Elektrobit

UDACITY

Technical Safety Concept Lane Assistance

Document Version: 1.0

Document history

Date	Version	Editor	Description
2018-10-21	1.0	Rodrigo Vasconcelos	Document creation.
2018-10-22	2.0	Rodrigo Vasconcelos	Adjusted LDW and LKA Safe State to reflect that a better safe state (rather than turning the LA system off) is to set the output torque from the LA functions to zero.

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Purpose of the Technical Safety Concept

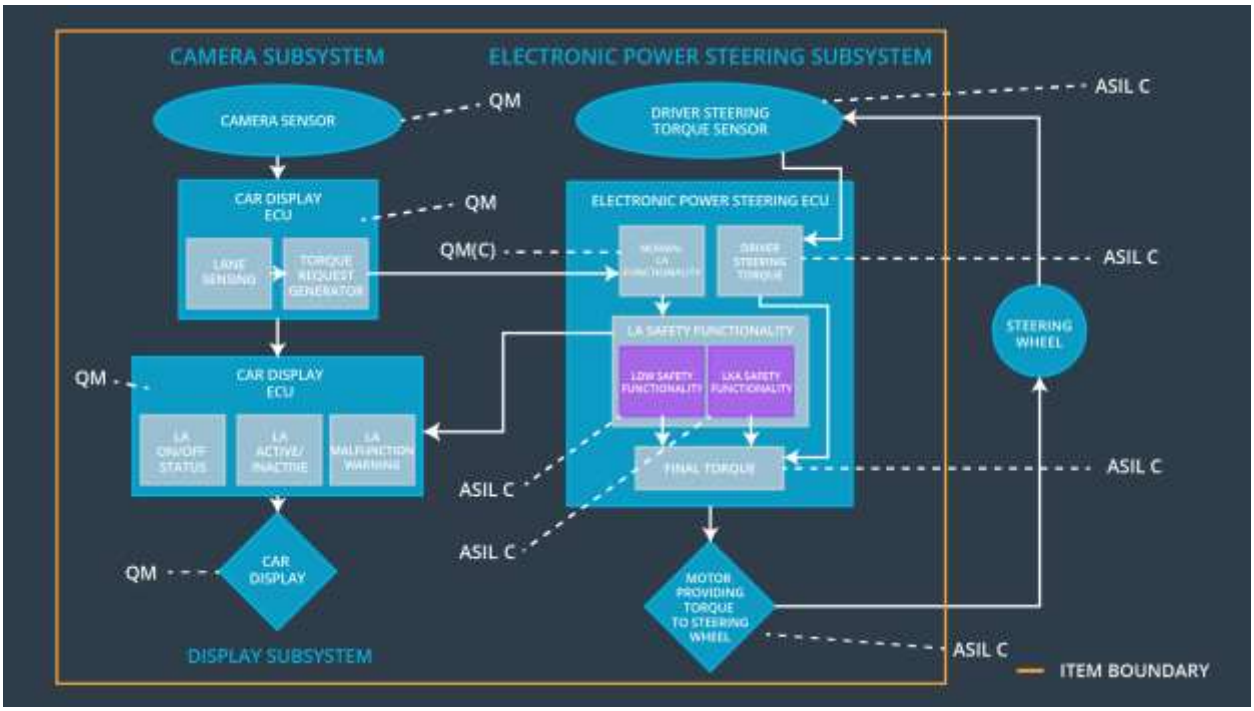
The purpose of this document is to describe what the Lane Assistance item will do when a malfunction violates the safety goal.

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 assistance item shall ensure that the lane departure warning oscillating torque amplitude is below Max_Torque_Amplitude	C	50ms	Set LDW output torque to zero
Functional Safety Requirement 01-02	The lane assistance item shall ensure that the lane departure warning oscillating torque frequency is below Max_Torque_Frequency	C	50ms	Set LDW output torque 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	500ms	Set LKA output torque to zero
Functional Safety Requirement 02-02	The electronic power steering ECU shall ensure that the lane keeping assistance torque applied is not higher than Max_Torque_Amount	C	50ms	Set LKA output torque to zero

