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Table of Contents

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1 Purpose of this Document

This document explains all design decisions that lead to the MasterTable contents relevant to the Powertrain Domain.

2 Description of Terms and Concepts

2.1 General remarks

2.1.1 Differences between SW-Cs and ECUs

The SW components defined below are not to be confused with an ECU's functionalities.
For example, a combustion engine control ECU may contain the Combustion Engine SW-C plus other SW-Cs.

2.1.2 Functional safety

- Many powertrain signals are safety-relevant, therefore
    - The AUTOSAR RTE will provide reliable communication for these signals at the low level, and
    - Diagnostics and safety concepts for these signals must be applied at the higher, functional level. However, the Powertrain Application Interfaces Sub-group has not been able to do so as these concepts have not yet been defined within AUTOSAR.
- A signal qualifier concept is also required for the Powertrain domain. This concept will be developed for all application domains after Release 3.0.
- AUTOSAR does not provide a Safety Concept for powertrain systems. This must be done at the project level. This means that the specified interfaces must be checked to fulfill the safety requirements on each specific project.

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

The hardware / feature "variant handling" concept is still under discussion and shall not be considered as part of AUTOSAR Release 3.0. Therefore information concerning Core / Cond / Optional attributes in the MasterTable shall be ignored in AUTOSAR Release 3.0. The definitions below are made by the Powertrain Application Interfaces sub-group and may not be consistent with the Explanation of Chassis Application Interfaces.

Core = Interface must exist in SW-C
Conditional = An interface that is dependent on the existence of a specific, optional, functional feature or SW-C, determined by vehicle configuration.
Option = Interface can exist in SW-C, but is not mandatory

2.2 Terminology – Terms used in this document

Completely defined:
The composition / component has been deeply studied and all of the defined interfaces are described in the Master Table.
Partially defined:
Parts of the composition / component have been deeply studied to create defined interfaces, which are described in the Master Table.
Initially defined:
The composition / component is only composed of shared interfaces with so-called *Completely defined* or *Partially defined* compositions / components (for consistency).

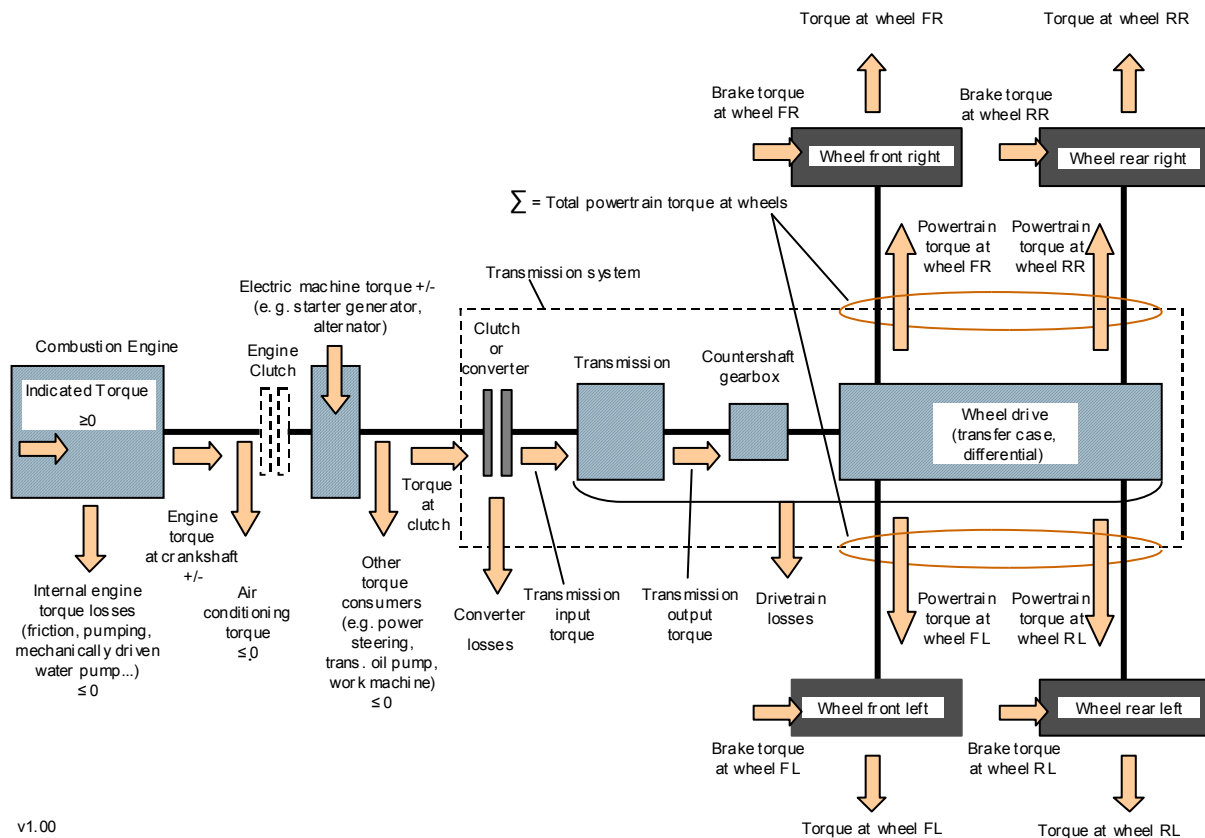## 2.3 Terminology – Torque within the Powertrain Domain

