Redefined virtual validation of ECUs

(Source: Dspace)

The recent FMI (functional mock-up interface) layered standard supports both OEMs (original equipment manufacturers) and suppliers in the early and virtual validation of ECU (electronic control unit) functions. Thus, virtual ECUs can be exchanged beyond the limits of individual manufacturers and tools.

The early and virtual validation of ECU functions is becoming increasingly important for the development of modern vehicles in automotive, off-highway, and aerospace industries. Virtual prototypes of ECUs, also known as virtual ECUs or V-ECUs, are indispensable for this, but their interchangeability beyond the limits of individual manufacturers and tools poses a challenge. This is where the Functional Mock-up Interface (FMI) standard comes into play. The standard is not new, but it is under constant development. One current focus lies on the network communication.

This article shows how one can evaluate the FMI layered standard network communication and prepare for its use at an early stage. It also informs how the standard helps OEMs (original equipment manufacturers) and suppliers efficiently create and use V-ECUs. This article also highlights the core problems that OEMs and suppliers face in virtual validation and how the FMI standard can solve these in the future.

Challenges when exchanging V-ECUs

The exchange of V-ECUs between OEMs and suppliers poses different challenges for both sides. OEMs want to put the ECU functionality into operation in an overall system or sub-system at an early stage and are therefore dependent on the timely delivery of V-ECUs by their suppliers. They must specify the precise form in which they want to receive the delivery. Manual effort is often required in order to integrate the supplied artifacts into the simulation environment. If the implementation does not precisely meet the requirements, additional iterations between the OEM and the supplier are necessary.

Suppliers have their own development process for the ECU software. Before they can supply a V-ECU to the OEM, it must have already been thoroughly tested and put into

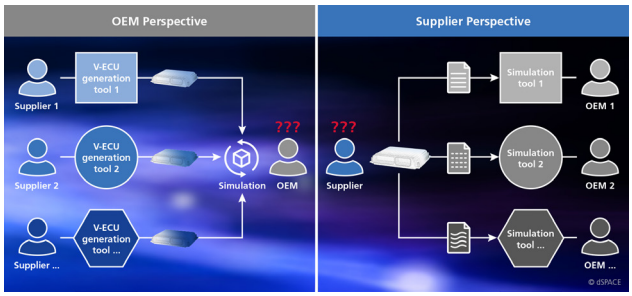

Figure 1: OEMs and suppliers face a variety of challenges if they wish to exchange V-ECUs with each other. Manual adjustments and frequent iterations lead to significant additional efforts on both sides. Often, the resulting costs and time expenditures even become a dealbreaker for virtual validation. (Source: Dspace)

operation – normally before the first hardware prototypes are available. In addition to virtualizing and validating the ECU software, they must then invest significant effort to precisely adapt the V-ECU to the OEM's specifications and requirements.

The current workflows therefore require additional effort for adapting the interfaces, the manual integration of the V-ECUs into the simulation environments, and frequent iterations between the OEM and the supplier. Often, the resulting costs and time expenditures even become a dealbreaker for virtual validation. This demonstrates how important a standard is for the efficient exchange of V-ECUs.

How to overcome challenges

A standard for V-ECUs in the field of network communication is therefore crucial for meeting the challenges described above. The layered FMI standard offers several benefits for this:

- High interoperability and cost reduction: OEMs and suppliers often use in-house solutions or rely on tool chains from different manufacturers. FMI has established itself as the standard for the integration of environment models and is therefore supported by numerous simulation platforms. Since the FMI layered standard network communication is based on the principles of FMI 3.0, existing simulators that support the FMI 3.0 core standard can be used without additional extensions, even for the simulation of V-ECUs with a network connection. This reduces the implementation costs and ensures high interoperability. At the ASAM International Conference 2024, the FMI working group showed how smoothly the exchange of V-ECUs and the interoperability of various tools work in practice thanks to the layered standard.
- Versatile applicability for the wide variety of use cases: The simulation scenarios of OEMs and suppliers often differ. OEMs often build simulation systems with several V-ECUs in order to validate the interaction of the supplied ECUs. Suppliers, on the other hand, tend to perform isolated testing and use restbus models, for example. The layered standard supports both: OEMs can realize complex simulation scenarios including the simulation of network errors, while suppliers can connect a V-ECU directly to a restbus model. The standard enables that the V-ECUs can be used in both scenarios without adjustments. In addition, it takes the different development phases of a V-ECU into account. In early phases (Level 1), network messages can be transmitted based on signals, while a simulation at the level of bus drivers is possible in advanced phases (Levels 2 to 4).
- High consistency and quality as well as rapid expandability: The layered standard is developed within the FMI project of the Swedish non-profit organization Modelica Association, ensuring both independence and the necessary consistency. The quality of the standard is ensured before its release through the exchange of V-ECUs in the context of cross-checks. In addition, the openness to contributions to the standard enables innovations and new network types to be promptly integrated into the standard.
- Simplified specification and implementation: OEMs no longer have to explain to their suppliers in detail what is to be supplied for the validation. The new standard provides specifications, demos, guidelines, and sample code. Suppliers do not lose valuable time but immediately know how they must implement the requirements without needing additional explanations.

