



Elektrobit



UDACITY

Functional Safety Concept Lane Assistance

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Document history

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Purpose of the Functional Safety Concept

The functional safety concept is a high level plan that defines both the architecture being implemented and the safety goals necessary to ensure the system satisfies ISO 26262.

Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	Limit the oscillation torque from the LDW system
Safety_Goal_02	Create a response time window to prevent the LKA system from responding too late

Safety_Goal_03	Alert driver by other means (audible or visual) when LDW cannot detect lane lines
Safety_Goal_04	Alert driver by other means (audible or visual) when LDW cannot detect lane lines

Preliminary Architecture

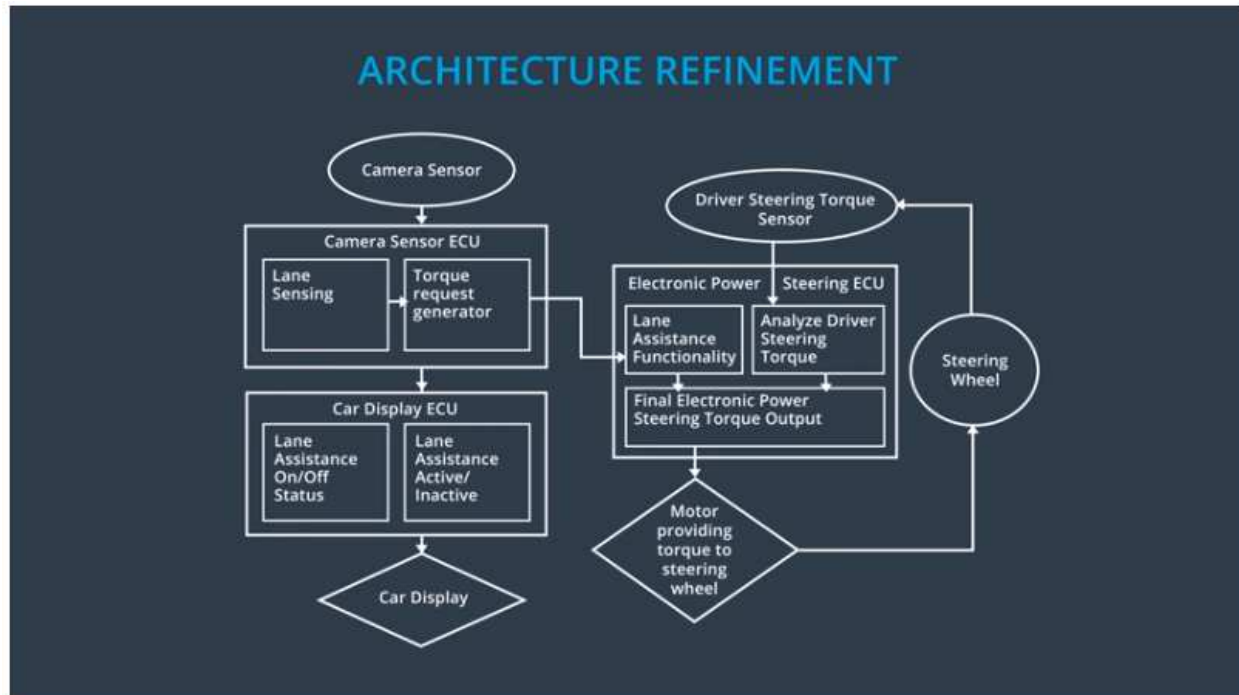


Figure 1 – System Architecture

Description of architecture elements

The system can be broken down into main components as shown in figure 1, defined as:

Element	Description
Camera Sensor	Camera device that retrieves images of the road in front of the vehicle
Camera Sensor ECU	Device which interfaces with camera, steering ECU, and camera display. It is also the processor of the image and interprets the road images with computer vision algorithms to determine the vehicles position relative to the road.

Car Display ECU	An informative display to display the road lines and their orientation, display warning and alert messages, and is the primary GUI for the vehicle operator.
Car Display	Controller for the camera display. Receives information from the camera ECU regarding the road line positions and any error or warning messages necessary to indicate.
Driver Steering Torque Sensor	A sensor that measures that amount of effort the driver is making to steer the vehicle. This is important so that we do not interfere with intentional steering commands from the driver and impede his ability to control the vehicle.
Electronic Power Steering ECU	The controller of steering assist motor. It takes input from the camera ECU and steering torque sensor and determines how much of a torque correction, if any, is necessary to correct the current vehicle path.
Motor	The actuator that directly influences the steering of the vehicle. It receives its command from the power steering 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

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	NO	Systems fails to alert the driver about unintentional lane departure

Malfunction_02	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	LESS	Driver fails to notice alert regarding unintentional lane departure
Malfunction_03	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	LATE	LKA fails to correct the vehicle trajectory, possibly sending it on a worse trajectory
Malfunction_04	Lane Departure Warning (LDW) function shall apply an oscillating steering torque to provide the driver a haptic feedback	LATE	Systems fails to alert the driver about unintentional lane departure in sufficient time to correct
Malfunction_05	Lane Keeping Assistance (LKA) function shall apply the steering torque when active in order to stay in ego lane	NO	LKA fails to prevent an unintentional vehicle lane departure

Functional Safety Requirements

Lane Departure Warning (LDW) Requirements:

ID	Functional Safety Requirement	A S I L	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 01-01	Apply limits to frequency and magnitude of haptic feedback to steering wheel to prevent interference with driver control	D	100 ms	LDW Disabled with visual indication
Functional Safety	Provide a visual indication when the system is enabled but not able to detect the road	Q M	500 ms	LDW Disabled with visual

