Classic hardware-in-the-loop (HIL) simulation uses the real electronic control units (ECUs) to test whether their software functions correctly. Now virtual validation and virtual ECUs are providing new potential for more efficient, high-quality HIL simulation tests.

### Virtual Validation in Preparation for HIL Simulation

Virtual validation describes the overall method of using PC-based simulation for validating, verifying and testing ECU software. A PC-based simulation platform is one way in which virtual validation benefits HIL simulation. It is used to create and validate test scenarios in advance, and also to configure the simulation model. Virtual ECUs (V-ECUs) for executing initial test scenarios are another. No connection to a real, physical system is needed: Open-loop and closed-loop tests of ECU software and plant models run on a PC to detect errors and enhance the quality of the ECU software before the actual HIL simulation is performed. Creating and preparing tests in advance in this way ensures that HIL simulator time is used more efficiently[1].

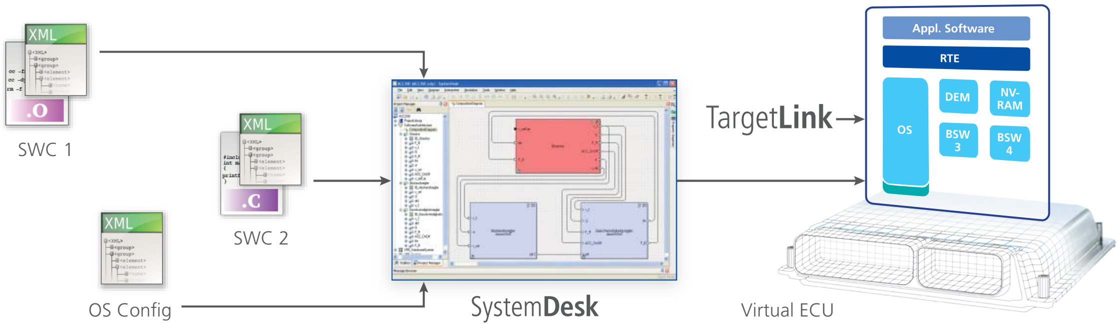
### Configuring and Creating Virtual ECUs

V-ECUs provide the same functions and software components as the final ECUs. They can be set up in several different ways:

- With individual AUTOSAR ECU functions
- With several or all AUTOSAR application software components
- With the entire integrated and configured application software, the run-time environment (RTE), the operating system and the hardware-independent basic software

dSPACE SystemDesk is used to generate V-ECUs straight from a software architecture according to AUTOSAR (see "All-Round Integra-

*Figure 1: SystemDesk and TargetLink can be used to generate virtual ECUs with varying configurations.*



