The “Electrifying” Side of AUTOSAR:
The Case for Using the ECU Resource Template

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In recent years, AUTOSAR has established itself as the standard for describing software architectures used in motor vehicles. By extending its original focus and exploiting the “virtual function bus” concept, users can employ the AUTOSAR methodology and implement a holistic E/E approach for coherent development of vehicular electrical architectures. This makes it possible to use the electrically relevant model artifacts to generate logical designs and ultimately the wiring harness.

The focus of **AUTOSAR** (AUTomotive Open System ARchitecture) is on software development and on the configuration of electronic control units (ECUs) in automotive applications. The meta-model that the AUTOSAR methodology defines includes a series of templates that cover specific portions of the methodology. The approach described here primarily uses the “ECU Resource Template.” In such cases, the electrically relevant model artifacts from an AUTOSAR model can be employed in a recursive and highly automated process for developing and evaluating architectures. At the same time, suitable interfaces enable effective and coherent coupling of tools from a wide variety of development domains.

**The ECU Resource Template**

The ECU Resource Template contains descriptions of items such as the hardware components that form a control unit’s electronic parts list, e.g., oscillators, timers, clocks, storage, etc. This also includes all hardware modules on the control unit that are responsible for connecting to peripheral devices or for signal processing, such as analog-to-digital converters (ADCs), digital-to-analog converters (DACs), digital IOs, etc.

Beyond these “on-board” components, it is also possible to use the AUTOSAR meta-model to describe all the units that have an electrical connection to the peripheral components in the control unit via signaling lines. In AUTOSAR Release 3.x, which provides the basis for the processes discussed here, the meta-model in the ECU Resource Template typically recognizes three types of hardware outside the ECU: display hardware, actuator hardware, and sensor hardware.

Hardware units are connected electrically with the corresponding hardware elements through the aid of “AssemblyHWConnections,” which can be defined for a control unit or a hardware container. With support from the right kind of tools, these electrically relevant model artifacts can be carried over into a logic circuit diagram and used as a basis for generating a wiring harness model.
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Figure 1: Hardware Description in the ECU Resource Template.

The AUTOSAR Meta-Model
The ECU Resource Template has hardly changed in AUTOSAR Releases 2.x and 3.x. The main reasons for this might be the fact that all of these specific artifacts – which are also required to generate a control unit’s ECU extract, the basis for the run-time environment and the basic software configuration – must be described with sufficient scope and accuracy. Release 4.0 completes this template to the extent that these dedicated types are replaced by a generic approach that can be employed to describe any hardware component using the types, categories, and attributes that can be defined in the meta-model.

The AUTOSAR System Topology
As shown in Figure 2, different system control units, which are described in the meta-model as ECUs or in a hardware container, are summarized together in the AUTOSAR System Template to form a system topology. This can cover the complete vehicle model or just individual (possibly alternative) subsystems. The ECU model contains “AssemblyHWConnectors,” which
connect the ports and pins on the ECU with the ones from the corresponding display, sensor, and actuator hardware components. An example of this is shown in Figure 1 using the VSA (Vehicle Systems Architect) AUTOSAR authoring tool from Mentor Graphics. With a suitable export interface, the model artifacts of the systems from the AUTOSAR model can be carried over into a configurable XML extract.

![Figure 1: VSA – Visualization of Alternative Topologies in the System Template.](image)

**Importing the Logical Design**

In a second step, the data extracted from the AUTOSAR model is imported into a suitable tool for developing logical designs or the wiring harness. In the case described here, this is accomplished with the Capital Architect from Mentor Graphics’ CHS (Capital Harness Systems) product line.

Importing is accomplished via a configurable adapter. Here, it is possible to either use configuration files or to intervene manually to establish which parts of the system extracts should be imported as a logical design. During the import process, the AUTOSAR ECUs are interpreted as logical devices, and the “AssemblyHWConnections” are interpreted as signals. Beyond that,
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using a corresponding set of rules, this approach can then be used to determine which of the model artifacts that have been extracted from AUTOSAR can be associated with logical component types from the CHS part library on the basis of their characteristics. It can also be used to establish whether they are to be depicted in a corresponding option and variant model (and if so, how).

Figure 3: Logical Circuit Diagrams in Capital Architect generated from the Signals, Controls Units, and Peripheral.

This leads to different logical designs, which contain the pin out from the individual control units or from the overall system, as shown in Fig. 3. Using shared conductors, these circuit diagrams can be coupled with logical signals from other designs. For example, the supply of electric power can be described in its own logical design (separately from the ECU peripheral models from the AUTOSAR model that were developed in VSA) and then in an additional step either manually or automatically connected with these peripheral models. This method allows a recursive, parallel process, in which the different development domains feed in the results from their development process at specific transfer points in the follow-up process flow.
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Mapping to the Physical Topology
In a third step, the logical designs are automatically distributed or depicted within a physical topology. Here, the topology can involve an overall model or only specific portions of the topology. The topology model can either be generated manually or, using suitable interfaces, brought together from 3D models using a “flattening” process. As shown in Figure 4, the topology model primarily consists of slots for the control units and auxiliary units and of bundles that connect the slots to each other.

With the aid of “mapping rules” (placement rules), it is possible to determine how the control units and auxiliary units will be automatically distributed to the containers (slots). In other words, this establishes how the logical designs and their content that are generated from the AUTOSAR model are allocated to physical spaces. The automatic mechanism primarily offers an advantage in connection with a recursive approach in which different system and functional alternatives should be examined, because this minimizes the amount of manual steps required.

Figure 4: Physical Vehicle Topology in Capital Architect: Bundles and Slots for Control Units and Hardware Units.
As the final step, after physical allocation of the logical design, the “wiring synthesis” is performed. In this step, the logical signals from the AUTOSAR model are carried over into electrical lines, the cable harness, connectors and contacts are generated from the vehicle topology, and the optimal splice is performed. This is then used to determine relevant cable harness information, such as the cable lengths, bundle diameters, and weight information as well as the initial material and production costs. The results are made available to the developer in corresponding charts as shown in Figure 6.

Figure 5: Rule-based Allocation of Hardware Auxiliary Units to Hardware Slots in Capital Architect.

Figure 6: Results and Comparison of the Different Mappings in Alternative System Topologies.
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Continuing the process, uses can take advantage of functions such as power/ground analysis, sneakpath analysis, FMEA, and transient simulation. Furthermore, they can add further detail to the automatically generated cable harness diagrams, for example, by adding mechanical components such as tapes, clips, and grommets (see Figure 7).

Figure 7: Model of a Door Cable Harness in CHS Capital HarnessXC.

Summary: Cooperation through Consistent Exchange of Data
Prior to the actual software development, the standardized and open AUTOSAR meta-model can
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also be used to develop the architecture. The ECU Resource Template is particularly well suited for such tasks, because it opens up the actual software-oriented AUTOSAR development methodology to the electrical architecture process.

Unlike the use of special tools for drafting the logical architecture or for optimizing partial aspects of the vehicle architecture, the approach described here is based on the use of established development tools. With the aid of suitable interfaces, the data that is present in the development tools can be reused directly, and the results of evaluations gained in this way provide new qualitative significance. Architecting can be accomplished directly in the developmental tools, and it is no longer decoupled from the development process.

Supplementing the exchange of specifications with the use of meaningful models brings the different departments and domains within the automaker and supplier companies closer together to achieve a consistent development process that minimizes errors.

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