

Functional Safety Concept Lane Assistance

**Document Version: [Version]**

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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 |
| 2017-12-26 | 1.0 | Sven Eriksson | Initial release |
| 2017-12-26 | 2.0 | Sven Eriksson | Updates to Verication and Validaction acceptance criteria to both LDW and LKA after feedback. |
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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**](https://support.google.com/docs/answer/116338?co=GENIE.Platform%3DDesktop&hl=en)**, you can use headings for each section and then go to Insert > Table of Contents.** [**Microsoft Word**](https://support.microsoft.com/en-us/help/285059/how-to-create-a-table-of-contents-by-marking-text-in-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?]**

The purpose of the functional safety concept is to further analyze the item to identify new requirements and allocate these to system diagrams. The functional safety concept focuses on a high-level system description and the general functionality of the item.

# 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 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]**

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### 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 | Captures an image of the road in front of the vehicle |
| Camera Sensor ECU | Processes that image |
| Car Display | Shows the state of the lane assistant item to the driver |
| Car Display ECU | Receives processed data from the Camera sensor ECU and prepares it to be shown to the driver |
| Driver Steering Torque Sensor | Measures the amount of torque the driver has applied |
| Electronic Power Steering ECU | Receives processed data from the Camera sensor ECU and controls the torque output |
| Motor | Applies torque to the 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 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 oscillating torque amplitude is below Max\_Torque\_Amplitude | C | 50mS | No torque is being applied to the steering wheel by the system. |
| Functional  Safety  Requirement  01-02 | The electronic power steering ECU shall ensure that the lane departure oscillating torque frequency is below Max\_Torque\_Frequency | C | 50mS | No torque is being applied to the steering wheel by the system. |

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 | Criteria: Set a limit on the maximum torque amplitude allowed in the LDW functionality  Method: Test how drivers react to different torque amplitudes. | Criteria: When torque amplitude crosses the limit, the lane assistance output is set to zero within the 50ms fault tolerant time interval.  Method: Software test by inserting a fault into the system: |
| Functional  Safety  Requirement  01-02 | Criteria: Set a limit on the maximum torque frequency allowed in the LDW functionality  Method: Test how drivers react to different torque frequencies. | Criteria: When torque frequency crosses the limit, the lane assistance output is set to zero within the 50ms fault tolerant time interval.  Method: Software test inserting a fault into the system |

**[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 | 500 mS | No torque is being applied to the steering wheel by the system. |

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 | Criteria: Set a time limit max\_duration.  Method: Test that the max\_duration chosen really did dissuade drivers from taking their hands off the steering wheel. | Criteria: When the duration of applying torque from LKA exceeds max\_duration, the lane assistance output is set to zero within the 500ms fault tolerant time interval.  Method: In vehicle test with test driver. |

## 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 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

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **ID** | **Degradation Mode** | **Trigger for Degradation Mode** | **Safe State invoked?** | **Driver Warning** |
| WDC-01 | The system will be turned off | Oscilating torque amplitude higher than Max\_Torque\_Amplitude | Yes | Warning light for LKA disabled on car display |
| WDC-02 | The system will be turned off | Oscilating torque frequency higher than Max\_Torque\_Frequency | Yes | Warning light for LKA disabled on car display |
| WDC-03 | The system will be turned off | Torque has been applied for more than Max\_Duration | Yes | Warning light on the car display |