and sent to the Motor.
Motor	Actuator responsible for applying requested torque to the steering column by the Electronic Power Steering ECU for either the LKA or the LDW functions.

Technical Safety Concept

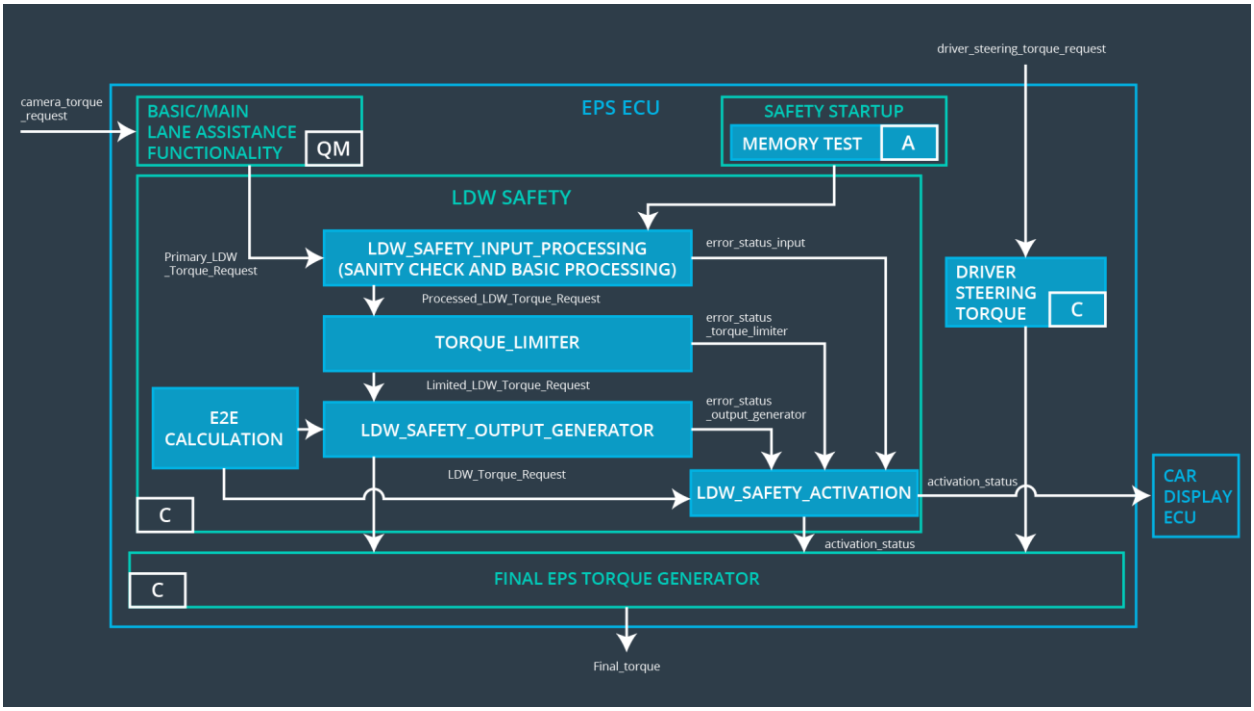
Technical Safety Requirements

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:

