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1 Introduction

This document explains the pattern for architecture of the Vehicle Motion Control Interface and its software components, as well as the design decisions that leads to an update of the Application Interface within Chassis Domain, as depicted in Figure 1.1.

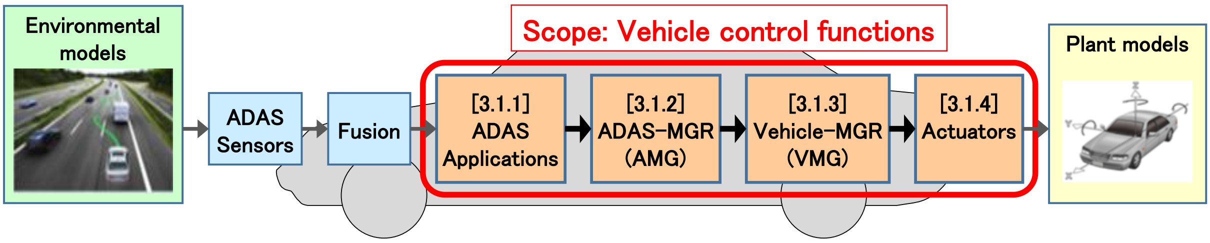

Figure 1.1: Scope of this document

The scope of the vehicle control functions in this document is "Implementation of ADAS requirements" only. The document will focus on a recommended signal cascading architecture for ADAS function (particularly for ACC, AEB and LKA functions), for which new SW-Components will be created. For other chassis components, including vehicle stabilization controls (ABS/TCS, etc.), refer to [1, AUTOSAR_EXP_AIChassis].

The purpose of defining the architecture (functional structure, I/F) in this document is to improve customer convenience in function development and development efficiency in no-competitive areas by achieving the ease of function update change, the ease of design and verification and the ease of mutual understanding.

2 Description of Terms and Concepts

This document refers to the formulation of unified Application Interfaces of the Domain Chassis in the frame of a specific pattern implementation of Advanced Driver Assistance Systems (ADAS) with a specific Vehicle Motion Control interface. The results of the Domain Chassis shall be aligned with the other domains, e.g. Body, Powertrain, Occupant and Pedestrian Safety. The Application Interface Table represents a good basis for this alignment and detection of conflicts.

2.1 Axis System

The standard coordinate system used by the Chassis Domain refers to the International Standard [2, ISO 8855]. Whether a fixed geometry point (e.g. near to the average Centre of Gravity (CoG) of all variants of a vehicle type) is used as a reference point for basic Centre of Gravity has to be decided on project level.

2.2 Definitions

2.2.1 Centre of gravity of passenger car

The car's chassis-fixed coordinate system's origin lies in the middle of the Front Axle (FA) see Figure 2.1. The car's Centre of gravity is defined as the origin of a chassis-free coordinate-system that is positioned relative to the FA co-ordinate system. The orientations of both these co-ordinate systems' axes are defined as follows:

With the car moving forward:

- x is positive to the front of the car
- y is positive to the left of the car
- z is positive to the top of the car
- Roll is positive in a left-hand bend, when the car body tips to the right-hand side
- Pitch is positive when a car is braking and the car body tips forward
- Yaw is positive in a left-hand bend

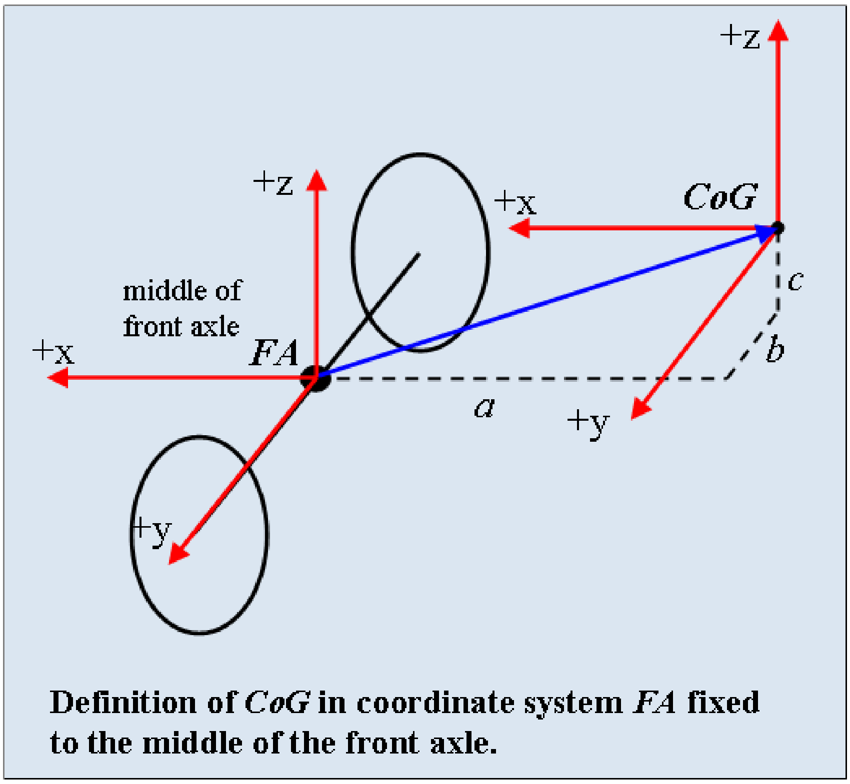

Figure 2.1: Definition of a car's Centre of Gravity (CoG)

2.2.2 Polar coordinate system

The polar coordinate system is defined as follows:

- With the vehicle moving forward, ϕ is positive in the counter clockwise direction

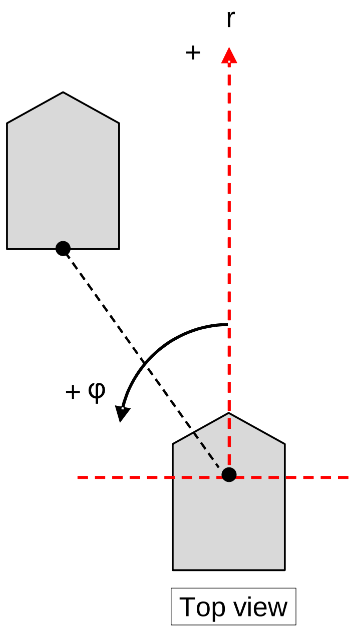

Figure 2.2: Polar coordinates system

2.2.3 Vehicle acceleration/propulsive force direction

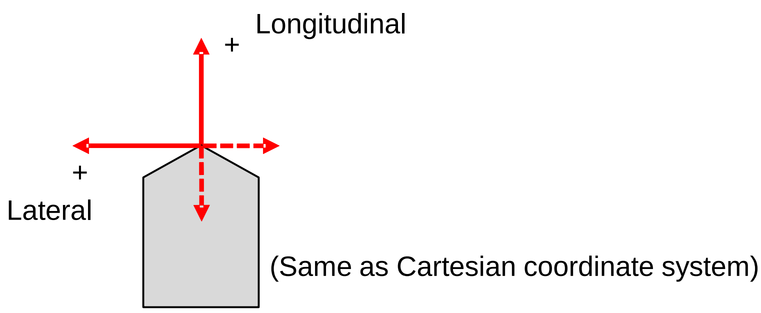

Figure 2.3: Plus, or minus sign of vehicle acceleration/propulsive force

Deceleration is expressed as negative value.

