Virtual Outlander

- Mitsubishi using a virtual vehicle to develop a new Outlander
- Real-time execution of Automotive Simulation Models (ASM) with a network simulator
- Monkey tests integrated into test automation

To develop the new Mitsubishi Outlander, a test system was required for the over 20 networked electronic control units (ECUs) and various electric drives. Mitsubishi aimed to meet the defined market launch deadlines and also fulfill quality requirements by running early integration tests on the networked functions. The test system was designed as a virtual vehicle consisting of a network simulator and the Automotive Simulation Models (ASM) from dSPACE.

Selecting a Test System for Integration Tests

The existing solutions for monitoring CAN traffic when failures are inserted in the system via switch box were no longer sufficient for the complexity of Mitsubishi Outlander's control systems. In particular, it was not possible to implement systematic, reproducible tests based on these tools with reasonable effort.

▲ *The new Mitsubishi Outlander is equipped with numerous networked ECUs and various electric drives for comfort functions.*

We therefore began by evaluating test systems from several providers. The hardware-in-the-loop (HIL) solutions from dSPACE came out on top. Good, intensive cooperation with dSPACE also convinced us. Even during the evaluation, we managed to locate a field fault using the dSPACE Simulator Mid-Size, which greatly boosted acceptance.

The Outlander Project's Special Requirements

The variant diversity and various internal requirements resulted in the following requirement profile for the test system:

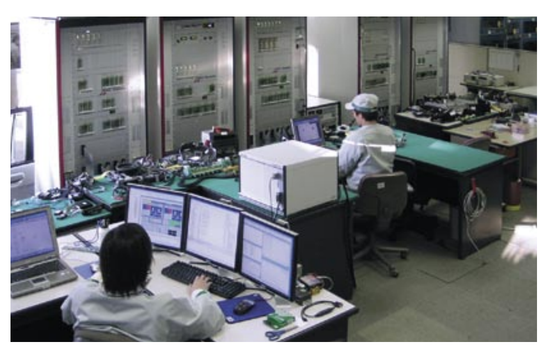
- Simulation of three different engines: 4- and 6-cylinder gasoline and 4-cylinder diesel
- Simulation of continuously variable transmission (CVT) and automatic transmission
- Integration and simulation of supplier models (transmissions, electric drives)
- Simulation of lock logics for electric doors and electric glass roof
- Different country variants: Japan, USA, Europe
- Installation of real parts such as power windows and power hatch in the HIL environment

"Virtual vehicle tests in real time are indispensable to assuring the quality of complex ECU systems."
Kunihiro Sakai, Mitsubishi Motors

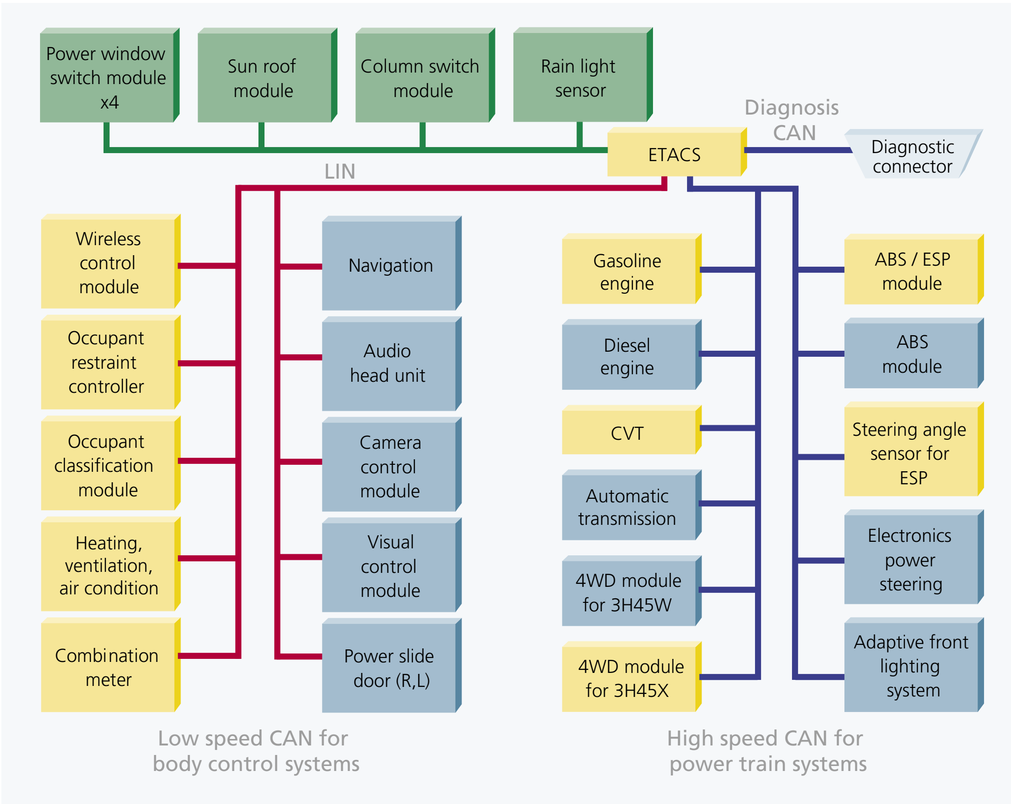
Different hardware versions of some ECUs had to be included. This required simple version detection on the part of the test system so that the correct test models are automatically activated when the ECU changes.
Another requirement was to perform automated monkey tests for all the vehicle's driver functions that can be activated by switch or button.

