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Disclaimer

Advice to users of AUTOSAR Specification Documents:

Table of Contents

1 Purpose of this Document

This document explains all design decisions that lead to the MasterTable contents and **shall not contain redundancies with the MasterTable contents.**

This document shall always be consistent with the MasterTable contents.

Work package chassis only delivers one explanation document.

2 Description of Terms and Concepts of the Work Package

The content of work package chassis is the formulation of unified application interfaces of the domain chassis. The goal is to define and publish functional catalogues of all unified interfaces and functions. Work package chassis shall align its results with the other working packages, e.g. powertrain, body, safety. The MasterTable represents a good basis for this alignment and detection of conflicts.

2.1 Axis System

The standard coordinate systems used in AUTOSAR work package chassis refers to the International Standard ISO 8855. As there are no manufacturer overlapping standards and as in some use cases, an "actual Center Of Gravity" (including load variances and maybe filtered dynamics) may be of interest, a signal named “deviation_of_actual_Center_Of_Gravity” to the basic Center Of Gravity definition (standard layout with only driver on board) is defined.
Whether a fixed geometry point (e.g. near to the average Center Of Gravity of all variants of a vehicle type) is used as a reference point for basic Center Of Gravity has to be decided on project level.
The actual Center Of Gravity (including load variances) has a deviation from this basic Center Of Gravity defined by a vector originated in the basic Center Of Gravity.
The Center Of Gravity definition defines the Center Of Gravity of the total vehicle (including unsprung masses).

2.2 General remarks

2.2.1 Differences between SW-Compositions and ECUs

The SW-Compositions defined below are not to be misunderstood with ECU functionalities.
For example, an ESC ECU may contain the ESC SW-Composition and other compositions like SSM SW-Composition, High Level Steering SW-Composition, etc.

2.2.2 Functional safety

- Work package chassis considers all chassis signals as safety relevant. Work package chassis assumes that in AUTOSAR, reliable methods of communication are available. No specification of reliable communication is done in chassis work package.

- Note that these values are meant as minimum requirements, i.e. optimization within the communication layer is possible.

- Data qualities for interfaces are not fully listed here but they are required. There is a generic concept for data qualifiers expected. Work package chassis assumes to get that concept to be applied accordingly here. It is needed here for example to rate the quality of the yaw rate from a functional point of view.

- AUTOSAR work package chassis has to deal with diagnostics and safety concepts, but up to now it could not. In order to prove that the discussed use cases are safety compliant (in accordance to the definition of ISO 26262), a joint discussion with the Application System Team and the Safety Team is necessary.

- The chassis work package does not provide a safety concept for active chassis systems. This has to be done on project level. This means that the specified interfaces have to be checked to fulfill the safety requirements on each specific project.

2.2.3 Concept of core-, conditional- and optional- ports

Work package chassis has defined a concept of different port attributes. This concept has to be taken into account for AUTOSAR release R4.0 (attributes to be attached to every single port). They will be defined via the MasterTable to be consistent with all other work packages. The port attributes are:

- Core provider and receiver ports
- Conditional provider and receiver ports
- Optional provider and receiver ports

THE DEFINITION OF CORE/COND/OPTIONAL IS STILL UNDER DISCUSSION AND SHALL NOT BE CONSIDERED AS PART OF THE R3.0. THIS DEFINITION IS NOT CONSISTENT WITH THE DOKUMENT AUTOSAR_POWERTRAIN_AI_EXPLANATION. INFORMATION CONCERNING CORE/COND/OPTIONAL ATTRIBUTES IN THE MASTERTABLE SHALL BE IGNORED IN THE R3.0.

2.2.4 Concept of raw-, base- and standard- signals

Work package chassis has defined a concept of different signal attributes.
The chassis group defined them in the chassis application interface definitions and they have to be consistent with all other work packages.

- Raw signal
  Raw sensor data w/o preprocessing. Not to be used as an interface since these raw signals are hardware dependent.

- Base signal
  Preprocessed sensor data. Model-free. Abstraction of sensor hardware.

- Standard signal
  Derived from Base signal(s) according to open AUTOSAR specification (Filtering, offset compensation, model-based plausibility check, etc.). The SW-

Compositions should provide standard signals from their sensor information to other SW-Compositions in order to avoid duplication of signal processing algorithms. Please refer to the MasterTable for definition of standard signals.

