AUTOSAR conformance testing using TTCN-3

TTCN-3 User Conference 2009

Sophia Antipolis, June 4

Alain Gilberg PSA, AUTOSAR Project Leader)

Overview

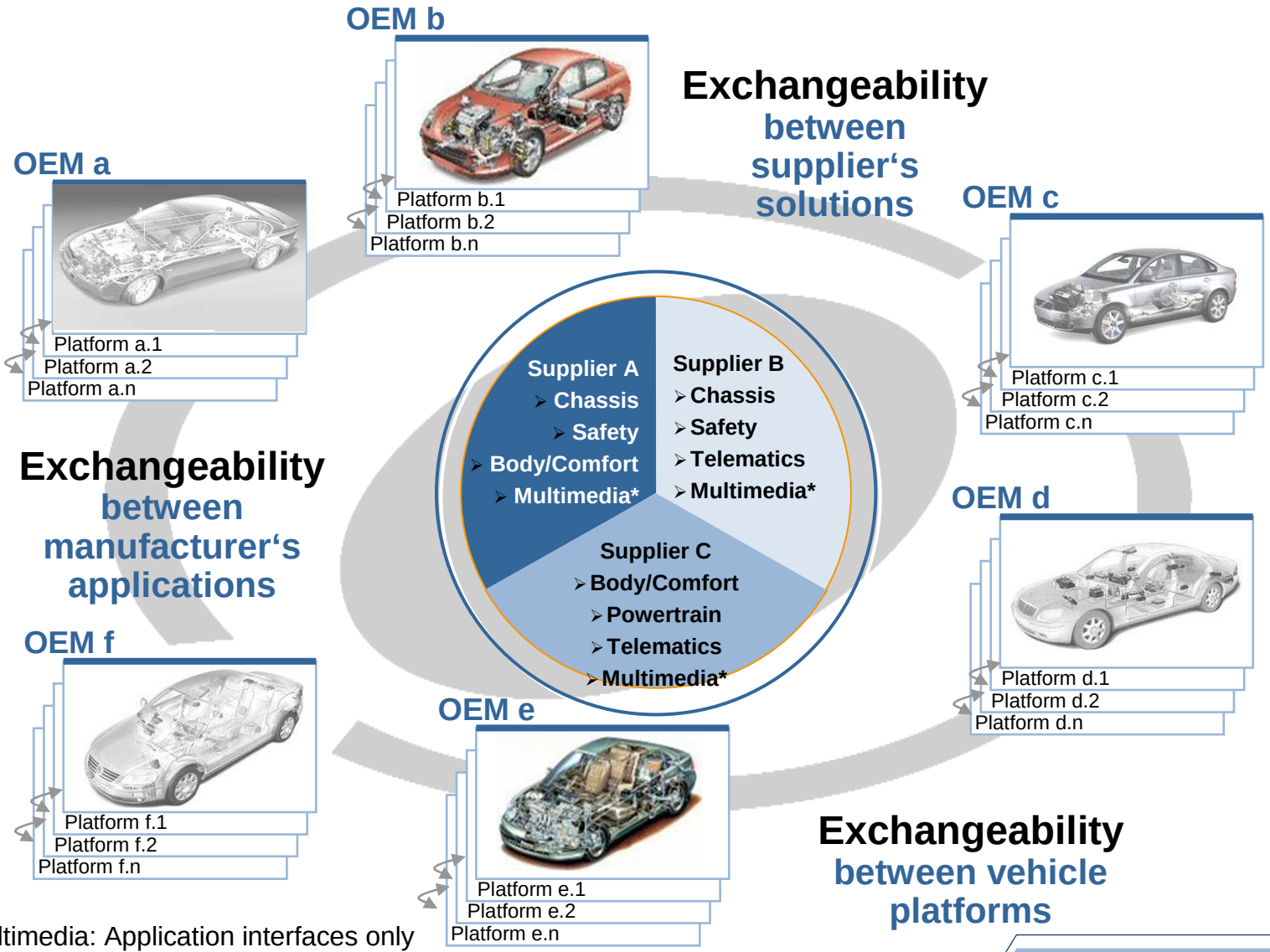
- Introduction to AUTOSAR
- Achievements of AUTOSAR
- Conformance testing with TTCN-3

Introduction

- AUTOSAR, AUTomotive Open System Architecture
  - De-facto standard, jointly developed by automobile manufacturers, suppliers and tool developers
  - More than 150 member companies

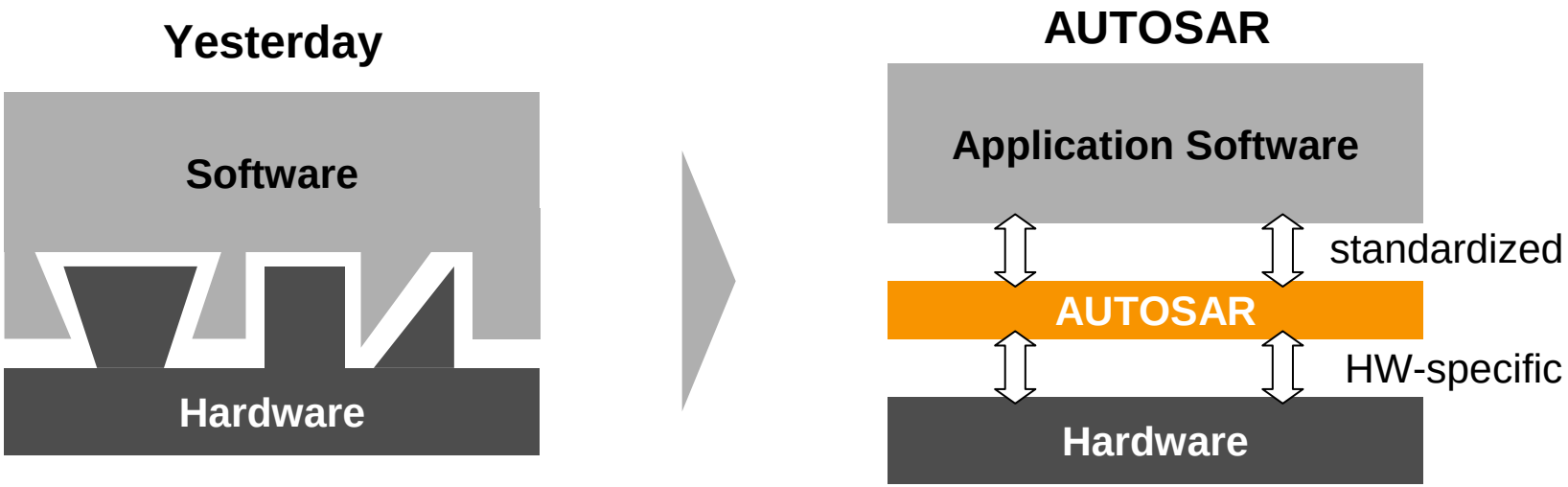
    “Cooperate on standards, compete on implementation.”
- During 6 years the partnership has been
  - Creating the baseline for software architecture of Automotive ECUs,
  - Adding major features and
  - Bringing the standard “On the road”
- The ongoing development of products by the member and core partner companies are providing a unique feedback loop into the development of the standard itself.

Main objective of AUTOSAR: Managing Complexity by Exchangeability and Reuse of Software Components