Configurable Virtual Vehicle

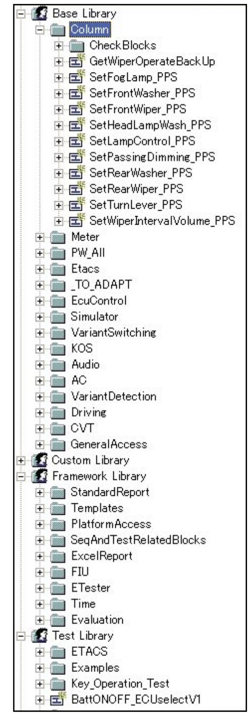
With this requirement profile as the basis, we worked with dSPACE on a specification for an extensive test system. The data and facts for the ECUs were included in the form of data sheets and ECU description files.



▲ *The virtual vehicle testing system as it is installed in the laboratory.*



▲ *The diverse ECUs and bus systems are connected by a central ECU, the Enhanced Total Access Communication System (ETACS).*



▲ *AutomationDesk libraries are the basis for fast, efficient test execution.*

The specified system is called a virtual vehicle, and it is equipped with push-button configuration for different variants. It consists of five networked HIL simulators, to which all the ECUs and real parts have to be connected. The models of the components to be simulated are installed on the simulators. For the engines and vehicle dynamics, these are the ASM models from dSPACE. The models of various electric drives and the CVT were provided by the suppliers and integrated into the dSPACE models. Thanks to the expertise of dSPACE, the specification was quickly completed.

Installation in Two Phases

To put the system into operation, we decided to perform two-phase installation: First the simulators for testing the body system were delivered and commissioned, then the test solutions for the powertrain were added. This procedure was successful. Splitting in two steps ensured that we could begin the complex integration tests on the new electric components at a very early stage.

Variant-Based Integration Tests

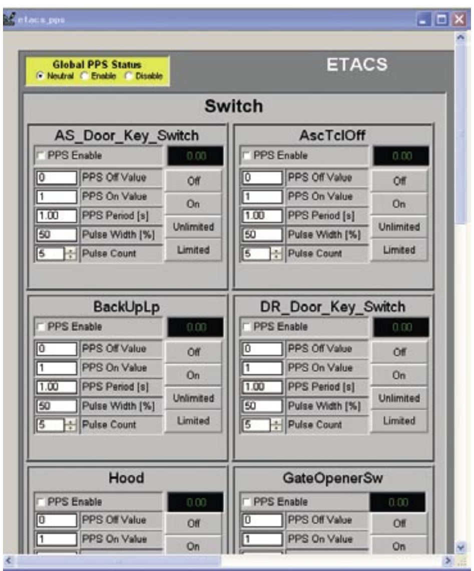
The installed test system is able to simulate all the variants of the Mitsubishi Outlander in real time. Variant handling is carried out in a user interface created