Figure 1: Powertrain Torque terminology

Sign definition for torque at clutch / torque at wheels :
Positive value means that torque is transmitted from the engine to the drivetrain / from the powertrain to the wheels.
Negative value means that torque is transmitted from the drivetrain to the engine / from the wheels to the powertrain.
Zero means that no torque is transmitted between engine and drivetrain / between wheels and powertrain.
Engine Clutch
For Hybrid Systems an additional clutch can be present between combustion engine and electric machine.

2.4 Terminology – Fast and Slow Torque Requests

Many torque request interfaces have the additional descriptors "Fast" or "Slow".
These descriptors are relevant to gasoline spark ignition engines, whose torque output can be modified by means of throttle angle (and hence air mass) and ignition timing. In general, the torque output responds slowly to changes in throttle angle due to fluid dynamics in the manifold and cylinder head. The reaction to ignition timing changes is almost instantaneous, especially at higher engine speeds.

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"Fast" refers to the "immediate" / "instant" torque request, typically achieved by ignition timing.

"Slow" refers to the longer term or "torque reserve" request, usually the input to throttle control.

Note that a gasoline engine running at optimum ignition timing cannot **increase** torque quickly as the throttle is the only means for the increase. However, pre-emptively opening the throttle and running with retarded ignition to maintain the original (lower) torque allows the torque to be increased quickly by ignition a short time in the future. This operation is usually achieved by setting the "Slow" torque request to be greater than the "Fast" torque request to provide this "torque reserve", allowing the torque to be rapidly increased by increasing the "Fast" request.
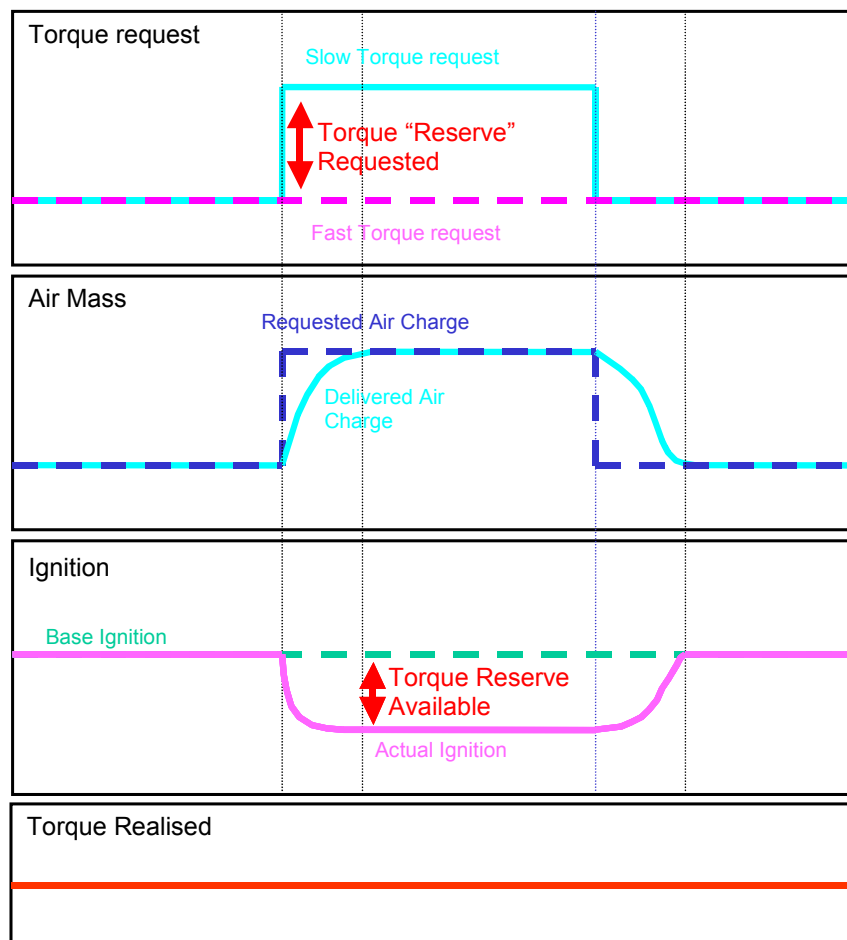
Figure 2: The Torque Reserve concept, with "Fast" and "Slow" torque requests

For conventional diesel engines only the fast torque interfaces are relevant. However, future diesel engines could have the possibility to use both fast and slow torque interfaces.

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3 Architecture Overview

Figure 3: Overview of Functional Architecture
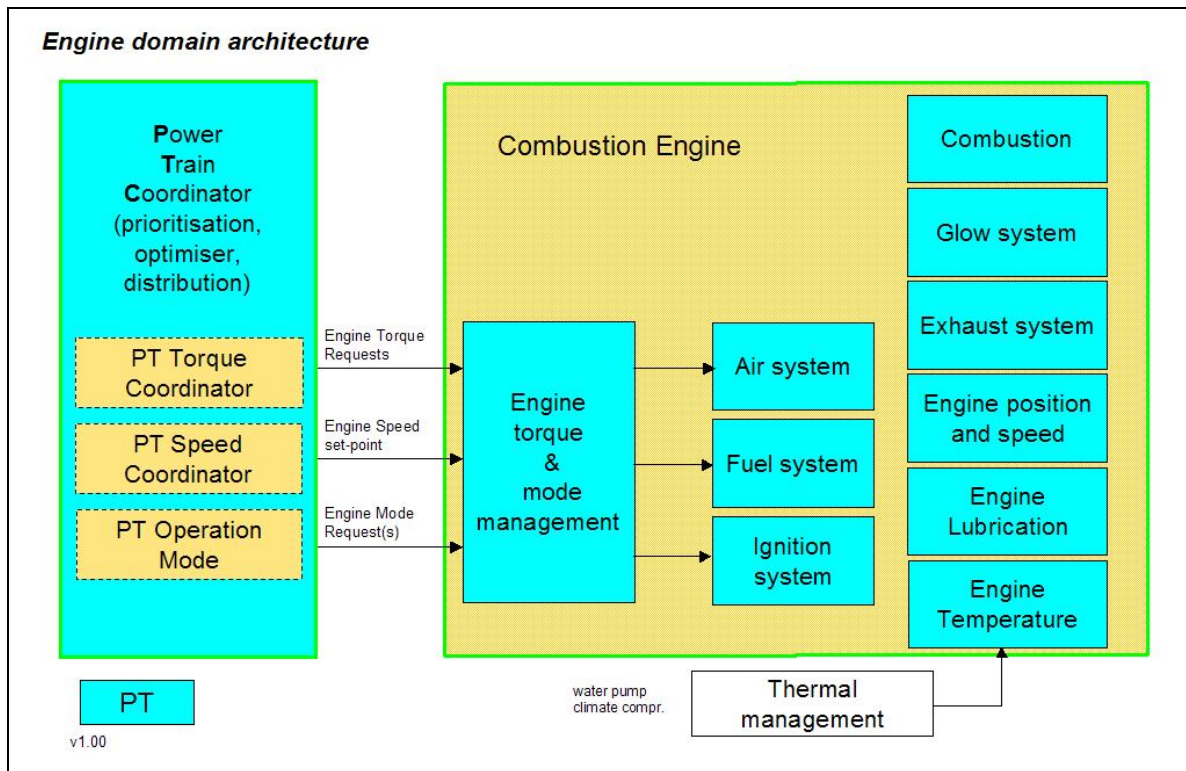
Figure 4: Detail - Combustion Engine Domain Architecture