Note on Multimedia: Application interfaces only

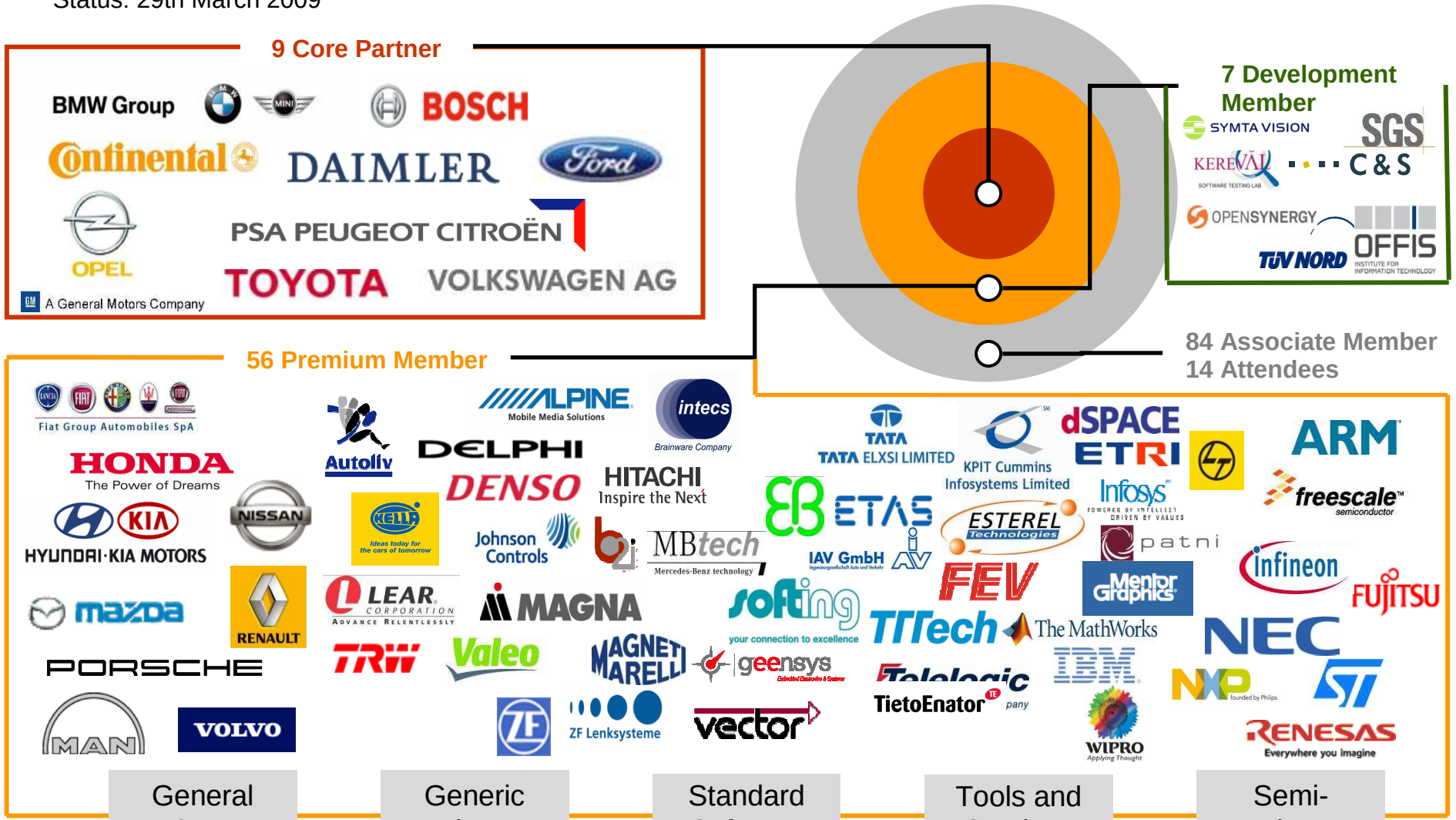
AUTOSAR has standardized the software architecture of ECUs



- **Hardware- and software** will be **widely independent** of each other.
- **Development processes** will be **simplified**.
  This **reduces development time** and **costs**.
- **Reuse** of **software increases** at OEM as well as at suppliers.
  This **enhances** also **quality** and **efficiency**.

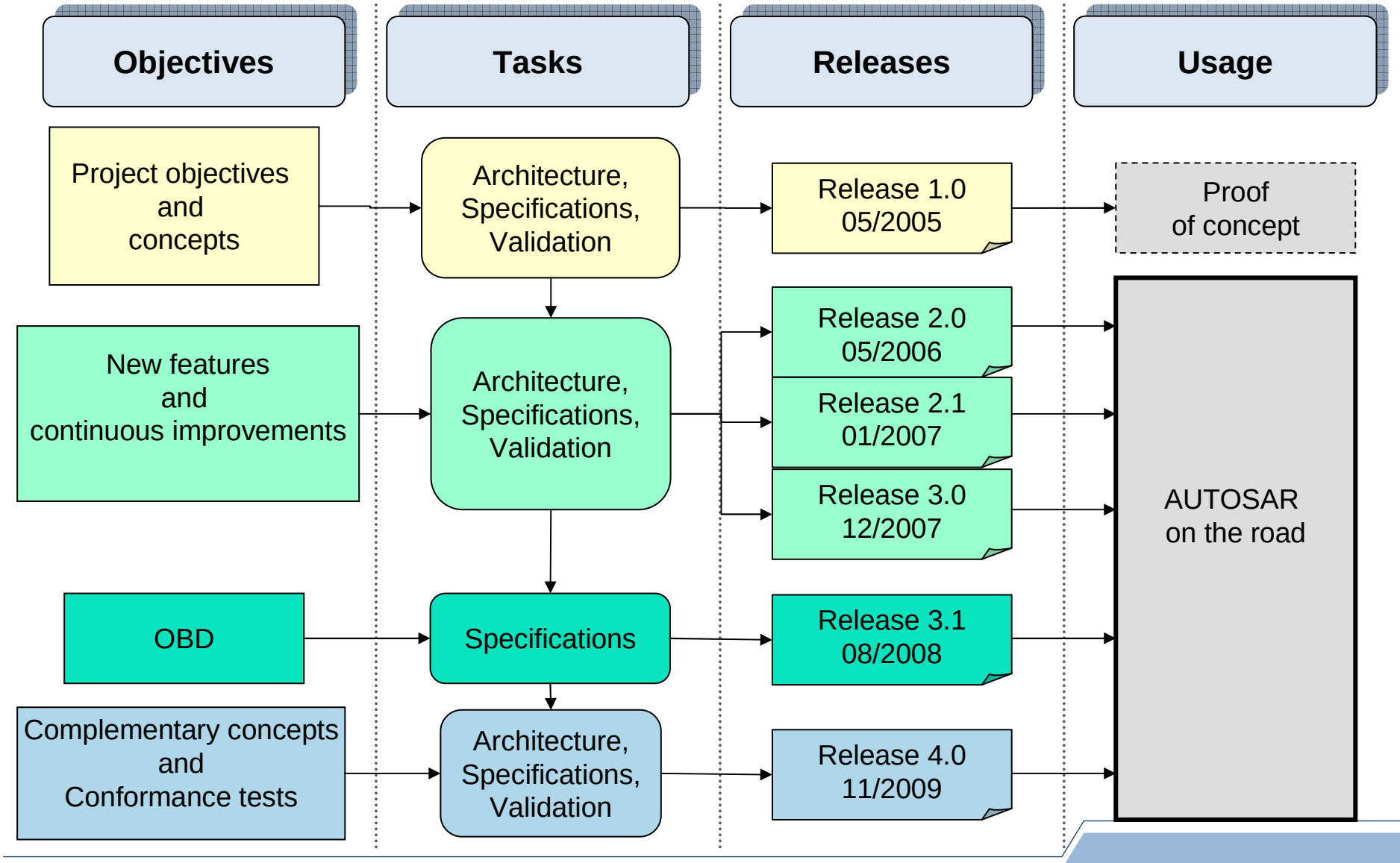
AUTOSAR – Core Partners and Members

Status: 29th March 2009



Up-to-date status see: http://www.autosar.org

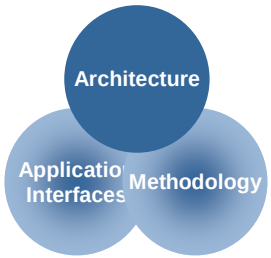
Development Approach: 2004-2008



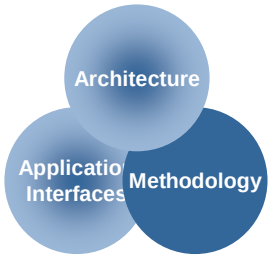
The AUTOSAR Roll Out Plan (2008 - 2012)

Core Partner	2008	2009	2010	2011	2012
BMW Group	■ ≈10 AUTOSAR BSW modules as part of Std Core in vehicles, tool / serial support in place			■ Powertrain-, Chassis-, Safety-, Body- ECUs use AUTOSAR architecture	
BOSCH	■ Body Computer with subset of AUTOSAR specs incorporated ■ Instrument Cluster with subset of AUTOSAR specs incorporated	■ ACC ECU using AUTOSAR architecture. ■ Powertrain EDC/ME(D)17 ECUs using AUTOSAR architecture ■ Domain Control Unit using AUTOSAR BSW	■ Chassis ECU using AUTOSAR architecture ■ Body Computer using AUTOSAR architecture		
Continental		■ Body ECU using AUTOSAR architecture ■ Powertrain ECUs using AUTOSAR architecture	■ Powertrain- ,Chassis- ECU using AUTOSAR architecture		
DAIMLER		■ First usage of AUTOSAR modules in vehicles	■ First AUTOSAR compatible ECUs in vehicles	■ Introduction of AUTOSAR architecture and methodology in vehicles	
Ford		■ 1-2 AUTOSAR conformant ECUs; first use of conformant tools/methodology	■ Continuous roll-out of ECUs into vehicle architecture increased use of conformant tools / methodology		
OPEL			■ First usage of AUTOSAR modules	■ First use of AUTOSAR architecture ECU	
PSA PEUGEOT CITROËN		■ Powertrain ECU using AUTOSAR architecture	■ Body ECU using AUTOSAR architecture		
TOYOTA			■ First usage of AUTOSAR modules		■ AUTOSAR Architecture ECU
VOLKSWAGEN AG		■ First AUTOSAR modules in series production		■ First complete ECUs in series production	

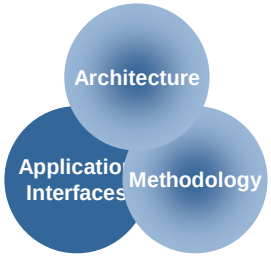
AUTOSAR Main Working Topics



- **Architecture:**
  Software architecture including a complete basic software stack for ECUs – AUTOSAR Basic Software – as an integration platform for hardware independent software applications.

