Functional Safety Concept Lane Assistance

Document Version: [V1.1]

Document history

[Instructions: Fill in the date, version and description fields. You can fill out the Editor field with your name if you want to do so. Keep track of your editing as if this were a real world project.

For example, if this were your first draft or first submission, you might say version 1.0. If this is a second submission attempt, then you'd add a second line with a new date and version 2.0]

Date	Version	Editor	Description
24.01.2019	V1.1	Liping S	First version with all required content

Table of Contents

[Instructions: We have provided a table of contents. If you change the document structure, please update the table of contents accordingly. The table of contents should show each section of the document and page numbers or links. Most word processors can do this for you. In Google Docs, you can use headings for each section and then go to Insert > Table of Contents. Microsoft Word has similar capabilities]

Purpose of the Functional Safety Concept

[Instructions: Answer what is the purpose of a functional safety concept?]

The functional safety concept looks at the general functionality of the item. The functional safety concept identify new requirements and allocate these requirements to system diagrams. Allocation means defining which part of the system architecture will implement each requirement.

Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

[Instructions:
REQUIRED:
Provide the lane departure warning and lane keeping assistance safety goals as discussed in the lessons and derived in the hazard analysis and risk assessment.

OPTIONAL:
If you expanded the hazard analysis and risk assessment to include other safety goals, include them here.
]

ID	Safety Goal
Safety_Goal_01	The steering torque related to lane departure warning shall be limited
Safety_Goal_02	LKA function shall only work for a certain amount of time.
Safety_Goal_03	LKA shall deactive and inform the driver when the lane detection is failed.
Safety_Goal_04	LKA shall provide certainty score of its measurement, and build mechanism to deal with low score situations.

Preliminary Architecture

[Instructions: Provide a preliminary architecture for the lane assistance item. Hint: See Lesson 3: Item Definition]

Description of architecture elements

[Instructions: Provide a description for each of the item elements; what is each element's purpose in the lane assistance item?]

Element	**Description**
Camera Sensor	Provide visual signal to camera sensor ECU
Camera Sensor ECU	Detect lane line and send behavior target to steering module
Car Display	Provide user interface to the driver and show the info of the system
Car Display ECU	Convert signal from camera sensor and steering module to visual signal for display
Driver Steering Torque Sensor	Sense the steering torque, and send to steering ECU
Electronic Power Steering ECU	Process torque sensor signal and send control signal to motor
Motor	Receive control signal from steering ECU and apply it 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

[Instructions: Fill in the functional safety analysis table below.]

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 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	Camera module cannot detect the lane line due to snow

Functional Safety Requirements

[Instructions: Fill in the functional safety requirements for the lane departure warning]

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	50ms	Function is deactivated
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency	C	50ms	Function is deactivated

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 analyze the react of driver to different torque amplitude and find the optimal value	Verify if the system can turn off as expected when exceeding the max torque amplitude
Functional Safety Requirement 01-02	Test and analyze the react of driver to different torque frequency and find the optimal value	Verify if the system can turn off as expected when exceeding the max torque frequency

[Instructions: Fill in the functional safety requirements for the lane keeping assistance]

Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	The steering ECU shall ensure that the wheel steering torque only be applied in the Max_Duration	B	500ms	LKA torque turns zero
Functional Safety Requirement 02-02	The LKA shall be deactivated when the Camera ECU outputs that the lane detection is failed	A	50 ms	Function is deactivated

