Fiat Auto – Testing Diagnostics Capability

- **Virtual Vehicle built on ASM Vehicle Dynamics Simulation Package**
- **Simulation results matched measured vehicle dynamics**
- **Being used to test ESP diagnostics**

As complexity continues to explode, vehicle diagnostics are vital. About 30-40% of memory in modern automotive electronic control units (ECUs) is dedicated to diagnostics. After successful evaluation of the Vehicle Dynamics Simulation Package, which is part of the Automotive Simulation Models (ASM), dSPACE's real-time models for hardware-in-the-loop simulation, Fiat Auto decided to use it in a turn-key solution with dSPACE Simulator to test the diagnostic capability of electronic stability programs (ESP).

Diagnostics means that the ECU is capable of detecting faults in the systems it is connected to. These are first of all the communication buses – in our case CAN – and also the wiring, for instance, to the wheel speed sensors. Safety-critical systems like electronic stability programs (ESP) are subject to fail-safe requirements aimed at preventing unwanted operations during critical driving situations. Detected faults can have several consequences:

- Fail-safe strategies are launched in the ECU
- A diagnostic trouble code (DTC) with a time stamp is written to the ECU's error memory
- A warning light tells the driver there is a problem

Diagnostic features are specified by Fiat Auto for vehicle-related functions, and by the ECU supplier for purely ECU-related functions in the ECU.

▼ *Diagnostic capability testing with the ASM Vehicle Dynamics Simulation Package was performed for the ESP controller of the Fiat Ducato.*

Frontloading with HIL

The aim is to implement diagnostic functions early on, in parallel to control function development. Vehicle prototypes are usually rare at that stage, and testing diagnostic capabilities on the road would be very difficult. Moreover, it is quite easy to create conditions such as road features (friction, bumps, etc.) or extreme driving maneuvers in the laboratory, so a frequent way of speeding up the development process is to use virtual vehicles in virtual environments in hardware-in-the-loop (HIL) simulators. Another reason why HIL tests are so useful is test reproducibility, which makes it easy to verify whether problems were really solved.

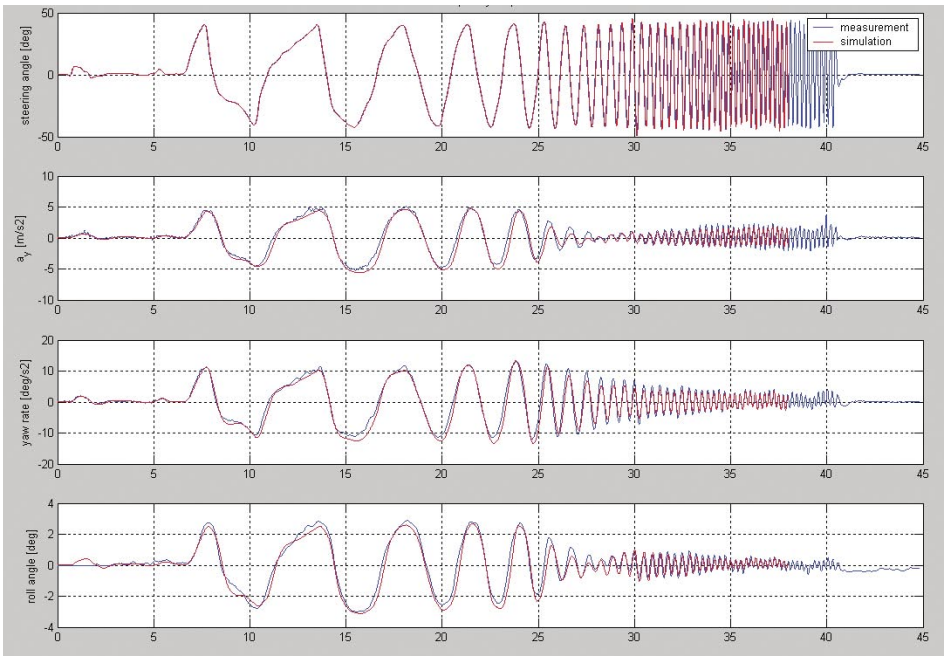
Fail-Safe Analyses

Fail-safe analyses have to be performed during certain vehicle maneuvers to determine the behavior of a safety-critical system in the event of failures. The key to testing diagnostic capability is the ESP system's reaction to CAN test messages. These are basically modified signals that would not be plausible in a certain context. Testing includes checking the plausibility and timing of messages, and electrical failures like wire breaks or short circuits can be simulated.
Precise, real-time simulation of a vehicle's dynamic behavior is required to test all these things properly.