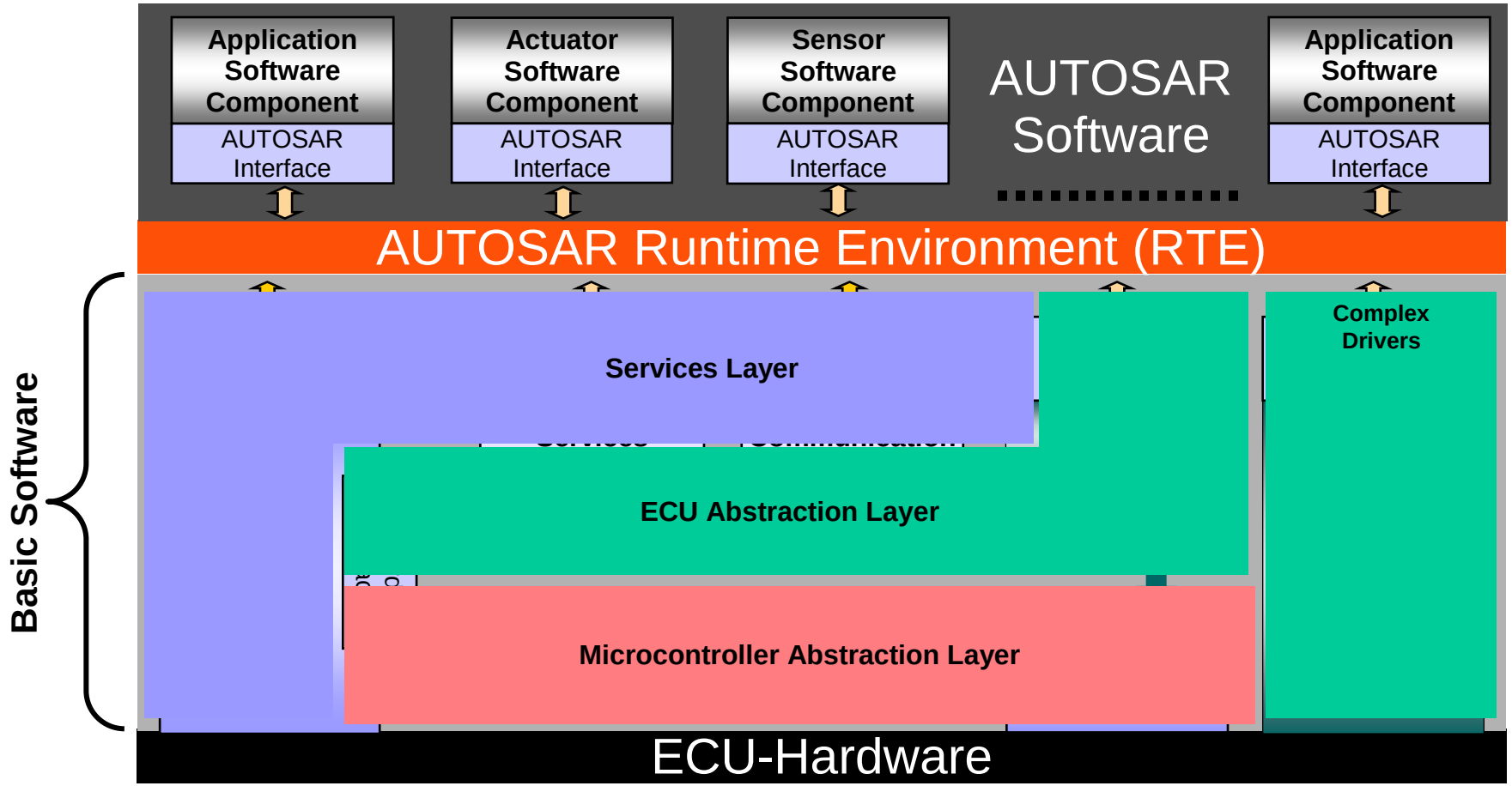


- **Methodology:**
  Description templates and exchange formats to enable a seamless configuration process of the basic software stack and the integration of application software in ECUs. Guidelines how to use this framework.

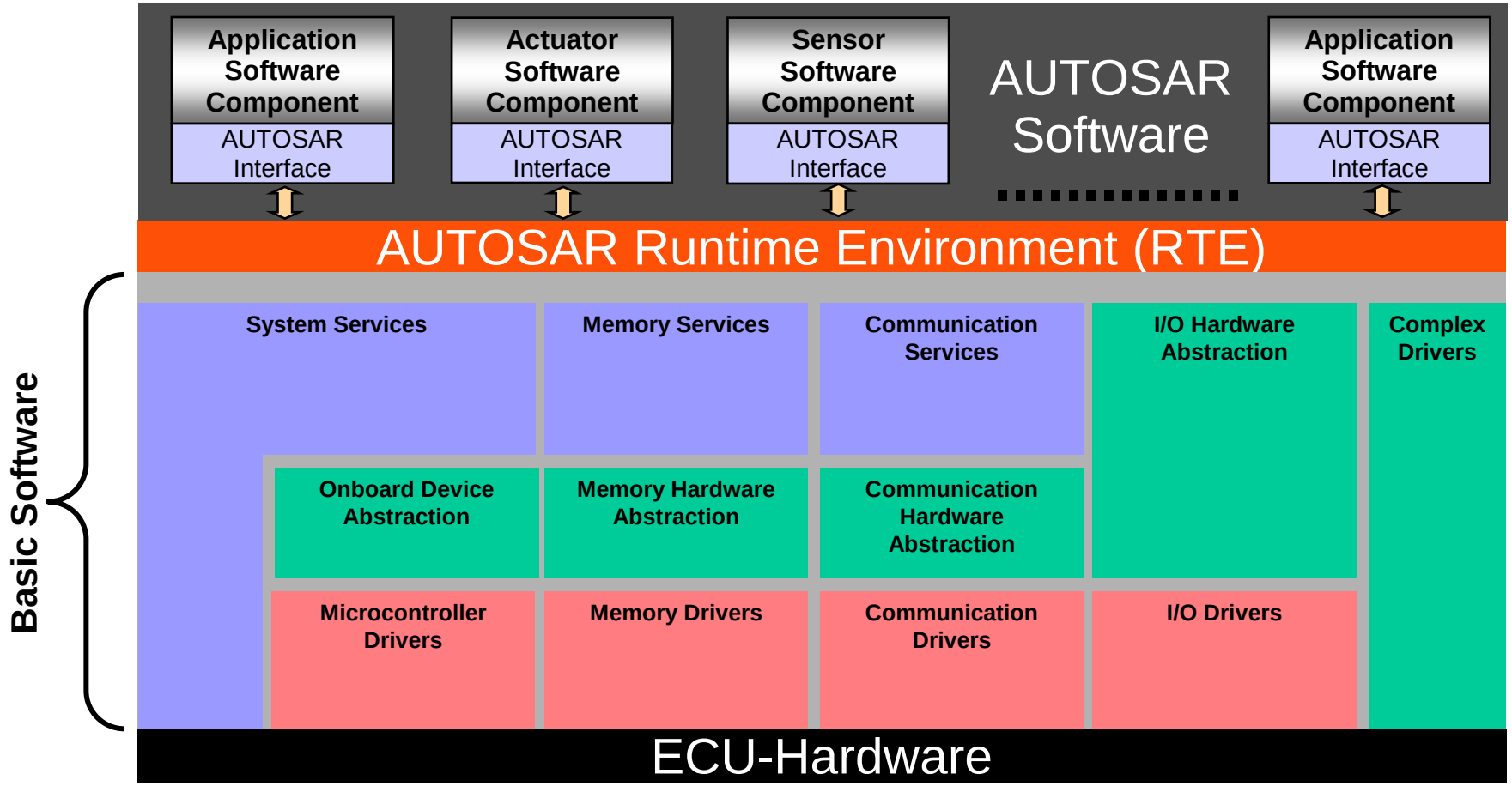


- **Application Interfaces:**
  Specification of interfaces of typical automotive applications from all domains in terms of syntax and semantics, which should serve as a standard for application software.