3 Architecture Overview

In the following, a rough explanation of what work package chassis does in context of the other AUTOSAR work packages body, powertrain, safety and telemetry & MMI is given.

The task of work package chassis is focused on data description of functional domain chassis within the AUTOSAR Application Layer.
In Figure 1 only the SW-Compositions of work package chassis are shown, without any signal flow.

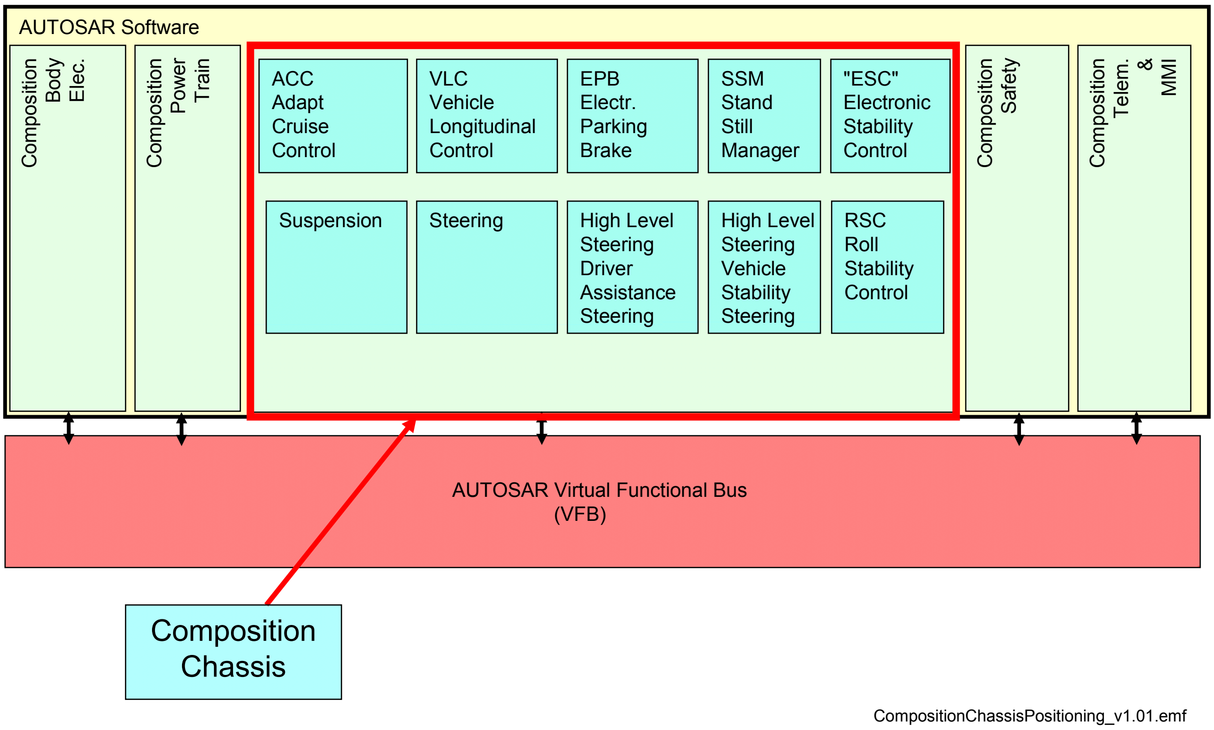

Figure 1: Work package chassis overview

4 Description of Software Compositions

The following SW-Compotitions are described in this chapter:

- ACC : Adaptive Cruise Control
- ESC : Electronic Stability Control
- EPB : Electronic Parking Brake
- SSM : Stand Still Manager
- VLC : Vehicle Longitudinal Control
- RSC : Roll Stability Control
- Steering and High Level Steering
- Suspension

4.1 Software Composition ACC (Adaptive Cruise Control)

The SW-Composition ACC (limited speed range) controls the vehicle velocity and distance to vehicles or other obstacles in front of the vehicle down to and from a reference speed (e.g. from 30 km/h). The used sensor signals can for instance be derived out of a sensor (e.g. radar, lidar or camera). The output of ACC SW-Composition is acceleration command values to VLC (ACC definition as in ISO 15622). In the present state of decomposition, the ACC SW-Composition doesn't include "Stop&Go". It includes as "basic" functions Vehicle Follow Control feature (with or without brakes) and Free Cruise Control feature (with or without brakes).
Stand-alone Free Cruise Control (without follow control) is not considered in the ACC SW-Composition for the current AUTOSAR release. It has to be defined for a later AUTOSAR release whether this feature is located in the powertrain domain or in ACC SW-Composition in the chassis domain.

