AUTOSAR – Shaping the Future of a Global Standard

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Abstract

AUTOSAR was founded as a worldwide development partnership in 2003. The objective of this global cooperation was to establish an industry standard in the field of automotive software architecture for OEMs and suppliers. Until now major specification releases have been produced, which are in use for several series projects of the different partners. AUTOSAR enables complexity management of integrated E/E architectures through increased reuse and simplifies collaboration between different partners by providing a unified language and methodology. From 2013, AUTOSAR will enter a new phase that represents a further evolutionary step towards deployment into world-wide series production.

1 Overview and Current Status of AUTOSAR

AUTOSAR (AUTomotive Open System ARchitecture) is a worldwide development partnership of car manufacturers, suppliers and other companies from the electronics, semiconductor and software industry. The partnership was founded in 2003 and was based until today on three contract phases, each of which lasting three years.

1.1 Release Overview

Phase I ended in 2006 and produced the first set of specifications. Phase II was finished in 2009 with releases 3.1 and 4.0. Phase III delivered the currently available most advanced release 4.0.3, which consists of 176 documents all available from the AUTOSAR website [1]. One of the major achievements of the partnership is the establishment of a vital organizational

structure capable of handling and maintaining the wide scope of technology while also assuring a high quality of the resulting specifications.

At the end of phase III, an evolution of release 4 was started with the incorporation of selected new and backward compatible concepts based on market needs. These new concepts will be part of the next release 4.1.1, which is planned for the first quarter of 2013. An additional major result of phase III was the publication of release 3.2.2, which provided new features and enhancements to the community, e. g. the ability to use partial networking.

Based on the exploitation planning of AUTOSAR OEM core partners, it is expected that in 2016 nearly 300 million ECUs will be produced with AUTOSAR inside [2] – the majority of them equipped with release 3 and 4.

1.2 Recent Activities of AUTOSAR

The following paragraphs provide a brief overview of selected topics that have been introduced in phase III.

Availability for Derived Applications

Usage of AUTOSAR was formerly restricted to »automotive applications«, which are defined as engine-powered, land-based, non-railed vehicles, intended for primary transportation purposes. The modified license agreement now reliefs this restriction and allows AUTOSAR to be used in »automotive *and derived* applications«, where the term »derived« characterizes the application to be based on a commercially available and proven in-use automotive application for one of the following non-automotive environments: marine, railway powertrain, agriculture or forest machinery, construction or mining machinery, compressors or pumps, or power generators.

Explicitly excluded is still the use in domains like nuclear power, aerospace or aviation, chemical and/or biological reactor, petrochemical, military (except for military marine transportation vessels), or other ultra-hazardous activities.

Improvements on Requirements Traceability

The internal requirements tracing was enhanced to support automatic checks in the development of AUTOSAR specifications and thus helps to prove that the standard fulfills all demanded objectives. This is specifically important for safety-related systems and essentially

improves the maintainability of the specifications. Also, for future enhancements of AUTOSAR the traceability provides reliable information to assist an impact analysis of affected specification items.

In order to provide the basis for an effective requirements tracing, a dedicated specification structure with well-defined dependency relationships was introduced. Figure 1 shows how the AUTOSAR specifications are internally organized following a five level hierarchy consisting of objectives, features and requirements. The actual specification items can be found on level 5. Within the shown hierarchy the “details” and “implements” relationships provide the framework for requirements tracing.

