Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
2018-6-29	1.0	XU Kuangzheng	Initial version
2018-6-29	2.0	XU Kuangzheng	Second Version

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Purpose of the Functional Safety Concept

The purpose of a functional safety concept is to identify new requirements and allocate these requirements to system diagrams in a high level. It describes high-level performance requirements, addressing all issues identified from HARA.
In functional safety, "concept" is synonymous with "document". So the warning and degradation concept would be a document that discusses:

- How the driver will be warned of a malfunction.
- What the system will do to "degrade" the functionality i.e. take the system to a safe state and also recover from a safe state.

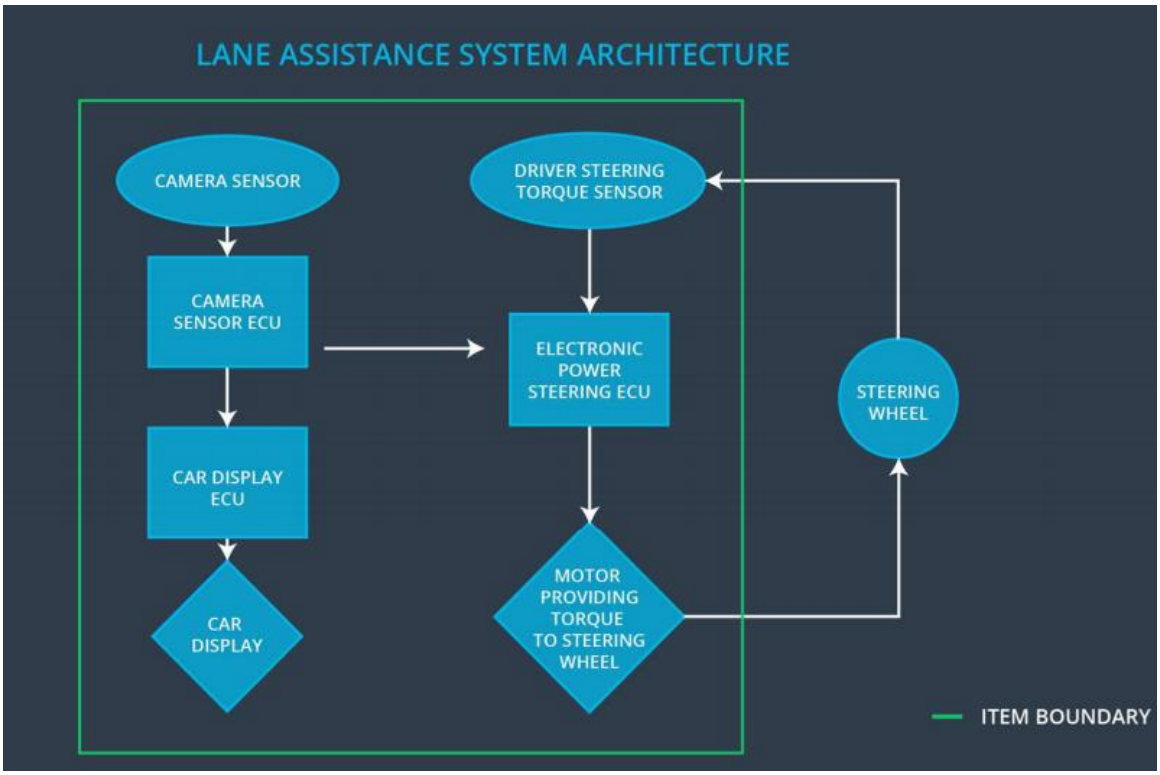
Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

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.

Safety_Goal_03	Alert driver by other means (audible or visual) when LDW cannot detect lane lines.
Safety_Goal_04	The LDW function shall deactivate when the camera sensor is unable to detect road markings, and shall warn the driver of its deactivation.
Safety_Goal_05	The LKA system should check if the Electronic Power Steering ECU is functioning and give warning to driver if it stops working.

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	Camera device that retrieves images of the road in front of the vehicle.
Camera Sensor ECU	The camera sensor ECU identifies when the vehicle has accidentally departed its lane and sends the appropriate messages to the Car Display ECU and the Electronic Power Steering ECU.