Refined System Architecture from Functional Safety Concept



Functional overview of architecture elements

Element	Description
Camera Sensor	Capture the scene in front of the car.
Camera Sensor ECU - Lane Sensing	Identify lane boundaries and the car's position relative to the center of the lane.
Camera Sensor ECU - Torque request generator	Calculate the torque needed to return the car to the center of the lane.
Car Display	Display Lane Assistance system status lights.
Car Display ECU - Lane Assistance On/Off Status	Interpret the Lane Assistance system state to activate the "on" light.
Car Display ECU - Lane Assistant Active/Inactive	Interpret the Lane Assistance system state to activate the "engaged" light.
Car Display ECU - Lane Assistance malfunction warning	Interpret the Lane Assistance system state to activate the "malfunction" light.
Driver Steering Torque Sensor	Encode the steering torque applied by the driver.
Electronic Power Steering (EPS) ECU - Driver Steering Torque	Record the steering torque applied by the driver.

EPS ECU - Normal Lane Assistance Functionality	Request the application of steering torque for lane assistance functions.
EPS ECU - Lane Departure Warning Safety Functionality	Ensure that the torque requested by the Normal Lane Assistance Functionality Element is never beyond Max_Torque_Amplitude or Max_Torque_Frequency
EPS ECU - Lane Keeping Assistant Safety Functionality	Ensure that the torque requested by the Lane Assistance Functionality Element is never beyond Max_Torque_Magnitude or in excess of Max_Duration.
EPS ECU - Final Torque	Calculates the final torque value from the Lane Assistance Safety Functionality elements and the Driver Steering Torque before sending it to the motor.
Motor	Transforms the steering torque commands to actual physical movement of 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	The LDW Safety component shall ensure that amplitude of the LDW_Torque_Request is below Max_Torque_Amplitude	C	50ms	LDW Safety Element	LDW_Torque_Request shall be set to zero
Technical Safety Requirement 02	The validity and integrity of the data transmission for the LDW_Torque_Request signal shall be ensured.	C	50ms	Data Transmission Integrity Check	LDW_Torque_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 Element	LDW_Torque_Request shall be set to zero
Technical Safety Requirement 04	As soon as the LDW function deactivates the LDW feature, the LDW Safety element shall send a signal to the Car Display ECU to turn on a warning light.	C	50ms	LDW Safety Element	LDW_Torque_Request shall be set to zero
Technical Safety Requirement 05	A memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition Cycle	Memory Test	LDW_Torque_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 frequency of the LDW_Torque_Request is below Max_Torque_Frequency	C	50ms	LDW Safety Element	LDW_Torque_Request shall be set to zero
Technical Safety Requirement 02	The validity and integrity of the data transmission for the LDW_Torque_Request signal shall be ensured.	C	50ms	Data Transmission Integrity Check	LDW_Torque_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 Element	LDW_Torque_Request shall be set to zero
Technical Safety Requirement 04	As soon as the LDW function deactivates the LDW feature, the LDW Safety element shall send the LDW_Error_Status signal to the Car Display ECU to turn on a warning light.	C	50ms	LDW Safety Element	LDW_Torque_Request shall be set to zero
Technical Safety Requirement 05	A memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition Cycle	Memory Test	LDW_Torque_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 Safety component shall ensure that the LKA_Torque_Request is only sent for Max_Duration	C	500ms	LKA Safety	LKA_Torque_Request shall be set to zero
Technical Safety Requirement 02	The validity and integrity of the data transmission for the LKA_Torque_Request signal shall be ensured.	C	500ms	Data Transmission Integrity Check	LKA_Torque_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	LKA_Torque_Request shall be set to zero
Technical Safety Requirement 04	As soon as the LKA function deactivates the LKA feature, the LKA Safety element shall send the LKA_Error_Status signal to the Car Display ECU to turn on a warning light.	C	500ms	LKA Safety	LKA_Torque_Request shall be set to zero

Technical Safety Requirement 05	A memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition Cycle	Memory Test	LKA_Torque_Request shall be set to zero

Functional Safety Requirement 02-2 with its associated system elements (derived in the functional safety concept)