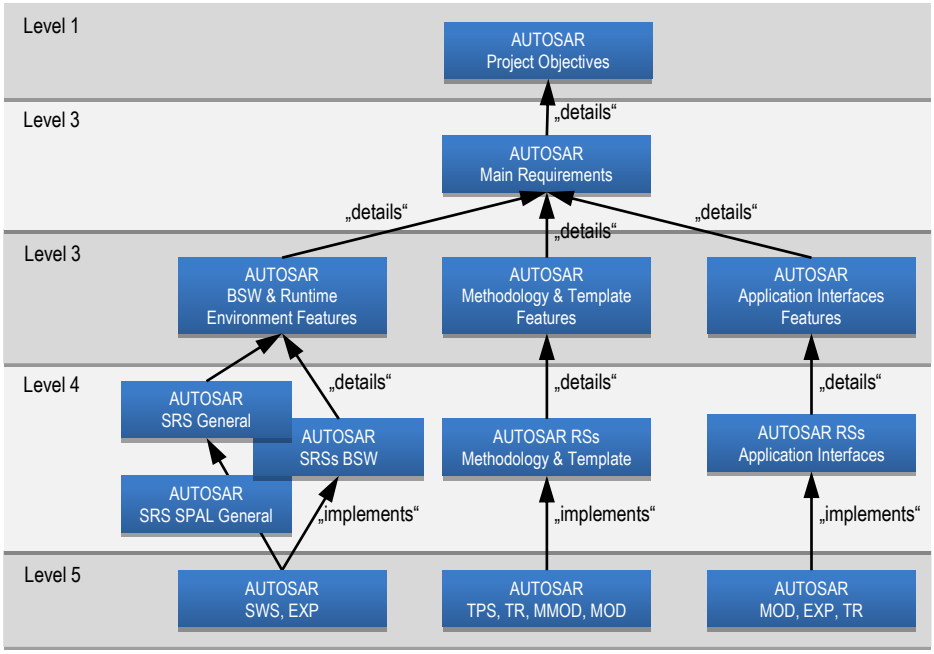


Figure 1: Illustration of the AUTOSAR-internal requirements hierarchy

Acceptance Tests

The purpose of acceptance tests is to ensure interoperability of AUTOSAR implementations. The decision of AUTOSAR to provide standardized acceptance tests will enable OEMs and integrators to setup a test environment for an AUTOSAR stack provided by a supplier. Acceptance tests are currently in development for AUTOSAR releases 3.2.1 and 4.0.3 and will be continuously further developed.

As illustrated in Figure 2 the tests focus on:

1. Bus compatibility: E. g. compatibility of protocols such as Transport Protocol or Network Management
2. Application compatibility: E. g. compatibility of interfaces to ensure integration of application software components (correct behavior of RTE features, BSW services)
3. Configuration compatibility: E. g. compatibility of templates to ensure that a typical ECU extract can be used for configuration

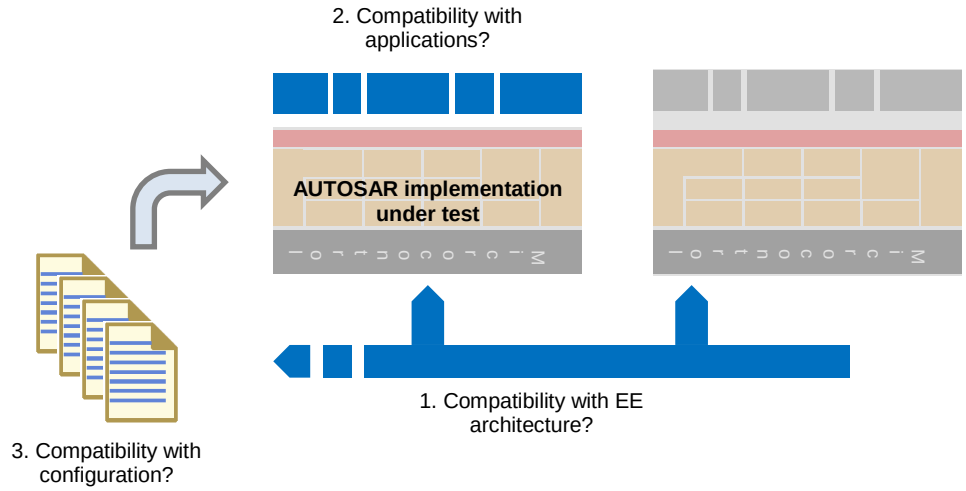


Figure 2: Focus of acceptance tests

2 Plans and Objectives of AUTOSAR Post Phase III

By end of 2012, the AUTOSAR contract for phase III will end. In opposite to the former project-oriented approach with time-limited phases, AUTOSAR decided to set up a continuous mode for post phase III, which is not limited to a certain end date. This reflects the importance the partners see to establish a reliable and maintained basis for the ongoing series roll-out of the standard.

2.1 Goals for Post Phase III

Figure 3 shows an overview of the major plans and objectives of AUTOSAR in post phase III (starting with 2013). The goals focus on improvements on a technical level, clearly driven by market needs, and are accordingly reflected as well on organizational level. The main intention is to balance needs for stability on the one hand and further enhancements on the other. In this sense stability has two aspects: One aspect is the close monitoring of backward compatibility between releases in order to ease the rollout of a new AUTOSAR release for the users. The other aspect implies concentration on only a few but high-quality level releases maintained in parallel. This is covered in detail by the next subsection.

