Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
02/03/2018	0.1	Michael Scharf	Initial attempt
02/03/2018	0.2	Michael Scharf	Start filling out document
02/03/2018	0.3	Michael Scharf	Fill out whole sheet
02/03/2018	1.0	Michael Scharf	Internal Review and smaller fixes.
02/04/2018	2.0	Michael Scharf	Correct review findings after submission.

Table of Contents

Purpose of the Functional Safety Concept

To achieve the overall goal of functional safety to avoid accidents by reducing risk to an acceptable level, the FSC is

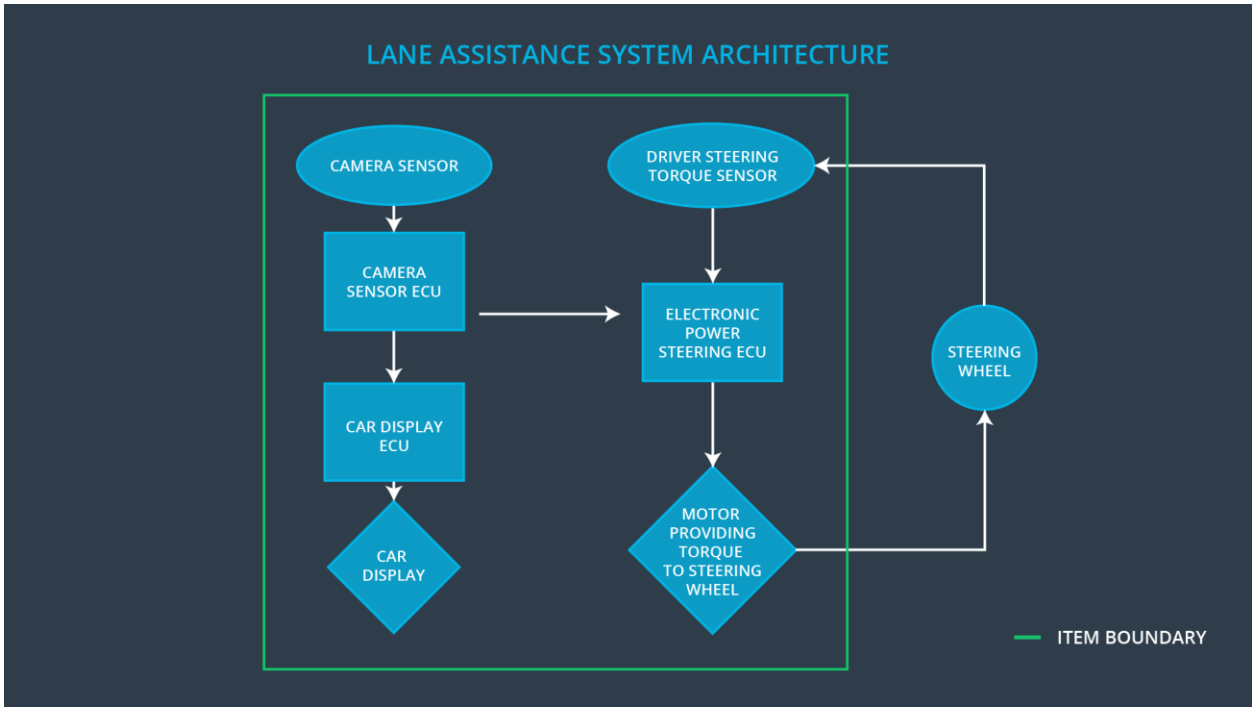
- Identifying subsystems containing high level of risk
- Identifying countermeasure to reduce risks and therefore prevent accidents.

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



Description of architecture elements

Element	Description

Camera Sensor	Grab surrounding/ camera images of the road
Camera Sensor ECU	Lane Sensing: identifies if the vehicle departs its lane. Torque request generator: sends messages to the Car Display ECU in order to react on the situation the car departed from its lane.
Car Display	Display status of the Lane Assistance. If the Lane Assistance is activated or not and if the Lane Assistance is actually “active” in sense of triggering correction of the steering torque
Car Display ECU	Manages the state and loopback of the Lane Assistance On/Off status as well as the Lane Assistance Active/ Inactive status. The Car Display ECU will switch on/off corresponding indication in Car Display depending on the state of the Lane Assistance.
Driver Steering Torque Sensor	Sensing steering wheel torque
Electronic Power Steering ECU	Is the “Lane Assistance Functionality” itself. It analyzes Driver Steering torque and reacts on the triggers from Camera Sensor ECU in order to generate a final electronic power steering torque output. This output signal is send to the Motor then. Depending on the status of the EPS ECU, a feedback is send to the Car Display ECU to indicate the active/ inactive state of the Lane Assistance (if it is currently influencing the steering wheel).
Motor	Providing torque to 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**	**Guidewords (NO,**	**Resulting**

	the Item Related to Safety Goal Violations	WRONG, EARLY, LATE, MORE, LESS)	Malfunction
Malfunction_01	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	The lane departure warning is giving MORE torque than what is safe	The lane departure warning function applies an oscillating torque with very high torque amplitude (above limit)
Malfunction_02	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	The lane departure warning is giving MORE torque than what is safe	The lane departure warning function applies an oscillating torque with very high torque frequency (above limit)
Malfunction_03	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	The lane keeping assistance function has NO limit in time duration which leads to misuse as an autonomous driving function.	The lane keeping assistance if misused for autonomous driving