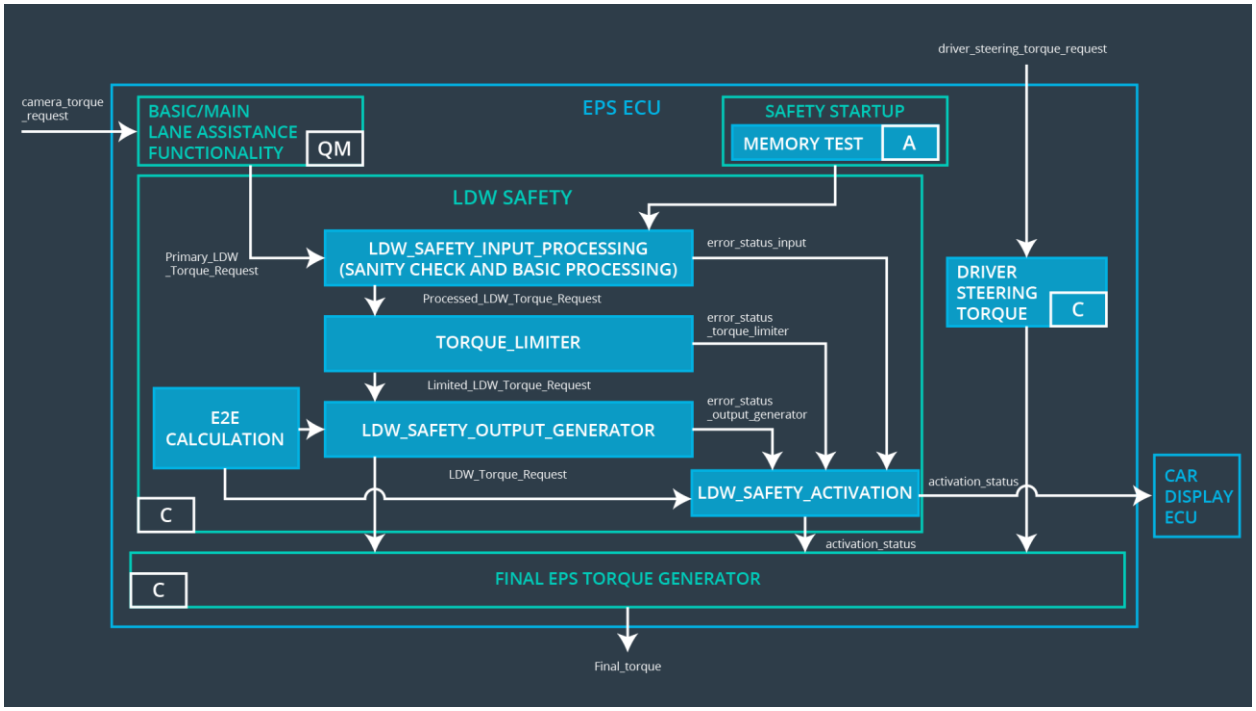


ID	Technical Safety Requirement	ASIL	Fault Tolerant Time Interval	Architecture Allocation	Safe State
Technical Safety Requirement 01-01-01	The LDW safety component shall ensure that the amplitude of the 'LDW_Torque_Request' sent to the 'Final electronic power steering Torque' component is below 'Max_Torque_Amplitude.	C	50 ms	LDW Safety block	Set 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	50 ms	LDW Safety block	Set 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	50 ms	LDW Safety block	Set 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	50 ms	LDW Safety block	Set 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	Data Transmission Integrity Check	Set 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 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 fequency of the 'LDW_Torque_Request' sent to the 'Final electronic power steering Torque' component is below 'Max_Torque_Fequency.	C	50 ms	LDW Safety block	Set lane departure warning torque to zero