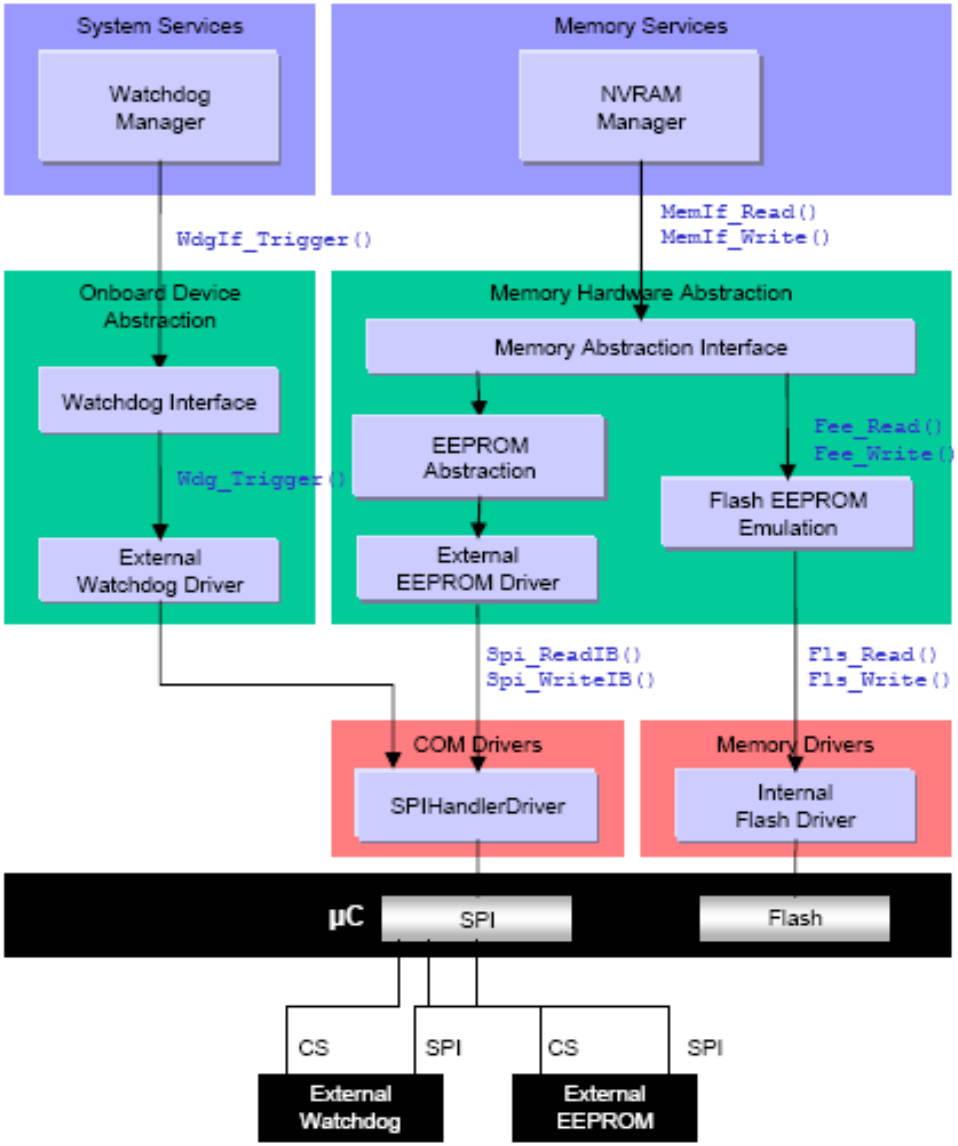
Layered Architecture



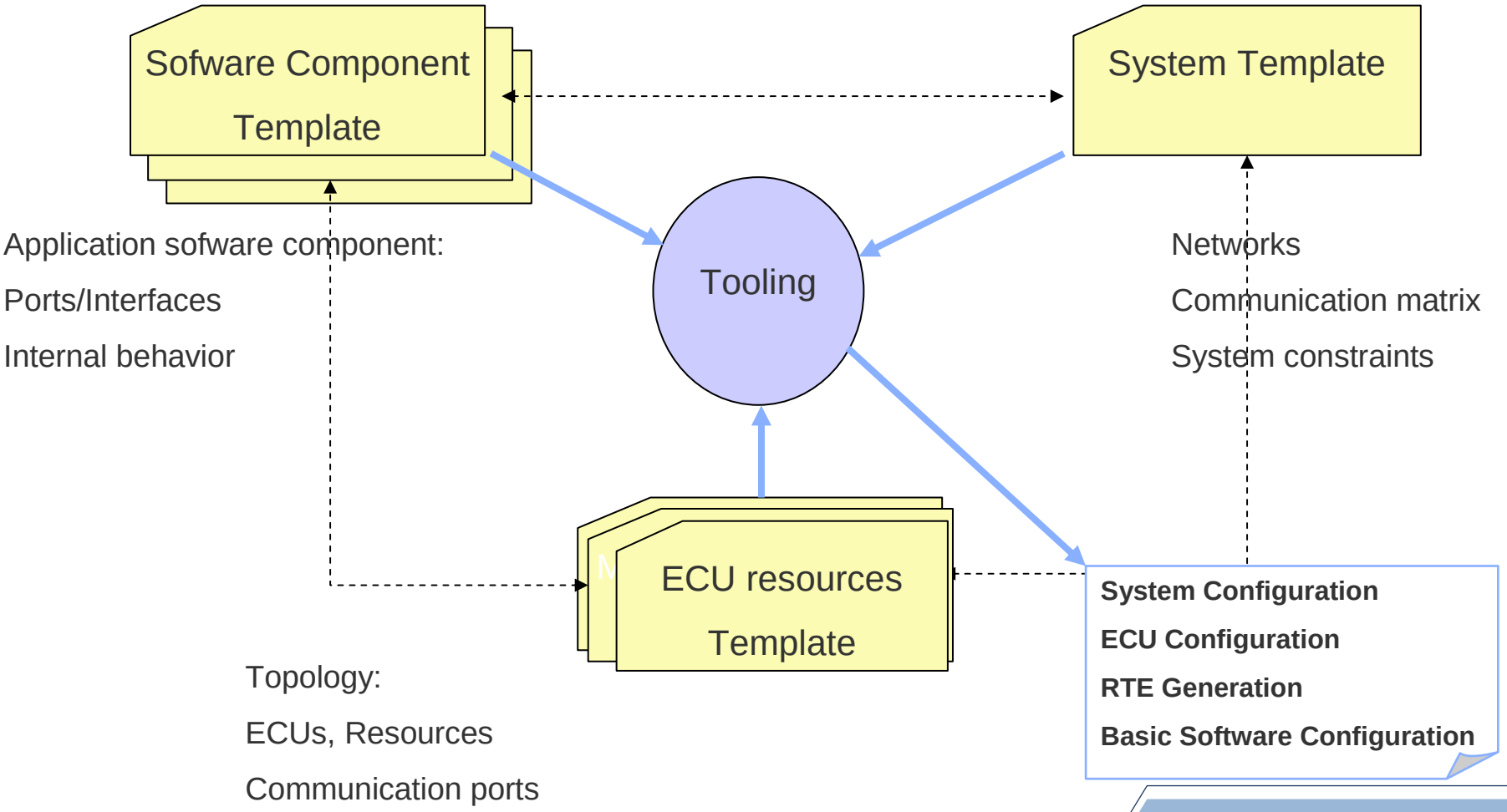
Architecture en couches



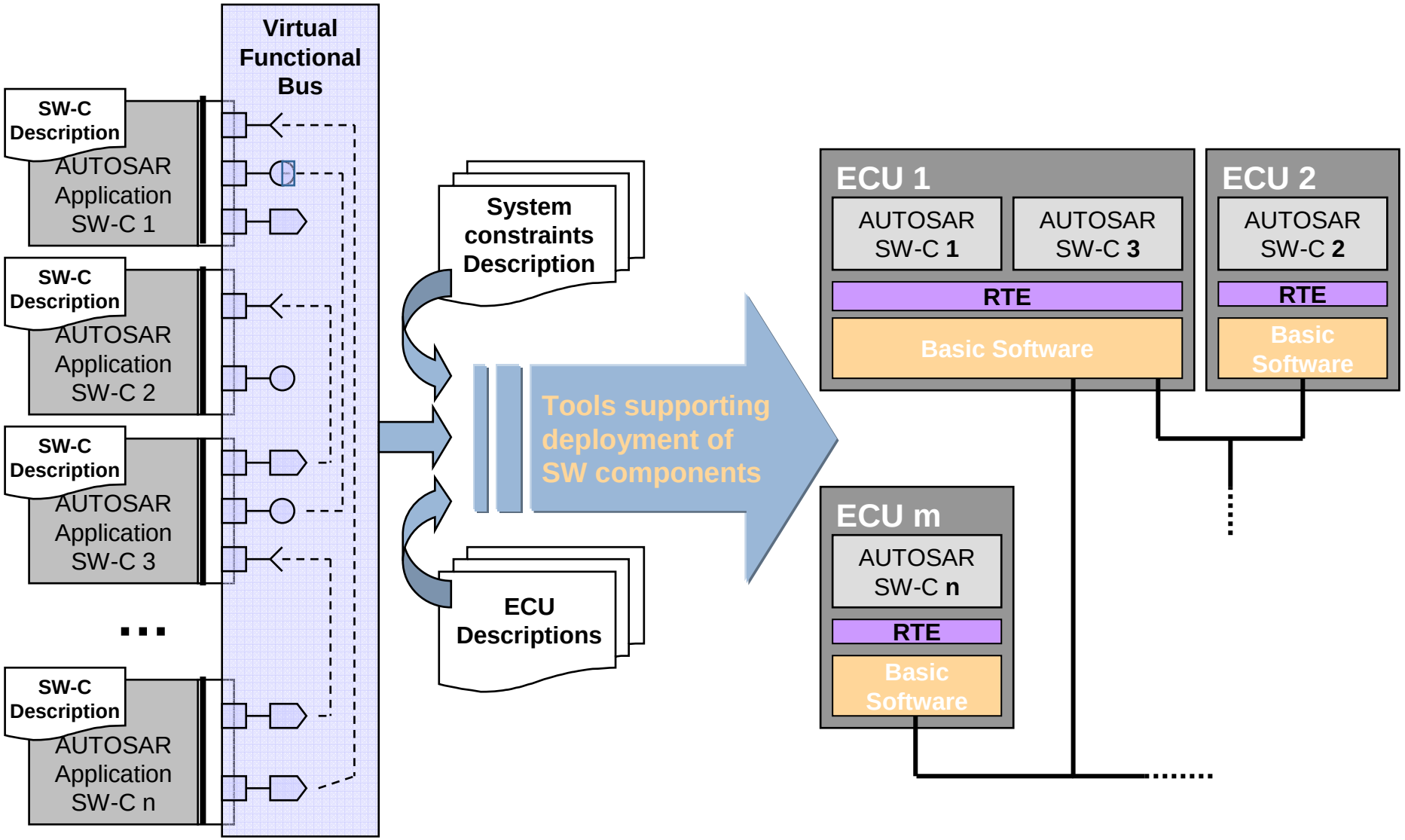
Details on the memory stack at basic software module level



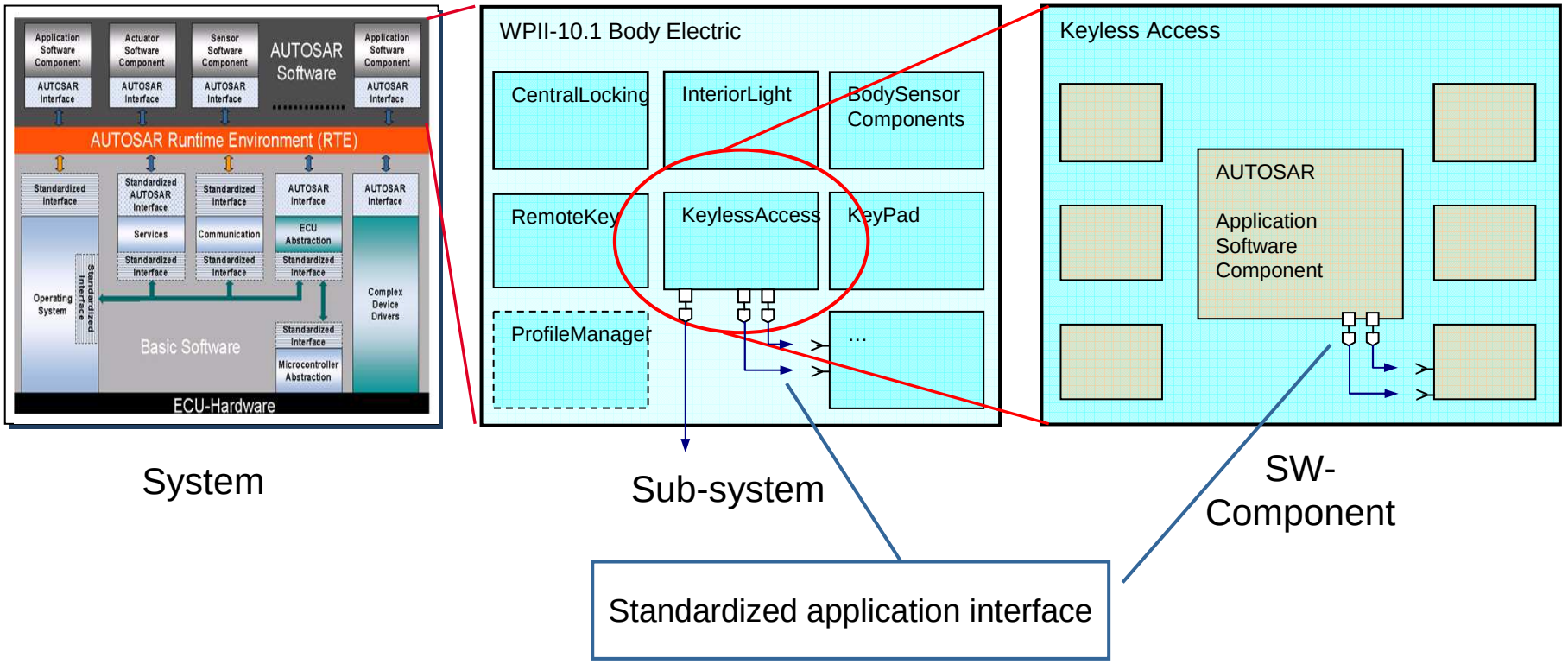
AUTOSAR Méthodology (1/2)



Méthodologie AUTOSAR (2/2)



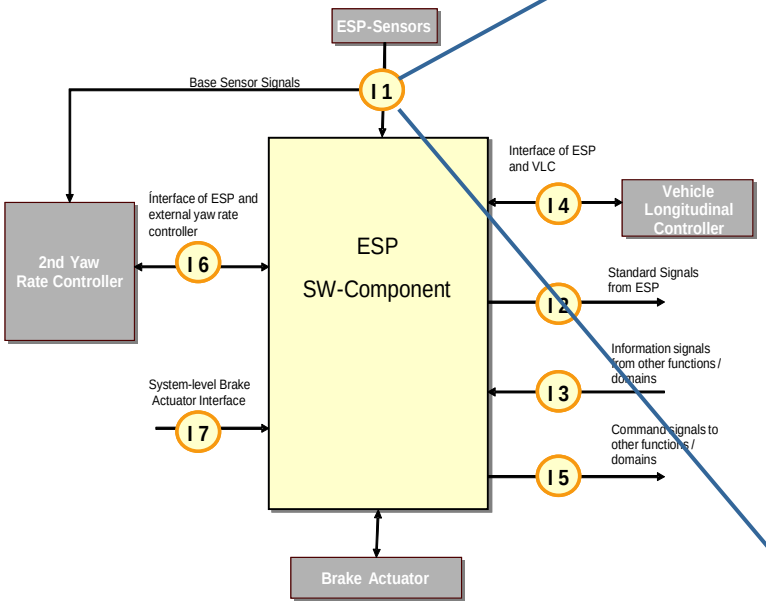
Application Interfaces



➔ AUTOSAR standardizes not all interfaces of a SW-component, only the widely required interfaces.

To ease the re-use of software components across several OEMs, AUTOSAR proceeds on the standardization of the application interfaces agreed among the partners.

