Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

Document Version: [Version]

Template Version 1.0, Released on 2017-06-21

Document history

Date	Version	Editor	Description
7/7/2018	1.0	A. Zheng	First Draft

Table of Contents

Purpose of the Functional Safety Concept

The functional safety concept documents the pertinent system high level requirements. These requirements are allocated to the various parts of the item architecture. The technical safety requirements are derived from the functional safety concept. The validation and verification method for these requirements are also included as well.

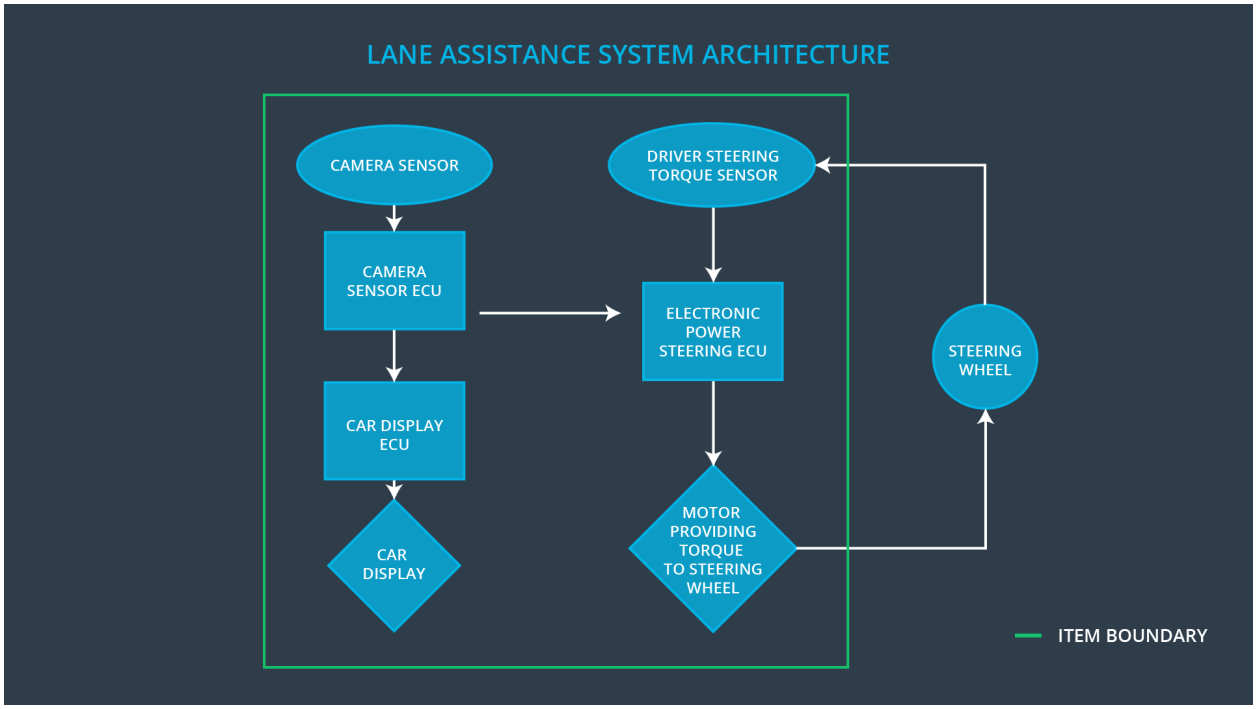
Inputs to the Functional Safety Concept

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 provide a sufficient torque to the steering wheel.
Safety_Goal_02	The LKA function shall be time limited so the driver cannot continuously use the system as an autonomous driving function
Safety_Goal_03	The oscillating steering torque from the lane departure warning function shall be torque limited.
Safety_Goal_04	The steering torque from the lane keeping function shall be torque limited.

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	Capture road images and provide them to the Camera Sensor ECU
Camera Sensor ECU	Analyze provided images to calculate the car position on the road with respect to the road lanes

Car Display	Provide feedback to the driver displaying warnings and the Lane Departure Assistance status
Car Display ECU	Controls the Car Display component to show the Lane Keeping Assistance warning and Lane Departure assistance status
Driver Steering Torque Sensor	Measure the torque applied to the steering wheel by the driver
Electronic Power Steering ECU	Use the information received from the Driver Steering Torque Sensor and the torque requested by the Lane Keeping Assistance and Lane Warning and request the necessary torque to be applied by the motor actuator
Motor	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	The lane departure warning function applies an oscillating torque with a high torque amplitude.
Malfunction_02	Lane Departure Warning (LDW)	LESS	The lane departure warning function

	function shall apply an oscillating steering torque to provide the driver a haptic feedback		applies an oscillating torque with a very low torque amplitude.
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 results in a 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 stays below the max torque amplitude.	C	50 mS	Lane departure oscillating torque amplitude is below the max torque amplitude.
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the oscillating torque amplitude stays above the minimum torque amplitude	C	50 mS	Lane departure oscillating torque amplitude is above the min torque amplitude.

