Elektrobit

UDACITY

# Technical Safety Concept Lane Assistance

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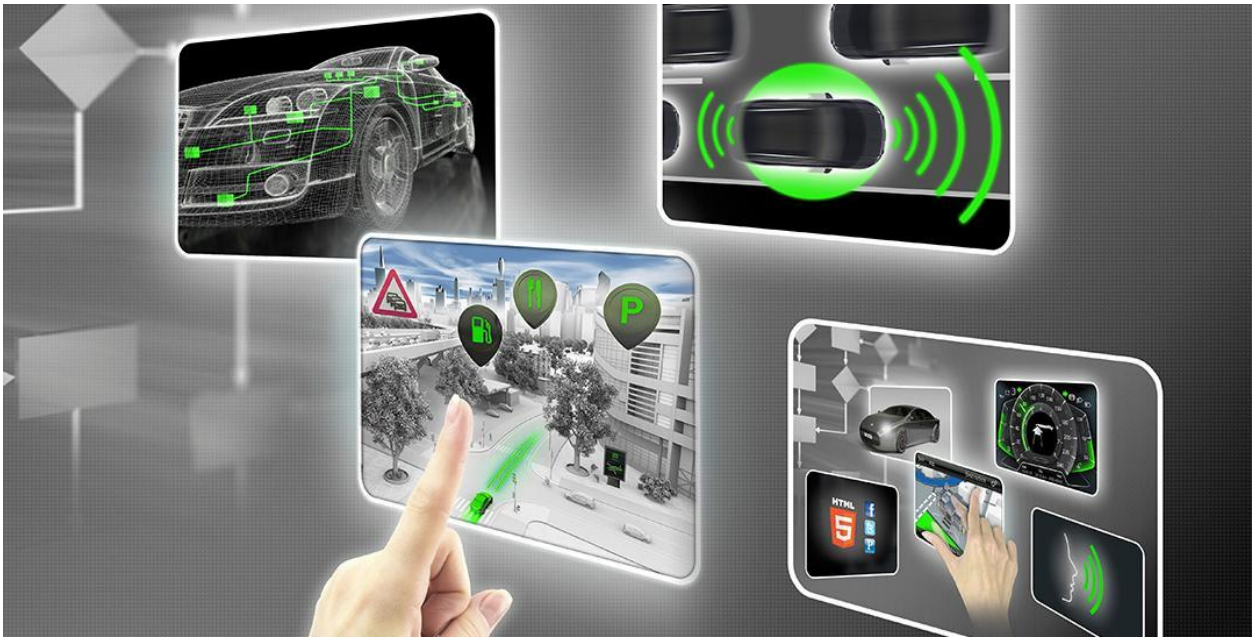

# Document history

| Date | Version | Editor | Description |
|---|---|---|---|
| 10/21/2018 | 1.0 | Chunfeng Yang | Initial version. |
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# Purpose of the Technical Safety Concept