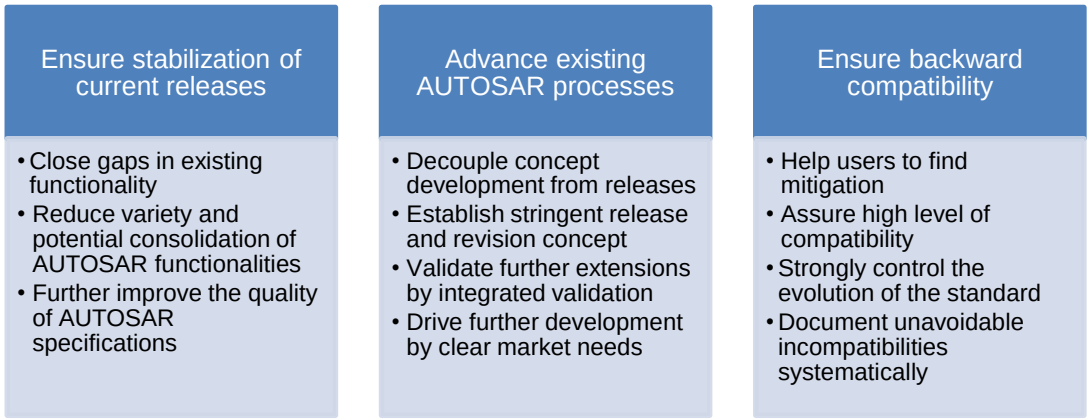


Figure 3: Goals for post phase III

2.2 Future Release Policy

In order to address the long-term planning reliability for suppliers as well as OEMs, a new release policy has been introduced. The new policy establishes a life cycle plan for major releases and additionally defines that a maximum of two release branches are allowed to actively evolve in parallel. This approach offers a higher degree of transparency to implementers about which release receives extensions and modifications and about which release is in a strict maintenance mode. In order to support the new release policy, the life cycle states of releases were newly defined as shown in the following list:

1. Development phase: Initial development of a major release
2. Evolution phase: Includes minor releases and revisions (e.g.: Rel. 4.x)
3. Maintenance phase: Includes revisions only (e.g.: Rel. 3.2.x)
4. Issue notice phase: Maintenance via LOKI (list of known issues)

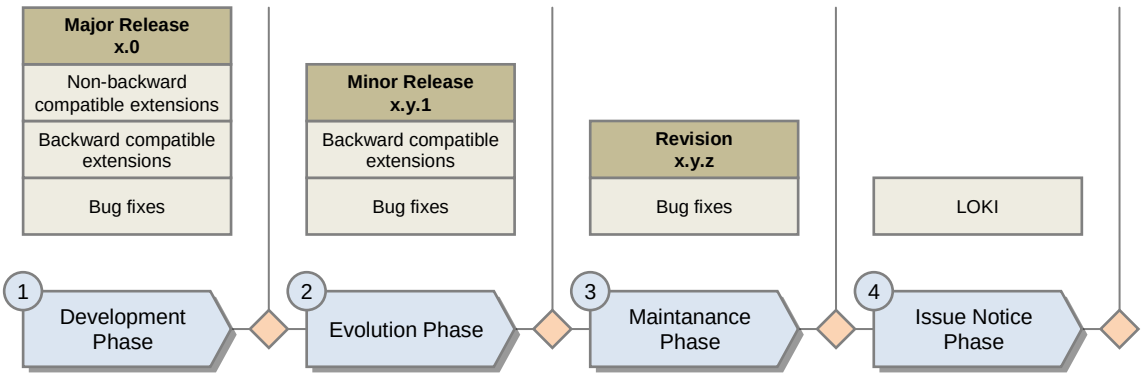


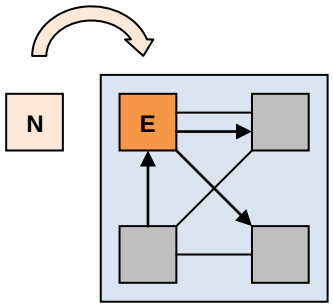
Figure 4: New life cycle plan for major releases

Figure 4, which illustrates the new release life cycle phases, also shows how the maintenance of releases is organized. As a result of the restriction to a maximum of two branches actively evolved in parallel, a new minor release will terminate the maintenance of the preceding minor release; e. g. with introduction of Rel. 4.1.1 there will be no explicit further maintenance of Rel. 4.0. The new minor release will also cover the maintenance for all preceding minor releases since the new minor release is backward compatible. In case of pure maintenance a revision will be created, in case of introduction of new, backward compatible features it will be a minor release.

