Geely and Volvo are jointly developing the vehicles of tomorrow on their Compact Modular Architecture platform.

Modular Fascination

Modern vehicles have to be safer and make driving more fun, while also being more economical in consumption. Efficiently developing these new vehicles requires the latest simulation methods. For the development of an innovative hybrid drive for a new SUV, Geely and Volvo relied on the SCALEXIO real-time system.

To develop new vehicles more efficiently and launch them on the market faster, Geely and Volvo have jointly designed a new vehicle platform for compact vehicles in the last years: the Compact Modular Architecture (CMA). The two companies also share this platform with the Geely subsidiary Lynk & Co. The company's first vehicle, the Lynk & Co 01, was developed using the platform and has already hit the road. With the CMA, Geely has created a highly versatile vehicle platform that, as a compact basis, allows for a modular design. Only the distance between the center of the front wheels and the pedal box is fixed. Everything else can be configured according to the intended vehicle design, including the drive types. In the coming years, the CMA will serve as a platform for vehicles with classic gasoline and diesel engines as well as for hybrid and all-electric vehicles.

Picture credits: © Lynk&Co

The Ambition: Building the Best Vehicle

For the development of the Lynk & Co 01 SUV, Geely gave the development team only three requirements, but they were nothing short of ambitious:

- They were to design the best vehicle in the entire industry.
- They had to develop a global vehicle.
- They had to take a different approach than the rest of the automotive industry.

As a result, the hybrid version of the Lynk & Co 01 features an innovative drivetrain based on a three-cylinder miller engine and a hybrid seven-speed dual clutch transmission (7DCTH) including an electric motor. A look at the engine management system for the current hybrid engine illustrates the complexity of the task (figure 1). For example, a number of functions had to be integrated into the system, including transmission control and the hybrid power management system. This was the only way to ensure that they would reliably guarantee the required safety and desired comfort at all times, under all operating conditions.

Test System for Powertrain Management

Geely and dSPACE have developed a closed-loop test system to comprehensively test the functions of the engine management system and transmission

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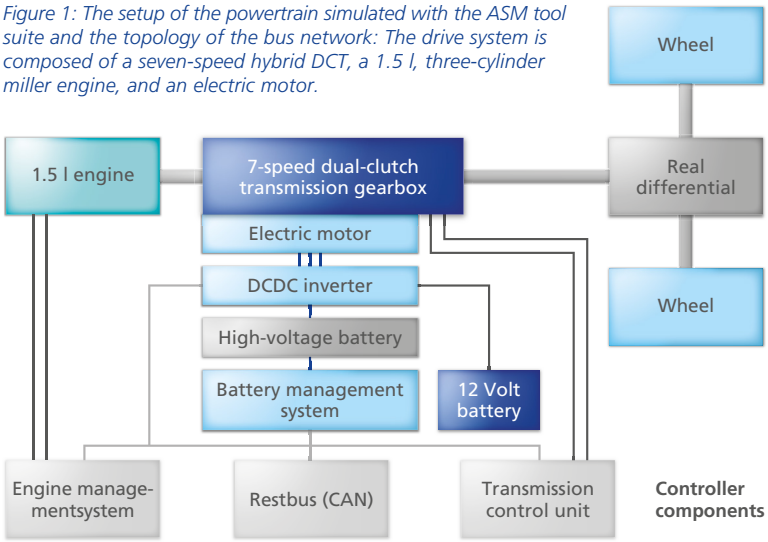
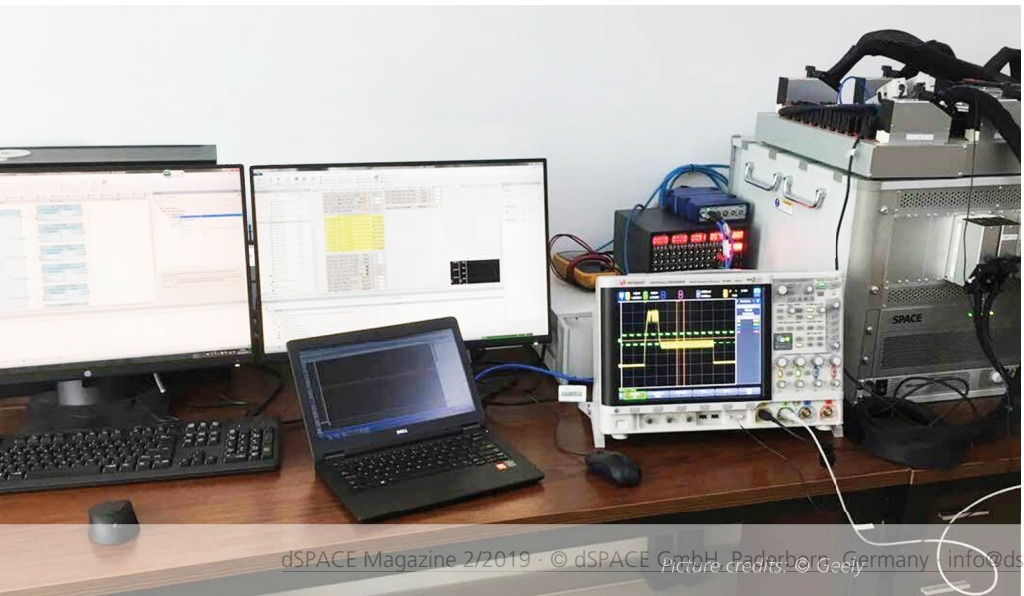
> "With the SCALEXIO real-time platform and the ASM simulation tool suite, we were able to master the challenges of economic efficiency and functionality involved in developing and testing the ECUs for a new hybrid drive."
>
> *Hui Yu, Geely*