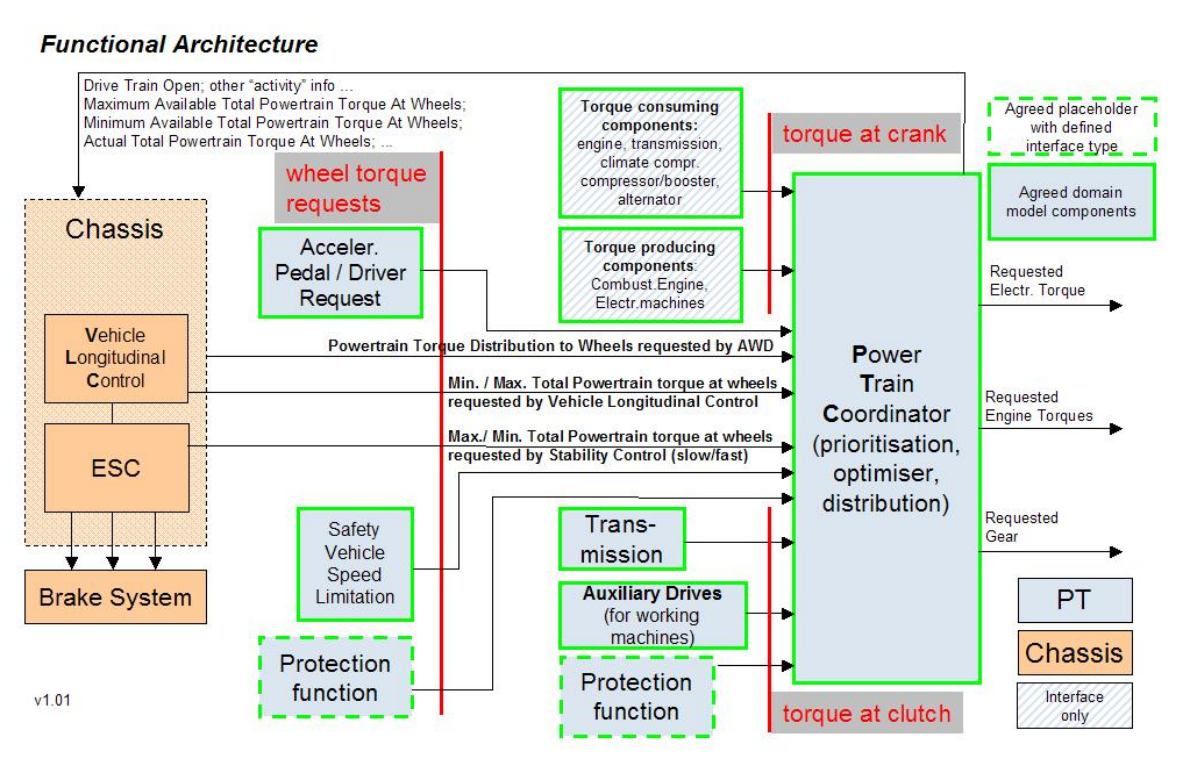**Transmission System Architecture**

Figure 5: Detail -Transmission System Architecture

NOTE: Figure 3, Figure 4 and Figure 5 are provided here purely as illustrations. If any information in these diagrams (or conclusions drawn from them) conflict with the information in the Master Table of interfaces, the Master Table should be regarded as definitive. Nevertheless, in general there is an intention to standardise the interfaces shown in these diagrams.