Figure 2 (chapter 5.2.1) shows the basic decomposition Compositions as well as the interfaces to be standardized and not to be standardized.

4.2 Software Composition ESC (Electronic Stability Control)

The SW-Composition ESC is a Composition which controls the stability of vehicle motion on ground plane, i.e. control of wheels' longitudinal slip, vehicle yaw rate and vehicle side slip. The used sensor signals among others can for instance be derived out of a sensor cluster, delivering for example yaw rate and lateral acceleration.
In the current AUTOSAR release the SW-Composition ESC exclusively controls applied wheel individual braking forces and/or the total powertrain torque.In this release, the SW-Composition ESC doesn't include steering and suspension interventions in order to stabilize the vehicle.

The SW-Composition ESC comprises of at least the following subfunctions :
- Antilock Braking System
- Traction Control System
- Electronic Brake force Distribution
- Regulation of the wheel individual torque
- Yaw Rate Control.

4.3 Software Composition SSM (Stand Still Manager)

The SW-Composition SSM manages stand still and supports driver during drive off. It also keeps the vehicle parked (long term, e.g. without a driver in the car, IGN off) and decelerates vehicle under driver request. To achieve this, it relies on ESC SW-Composition (service brake) and EPB SW-Composition (Parking Brake) by sending them braking requests.

The motivation to create this SSM SW-Composition comes from the fact that on vehicles, these “SSM functions” we just mentioned may be included either in ESC ECU or EPB ECU.

4.4 Software Composition EPB (Electronic Parking Brake)

The EPB corresponds to the parking brake actuator. Its functions are :

Realizing the requests from SSM by controlling the EPB actuator.
Interpretation of the driver’s wish for chassis domain when pushing the EPB button.

4.5 Software Composition VLC (Vehicle Longitudinal Control)

In the current release, VLC gets the longitudinal acceleration command from ACC and distribute torque-commands to powertrain and/or brake-system to achieve this longitudinal acceleration command.

4.6 Software Composition RSC (Roll Stability Control)

The goal of the RSC SW-Composition is to prevent rollover of the vehicle. For that, it controls the vehicle roll motion, i.e. control of roll angle, by reducing the lateral forces at tyres’ contact areas. The reduction of these forces can be realized by requesting brake torques from the ESC SW-Composition or/and by requesting a powertrain torque from the powertrain domain with feed through the ESC SW-Composition.

4.7 Software Composition Steering

The three main functions of the Steering SW–C (each one of them to be achieved by a specific actuator) are:

- Basic Steer Torque Superposition (BSTS): It provides steer torque to support the driver in steering maneuvers. This is the assistance torque, i.e. power steer assist or torque overlay function.

- Basic Steer Angle Superposition (BSAS): It provides additional front steer angle to the driver’s steering wheel angle to support the driver in steering maneuvers. This comprises VGR function (Variable Gear Ratio) and “Lead Lag” compensation functions.

- Basic Rear Wheel Steering (BRWS): It generates rear road wheel steer angles to support the driver in steering maneuvers.

The conversion between pinion angle and the road wheel angle is part of this Steering SW-Composition. This road wheel angle is provided to other SW-Compositions, e.g. ESC.

The steering SW–Composition receives requests (either angle or torque requests) from high level steering functions described below. The steering SW–Composition arbitrates and dispatches the requests to the different steering actuators.

A more detailed steering architecture can be seen in **Fehler! Verweisquelle konnte nicht gefunden werden.** (Chapter 5.2.5).

4.8 High Level Steering DAS

In the current release, the High Level Steering Driver Assistance System SW-Composition is a place holder for high level vehicle comfort functions which send requests to the steering SW-Composition. The nature of these requests (angle or torque) depends on the steering system(s) onboard the vehicle.