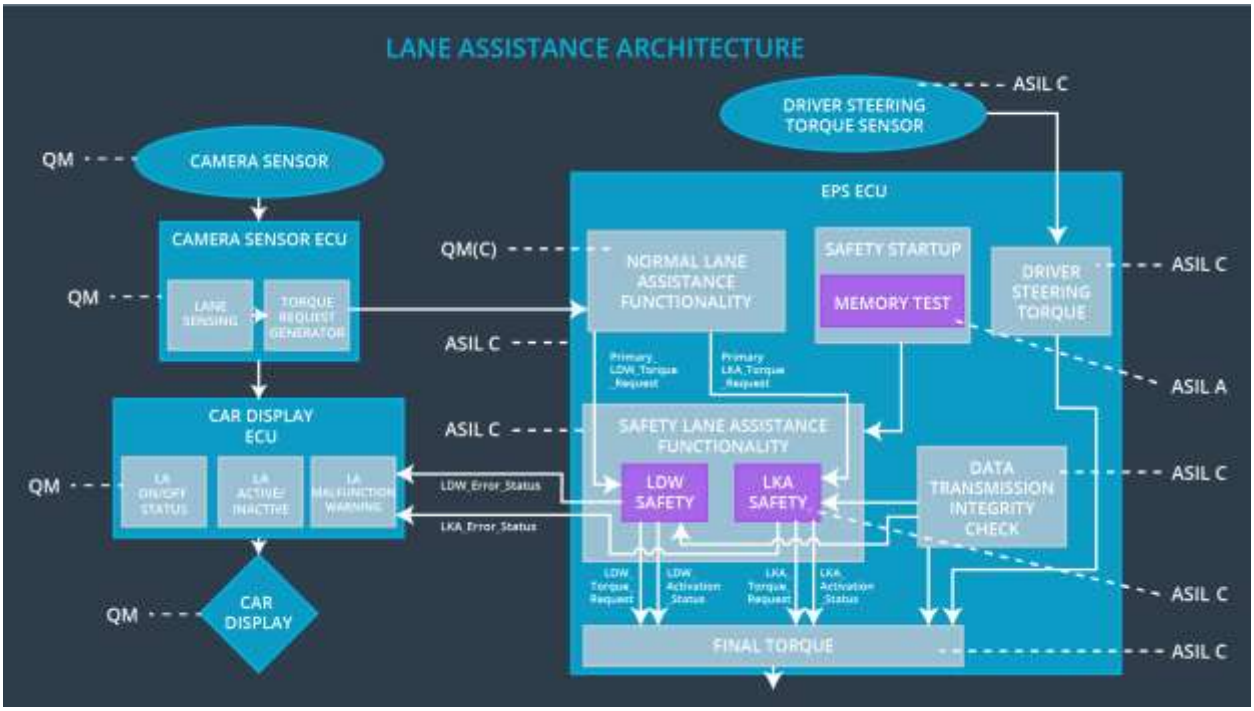
ID	Functional Safety Requirement	Electronic Power Steering ECU	Camera ECU	Car Display ECU
Functional Safety Requirement 02-02	The electronic power steering ECU shall ensure that the lane keeping assistance torque applied is not higher than Max_Torque_Amount	X		

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 01	The LKA Safety component shall ensure that amplitude of the LKA_Torque_Request is below Max_Torque_Amount	C	50ms	LKA Safety	LKA_Torque_Request shall be set to zero
Technical Safety Requirement 02	The validity and integrity of the data transmission for the LKA_Torque_Request signal shall be ensured.	C	50ms	Data Transmission Integrity Check	LKA_Torque_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	50ms	LKA Safety	LKA_Torque_Request shall be set to zero

Technical Safety Requirement 04	As soon as the LKA function deactivates the LKA feature, the LKA Safety element shall send the LKA_Error_Status signal to the Car Display ECU to turn on a warning light.	C	50ms	LKA Safety	LKA_Torque_Request shall be set to zero
Technical Safety Requirement 05	A memory test shall be conducted at start up of the EPS ECU to check for any faults in memory.	A	Ignition Cycle	Memory Test	LKA_Torque_Request shall be set to zero

Refinement of the System Architecture



Allocation of Technical Safety Requirements to Architecture Elements

For the Lane Assistance item, all the technical safety requirements are allocated to the Electronic Power Steering ECU. Specific element allocation is available in the requirement allocation tables.

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn off the Lane Assistance item.	Steering oscillating amplitude is too high.	Yes	Display light on dashboard.
WDC-02	Turn off the Lane Assistance item.	Steering oscillating frequency is too high.	Yes	Display light on dashboard.
WDC-03	Turn off the Lane Assistance item.	The lane keeping assistance function is active for more than Max_Duration.	Yes	Display light on dashboard.
WDC-04	Turn off the Lane Assistance item.	The lane keeping assistance function applies a torque that is too high.	Yes	Display light on dashboard.