Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

Document Version: [Version]

Template Version 1.0, Released on 2017-06-21

Document history

Date	Version	Editor	Description
23rd May, 2019	1.0	Microsoft Word	Initial Version of Functional Safety Concept

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Purpose of the Functional Safety Concept

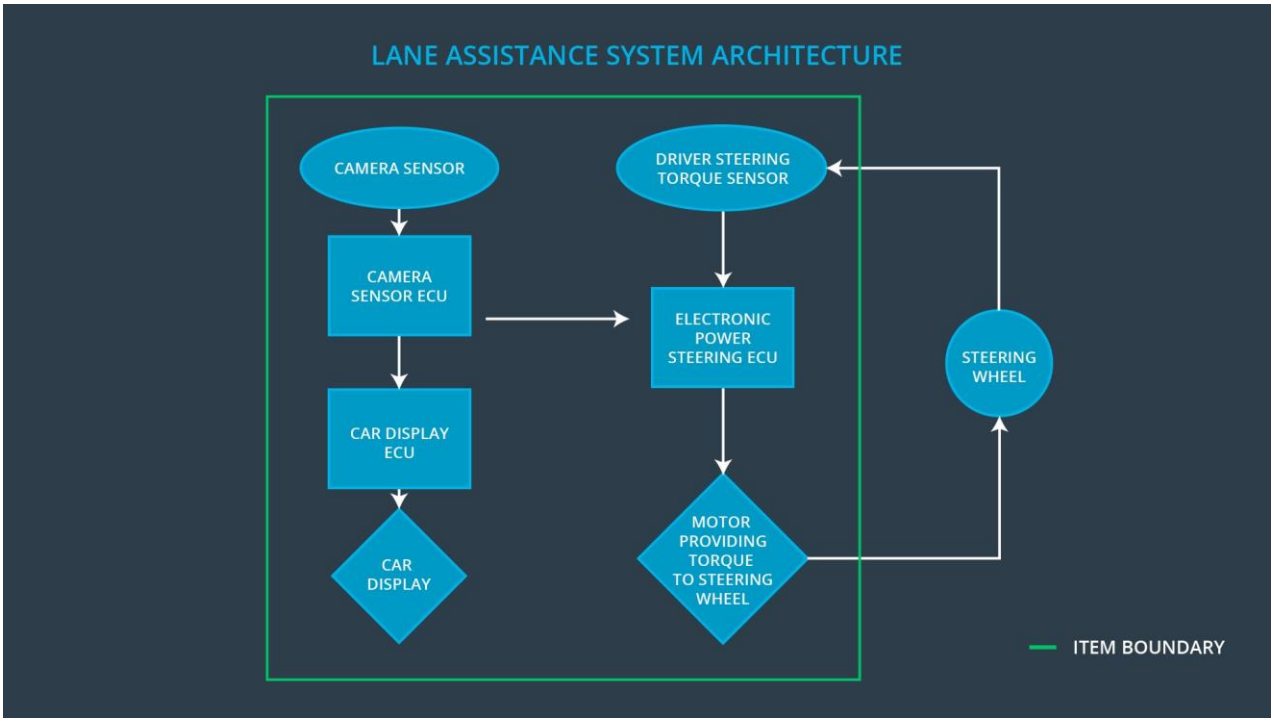
We need to consider what subsystems contain high levels of risk and what's needed to prevent accidents. Looking at the item's architectural design, we'll figure out what subsystems can be used to meet safety goals. We'll need to refine the high-level safety goals into what's called functional safety requirements. Each functional safety requirement is then allocated to it's appropriate place in the item architecture. All this information is taken and put into a document called the functional safety concept.

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 system 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



Description of architecture elements

Element	Description
Camera Sensor	Lane sensing
Camera Sensor ECU	Determine if the car is leaving the lane and if so, send a vibrational torque request to the power steering ECU

Car Display	Displaying whether the lane keeping assistance function is on/off; Displaying whether the lane departure warning function is activated
Car Display ECU	Receives signals from the camera ECU if either of the functions have been activated
Driver Steering Torque Sensor	Senses how much torque is already being applied to the steering wheel.
Electronic Power Steering ECU	Receives the vibrational torque request from the camera ECU. Computes the residual torque needed to be applied after taking into account the input from the torque sensor. Sends the torque output request to the motor
Motor	Actually applies the torque to the steering wheel in order to keep the car in the current lane

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 ECU shall ensure that the lane departure warning oscillating torque amplitude is below Max_Torque_Amplitude	C	50ms	Lane Departure warning function is not activated
Functional Safety Requirement 01-02	The electronic power steering ECU shall ensure that the lane departure warning oscillating torque frequency is below Max_Torque_Frequency	C	50ms	Lane Departure warning function is not activated

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	For whatever value we end up choosing for the max torque amplitude, we need to **validate** that we chose a reasonable value. We would need to test how	When the torque amplitude crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval.
	drivers react to different torque	
	amplitudes to prove that we chose an	
	appropriate value.	
Functional Safety Requirement 01-02	For whatever value we end up choosing for the max torque frequency, we need to **validate** that we chose a reasonable value. We would need to test how	When the torque frequency crosses the limit, the lane assistance output is set to zero within the 50 ms fault tolerant time interval.
	drivers react to different torque	
	frequencies to prove that we chose an	
	appropriate value.	

