Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
08-Jun-2018	0.1	Nikhil Patel	Initial Draft
13-Jun-2018	1.0	Nikhil Patel	Added details on “Hazard Analysis And Risk Assessment” document

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Purpose of the Functional Safety Concept

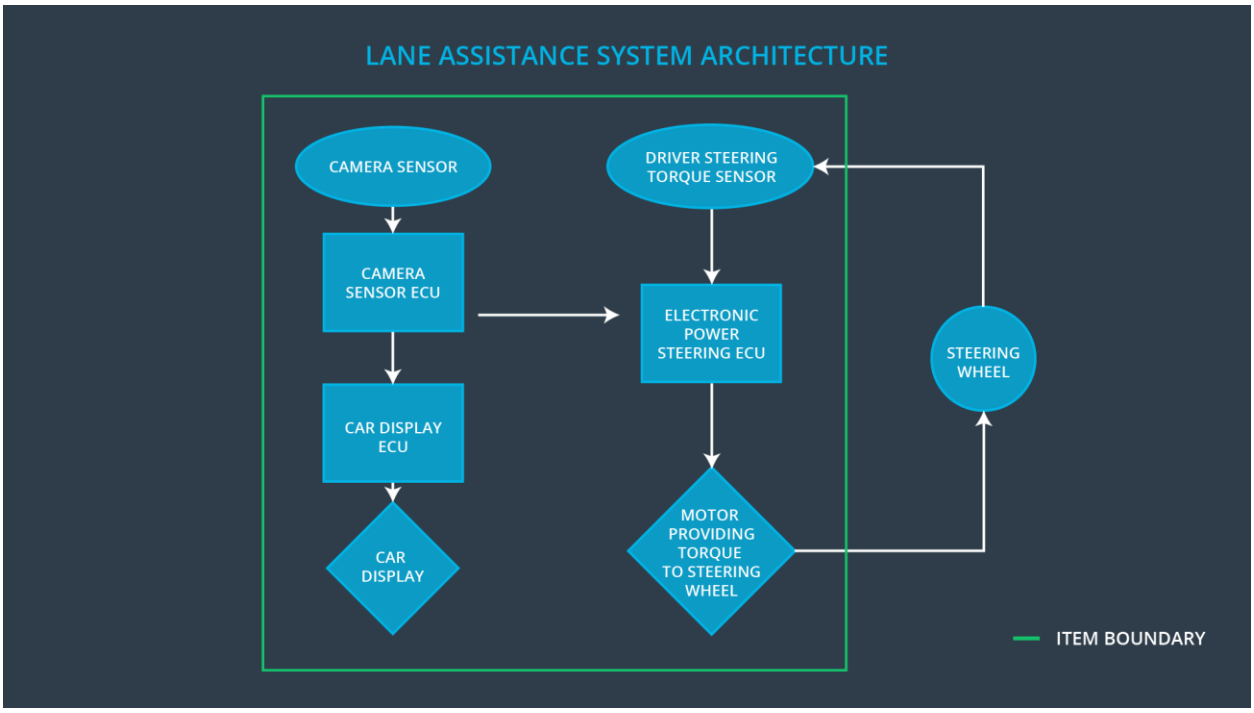
The purpose of Functional Safety Concept document is to identify system high level requirements and allocate them to different parts of the item architecture without going into technical detail. Finally, to prove that a system actually meets requirements, they have to be verified and validated. The information in the functional safety analysis comes from the hazard analysis and risk assessment. The guide words help to analyze functions and malfunctions methodically. The malfunctions are then converted into functional safety requirements

Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	Reduce the vibrating torque of steering wheel to bring to the acceptance level.
Safety_Goal_02	Total functional time of the LKA should be reduced.
Safety_Goal_03	While driving in the driving on *off road conditions*, the LDW function should be turned off.
Safety_Goal_04	When there is no response from the camera sensors then the LKA function should be deactivated driver should be warned about the deactivation by displaying the issue on the car dashboard.

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	This Sensor responsible for capturing road images and provide them to the Camera Sensor ECU
Camera Sensor ECU	Electronic Control Unit (ECU) responsible for calculates the deviation from center lane and request for oscillation torque(LDW) wherever required.
Car Display	Displays status of (active/inactive) LDW & LKA function, thus informing the driver about the current status so that driver is well informed before any mishap happens
Car Display ECU	Electronic Control Unit (ECU) responsible for displaying status of (active/inactive) LDW & LKA function on the Car Display.
Driver Steering Torque Sensor	Sensor responsible for measuring the torque applied on driver wheel, this calculation is based on the signals received.
Electronic Power Steering ECU	Electronic Control Unit (ECU) responsible for

	calculating extra torque need to be applied for LKA function and vibrates steering wheel when LDW is activated.
Motor	An electric motor that applies the torque indicated by the Electronic Power Steering ECU to 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	Above the limit an oscillating torque with very high torque amplitude is applied by the lane departure warning.
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 which had a very high torque frequency (above limit)
Malfunction_03	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order	NO	The lane keeping assistance function is not limited in time duration which leads

	to stay in ego lane		to misguiding the autonomous driving system.
Malfunction_04	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	WRONG	When camera sensor is not working, the lane keeping assistance function is activated randomly.