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

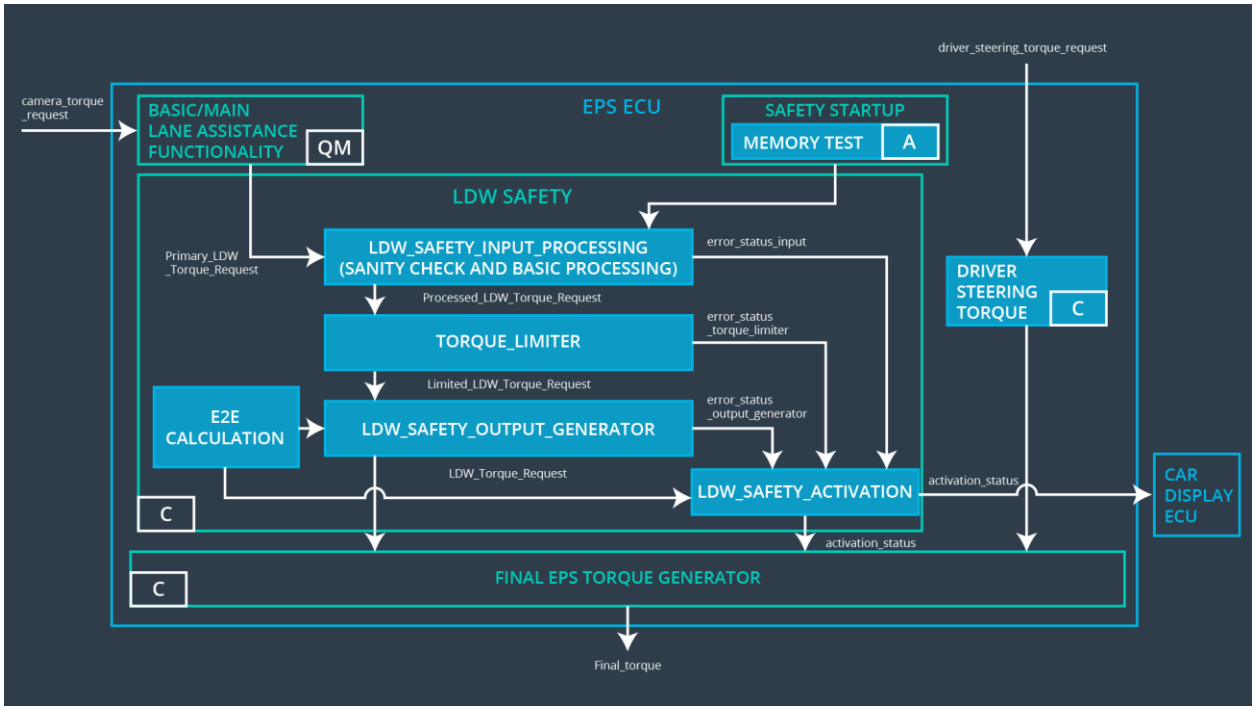
ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Technical Safety Requirement 01-01-01	Validate that the Max_Torque_Amplitude set is the chosen from LDW Validation Acceptance Criteria.	Verify that the system really does turn off if the lane departure warning 'LDW_Torque_Request' ever exceeded Max_Torque_Amplitude
Technical Safety Requirement 01-01-02	Validate that the “TORQUE_LIMITER” in the “LDW Safety” software block sends the error_status_torque_limiter signal to the LDW_SAFETY_ACTIVATION.	Verify that the Car Display ECU displays the LDW malfunction warning light.
Technical Safety Requirement 01-01-03	Validate that the “TORQUE_LIMITER” in the “LDW Safety” software block sends a zero LDW_Torque_Request.	Verify that the Final EPS TORQUE Generator receives a 0 LDW_Torque_Request
Technical Safety Requirement 01-01-04	Validate that the “TORQUE_LIMITER” in the “LDW Safety” software block calculate and sends a correct CRC (cyclic redundancy check) and Alive counter for data transmission validity and integrity.	Verify that the system really does turn off if the lane departure wanring “LDW_Torque_Request” ever has an invalid CRC or Alive counter.
Technical Safety Requirement 01-01-05	Validate that the Safety Startup Memory test to check memory faults will catch memory faults.	Verify that the LDW system really does turn off if the Safety Startup Memory test fails.
Technical Safety Requirement 01-02-01	Validate that the Max_Torque_Frequency set is the chosen from LDW Validation Acceptance Criteria.	Verify that the system really does turn off if the lane departure warning 'LDW_Torque_Request' ever exceeded Max_Torque_Frequency

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:



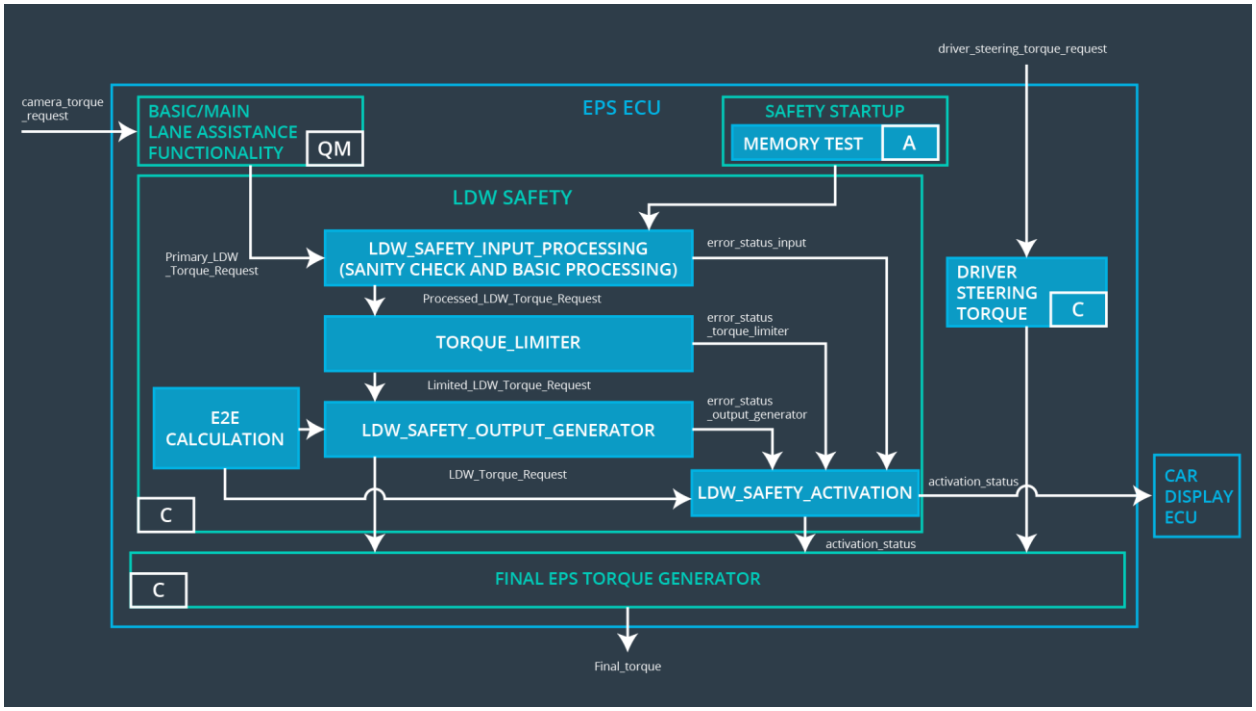
ID	Technical Safety Requirement	ASIL	Fault Tolerant Time Interval	Allocation to Architecture	Safe State
Technical Safety Requirement 02-01-01	The LKA safety component shall ensure that the duration of the lane keeping assistance torque applied is less than Max_Duration.	C	500 ms	LKA Safety block	Set lane keeping assistance torque to zero
Technical Safety Requirement 02-01-02	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	500 ms	LKA Safety block	Set lane keeping assistance torque to zero
Technical Safety Requirement 02-01-03	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	500 ms	LKA Safety block	Set 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	LKA Safety block	Set 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 faults in memory.	A	Ignition cycle	Data Transmission Integrity Check	Set lane keeping assistance torque to zero

Functional Safety Requirement 02-02 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	The electronic power steering ECU shall ensure that the lane	X		

02-02	keeping assistance torque is set to zero when the camera sensor ECU stops detecting road markings and shall send its off status to the Car Display.			

