

# **AUTOSAR - A worldwide standard**

## **Current developments, roll-out and outlook**

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### **1. Abstract/Summary**

The AUTomotive Open System ARchitecture (AUTOSAR) was founded as a development partnership in 2003. Surveys show that it is today the global automotive software standard. Currently AUTOSAR is in the middle of its third development phase (2010-2012).

This document will give a short overview of the most important results of Phase II (2007-2009), which were made available by releases 3.0/3.1 and 4.0. The focus of release 3.x was on internal harmonization of the basic software modules and templates, whereas release 4.0 introduced important new technologies such as support for functional safety and multi-core architectures.

Exploitation plans show that releases 3.x are today widely used in series production and will be in the future. Release 4.0 however will gain importance rapidly and is currently getting introduced in series development.

An update on achievements of Phase III and the future release plans will be presented.

## 1. Introduction

### 1.1. Technical Background

The objective of AUTOSAR is to establish an open global industry standard for the automotive software architecture between suppliers and manufacturers [2]. The standard comprises a set of specifications describing software architecture components and defining their interfaces [3]. The principal aim of the standard is to master the growing complexity of automotive electronic and software architectures. The need to build a common architecture as well as development methodology and application interfaces became stringent for a variety of reasons, among which:

- Defining a common understanding how electronic control units (ECU) cooperate on same functions.
- Separating the software from the hardware in order to allow software reuse and smooth evolutions limiting re-development and validation.
- Finally AUTOSAR is enabling multiple different functions as for example software modules to be hosted on the same ECU, independently from the supplier of either part.

The ongoing development of AUTOSAR based products by the member companies provides a unique feedback loop into the development of the standard itself. This allows fast and pragmatic improvements and adaptations to market needs. The reusability of software has already been experienced in major developments and it has resulted in substantial savings in the overall development costs.

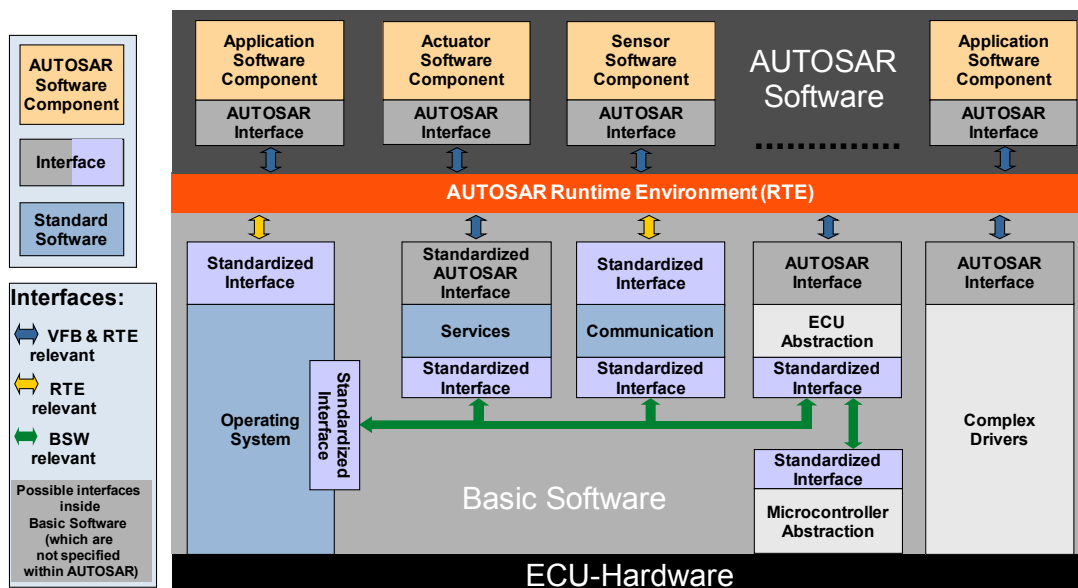
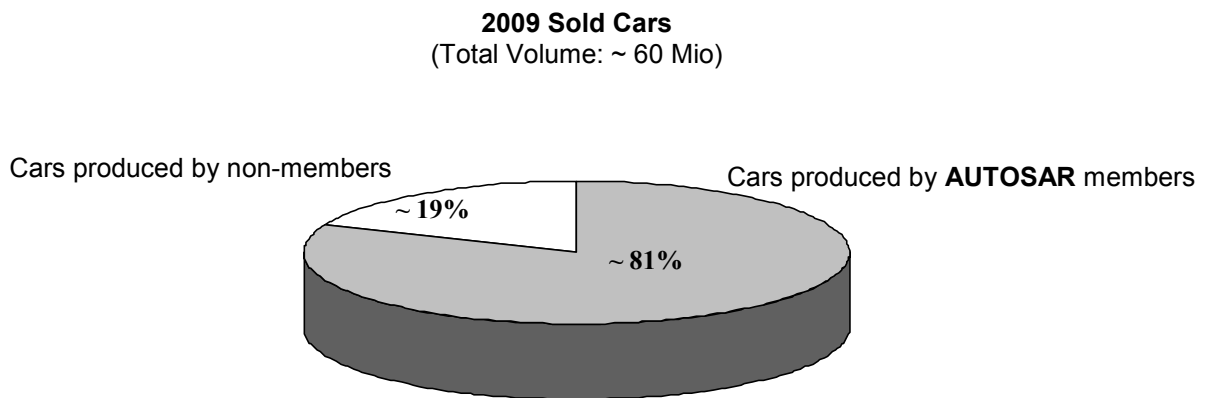