Examples of these high level vehicle functions are:

- Lane Keeping
- Parking Aid
- Haptic Feedback Request
- etc.

4.9 High Level Steering VSS

In the current release, the High Level Steering Vehicle Stability System SW-Composition is a place holder for high level vehicle stabilizing functions which send requests to the steering SW-Composition. The nature of these requests (angle or torque) depends on the steering system(s) onboard the vehicle.

Examples of these high level vehicle functions are:

- Oversteering / understeering support
- Counter steering during μ-split braking
- etc.

4.10 Software Composition Suspension

The SW-Composition Suspension controls besides others:

- The vehicle body ride height (level control)
- The vehicle body pitch during braking and acceleration
- The vehicle body roll during cornering and straight ahead driving
- Ride control on uneven roads via suspension
- Rollover stability via suspension
- Handling balance via suspension to change the vehicle understeer behavior

- Yaw behavior via suspension
- etc.

The different suspension actuators onboard could be:

- Semi-active dampers
- Switchable dampers
- Active stabilizers
- Switchable stabilizers (Semi-active stabilizers)
- Switchable springs
- Body level actuator
- Full active suspensions
- Active camber and/or Active toe

5 Additional Information

5.1 Limitations

There are some fundamental limitations to work package chassis. These limitations can be listed as follows:

- The objective of this project is not to make any software architecture proposal. Any architecture shown on any of the WP documents are only used for clarification and have to be treated as "not binding".

- Properties of a signal qualifier are not defined by the work package chassis but by another AUTOSAR work package. Work package chassis will define whether any interface requires a signal qualifier or not.

- Interfaces are defined on vehicle related physical values like torques or forces, and not on actuator specific interfaces like current or PWM (Pulse Width Modulation) duty cycle.

5.2 Further SW-Compositions description and additional Information

5.2.1 ACC

All conclusions derived from the following picture that are inconsistent with the MasterTable content should not be considered. This picture is just presented here as an illustration