2.2.4 Cant direction

Figure 2.4: Plus, or minus sign of cant

2.2.5 Steering wheel angle

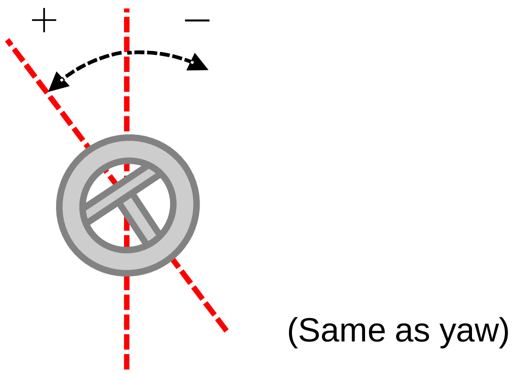

Figure 2.5: Plus, or minus sign of steering wheel angle

2.2.6 Road Variables

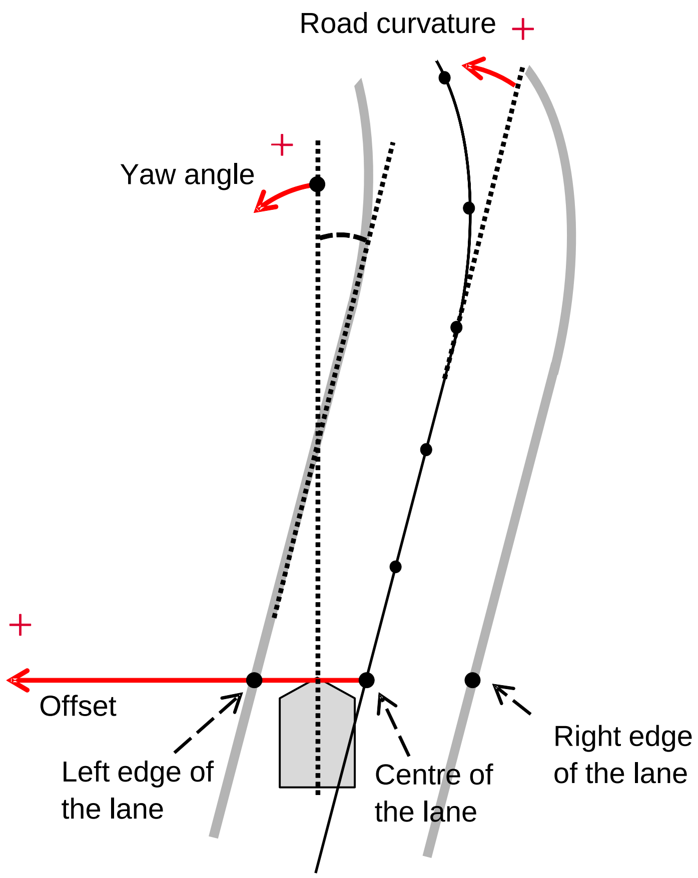

Figure 2.6: Variables of road

2.2.7 Definition of the car surroundings

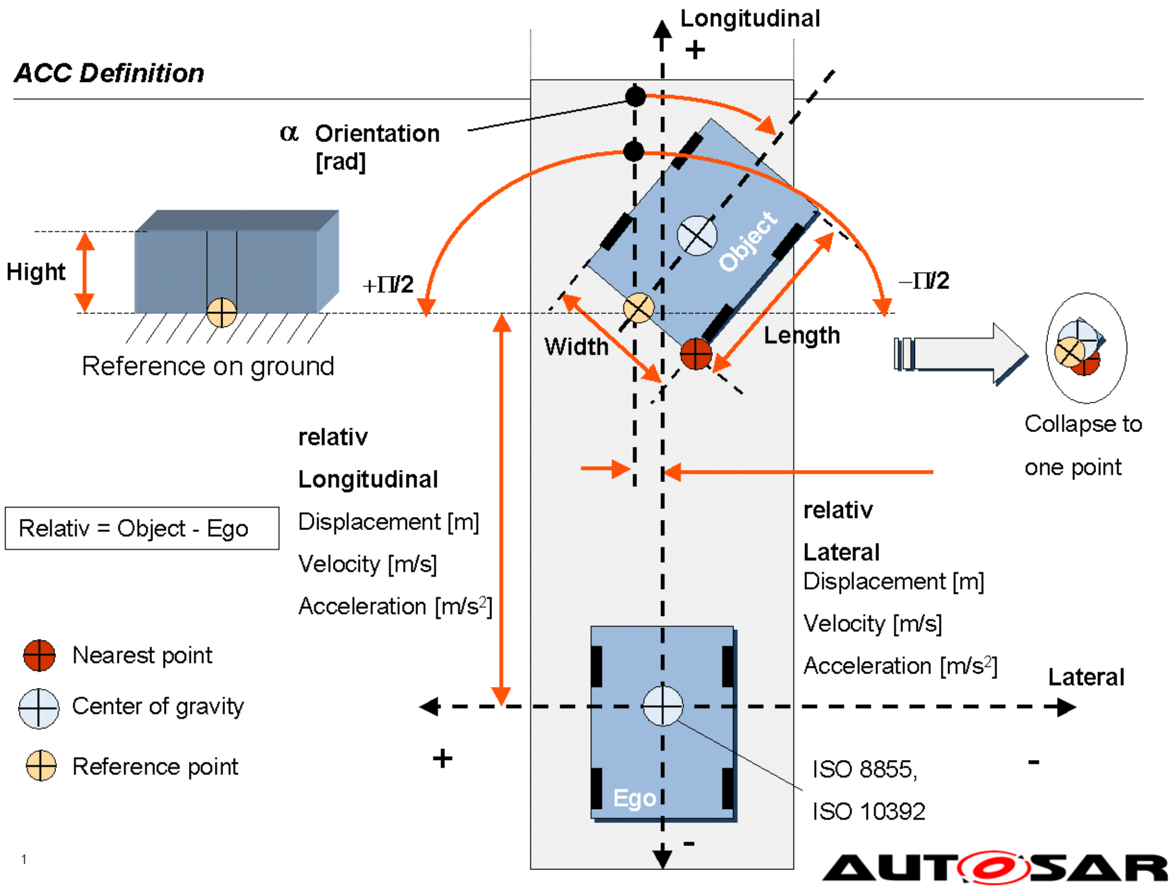

Figure 2.7: Definition of car surrounding for ACC

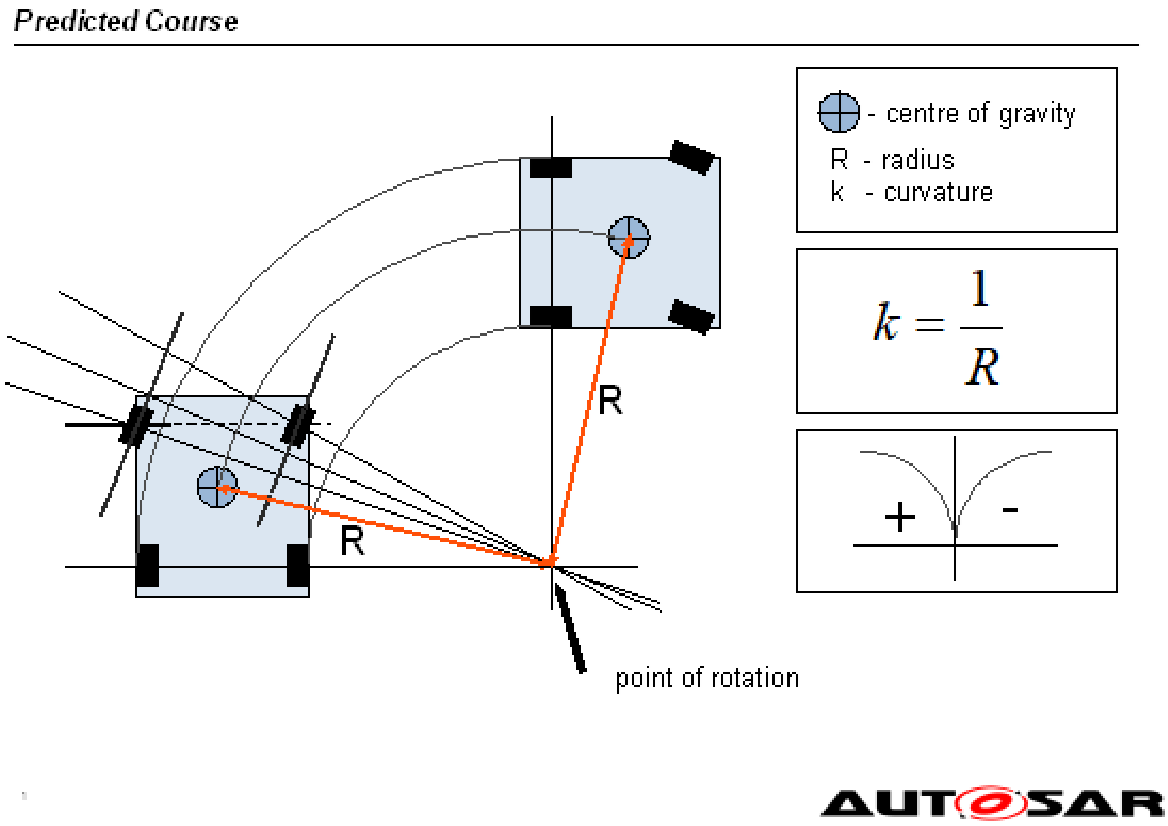

Figure 2.8: Definition of predicted course

2.3 Acronyms and Abbreviations

Please also refer to [3, AUTOSAR_TR_Glossary] for explanation of commonly used terms and abbreviations within AUTOSAR.

Abbreviation / Acronym:	**Description:**
ABS	Antilock Braking System
ACC	Adaptive Cruise Control
ACL	Acceleration
ACT	Actuator
ADAS	Advance Driver Assistance System
AEB	Autonomous Emergency Braking
BAS	Brake Assist
BRK	Brake
BRWS	Basic Rear Wheel Steering
BSTS	Basic Steering Torque Superposition
BSAS	Basic Steering Angle Superposition
CBC	Cornering Brake Control
CoG	Centre of Gravity
DAS	Driver Assistance System
DTC	Regulation of the Drag Torque
EBD	Electronic Brake Force Distribution
ECU	Electronic Control Unit
EPB	Electronic Parking Brake
ESC	Electronic Stability Control
FA	Front Axle
HDC	Hill Decent Control
HHC	Hill Hold Control
HMI	Human Machine Interface
HW	Hardware
I/F	Interface
LKA	Lane Keep Assist
MGR	Manager
NVH	Noise, Vibration, Harshness
OEM	Original Equipment Manufacturer
PT	Powertrain
RA	Rear Axle
RSC	Roll Stability Control
SR	Situation Recognition
SSM	Stand Still Manager/Management
STR	Steering
SW	Software
SW-C	Software Component
TCS	Traction Control System
VFB	Virtual Function Bus
VGR	Variable Gear Ratio
VLC	Vehicle Longitudinal Control
VM	Vehicle Model
VMC	Vehicle Motion Control
VSS	Vehicle State Sensors
YRC	Yaw Rate Control

2.4 General remarks

2.4.1 Limitations

This Explanatory is set to status "‘draft"’ in R20-11. Detail I/Fs are not defined.

The logical architectures proposed do not restrict the development or products of companies or organizations participating in AUTOSAR.

2.4.2 Sensor signals

In ADAS, signals of different processing levels are handled for I/F definition.

- Raw signal: Raw sensor data without pre-processing
- Pre-processed signal: Pre-processed sensor data. Abstraction of sensor hardware
- Fused signal: Several sensor signals are processed to generate a fused signal

Raw signals (raw data) should not be used as standard I/F because they are hardware dependent.

2.4.3 Functional Safety

Most ADAS domain signals are considered as relevant to safety. It is assumed that in this document, reliable methods of communication are available. No specification of communication methods is provided in this document.