Figure 1: AUTOSAR Software Architecture – Components and Interfaces

AUTOSAR has become the global automotive SW standard with regards to technology leadership and overall industry participation. Analysis of sales data show that more than 80% of the global automotive production volume is made by OEMs which are AUTOSAR members.

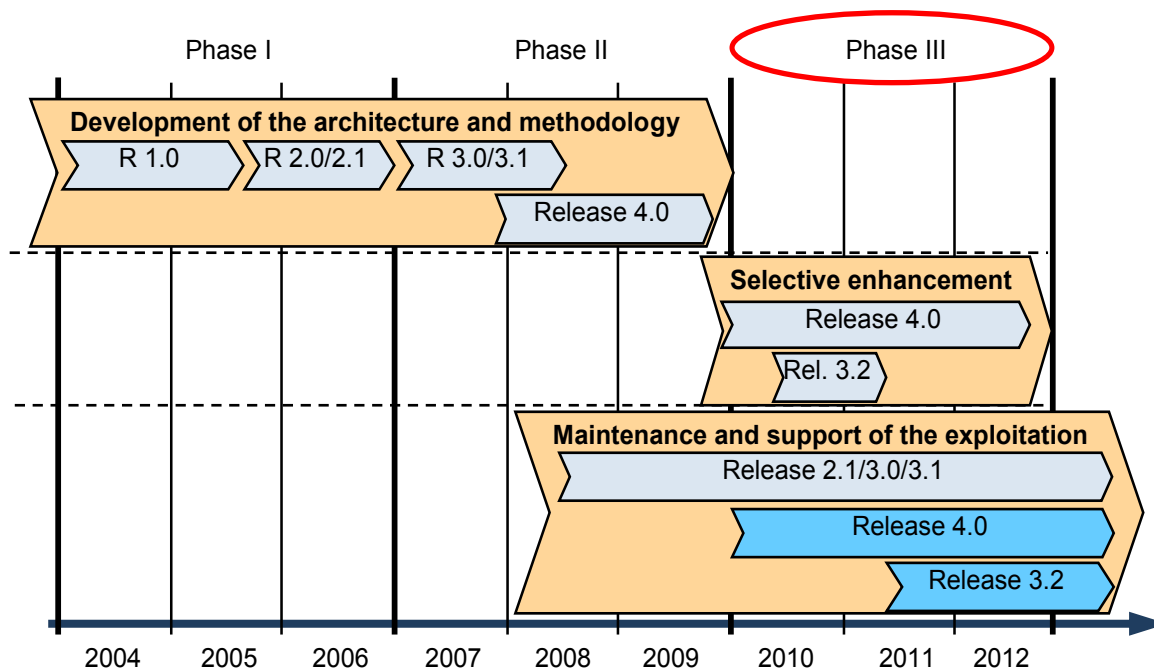


**Figure 2: Volume of cars sold in 2009**

## 1.2. Project Organization

Since its foundation in 2003, the AUTOSAR Development Partnership has provided several releases as a result of its joint development activities. The work of the AUTOSAR Partnership can be divided into the following periods:

- Phase I (2004-2006): Basic development of the standard (Release 2.1 at the end of Phase I in 2006, AUTOSAR finalized the first set of major specifications).
- Phase II (2007-2009): Extension of the standard in terms of architecture and methodology to serve market needs and increase robustness (Release 3.0/3.1 and release 4.0).
- Phase III (2010-2012): Maintenance and improved maintainability of the different releases used for series production and support of the exploitation into the market.



**Figure 3: AUTOSAR Timeline**

Currently AUTOSAR is in the middle of its third phase (2010-2012).

## 2. Current Releases of AUTOSAR

### 2.1. A Brief Reflection on AUTOSAR Phase II

The main focus of phase II was extension to market needs of the advanced architecture and methodology standard. As a result, releases 3.0 and 3.1 closed the remaining gaps in the basic software and harmonized the basic software modules and templates. The releases helped to mature the standard. Basic software (BSW) implementations are available and are actively used in various series projects within the industry. Tool suppliers support the exchange formats and templates specified by these releases. The interoperability of the tools, provided by the standardized exchange format, results in a more powerful tool chain that enables a true systems engineering approach. Overall the acceptance of the 3.x releases is high.

The AUTOSAR presentation in Baden-Baden in 2009 [4] announced the upcoming release 4.0 and its new technical content. It has been released on time end of 2009.

Release 4.0 introduced important new concepts which are all driven by further developing market needs to enable state-of-the-art automotive applications. These include most notably:

- Support for functional safety  
(e.g. memory partitioning, program flow control, end-to-end library)
- Multi-core support
- Application / vehicle mode management
- Variant handling
- Timing model
- Standardized application interfaces

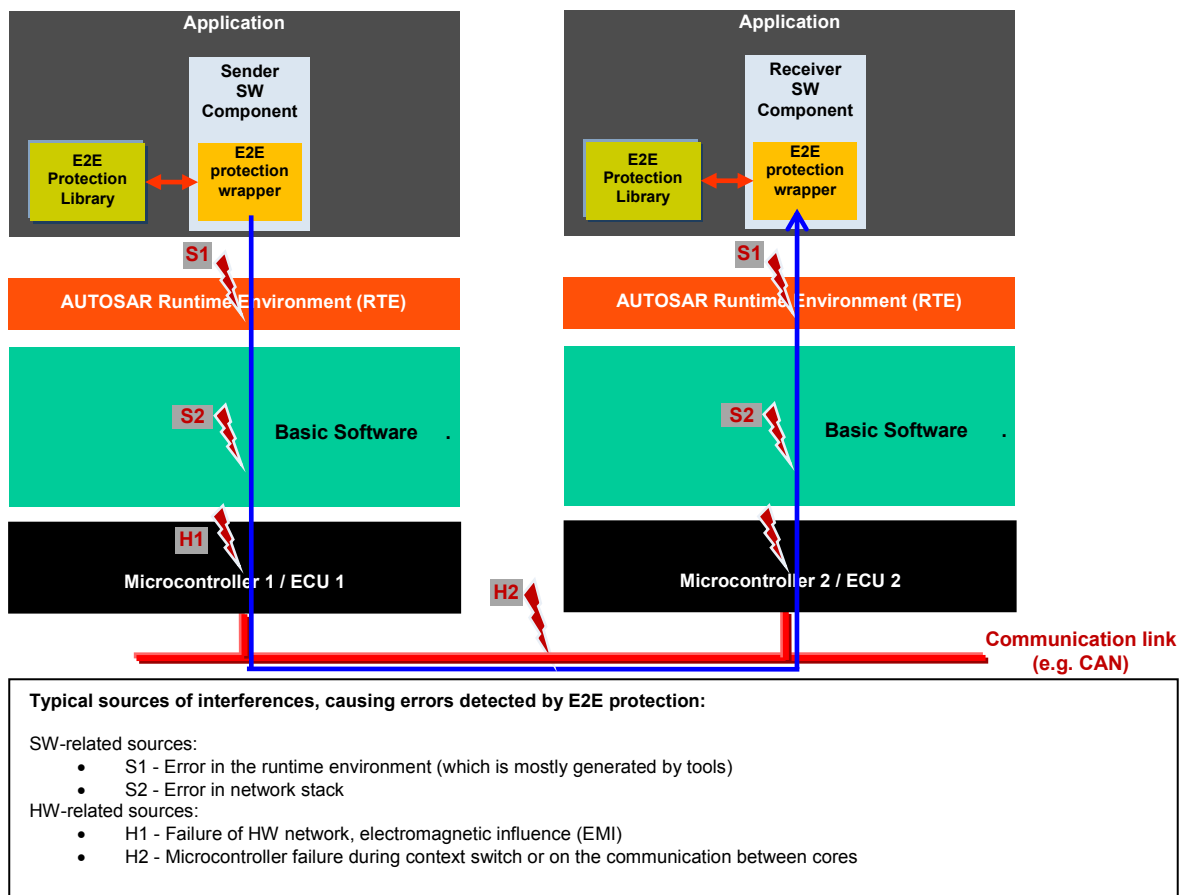
Comprehensive solutions for functional safety and multi-core technology are an integral part of the AUTOSAR standard. They address technical challenges which are not covered by any other standard in the automotive software domain worldwide and in this way strengthen the importance of the standard.