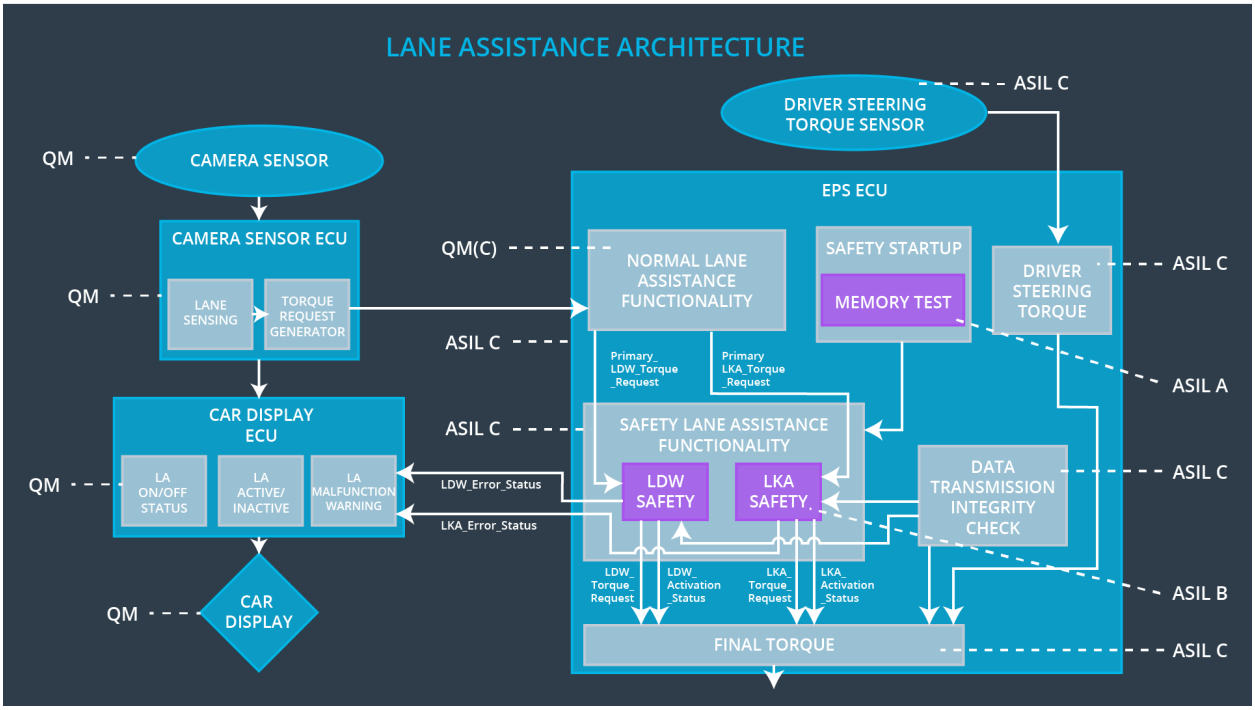
The Technical Safety Concept defines how the subsystems interact at the message level and describes how the ECUs communicate with each other.

# Inputs to the Technical Safety Concept

## Functional Safety 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 oscillating torque amplitude requested by the LDW function is below Max_Torque_Amplitude. | C | 50 ms | Vibration torque amplitude is below Max_Torque_Amplitude. |
| Functional Safety Requirement 01-02 | The Electronic Power Steering ECU shall ensure that the oscillating torque frequency requested by the LDW function is below Max_Torque_Frequency. | C | 50 ms | Vibration 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 only Max_Duration. | B | 500 ms | Lane Keeping Assistance torque is zero. |

## Refined System Architecture from Functional Safety Concept




## Functional overview of architecture elements

| Element | Description |
|---|---|
| Camera Sensor | Capture road images and provide them to the Camera Sensor ECU. |
| Camera Sensor ECU - Lane Sensing | Software module detecting the lane line positions from the Camera Sensor images. |
| Camera Sensor ECU - Torque request generator | Software module calculating the necessary torque to be requested to the Electronic Power Steering ECU. |
| Car Display | Display warning for the driver. |
| Car Display ECU - Lane Assistance On/Off Status | Indicate the status of the Lane Assistance functionality (On/Off). |
| Car Display ECU - Lane Assistant Active/Inactive | Indicate if the Lane Assistance functionality is properly functioning (Active/Inactive). |
| Car Display ECU - Lane Assistance malfunction warning | Indicate a malfunction on the Lane Assistance functionality. |

| | |
|---|---|
| Driver Steering Torque Sensor | Measure the torque applied to the steering wheel by the driver. |
| Electronic Power Steering (EPS) ECU - Driver Steering Torque | Software module receiving the driver's torque request from the steering wheel. |
| EPS ECU - Normal Lane Assistance Functionality | Software module receiving the Camera Sensor ECU torque request. |
| EPS ECU - Lane Departure Warning Safety Functionality | Software module ensuring the torque amplitude is below Max_Torque_Amplitude and torque frequency is below Max_Torque_Frequency. |
| EPS ECU - Lane Keeping Assistant Safety Functionality | Software module ensuring the Lane Keeping Assistance functionality application is not active more than Max_Duration time. |
| EPS ECU - Final Torque | Combine the torque request from the Lne Keeping and Lane Departure Warning functionalities and sends them to the Motor. |
| Motor | Applies the required torque to the steering wheels. |

