Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
12-02-2018	1.0	Fuqiang Huang	First Attempt for Submission

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Purpose of the Functional Safety Concept

The functional safety concept is composed of the following information:

- Refine the safety goals in what are called functional safety requirements defining the vehicle's functions.
- Allocate these safety requirements to the relevant parts of the system diagram. This could involve expanding the system architecture with new element blocks.
- Refine the system architecture to handle the new requirements with a few more attributes, including the ASIL level, the fault tolerant time interval and the safe state.
- Discuss validation and verification, which is how to prove that the system actually meets the requirements.

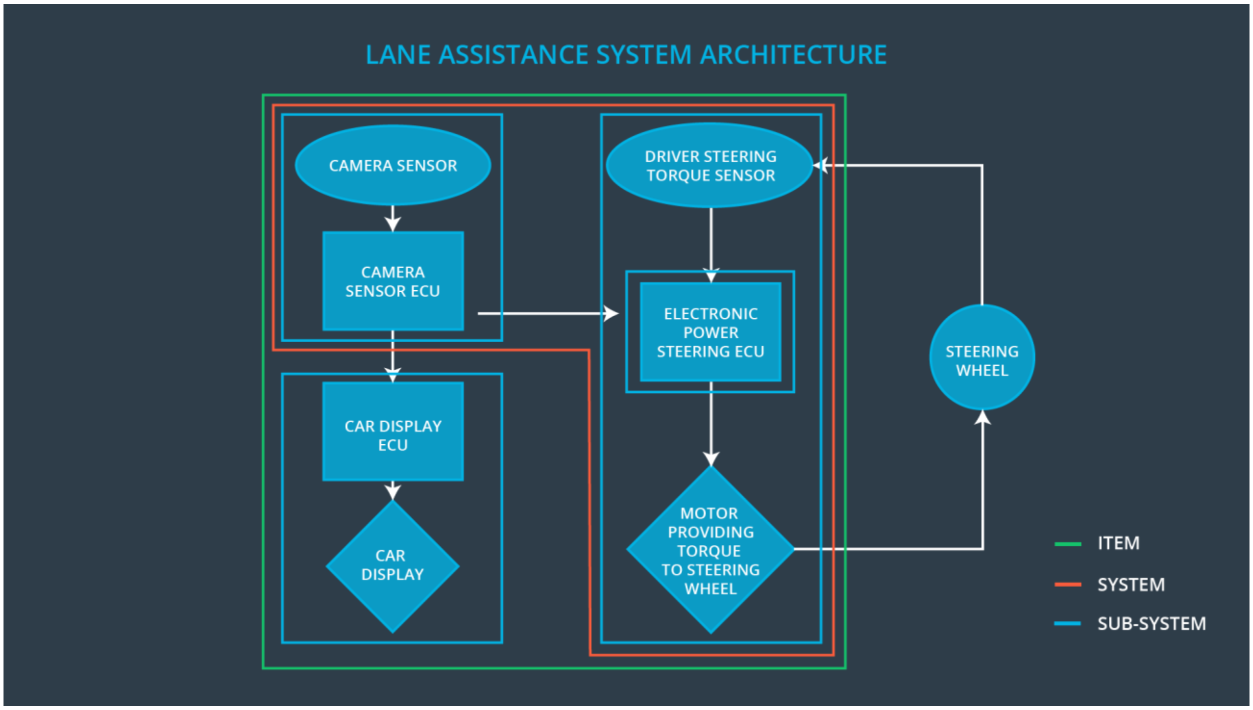
The functional safety concept is looking at the item from a high level and does not go into technical details. The functional safety concept looks at the general functionality of the item; the technical safety concept looks at the technical implementation of the item. In practice, developing these two documents is an iterative process where new functional requirements could lead to new technical requirements which could lead back to new functional requirements.

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 LKA 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.
Safety_Goal_03	The LDW function shall be disabled in low visibility environment.
Safety_Goal_04	The LDW function shall be deactivated automatically and promptly when the drive applies the brake.