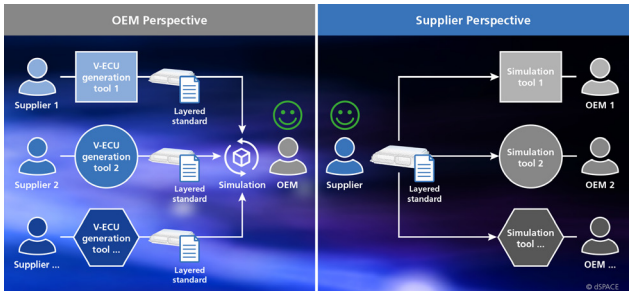

Figure 2: The FMI standard supports OEMs and suppliers in the early and virtual validation of ECUs. Virtual ECUs can be exchanged beyond the limits of individual manufacturers and tools. (Source: Dspace)

FMI standard support by tools

The FMI layered standard has the potential to fundamentally change the collaboration between OEMs and suppliers in the validation of their ECUs. Dspace is committed to support the introduction and establishment of the strandard. FMI standard implementation into the company's tools therefore plays a central role for Dspace.

With Dspace Release 2024-B, the layered standard for CAN is supported by the following tools:

- SystemDesk tool for the generation of V-ECUs;
- Veos platform for PC-based simulation.

SystemDesk users can now create V-ECUs based on the new standard and then import these V-ECUs into Veos. There, the V-ECUs can be connected to restbus simulations in the form of bus simulation containers (BSCs), for example. In addition, Flexray support is available with Dspace Release 2025-A. This enables users to take the first steps in the creation and simulation of V-ECUs with SystemDesk and Veos at an early stage.

New, additional features of SystemDesk are available. The microcontroller abstraction layer (MCAL) modules for the CAN and Flexray bus drivers can be integrated into V-ECUs that are subsequently to be exported as functional mock-up units (FMUs, *.fmu). This means that V-ECUs can be created on the basis of FMI 3.0 and the network abstraction of the layered standard. These virtual MCAL modules provide the foundation for integrating platform-independent software components of the real ECU, including network-related modules such as:

- Autosar COM for standardized communication between software components;
- J1939 used in heavy-duty vehicles for robust CAN-based communication:
- ISO-TP, a transport protocol for transmitting large messages over a CAN network;
- Unified Diagnostic Services (UDS), a communication protocol for ECU diagnostics.

These examples represent only part of the integration scope, which extends beyond network communication modules all the way to the application layer.

The Veos simulation platform now automatically recognizes FMUs with FMI layered standard network communication based on network abstraction during import and creates corresponding bus controllers for them. Restbus simulations in the form of BSCs for CAN can still be connected directly to V-ECUs. Thanks to the bus simulation integrated in Veos, the creation of complex simulation systems is considerably simplified. Bus controllers can still be connected via drag-and-drop, and the bus behavior is simulated in detail as usual.

Figure 3: SystemDesk users can now create V-ECUs based on the new standard and then import these V-ECUs into Veos. There, the V-ECUs can be connected to restbus simulations. (Source: Dspace)

Summary and outlook

At the ASAM International Conference 2024, the FMI standard was presented to a wider audience for the first time. The FMI working group demonstrated how smoothly the exchange of V-ECUs and the interoperability of various tools work in practice thanks to the new standard. In 2025, the FMI Steering Committee officially released the version 1.0 of the layered standard for CAN, along with a pre-release for Flexray and Ethernet. LIN is also already on the roadmap. As all bus types are based on the same fundamental principles, further milestones can be expected soon.

Following these achievements, Dspace has decided to support the layered standard in its SystemDesk and Veos tools at an early stage. Support for CAN and Flexray is already available, and Ethernet will follow with Release 2025-B.

The great interest and the consistently positive feedback from customers motivate the company's experts to continue their involvement in the FMI committee and to further advance the support provided by their tools.

Authors

Markus Süvern
Christian Becker
Dspace
msuevern@dspace.de
cbecker@dspace.de
www.dspace.com