# ELASIS: Adaptivity Counts

- Testing new ECUs with hardware-in-the-loop simulation
- Complete motor vehicle simulation with networked dSPACE Simulators
- Maximum flexibility for future Fiat projects

ELASIS is a Fiat-owned engineering company, which works mainly for Fiat Auto and on the Fiat-GM Powertrain joint venture (FGP), carrying out research and development on vehicles and powertrains. ELASIS plays a key role in many innovations. Recently, ELASIS went online with a dSPACE Simulator network to test networked electronic control units (ECUs) of new car models. This test environment stands out in terms of flexibility, and is designed for a huge variety of car models. Successful projects already ran with the new Fiat Stilo.

Thorough testing reduces the risk of ECU malfunction. However, many faults are difficult to discover unless tests are performed at integration and system level. At ELASIS, we use a virtual car to run these tests. It is based on dSPACE Simulators and is an excellent tool for improving software quality. The virtual car is designed to find errors and bugs in the software of powertrain, body, and vehicle dynamics ECUs through automatic ECU testing based on user-defined test procedures.

## The Limits of Conventional Tests

Conventional tests on "static" test benches can test the ECUs together with the network management, gateway functionality and CAN physical level. But there are many restrictions. The tests can only be performed manually and are not reproducible. Moreover, there is no automatic test report generation. Worst of all, test coverage is incomplete and CAN communication cannot be checked thoroughly.

So we were understandably looking for a new hardware-in-the-loop (HIL) simulation system to fulfill our requirements:

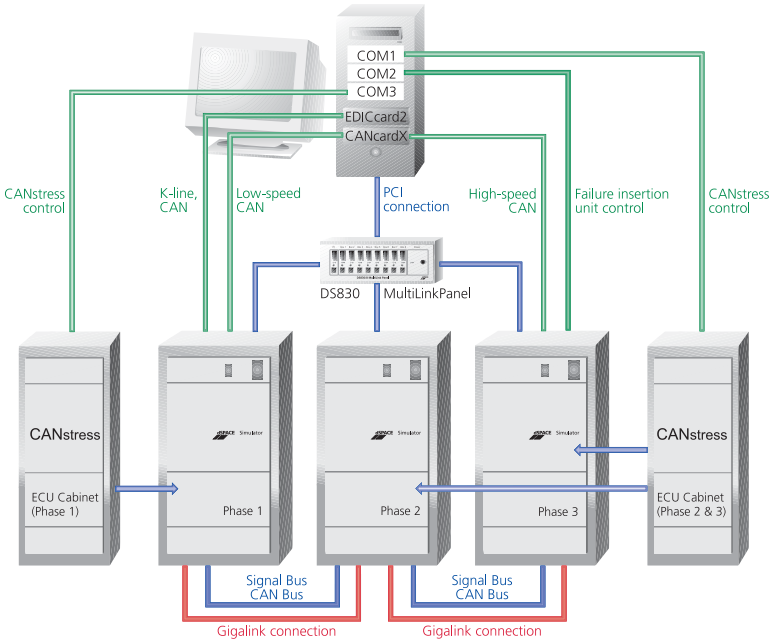
- Read-in of all pertinent ECU power drivers and signal outputs
- Stimulation of all ECU inputs
- Electrical fault insertion capability
- Logging of all CAN messages
- Network management functionality
- Interface to diagnostic serial line, in our case ISO9141
- Flexible and powerful automation software
- Flexible, scalable and reusable hardware
- Behavior like a real car and real-time-capable models (for engine, transmission, vehicle dynamics and parts of body/comfort)

We evaluated several HIL systems available on the market and opted for dSPACE Simulator over other HIL vendors' products, not only because of its technical lead. What was also decisive were successful earlier projects with dSPACE Simulators and good experience with many other dSPACE tools both at ELASIS and in other parts of the FGP group.

▲ *ELASIS' virtual car: The networked simulators are controlled from one central PC.*

## Designed for Many Projects

The philosophy of the virtual car is to cover a wide range of different test types – from unit test, through integration tests, to system tests. Our aim was maximum flexibility and adaptability to as many vehicle models as possible. This is a real challenge. Because the test phase is extremely short nowadays, an HIL system needs to be configurable in a minimum of




▲ *The system setup: Flexibility is crucial for switching to new vehicle versions.*

time, and must then be available 24 hours a day, 7 days a week. Due to the complexity of the electronic systems, many variables have to be controlled and signals have to be acquired with precise timing. This is possible only with test software that automatically drives the simulated vehicle in the states to be tested. Our ELASIS test automation, based on dSPACE software, solves these problems, so that tests require less time and more details can be tested, resulting in broader test coverage and greater test depth. The heart of the virtual car is three 19" cabinets (dSPACE Simulator Full-Size). The cabinets are all similar in construction and contain a real-time processor, I/O boards for discrete signals, signal conditioning, and failure insertion units, plus loads for generating electrical faults. Moreover, components like an A/W bus simulator (gateway to the Fiat A- and W-bus), a dSPACE CAN gateway and CANstress systems from Vector Informatik (for generation of CAN errors) were included.

## Control from One PC

The host PC contains a CANcardX for accessing the B and C CAN bus, and an EDICcard2 system with DTS software from Softing for accessing diagnostic services via K-line. All these tools are controlled by the test automation software; in the future this will be AutomationDesk. The host PC is also used for real-time model development and for running the experiment software. The real-time models were completely specified in MATLAB®/Simulink®. A team consisting of experts from dSPACE, TESIS and ELASIS worked closely together and included models for vehicle dynamics and engine (TESIS), manual automatic transmission (ELASIS) and body (dSPACE). An ACC model was added to the vehicle dynamics model for active cruise control (ACC) simulation, and the MotionDesk software was integrated for 3-D online animation.

## Looking Ahead

We installed the system during the late development stage of the new Fiat Stilo. Our primary goal was to gain experience for upcoming projects, but as it happened, the virtual car already worked well in the Stilo project, with 27 ECUs on three different networks. Since all data is stored systematically, it is now easy to analyze malfunctions by reproducing the failure situation. Moreover, simulating ECUs that are not yet available allows us to execute tests much earlier. In the future, the virtual car will be used from the very beginning of new car projects. As soon as an ECU supplier develops the first version of a new ECU, the virtual car will be updated according to the same specifications. This way, the HIL system and the automatic tests will always be up-to-date, and new ECUs can be tested intensively over a long period of time.

**I/O channels required for testing the Fiat Stilo's ECU network**

- 88 ADC channels
- 99 DAC channels
- 366 digital I/O channels
- 6 resistor simulation channels
- 10 PWM input channels
- 10 PWM output channels
- Special channels for ignition, injection, crankshaft and camshaft signals
- 4 different CAN controllers
- Total number of ECU pins: about 900

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