Figure 1: The setup of the powertrain simulated with the ASM tool suite and the topology of the bus network: The drive system is composed of a seven-speed hybrid DCT, a 1.5 l, three-cylinder miller engine, and an electric motor.



control. The aim was to test the fast, highly integrated controls of engine and transmission controls reproducibly under dedicated test conditions. For this it was necessary to simulate the engine and motor, the turbocharger, and the seven-speed dual clutch transmission with high precision. Such complex control systems cannot be implemented at a reasonable cost and within a suitable timeframe without specially tuned high-precision simulators. Even the design and parameterization of vehicle models with particularly high accuracy requirements in a hardware-in-the-loop application pose major challenges. In search of a reliable and powerful simulation solution, Geely finally chose the SCALEXIO real-time platform and the Automotive Simulation Models (ASM) tool suite, both from dSPACE. The compact SCALEXIO system has extensive input/output functions and high computing power (figure 2). Specific actuators are integrated in the simulation as real loads.

Figure 2: The dSPACE test bench consists of a SCALEXIO simulator and a drive load box. The compact system has a small footprint. It is easy to operate from the host PC. The signals are measured with an oscilloscope.



Picture credits: © Geely

Open Simulation Models for Added Value

During systemic model design, the team used the advantages of the open Automotive Simulation Models (ASM), such as ASM Gasoline Engine InCylinder, for the engine simulation with operating cycle resolution. The components of an ASM model can easily be supplemented or replaced by customer-specific models. This makes it possible to adapt the model properties to individual projects, while the standardized interfaces of the ASMs simplify model extensions. It was important for all participants to parameterize the model as accurately as possible by using engine test bench measurements to realistically simulate the changes in engine temperature and pressure in the cylinder. A semi-physical simulation of turbocharging was another vital aspect in this project to plausibly simulate the required sensor data and validate the control strategies (figure 3). In addition to simulating the engine, the developers focused on parameterizing the transmission model. The ASM model simulated a complete seven-speed dual clutch transmission, including the hydraulics circuit and mechanical structure. Because the real transmission control unit was not yet available, Geely used the transmission

control unit from ASM to simulate the control logic of the actuator. This enabled them to implement and suitably validate the gear switch requirements of the engine management system.

Central Simulation Control and Data Acquisition

A core component of the simulator system is the experiment software dSPACE ControlDesk. It lets the developers capture, modify and calibrate data online, and replay it offline. The software provides a comprehensive set of tools for setting up a user interface for the experiment that is close to the actual instruments in the real vehicle. In addition, the animation lets users better observe and comprehend the simulated physical processes (figure 4).

Joint Success

To validate the complex management systems of the powertrain in hybrid vehicle variants of the new CMA platform, Geely relies on a simulation solution built with the SCALEXIO simulation platform and the ASM tool suite from dSPACE. The powerful simulator supports engineers both in developing new functions and in their validation. Together, Geely and dSPACE were able to develop precise plant models for the demanding simulation tasks, thereby creating a realistic test environment.

Thanks to the dSPACE technologies and services, the Geely development team was able to implement the hybrid drive. A successful project whose result is already safely roaming the streets in form of the Lynk & Co 01.

Xueying Xu, Hui Yu, Geely

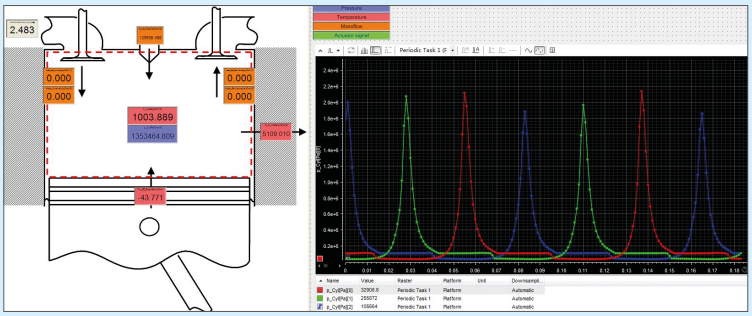


Figure 3: Real-time simulation of the pressure change in the 1.5 l three-cylinder engine with the ASM Gasoline Engine InCylinder Model.

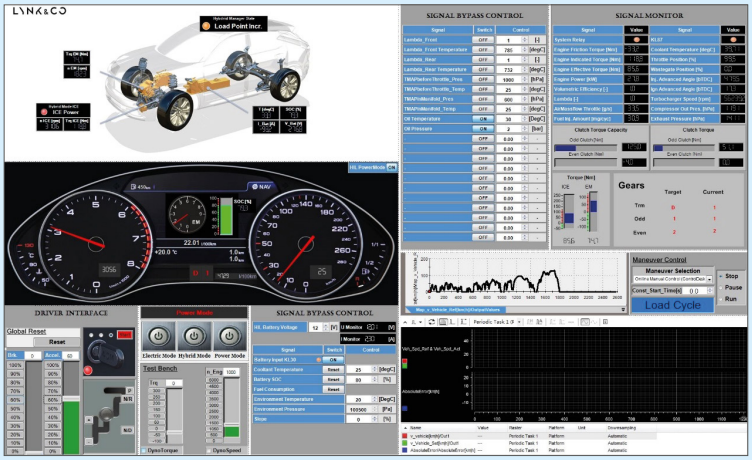


Figure 4: A user-friendly interface was designed using the many instruments of the ControlDesk experiment software, making realistic simulation of all processes very convenient.

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