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	Set amplitude to zero.
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency	C	50 mS	Set frequency 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	The drivers respond in a safe way on the chosen Max_Torque_Amplitude value chosen.	Test that in case of a violation of the Max_Torque_Amplitude, the lane assistence output Amplitude is set to zero within 50 mS (Safe state).
Functional Safety Requirement 01-02	The drivers respond in a safe way on the chosen Max_Torque_Frequency value chosen.	Test that in case of a violation of the Max_Torque_ Frequency, the lane assistence output Frequency is set to zero within 50 mS (Safe state).

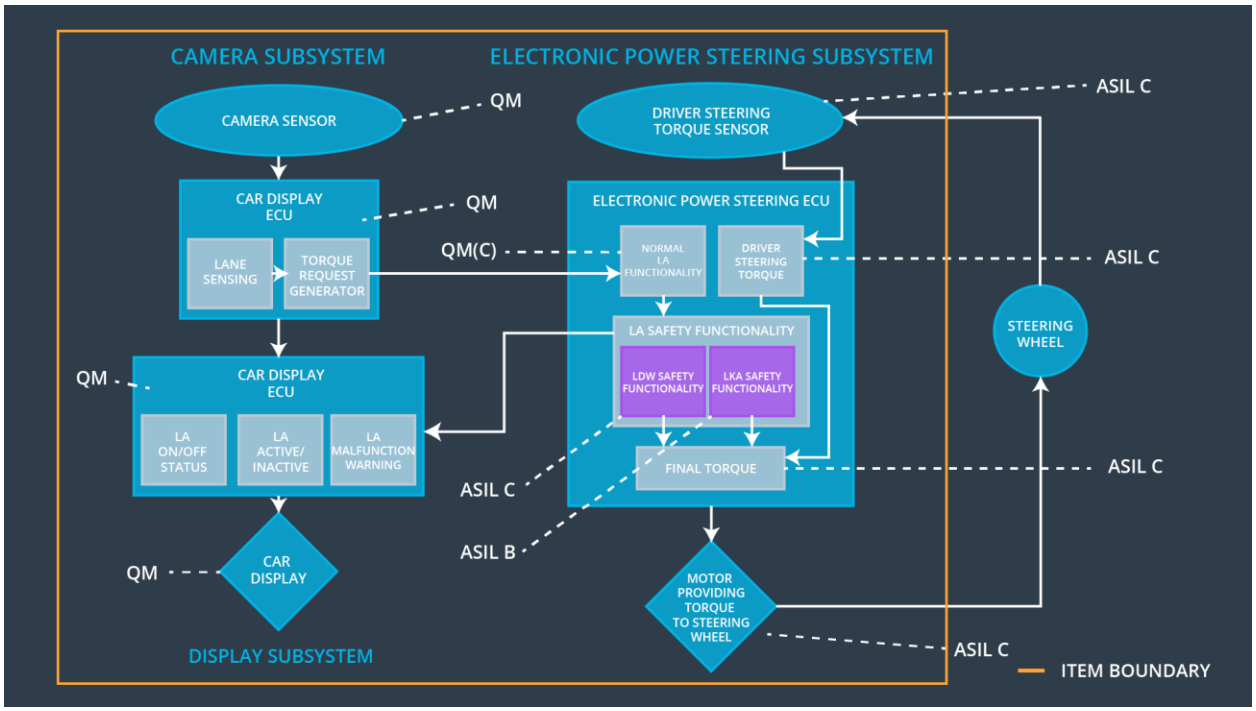
Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	The lane keeping item shall ensure that the lane keeping assistance torque is applied for only Max_Duration	B	500 mS	Set the lane keeping assistance torque 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	The chosen Max_Duration dissuade drivers from taking their hands of the wheel.	Verify that lane keeping assistance torque is set to zero if the lane keeping assitance every 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 electronic power steering ECU shall ensure that the lane departure oscillating torque amplitude is below Max_Torque_Amplitude	**X**		
Functional Safety Requirement 01-02	The electronic power steering ECU shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency	**X**		
Functional Safety Requirement 02-01	the electronic power steering ECU shall ensure that the lane keeping assistance torque is	**X**		

	applied for only Max_Duration			

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn of functionality	ECU receives a vibrational torque request beyond the allowed maximum	yes	Indication of malfunction via driver dashboard
WDC-02	Turn off functionality	ECU recognizes timeout of drivers interaction for lane keeping	yes	No automatic lane keeping. Eventually warning notification in drivers dashboard or hint in the manual that driver maintains responsibility for safe operation of the vehicle.