Ford was looking for a method to train individuals who are migrating to AUTOSAR and to address a common challenge for the software industry, especially in automotives: software delivery schedules. Simply put, everyone knows more software is being delivered at a faster rate than ever, and this trend continues. Unlike some products in the consumer electronics industry, the automotive industry is unique, because the products are not disposable and are required to operate despite environmental extremes. Yet consumers demand an experience akin to consumer electronics. How can the automotive industry keep pace with consumer electronics while addressing stringent validation requirements? Simply implementing AUTOSAR does not alleviate the concern, since many AUTOSAR users still test their code too late in the development cycle. Adding more people is successful only if they understand the methods that can accelerate the pace of development. The challenge was how to train those new to the process efficiently. By providing a simulation environment with dSPACE VEOS®, Ford enables its developers to test software sooner and even before hardware is available, and provides an environment for them to experiment with AUTOSAR.

Acceleration via Simulation

Virtual ECU simulation supports these goals in several ways. First, it can identify and eliminate many issues on the feature developer's computer prior to costly, resource-limited hardware-in-the-loop (HIL) testing. This non-HIL approach maximizes the utility and return on investment of HIL resources, which are now used for their intended purpose of executing HIL tests without costly interruptions due to non-HIL tasks. In terms of virtual simulation tools from dSPACE, feature developers use ControlDesk® Next Generation, which is the same calibration and visualization tool used by the HIL team and calibrators. Therefore, the experiments, layouts, and settings are developed first by the feature developers, providing earlier test preparation for HIL engineers. While it is true that model-based design processes include software-in-the-loop (SIL) simulation, oftentimes this means that 'soft ECUs' in Simulink are used to approximate the functional behavior of a missing ECU.

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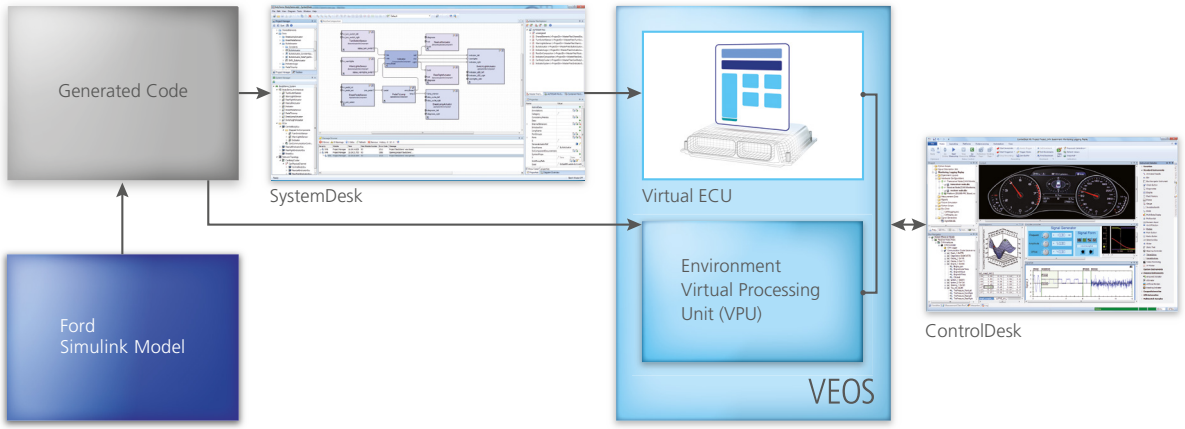
AUTOSAR simulation with VEOS

Rapid AUTOSAR Adoption

Source: © Ford

The Ford Motor Company needed a tool chain that on the one hand accelerates the development process to meet customers' expectations and on the other hand reduces the time and effort required by new adopters to familiarize with its methods. With the dSPACE virtual validation tool chain, they found both.



VEOS simulates AUTOSAR code produced with SystemDesk by using a bottom-up workflow. The simulation software integrates with the well-known, industry-standard calibration and measurement tool ControlDesk.

However, this practice is susceptible to errors. A better approach is to integrate the real-time operating system and other lower-level components' software with the application layer. In the best case, with all ECUs included, the simulation is essentially a virtual ECU breadboard, and hardware unavailability should not prevent networked, system-level testing.

Top-down or Bottom-up

In many cases, Ford's AUTOSAR workflow design process actually begins in a behavioral modeling tool instead of an authoring tool because many models already exist today. But there are some cases when a new architecture is developed. In that case, the workflow begins in SystemDesk®. Although it is tempting to always begin in the SystemDesk authoring tool, Ford found it more beneficial to begin the workflow with a model constructed in Simulink. SystemDesk automatically sets up everything in accordance with the imported Simulink model, saving significant time compared to performing manual configuration steps. Since many of these steps are architectural and reflect the model's structure, data types, and interfaces, this information is easily acquired from the Simulink model and was a real time-saver.