4 Description of Software Compositions and Components

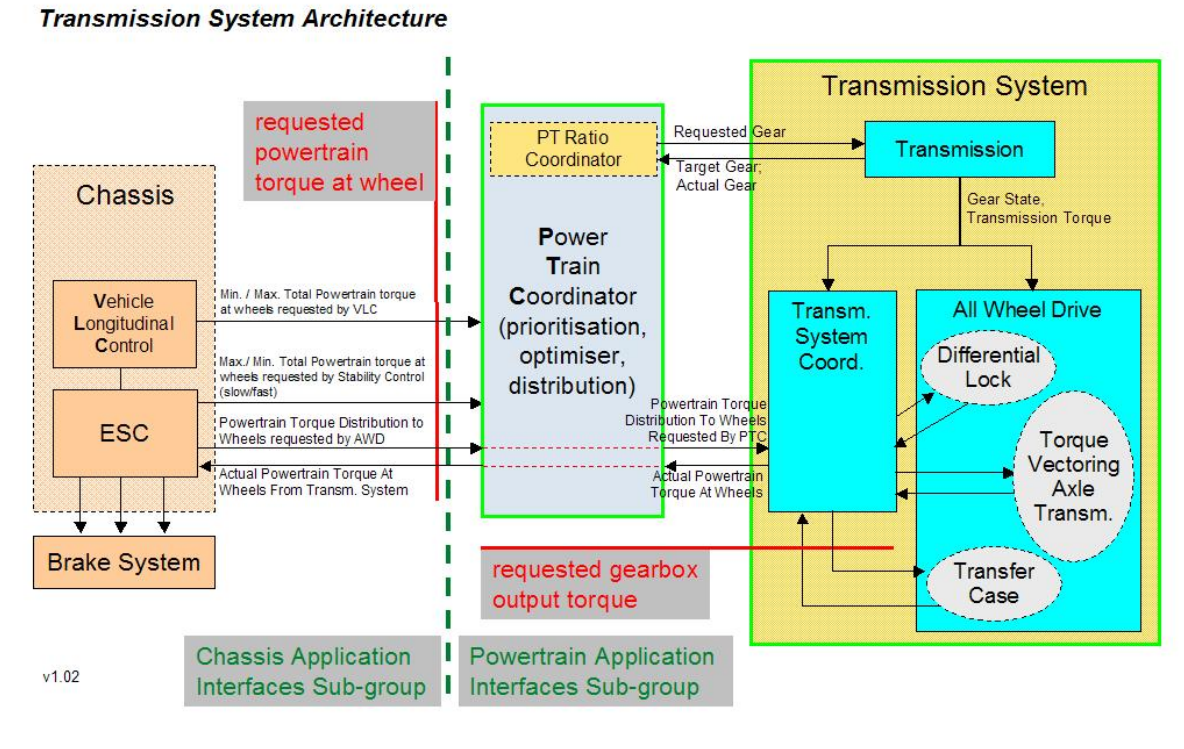The Powertrain Application Interfaces Sub-group covers the hierarchy within the numbering of the title of the excel sheet within Master Table. Here the components are listed without taking into account this hierarchy. Sub-headings within each component / composition description describe Powertrain functions covered by a component / composition, they do not define further decomposition.

