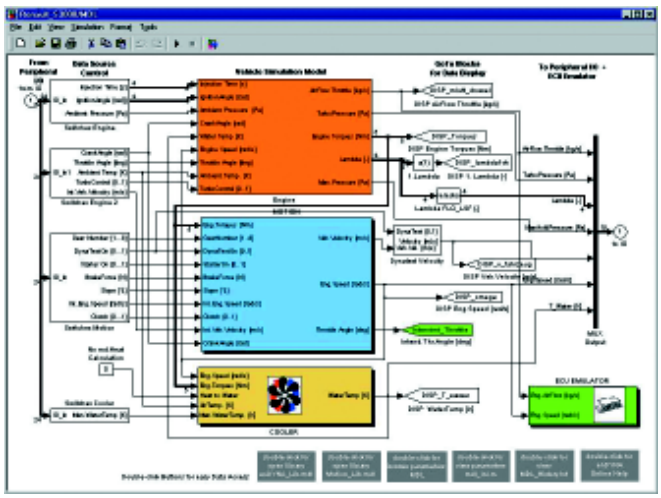
Renault: Validation of Powertrain ECUs

- Test automation for gasoline and diesel engines
- dSPACE Simulator as an essential tool for developing powertrain control
- Simulation with TESIS DYNAware models

The increasing complexity of embedded software for electronic control units (ECUs) means that Renault needs a convenient and flexible environment for system testing. Since the company employs ECUs from different suppliers, the decision to switch to the independent system partner dSPACE was an easy one. The first turn-key Simulator was delivered to Renault in early 2001. The good results achieved with this, together with positive experiences with the flexible dSPACE concept in other projects, prompted Renault to acquire additional dSPACE Simulators shortly afterwards.

As engines become increasingly sophisticated, engine control software is forced to handle more and more demanding functions. Compliance with the growing constraints on all automotive systems, such as safety and environmental aspects, time-to-market engineering, etc., is also essential. The complexity of the new controllers makes extensive tests on hardware and software indispensable. As the ECUs contain complex control algorithms with sensitive fault recognition, they cannot be operated realistically without a hardware-in-the-loop (HIL) environment.

To meet all these demands, José Amorim, head of Powertrain Control Software Tools, chose dSPACE Simulator Full-Size as a turn-key solution for the software development of engine ECUs at Renault. A key objective was to automate test runs, in order to reduce delays in software validation and at the same time enlarge the test range.



Simulink engine model from TESIS.

ECU Development at Renault

Renault gives its engine ECU suppliers not only the written software specifications, but also some controller strategies and functions. These are produced by Renault's development teams using specification tools such as MATLAB/Simulink/StateFlow from The MathWorks.

The ECU suppliers then implement the controller functions.

By the time Renault receives the first prototype of an ECU, the hardware has already been tested in open-loop tests.

dSPACE Simulator

In spring 2001, a turn-key dSPACE Simulator Full-Size was delivered to Renault. This had been adapted to the company's needs and was ready to use in all kinds of applications.

The Simulator's modular hardware architecture is based on a PowerPC processor board. There are components for realistic sensor signal simulation, simulation of electric faults and signal conditioning. This modularity will enable Renault to add other components later on, and even to test networked ECUs. An ASAM-MCD 3MC interface allows the remote control of external calibration tools.

The Simulink-based real-time engine model en-DYNA from TESIS (adjustable to various engines, such as diesel, gasoline) was already fully integrated and parameterized for Renault's engine.

ControlDesk is used to change parameters and monitor the test results during real-time simulation. Here, initial layouts were also provided. As Renault wanted to start by using dSPACE Simulator as a platform for software validation, the enhanced ControlDesk Test Automation options were very useful. With the test algorithms prepared by dSPACE as a reference, it was easy for Renault to develop further test sequences step-by-step, and set up an extensive test database.

Function Development at Renault

With en-DYNA, each engine model can be modified to simulate a different engine (VVT, turbocharger, etc.). This allows Renault to test newly implemented functions on the ECU before the real engine actually exists. Once the functions have been sufficiently validated on the Simulator, they are passed to Renault's supplier for implementation.

On the other hand, if an engine is already physically available at Renault, its ECU functionality also undergoes thorough testing with the HIL system before final tests are run on a test bench, followed by test drives.

The two approaches significantly reduce test and validation runs on real-engine test benches, and even more importantly: They allow wider test ranges with no risk.

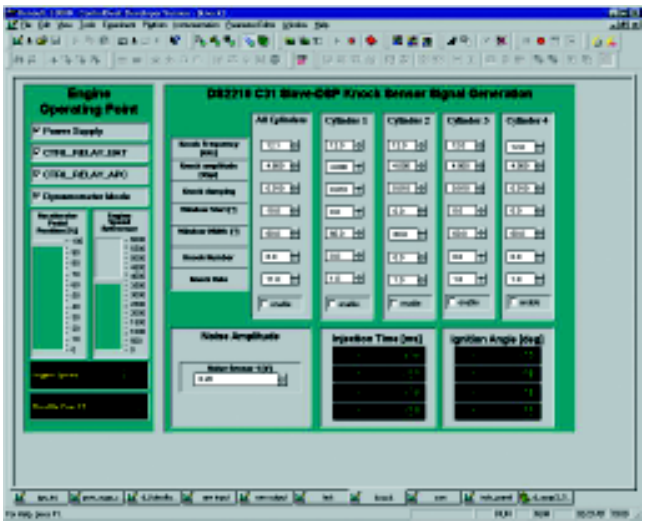
ECU Software Validation – Status Quo

dSPACE Simulator's first task at Renault is software validation. The team has already developed a series of engine-specific tests and run them as lights-out tests overnight and on weekends. Several common and specific test series had been produced in an impressively short time. This made it possible to find and understand hardware-related bugs that had previously been impossible to locate even for the supplier. Renault's choice of such a comprehensive hardware-in-the-loop Simulator had proved to be a good one.

During test drives (test bench or road), external data measured by the ECU is collected by a calibration tool and can be reproduced in the lab with the help of ControlDesk's Test Automation Library (TALib). The advantage lies in repeatability and in the ability to run large numbers of tests with different parameter settings.

Renault's Further Plans

José Amorim's team will continue setting up a detailed test database covering all imaginable scenarios. Renault has already employed standard Rapid Control Prototyping systems (MicroAutoBox, modular dSPACE Prototyper systems) to develop and prototype new control functions for existing engines. Now the dSPACE Simulator will be used to develop new strategies for new engines and new controllers. Renault has already acquired more Simulators and intends to make intensive use of them in the management of complex gasoline and diesel engines, such as common rail.



ControlDesk layout for knock sensor simulation.

They plan to perform on-board diagnostics (OBD) tests, plus functionality and RAMS (Reliability Availability Maintainability Safety) tests. Suppliers will also be expected to eliminate hardware and software problems at an early stage using comprehensive HIL Simulators. Moreover, Renault plans to simulate new engines and test prototyping ECUs with dSPACE Simulator even before the specifications go to its manufacturers, and is also about to test networked ECUs (such as gearboxes, ABS, ESP). HIL is an essential element in Renault's strategy for developing powertrain control systems.

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