Highly Accurate Test System

In order to get reliable results regarding DTC correctness, we first evaluated the ASM Vehicle Dynamics Simulation Package from dSPACE to check if simulation results matched measured vehicle data.

We drove a prototype of the new Fiat Ducato on our test tracks in Turin and captured vehicle dynamics data. Then we created a virtual test scenario via the Maneuver Editor in ModelDesk, the graphical configuration and parameterization software for the vehicle model. Performing simulations with the properly parameterized vehicle model delivered results that matched the actual vehicle dynamics data very closely. The ASM Vehicle Dynamics Simulation Package is clearly of high quality and well parameterized by dSPACE, as it delivers very precise real-time simulation results.



▲ *Comparison of simulation results with measured vehicle dynamics data during a sinus steering maneuver. The test car was a fully loaded Fiat Ducato (weight 3.5 t).*

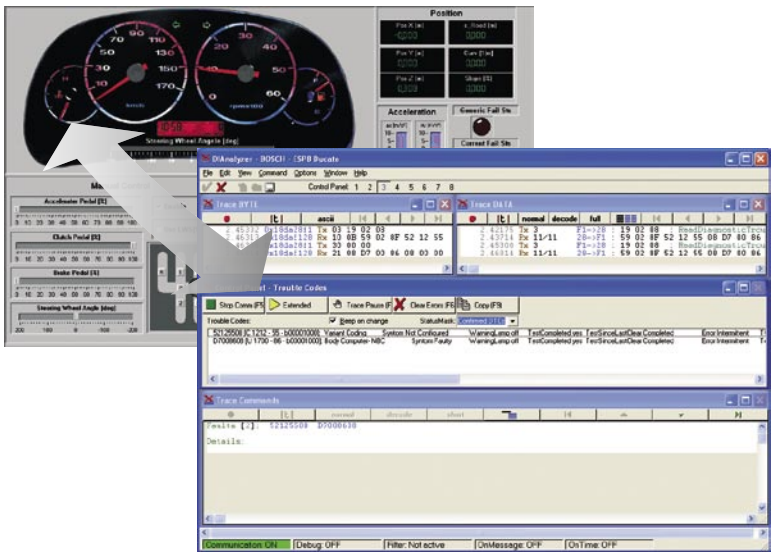
Virtual Test Drives with ASM Vehicle Dynamics

To test the ECU against our requirements specification in early stages of the vehicle's development process, we used a dSPACE Simulator Mid-Size that ran the ASM Vehicle Dynamics Simulation Package. We performed virtual test drives with several maneuvers which we created to simulate driving situations requiring ESP activities, including different lateral and longitudinal accelerations at certain speeds. With the Stimulus Editor in dSPACE's ControlDesk, we created test sequences to insert CAN test messages into the ESP's CAN communication. The driving behavior was visualized with dSPACE's 3-D online animation tool, MotionDesk. If signals are not plausible to the ECU, DTCs are written to the ECU's fault memory together with a time stamp. Thus, DTC correctness can be verified relative to maneuver progress and CAN test messages. Since the same maneuvers and tests can be performed with high reproducibility, we can verify whether faults were solved and reliably validate the diagnostic capability of the ESP system. We have a test automation system based on Python installed, and integrated ControlDesk with DIAnalyzer, the diagnostic tool from Fiat Auto, as a link to the diagnostic bus.

"The simulation results of the ASM Vehicle Dynamics Simulation Package matched the measured vehicle dynamics very closely. We are convinced that the model is of high quality."
Luca Remolif

Achievements and Outlook

So far we successfully used the dSPACE Simulator and the ASM Vehicle Simulation Package to test the ESP systems of the Fiat Ducato. We are satisfied with the system and plan to use it for other ESP controllers as well. An extended test automation shall be implemented. The announced ModelDesk tool automation interface will therefore be very useful for us.



▲ *ControlDesk and DIAnalyzer exchange diagnostic data.*

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