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# Functional Safety Concept Lane Assistance

**Document Version:** [Version]

Template Version 1.0, Released on 2017-06-21

## 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 |
|---|---|---|---|
| 2018-03-15 | 1.0 | Mike Ni | First attempt |
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# 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]

Document history

Table of Contents

Purpose of the Functional Safety Concept

Inputs to the Functional Safety Analysis
- Safety goals from the Hazard Analysis and Risk Assessment
- Preliminary Architecture
  - Description of architecture elements

Functional Safety Concept
- Functional Safety Analysis
- Functional Safety Requirements
- Refinement of the System Architecture
- Allocation of Functional Safety Requirements to Architecture Elements
- Warning and Degradation Concept

# Purpose of the Functional Safety Concept

**[Instructions: Answer what is the purpose of a functional safety concept?]**
**Determine which subsystems are responsible for meeting the safety goals, and further refine the high level goals into functional safety requirements. Allocate each functional safety requirement to its appropriate place in the item architecture.**

# Inputs to the Functional Safety Concept

## Safety goals from the Hazard Analysis and Risk Assessment

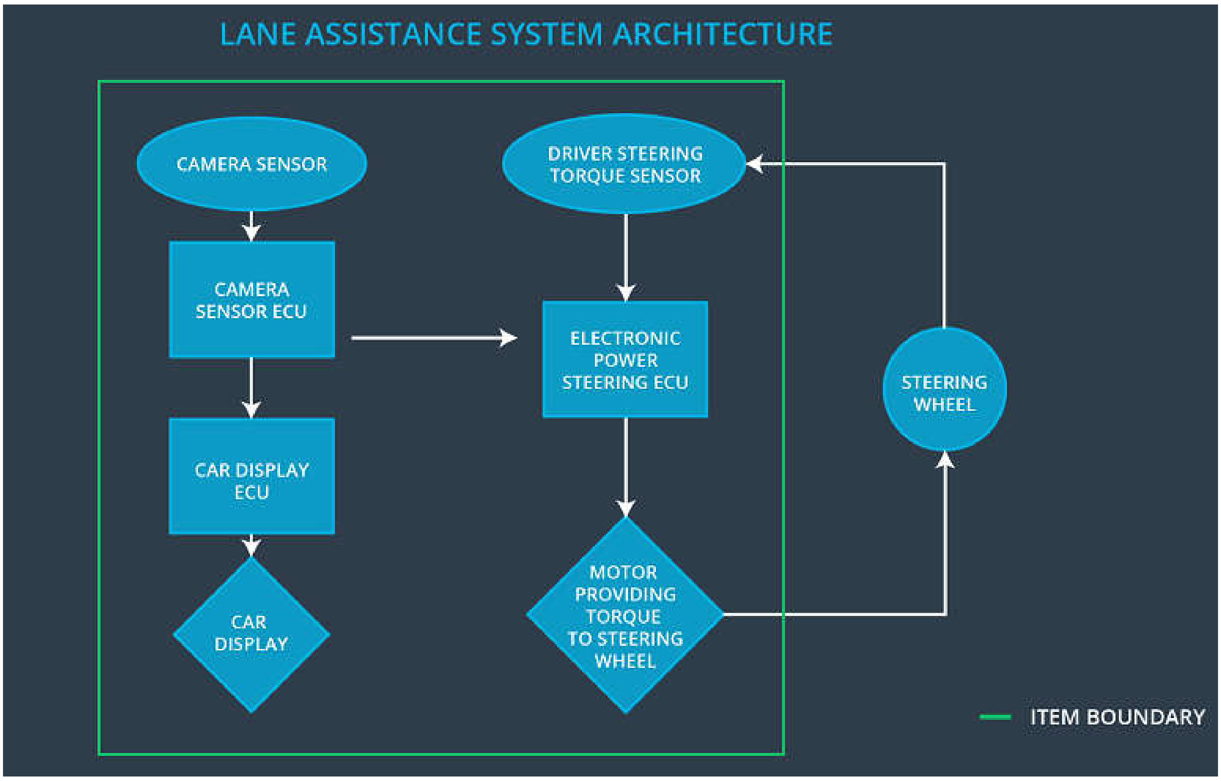
**[Instructions:**
**REQUIRED:**
**Provide the lane departure warning and lane keeping assistance safety goals as discussed in the lessons and derived in the hazard analysis and risk assessment.**