Example



Data Type Name	**YawRateBase**
Description	Yaw rate measured along vehicle z- axis (i.e. compensated for orientation). Coordinate system according to ISO 8855
Data Type	S16
Integer Range	-32768..+32767
Physical Range	-2,8595..+2,8594
Physical Offset	0
Unit	rad/sec
…	….
Remarks	This data element can also be used to instantiate a redundant sensor interface. Range might have to be extended for future applications (passive safety).
…	
Data Type Name	**RollRateBase**

Standardized application interfaces on system level
(ESP-system, chassis domain)

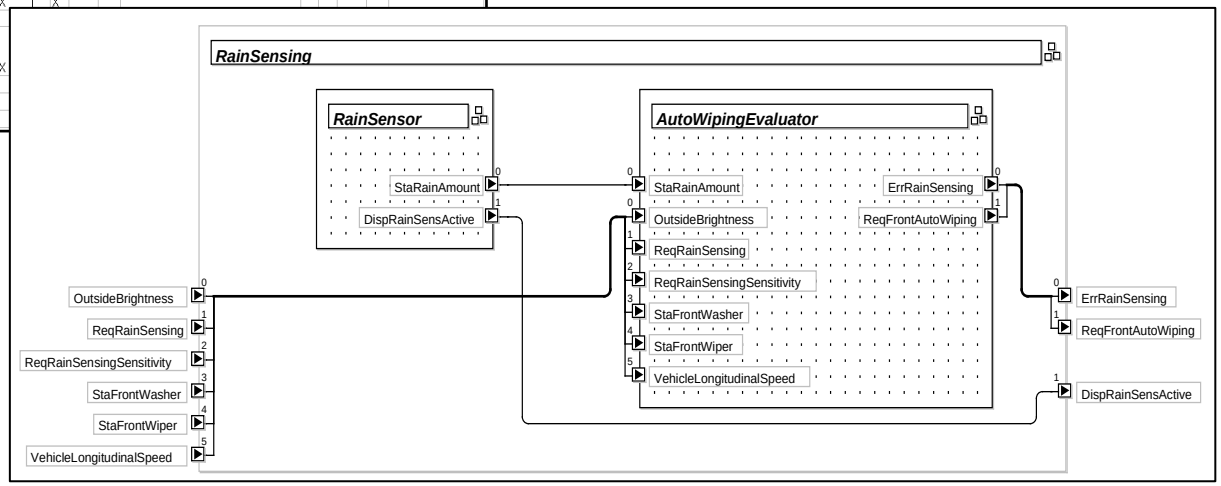
Integrated Master Table as Engineering Tool

