Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
12.02.2019	1.0	Hiep Truong Cong	Draft
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Purpose of the Functional Safety Concept

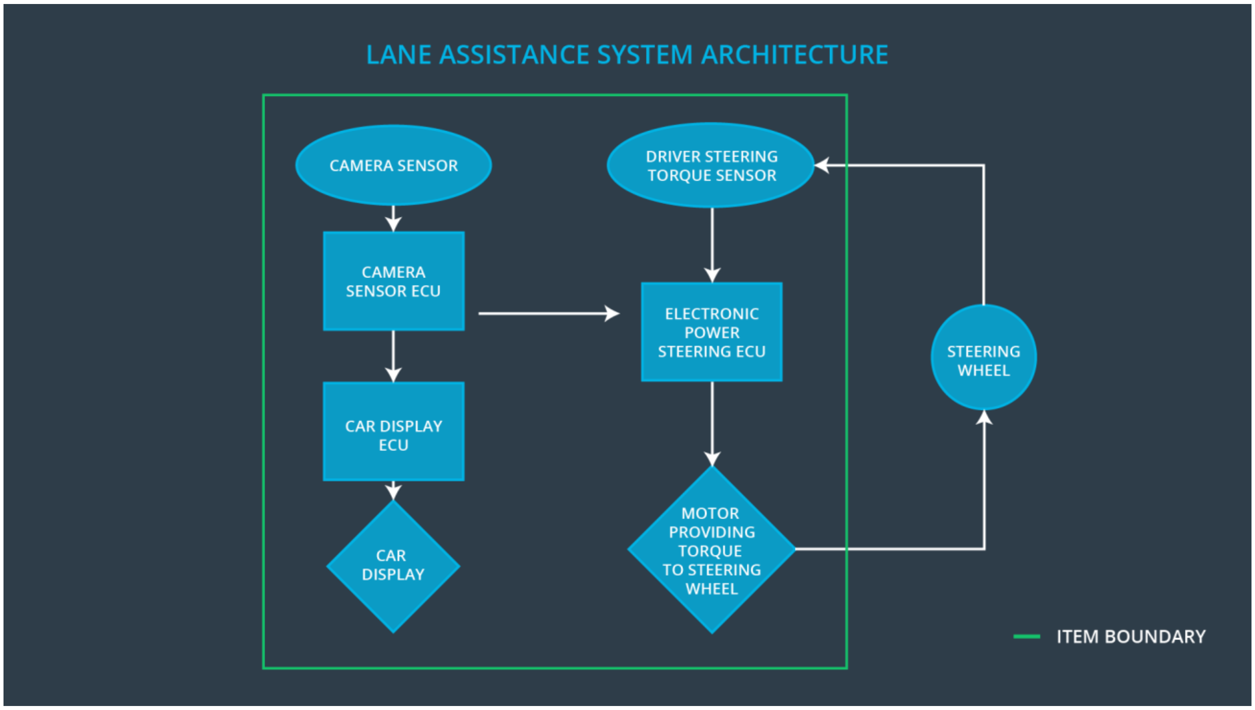
The Technical Safety Concept defines how the subsystems interact at the message level and describes how the ECUs communicate with each other

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 dditional 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
DRIVER STEERING TORQUE SENSOR
CAMERA SENSOR ECU
ELECTRONIC POWER STEERING ECU
STEERING WHEEL
CAR DISPLAY ECU
CAR DISPLAY
MOTOR PROVIDING TORQUE TO STEERING WHEEL
ITEM BOUNDARY

Description of architecture elements

Element	**Description**
Camera Sensor	Take images from the road
Camera Sensor ECU	Detecting lane lines and determining when the vehicle leaves the lane, request electronic power steering ECU to generate a demand torque, send appropriate messages to the car display ECU
Car Display	Display warning messages and system states
Car Display ECU	Process request from camera sensor ECU and prepare display information
Driver Steering Torque Sensor	Measure steering torque on the steering wheel, produced by the driver
Electronic Power Steering ECU	Receive requests from camera sensor ecu, control motor to generate torque to steering wheel, based on measured torque from driver steering torque sensor
Motor	Generate torque 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 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	MORE	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	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	LDW will set the oscillating torque to 0.
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	LDW will set the oscillating torque to 0.

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 the Max_Torque_Amplitude is high enough to warn the driver but not too high, so that the driver loses control	Verify that the the lane assistance output is set to zero with within the 50 ms fault tolerant time interval, when when the torque amplitude crosses the limit
Functional Safety Requirement 01-02	Validate the Max_Torque_Frequency is high enough to be detected by the driver but not too high, so that the driver loses control	Verify that the the lane assistance output is set to zero with within the 50 ms fault tolerant time interval, when when the torque frequency crosses the 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 shall ensure that the lane keeping assistance torque is applied for only Max_Duration	B	500 ms	Lane Keeping Assistance torque is 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	Validate the chosen Max_Duration not allow the driver to misuse the LKA as autonomous driving	Verify that the LKA will be deactivated if the active time 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 warning 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 warning 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 applied for only Max_Duration	x		

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Lane departure warning shall be turned off	Malfunction_01 Malfunction_02	yes	Warning on car display
WDC-02	Lane keeping assistance shall be turned off	Malfunction_03	yes	Warning on car display