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 should ensure that the lane departure oscillating torque amplitude is below Max_Torque_Amplitude value.	C	50 ms	Turn Off System
Functional Safety Requirement 01-02	The lane keeping item should ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency value	C	50 ms	Turn Off System

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	Validate that the Max_Torque_Amplitude value chosen is low enough that the driver should not loss control over the car and high enough to be detected by driver, so that driver can act in given time frame	Verify that the system does turn off within a fault tolerant time interval, if Max_Torque_Amplitude is exceeded the given limit.

Functional Safety Requirement 01-02	Validate that the Max_Torque_Frequency value chosen is low enough that the driver does not loss control over the car and high enough to be detected by driver, so that driver can act in given time frame	Verify that the system does turn off within a fault tolerant time interval, if Max_Torque_Frequency is exceeded the given limit.

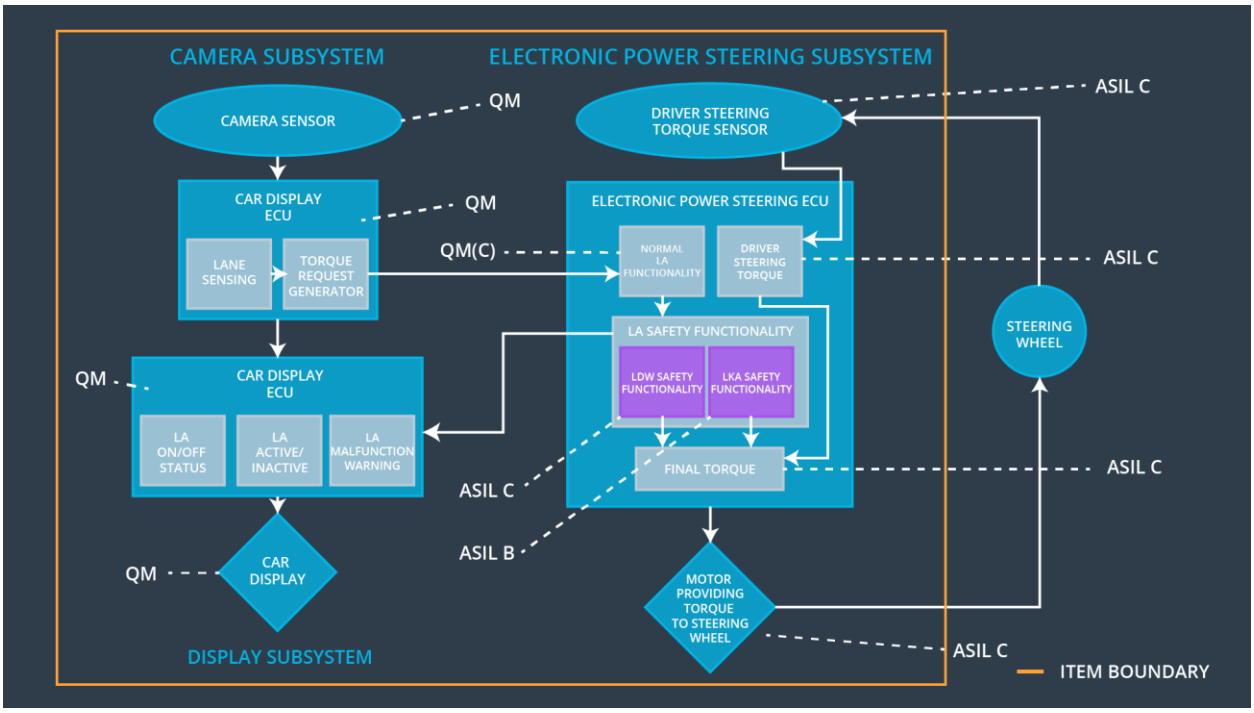
Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	The electronic power steering ECU should ensure that the lane keeping assistance torque is applied for only Max_Duration value	B	500 ms	Turn Off System
Functional Safety Requirement 02-01	The electronic power steering ECU should be deactivated when the electronic power steering ECU detects the no response (not working state) of the camera sensor.	B	50 ms	Turn Off System

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	Validate that the value chosen for Max_Duration dissuades drivers from taking their hands off the wheel.	Verify that the system should turn off within a fault tolerant time interval, if the lane keeping assistance ever exceeds Max_Duration limit.
Functional Safety Requirement 02-02	Validate that Lane Keeping assistance should be deactivated when the camera sensor stop working.	Verify that the system should turn off within a fault tolerant time interval, if the camera sensor stopped working.

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 departure oscillating torque amplitude is below Max_Torque_Amplitude, this would be ensured by the lane keeping item.	**X**		
Functional Safety Requirement 01-02	The lane departure oscillating torque frequency is below Max_Torque_Frequency, this would be ensured by the lane keeping item.	**X**		
Functional Safety	The lane keeping assistance torque is applied for only	**X**		

Requirement 02-01	Max_Duration, this would be ensured by the electronic power steering ECU.			
Functional Safety Requirement 02-02	When the camera sensors are not responding then electronic power steering ECU should be deactivated.	**X**		

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