"With the Automotive Simulation Models (ASM), we can virtualize the chassis and powertrain of the Mitsubishi Outlander realistically."
Masahiro Kaneda, Mitsubishi Motors

with ControlDesk and takes only minutes. All the models are then correctly configured, the required parameter sets are loaded, and where necessary relays are switched to address the real installed components – all automatically. Hardware version detection for the ECUs was implemented as intelligent evaluation of connector coding. This automatically selects the correct variants for different ECU versions. It makes it particularly easy to replace ECUs quickly and then test them immediately. We run all tests with AutomationDesk. dSPACE set up a test frame in which our test engineers integrated all the test cases.

Virtual Vehicle in Action

The new virtual vehicle based on dSPACE network simulators enables us to test all the ECU functions in the Mitsubishi Outlander, including diagnostic functions, reliably and systematically with a single test system.
In addition to the systematic tests, we successfully perform monkey tests to validate the controls of the new electric body systems. dSPACE developed a special function for this, which works like a random generator and can be connected with all the relevant function inputs. With the new dSPACE system we can perform functional test as well as study the behavior of all ECUs and network communication during any maneuver. During all tests, the HIL also lets us monitor the power consumption of each ECU, which becomes especially important when the ECU network enters sleep mode.



▲ *ControlDesk layout for controlling and evaluating a lock logic featuring a Programmable Pulse Stimulus (PPS) for monkey tests.*

Automated Tests Achieve Objectives Faster

The greatest advantage of an HIL system is test automation. In place of manual procedures, complex test sequences can be defined, executed, and reproduced as often as desired. Thus, it is easy to validate new versions of the ECU software for errors that were remedied. Simple test routines can be created, combined, and integrated in sequences for the numerous combinations of inputs/outputs and precise operating conditions of the algorithms. The entire control system can be subjected to stress tests in this way. Last but not least, the detailed test reports provide clear information on the maturity status – even at network level. The major benefits for the Outlander project:

- Simple regression tests
- Efficient stress tests on ECU software
- Automated lifetime tests
- Efficient test analysis

The Performance of the dSPACE Virtual Vehicle

The virtual vehicle enables us to validate the quality of the ECU software we develop at a very early stage in the development process. Problematic code can be detected and identified simply and reliably. Our engineers were very quickly familiar with the system and are convinced of its reliability and quality. We particularly appreciate the flexibility of the ASM simulation models, which are easy to extend by models from suppliers – this was very important to us. The test system from dSPACE gives us very great test depth, and we can also reduce the time required for testing. Overall, we have been able to improve quality and even reduce development time.

"The new virtual vehicle based on dSPACE network simulators enables us to test all the ECU functions, including diagnostic functions, reliably and systematically with a single test system."
Kunihiro Sakai, Mitsubishi Motors

Lancer Evolution X and Further Steps at Mitsubishi

The networked simulator we used for the Outlander was flexible enough to simulate other vehicles as well. In particular the HIL system helps us to develop the 6-speed twin clutch "Sport Shift Transmission (SST)" of the all-new Mitsubishi Lancer Evolution X. This is an automated manual transmission that delivers slicker shifting through the gears while freeing the driver from the need to operate the clutch.
In general, to ensure the quality of complex, extensive ECU software in the future, we will continue investing in HIL-based test methods and expand them further. We are convinced that this is an important and necessary step for enhancing the reliability of automotive controls. The dSPACE systems will play a major role in this.

Kunihiro Sakai
Masahiro Kaneda
Mitsubishi Motors, Tokyo, Japan

Web presentation
Lancer Evolution X
http://www.mitsubishi-motors.co.jp/evo/special/index.html

Glossary

Monkey test –
Random activation of switches in arbitrary combinations. Can be compared to the presumed behavior of a monkey sitting in the vehicle.

CVT (Continuously Variable Transmission) –
Allows an infinite variability between highest and lowest gears with no discrete steps or shifts using conical rollers that can be shifted axially.