Remark: for R3.0 the following components, except Driver Request should be presented as "ongoing projects" in order to highlight the difference between what has been fully studied (Driver Request) and what has only been partly studied.

4.1 Powertrain Coordinator (PTC) –Partially defined

This composition includes all functions that coordinate the operation of the powertrain, including:

Powertrain operation mode – management of states of all actuators (e.g. combustion engine, clutch(es), transmission, electric motors, etc.), including engine start / stop management (conventional & hybrid powertrains).

Powertrain torque coordination – Torque coordination at Powertrain (PT) level, torque request prioritisation, torque distribution for realisation at PT level, torque reserve request for the PTC, pre-coordination of driveability functions for hybrids, powertrain driveability filters, determination of total powertrain losses for torque calculation, wheel torque calculation (min, max, actual), torque at clutch calculation (min, max, actual), transformation of torque set point from wheel torque to torque at clutch, transformation of torque set point from torque at clutch to torque at crankshaft, control/coordination of auxiliary drivers/actuators.

Powertrain speed coordination – Maximum speed limitation coordination (for protection of all PT components from damage from over speed) and coordination of idle speed / engine speed set point requests from all sources, e.g. transmission.

Powertrain ratio coordination – all transmission ratio set point logic. Note that realisation of ratio set point is carried out by transmission system, not PTC.

4.2 Transmission System –Initially defined

This composition includes all functions of the transmission system, including:

Transmission system coordination - Determines the torque and speed ratio over transmission, converter and differential, including the calculation of torque losses in the transmission system. Coordinates mechanical protection of the Drivetrain (gearbox, driveshafts, etc.), including calculation of torque limitation.

For manual transmission, this function includes the determination of the current gear and clutch status.

Transmission - Management of particular states in the transmission, including shift transition, driving off situation, creeping mode etc. In case of shift transition, this functionality calculates torque requests to optimise the transition.

Control of transmission actuators to adjust the gear to the target gear (or to adjust the gear ratio to the target gear ratio in case of CVT). Gear ratio means the theoretical / physical ratio belonging to each gear and not any actual measured value. Control of gearbox countershaft (low/higher range) actuators is not included.

Calculates the torque gain of a hydrodynamic converter and the torque required to the converter input side in idle, etc. and controls clutch or converter actuators.

All functionality related to the protection of the transmission, including calculation of torque limitation, measurement or calculation of gearbox oil temperature, etc., and calculation of requests to other systems.

AWD Differential Lock - All functionality related to the differential(s), which manage the torque distribution between left and right wheels, for example locking of the differential. Does not include the calculation of the distribution set point.

AWD Transfer Case - All functionality related to the transfer case, which manages the torque distribution between front and rear wheels. Does not include the calculation of the distribution set point.

AWD Torque vectoring axle transmission – All functionality related to active distribution of powertrain torque to all four wheels individually. Does not include the calculation of the distribution set point.

4.3 Combustion Engine –Initially defined

This composition includes all functions directly related to the operation and control of the vehicle's combustion engine. The following sections, 4.3.1 to 4.3.3 inclusive, define the components as a result of Combustion Engine functionality decomposition agreed to date.

4.3.1 Engine Speed And Position –Initially defined

Functions that provide all parameters linked to engine shaft position and speed, including the synchronisation between crankshaft and camshaft.
* Crankshaft and camshaft signal acquisition.
* Calculation of the engine position.
* Calculation of the relative camshaft position for systems with variable valve timing and/or lift.
* Related diagnosis and plausibility checks.