Dynamic design and safety concepts are not considered in this document. In order to prove that the discussed use cases are safety compliant (in accordance with the definition of [4, ISO 26262], [5, ISO 21448], etc.), studies across all applicable domains will be necessary, and these must be performed at the project level.

2.4.4 Assumption for ADAS application

This document applies the architecture to three ADAS applications (ACC, AEB, and LKA) as a first version.

Assumptions for these three applications are shown below:

- ACC: Does not include the operating range of 30 km/h or less.
- AEB: Does not include restarting after stopping.
- LKA: Does not include the operating range of 65 km/h or less.

3 Related Documentation

[6, ”JASPAR Standards Document: ST-AVI-1”] is also used as a reference for this document.

[1] Explanation of Application Interfaces of the Chassis Domain
AUTOSAR_EXP_AIChassis

[2] ISO 8855:2011, Road vehicles – Vehicle dynamics and road-holding ability – Vocabulary
http://www.iso.org

[3] Glossary
AUTOSAR_TR_Glossary

[4] ISO 26262:2018 (all parts) – Road vehicles – Functional Safety
http://www.iso.org

[5] ISO/PAS 21448:2019 – Road vehicles – Safety of the intended functionality
http://www.iso.org

[6] JASPAR Standards Document: ST-AVI-1 – AD/ADAS Vehicle Control Interface Specification Ver. 1.0
https://www.jaspar.jp/en

4 Architecture Overview

4.1 Functional Structure

This document defines the vehicle control functions for ADAS in four layers. (Thick bordered frame in Figure 4.1).

1. ADAS Application
2. ADAS-MGR
3. Vehicle-MGR
4. Domain Actuators (+ related Domain Sensors)

A MGR layer is set for each ADAS and actuator system and the I/F between each layer is standardized in order to loosen the relationship between the ADAS applications and actuators, and reduce the effect that adding or changing functions for one element has on another. For example, the effect of adding or changing a function for the ADAS system can be absorbed in the ADAS-MGR layer. ADAS-MGR can communicate with Vehicle-MGR via the standardized I/F, which reduces the effects on subsequent functions. Also, it can make it easier to add and/or change actuators without drastically affecting the Vehicle-MGR; the reduction in interdependency can also simplify functional safety analysis of the system.

The whole ADAS architecture consists of the four layers above, ADAS sensor layer and fusion layer. Examples of ADAS sensors include vision sensors (e.g., camera), radar, and LiDAR. ADAS sensors monitor the vehicle surroundings and send raw signals (raw data) or pre-processed signals to the fusion layer. The fusion layer fuses signals from each sensor to recognize surrounding conditions. The recognition results are sent to the ADAS application layer.

