Functional Safety Concept Lane Assistance

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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
10/10/2017	1.0	Sung jin, Kwon	First draft

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?]

Functional safety concept is the documentation of
- Refining of the high-level safety goals into functional safety requirements.
- Allocation of each functional safety requirement to the system architecture.

Inputs to the Functional Safety Concept

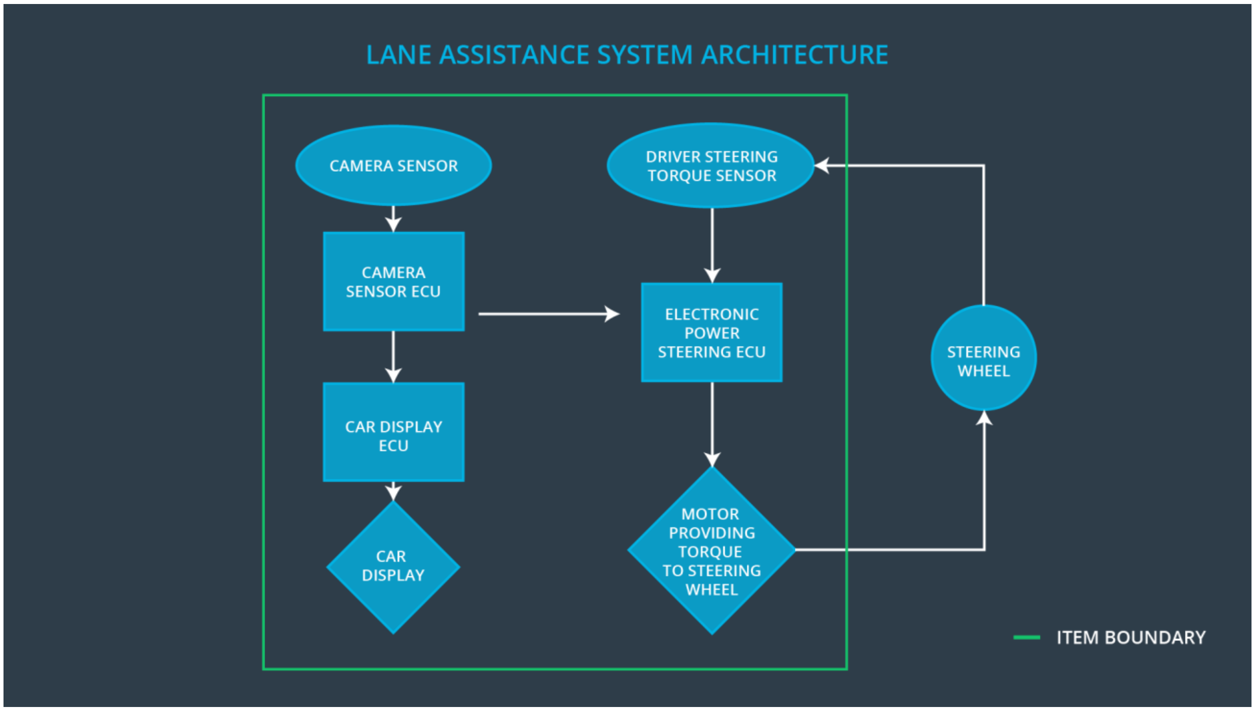
Safety goals from the Hazard Analysis and Risk Assessment

[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.
]

ID	**Safety Goal**
Safety_Goal_01	The oscillating steering torque from the lane departure warning system 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

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


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

[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	Get an image
Camera Sensor ECU	Detecting lane from image and decide LDW or LKA

	function is needed. If so, send appropriate torque request to the EPS ECU
Car Display	Displaying whether the lane keeping assistance function is on/off; Displaying whether the lane departure warning function is activated or not
Car Display ECU	Receives signals from the camera ECU or EPS ECU about function activation and send appropriate image to the car display
Driver Steering Torque Sensor	Senses the amount of torque from the steering wheel
Electronic Power Steering ECU	Receives the torque request from the camera ECU. Computes the residual torque or vibration amplitude and frequency needed to be applied after taking into account the input from the torque sensor. Sends the torque output request to the motor
Motor	Generate torque to the wheel requested by EPU ECU

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 large 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

[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 electronic power steering ECU shall ensure that the lane departure warning oscillating torque amplitude is below Max_Torque_Amplitude	C	50ms	Lane Departure warning function is not activated
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	C	50ms	Lane Departure warning function is not activated

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	For whatever value we end up choosing for the max torque amplitude, we need to validate that we chose a reasonable value. We would need to test how drivers react to different torque amplitudes to prove that we chose an appropriate value.	When the torque amplitude crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval.
Functional Safety Requirement 01-02	For whatever value we end up choosing for the max torque frequency, we need to validate that we chose a reasonable value. We would need to test how drivers react to different torque frequencies to prove that we chose an appropriate value.	When the torque frequency crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval.