Requirement 01-02	lanes and correct vehicle position			indication
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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	Perform controlled study with multiple drivers to determine thresholds for noticeable feedback and feedback that interferes with driver control	Verify that in conditions are established limits exceeded
Functional Safety Requirement 01-02	Perform study for best means of indication to a driver that the LDW system fails to detect road lane	Verify that in any scenario where the road lane cannot be determine indication appears within a set time window

Lane Keeping Assistance (LKA) Requirements:

ID	Functional Safety Requirement	ASIL	Fault Tolerant Time Interval	Safe State
Functional Safety Requirement 02-01	Create a response window that if a torque command is not executed within a set time the system disables	C	100 ms	LKA Disabled with visual indication
Functional Safety Requirement 02-02	Provide a visual indication when the system is enabled but not able to detect the road lanes and correct vehicle position	QM	500 ms	LKA Disabled with visual indication

Lane Keeping Assistance (LKA) Verification and Validation Acceptance Criteria:

ID	Validation Acceptance Criteria and Method	Verification Acceptance Criteria and Method
Functional Safety Requirement	Evaluate typical controller response time and tuning to determine what an acceptable response time is.	Verify that the actuator will always be disabled if it doesn't respond to the time within that window

02-01		
Functional Safety Requirement 02-02	Perform study for best means of indication to a driver that the LDW system fails to detect road lane	Verify that in any scenario where the road lane cannot be determine indication appears within a set time window

Refinement of the System Architecture

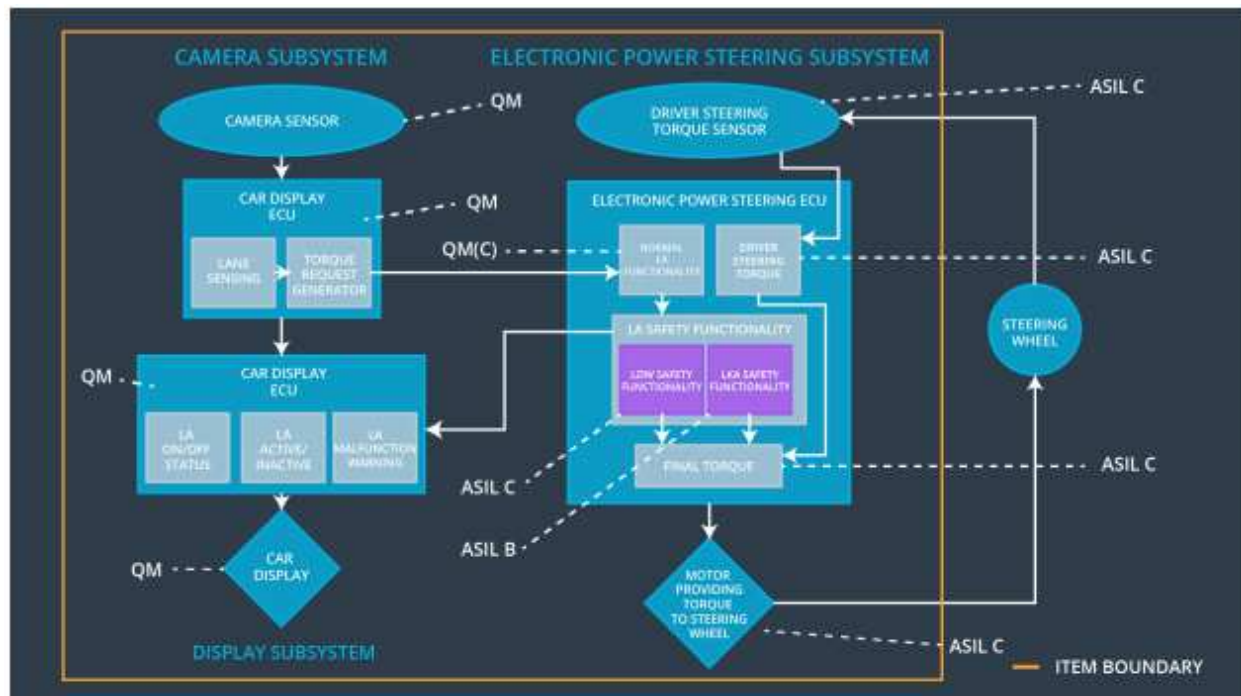


Figure 2 – Detailed system architecture with ASIL ratings

Allocation of Functional Safety Requirements to Architecture Elements

ID	Functional Safety Requirement	Electronic Power Steering ECU	Camera ECU	Car Display ECU
Functional Safety Requirement 01-01	Apply limits to frequency and magnitude of haptic feedback to steering wheel to prevent interference with driver control	X		X

Functional Safety Requirement 01-02	Provide a visual indication when the system is enabled but not able to detect the road lanes and correct vehicle position		X	X
Functional Safety Requirement 02-01	Evaluate typical controller response time and tuning to determine what an acceptable response time is.	X		X
Functional Safety Requirement 02-02	Perform study for best means of indication to a driver that the LDW system fails to detect road lane		X	X

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Disable LDW and alert	Malfunction_01	Yes	Driver indication of fault in LDW system
WDC-02	Disable LDW and alert	Malfunction_02	Yes	Driver indication of fault in LDW system
WDC-03	Disable LKA and alert	Malfunction_03	Yes	Driver indication of fault in LKA system
WDC-04	Disable LDW and alert	Malfunction_04	Yes	Driver indication of fault in LDW system
WDC-05	Disable LKA and alert	Malfunction_05	Yes	Driver indication of fault in LKA system