Car Display	Graphic interface used to display the warning messages.
Car Display ECU	Processes input from camera subsystem and display the messages on the Car Display.
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	Vibrates the steering wheel when vehicle is drifting away from the current lane unintentionally. Add appropriate amount of torque based on feedback from torque sensor to keep vehicle in current lane.
Motor	Actuator used to apply requested torque to 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

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

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 subsystem shall ensure that the oscillating torque amplitude is less than Max_Torque_Amplitude	C	50MS	Set LDW system torque 0 and visual indication
Functional Safety Requirement 01-02	The electronic power steering subsystem shall ensure that the oscillating torque frequency is less than Max_Torque_Frequency	C	50MS	Set LDW system torque 0 and visual indication

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	Verify that 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 amplitudes to prove that we chose an appropriate value	Verify that when the torque frequency crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval

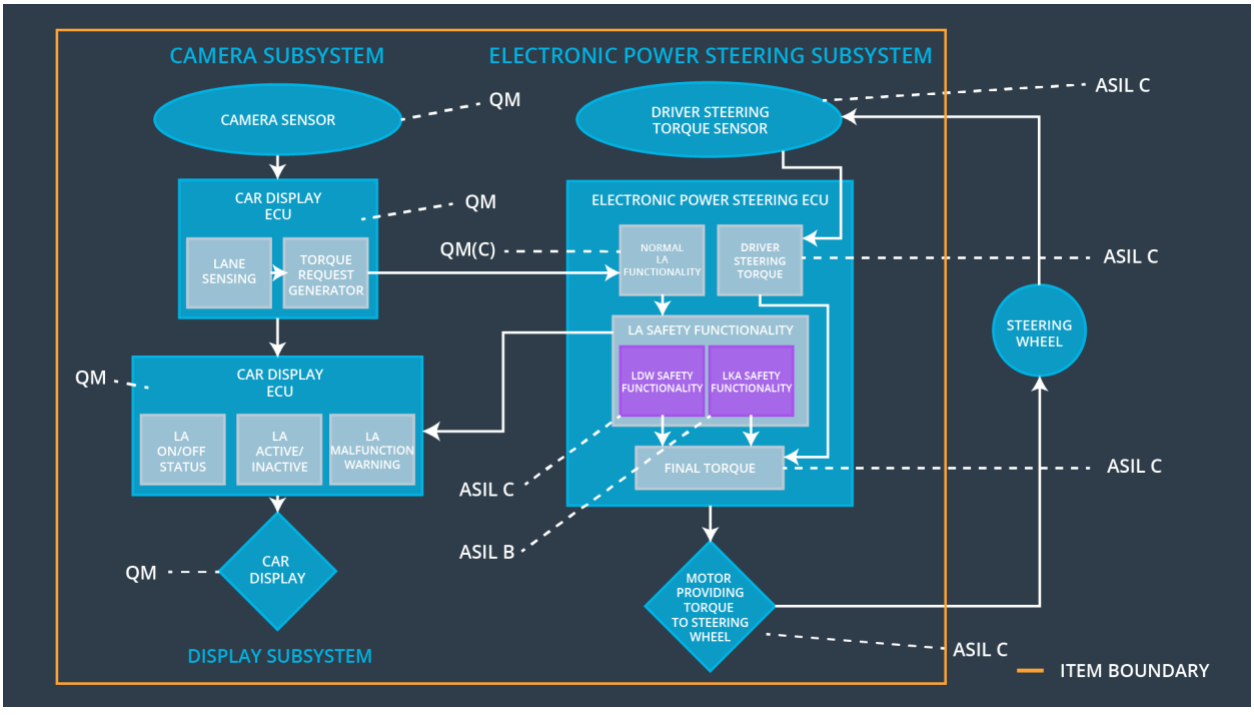
Lane Keeping Assistance (LKA) Requirements:

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	LKA torque is zero.

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	Confirm that the selected max_duration dissuades drivers from taking their hands off the wheel.	Verify that the system really does turn off if the lane keeping assistance every exceeded Max_Duration

Refinement of the System Architecture



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	The electronic power steering ECU shall ensure that the oscillating torque amplitude is below Max_Torque_Amplitude	√		
Functional Safety Requirement 01-02	The electronic power steering ECU shall ensure that the oscillating torque amplitude 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 for only Max_Duration	√		

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Disable LDW and alert	Oscillating torque frequency is higher than Max_Torque_Frequency or torque is higher than Max_Torque_Amplitude	YES	Driver indication of fault in LDW system
WDC-02	Disable LKA and alert	Lane keeping assistance torque is applied for more than Max_Duration	YES	Driver indication of fault in LKA system
WDC-03	Turn off functionality.	The lane departure warning function	Yes	

		applies an oscillating torque with very high torque frequency (above limit).		