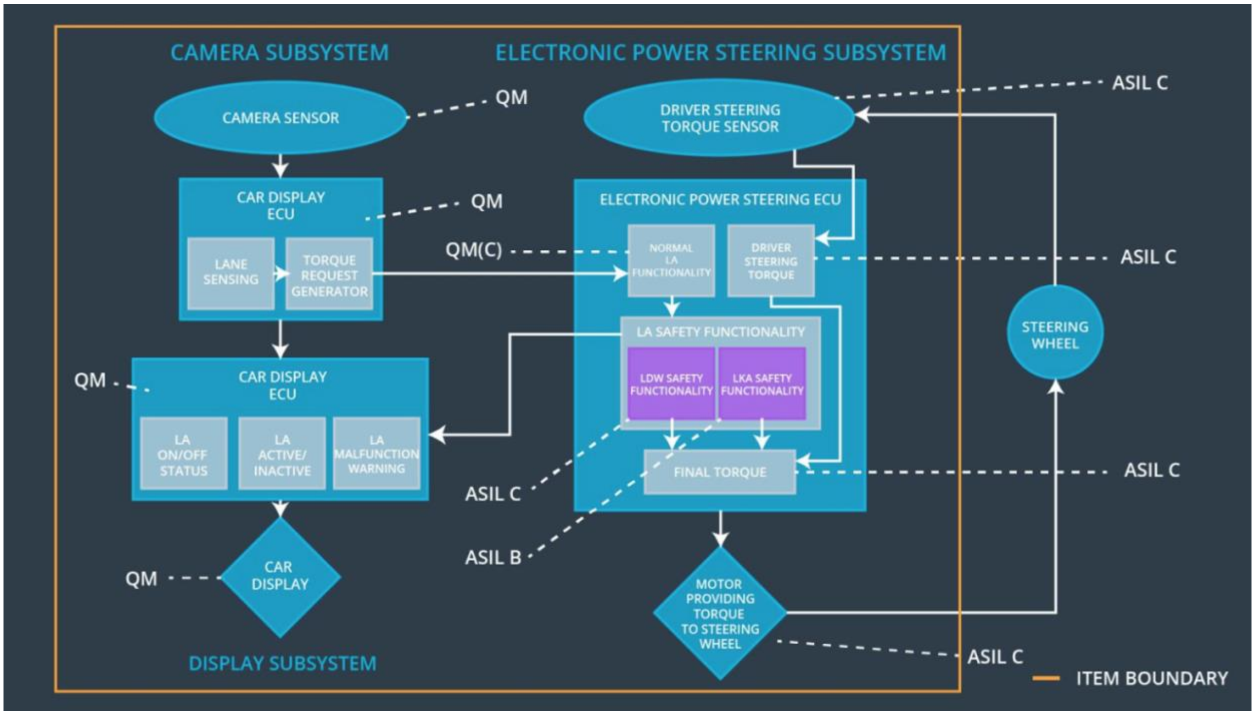
Lane Keeping Assistance (LKA) Verification and Validation Acceptance Criteria:

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Functional Safety Requirement 02-01	Validate the choice of Max_Duration does not mislead the driver into autonomous driving	Verify the system does be deactivated if the LKA function exceeds Max_Duration
Functional Safety Requirement 02-02	Validate the LKA shall be deactivated when camera cannot work properly (lane detection failed)	Verify the LKS does be deactivated if the camera cannot work properly

Refinement of the System Architecture

[Instructions: Include the refined system architecture. Hint: The refined system architecture should include the system architecture from the end of the functional safety lesson including all of the ASIL labels.]

As shown below, the refined system architecture:



Allocation of Functional Safety Requirements to Architecture Elements

[Instructions: Mark which element or elements are responsible for meeting the functional safety requirement. Hint: Only one ECU is responsible for meeting all of the requirements.]

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 is below Max_Torque_Amplitude	•		
Functional Safety Requirement 01-02	The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency	•		
Functional Safety Requirement	The steering ECU shall ensure that the wheel steering torque only be applied in the	•		

02-01	Max_Duration			
Functional Safety Requirement 02-02	The LKA shall be deactivated when the Camera ECU outputs that the lane detection is failed	•		

Warning and Degradation Concept

[Instructions: Fill in the warning and degradation concept.]

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn off Lane Assistant functionality	Malfunction_01	Yes	Lane assistance malfunction warning on car display
WDC-02	Turn off Lane Assistant functionality	Malfunction_02	Yes	Lane assistance malfunction warning on car display
WDC-03	Turn off Lane Assistant functionality	Malfunction_03	Yes	Lane assistance malfunction warning on car display