# Technical Safety Concept

## Technical Safety Requirements

**Lane Departure Warning (LDW) Requirements:**

Functional Safety Requirement 01-01 with its associated system elements (derived in the functional safety concept)

| 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 | | |

Technical Safety Requirements related to Functional Safety Requirement 01-01 are:

| ID | Technical Safety Requirement | ASIL | Fault Tolerant Time Interval | Architecture Allocation | Safe State |
|---|---|---|---|---|---|
| Technical Safety Requirement 01 | The Lane Departure Warning safety component shall ensure that the amplitude of the 'LDW_Torque_Request' sent to the 'Final electronic power steering Torque' component is below 'Max_Torque_Amplitude.' | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| Technical Safety Requirement 02 | When the Lane Departure Warning is deactivated, the 'LDW Safety' software module shall send a signal to the Car Display ECU to turn on a warning signal. | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| Technical Safety Requirement 03 | When a failure is detected by the Lane Departure Warning functionality, it shall deactivate the Lane Departure Warning feature and set 'LDW_Torque_Request' to zero. | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| Technical Safety Requirement 04 | The validity and integrity of the data transmission for 'LDW_Torque_Request' signal shall be ensured. | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |

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|---|---|---|---|---|---|
| Technical Safety Requirement 05 | Memory test shall be conducted at startup of the EPS ECU to check for any memory problems | A | Ignition cycle | Data Transmission Integrity Check | Lane Departure Warning torque to zero. |

Functional Safety Requirement 01-2 with its associated system elements (derived in the functional safety concept)

| ID | Functional Safety Requirement | Electronic Power Steering ECU | Camera ECU | Car Display ECU |
|---|---|---|---|---|
| Functional Safety Requirement 01-02 | The lane keeping item shall ensure that the lane departure oscillating torque frequency is below Max_Torque_Frequency | X | | |

Technical Safety Requirements related to Functional Safety Requirement 01-02 are:

| ID | Technical Safety Requirement | ASIL | Fault Tolerant Time Interval | Architecture Allocation | Safe State |
|---|---|---|---|---|---|
| Technical Safety Requirement 01 | The LDW safety component shall ensure that the *frequency* of 'LDW_Torque_Request' sent to the 'Final electronic power steering Torque' component is below 'Max_Torque_Frequency'. | C | 50 ms | LDW Safety | Lane Departure Warning torque to zero. |
| Technical Safety | As soon as a failure is detected by | C | 50 ms | LDW Safety | Lane Departu |

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|---|---|---|---|---|---|
| Requirement 02 | the LDW function, it shall deactivate the LDW feature and the 'LDW_Torque_Request' shall be set to zero. | | | | re Warning torque to zero. |
| Technical Safety Requirement 03 | As soons as the LDW function deactivates the LDW feature, the 'LDW Safety' software block shall send a signal to the car display ECU to turn on a warning light. | C | 50 ms | LDW Safety | Lane Departu re Warning torque to zero. |
| Technical Safety Requirement 04 | The validity and integrity of the data transmission for 'LDW_Torque_Request' signal shall be ensured. | C | 50 ms | Data Transmission Integrity Check | Lane Departu re Warning torque to zero. |
| Technical Safety Requirement 05 | Memory test shall be conducted at start up of the EPS ECU to check for any faults in mermory. | A | Ignition cycle | Memory Test | Lane Departu re Warning torque to zero. |

**Lane Departure Warning (LDW) Verification and Validation Acceptance Criteria:**

| ID | Validation Acceptance Criteria and Method | Verification Acceptance Criteria and Method |
|---|---|---|
| Technical Safety Requirement 02-01-01 | Validate the Max_Duration is set to the chosen value from LKA Validation Assistance Criteria | Verify the functionality is turned off after it is applied for Max_Duration. |
| Technical Safety Requirement | Validate the 'TORQUE_LIMITER' sends the error_status_torque_limiter signal to the | Verify the Car Display ECU displays the Lane Keeping Assistance |

