Elektrobit

UDACITY

# 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 |
|---|---|---|---|
| 01/23/2019 | 1.0 | Rouzbeh Shirvani | First attempt |
| 01/26/2019 | 1.1 | Rouzbeh Shirvani | Second attempt |
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**[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]**


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# Purpose of the Functional Safety Concept

**[Instructions: Answer what is the purpose of a functional safety concept?]**
Functional safety concept looks at the general functionality of each item and does not go into technical detail. Functional safety concept allows us to determine functional safety requirement of each subsystem and allocate it in the item archiecture. All these information will ultimately go into a document called functional safety concept.

# Inputs to the Functional Safety Concept

## Safety goals from the Hazard Analysis and Risk Assessment

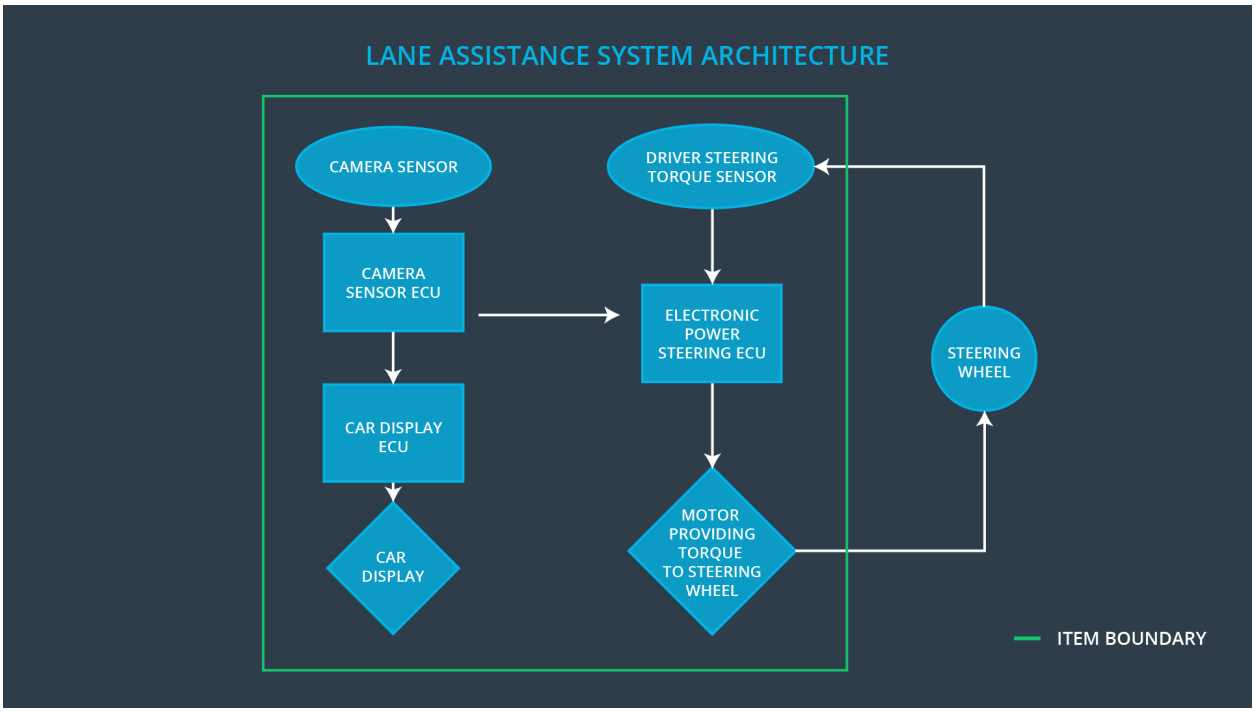
**[Instructions:**
**REQUIRED:**
**Provide the lane departure warning and lane keeping assistance safety goals as discussed in the lessons and derived in the hazard analysis and risk assessment.**

**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 oscillating 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]**




## 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 | The camera system reads images from the road |
| Camera Sensor ECU | The camera system ECU identifies when the vehicle accidentally departds its lane and sends the approprate messages to the car display ECU and the electronic power steering ECU |
| Car Display | Car Displays system visualizes information and provides feedback for driver about the Lane Assistance system among other display functionality |
| Car Display ECU | Car Display ECU is responsible for processing the information and dispalying relevant information on the car display system. |
| Driver Steering Torque Sensor | Driver Steering Torque Sensor senses how much torque is applied to the steering wheel and sends it to the power steering ECU |
| Electronic Power Steering ECU | Electronic power Steering ECU receives relevant infomration from all the sensors and sends signal to |

| | |
|---|---|
| | the car display as well as motor in order to apply appropriate force. |
| Motor | The motor provides required force in order to move the steering wheel in the appropriate direction. |

# 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_1 | 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_2 | The lane departure warning function applies an oscillating torque with very high torque **frequency** (above limit) |
| Malfunction_03 | Lane Keeping Assistance (LKA) | No | The lane keeping assistance function |

| | | | |
|---|---|---|---|
| | function shall apply the steering torque when active in order to stay in ego lane | | 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 oscillating torque amplitude is below Max_Torque_Amplitude | C | 50ms | LDW will set the oscillating torque amplitude to 0 |
| Functional Safety Requirement 01-02 | The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency | B | 50ms | LDW will set the oscillating frequency to 0 |

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 | The lane keeping item shall ensure that a reasonable value has been chosen for Max_Torque_Amplitude | **verify** that the safety requirement is met; when the torque amplitude crosses the limit, the lane |

| | | |
|---|---|---|
| | and test how drivers react to different torque amplitudes to prove that we chose an appropriate value. | assistance output is set to zero within the 50 ms fault tolerant time interval. For this specific case, we would probably do a software test inserting a fault into the system and seeing what happens. |
| Functional Safety Requirement 01-02 | The lane keeping item shall ensure that a reasonable value has been chosen for Max_Torque_Frequency and test how drivers react to different torque frequencies to prove that we chose an appropriate value. | **verify** that the safety requirement is met; when the torque frequency crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval. For this specific case, we would probably do a software test inserting a fault into the system and seeing what happens. |

**[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 | Safe state would be a state that the driver takes control of the wheel and does not rely on the system. Deactivating the system so that the driver takes control. |

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 | We would have to test and validate that the max_duration chosen really did dissuade drivers from taking their hands off the wheel | We would verify that 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 oscillating 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 | For the lane departure warning function, the degradation mode is to turn off the functionality | Lane Departure Warning (LDW) function applies an oscillating torque above Max_Torque_Amplitude | Yes | Beep Sound and warning on the Car Display |
| WDC-02 | For the lane keeping assistance function, the degradation mode is to turn off the functionality | Lane Departure Warning (LDW) function applies an oscillating torque with a frequency above Max_Torque_Frequency | Yes | Beep Sound and warning on the Car Display |