This document does not cover ADAS sensors and fusion layers that do not have a direct I/F with vehicle control, as described in Figure 1.1. As a general rule, where possible, interaction between the actuators is avoided in the VMC architecture.

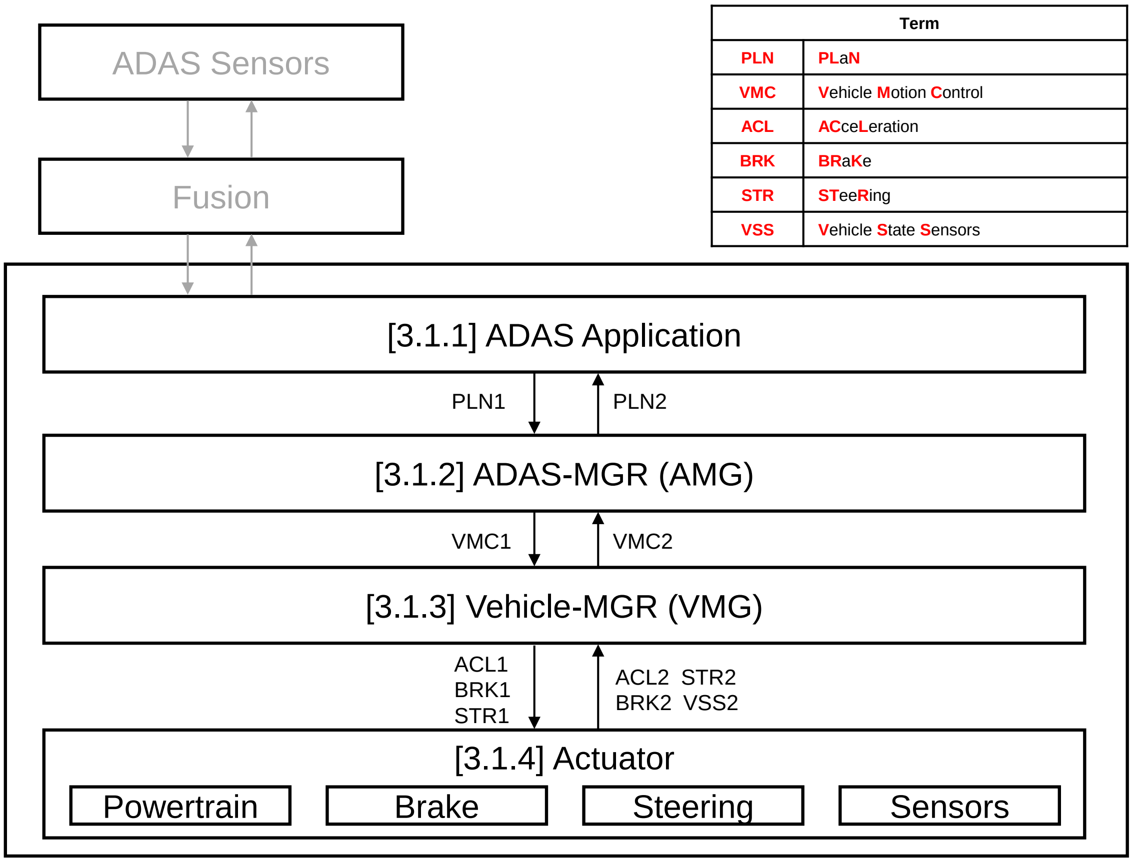

Figure 4.1: Functional architecture of vehicle control

Table 4.1 shows the main I/Fs between layers.

I/F	Explanation
ABS	Antilock Braking System
PLN1	I/F from ADAS application layer to ADAS-MGR layer
PLN2	I/F from ADAS-MGR layer to ADAS application layer
VMC1	I/F from ADAS-MGR layer to Vehicle-MGR layer
VMC2	I/F from Vehicle-MGR layer to ADAS-MGR layer
ACL1	I/F from Vehicle-MGR layer to Actuator layer (Powertrain)
ACL2	I/F from Actuator layer (Powertrain) to Vehicle-MGR layer
BRK1	I/F from Vehicle-MGR layer to Actuator layer (Brake)
BRK2	I/F from Actuator layer (Brake) to Vehicle-MGR layer
STR1	I/F from Vehicle-MGR layer to Actuator layer (Steering)
STR2	I/F from Actuator layer (Steering) to Vehicle-MGR layer
VSS2	I/F from Actuator layer (Sensor) to Vehicle-MGR layer

Table 4.1: Main I/Fs between layers

4.1.1 ADAS Application

The functions of the ADAS application are shown in Figure 4.2 and Table 4.2.

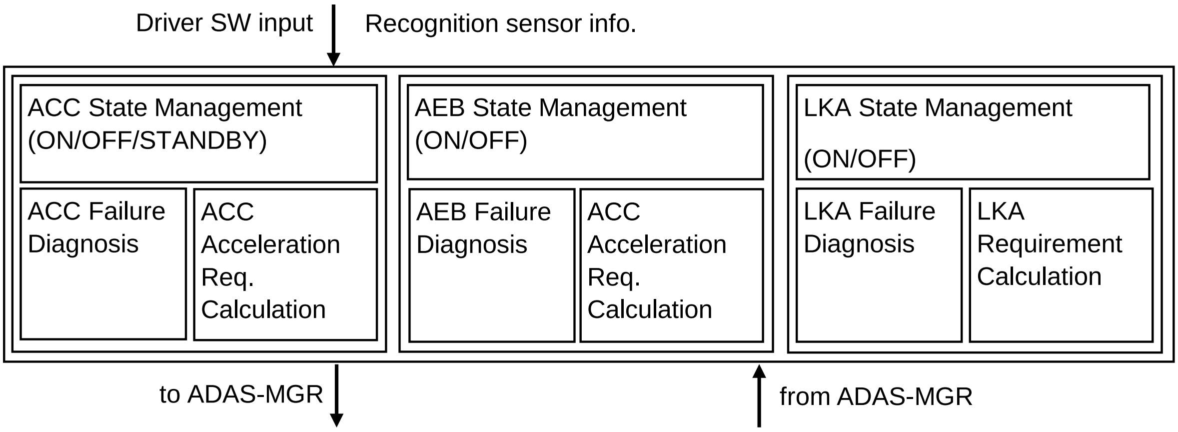

Figure 4.2: ADAS application functions

Function
Based on a driver assist request via a user interface, such as a switch and/or recognition sensor information, each ADAS application requests as individual kinematic plan (longitudinal acceleration/deceleration, etc.) for securing safety and/or comfort.
Each ADAS application performs failure detection and internal state management by itself.
Each ADAS application acts based on status of the ADAS application selected by ADAS-MGR.
**The external stop function is undecided and needs further discussion.* Each ADAS application act based on the external stop request.