Procedures for Handling Backward Compatibility

Series projects integrate components from different sources. This involves different suppliers but also OEM-internal platform development. Compatibility of all components is a major requirement for successful integration. In order to accomplish this, all change requests are assessed against the actual releases of the AUTOSAR standard for backward compatibility and controlled by a well-established change management process. Backward compatibility is also a precondition for changes to be incorporated into a minor release or a revision.

AUTOSAR regards a change of an already released specification as backward compatible if functionality developed on the basis of the changed specification can be used in an environment developed on a prior released specification (see Figure 5).



New product *N* is backward compatible to an established product *E* if *N* is able to take the place of *E* and interact with other products (which are left untouched) designed for product *E*.

This implies that *N* provides at least all of the functionality of *E*.

Figure 5: Backward compatibility model

For each change, experts working on the standard rate the backward compatibility status on a five-level scale:

- 1: Fully backward compatible
- 2: Backward compatible if feature is not used
- 3: Compatibility affected, but mitigation is possible via configuration

- 4: Compatibility affected, mitigation requires manual adaptation
- 5: Incompatible change

The levels are each applied to three different areas of the standard:

- Bus compatibility
- Application interface compatibility
- Specification-wise compatibility

The assessment is documented for each individual change item and published together with the corresponding release. This allows implementers to easily check which specification items are affected and to what degree these changes might affect their implementation.

2.3 Project Schedule

Since the new release policy supports a maximum of two releases in parallel, the current project schedule concentrates on two major release branches as shown in Figure 6.

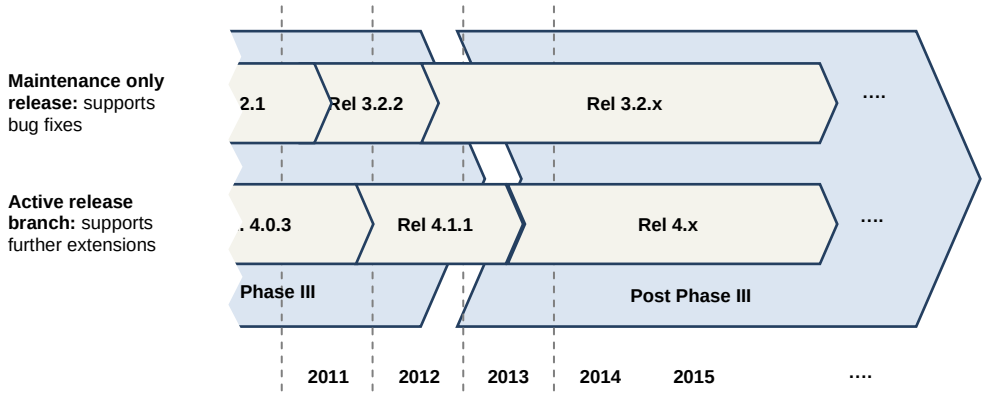


Figure 6: Current AUTOSAR release plan

For the shown active release branches, the following approaches are planned:

- Release 3.2: Continued maintenance. Release on demand.
- Release 4.x: Selective backward compatible enhancements and maintenance. Future release decisions considered at about 1½ year intervals.

A new major release (e. g. release 5) is not expected within the next five years, but will be considered according to market needs (e. g. in case of necessary structural changes to the architecture).

2.4 Concept Development

Selective enhancement of the standard is an important requirement to allow further innovations. Therefore, AUTOSAR decided that requests for new concepts can now be submitted continuously without waiting for a specific submission date for concept requests. Accepted concept requests are developed according to specific internal milestones, which are independent from the overall AUTOSAR release schedule, so that evolutionary concept incorporation is enabled. If a concept proves to be backward compatible, the worked-out concept will be a candidate to be incorporated into the next minor release (see Figure 7). For concepts not fulfilling this requirement, a pool of new non-backward compatible concepts will be created and associated with the next major release.