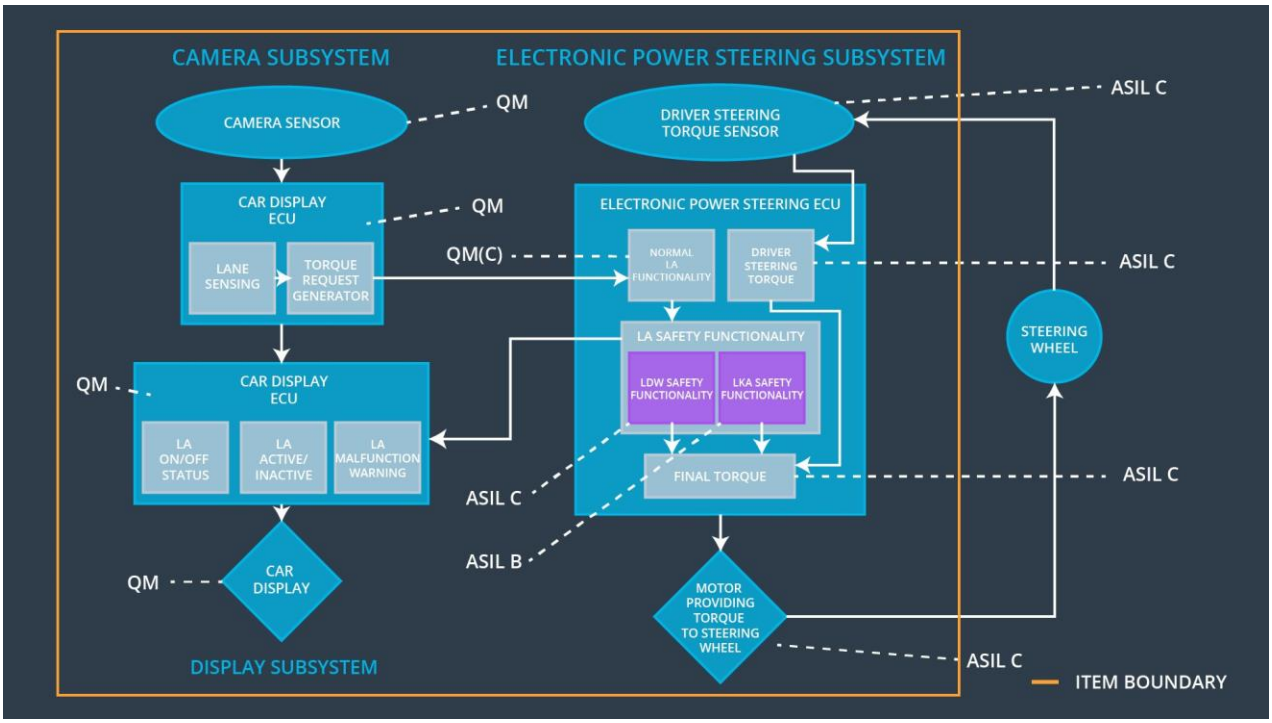
Lane Keeping Assistance (LKA) Requirements:

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	Lane Keeping assistance system is not activated

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	Validate that the max_duration chosen really did dissuade drivers from taking their hands off the wheel.	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 lane departure warning oscillating torque amplitude is below Max_Torque_Amplitude	**YES**	**NO**	**NO**

Functional Safety Requirement 01-02	The electronic power steering ECU shall ensure that the lane departure warning oscillating torque frequency is below Max_Torque_Frequency	**YES**	**NO**	**NO**
Functional Safety Requirement 02-01	The electronic power steering ECU shall ensure that the lane keeping assistance torque is applied for only Max_Duration	**YES**	**NO**	**NO**

Warning and Degradation Concept

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn off functionality	The malfunction of the steering wheel vibrating too much	Yes	Warning light on the dashboard
WDC-02	Turn off functionality	The malfunction of the lane keeping assistance function being applied for too long	Yes	Warning light on the dashboard