Table 4.2: Functional description of ADAS Application

4.1.2 ADAS-MGR

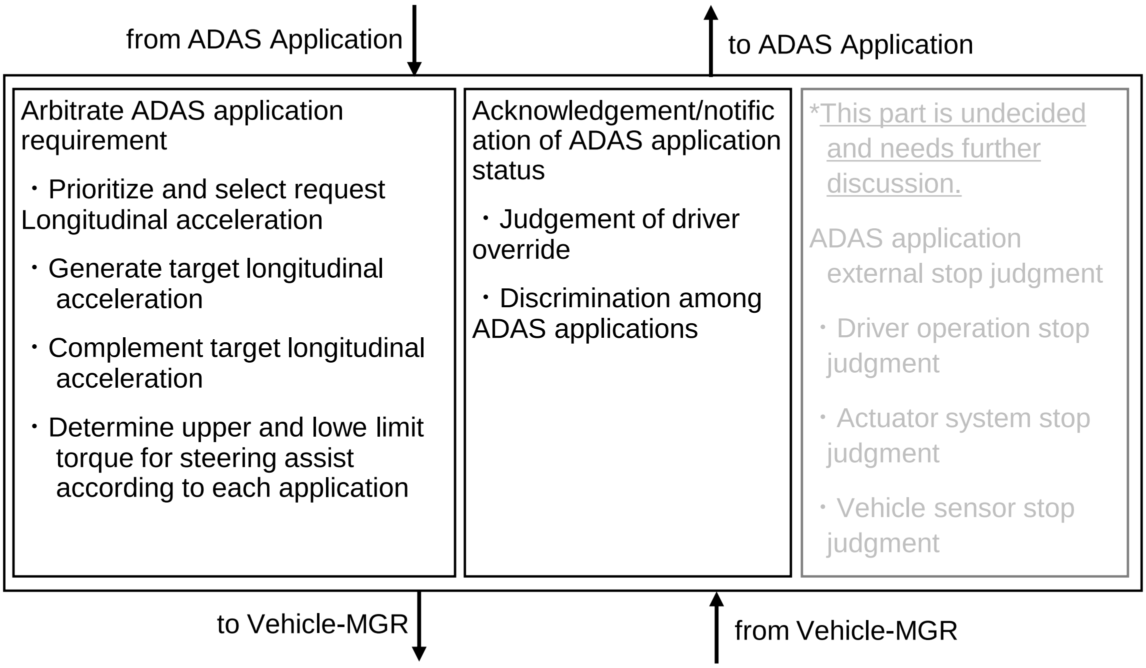

Figure 4.3: ADAS-MGR functions

Function
ADAS-MGR arbitrates individual requested kinematic plans from each ADAS application and integrates ADAS kinematic plan for securing safety and/or comfort.
ADAS-MGR requests Vehicle-MGR for arbitration mode of the requested kinematic plan (including preparations for the kinematic plan) and driver operations.
ADAS-MGR performs the driver override judgment based on the vehicle state, and informs each ADAS application of the results of arbitration of the kinematic plan request and the selected ADAS application.
**The external stop function is undecided and needs further discussion.* ADAS-MGR judge witch ADAS application cancel by witch level based on vehicle status and inform to each ADAS application *discussion need to be continued.

Table 4.3: Functional description of ADAS-MGR

4.1.3 Vehicle-MGR

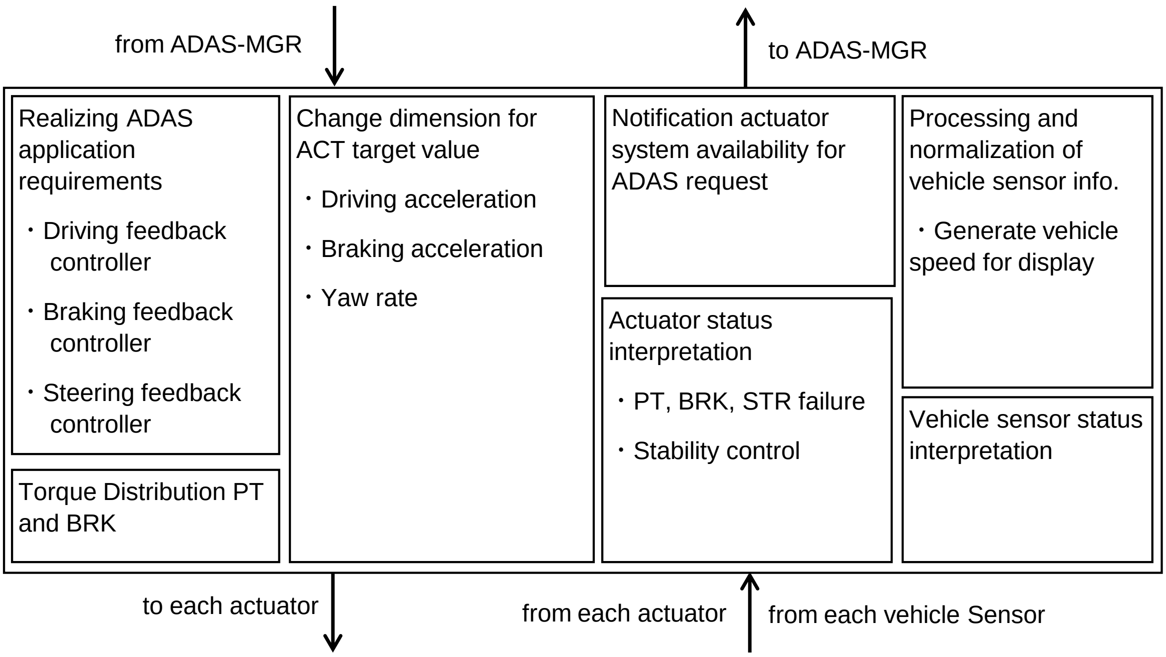

Figure 4.4: Vehicle-MGR functions

Function
Vehicle-MGR calculates/distributes the motion request (driving, braking, steering) for the actuator system in order to realize the kinematic plan requested by ADAS-MGR.
Vehicle-MGR requests each actuator for the arbitration mode between the motion request and driver operation request.
Vehicle-MGR informs ADAS-MGR of the vehicle status based on each actuator system status and momentum sensing information that have been processed if needed.

Table 4.4: Functional description of Vehicle-MGR

4.1.4 Actuator

Function
Actuator system realizes vehicle motion request (driving, braking, steering) based on driver operation.
Actuator system realizes vehicle motion request (driving, braking, steering) from Vehicle-MGR.
Each actuator system realizes vehicle motion request based on arbitration request from Vehicle-MGR.
Actuator system notifies Vehicle-MGR of ON/OFF information about driver operation (accelerator pedal, brake pedal, holding steering wheel).
Actuator system notifies Vehicle-MGR of status of actuator system (driving, braking, steering).
Actuator system notifies Vehicle-MGR of information about vehicle momentum.

Table 4.5: Functional description of actuator system

The actuator system consists of following sub-systems.

