Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
23/05/2018	1.0	Krishna	1st version of Functional Safety Concept
25/05/2018	2.0	Krishna	2nd version of Functional Safety Concept

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Purpose of the Functional Safety Concept

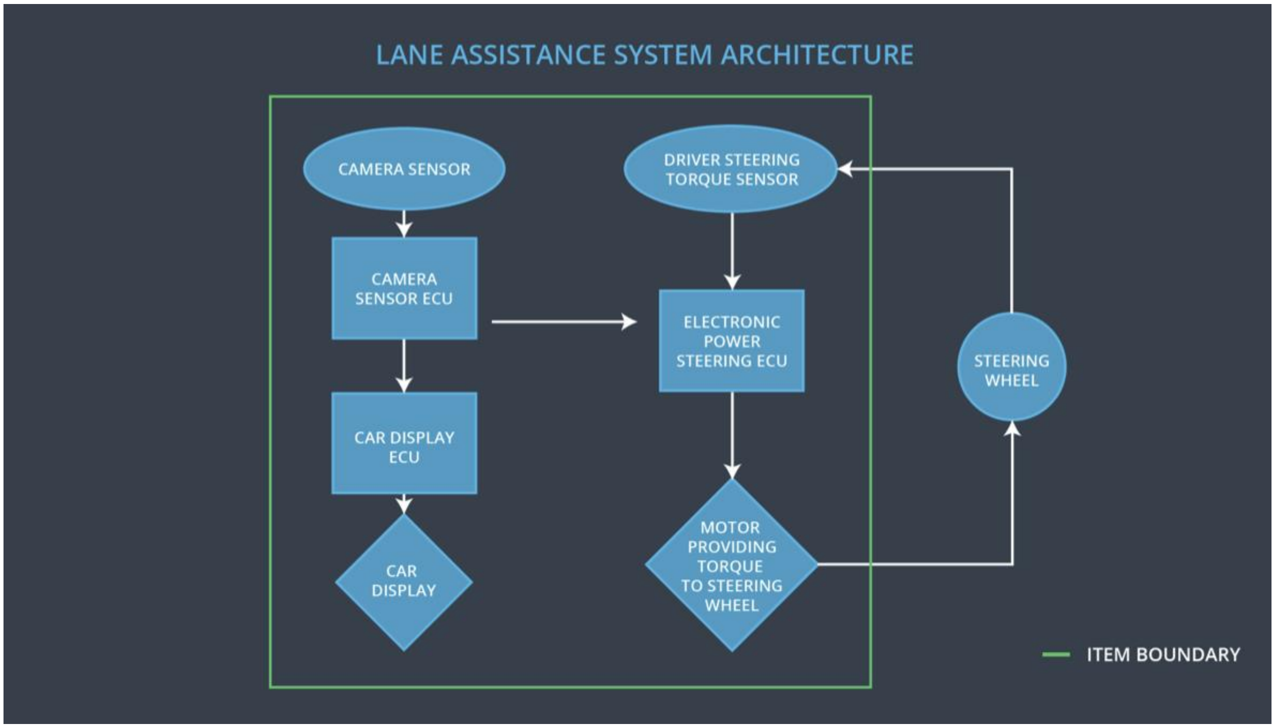
The main purpose of the Functional Safety Concept is to refine the Safety Goals, identify new requirements and allocate these requirements. Using the concept from Hazard Analysis and Risk Assessment, it tries to identify the requirements to lower the risk levels. It evaluates the risk of the hazardous situation so that we know how much we need to lower the risk. The functional safety concepts lead to Technical Safety Concept.

Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	The oscillating steering torque from the Lane Departure Warning function shall be limited.
Safety_Goal_02	The Lane Keeping Assistance function shall be time limited, and additional steering torque shall end after a given time interval so the driver cannot misuse the system for autonomous driving.

Preliminary Architecture


LANE ASSISTANCE SYSTEM ARCHITECTURE
CAMERA SENSOR
CAMERA SENSOR ECU
CAR DISPLAY ECU
CAR DISPLAY
DRIVER STEERING TORQUE SENSOR
ELECTRONIC POWER STEERING ECU
MOTOR PROVIDING TORQUE TO STEERING WHEEL
STEERING WHEEL
ITEM BOUNDARY

Description of architecture elements

Element	Description
Camera Sensor	It takes visual feedback for the lane detection. It captures images and feeds the images to the Camera Sensor ECU
Camera Sensor ECU	It analyses the camera images using computer vision or some other techniques. It determines whether the car is going out of the lane. It sends this information to the Car Display system as well as power steering ECU
Car Display	It displays whether the lane keeping and departure assistance system is on/off. So, basically it is a visual feedback for the driver.
Car Display ECU	Generates warning signals depending upon the input from the camera sensor ECU and Electronic Power Steering ECU to pass it to the Car Display.
Driver Steering Torque Sensor	It measures the amount of torque being applied on the steering wheel and sends it to the Electronic Power Steering ECU

Electronic Power Steering ECU	Processes inputs from the camera sensor ECU, driving steering torque sensor and generates appropriate Lane Assistance functionality. Sends the output to the motor.
Motor	It is the component which actually applies the torque to rotate the steering wheel

Functional Safety Concept

The functional safety concept consists of:

- Functional safety analysis
- Functional safety requirements
- Functional safety architecture
- Warning and degradation concept

Functional Safety Analysis

Malfunction ID	**Main Function of the Item Related to Safety Goal Violations**	**Guidewords (NO, WRONG, EARLY, LATE, MORE, LESS)**	**Resulting Malfunction**
Malfunction_01	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	MORE	The lane departure warning function applies an oscillating torque with very high torque amplitude
Malfunction_02	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	MORE	The lane departure warning function applies an oscillating torque with very high torque frequency
Malfunction_03	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	NO	The lane keeping assistance function is not limited in time duration which leads to misuse as an autonomous driving function.