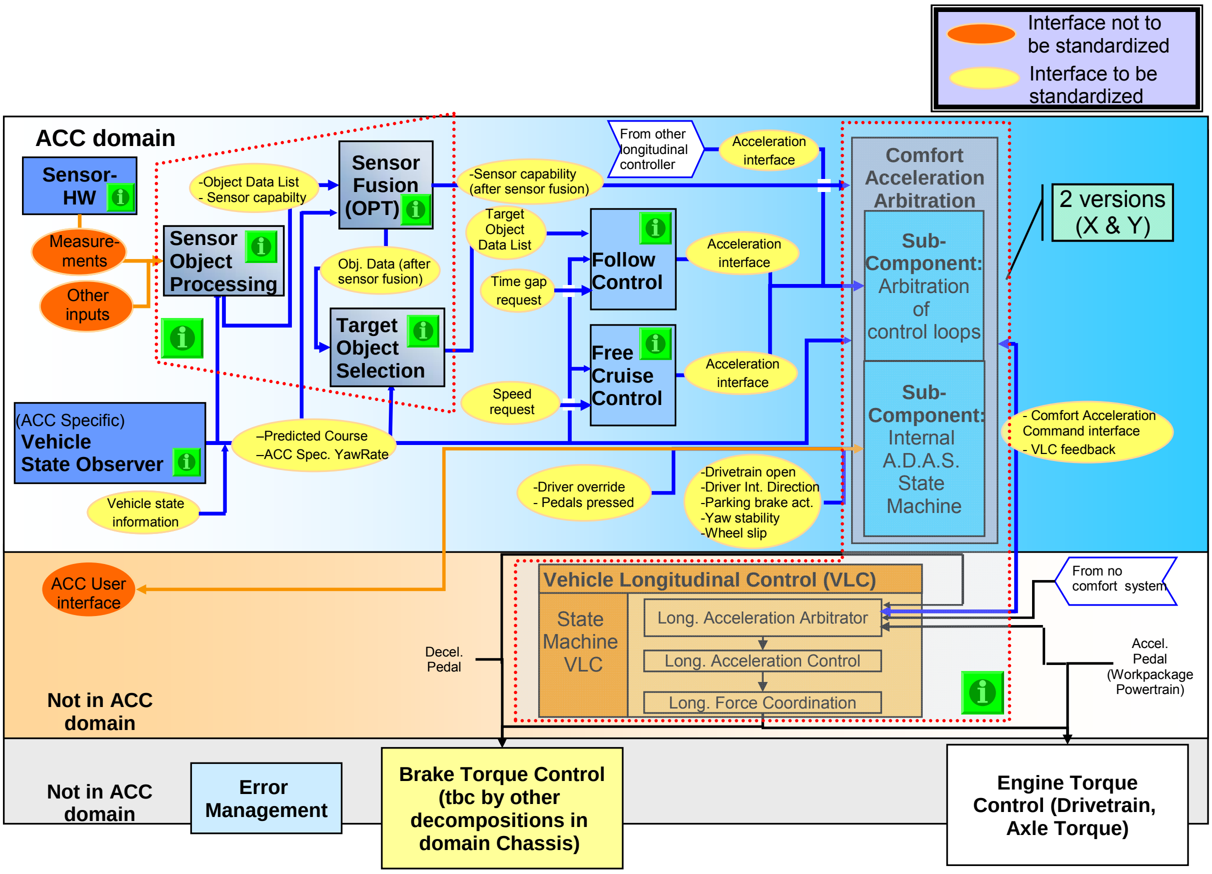

Figure 2: preliminary decomposition of the SW-Composition ACC

5.2.2 ESC

Standard functions of the software Composition ESC are the following:

ABS : Wheel level brake control
TCS : Traction control system, Propulsion torque control, Engine drag torque control
YRC : Yaw rate control, Vehicle level wheel intervention brake control, deceleration control
EBD : Electronic brake force distribution (front / rear)
CBC : Cornering brake control (brake force distribution right / left)
HDC : Hill descend control
HHC : Hill hold control
BAS : Brake assistance system (hydraulic / electronics)
VM : Vehicle model / observer
SR : Situation recognition
Actuator software Composition (device driver): valve control, pump control
Sensor software Composition: Wheel speed sensor, yaw rate sensor, lateral acceleration sensor, steering wheel angle sensor
Actuator access software Composition: Calculating the actuator applied value

5.2.3 EPB

Actual EPB implementation in the market comprises 3 main versions:
1) EPB stand-alone: EPB is not working in conjunction with ESC; minimal number of interfaces are used to avoid conflicts.
2) EPB master-ESC slave: the EPB unit controls the ESC as an actuator.
3) ESC master-EPB slave: the ESC controls the EPB actuator; some backup modes are implemented at EPB Actuator unit in case of ESC fault.
The AUTOSAR definition of EPB/ESC interfaces supports all 3 variants.
Table 2 shows an overview of features that can be realized by typical EPB configurations.

All conclusions derived from the following table that are inconsistent with the MasterTable content should not be considered. This table is just presented here as an illustration

Table 2: List of features of different EPB - configurations

Configuration **I: EPB / ESC Cooperation** **II: EPB stand-alone (or Config I w/ brake actuator failure)** **III: Config I w/ brake ECU or bus failure**		**I**	**II**	**III**
Feature	**Feature Description**			
EPB Driver Request Interpretation	Switch processing and generation of the driver command (apply/release)	SSM (opt. VLC for Dynamic Apply, CAS implementation)	SSM	EPB
Active Vehicle Deceleration	Arbitration and control of deceleration requests from driver assistance systems using hydraulic brake and powertrain	ACC -> VLC -> ESC / PTC	n/a	n/a
EPB Dynamic Apply	Vehicle deceleration using hydraulic or mechanical brake in case EPB switch is applied while driving	EPB -> SSM opt. VLC (CAS) -> ESC	EPB-->SSM-->EPB	EPB
EPB Static Apply	Hold / park the vehicle using hydraulic or mechanical brake in case EPB switch is applied while vehicle is in standstill	EPB -> SSM -> ESP / EPB	EPB -> SSM -> EPB	EPB
ACC Stop&Go	Hold / park the vehicle using hydraulic or mechanical brake on request from ACC	ACC-> VLC -> SSM -> ESC / EPB	n/a	n/a
EPB Drive-away Release	Release hydraulic and /or mechanical brake for drive-away	SSM -> ESP / EPB	SSM -> EPB	n/a
EPB Auto Apply	Automatic application without driver action on EPB control (e.g. vehicle at stand still and engine or IGN off)	SSM -> ESC / EPB	SSM -> EPB	n/a
Rolling / Skidding Detection / Preve	System behaviour in case vehicle starts to move unintendly t.b.d	SSM -> ESC / EPB	SSM-->EPB	possibly, EPB
EPB Anti-Lock braking	Preventition of wheel locking due to mechnaical brake apply while driving	n/a	EPB	n/a
Mechanical Actuator Control	Force control considering all actuator-specific features, e.g. re-clamping due to cooling down	SSM-->EPB or EPB only	SSM-->EPB or EPB only	possibly, EPB
Hydraulic Actuator Control	Brake torque control considering all actuator-specific features, e.g. compensation for valve leakages	ESC	n/a	n/a