a) Powertrain

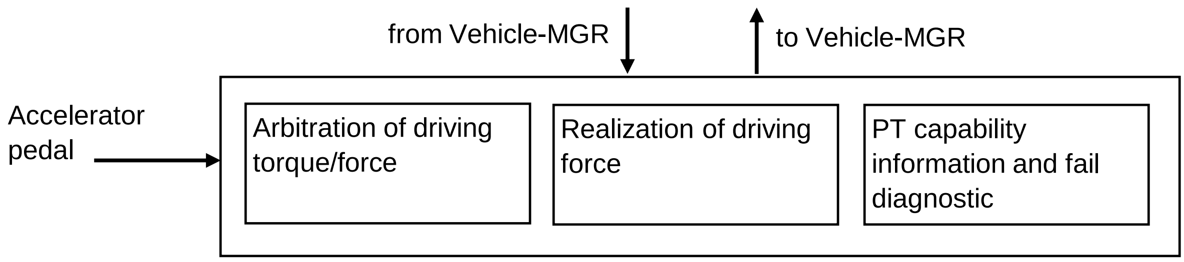

Figure 4.5: Powertrain system functions

b) Brake

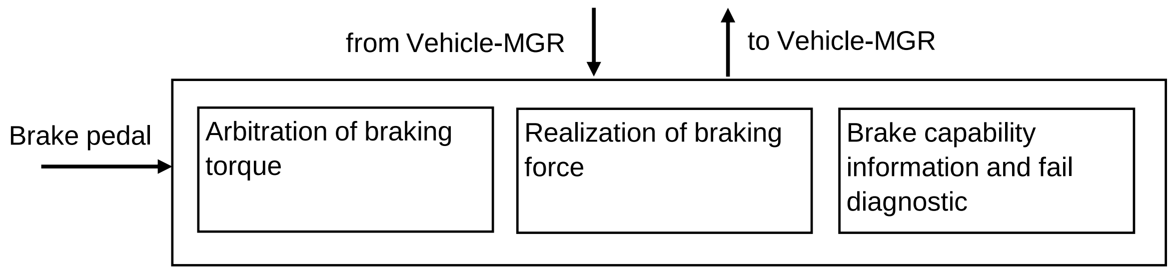

Figure 4.6: Brake system functions

c) Steering

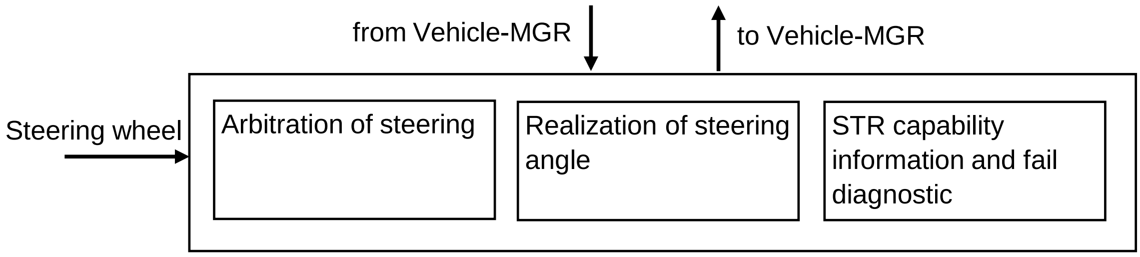

Figure 4.7: Steering system functions

4.2 Scalability

Use cases of applying this architecture to ACC, AEB, and LKA are shown below. The I/F or functions to be used can be selected to enable the scalability of this architecture even when combining multiple ADAS applications or adding applications in the future.

4.2.1 ACC

Figure 4.8 shows a use case that uses ACC only.

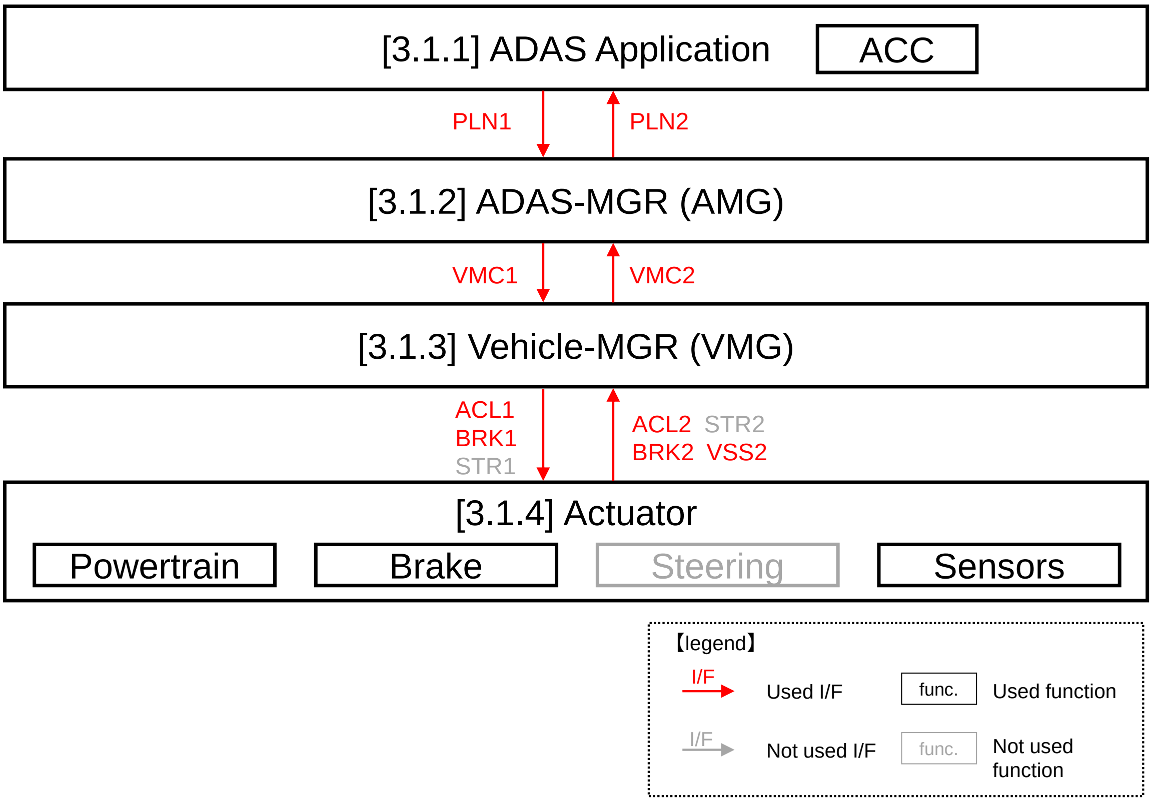

Figure 4.8: Use case: ACC

4.2.2 AEB

Figure 4.9 shows a use case that uses AEB only.

