The Standard Mix does it:

Diagnostics with AUTOSAR and ODX – Part 2: ODX in the AUTOSAR Development Process

The Open Diagnostic data eXchange (ODX) format is an XML-based data format for describing the data relevant to vehicle diagnostics. ODX was conceptualized as an open format for exchanging diagnostic data between automotive OEMs and their suppliers. AUTOSAR is the future-oriented reference architecture for ECU software. Clearly specified interfaces, standardized behavior and XML-based data formats are key features of the AUTOSAR standard. This is the second article of the "Diagnostics with AUTOSAR and ODX" series, and it addresses the topic of ODX and how available ODX data can be profitably integrated in AUTOSAR development.

ODX was standardized in the framework of an ASAM/ISO working group, initially in ASAM since 2003 and later in ISO. The necessity of ODX development resulted from the lack of acceptance of the previous standard for describing diagnostic data. The exchange of diagnostic data beyond process boundaries was only possible with tremendous effort. A key goal of ODX standardization is data reuse. It should be possible to use and further process the data with different tools – including in different business areas.

The ODX data model in Version 2.2.0 consists of seven sub-models **(Figure 1)**. The focus of standardization activities was on parameterizing diagnostic testers. Therefore, the lower three submodels with definition of diagnostic services, communication parameters and a description of vehicle accesses represent the real core of the standard. At the same time, they form the typical content that is required for tester communication with one or more ECUs, including data interpretation.

The flash container, ECU configuration, function-oriented diagnostics and so-called Multiple ECU Jobs are described in the upper four sub-models. Their processing and significance are lower compared to the first named sub-models. In this article, only ODX-D and ODX-FD will be discussed in depth, because these two categories are of special interest with regard to AUTOSAR. ODX-D contains the service description, which defines diagnostic requests and associated responses together with interpretation of the transmitted data.

ODX-FD is an extension to ODX-D, in which diagnostic-relevant aspects of vehicle functions can be described. Functions can be hierarchically structured and grouped according to any desired criteria. Input/output parameters and diagnostic data (e.g. DTC, DID, etc.) may be allocated to each function. This data is assigned specific values and is allocated to diagnostic services via references in the ODX-D section. Essentially, ODX-FD documents vehicle diagnostics from the perspective of functions. If problems occur in a vehicle function, the ODX-FD data can be used to determine the relationship between the function and potential error sources – i.e. ECUs, sensors and actuators.

ODX was released as ISO standard 22901-1 in 2008. ASAM published the first version of the standard as ODX 2.0.0 in 2004. Before ISO release, two other ASAM releases were issued into which corrections, explanations, improvements and extensions flowed **(Figure 2)**.

ODX and ECU Software

ODX gives the author of diagnostic data wide-ranging freedom with regard to the structures used. One and the same behavior can be described differently. This lets users optimally prepare diagnostic data for use in specific test systems. Nonetheless, support for all conceivable variations of the standard in processing tools continues to be more of an aspiration than reality. It is possible to exchange data, provided that the structures used are supported in both worlds. A commonly used method for documenting the exchangeable contents are authoring guidelines. They specify the type and scope of the ODX subset to be used for the process partners. This approach is established today. The automotive OEMs who participated in ODX standardization also took up the process and created an authoring guideline for data exchange between automotive OEMs (ODX-RS, Recommended Style).

The main motivation for ODX standardization was the desire to standardize the parameterization of data-driven test systems. The data's usability in other application areas is limited, because the different application areas place different requirements on the structure and degree of detail. A generic tester is expected to support as many vehicle configurations or ECU configurations as possible. A multiple or ambiguous description of tester data gives the user flexibility here. For example, in ODX it is possible to describe multiple ECU responses to one diagnostic service. At runtime, the appropriate response is utilized to decode the diagnostic data. This is especially helpful if it is not entirely clear which specific software is running on the ECU. On the other hand, unambiguous and exact data description in specification quality is essential for code generation. It is obvious that the description with multiple responses cannot be used to generate the ECU software, because the ECU must react unambiguously (in a defined way) to a diagnostic request. The example shows that requirements for the (quality of) diagnostic data are different – even contradictory – for the two use cases.

Therefore, if the diagnostic software components will be generated based on ODX, the parts of the standard that do not conform to the requirements cited above (specification quality) must be excluded.

The following list identifies some data configurations that violate the specification character.

> Multiple responses to one diagnostic request (see above).

> Diagnostic services that are not defined for the underlying protocol, e.g. KWP services in a UDS-ECU.

> Multiple diagnostic services with the same service signature (SID/LID), making it impossible to derive clearly defined ECU behavior.