AUTOSAR Interface Name	Shortname of Port	WP10.x Source	Consistency Check			RainSen		EvIrWipgAut						RainSnsr					
								EvIrWipgAut						RainSnsr					
						S1MS2		S1MS2						S1MS2					
			0	0	0			10.1						10.1					
			multiple Provider	no Provider	no Receiver	P	R	P	R	core cond opt	IV	components specific description		P	R	core cond opt	IV	components specific description
OutdBriSts1	OutdBri	10.1					X		X			Outside brightness impacts the calculation of automatic wiping re-quests.						
AmbAirT1	OutdT	ID/10.1					X		X			Temperature impacts the calculation of the automatic wiping re-quest.						
RainSenReq1	RainSenReq	10.1					X		X									
RainSenSReq1	RainSenSReq	10.1					X		X			The sensitivity impacts the calculation of the automatic front wiping request.						
WshrSts1	WshrStsFrnt	10.1					X		X			Front washing impacts the calculation of the automatic front wiping request						
WiprSts1	WiprStsFrnt	10.1					X		X									
RainAmntSts1	RainAmntSts	10.1																
VehSpdLgt1	VehSpdLgt	ID/10.3					X											
RainSenErr1	RainSenErr	10.1				X												
WipgAutReq1	WipgAutFrntReq	10.1				X												
DispRainSnsr1	DispRainSnsrAcv	10.1				X												

automatic generation

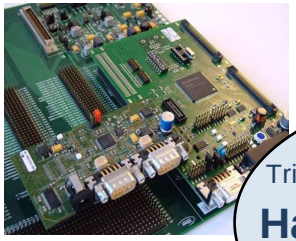
XML representation as standard document

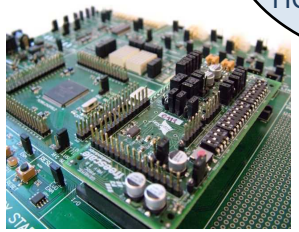
import



Graphical representation /
Import to AUTOSAR compliant modeling tool

A validation project was set up to validate the results of AUTOSAR





AUTOSAR Specifications

AUTOSAR Concepts & Methodology

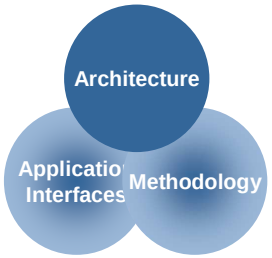
Validator dealt with …

TriCore 1766 (32 Bit)
Hardware Platforms
HCS12X (16 Bit)

Integration
by independent companies

Module Implementations & ECU Configuration Tools

Major Achievements of Releases 3.0/3.1

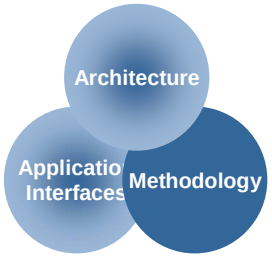


Architecture (BSW and RTE):

Industrially useable

- High stability of architecture and functionality
- Concepts for wake-up and bus state management incorporated
- On Board Diagnostic introduced in Release 3.1

→ Commercial implementations of BSW and RTE available

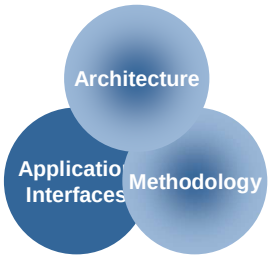


Methodology:

Major cornerstones set

- Improved implementation/configuration methodology by new BSW Module Description Template
- Good progress in the consistency of templates starting from the system view down to the ECU configuration

→ Commercial tooling for AUTOSAR available



Application Interfaces:

First set of cross-domain standardization

- First vehicle-wide specification of application interfaces
- Integration procedures available for further interface specifications

Release 4.0: main focus

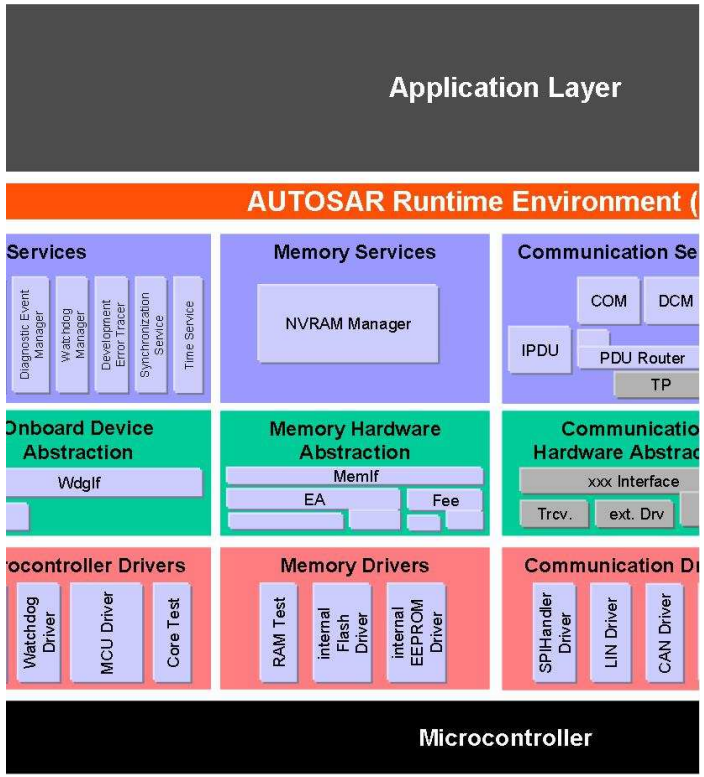
- **Architecture and Basic Software**
  - Functional safety, error handling harmonization,
  - Evolutions of the communication stack
  - Architectural extensions
  - Conformance tests specifications for basic software modules
- **Methodology**
  - Variant handling and calibration
  - Timing model
  - Improvement of templates
- **Application interfaces**
  - Continuous development in the domains of
    - Body, Powertrain, Chassis, Passive Safety, Telematics/Multimedia/HMI

Conformance testing in the AUTOSAR project

- The AUTOSAR standard is focussed on
  - The use by all partners (OEM, Tier 1s, software vendors) of a common architecture
  - The standardization of interfaces for basic software modules, RTE and application interfaces
  - A high configurability to cover all the needs and to enable scalability to different vehicle platforms
- The conformance testing has been a target from the very beginning to enable those objectives of transferability and reuse
  - The Workpackage #20 has been set up to build the conformance testing process
  - A specific Workpackage #2.2 is in charge of the development of the conformance tests

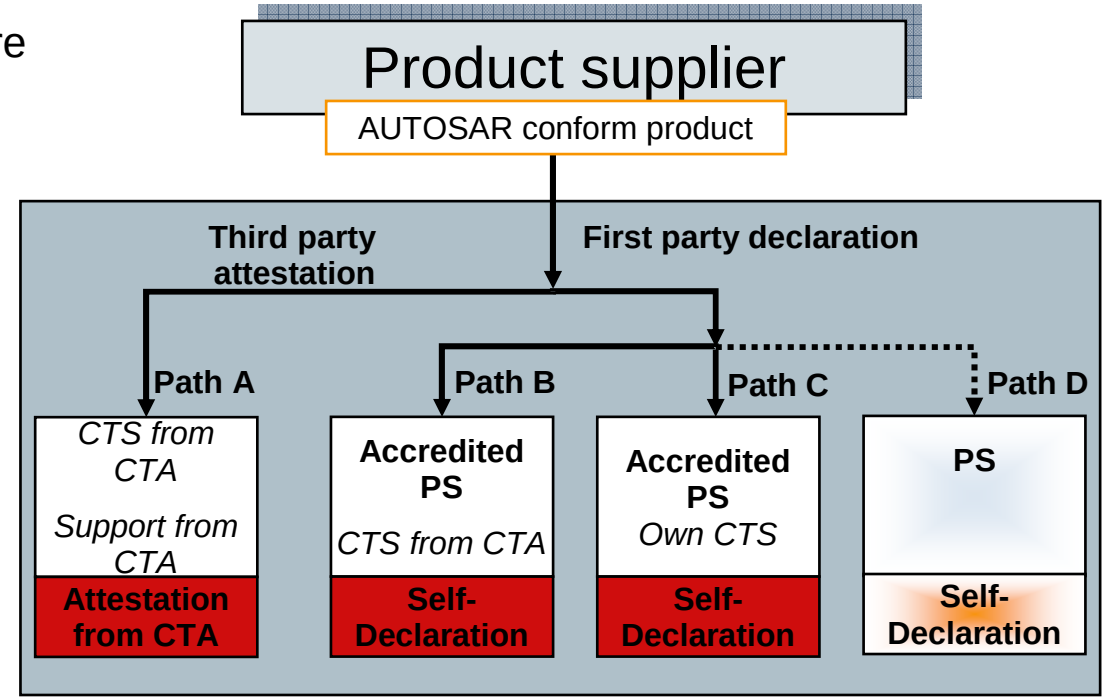
Conformance testing objectives

- The conformance of BSW implementations to the AUTOSAR specifications is a basic condition for
  - Interoperability and reuse
  - using AUTOSAR trademark
- They are developed for basic software modules and for the RTE
- Conformances tests will be part of the Release 4.0