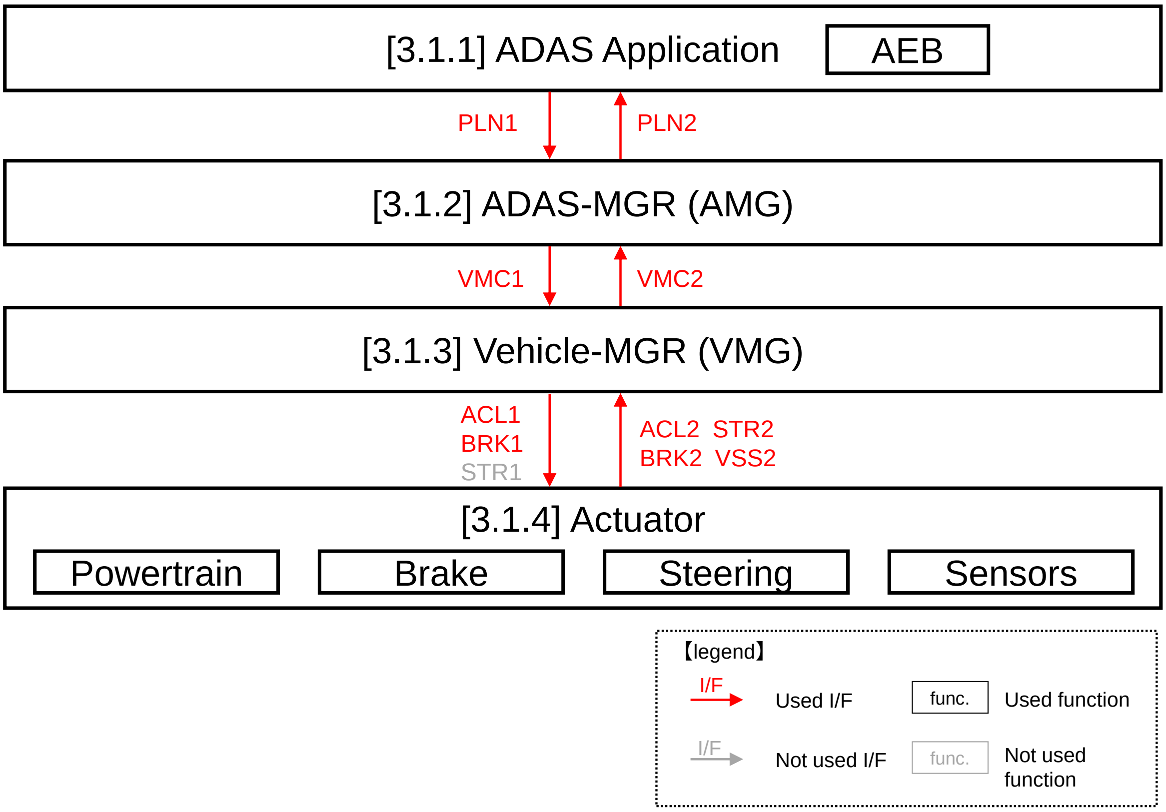

Figure 4.9: Use case: AEB

4.2.3 LKA

Figure 4.10 shows a use case that uses LKA only.

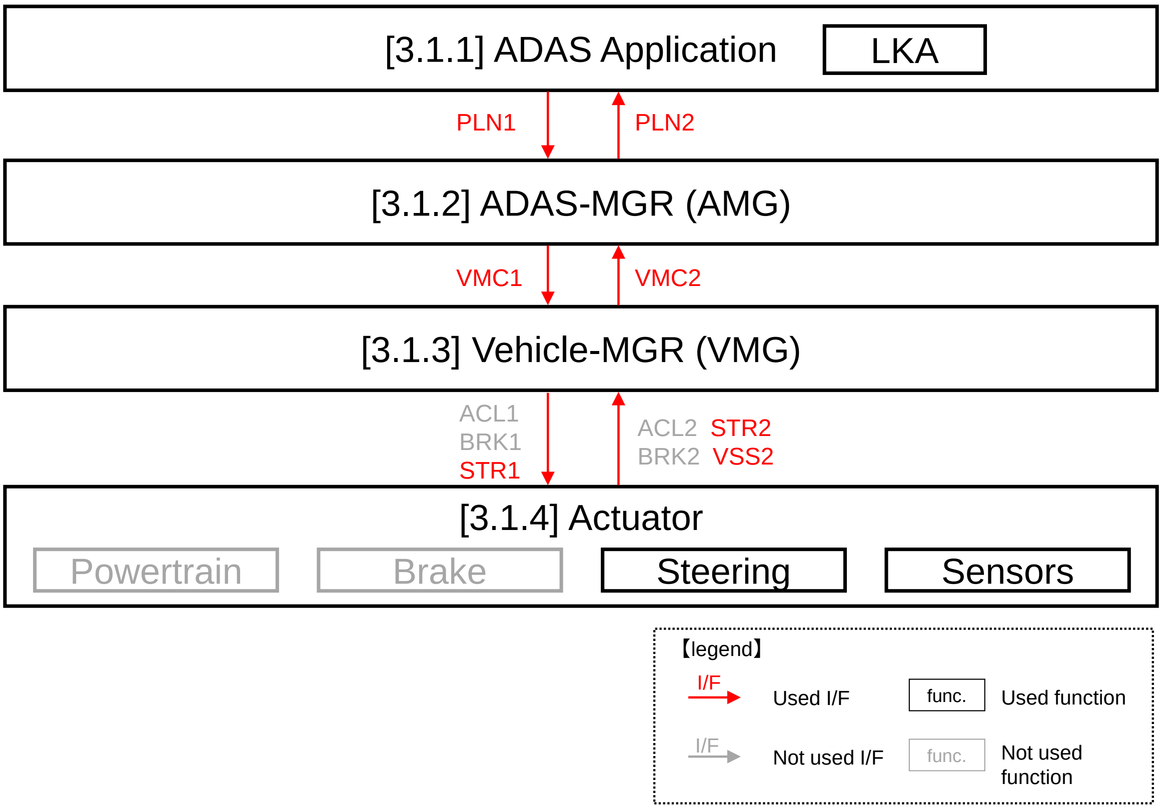

Figure 4.10: Use case: LKA

5 Description of the Chassis Domain Software Compositions and Components for VMC Architecture implementation

5.1 VMC Architecture as new SW-Components

The implementation of ADAS functionalities within the Chassis Domain was already introduced through the introduction of Application Interfaces (Figure 5.1 and Figure 5.2).