### **Functional Safety**

Functional safety is one of the main objectives of AUTOSAR [5]. The standard will support safety related applications and therefore has to consider the upcoming ISO 26262 standard (which will be published in Oct. 2011). Exemplarily the end-to-end communication protection library (E2E library) is illustrated below as one of the AUTOSAR features, which support functional safety.

The E2E library implements a state-of-the-art safety protocol at application level. By using protection mechanisms provided by the library, potential faults in a communication link can be detected and handled at runtime. The provided mechanisms for E2E protection are adequate for safety-related communication having requirements up to ASIL D. The E2E protection offers the following features:

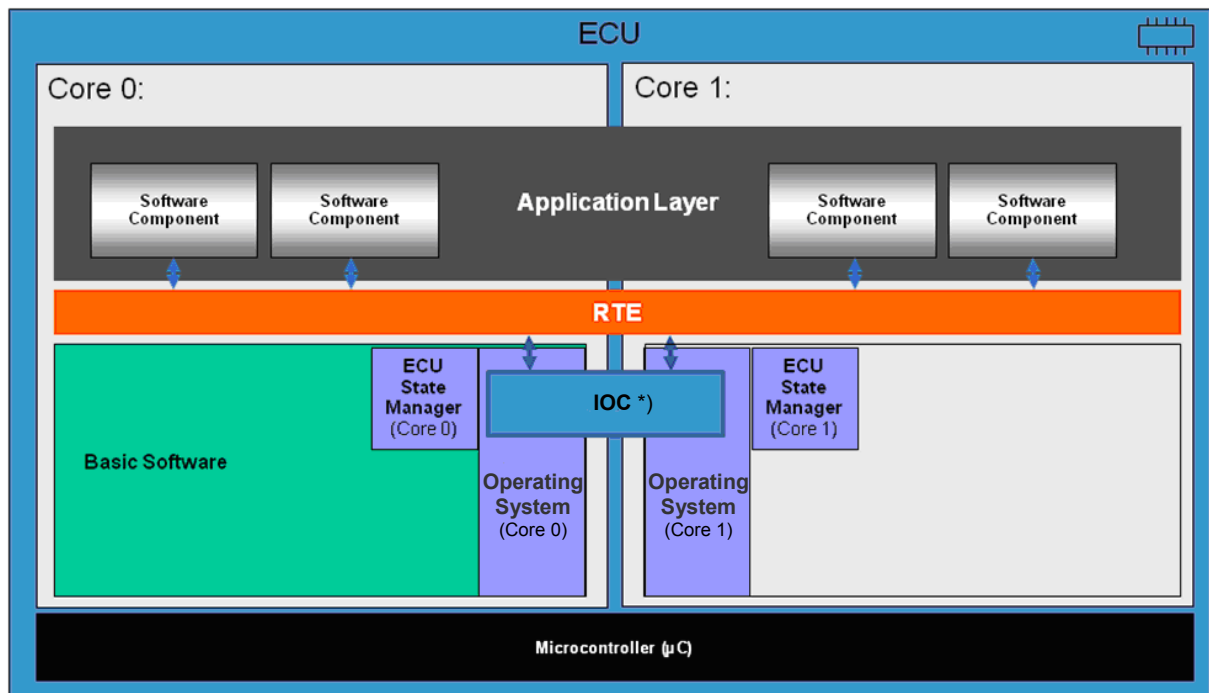
- It protects the safety-related data elements to be sent over the runtime environment (RTE) by attaching control data (e.g. data id, sequence counter, checksum).
- It verifies the safety-related data elements received from the RTE using this control data.
- It indicates that received safety-related data elements are faulty, which then has to be handled by the receiver SW-C.