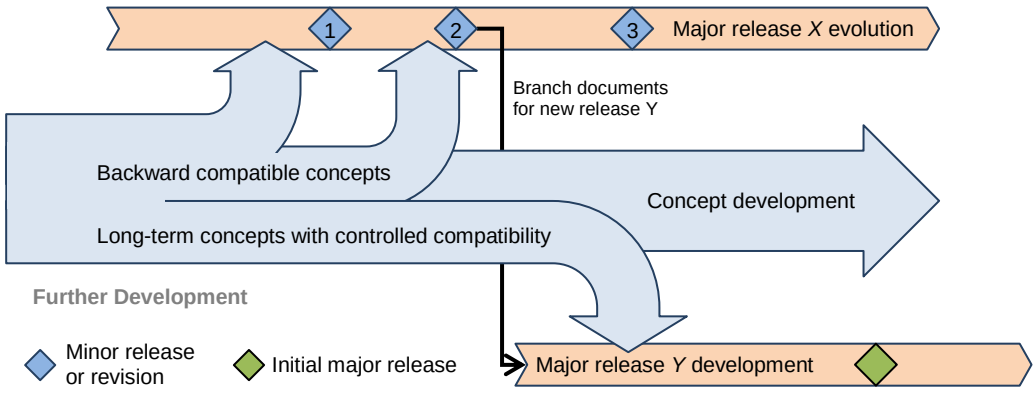


Figure 7: Continuous concept development

Integrated Validation

The purpose of validation is to assure the quality of the concept incorporation. In AUTOSAR, every concept shall be validated before the resulting standard is released. In order to detect issues with concept incorporation as early as possible a new process of integrated validation has been established. Figure 8 compares the previously used conventional approach with the new one.

The enhanced process offers the following advantages:

- Concept detailing can be achieved in one or several cycles.

- Concept validation takes place after each cycle and before incorporation into the standard.

By applying the described approach, validation steps can be scaled to smaller sizes that enable early prototypical implementation. Therefore, this approach is especially suited for integration of upcoming technology demanded by the market without jeopardizing cost-efficiency or quality. Especially for complex concepts, that involve multiple specification documents or are otherwise technically sophisticated, integrated validation is preferable because potential concerns can be detected and mitigated early before incorporation into the release specification documents has taken place. The new process has already been evaluated by piloting two selected concepts for release 4.1.1. For future releases, integrated validation will be the preferred process.

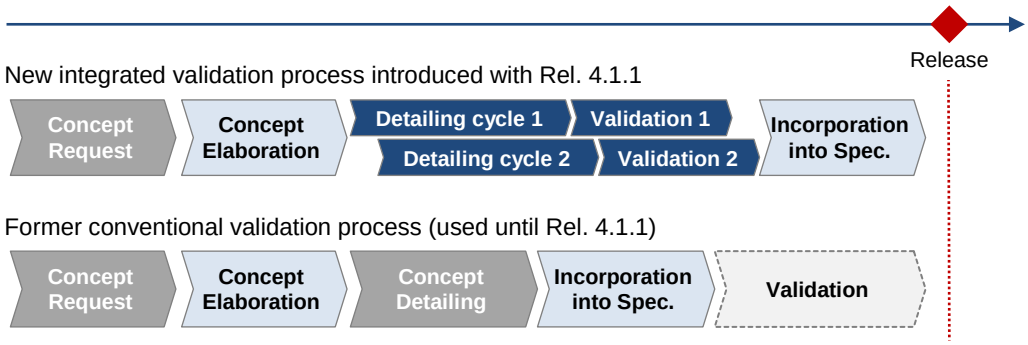


Figure 8: Process of integrated validation vs. conventional validation

2.5 Globalization

The car production of AUTOSAR OEM partners and members covers about 80% of the global production. The most high-volume markets currently involve Europe, North America, Japan and South Korea. From the remaining 20%, the most important markets arising are China and India.

As AUTOSAR is a worldwide standard, an increased presence on these new markets is planned. This requires broader recognition and acceptance in the mentioned markets. Various activities have been launched to increase both aspects.

For the Chinese market, this is addressed by locating the 5th AUTOSAR Open Conference in Beijing and also by organizing a special AUTOSAR session during the FISITA 2012 conference in Beijing. In order to gain acceptance, it is important to serve the specific local

requirements of the respective areas. Therefore, an AUTOSAR representative in China has been put in place in 2011 to establish and keep in contact with local OEM, suppliers and standardization bodies (CASA, AESC).