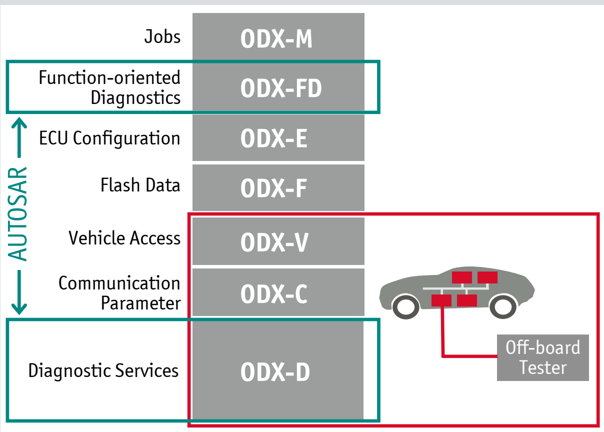

Figure 1: ODX categories

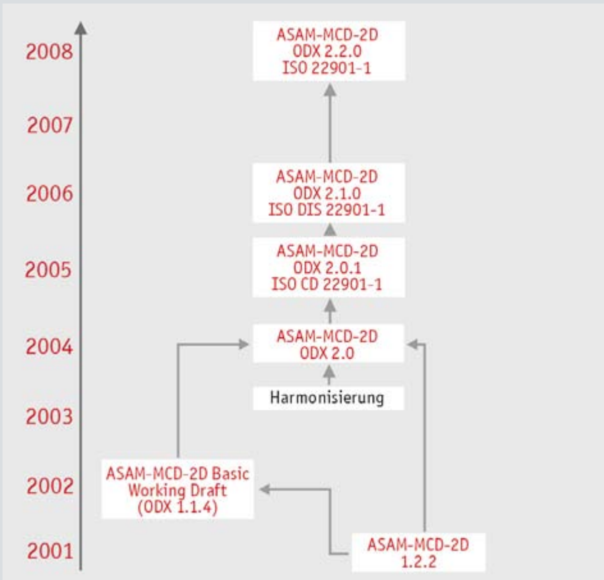

Figure 2: ODX history

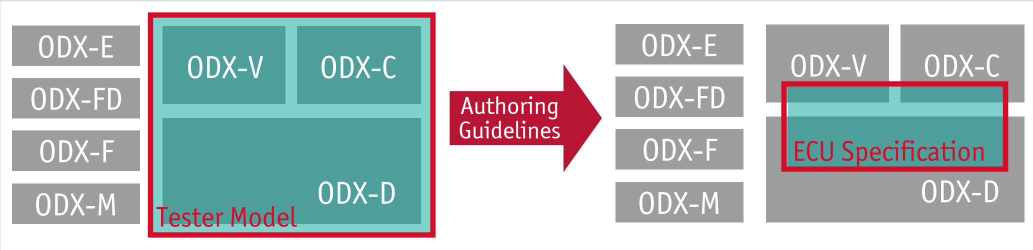

Figure 3: Parameterization of test systems via ODX (left). Parameterization of Software Components via ODX using authoring guidelines (right)

> Use of special context conventions in error memory: the standard does not aim to provide a detailed description of error memory in ODX. In principle, it is possible to describe supplemental information for DTCs, but the standard only specifies the format here (SDG = interleaved list of name-value pairs). The semantics of the data, on the other hand, are not defined; therefore, generic processing in automated tools is not possible.
> The widely used ODX Version 2.0.1 lacks a mechanism for describing the dependency of a diagnostic service on session/security levels. The related executability tests and resulting rejecting responses cannot be generated, rather they must be implemented in the individual application. In the ODX 2.2.0 version, this problem no longer exists. Status information can be formally described here.

The list shows that conformance to the ODX standard is necessary but insufficient to parameterize software components. Checker rules defined in the standard primarily cover the use case of tester parameterization. To assure specification quality, numerous consistency checks are necessary, which must exclude data constellations such as those identified here.

In summary, the following picture emerges: ODX was designed to fulfill the requirements necessary for parameterizing test systems (see **Figure 3, left**). However, parameterization of software components assumes that the possible degrees of freedom are limited to the degree required by a specification (see **Figure 3, right**). This can be achieved by means of authoring guidelines.