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

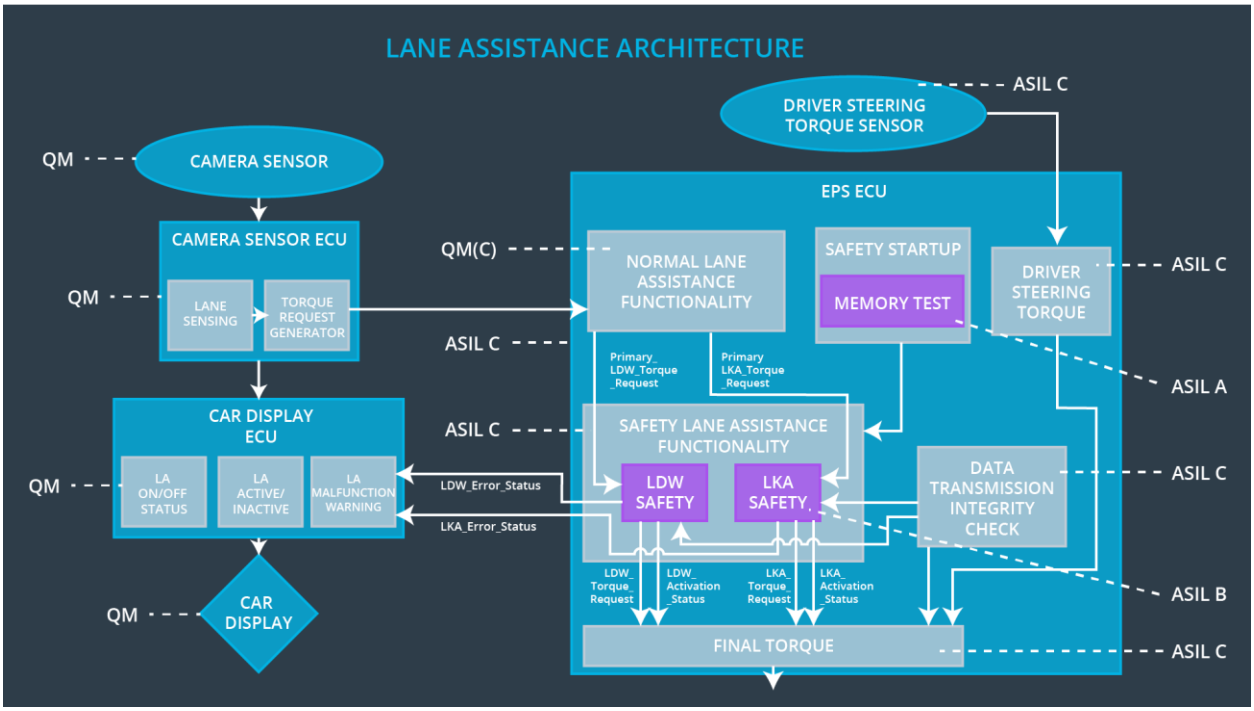


ID	Technical Safety Requirement	ASIL	Fault Tolerant Time Interval	Allocation to Architecture	Safe State
Technical Safety Requirement 02-01-01	The LKA safety component shall ensure that the duration of the lane keeping assistance torque applied is less than Max_Duration.	C	500 ms	LKA Safety block	Set lane keeping assistance 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 that the Max_Duration set is the chosen from LKA Validation Acceptance Criteria.	Verify that the system really does turn off if the lane keeping assistance 'LKA_Torque_Request' ever exceeded Max_Duration
Technical Safety Requirement 02-01-02	Validate that the “TORQUE_LIMITER” in the “ LKA Safety” software block sends the error_status_torque_limiter signal to the LKA_SAFETY_ACTIVATION.	Verify that the Car Display ECU displays the LKA malfunction warning light.
Technical Safety Requirement 02-01-03	Validate that the “TORQUE_LIMITER” in the “ LKA Safety” software block sends a zero LKA_Torque_Request.	Verify that the Final EPS TORQUE Generator receives a 0 LKA_Torque_Request
Technical Safety Requirement 02-01-04	Validate that the “TORQUE_LIMITER” in the “ LKA Safety” software block calculate and sends a correct CRC (cyclic redundancy check) and Alive counter for data transmission validity and integrity.	Verify that the system really does turn off if the lane keeping assistance “LKA_Torque_Request” ever has an invalid CRC or Alive counter.
Technical Safety Requirement 02-01-05	Validate that the Safety Startup Memory test to check memory faults will catch memory faults.	Verify that the LKA system really does turn off if the Safety Startup Memory test fails.
Technical Safety Requirement 02-02-01	Validate that the camera ECU sends zero ‘LKA_Torque_Request’ when it fails to detect lane lines and stop Alive counter for data transmission validity and integrity.	Verify that the system really does turn off if the lane keeping assistance 'LKA_Torque_Request' ever has an invalid CRC or Alive counter failure from the camera ECU.