For the Indian market, similar activities are installed. This includes the »Explore AUTOSAR User Conference« in August 2012 in Pune, as well as contacts with companies and organizations involved in the S3C (Software Standard for Small Cars) initiative. As well an AUTOSAR representative is established as a direct contact for local activities in India.

3 Technical Focus of Future AUTOSAR Releases

The following chapters present a selection of typical concept requests by partners and members, currently under discussion for future AUTOSAR releases.

3.1 Functional Safety

Functional safety is currently a major topic to be addressed by the automotive industry. AUTOSAR has already provided mechanisms to support functional safety in previous releases and is now going to improve its safety support in several areas. This covers robust and predictable software execution and assistance in decoupling safety-related functions from failure in other applications (freedom from interference). Additional improvements will be applied to end-to-end protection of communication paths. Also, the AUTOSAR methodology will be enhanced in order to help exchanging safety-related information between the related stakeholders. This will allow to hand-over safety integrity level (ASIL) classifications when exchanging configurations or facilitation of ASIL requirements decomposition.

3.2 Multi-Core

AUTOSAR release 4.0 already supports multi-core architectures. Concepts for enhanced multi-core support will address better load balancing capabilities especially for the distribution of individual basic software modules to specific cores. The intention is to increase the basic software performance and the efficiency of the application software components' access to the basic software due to better utilization of available computational power in the MCU. Flexibility in allocating basic software modules to more than one OS partition (e. g. non-trusted partitions) can also support specific safety use cases where additional protection and isolation is required inside of the operating system.

3.3 Ethernet

AUTOSAR release 4.1.1 specifies a TCP/IP protocol suite over Ethernet as a new general communication mechanism. It includes the support for applicative protocols such as:

- Diagnostic OBD (On-Board Diagnostic) communication with software and hardware
- Service Discovery.

Further applicative protocols will be needed to support automotive use cases, such as:

- Support of worldwide harmonization of OBD on Ethernet (ISO 27145)
- Support of upcoming vehicle to grid communication protocol (ISO 15118)
- Streaming interface
- Support for safety-related communication over the TCP/IP protocol suite.

3.4 Timing Analysis

The AUTOSAR methodology will be improved in order to exchange new parametric execution times between involved parties. Furthermore, the objective is to increase predictability of systems that are composed of concurrent software execution units (e.g. concurrently scheduled tasks, concurrent interrupt service routines, tasks running in parallel) on single or multi cores. Approaches under discussion are specifying temporal constraints and timing of tasks and interrupts, investigating alternative task scheduling such as dDMS (dynamic deadline monotonic scheduling) or EDF (earliest deadline first) or monitoring the temporal behavior of the application.

3.5 Diagnostics

In order to harmonize the diagnostic software implementation while also providing compliance to new legislations, the support for multiple active diagnostic clients will be added. This includes onboard clients as well as external clients and the concurrent handling of external diagnostic scan tools for a better support of diagnostics in the truck domain (J1939).

3.6 Improvements of Methodology

For development scenarios in series development projects, iterative development needs to be supported. Intermediate work results are often exchanged between OEM and supplier during series development. It is planned that the AUTOSAR methodology and templates are enhanced by features to keep track of the changes made during that process so that a seamless, bi-directional information flow between OEM and its suppliers can be enabled.

3.7 Development and Test Support

Release 4.1.1 contains a first implementation of rapid prototyping support for ECUs. This allows e. g. the demonstration and test of new control algorithms inside prototype samples based on existing ECUs. The available solution can be used by an OEM after preparation of the ECU by the tier-1. An enhanced solution shall in future ease this preparation task and thereby provide better balance between AUTOSAR functionality and integration with existing rapid prototyping solutions.

3.8 Energy Management

The goal of efficient energy management in AUTOSAR is to provide mechanisms for power saving in ECUs, especially while bus communication is active. The concept of pretended networking achieves this by an ECU-local approach that reduces runtime power consumption by increasing the idle time of the MCU. This ECU-local approach allows an easy integration into existing networks. The pretended networking concept will be enhanced by support for specialized transceiver hardware with higher energy saving potential and incorporation of support for the FlexRay bus system. Further aspects to reduce power usage in automotive applications shall be identified and supported by AUTOSAR.

References

[1] Official AUTOSAR web site: http://www.autosar.org

[2] AUTOSAR - A Global Standard; Frank Kirschke-Biller; 4th AUTOSAR Open Conference, Paris, France, June 11, 2012