Overcoming bottlenecks in the test process by means of virtual validation

Bottleneck Relief

CNH Industrial has set itself the goal of optimizing the processes for testing the ECU software of its commercial vehicles and machines. This was achieved by implementing a combination of HIL tests and virtual validation. For this, CNH Industrial relies on the SCALEXIO and VEOS platforms from dSPACE.

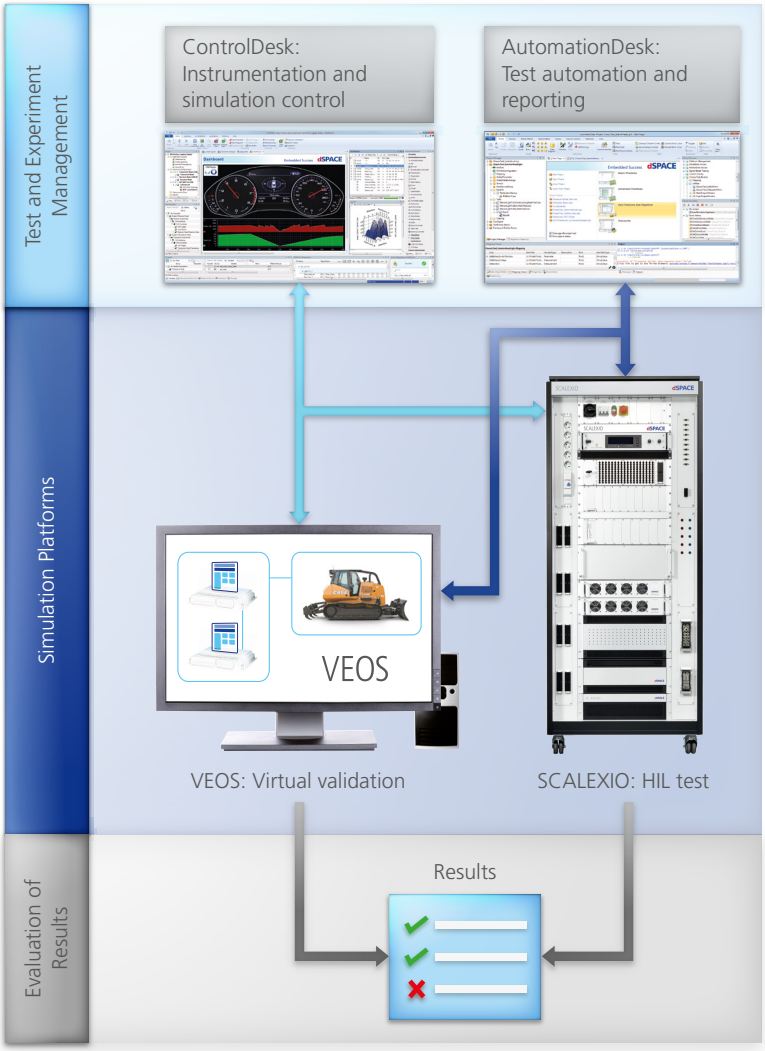
The ability to perform software tests faster and more efficiently is of utmost importance to CNH Industrial. As a designer, manufacturer, and seller of agricultural and construction equipment, trucks, commercial vehicles, buses, and specialty vehicles, precisely timing all development steps in many parallel projects is crucial for this multifaceted company. The sooner new software updates can be tested, the sooner new functions and systems can be implemented in the production line. CNH Industrial is therefore specifically focused on increasing the efficiency of its test environment. One method is to frontload selected tests to early stages of development. The Hardware-in-the-Loop (HIL) Group at CNH Industrial relies on virtual validation with software-in-the-loop (SIL) tests to implement a faster and more efficient process for testing electronic control unit (ECU) software.

Challenge: Test Efficiency

The HIL Group is responsible for testing ECU software and releasing ECUs used in tractors, combines, agricultural implements, and construction vehicles. It uses five PHS-bus-based HIL simulators and four SCALEXIO simulators from dSPACE. According to HIL System Design Engineer Pedro De La Torre, the focus of the search for an optimized test solution was to eliminate several bottlenecks that occurred during the test design and test phase. "When creating a new test project, we were not able to verify and validate the tests until we had the devices, such as the HIL simulator and physical harnesses, on site," explains De La Torre. The tests for a particular ECU were delayed by this setup time. Another aspect concerned all tests: "If a new software version for a different vehicle came out and needed testing, we would have to wait until the current test was finished before moving on to the next one," says De La Torre. "These restrictions posed a constant challenge to project management, highlighting the need for a more efficient process."