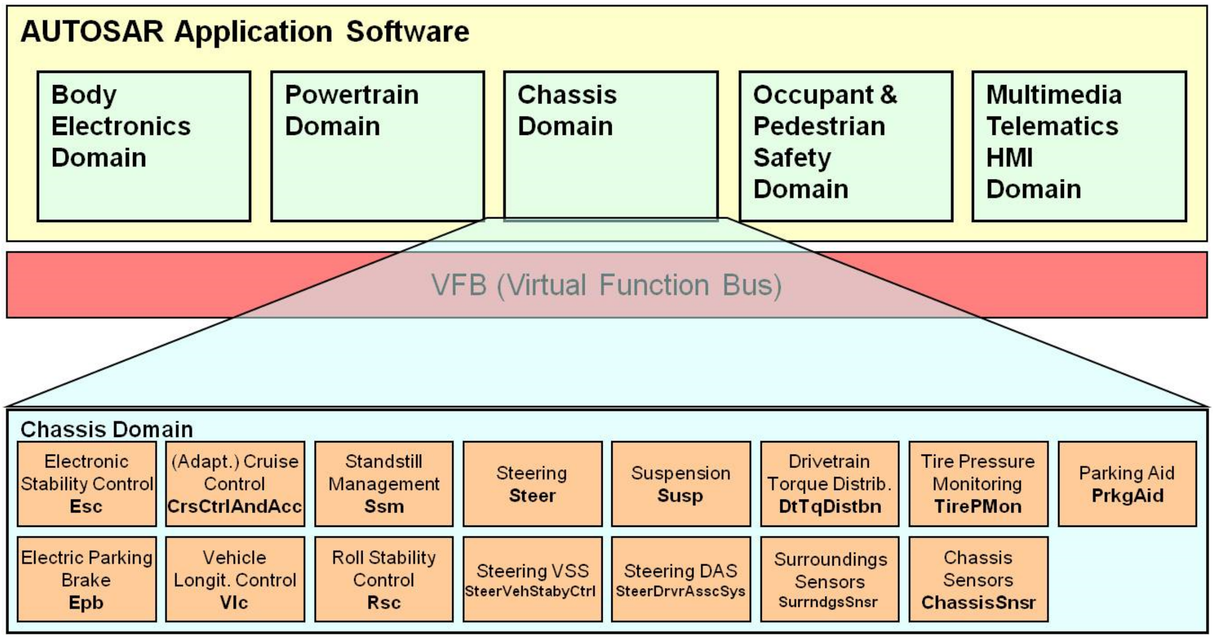

Figure 5.1: Chassis Domain Overview

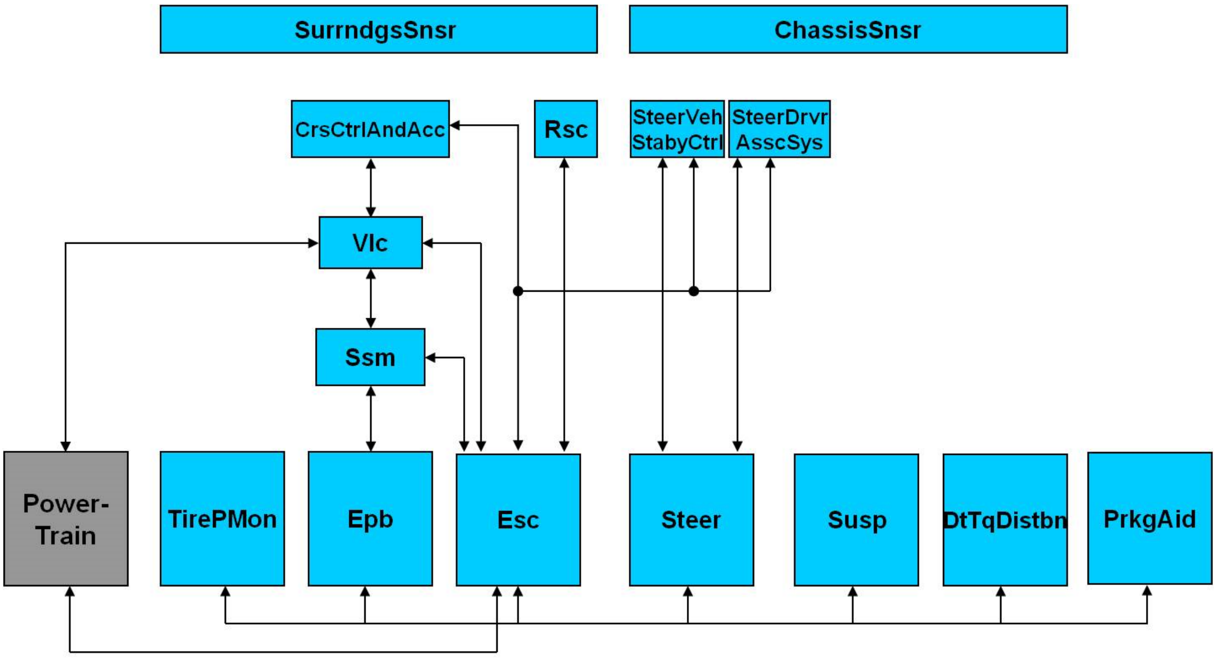

Figure 5.2: Example of a Chassis Domain Structure

In addition, as mentioned in the example of Chapter 5.1 of [1, AUTOSAR_EXP_AIChassis], several structures can be discussed to arrange the global architecture of the functional components, as in following example (Figure 5.3):

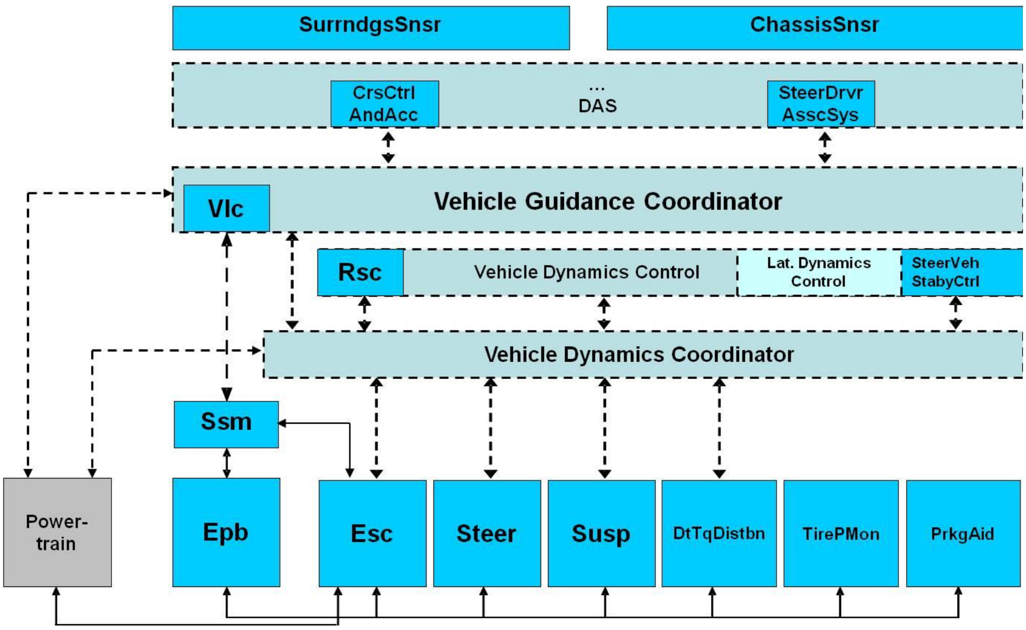

Figure 5.3: Example of a dedicated structure of existing AI Chassis domain components for ADAS purpose

The understanding of the VMC architecture should also be interpreted as another Chassis Domain structure, for which each layer of the VMC architecture can or cannot be composed of other existing Chassis Domain SW-Components.

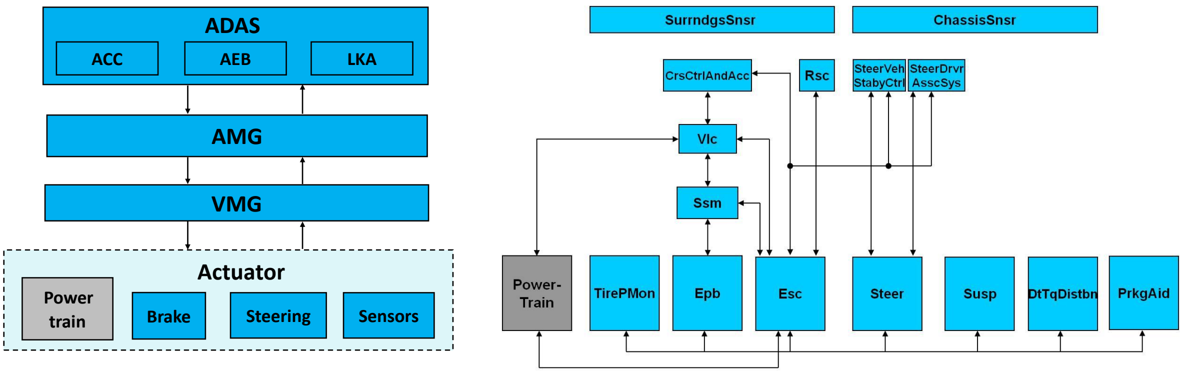

Figure 5.4: New Example of VMC Structure (left) compared to Example of Chassis Domain Structure (right)

The scope of this document is limited only to the definition of the interfaces between the SW-Components that comprise the VMC architecture: ADAS, AMG, VMG and (existing) Actuators/Sensors. Therefore, the content of each components is left up to project convenience and the way the existing SW-Components is integrated in VMC architecture is not defined in this document. However, in case the VMC architecture is implemented along the existing SW-Components in AI Chassis domain, it will be needed to:

- limit the information flow from currently existing Chassis Domain SW-C ports
- consider arbitration gates that will be defined through new SW-Components.