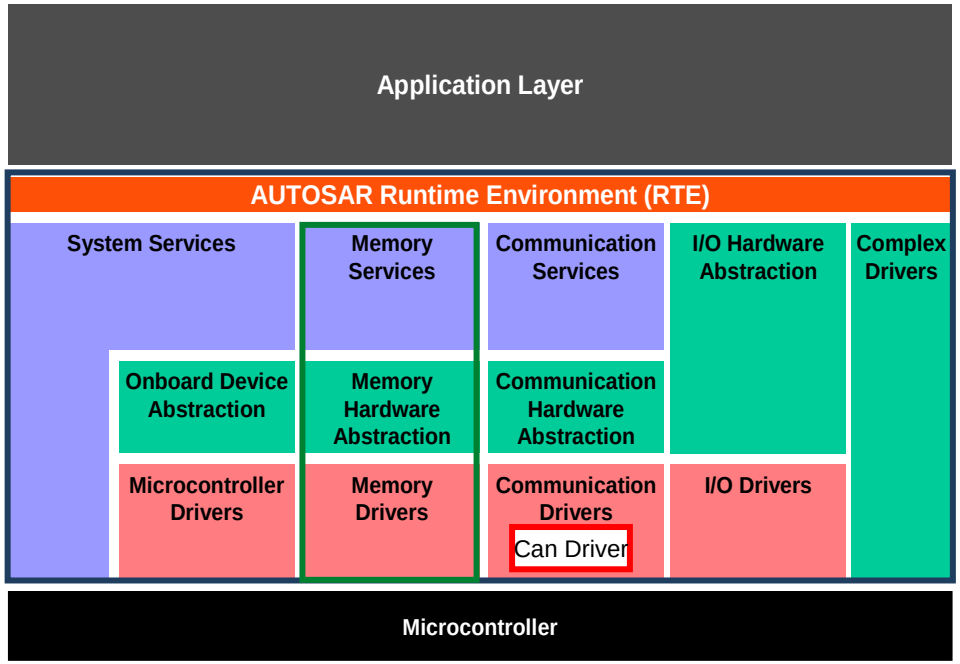
Conformance Testing for AUTOSAR products

- Conformance test agencies (CTA) are entitled companies for delivering conformance attestations on AUTOSAR implementations
- Conformance Test Agencies (CTA): produce/perform conformance test suites (CTS) derived from the conformance test specifications
- Different paths are defined for conformance from 3rd party attestation to self declaration



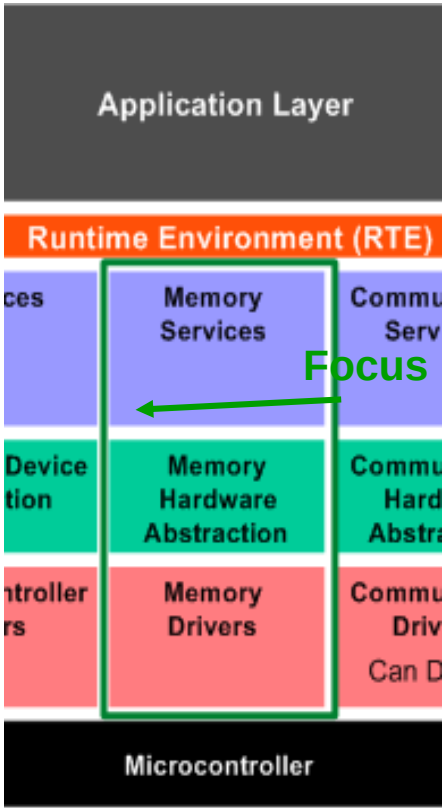
AUTOSAR Implementation Conformance Classes (ICC)

- **3 Implementation Conformance Classes**
  - **ICC3**: RTE + all BSW modules separately.
    - Maps full AUTOSAR module granularity
    - superset of all features in AUTOSAR
  - **ICC2**: RTE + BSW bundled into separate clusters.
    - Maps existing solutions and clusters (e.g. Memory-Cluster includes several modules)
  - **ICC1**: RTE + BSW in one single cluster:
    - Can be used for migrating to AUTOSAR.
    - Can be used to embed existing proprietary solutions.
    - Offers the highest level of integration.



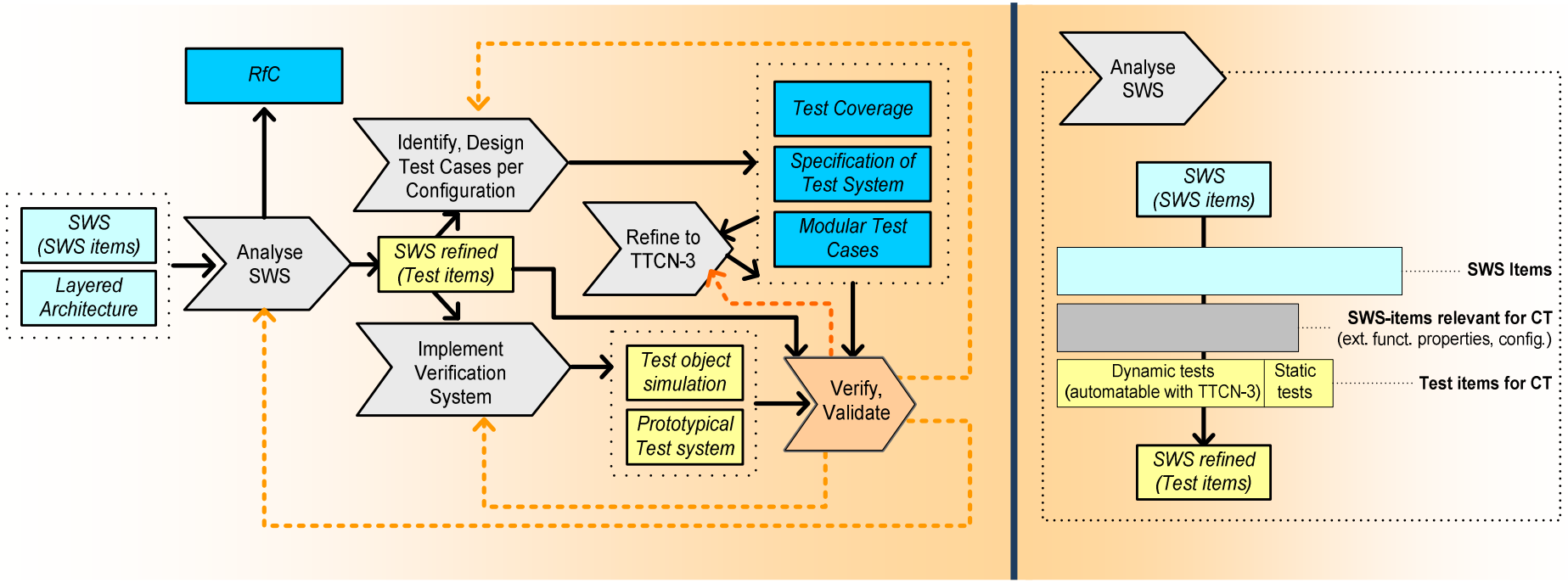
Conformance Test Specification process

- Objectives
  - CT methodology: How to test which test objects and features?
  - CT specification: How to organize the specification process?
  - CT verification: How to verify the quality of the tests?
- Scope
  - CT Specification on BSW, ICC3 level,
- Approach
  - Analysis and refinement of design specifications (SWS)
  - Identification and classification of SWS items
  - Design and specification of conformance tests
  - Verification of test specifications



Conformance Test Specification process

- Roles: Test designer, Test implementer, Test verification implementer, Test assessor
  - Phases: Analysis, Design, Implementation, Verification on dev machines and target platforms