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|---|---|---|
| 02-01-02 | LKA_SAFETY_ACTIVATION. | malfunction warning signal. |
| Technical Safety Requirement 02-01-03 | Validate the 'TORQUE_LIMITER' sends 'LKA_Torque_Request' with zero. | Verify the Final EPS Torque generator receives a LKA_Torque_Request of zero. |
| Technical Safety Requirement 02-01-04 | Validate the 'TORQUE_LIMITER' calculate and sends the correct cyclic redundancy check (CRC) and Alive counter for data transmission validity and integrity. | Verify the functionality is turn off if there is a CRC or Alive counter discrepancy. |
| Technical Safety Requirement 02-01-05 | Validate the Safety Startup Memory test to check memory faults catch memory faults. | Verify the Lane Keeping Assistance is turned off when the Safety Startup Memory fails. |

**Lane Keeping Assistance (LKA) Requirements:**

Functional Safety Requirement 02-1 with its associated system elements (derived in the functional safety concept)

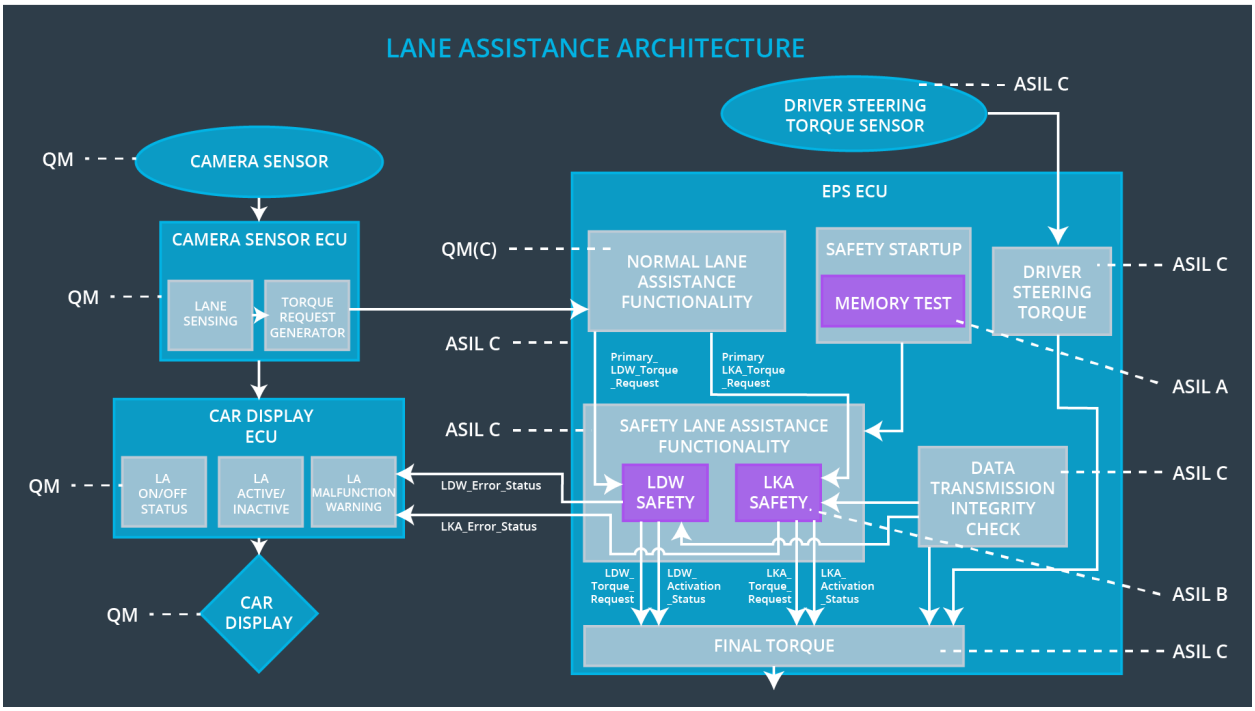
| ID | Functional Safety Requirement | Electronic Power Steering ECU | Camera ECU | Car Display ECU |
|---|---|---|---|---|
| Functional Safety Requirement 02-01 | The lane keeping item shall ensure that the lane keeping assistance torque is applied for only Max_Duration | X | | |

