The Standard Mix does it:

Diagnostics with AUTOSAR and ODX – Part 1: Diagnostics with AUTOSAR

AUTOSAR is the future-oriented reference architecture for ECU software. Clearly specified interfaces, standardized behavior and XML-based data formats are the key features of this standard. In AUTOSAR, diagnostics is handled in the modules DCM (communications) and DEM (fault memory). This article first addresses diagnostics in AUTOSAR and related data formats. Description data in ODX format (Open Diagnostic Data Exchange) represents an alternative to configuring the diagnostic software. Part 2 will address the topic of "ODX in the AUTOSAR development process".

Standardization is very much the trend in the development of automotive electronics. The use of open architectures and configurable components are intended to let developers focus more on the innovative and differentiating aspects of the development process. In addition, standardization is intended to be a central measure that contributes towards reducing costs. In the past, automotive ECU software architectures were not standardized. For the supplier, this resulted in different, OEM-specific software architectures that required different development processes, development tools and data exchange formats. AUTOSAR (AUTomotive Open System ARchitecture) has the stated goal of standardizing a common, open automotive software architecture. The primary goals of the AUTOSAR architecture are:

- Hardware abstraction
- Clearly specified interfaces
- Standardized behavior of the basic software
- Standardized data exchange formats between OEM and suppliers
- Definition of a harmonized methodology for developing software
- Support of model-based functional development
- Scalability over all ECU and vehicle classes
- Considers safety requirements per ISO 26262

Today, AUTOSAR is the reference architecture for ECU software. The first production launches with complete AUTOSAR software will occur in the near future. The number of development projects utilizing AUTOSAR methodology is continually growing.
The AUTOSAR Consortium is currently working on versions 3.2 and 4.x. Versions 2.x, 3.x and 4.0, which were released prior to this, have already been used as a basis for implementing vehicle projects. Today, most vehicle producers work to versions 3.x.

Functional orientation is increasingly gaining in significance in electronic development. AUTOSAR standardizes the description of individual component or vehicle functions and the description of the overall system in what is known as the System Configuration Description. The methodology for distributing vehicle functions to ECUs is also standardized. As a result, developed functions can be reused in other vehicle projects without changes.

The example in **Figure 1** illustrates this: The Lighting vehicle function from the Function Library is subdivided into three subfunctions. In vehicle A, the subfunctions are distributed to two network ECUs, while in vehicle B they are distributed unchanged to three ECUs. The communication between the subfunctions is defined in the System Configuration Description.

In AUTOSAR, there is an ECU Extract of the System Configuration for each ECU that covers the system content relevant to the ECU – and often also relevant to a supplier. The elementary components of AUTOSAR architecture for ECU software are:

> Functional software (SWC)
> Run-Time environment (RTE)
> Basic software (BSW)

The high level of reusability of the functional software is due to the abstraction of communication by the Virtual Function Bus (VFB). The application can be developed and tested without knowledge of the underlying communication mechanisms. It does not matter here whether communication occurs within the ECU or over a network (CAN, FlexRay, etc.). The Run-Time-Environment (RTE) serves as the runtime environment for the functional software, and it implements the Virtual Function Bus for a specific ECU. The basic software is developed as a component kit and is commercially available (off-the-shelf software). It contains fundamental system functions and abstracts the functional software from the hardware. It is subdivided into three areas **(Figure 2)**:

> The Service Layer provides basic services for the functional software and other basic software modules.
> The ECU Abstraction Layer abstracts higher layers from the ECU hardware
> The Microcontroller Abstraction Layer abstracts higher layers from the specific microcontroller device

The ECU Configuration Description is used to configure the basic software and the RTE. Initially, this configuration is generated from the ECU Extract of the System Configuration Description (e.g. communication over the network). The ECU Configuration Description plays a central role for the behavior of the entire ECU software and is extended and adapted, step by step, over the course of further development.

Diagnostics with AUTOSAR

The diagnostic software in AUTOSAR consists of three modules: DCM, DEM and FIM. The DCM (Diagnostic Communication Manager) implements the diagnostic communication per ISO 14229-1 (UDS) and SAE J1979 (OBDII). All diagnostic requests are first preprocessed by the DCM. One of the tasks of the DCM is comprehensive handling of invalid diagnostic requests. The DCM can already fully process a majority of valid requests; it routes other requests to the functional software. Each AUTOSAR release has in-