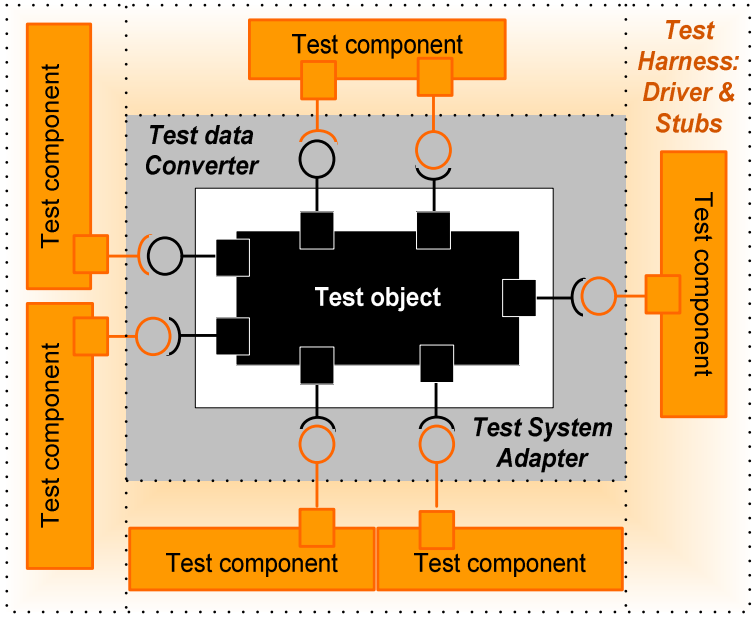


- Supporting disciplines, e.g.
  - Requirements management, Configuration management

Conformance Test Methodology

- Check test objects for conformance to design specifications (SWS)
  - Conformance tests
    - Primarily automatable, dynamic tests
    - Black-box unit tests of valid configurations
    - Functional properties of provided and required operations
  - Abstract test cases specified in TTCN-3
- Implementation Conformance Statement (ICS):
  - Is used to adapt the test suite to the actual variant of the test object

- **Test scope**
  - Interfaces, behavior and configurations
  - Functional tests of individual basic software modules
- **Requirements on tests**
  - Tests case specifications shall be stringent, accurate and non ambiguous
  - Executable test procedures shall be derived automatically from tests specifications



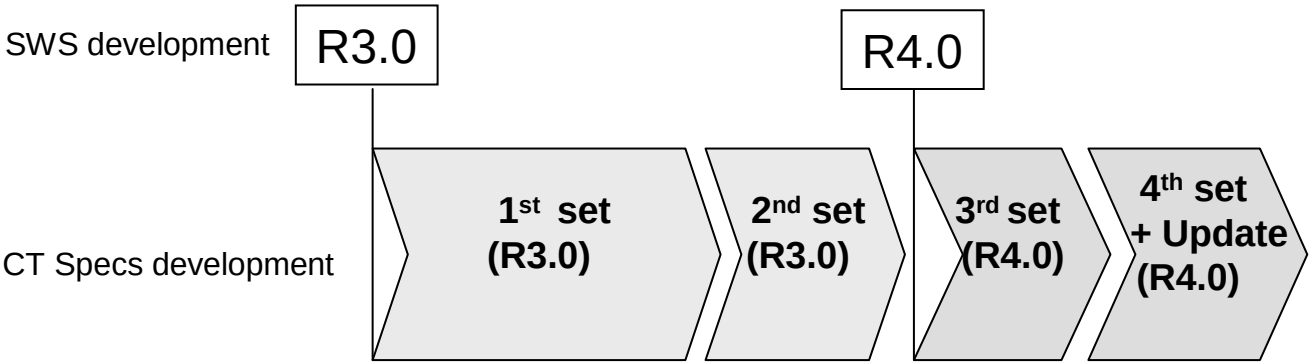
Rationale for choosing TTCN-3 for test specifications

- TTCN-3 is used for dynamic tests
  - Abstract notation for test specifications and stubs
  - Tests procedures can automatically be derived from test specifications
  - Test specifications delivered to CTAs by AUTOSAR are non ambiguous
  - Test suites developed by CTAs will keep the same behaviour.

- Boundary conditions
  - The tooling available on the market should behave the same wrt the TTCN-3 notation
  - TTCN-3 rules had to be elaborated in order to fit to the tools capabilities

Strategy for development

- Target is the AUTOSAR R4.0
  - Synchronize the development of SWS and CT specs
    - Anticipate with R3.0 modules
    - Start with modules where less changes are expected
- Improvements of SW specifications due to CT are included



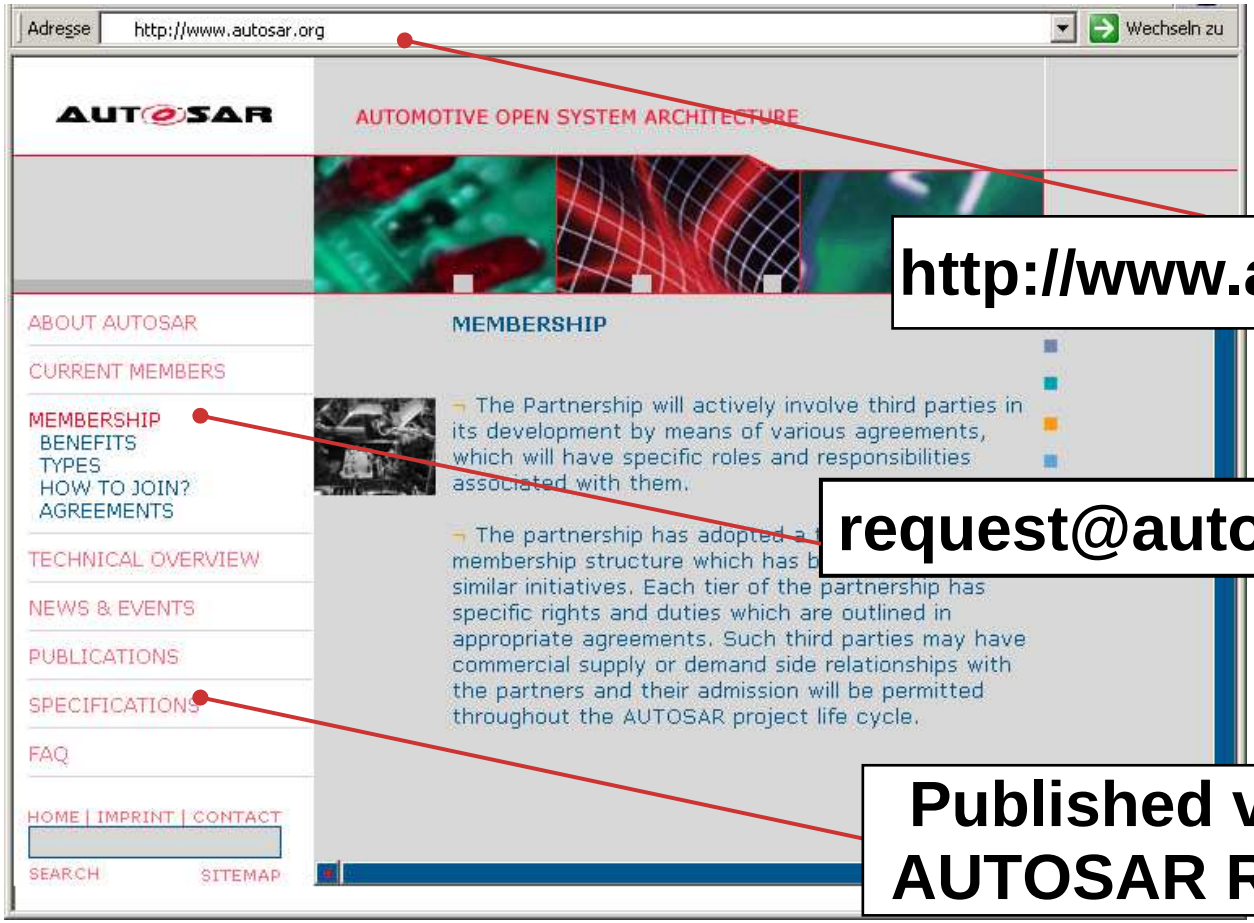
Outcome from the CTSpecs project

- **Analysis of 70% of the BSW modules**
  - ~5000 requirements have been already analyzed
  - 37% are testable by behavioral tests
- **Improvement of SW specifications**
  - Atomic requirements, testable, local to this module
  - Some functional bugs have been fixed too
- **Coverage (relevant for CT)**
  - Hardware dependent & real time dependent requirements are considered not testable
  - Test coverage is depending on the modules
    - Maximum: 100%
    - Average: 84%
    - Minimum: 61%
- **Test validation**
  - All the test cases has been validated on a simulated environment
  - A feed back loop has been established with pilot CTAs

Conclusion

1. **The AUTOSAR development partnership has brought to reality a unique and worldwide standard,**
2. **AUTOSAR products are now available on the market,**
3. **Conformance test has already made the specifications more robust**
4. **Conformance test will help us to keep the integrity of the standard**

Thank you for your attention!



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request@autosar.org

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