4.3.2 Engine torque and mode management – Initially defined

Includes calculation of engine torque set point, realisation of that set point (coordination of air / fuel / ignition, etc.), determination of actual engine torque, control of engine speed (idle / off-idle / limitation), and management of engine modes (including overall mode, modes for realisation of engine start & stop, and combustion modes).

4.3.3 Combustion Engine Misc – Initially defined

Combustion Engine Misc gathers together miscellaneous engine interfaces. In general these are common data required for correct operation of the engine (engine temperature, ambient air pressure and battery voltage) or required for fail-safe actions (crash status). The way in which these interfaces are used is not

standardised. In future AUTOSAR releases, it is likely that these interfaces may be be moved to different (more appropriate) provider or receiver components / compositions.

4.4   Electric Machine – Initially defined

Conventional starter - Includes all functions related to the starter, which are dedicated to the provision of mechanical energy.
Integrated starter alternator - Includes all functions related to the starter generator, which are dedicated to the provision of mechanical energy.
Electric motors (Hybrids, electric vehicle) - control and management of electric motors within hybrid systems.

4.5   Vehicle Motion PT – Initially defined

This composition includes Powertrain functions related to vehicle motion. The following sections, 4.5.1 to 4.5.3 inclusive, define the components that have so far been agreed as part of this composition.

4.5.1   Driver Request (DriverReq) – Completely defined

Driver-specific conversion of accelerator pedal position to requested torque: determines the driver request related to the motion of the vehicle. For longitudinal motion, this functionality interprets the driver request as a torque request.

4.5.2   Accelerator Pedal Position – Initially defined

The component calculates a percentage from the acquired position of the sensor, and contains plausibility checks to ensure the information. Kick-down detection is included in this component.

4.5.3   Safety Vehicle Speed Limitation – Initially defined

Hard limitation of vehicle speed by engine torque reduction, without any comfort functionality.

5 Additional Information

5.1 Limitations

The currently defined ports, interfaces, data elements and data types may require modification in future AUTOSAR releases as a result of changes, considering the following points:

- Architecture (both functional and software) is still under development
- A "Variant Handling" concept will be developed for a future AUTOSAR release
- Signal Qualifiers will be introduced in a future AUTOSAR release
- Data Types & Data Elements may be optimised in future AUTOSAR releases
- A Naming Convention will be introduced in a future AUTOSAR release

5.2 Powertrain Application Interfaces - Decisions / Assumptions

5.2.1 Scope

In this first release of Powertrain Application Interfaces, only passenger cars have been considered.

5.2.2 PTC Composition

The PTC is not an atomic AUTOSAR SW-Component. In fact its functionalities should be separated, into several sub-components. These sub-components will communicate with each other and with AUTOSAR SW-Components outside the PTC. The interfaces between the sub-components are not in the current scope, which is restricted to the definition of main interfaces between the non-PTC components and the PTC sub-components. The complete list of external interfaces will not be documented in the Master Table.

5.2.3 Definition of overboost

Overboost is a state in which the maximum torque which the combustion engine can deliver is increased for a limited period of time. Depending on the engine type, this could be realised, for example, as an increase in boost pressure on a turbocharged engine.

5.2.4 Coordination at the vehicle level

Coordination of vehicle energy (mechanical / electrical / thermal), vehicle operation modes, vehicle personalisation, etc., should be done at the vehicle level. This is not in the scope of the Powertrain Application Interfaces Sub-group.

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The Powertrain Application Interfaces Sub-group added the composition VehicleMotionPT to the Master Table as an interim solution for some vehicle level issues relevant to the sub-group.

5.2.5 PTC Arbitration between Driver and Chassis torque requests

Figure 6, below, shows how the VLC and Stability Control torques requests could be arbitrated with the Driver Request. This is just an example to illustrate the concept behind the standardised torque request interfaces defined in the Master Table, it is not intended to standardise the arbitration behaviour in the PTC.