Solution: Virtual Validation

To conquer these challenges, the HIL Group has found a way to optimize the entire process of software and application development: Team members accelerate the test process by performing more tests during the development phase with the help of virtual validation. This results in faster and more frequent software releases. Moreover, the HIL Group relies on the PC-based simulation platform dSPACE VEOS. The benefit: The existing HIL tests can also be reused relatively easily in VEOS. Conversely, it is also possible to reuse new tests created with VEOS on a HIL simulator. De La Torre explains the benefits: "With VEOS we can develop, debug, and verify a new test project before the HIL simulation equipment arrives. This means we can begin testing software earlier in the design process." He adds that virtual validation also allows them to perform several tasks in parallel: By using VEOS, it is possible to work on several software releases simultaneously, instead of just one release as was the case in the past. For example, tests can be performed for the software release of one >>



Design of the tool chain for the validation of control unit software. The test platform VEOS and the HIL simulator can be used in parallel with identical test environments.

vehicle while updating and preparing tests for the software release of another vehicle. "Since virtual validation with VEOS is executed by only using software that is running on PCs, we can achieve more in a shorter time frame because tests can run in parallel," continues De La Torre. In addition, virtual validation helps reduce the test duration by testing different software features in parallel with SIL and HIL simulations.
This leaves more time for debugging the current software release and testing the next release.

Setting up Virtual Validation

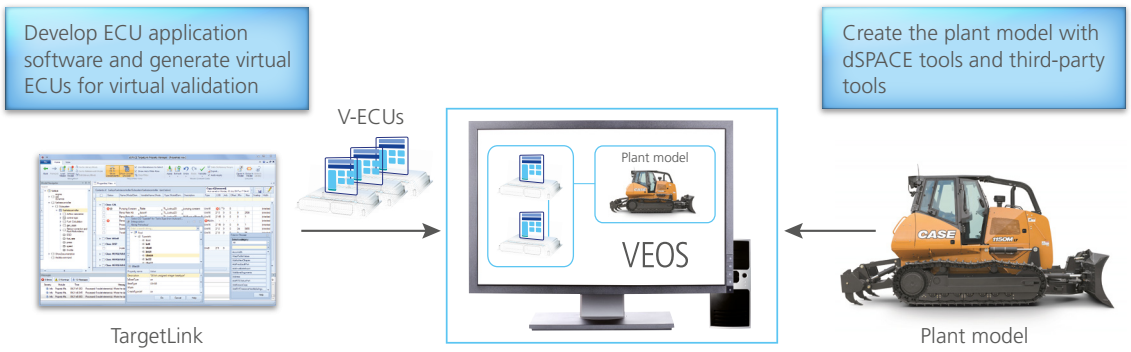
It took the HIL Group approximately seven months to use VEOS productively. During this time, four months were invested in evaluating VEOS and learning its capabilities and functions. The remaining three months were necessary to adapt the interfaces of the HIL plant models and to develop a procedure for generating virtual ECUs so that controller and plant models could be used both with the HIL simulators and with VEOS. With dSPACE ControlDesk and AutomationDesk, the HIL Group was able to make minor changes to the tests so that they work with both virtual and HIL platforms. With additional minor modifications, it was possible to reuse important workflows and working techniques from the HIL test with VEOS.

Creating Virtual ECUs

An important prerequisite for comprehensive virtual validation is the use of virtual ECUs (V-ECUs). They contain all software components and functions of the final control unit. To create the V-ECUs, CNH Industrial uses the TargetLink production code generator. "TargetLink plays a major role in our software development process. With VEOS simulation testing, TargetLink has the added role of generating the V-ECUs used in virtual validation. This provides us with seamless integration with VEOS and a consistent build process. This also minimizes the amount of changes needed to be done to software on the part of the HIL team," explains De La Torre. To solve possible software problems, the HIL Group works closely with the software developers. This ensures that the V-ECUs generated for VEOS contain all functionalities that can also be found in the ECU software. Part of the collaboration is also a comparison of the test results of the V-ECUs and the HIL simulation tests to determine whether their behavior matches.

Listing and Comparing Results

Virtual validation is being used in a current project for testing the CASE Wheel Loader series. From this, typical application scenarios for the different platforms can be derived: While pure function tests run largely in VEOS, tests of time-dependent functions and physical and electrical properties as well as stress tests are performed on an HIL system. Finally, a complete test of the software is performed with the HIL simulator



The TargetLink production code generator supports generating virtual ECUs for virtual validation with VEOS.

and then compared with the test results from VEOS. This makes it possible to determine whether the VEOS tests can be further expanded and refined, thus maximizing the test coverage with VEOS. De La Torre summarizes the results as follows: "This helps us make better use of our HIL time, because it reduces a major testing bottleneck, giving us flexibility on how we approach testing and speeding up the testing process. The less software functionalities exclusively covered by HIL simulation the better, since we will then be able to run more tests in parallel with VEOS. In an initial project, VEOS reduced our test execution time by 22% when compared to normal HIL execution."

Conclusion

The earlier errors are found, the more cost-effective it is to correct them. And the more tests run in parallel, the shorter the test phases. The frontloading and parallelization of tests can be integrated in the development process with the help of VEOS. "In the future, we will develop our ECU software faster, because VEOS will make our software development process more efficient in every respect," De La Torre concluded. ■

Courtesy of CNH Industrial.

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>
> *Pedro De La Torre, CNH Industrial*

Examples of agricultural machines from CNH Industrial in action.

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