5.2.4 VLC

All conclusions derived from the following picture that are inconsistent with the MasterTable content should not be considered. This picture is just presented here as an illustration

Generic Architecture for vehicle longitudinal control including standstill

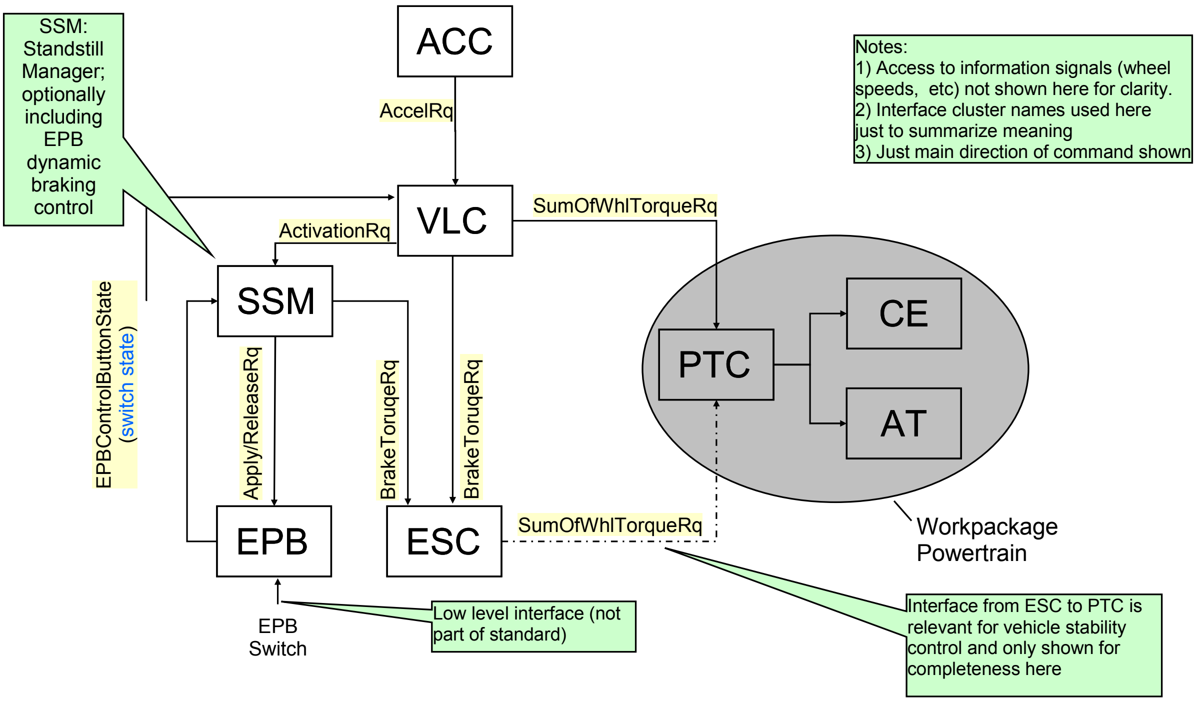

Figure 3: Overview of the Software Composition VLC

- ACC: Adaptive Cruise Control
- CM: Collision Mitigation
- VLC: Vehicle Longitudinal Control
- ESC: Electronic Stability Program
- EPB: Electronic Parking Brake
- SSM: Stand Still Management
- PTC: PowerTrain Coordinator
- CE: combustion Engine
- AT: Automatic Transmission

5.2.5 Steering

All conclusions derived from the following picture that are inconsistent with the MasterTable content should not be considered. This picture is just presented here as an illustration

Since the illustration of the architecture of Steering SW-Composition has no additional information to the Master Table content, it is not shown here.