**Figure 4: End-to-end communication protection library**

## Multi-core Support

Latest embedded multi-core micro controllers provide superior computing power at reduced power consumption. This increase in computing power is necessary in order to meet the needs of future control software and further integration of functionality. However multiple cores' computing power can only be taken advantage of, if the software is designed accordingly. In release 4.0 of the AUTOSAR specification the runtime environment (RTE) and AUTOSAR-based OSEK operating system (OS) is extended by multi-core specific functions. The RTE hides the multi-core details from the application, so the application software can be developed independent of multi-core issues in a reusable fashion.



\*) Inter OS-Application communicator

**Figure 5: Multi-core architecture**

The distribution of application software among cores is supported by the AUTOSAR methodology and hence by the tool chain. Adding further flexibility w.r.t. load balancing and basic software distribution is planned for the future.

### 3. AUTOSAR Phase III

With phase III, beginning in 2010, the AUTOSAR Development Partnership continued the project with a stable register of members.

Main objectives of Phase III are:

- Maintenance of existing releases
- Selective enhancement of the standard driven by market needs
- Improve maintainability of the standard

With revision 2 release 4.0 has reached a stable and mature stage, which covers important technologies requested by the market. Revision 2 is the base for first series implementations.

Feedback from these implementations, however, show, that revisions 3 and 4 are required to further optimize release 4.0 and to make it applicable without OEM specific extensions.

In order to get a better understanding about the current and planned usage of available AUTOSAR releases, feedback from series projects and the intended business model for the respective parts of the AUTOSAR standard a comprehensive survey among the Core Partners was conducted. The results have been used to adopt the release timing and technical content of phase III.


### 3.1. AUTOSAR Core Partner Exploitation Plans

In this Core Partner survey, different aspects of their AUTOSAR exploitation plans, like

- Preferred migration strategy
- Releases being used / planned to be used in series projects
- Preferred license model for BSW/RTE
- Usage of application interfaces
- Projected volumes of ECUs with AUTOSAR

have been collected and analyzed.

	already in use	planned SOP in 2011	planned SOP in 2012	planned SOP in 2013	planned SOP in 2014	planned SOP in 2015	planned SOP in 2016	planned SOP later than 2016
Mandated in new platforms	PSA PEUGEOT CITROËN VOLKSWAGEN <sup>1)</sup>		BMW Group	DAIMLER	VOLKSWAGEN		GM	
Optional for new platforms	BMW Group Continental Ford TOYOTA		VOLKSWAGEN					

 "Each domain is about to establish a migration path to AUTOSAR"