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

Lane Keeping Assistance (LKA) Requirements:

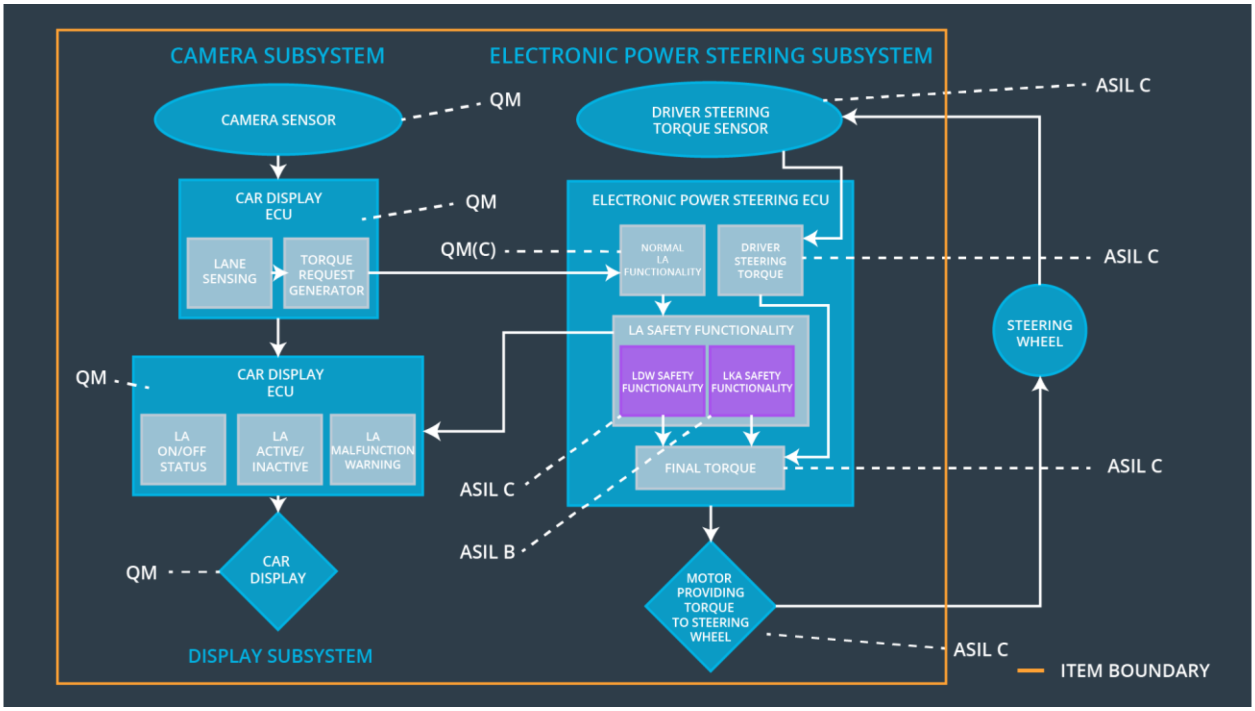
ID	**Functional Safety Requirement**	**ASIL**	**Fault Tolerant Time Interval**	**Safe State**
Functional Safety Requirement 02-01	The electronic power steering ECU shall ensure that the lane keeping assistance torque is applied for only Max_Duration	B	500ms	Lane Keeping assistance system is not activated

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 that 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

[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.]



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 electronic power steering ECU shall ensure that the lane departure warning oscillating torque amplitude is below Max_Torque_Amplitude	**Y**	**N**	**N**
Functional	The electronic power steering	**Y**	**N**	**N**

Safety Requirement 01-02	ECU shall ensure that the lane departure warning oscillating torque frequency is below Max_Torque_Frequency			
Functional Safety Requirement 02-01	The electronic power steering ECU shall ensure that the lane keeping assistance torque is applied for only Max_Duration	**Y**	**N**	**N**

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 functionality	The malfunction of the steering wheel vibrating too much	Y	Warning light on the dashboard
WDC-02	Turn off functionality	The malfunction of the lane keeping assistance function being applied for too long	Y	Warning light on the dashboard