Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

Document Version: 1.0.0
Released on 2017-12-19

Document history

Date	Version	Editor	Description
19.12.2017	1.0.0	Bernhard Rode	Initial version of the safety concept

Table of Contents

Table of Contents

Purpose of the Functional Safety Concept

The technical safety concept involves:

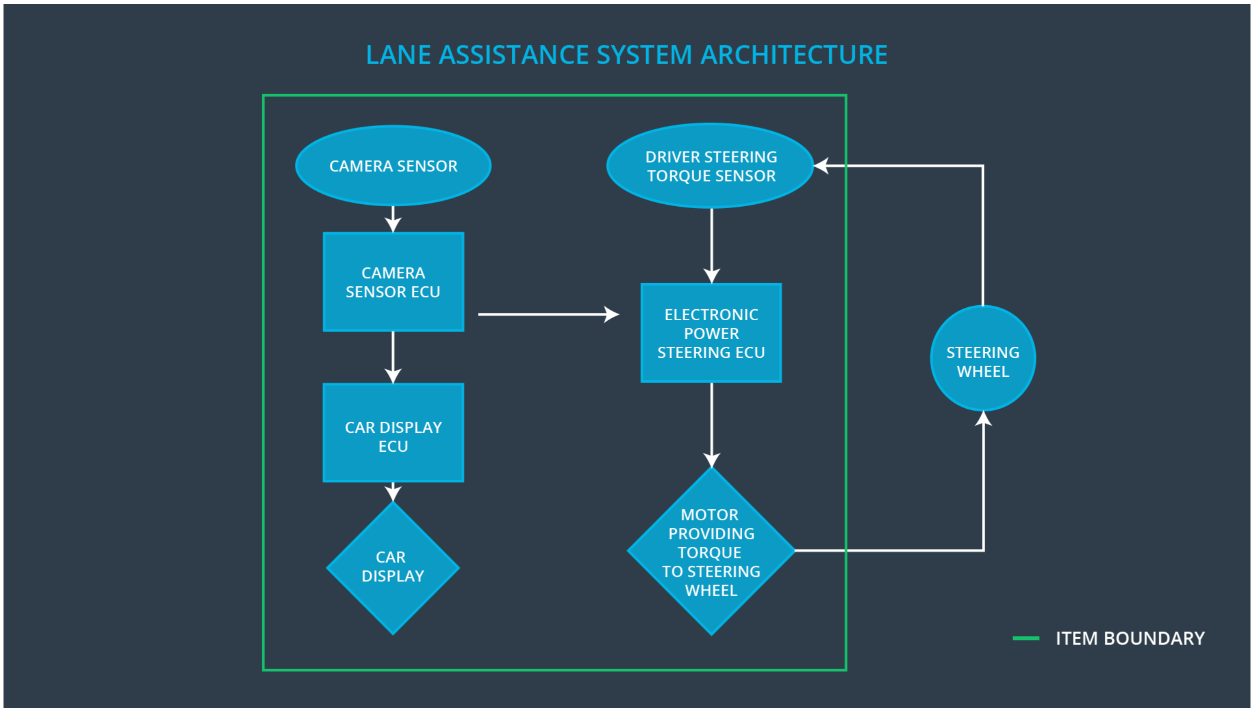
- Turning functional safety requirements into technical safety requirements
- Allocating technical safety requirements to the system architecture

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	lane keeping assistance function shall be time limited and the additional steering torque shall end after a given timer interval so that the driver cannot misuse the system for autonomous driving

Preliminary Architecture


LANE ASSISTANCE SYSTEM ARCHITECTURE
CAMERA SENSOR
CAMERA SENSOR ECU
CAR DISPLAY ECU
CAR DISPLAY
DRIVER STEERING TORQUE SENSOR
ELECTRONIC POWER STEERING ECU
MOTOR PROVIDING TORQUE TO STEERING WHEEL
STEERING WHEEL
ITEM BOUNDARY

Description of architecture elements

Element	Description
Camera Sensor	The camera sensor reads in images from the road
Camera Sensor ECU	The camera sensor ECU identifies when the vehicle has accidently departed its lane, and sends the appropriate messages to the car display and the electronic power steering ECU
Car Display	The car display shows messages to the driver
Car Display ECU	The car display ECU determines when to show messages
Driver Steering Torque Sensor	The driver steering torque sensor detects the steering input by the driver
Electronic Power Steering ECU	The electronic power steering ECU determines the amount of steering sent to the wheels
Motor	The steering motor provides force 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 EPS ECU shall ensure that the lane departure oscillating torque amplitude is below Max_Torque_Amplitude	C	50ms	LDW will set the oscillating torque amplitude to zero
Functional Safety Requirement 01-02	The EPS ECU shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency	C	50ms	LDW will set the oscillating torque amplitude 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	test how drivers react to different torque amplitudes and frequencies to prove that we chose an appropriate value	software test inserting a fault into the system and seeing what happens
Functional Safety Requirement 01-02	test how drivers react to different torque amplitudes and frequencies to prove that we chose an appropriate value	software test inserting a fault into the system and seeing what happens

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	500ms	LKA will set the oscillating torque amplitude 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 max_duration chosen really did dissuade drivers from taking their hands off the wheel	the system really does turn off if the lane keeping assistance 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 warning oscillating torque amplitude is below Max_Torque_Amplitude	**responsible**		
Functional Safety Requirement 01-02	The electronic power steering ECU shall ensure that the lane departure warning oscillating torque amplitude is below Max_Torque_Frequency	**responsible**		
Functional Safety Requirement 02-01	The functional safety requirement needs to only be allocated to the electronic power steering ECU.	**responsible**		

Warning and Degradation Concept

ID	**Degradation Mode**	**Trigger for Degradation Mode**	**Safe State invoked?**	**Driver Warning**
WDC-01	turn off the functionality	Steering torque exceeds maximum levels	Yes	Warning light on dashboard
WDC-02	turn off the functionality	Steering torque exceeds maximum levels	Yes	Warning light on dashboard