**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 oscillation steering torque from the lane departure warning function 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 | Detect the lane of  the road. |
| Camera Sensor ECU | Calculate where is lane of road and send out torque request. |
| Car Display | Display warning information. |
| Car Display ECU | Control which warning lamp should be lighten up. |
| Driver Steering Torque Sensor | Detect how much of the real turning torque. |
| Electronic Power Steering ECU | Calculate the reasonable turning torque composed of driver's steering torque and adding an appropriate amount of torque based on a lane assistance system torque request. |
| Motor | The actuator that execute the torque command. |

# 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<br>the lane departure warning is giving MORE torque than what is safe. | 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<br>the lane departure warning is giving MORE torque than what is safe. | 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<br>the assistance has no time limit | 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 lane keeping item shall ensure that the lane departure oscillation torque amplitude is below Max_Torque_Amplitude. | C | 50ms | turning the system 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 | 50ms | turning the system 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 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 | Test how drivers react to different torque frequencies to prove that we chose an appropriate value. | when the torque frequencies 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 | ASI | Fault Tolerant Time | Safe State |
|---|---|---|---|---|

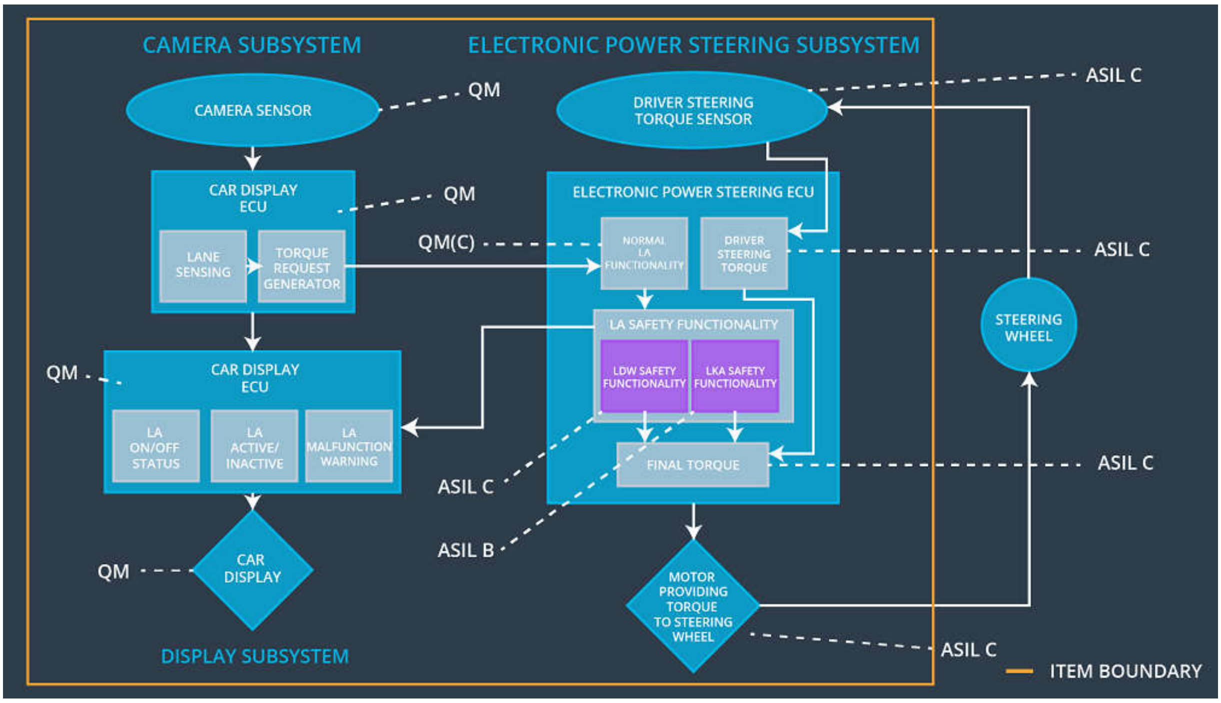
| | | L | Interval | |
|---|---|---|---|---|
| Functional Safety Requirement 02-01 | the electronic power steering ECU shall ensure that the lane keeping assistance torque is applied for only Max_Duration | B | 500ms | turning the system off |

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 | 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 lane keeping item shall ensure that the lane departure oscillation torque amplitude is below Max_Torque_Amplitude. | X | | |
| Functional Safety Requirement 01-02 | The lane keeping item 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

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

| ID | Degradation Mode | Trigger for Degradation Mode | Safe State invoked? | Driver Warning |
|---|---|---|---|---|
| WDC-01 | turn off the functionality | Malfunction_01<br>Malfunction_02 | Yes | A warning light will turn on. |
| WDC-02 | turn off the functionality | Malfunction_03 | Yes | A warning light will turn on. |