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
SYSTEM
SUB-SYSTEM

Description of architecture elements

Element	**Description**
Camera Sensor	Captures road and vehicle images for the Camera Sensor ECU.
Camera Sensor ECU	Detects lane departures based on images captured, sends a signal to the electronic power steering system asking to turn and vibrate the steering wheel, and requests a warning light in the car display dashboard.
Car Display	Provides a warning light in the car display dashboard to let the driver know whether the lane assistance system is active, and provides a button on the dashboard so that the driver can turn off the system completely if in need.
Car Display ECU	Gets the request signal from the Camera Sensor ECU to control the warning light, and receives the on/off signal from the Car Display to ask for activating/deactivating the assistance system.
Driver Steering Torque Sensor	Detects how much the driver is already turning the steering wheel.
Electronic Power Steering ECU	Receives the request from Camera Sensor ECU and then sends a control signal to Motor to vibrate the steering wheel to give a warning to the driver, and calculates extra steering torque needed to help the driver move back towards the center of the lane.
Motor	Vibrates the steering wheel to give a warning to the driver based on the information from Electronic Power Steering ECU, and applies the extra torque to the steering wheel to draw the vehicle back to the center of the lane.

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	The system shall be switched off.
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	The system shall be switched off.

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 and validate that the Max_Torque_Amplitude chosen is appropriate that the driver does not lose control over the car.	Verify that the system does turn off in time if Max_Torque_Amplitude crosses the limit.
Functional Safety	Test and validate that the Max_Torque_Frequency chosen is appropriate that the driver does not lose	Verify that the system does turn off in time if Max_Torque_Frequency crosses the limit.

Requirement 01-02	control over the car.	

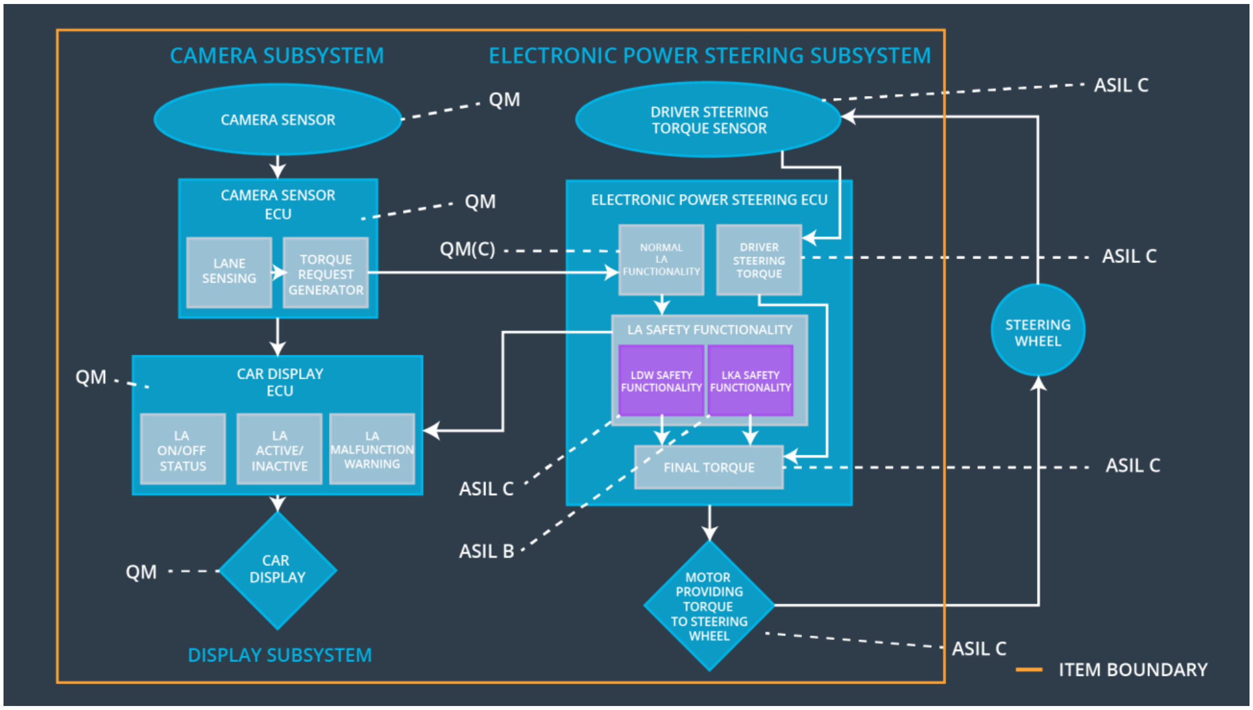
Lane Keeping Assistance (LKA) Requirements:

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	The system shall be switched off.

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 chosen is appropriate so that it helps prevent drivers from taking their hands off the wheel.	Verify that the system does turn off if the lane keeping assistance duration 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 applied for only Max_Duration.	x		

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn off the functionality.	Malfunction_01 Malfunction_02	Yes	Warning light on the dashboard
WDC-02	Turn off the functionality.	Malfunction_03	Yes	Warning light on the dashboard