NOTE: Figure 6 is provided here purely as an illustration. If any information in this diagram (or conclusions drawn from it) conflict with the information in the Master Table of interfaces, the Master Table should be regarded as definitive. Nevertheless, in general there is an intention to standardise the interfaces shown in this diagram.
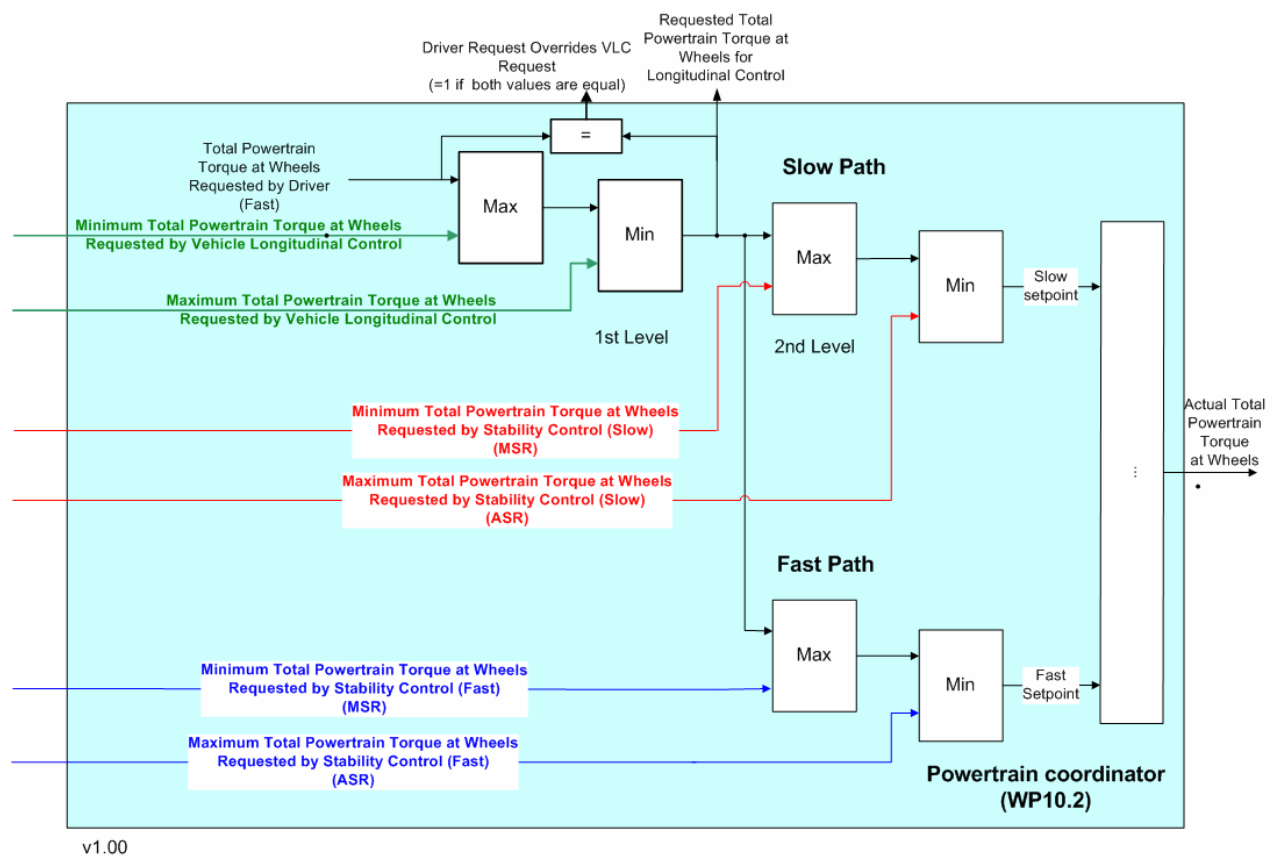

Figure 6: Example of possible PTC arbitration between Driver and Chassis torque requests