1) FlexRay ECUs only

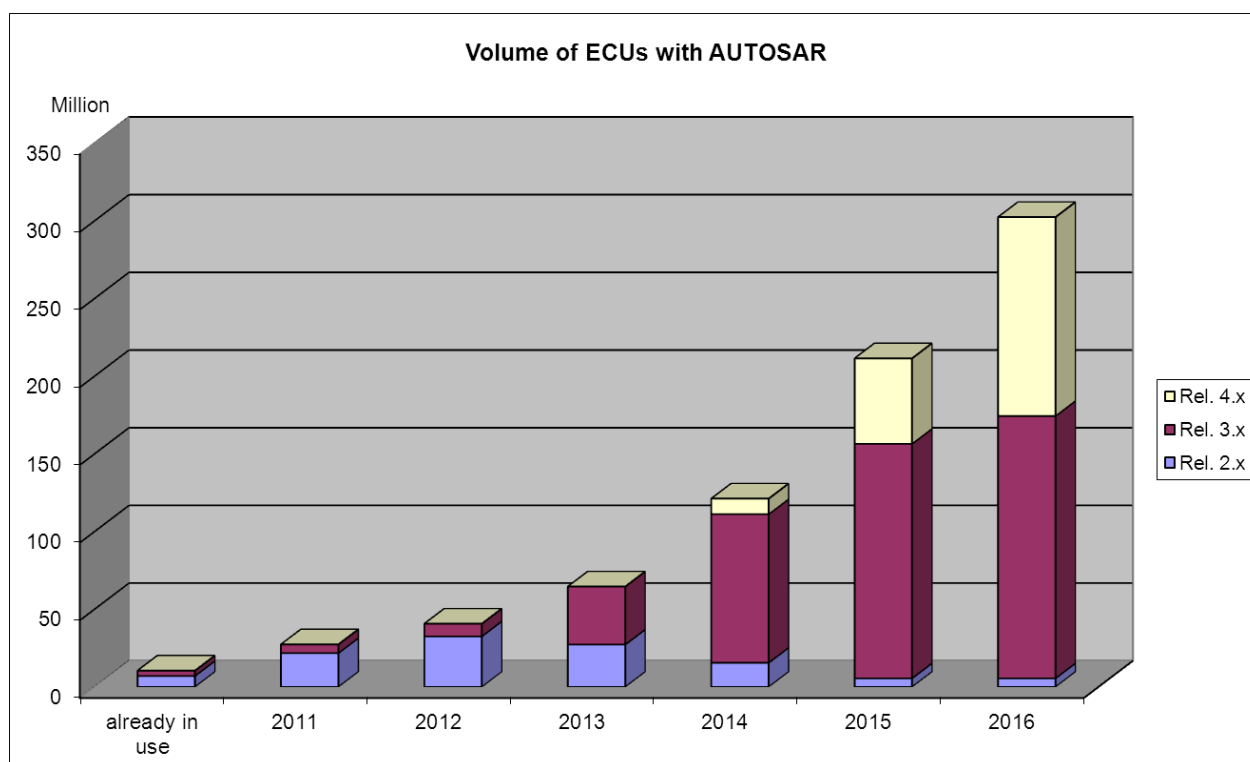
**Figure 6: Core Partner exploitation plans in platforms (vehicle or ECU platforms)**

All Core Partners are using AUTOSAR or are planning to mandate AUTOSAR in future platforms.

One key result is the predicted rapid growth of AUTOSAR's market penetration between now and 2016. Figure 7 indicates the increasing number of automotive ECUs with AUTOSAR technology.

Further important key findings from the survey are:

- The main stream of AUTOSAR releases are R3.x and 4.0.
- Different migration strategies and license models for the BSW and the RTE co-exist and will continue to co-exist, even within an OEM.
- Core Partner Tier1s prefer own development of AUTOSAR BSW, instead of purchasing it from Tier2s.
- The majority of the Core Partners will finish their migration to fully compliant AUTOSAR BSW in 2015.



**Figure 7: Volume of ECUs with AUTOSAR inside**  
(accumulated figures from BMW, Daimler, Ford, GM, PSA, Toyota and Volkswagen)

The detailed results of the survey have been shared at the 3<sup>rd</sup> AUTOSAR open conference and are published at [6].

### 3.2. Maintenance of Releases

Implementations based on releases 3.x are already widely used in series projects. The exploitation survey shows the high acceptance and importance of these releases.

