Elektrobit

UDACITY

Functional Safety Concept Lane Assistance

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Document history

Date	Version	Editor	Description
3/3/18	0.1	Ken Overholt	Initial draft
3/7/18	0.2	Ken Overholt	Candidate for final submission
3/8/18	1.0	Ken Overholt	Final Release

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Purpose of the Functional Safety Concept

The safety goals are refined into functional safety requirements which are then allocated to the relevant parts of the system diagram where they will be implemented. This allocation may involve expanding the system architecture with new element blocks.

Next, the system architecture is refined to handle the new requirements. Each functional safety requirement will have the following attributed defined:

1. ASIL level
2. Fault tolerant time interval
3. Safe state

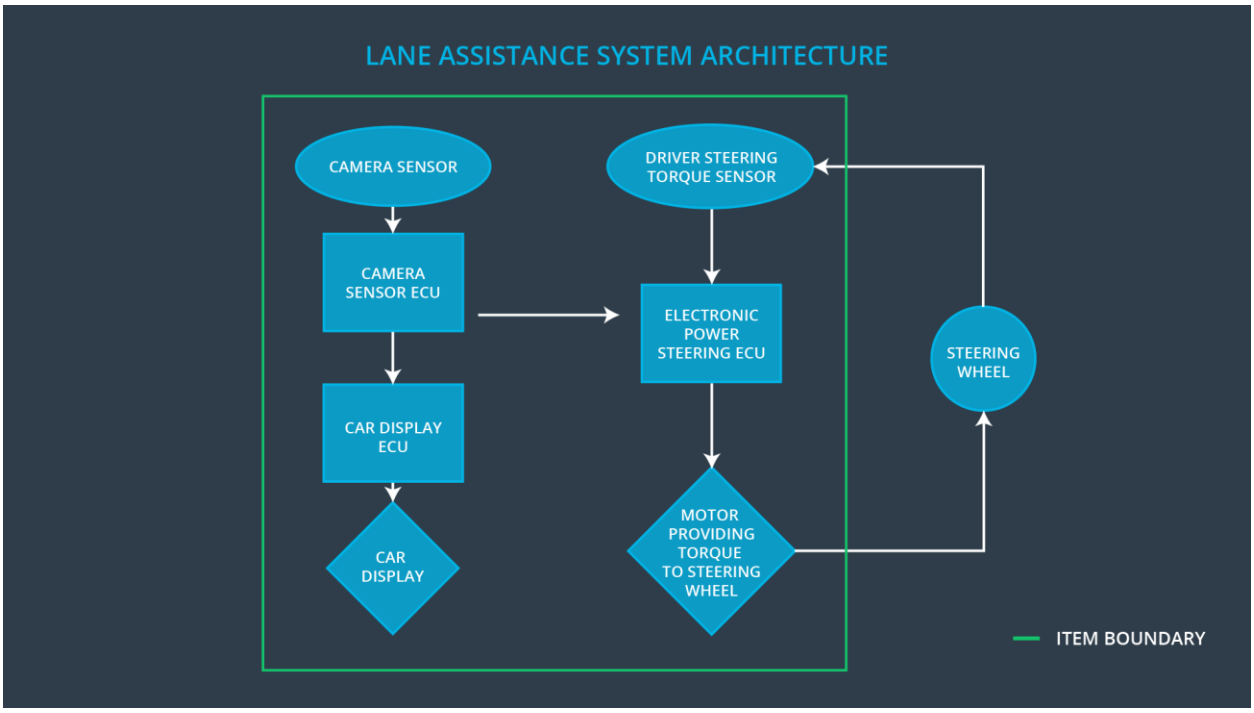
The purpose of the functional safety concept is to document all of this information.

Inputs to the Functional Safety Concept

Safety goals from the Hazard Analysis and Risk Assessment

ID	Safety Goal
Safety_Goal_01	The oscillating torque to the steering wheel 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 internal so that the driver cannot misuse the system for autonomous driving.

Preliminary Architecture



Description of architecture elements

Element	Description
Camera Sensor	The Camera Sensor reads in images from the road.
Camera Sensor ECU	The Camera Sensor ECU identifies when the vehicle has accidentally departed its lane and sends the appropriate torque request to the Electronic Power Steering ECU as well as sending a message to the Car Display ECU.
Car Display	The Car Display shows a sign in indicating the car has veered from its lane.
Car Display ECU	The Car Display ECU controls a light that tells the driver if the Lane Keeping system is on or off. It also controls a light that tells the driver that the Lane Departure Warning is activated.
Driver Steering Torque Sensor	The Driver Steering Torque Sensor detects how much the driver is turning the steering wheel, receive the torque request from the Camera subsystem, and add these two torque values together to output a final torque request to the motor.