Refinement of the System Architecture



Functional overview of architecture elements

Element	Description
Camera Sensor	Sensor responsible for capturing vehicle driving condition including detectable lane lines.
Camera Sensor ECU - Lane Sensing	Software Module in the Camera Sensor ECU responsible for detecting lane lines and determining when the vehicle leaves the lane by mistake.
Camera Sensor ECU - Torque request generator	Software Module in the Camera Sensor ECU responsible for calculating and sending the additional torque for the LDW and LKA functions with CRC and Alive counter for data transmission validity and integrity check.
Car Display	Visual display responsible to displaying warning of lane departures and LKA and LDW activation and deactivations.
Car Display ECU - Lane Assistance On/Off Status	Visual display responsible to displaying LKA and LDW ON/OFF status.
Car Display ECU - Lane Assistant Active/Inactive	Visual display responsible to displaying displaying warning of lane departures, LKA and LDW

	activation and deactivations.
Car Display ECU - Lane Assistance malfunction warning	Visual display responsible to displaying warning of LKA and LDW malfunctions.
Driver Steering Torque Sensor	Sensor responsible for measuring how much force (steering torque) the driver is applying to the steering wheel.
Electronic Power Steering (EPS) ECU - Driver Steering Torque	Software Module in the electronic power steering ECU responsible for receiving the Camera Sensor ECU torque requests.
EPS ECU - Normal Lane Assistance Functionality	Software Module in the electronic power steering ECU responsible for receiving the Driver Steering torque sensor input from the steering wheel.
ESP ECU – Safety Startup – Memory Test	Software Module in the electronic power steering ECU responsible for the memory test conducted at start up of the EPS ECU to check for any faults in memory.
EPS ECU - Lane Departure Warning Safety Functionality	Software Module in the electronic power steering ECU responsible for keeping the lane departure oscillating torque amplitude and frequence below MAX_Torque_Amplitude and MAX_Torque_Fequency respectively.
EPS ECU - Lane Keeping Assistant Safety Functionality	Software Module in the electronic power steering ECU responsible for ensuring the application of the lane keeping assistance torque does not ever exceeded Max_Duration and if lane detection is lost, the LKA function is deactivated.
ESP ECU – Data Transmission Integrity Check	Software Module in the electronic power steering ECU responsible for checking the data validity and integrity of the data transmission
EPS ECU - Final Torque	Software Module in the electronic power steering ECU responsible for ensuring the LDW, LKA and the driver’s steering torque requests are combined and sent to the Motor.
Motor	Actuator responsible for applying requested torque to the steering column by the Electronic Power Steering ECU for either the LKA or the LDW functions.

Allocation of Technical Safety Requirements to Architecture Elements

All Technical Safety Requirements have been allocated to the Electronic Power Steering ECU. The table below summarizes what was already identified in the Technical Safety Requirements section.

ID	Functional Safety Requirement	Electronic Power Steering ECU	Camera ECU	Car Display ECU
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.	X		
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.	X		
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.	X		
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 faults in memory.	X		
Technical Safety Requirement	The LDW safety component shall ensure that the fequency of the	X		

01-02-01	'LDW_Torque_Request' sent to the 'Final electronic power steering Torque' component is below 'Max_Torque_Fequency.			

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State inboked?	Driver Warning
WDC-01	Turn off LDW functionality	Malfunction_01 , Malfunction_02	Yes, LDW torque shall be set to zero	Lane Assist Inactive and Malfunction Warning will be set in the Car Display ECU
WDC-02	Turn off LKA functionality	Malfunction_04 Malfunction_05	Yes, LKA torque shall be set to zero	Lane Assist Inactive and Malfunction Warning will be set in the Car Display ECU