Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
01.06.2019	1.0	Sandeep Patil	Initial Version
02.06.2019	2.0	Sandeep Patil	Final Version

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Purpose of the Functional Safety Concept

The purpose of functional safety concept is to derive functional safety requirements from functional safety goals. The functional safety requirements thus derived will be high level requirements which will be allocated to different parts of the item architecture. This document also provides the warning and degradation concept

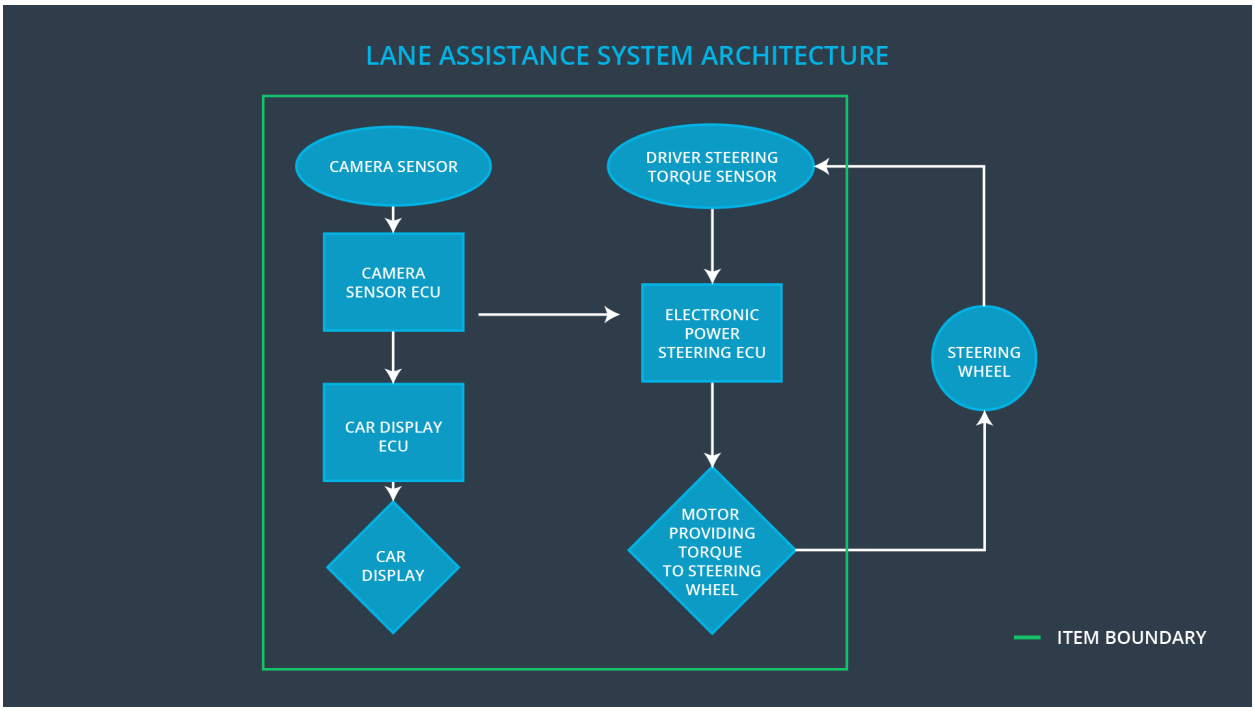
Inputs to the Functional Safety Concept

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 the additional steering torque shall end after a given time interval so that the driver cannot misuse the system for autonomous driving

Preliminary Architecture

The following figure shows the preliminary architecture for the item LAS



Description of architecture elements

Element	Description
Camera Sensor	Capture image of the road and provide it to Camera Sensor ECU
Camera Sensor ECU	Detect road lanes and the ego car position in the lane
Car Display	Provide feedback to the driver regarding LAS Function enable status and LDW/LKS activation status
Car Display ECU	Drive the car display to show the function status and activation information
Driver Steering Torque Sensor	Measure the torque applied on steering wheel by driver
Electronic Power Steering ECU	Calculate the effective torque to be applied on steering wheel using both torque information from driver and the camera sensor ECU
Motor	Apply the final torque calculated by the Electronic

	Power Steering ECU

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 LDW function shall apply an oscillating steering torque with very high amplitude (above Limit)
Malfunction_02	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	MORE	The LDW function shall apply an oscillating steering torque with very high frequency (above Limit)
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 assist is not limited in time which leads to misuse of LKA as autonomous system