Electronic Power Steering ECU	The Electronic Power Steering ECU controls the power steering system.
Motor	The motor receives the torque request from the Driver Steering Torque Sensor and moves 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

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	50 ms	No torque is being applied
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	50 ms	No torque is being applied

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 and frequencies to prove that we chose an appropriate value.	Perform a software test inserting a fault into the system causing the Max_Torque_Amplitude value to cross the limit verify the torque drops to 0 and see what happens.
Functional Safety Requirement 01-02	Test how drivers react to different torque amplitudes and frequencies to prove that we chose an appropriate value.	Perform a software test inserting a fault into the system causing the Max_Torque_Frequency value to cross the limit verify the torque drops to 0 and see what happens.

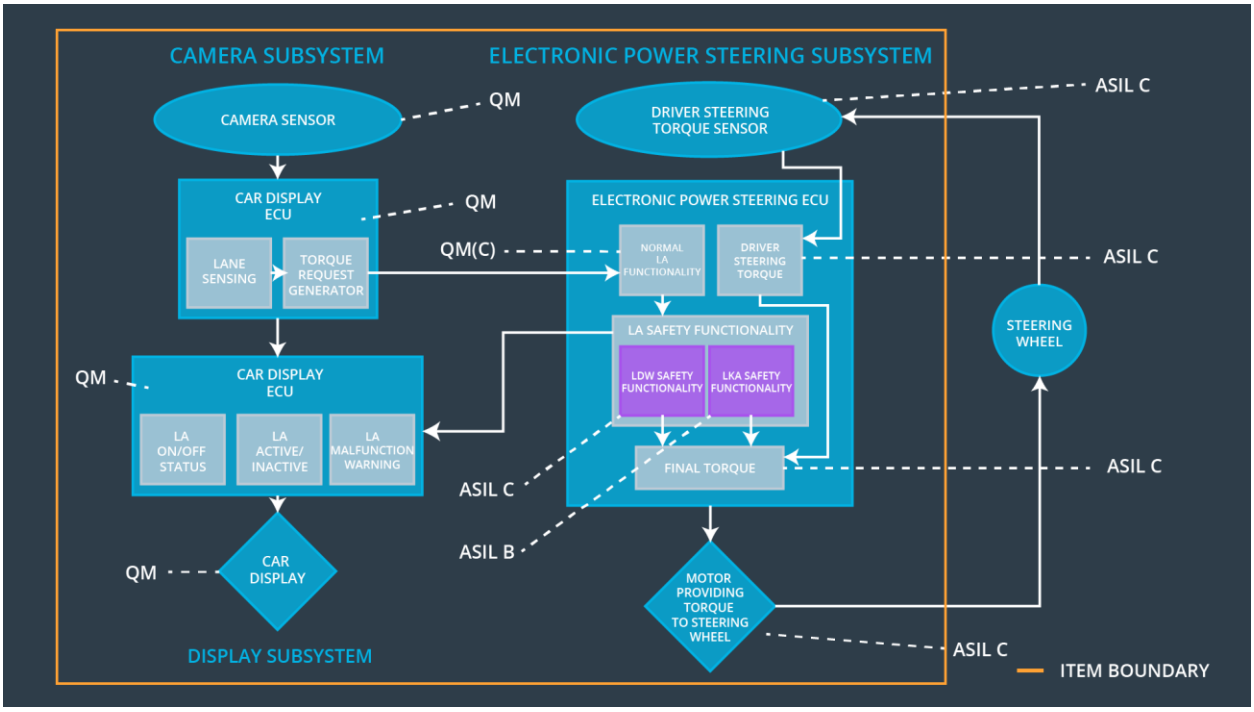
Lane Keeping Assistance (LKA) Requirements:

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

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	Test and validate that the Max_Duration chosen really did dissuade 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 lane departure warning 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 warning oscilating 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

ID	Degradation Mode	Trigger for Degradation Mode	Safe State invoked?	Driver Warning
WDC-01	Turn off the functionality	lane departure warning function applies an oscillating torque with very high torque frequency and amplitude	Yes	The owner's manual will state that the feature will be turned off if it becomes too forceful. The driver will see a warning light on the dashboard when the system malfunctions.

WDC-02	Turn off the functionality	Oscillating torque has reached the max_duration value	Yes	The owner's manual will state that the vehicle is not to be used for autonomous driving and that this feature will only be active for a short period before turning off. The driver will see a warning light on the dashboard when the lane keeping assistance is activated and it will disappear when not activated.