Flexible Tool Chain

Like many software tool providers, dSPACE partitions its tools into various subcomponents to appeal to a wide customer base. Different tool combinations can be used depending on work responsibility. In a production environment, employees require only subsets of the tool chain based on their job function. For example, a system architect might be the only team member requiring SystemDesk, lowering the average cost per seat.

Allocation with Ease

Once the software components (SWCs) are imported into SystemDesk, a composition diagram is built showing the interconnections of the software components. This composition diagram maps easily to the system in SystemDesk. The system describes the integration of AUTOSAR software components into a network of ECUs. All software components can be allocated or mapped to the same ECU instance. If another ECU is added to the system, the system architect can remap certain SWCs to a new ECU. SystemDesk automatically handles any implications of the reallocation.

The Right Level of Basic Software, Automatically

Users, especially those new to AUTOSAR, benefit from SystemDesk's automatic functionality that greatly simplifies the workflow. The Automatic Configuration and Generate step creates basic software (BSW) code for the RTE and I/O. For example, in the New ECU Configuration dialog of SystemDesk, users can choose from predefined configurations. When users select Default Single ECU Configuration, SystemDesk automatically generates the required subset of the basic software layer tailored for simulation. This is helpful

> "With VEOS, Ford went from training and software evaluation to significant results within months."
>
> *Kurt Osborne, Ford Motor Company*

since SystemDesk generates a custom ECU configuration based on the application layer. Ford benefited from the range of virtual ECU abstraction levels and automatic configurations offered by SystemDesk. Furthermore, all runnables can be mapped to operating system tasks automatically. This is a great starting point, which also simplifies the task for new adopters. Exploiting an industry-standard scheduler eliminates the need to develop one in a Simulink model. An automatic configuration and generation step also creates virtual processing unit (VPU) ports for connecting V-ECUs to VPUs. I/O Hardware Abstraction and Data Access Point modules are manually added to the ECU configuration to access the ports from the environment virtual processing unit. "Environment virtual processing unit" is the name for the plant model. Via the Auto Configure and Generate button, users can have SystemDesk generate ECU code for simulation purposes. After code generation, the simulation system for simulation on the VEOS platform is built.

Virtual ECU Simulation with VEOS

Ironically, the backbone of this simulation environment is a tool that intentionally has minimal direct user interaction. VEOS, the offline simulation platform, has been available since 2012 but can be somewhat inconspicuous.

VEOS provides a unique simulation environment. Simulink alone can perform SIL validation with AUTOSAR-based C code for the application layer. However, VEOS takes the next step by providing the ability to simulate a fully integrated application layer with the rest of the AUTOSAR stack (i.e., BSW and RTE). VEOS delivers an integrated solution that allowed Ford to find problems earlier in the development cycle.

Simulation log files can be produced for the simulation, universal calibration protocol (XCP), and bus communication, and there is feedback on controller area network (CAN) bus loading. CAN bus trace information can be analyzed by the user to determine the loading or exported to another tool. Inspired by this project's feedback, a future software release will include integration with ControlDesk's Bus Navigator.

Automate, Automate, Automate

One deliverable of Ford's project was an automated, model-based workflow to aid new adopters. During a presentation at the MAC 2015 in Stuttgart, MathWorks stressed the importance of automating the AUTOSAR workflow. This AUTOSAR presentation highlighted nine recommendations. One was "automate, automate, automate". Ford automates two separate parts of the workflow, which was partitioned by tool chain components. The Simulink part was automated by using a MATLAB M script. The workflow of the dSPACE tools was automated via a Python script, which makes it easy to put the recommendation into practice.

Next Steps

dSPACE and Ford made a great development team that quickly established a virtual ECU simulation environment useful for rapid AUTOSAR adoption and accelerated software time to market. Ford went from training and software evaluation to significant results within months. Due to this success, Ford will be able to quickly increase its efforts in AUTOSAR. Already, there is interest from other colleagues who are eager to apply VEOS for their projects. ■

Kurt Osborne,
Dalya Kozman,
Ford Motor Company

Why Virtual Validation?

- This non-HIL approach maximizes the utility and return on investment of HIL resources.
- SystemDesk automatically sets up everything in accordance with the imported Simulink model, saving significant time compared to performing manual configuration steps, and automatically handles any implications of the reallocation.
- Virtual validation enables Ford to accelerate software time to market.

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