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

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Functional Safety Requirement	Test and validate that the max torque amplitude chosen is small enough that	Verify that the system is in the off state if the max torque amplitude is exceeded

01-01	the driver is able to maintain control of the vehicle	
Functional Safety Requirement 01-02	Test and validate that the max torque amplitude chosen is large enough that the driver is able to respond to the vehicle	Verify that the system is in the off state if the minimum torque amplitude is exceeded

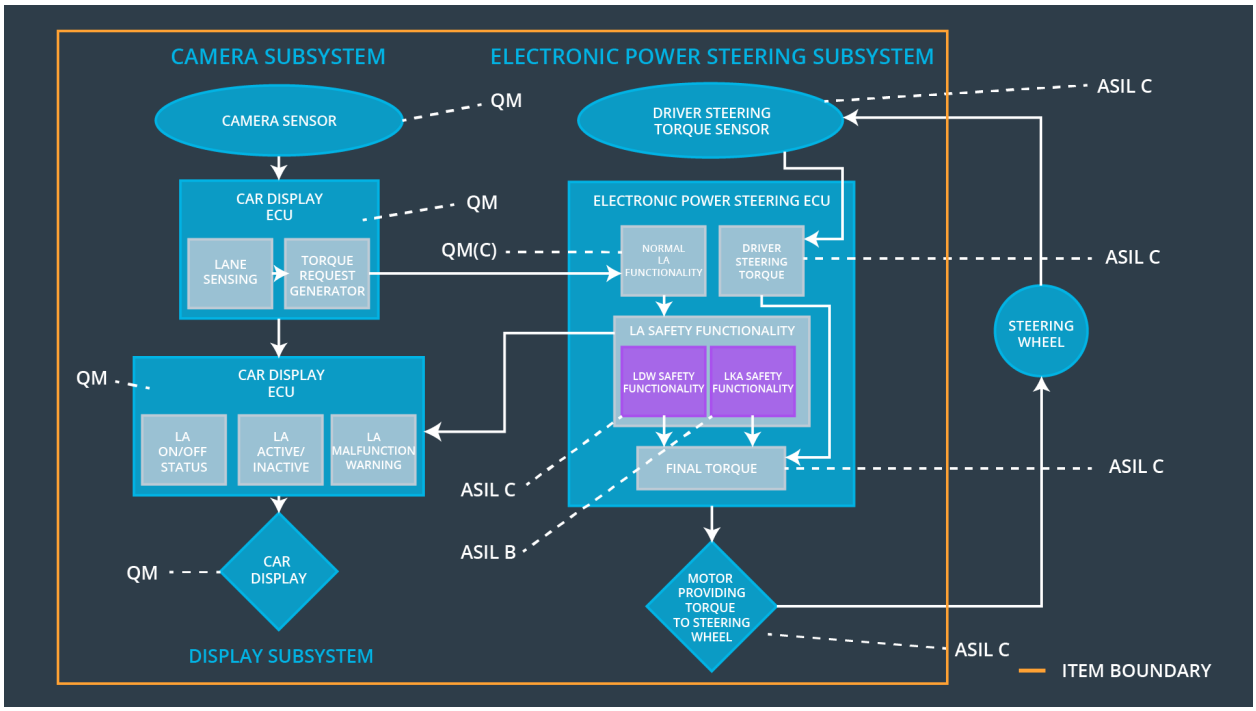
Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	The electronic power steering control unit shall ensure that the lane keeping assistance torque is applied only until a max duration.	B	500 ms	LKA torque is set to 0

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 selected forces drivers to re-take control of the steering wheel	Verify that the system does turn off after 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 stays below the max torque amplitude.	**x**		
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the oscillating torque amplitude stays above the minimum torque amplitude	**x**		
Functional Safety Requirement 02-01	The electronic power steering control unit shall ensure that the lane keeping assistance torque is applied only until a max duration.	**x**		

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn System off	Malfunction 01 Malfunction 02	Yes	Dashboard warning light
WDC-02	Turn System off	Malfunction 03	Yes	Dashboard warning light