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	50ms	Vibration torque amplitude < MAX_TORQUE_AMPLITUDE
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below MAX_TORQUE_FREQUENCY	C	50ms	Vibration torque frequency < MAX_TORQUE_FREQUENCY

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 MAX_TORQUE_AMPLITUDE chosen is appropriate to be detected by driver and not hindering the steering action	Verify if the system turns off when the amplitude increase more than MAX_TORQUE_AMPLITUDE
Functional Safety Requirement 01-02	Validate MAX_TORQUE_FREQUENCY chosen is appropriate to be detected by driver and not hindering the steering action	Verify if the system turns off when the frequency increase more than MAX_TORQUE_FREQUENCY

Lane Keeping Assistance (LKA) Requirements:

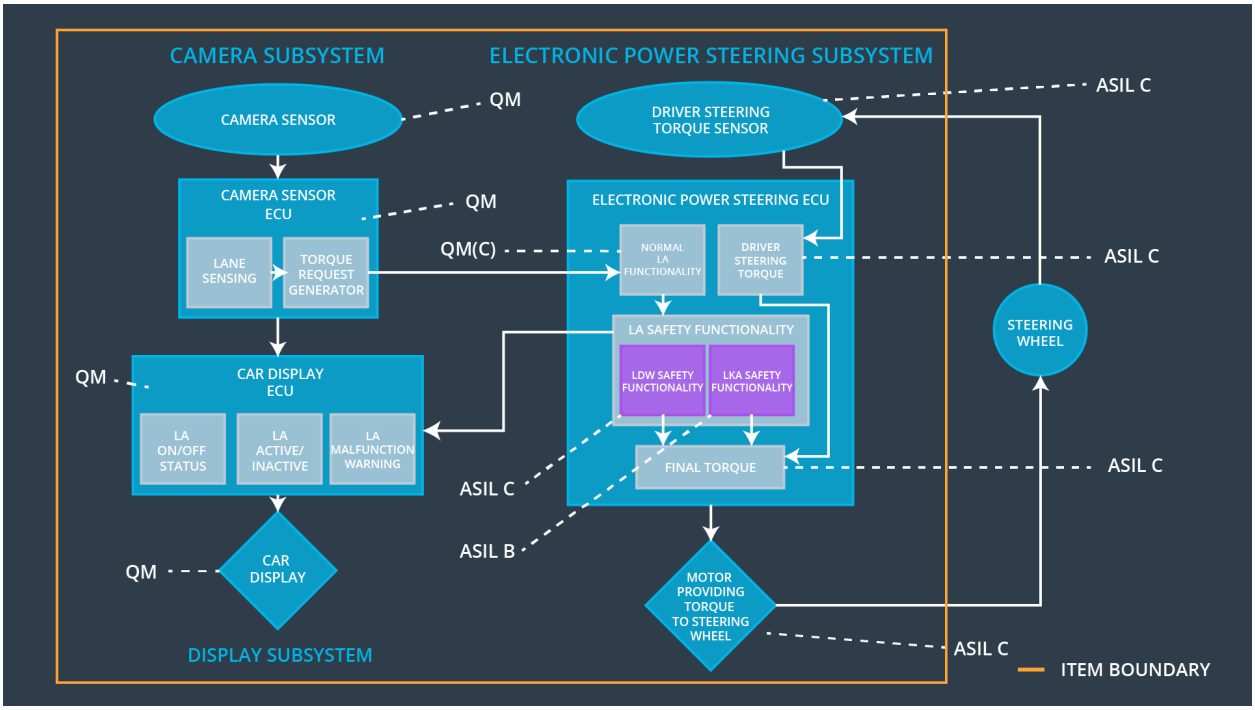
ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety	The EPS Subsystem shall ensure that the	C	500 ms	LKA torque = 0

Requirement 02-01	LKA torque is applied only for MAX_DURATION			

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 MAX_DURATION is chosen so that the driver cannot use it as self driving car	Verify the system does not deactivate if the LKA torque application exceeds the 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	**x**		
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below MAX_TORQUE_FREQUENCY	**x**		
Functional Safety Requirement 02-01	The EPS Subsystem shall ensure that the LKA torque is applied only for MAX_DURATION	**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	LDW Malfunction warning on display
WDC-02	Turn off LKS functionality	Malfunction_03	Yes	LKS Malfunction warning on display