To protect the investments in these releases (e.g. in tooling and software implementations) AUTOSAR members require further maintenance and improvements of R3.x. The feedback

from the series projects is valuable input for the improvement process. However, at the same time there is an obvious need for selective enhancements - such as specific R4.0 features - and support of new technologies in these release 3.x-based projects. One of the main drivers for the introduction of a release 3.2 was the strong and short term market need for partial networking.

Additional new features in release 3.2 are

- Robustness features (especially in state manager modules)
- Improvement of error handling (e.g. production vs. development errors)

In addition the following features were back-ported from Rel. 4.0

- End-to-end communication protection
- Extended Complex Device Driver (CDD) concept
- Basic Software Mode Manager
- FlexRay ISO Transport Protocol

## **Partial Networking**

By incorporating Partial Networking into the standard (release 3.2.1 as well as 4.0.3), AUTOSAR addresses the important need for an efficient energy management. The objective is to reduce power consumption of the overall electrical system by reducing the number of active ECUs on the bus during vehicle operation. Requirements for the basic software stack have been identified to enable AUTOSAR to realize a shut down and startup of the bus communication interfaces of groups of ECUs (Partial Network Cluster) during normal bus communication.

The power consumption can be reduced by e.g.

### Shutting down of seat control functions

It shall be possible to shut down nodes responsible for seat control functions during driving. By default these nodes are in a sleep state. Only when the driver pushes the seat control switch, those nodes ("seat control" Partial Network) required for seat control functions are woken up. The "seat control" Partial Network is shut down if none of the nodes requires bus communication.

### Shutting down of park assistant functions

It shall be possible to shut down nodes responsible for park assistant functions depending on the vehicle speed. At a vehicle speed higher than e.g. 30 km/h the nodes

(“park assistant” Partial Network) required for park assistant functions are shut down.  
At a lower speed, only those nodes that belong to this Partial Network are woken up.

AUTOSAR is the first initiative to standardize the Partial Networking technology.

Release 3.2 is in general backward compatible to releases 3.1/3.0. Where needed detailed Backward Compatibility statements are available in order to ease the transition from release 3.1 to release 3.2 or to assess interoperability.

The fact that there are two main release streams – 3.x and 4.0 – within AUTOSAR and their increasing usage in series projects requires a strict control of the backward compatibility (BWC).

For this purpose Phase III introduces process enhancements to impede incompatible developments in the standard. The AUTOSAR Backward Compatibility Statement will support AUTOSAR users in the migration analysis between releases or revisions. The scope is bus and application level, including templates.

### **3.3. Evolutionary Release Approach**

Based on the exploitation plan feedback and the wide acceptance of release 3.2 and release 4.0 the AUTOSAR Core Partners decided not to introduce another major or minor release (4.1 or 5.0) during Phase III, but instead to stepwise introduce new content with a clear focus on backward compatibility. This will further strengthen the stability of AUTOSAR and stabilize the overall AUTOSAR ecosystem. Selected backward compatible concepts will be introduced in release 4.0.4 by the end of 2012.

## **4. AUTOSAR Test Standardization**

### **4.1. AUTOSAR Conformance Testing**

With release 4.0.2 Conformance Test (CT) specifications for 43 Basic SW modules are available. These CT specifications are partially specified in TTCN-3<sup>1</sup> for automated test execution in a test suite and partially in check lists that can be automated by the user if required later on. Undoubtedly, the creation of the AUTOSAR conformance test specification has helped to improve the quality of each of the BSW module specifications and the overall standard. However it has turned out, that neither the fine granularity of the tested modules