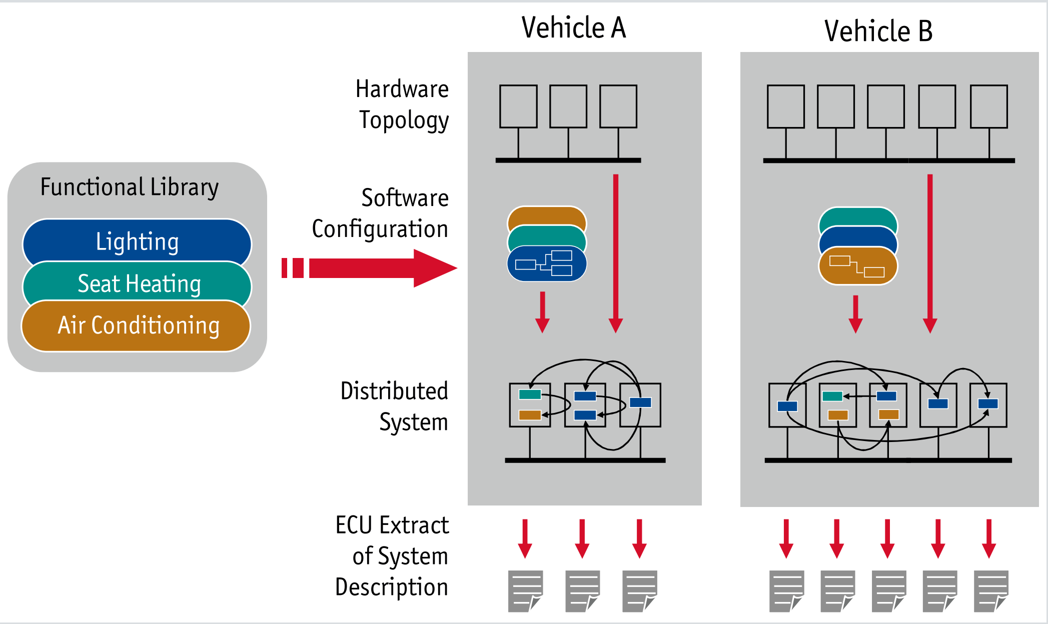


Figure 1: Functional distribution in AUTOSAR

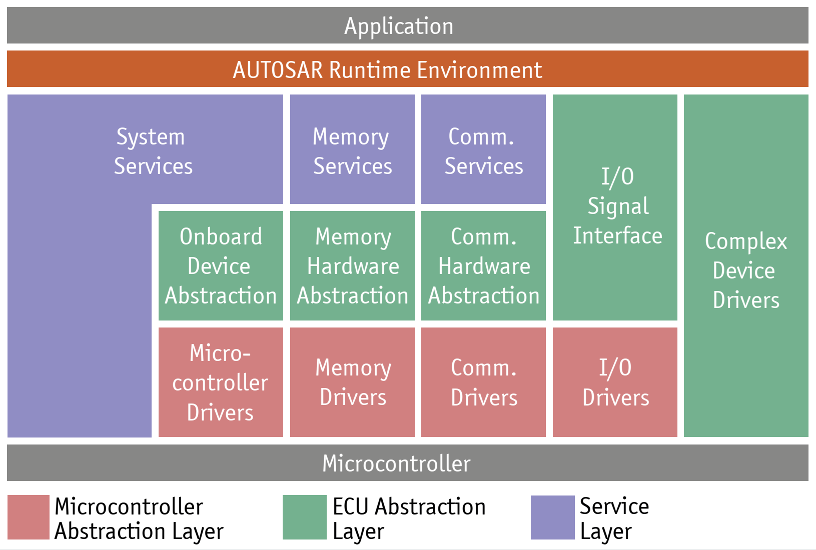


Figure 2: Structure of the basic software (BSW)

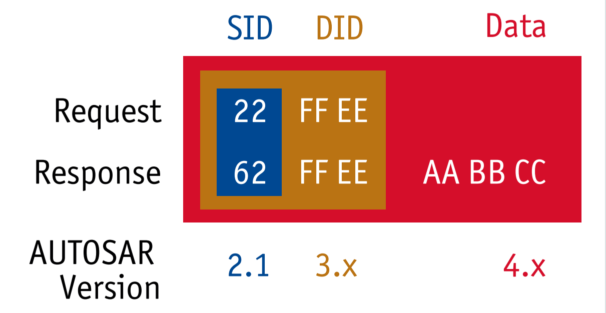
creased the functional range of the DCM, while continually decreasing the remaining diagnostic content of the functional software. Handling of a DID **(Figure 3)** illustrates this development. Up to Version 3, signal structures had to be resolved in the functional software. In Version 4, this task can also be handled by the DCM.

The DCM is configured based on a ECU Configuration Description. This includes the service identifiers, subfunctions, data identifiers (with associated signal structure) and routine identifiers (with parameter lists). In addition, execution of diagnostic requests can be made dependent on the current ECU state (session and security level).

The DEM (Diagnostic Event Manager) implements an error memory. Up to (and including) AUTOSAR Version 3.x, the DEM is only specified as a facade, because details of error memory behavior are OEM-specific. Since Version 4, the goal has been to standardize an OEM-independent error memory, so that its behavior can be defined in AUTOSAR.

The DEM has the following primary tasks:

> Administer the DTC status bit
> Organize error storage, including NVRAM
> Organize snapshot data (freeze frame)
> Administer extended data records
> Provide for unlearning of errors
> Provide an interface for error readout for the DCM



	SID	DID	Data
Request	22	FF EE	
Response	62	FF EE	AA BB CC
AUTOSAR Version	2.1	3.x	4.x

Figure 3: DCM in different AUTOSAR versions

A standardized interface and various debounce algorithms for diagnostic monitors (error path) enable uniform and cross-project development of the functional software. One or more error paths can be mapped to a diagnostic trouble code (DTC). The DEM is also configured from the ECU Configuration Description. It contains information related to error paths, DTC numbers and the structure of extended error data (snapshot and extended data records).

The FIM (Function Inhibition Manger) makes it possible to inhibit the execution of certain functions in case of active errors, start substitute functions and suppress secondary errors. The FIM is also configured from the ECU Configuration Description.

Basic Software Modules for Diagnostics with AUTOSAR

Vector's MICROSAR product line provides an AUTOSAR solution for ECU software consisting of the RTE and basic software modules that cover the entire scope of the AUTOSAR standard. Each AUTOSAR BSW module is assigned to a MICROSAR package. The MICROSAR DIAG package is specially available for diagnostics. It contains the three BSW modules DCM, DEM and FIM from the AUTOSAR architecture. MICROSAR DIAG as the diagnostic software provides vehicle projects with an AUTOSAR-compatible implementation of the UDS protocol ISO 14229-1:2006.

Note: Part 2 "ODX in the AUTOSAR development process" is also available for download at www.vector.com/downloads/.

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Literature:

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[4] ISO 14229: Road vehicles – Unified diagnostic services (UDS)

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