Virtual Validation in Practice

Functional SIL stations at BMW

The higher the number of people involved in the development of ECU software, the more important it is to test the individual components early and realistically. BMW has chosen dSPACE VEOS as their central, PC-based simulation platform.

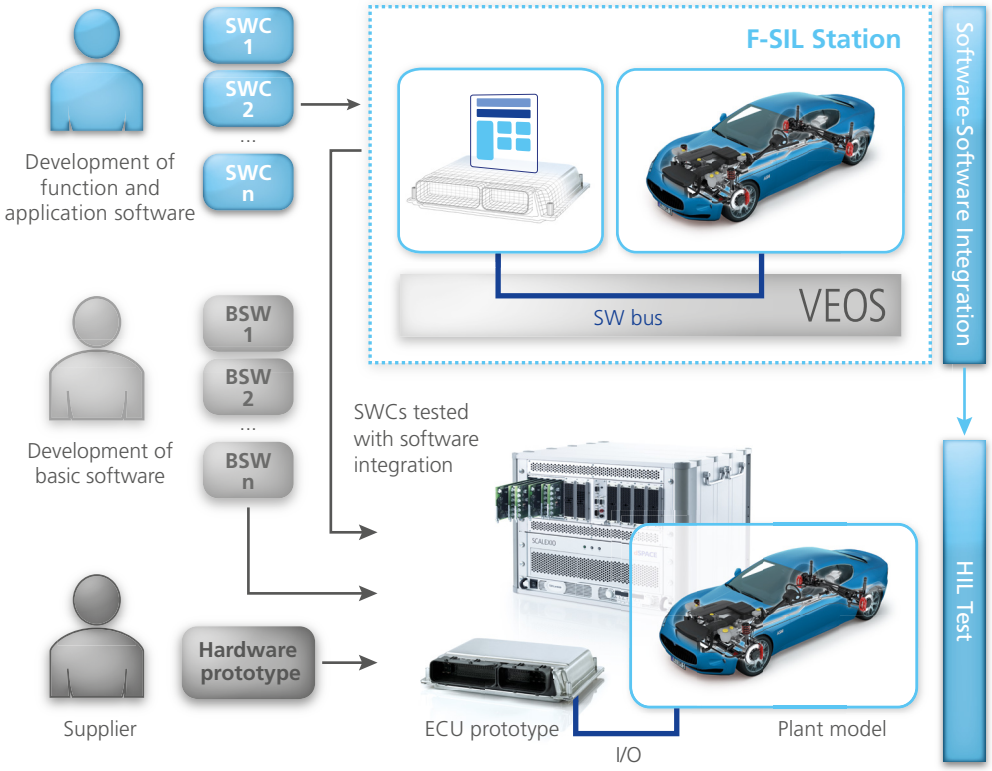


Figure 1: The F-SIL station adds a new step – the software-software integration that takes place before software-hardware integration.

Virtualizing a vehicle opens up new ways for testing and simulation in the development of new control strategies. Virtualization helps tackle two major challenges:

1. Reducing errors caused by distributed development

The individual components, such as the function and application software, basic software, and electronic control unit (ECU) hardware prototypes, are delivered by various teams. Identifying the error sources can therefore be tedious if the errors occur during integration.

2. Overcoming the limitations of MATLAB®/Simulink®

When simulating realistic AUTOSAR Software Components and basic software modules, MATLAB®/Simu-

link® soon reach their limits. The development of new functions is becoming increasingly complex and therefore involves more work areas than before. Because development tasks are distributed across more teams and departments while time to market is becoming shorter, tests in the early development phases are a must.

Solution for Challenge No. 1: F-SIL Stations

The current development process involves three main teams:

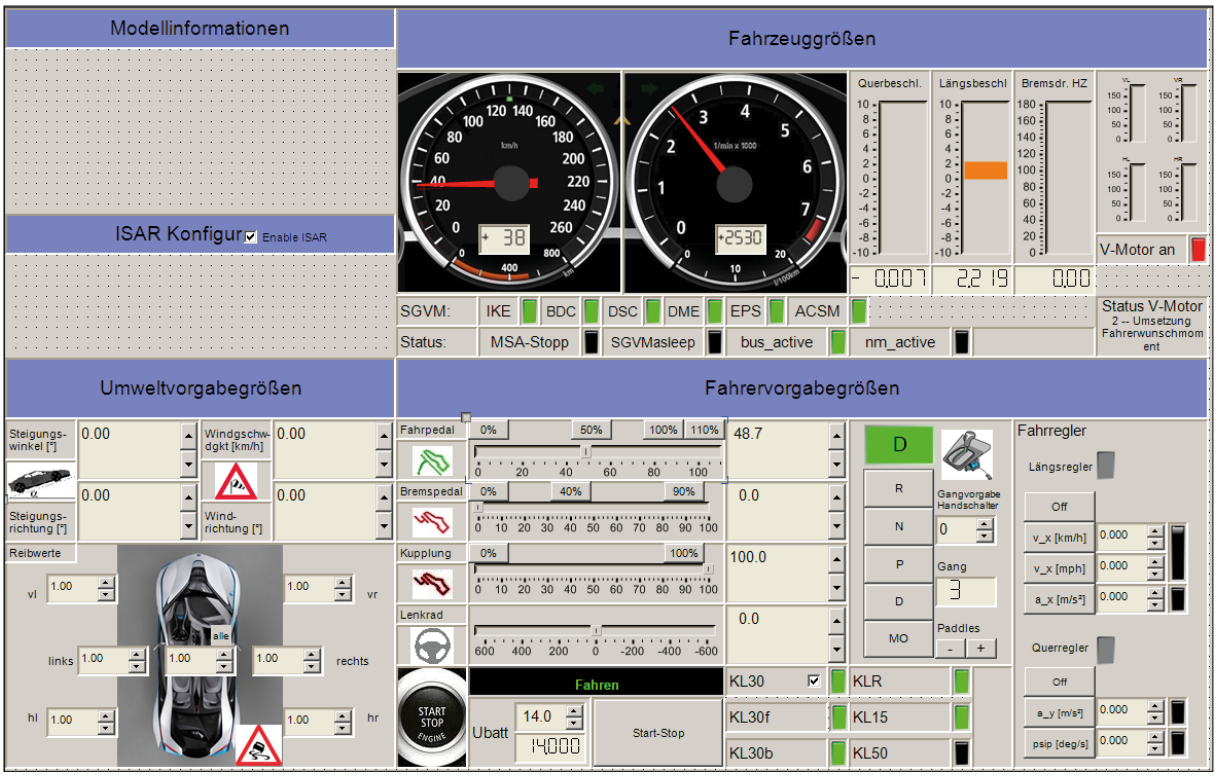
- Developers of function and application software: They provide the software components (SWCs).
- Developers of the basic software: They provide the basic software components (BSWCs).
- Suppliers: They provide the ECU hardware prototype.

At a certain point in time, software-hardware integration starts. Here, all SWCs and BSWCs are integrated and loaded onto the ECU prototype. The next step is comprehensive hardware-in-the-loop (HIL) testing. BMW has introduced a step that comes before software-hardware integration: They use a functional software-in-the-loop (F-SIL) station to first perform a purely software-based integration (figure 1). This makes it possible to test the interaction of the components developed for function and application software early on. The developers can check each new development state and correct potential errors right away. Thanks to these tests and corrections, the software reaches a high quality early in the development cycle. During the subsequent integration tests, only a few, easily identifiable errors occur.

Setup of the F-SIL Stations

BMW chose dSPACE VEOS as the basis of the F-SIL station, which is the company's integration and simulation platform. Because the software-software integration has to be independent of the hardware specifications of the target platform, the conventional Windows® PCs are ideal, as they are the everyday working environment at BMW. Another clear advantage of VEOS is its solid support of several de facto standards, such as AUTOSAR and the Functional Mock-up Interface (FMI), and MATLAB®/Simulink®. In addition, VEOS can be easily connected to existing hardware-in-the-loop (HIL) test and experiment tools, such as dSPACE ControlDesk® Next Generation and ECU-TEST from TraceTronic. This connection makes it easy to integrate the F-SIL station into the existing BMW tool chain. >>

Figure 2: Virtual BMW cockpit in ControlDesk Next Generation.