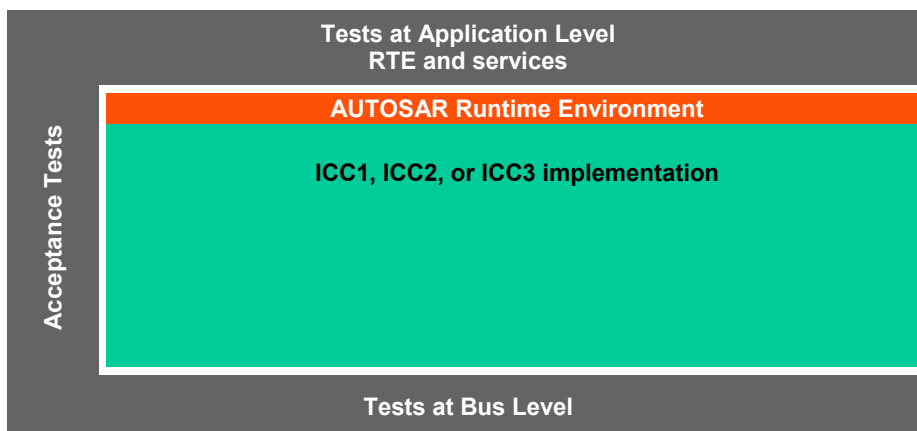
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<sup>1</sup> TTCN-3: Testing and Test Control Notation

nor the strict test processes on such a detailed level do exactly fit the business needs of the AUTOSAR users. Experience shows, that the AUTOSAR BSW is usually not purchased module-wise, but as a whole. AUTOSAR has therefore decided to create a leaner, more efficient way of testing, which is named Acceptance Testing.

#### 4.2. AUTOSAR Acceptance Testing

The details of the future AUTOSAR acceptance test are currently worked out. So far the scope and the main objectives have been agreed. The acceptance test shall enable the OEM's and/or integrator's acceptance of a supplier's platform at bus and application level (ICC1)



**Figure 8: Volume of ECUs with AUTOSAR inside**

This includes tests for

- Bus compatibility (e.g. compatibility of protocols such as TP, NM)
- Application compatibility (Compatibility of interfaces to ensure integration of SWCs)
- Configuration compatibility (Compatibility of templates to ensure that a “typical” ECU extract can be used for configuration)

#### 5. AUTOSAR's co-operation with other organizations

AUTOSAR as an international standard will further extend co-operation with other international organizations. It will continue its close co-operation with the Japanese Jaspar automotive standardization consortium

- Common high level meetings are taking place twice a year.
- Exchange between Jaspar and AUTOSAR experts on WP level.
- Integration of several Jaspar results into release 4.0.4 is ongoing.

- The AUTOSAR conference in May 2010 took place in Tokyo with strong support by Jaspar.

A focus will also be on the emerging markets India and China, which show a high interest in AUTOSAR as the international automotive software standard. Exchanges on technical collaborations with the Chinese Automotive Electronics Standardization Committee (AESC) and Indian organizations are currently ongoing. With the support of a Core Partner, local AUTOSAR representatives have been established in India and China. These additional regional standardization bodies are not seen as an overlap with AUTOSAR but are rather complimentary. For example, AUTOSAR does not produce implementations so regional organizations can collaborate to create a standard implementation. Additionally, regional standardizations may bring a unique perspective of their respective market and drive those change requests into the AUTOSAR standard (i.e. ECUs to support low content vehicles in emerging markets).

## **6. Conclusion**

AUTOSAR has become the global standard for embedded automotive software, providing specifications for

- Software architecture
- Software development methodology
- Standardized application interfaces

Exploitation plans show that the main stream of AUTOSAR releases are releases 3.x and releases 4.0. AUTOSAR will help to protect the investments in releases 3.x by maintaining the release 3.2

The achievements of Phase III so far can be summarized as

- A new minor release 3.2 was introduced addressing the strong market need to enable partial networking.
- Only backward compatible concepts will be introduced in revision of release 4.0 instead of introducing a new minor or even major release by end 2012. This stepwise introduction of concepts will strengthen the stability of AUTOSAR and stabilize the overall AUTOSAR ecosystem.
- AUTOSAR Application Interfaces are ready for use and standardization continues.
- Backward Compatibility requirement of Phase III brought to practice.

- Acceptance Tests will fulfill the market demands much better than Conformance Tests.

## 7. References

- [1] Official website of the AUTOSAR Partnership: [www.autosar.org](http://www.autosar.org)
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- [5] AUTOSAR Main Requirements: AUTOSAR\_MainRequirements.pdf
- [6] 3<sup>rd</sup> AUTOSAR Open Conference, May 11<sup>th</sup> 2011, Frankfurt:  
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