New option
for hardware-in-the-loop simulation

# Virtual ECUs in Action

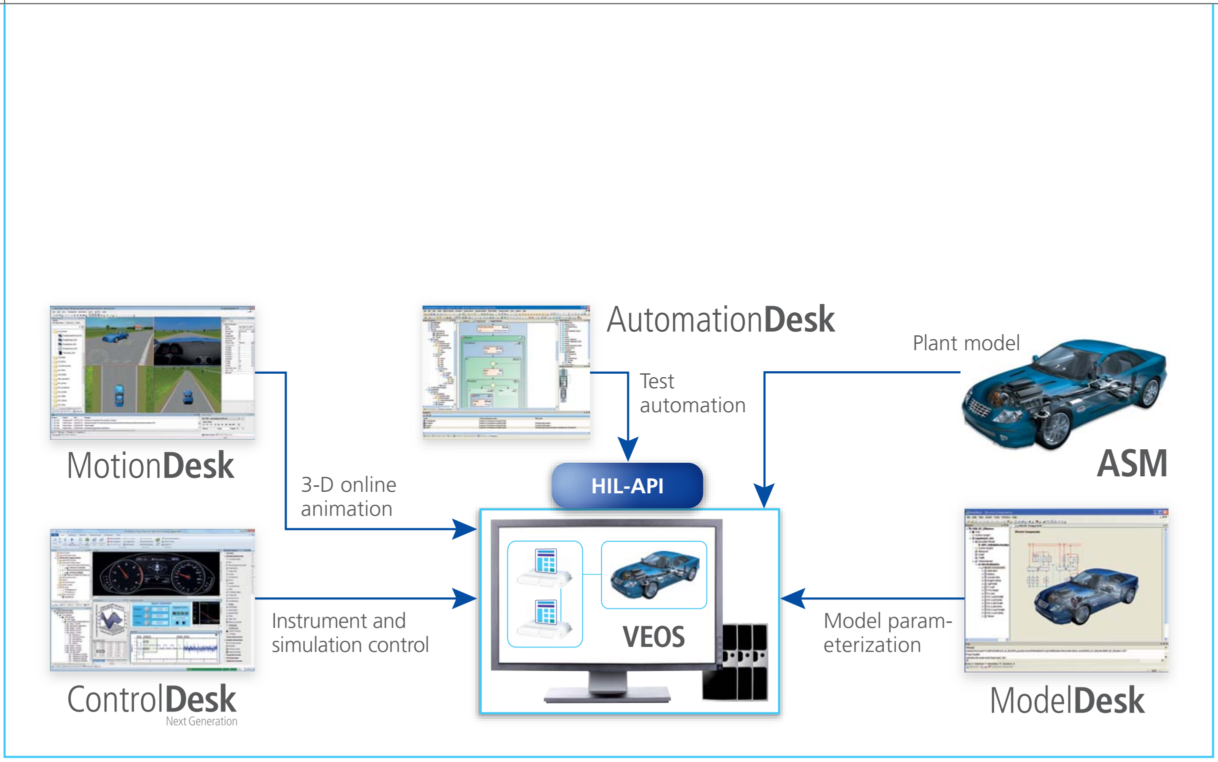


*Figure 2: With VEOS, test scenarios can be designed, prepared and tested without a HIL simulator.*

tion”, page 56). They can also be generated from a function model in Simulink® or TargetLink® (figure 1). Once generated, the V-ECUs can be used for PC-based simulation on dSPACE VEOS® or for HIL simulation on SCALEXIO®.

### V-ECUs in HIL Simulation

In a HIL scenario, if there is no real ECU hardware available for a particular part of the ECU network, a V-ECU can be used as a substitute. The V-ECU is created from AUTOSAR software components that represent the ECU. The V-ECU can be directly integrated into the HIL simulation together with other plant models, so no additional work is required to produce a software behavior model. Reusing existing ECU code in this way saves users development and validation effort.

Several SCALEXIO plant models and V-ECUs can be executed on a SCALEXIO system simultaneously. The configuration is produced in ConfigurationDesk® by connecting the interfaces of the V-ECUs with the plant model. The models and the configuration are stored separately so that the configuration settings are preserved if a model is modified.

### Dynamic Restbus Simulation with V-ECUs

V-ECUs can be used for high-quality CAN restbus simulation. If the object under test is a real ECU in a closed-loop test, the classic method in restbus simulation is to create ECU behavior models that form part of the plant model. For static restbus simulation, no behavior models are necessary, but dynamic restbus simulation

## dSPACE VEOS

The VEOS simulation platform is used in the early stages of development to simulate individual software components, ECUs and ECU networks on a PC. The interfaces are open, so additional tools can be used: ControlDesk® for instrumentation and control, MotionDesk for visualization, AutomationDesk® for automating the simulation sequence, third-party products, and so on. Users can therefore continue working in their familiar tool environment and reuse all their existing data, models, layouts and configurations.

The V-ECUs, models, layouts and simulation scenarios that are created and used for VEOS can be reused in HIL simulation. This reduces the work involved in preparing for HIL tests (figure 3).