5.2.6 Suspension

Subsequent, an overview of the technologies used for suspension feature realization is shown.

All conclusions derived from the following picture that are inconsistent with the MasterTable content should not be considered. This picture is just presented here as an illustration

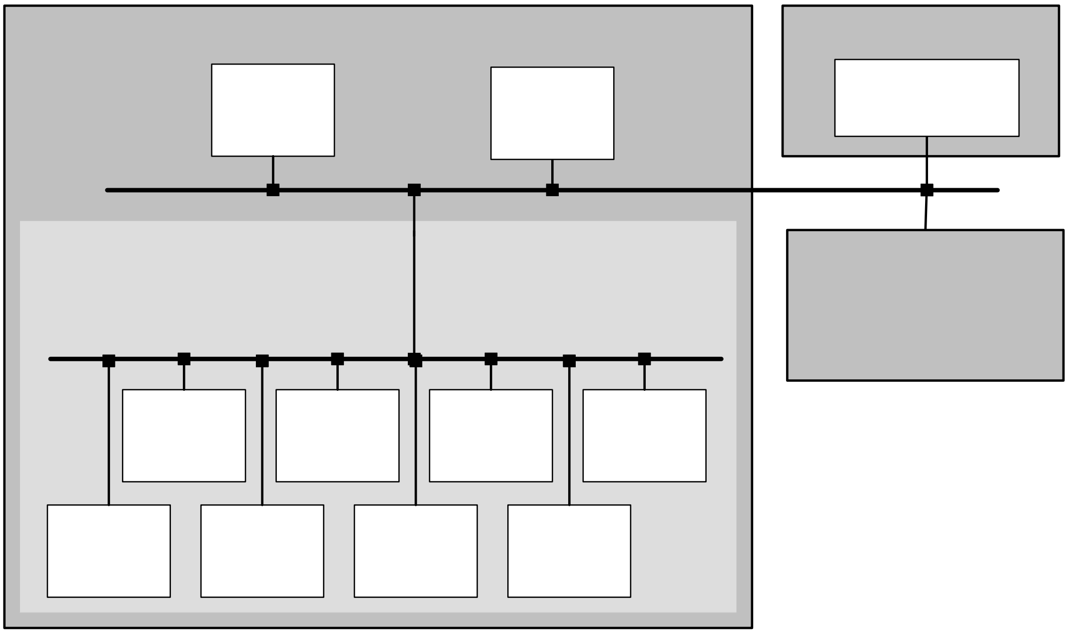

Figure 4: Overview of the software Composition suspension

For describing the use case Suspension, a unique methodology was established in AUTOSAR work package chassis: a features versus technologies matrix, shown in Appendix: Suspension.

6 Appendix

6.1 Suspension

Feature matrix of the use case suspension.