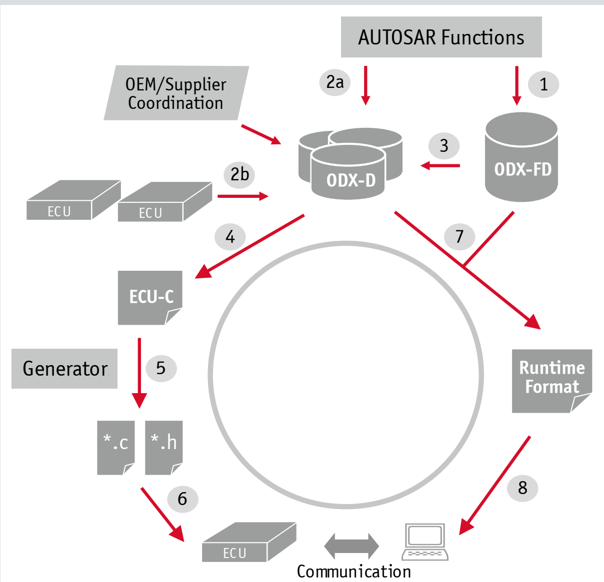

Figure 4: Combination of ODX and AUTOSAR

AUTOSAR with ODX

ODX and AUTOSAR are established standards for developing ECU software or describing the diagnostic data of a vehicle or individual ECUs. It therefore makes sense to determine how available ODX data might be integrated in the development of the diagnostic content of the ECU software (DCM/DEM).

AUTOSAR development is very function-oriented (see Part 1 of this series of articles in the last issue, 10/2011). In early phases of development, it is therefore functional descriptions and definitions that are primarily created. ODX-FD bridges the gap between an ECU's functions and diagnostic content, but it is primarily relevant to testers. ODX-FD data can therefore be derived from AUTOSAR functions, even if the concrete diagnostic description does not exist yet in the form of ODX-D data (see **Figure 4, step 1**). The ODX-FD description that results reflects the structure and grouping of AUTOSAR functions in ODX. Linking in the ODX-D container (i.e. mapping between functions and the specific diagnostic data) is still not possible at this time point.

It was shown above that the information needed to configure software components can primarily be found in ODX-D. In AUTOSAR, the ECU configuration is described in the ECU Configuration Description, from which the ECU software is also generated. It therefore makes sense to transfer the ODX-D data (if it exists) to the ECU Configuration Description and use it in the AUTOSAR process. Whether and to what extent ODX-D data exists depends on the cooperation model between the automotive OEM and suppliers. An extreme case is the new development of an ECU "from scratch" (see **Figure 4, step 2a**). In this case, a large share of the diagnostic content is prescribed by the OEM. The other extreme case involves integrating an existing ECU in a new vehicle (see **Figure 4, step 2b**). Changes to the diagnostics are then only possible with tremendous effort. The diagnostics are therefore influenced much more by the ECU than by functions.

In general, neither extreme is exclusively applicable, rather the different approaches are combined. Typically, diagnostic requirements are specified between automotive OEM and the supplier from the functional perspective and ECU perspective (and the perspective of its periphery), to finally yield the ODX-D data for the ECU.

In the next step, ODX-FD data can be linked to ODX-D data (see **Figure 4, step 3**). From the ODX-D data, the ECU Configuration Description is generated, which then serves as the foundation for creating the software components (see **Figure 4, steps 4, 5**). Furthermore, the ODX-FD and ODX-D data form the foundation for creating the tester run-time format (see **Figure 4, step 7**). The use of ODX as a foundation for both aspects of the process (software components and tester parameterization) ensures that different development versions of the tester and ECU will match one another precisely.

The question arises whether the reverse process is also possible, i.e. generating ODX-D from the ECU Configuration Description. The answer depends in part on the AUTOSAR version being used: The AUTOSAR format of versions up to and including 3.x is not powerful enough to describe the key information needed for tester parameterization, e.g. it lacks conversion information for data objects. AUTOSAR 4 is more powerful and may contain this conversion information. Nonetheless, this information in particular is usually irrelevant to the use case of ECU parameterization, so it is questionable whether this information is actually described here in practice.

In addition, the function-driven approach prevents cross-vehicle harmonization of the diagnostic contents as described in this article. Therefore, it remains to be seen which direction future diagnostic data flows will take. Experience suggests that pure forms of the discussed approaches will not prevail, but instead they will be adapted to the specific development situation and combined.

Integration

Integration of the different subprocesses with their various interfaces (interfaces, data formats, etc.) is one of the greatest challenges in introducing new technologies such as AUTOSAR and ODX. Prior experience suggests that the most efficient approach is to rely on practice-proven solutions in introducing these technologies. Vector offers comprehensive AUTOSAR and ODX tool chains from a single source. You will find more information on this subject at: www.autosar-solutions.de and www.odx-solutions.de.

Note: Part 1 "Diagnostics with AUTOSAR" is also available for download at www.vector.com/downloads/.

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Literature:

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