Functional Safety Requirements

Lane Departure Warning (LDW) 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	The LDW torque amplitude should be below Max_Torque_Amplitude and if fault occurs its value should be set to zero
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillati9ng torque frequency ids below Max_Torque_Frequency	C	50 mS	The LDW torque frequency should be below Max_Torque_Frequency and if fault occurs its value should be set to zero

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

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Functional Safety Requirement 01-01	For whatever value we end up choosing for the max torque amplitude, we need to **validate** that we chose a reasonable value. We would need to test how drivers react to different torque amplitudes to prove that we chose an appropriate value.	When the torque amplitude crosses the limit, the lane assistance output is set to zero within the 50 mS fault tolerant time interval.
Functional Safety Requirement 01-02	For whatever value we end up choosing for the max torque frequency, we need to **validate** that we chose a reasonable value. We would need to test how drivers react to different torque	When the torque frquency crosses the limit, the lane assistance output is set to zero within the 50 mS fault tolerant time interval.

	frequency, to prove that we chose an appropriate value.	

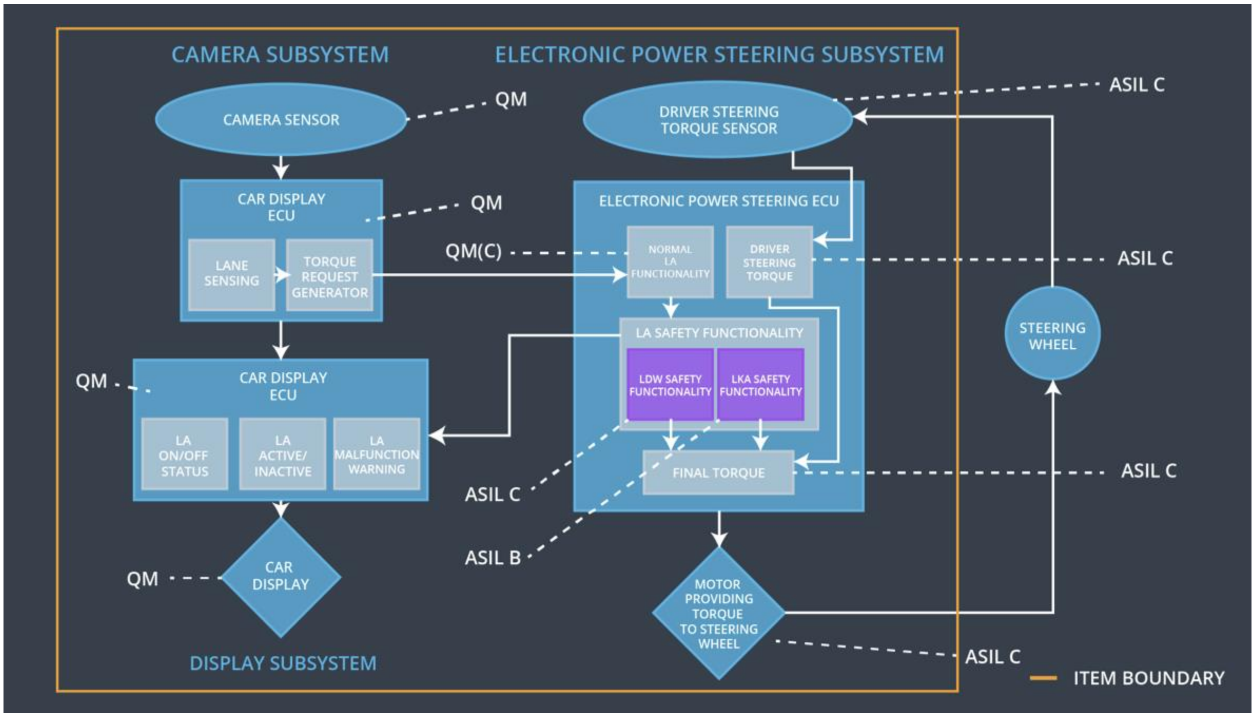
Lane Keeping Assistance (LKA) Requirements:

ID	**Functional Safety Requirement**	**ASIL**	**Fault Tolerant Time Interval**	**Safe State**
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	Lane Keeping Assistance System torque should be set to zero.

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

ID	**Validation Acceptance Criteria and Method**	**Verification Acceptance Criteria and Method**
Functional Safety Requirement 02-01	Test and validate that the max_duration chosen really did dissuade drivers from taking their hands off the wheel.	The system turns off if the lane keeping assistance ever exceeded max_duration

Refinement of the System Architecture



Allocation of Functional Safety Requirements to Architecture Elements

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	**Yes**	**No**	**No**
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillati9ng torque frequency ids below Max_Torque_Frequency	**Yes**	**No**	**No**
Functional Safety Requirement 02-01	The electronic power steering ECU shall ensure that the lane keeping assistance torque is applied for only Max_Duration	**Yes**	**No**	**No**

Warning and Degradation Concept

ID	**Degradation Mode**	**Trigger for Degradation Mode**	**Safe State invoked?**	**Driver Warning**
WDC-01	Turn off the functionality	The malfunction of steering wheel vibrating too high or with more frequency	Yes	Display will show the warning light on
WDC-02	Turn off the functionality	The malfunction of lane keeping assistance applied for long duration	Yes	Display will show the warning on