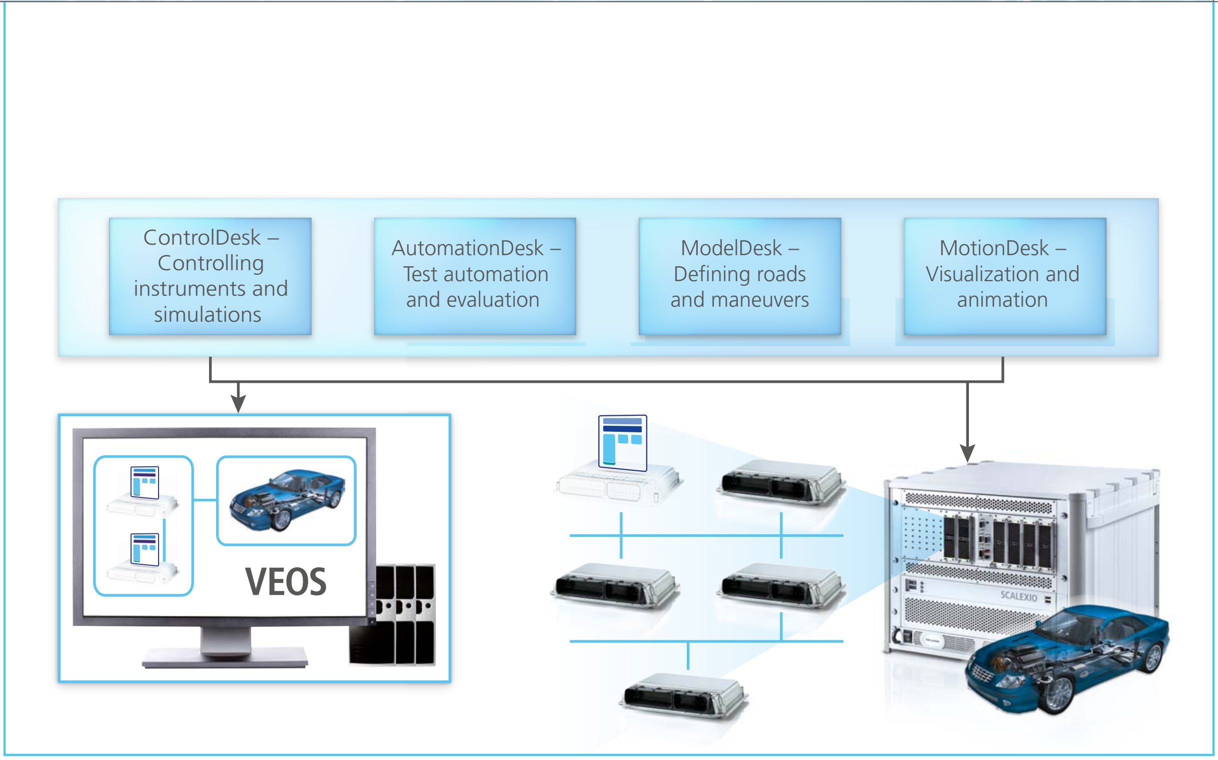

ControlDesk – Controlling instruments and simulations
AutomationDesk – Test automation and evaluation
ModelDesk – Defining roads and maneuvers
MotionDesk – Visualization and animation
VEOS
SCALEXIO

*Figure 3: Using the same tool landscape for both VEOS and SCALEXIO.*

can involve a considerable amount of modeling. However, no extra modeling is required if the ECU software is already available as a V-ECU, because V-ECUs themselves contain network communication settings. As usual with dSPACE restbus simulation, the V-ECU configuration is based on DBC, FIBEX or ARXML files. The imported V-ECUs can easily be connected to the physical interfaces of the SCALEXIO system with ConfigurationDesk® – without modifying the plant model. If a SCALEXIO system includes V-ECUs as part of the restbus simulation for the object under test (usually another ECU), they can be replaced by real ECUs later, also without changing the plant model. V-ECUs are described by ASAP2 files and accessed via Ethernet according to the XCP protocol. Any calibration tools that support these standards can be used, and layouts and test descriptions can be applied efficiently.
The practicability of the new methodology has been confirmed by a pilot application at Daimler AG[2]. ■

*Further reading:*

*[1] Real Tests for Virtual ECUs, dSPACE Magazine, 1/2012, pages 46 - 49*

*[2] Virtual integration and testing of vehicle E/E systems, ATZ Elektronik, 05/2013, Artur Honisch (Daimler AG), Dr. Karsten Krügel (dSPACE GmbH)*

## Conclusion

With V-ECUs, many aspects of ECU real-time behavior and bus behavior can be simulated more easily and more realistically by reusing software parts from ECU development. This approach provides realistic results and enhances the quality of functions at an early stage, before the final ECU is available. Moreover, being able to configure the SCALEXIO systems via software and perform PC-based simulation in advance (figure 2) means less time is required for commissioning and setting up the HIL simulator. This is why these new technologies – virtual validation and V-ECUs – are being incorporated into existing validation and testing processes for ECU software. dSPACE will continue to promote this integration, focusing mainly on the reusability of existing hardware, software and models.