Features of active suspension		5/24/2006									
Features		Technologies (actuators)								for completeness:	for completness :
Feature name	Feature description	Categorie -->	semi-active damper	switchable damper	active stabilizer	switchable stabilizer	switchable spring	Body level actuator	Full active suspension	Active camber	Active toe
	Note: we might end up in changing the grouping (on actuators, comfort and safety or degrees of freedom, ...) of the features. --> grouping all right? --> features missing?	Comments -->	fast change of damping (e.g continuous or discrete)	manually or automatic switched damper (slow changing of damping)	either single or dual channel. Single channel could mean a single hydraulic circuit (fixed distribution of active roll moment). Single channel could also be either a front or a rear actuator. Dual means front and rear actuator work independantly . Active generation of a torque in a stabilizer bar.	manually or automatically switched stabilizer stiffness (as well as: decouple the stabilizer) either ride or roll	Stiffness regulation.	Slow adjustment of the ride height. Front, rear or both axles.	wheel individual vertical force generation and optionally dissipation	wheel individual change of the camber angle	wheel individual change of steering wheel angle (could be defined in the steering use case)
body ride height control	- adjust the ground clearance - optimize aerodynamic forces - lower centre of gravity - adjust for loading conditions - independant control of front and rear axle		NO	NO	NO	NO	NO	YES (no restrictions)	YES (no restrictions)	NO	NO
body pitch control	- **dynamic** control of body pitch angle - pitch control due to braking or acceleration - pitch control due to road excitation - vertical wheel force control during braking or acceleration - high speed aerodynamic improvement by changing the pitch angle of the vehicle - pitch control on inclined roads		´- only transient for braking and acceleration compensation - comfort control during road excitations	´- change of damper coefficient during braking and accelerartion - only transient for braking and acceleration compensation - comfort control during road excitations	NO	NO	´- reduce the steady-state pitch angle - comfort control during road excitations (limited relative to full active suspension)	compensate the pitch angle - for load compensation - for aerodynamic improvement - for inclined roads	YES (no restrictions)	NO	NO
body roll control	- control of body roll angle due to - cornering - road excitation - banked road compensation		´- only transient for cornering - comfort control during road excitations	´- change of damper coefficient during cornering - only transient for cornering - comfort control during road excitations	´- comfort control during road excitations (limited performance relative to full active suspension) - full body roll compensation for two actuators (front and rear) - trade-off between vehicle understeer characteristics and roll control for single actuator systems	´- switched state control - trade-off between vehicle understeer characteristics and roll control for single actuator systems - reduce roll angle only (no full compensation)	´- reduce the steady-state roll angle - comfort control during road excitations (limited relative to full active suspension)	compensate the roll angle - for load compensation - for banked roads	YES (no restrictions)	NO	NO
roll stability control via suspension	- preventing roll over by (over-) compensating the roll angle - fast lowering of the centre of gravity		´- only transient for cornering - increase damper coefficient on front outside wheel to support the brake intervention	´- change of damper coefficient during severe cornering - only transient for cornering	´- full body roll (over-)compensation for two actuators (front and rear) - trade-off between vehicle understeer characteristics and roll control for single actuator systems	´- switched state control - trade-off between vehicle understeer characteristics and roll control for single actuator systems - reduce roll angle only (no full compensation)	increase the stiffness to reduce the roll angle	NO	´- full body roll (over-)compensation - distribute vertical force to obtain optimal lateral tire forces (also for brake intervention)	NO	NO
handling balance control via suspension	- actively change the vertical load on the wheels in order to effect the vehicle understeering characteristic (handling related) - body roll moment distribution to front and rear axle to influence the vehicle understeering characteristic - improved handling by lowering the COG (see feature Body ride height control)		´- only during transient steering - wheel individual damper control to - optimize roll moment distribution - optimize vertical forces on rough roads	´- set damper coefficient to optimize vertical forces on rough roads	´- for dual-channel or single actuator systems (front or rear)	´- for dual-channel or single actuator systems (front or rear) less design freedom relative to active stabilizer	´- set spring stiffness to optimize vertical forces on rough roads (limited influence)	NO	YES (no restrictions)	YES	YES
yaw stability control via suspension	- actively change the vertical load on the wheels in order to effect the vehicle yaw motion (vehicle stability related). - The vehicle is not behaving as it should be (target yaw rate; safety related) - based on yaw control and/ or on side slip control (- increase the vertical load on an individual wheel that is used for yaw brake control intervention)		´- only during transient steering - wheel individual damper control to - optimize roll moment distribution - optimize vertical forces on rough roads	NO	´- for dual-channel or single actuator systems (front or rear)	NO	´- set spring stiffness to optimize vertical forces on rough roads (limited influence)	NO	YES (no restrictions)	YES	YES
ride control via suspension	- vertical body control (minimize vertical body accelerations) - improve road holding (grip) by minimizing the variations in vertical load at the wheel.		´- limited to force dissipation	´- limited to force dissipation - reduce performance	NO	NO	´- set spring stiffness to optimize vertical forces on rough roads	No	YES (no restrictions)	NO	NO
Lateral acceleration control	Increasing the max lateral acceleration during cornering		NO	NO	NO	NO	NO	NO	NO	YES	NO