Technical Safety Requirements related to Functional Safety Requirement 02-01 are:

| ID | Technical Safety Requirement | ASI | Fault Tolerant Time | Allocation to Architecture | Safe State |
|---|---|---|---|---|---|

| | | L | Interval | | |
|---|---|---|---|---|---|
| Technical Safety Requirement 01 | The LKA safety component shall ensure that 'LKA_Torque_Request' is sent to the 'Final electronic power steering Torque' component for only 'Max_Duration'. | B | 500 ms | LKA Safety | Lane Keeping Assistance activation status to zero. |
| Technical Safety Requirement 02 | As soon as a failure is detected by the LKA function, it shall deactivate the LKA feature and the 'LKA_Torque_Request' shall be set to zero. | B | 500 ms | LKA Safety | Lane Keeping Assistance activation status to zero. |
| Technical Safety Requirement 03 | As soons as the LKA function deactivates the LKA feature, the 'LKA Safety' software block shall send a signal to the car display ECU to turn on a warning light. | B | 500 ms | LKA Safety | Lane Keeping Assistance activation status to zero. |
| Technical Safety Requirement 04 | The validity and integrity of the data transmission for 'LKA_Torque_Request' signal shall be ensured. | B | 500 ms | Data Transmission Integrity Check | Lane Keeping Assistance activation status to zero. |
| Technical Safety Requirement 05 | Memory test shall be conducted at startup of the EPS ECU to check for any faults in mermory. | A | Ignition cycle | Memory Test | Lane Keeping Assistance activation status to zero. |

## Refinement of the System Architecture




## Allocation of Technical Safety Requirements to Architecture Elements

| ID | Technical Safety Requirement | Electronic Power Steering ECU | Camera ECU | Car Display ECU |
|---|---|---|---|---|
| Technical Safety Requirement 01-01 | The Lane Departure Warning safety component shall ensure that the amplitude of the ‘LDW_Torque_Request’ sent to the ‘Final electronic power steering Torque’ component is below ‘Max_Torque_Amplitude.’ | X | | |

| | | | | |
|---|---|---|---|---|
| Technical Safety Requirement 01-02 | When the Lane Departure Warning is deactivated, the ‘LDW Safety’ software module shall send a signal to the Car Display ECU to turn on a warning signal. | X | | |
| Technical Safety Requirement 01-03 | When a failure is detected by the Lane Departure Warning functionality, it shall deactivate the Lane Departure Warning feature and set ‘LDW_Torque_Request’ to zero. | X | | |
| Technical Safety Requirement 01-04 | The validity and integrity of the data transmission for ‘LDW_Torque_Request’ signal shall be ensured. | X | | |
| Technical Safety Requirement 01-05 | Memory test shall be conducted at start up of the EPS ECU to check for any memory problems | X | | |
| Technical Safety Requirement 02-01 | The Lane Departure Warning safety component shall ensure the frequency of the ‘LDW_Torque_Reques’ sent to the ‘Final electronic power steering Torque’ component is below ‘Max_Torque_Frequency.’ | X | | |
| Technical Safety Requirement 02-02 | The Lane Keeping Assistance safety component shall ensure the duration of the lane keeping | X | | |

| | | | | |
|---|---|---|---|---|
| | assistance torque is applied for less than Max_Duration | | | |
| Technical Safety Requirement 02-03 | When the Lane Keeping Assistance function deactivates, the ‘LKA Safety’ shall send a signal to the Car Display ECU to turn on a warning light. | X | | |
| Technical Safety Requirement 02-04 | When a failure is detected, the Lane Keeping Assistance function shall deactivate and the ‘LKA_Torque_Request’ shall be zero. | X | | |
| Technical Safety Requirement 02-05 | The validity and integrity of the data transmission for ‘LKA_Torque_Request’ signal shall be ensured. | X | | |

## Warning and Degradation Concept

| ID | Degradation Mode | Trigger for Degradation Mode | Safe State Invoked? | Driver Warning |
|---|---|---|---|---|
| WDC-01 | Turn off Lane Departure Warning functionality | Malfunction_01, Malfunction_02, Malfunction_04 | Yes | Lane Departure Warning Malfunction Warning on Car Display |
| WDC-02 | Turn off Lane Keeping | Malfunction_03, | Yes | Lane Keeping |

| | | | | |
|---|---|---|---|---|
| | Assistance functionality | Malfunction_05 | | Assistance Malfunction Warning on Car Display |