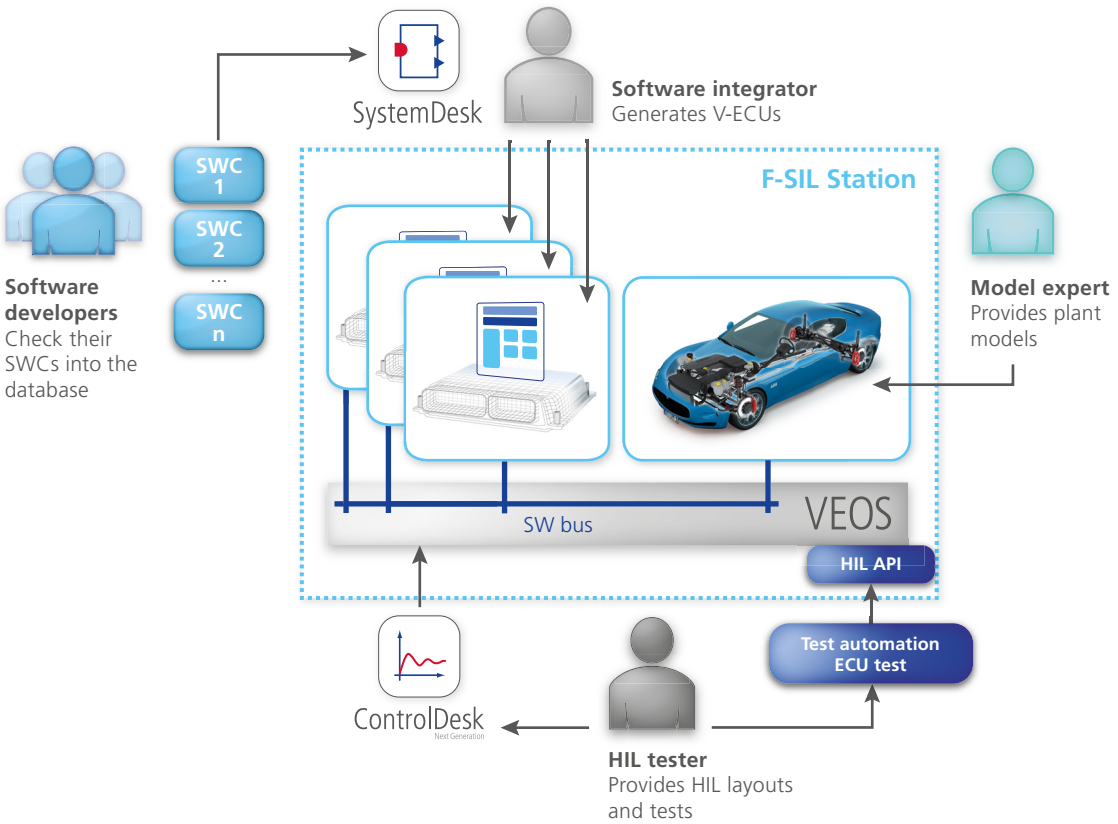


Figure 3: Overview of the products, artifacts and roles involved in the F-SIL station.

Solution for Challenge No. 2: VEOS-Based Workflow

Work on the F-SIL station clearly shows the strong interdisciplinarity and the exchange of information between various teams. As soon as the AUTOSAR SWCs are available, the software integrator generates virtual ECUs (V-ECUs), including the appropriate A2L description file. Interface and linker errors are easy to eliminate in this step. After creating the V-ECU, the software integrator connects the interfaces between the V-ECU and the plant model or environment model. The models are provided by the model preparation team, which also makes these models available to the HIL department. This involves connecting several thousand signals, so this integration step is done completely automatically. In the last step, the software integrator receives the ControlDesk Next Generation project files and layouts from the HIL department (figure 2). They are used to test the V-ECU functions in a closed-loop simulation on the F-SIL station. If everything goes as planned, the software integrator publishes a project configuration that the function and software developers can use for their own tests on the F-SIL station (figure 3). VEOS' open interface and the supporting standards make it possible to reuse existing HIL test scenarios and layouts for testing on the F-SIL station. This reduces the workload and ensures a seamless transition between tests. Because the function developers use realistic test scenarios, they can now avoid the limitations of simulation based on MATLAB/Simulink alone.

Importance of the F-SIL Stations at BMW

Function and software developers mainly use the F-SIL station in the early integration phase, because at this point in time, target platforms either do not exist or are not available, due to the low number of units or high costs. BMW currently has over 60 users working with three F-SIL stations for the virtual validation of four different project configurations. Because the software-software integration takes place before the software-hardware integration, the stressful integration

phase is much more relaxed. In addition, software and function developers can work on their PC as if on a HIL simulator, while still benefitting from the advantages of non-real-time simulation, such as debugging, code coverage analysis, and parameter optimization.
The F-SIL tool chain perfectly supports the tools currently being used in the validation process, so there are no noteworthy acceptance problems among the various teams and roles in the company. This opens up new possibilities for interdisciplinary work and ensures that new validation steps are readily accepted. ■

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Conclusion and Outlook

It has already been shown that for BMW, including a new validation step in the development process has paid off significantly. While introducing this new step did entail some effort because the interaction of the various departments requires more coordination, the synergies more than make up for it. Furthermore, using VEOS as the simulation platform has even more advantages, which were not expected at the beginning. For example, VEOS helped considerably reduce issues related to compatibility and performance with MATLAB®/Simulink® during the pure offline simulation. There will be more users and project configurations in the future. The F-SIL stations are now an established key component of the validation process and are already an inherent part of the next production series.