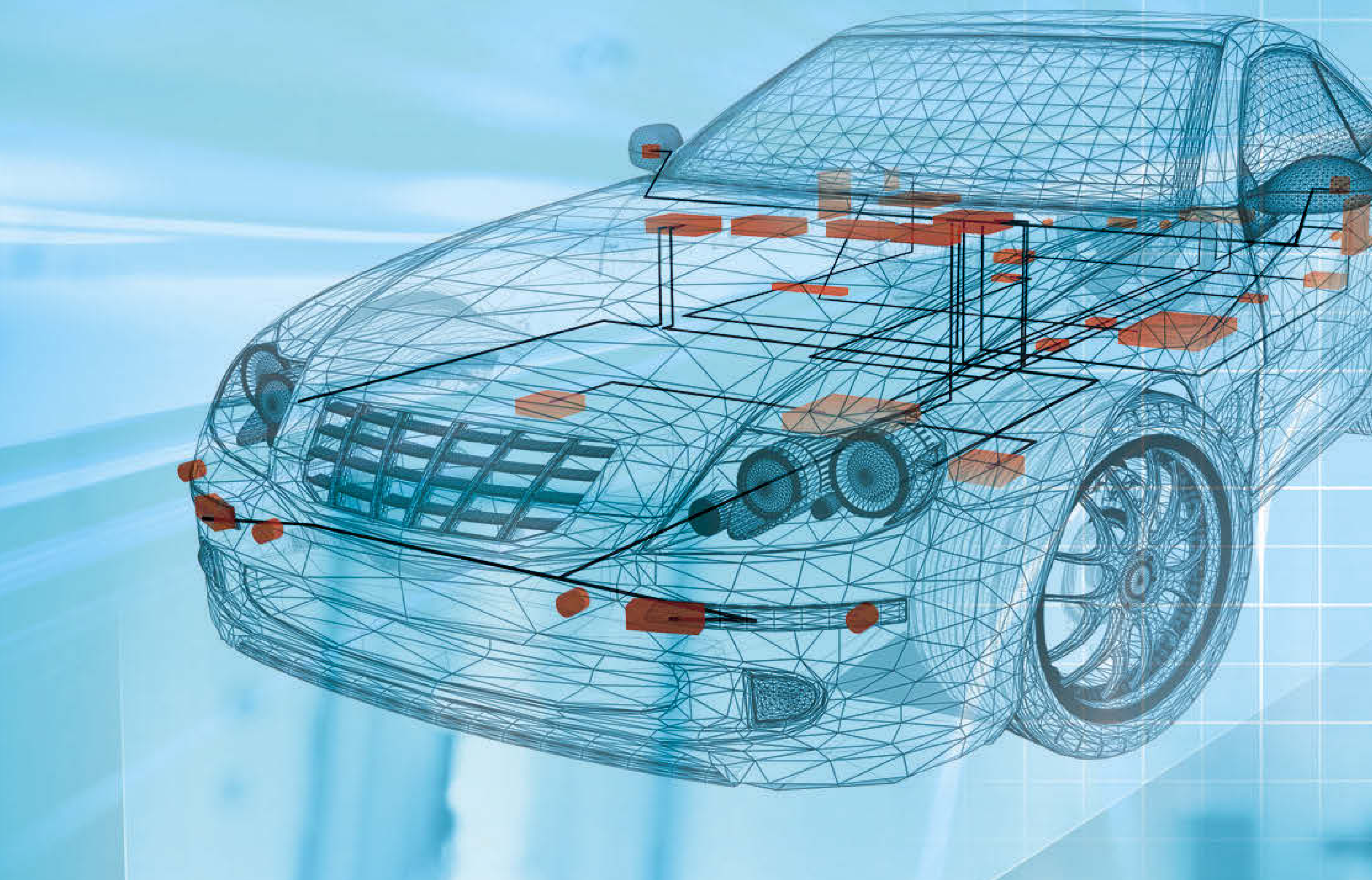
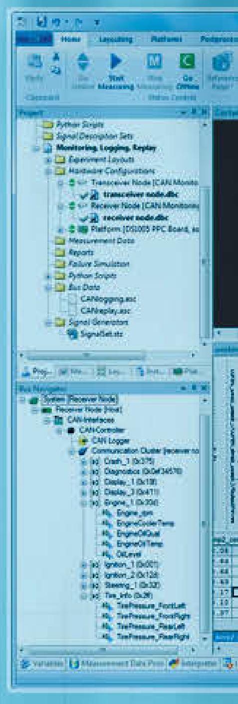
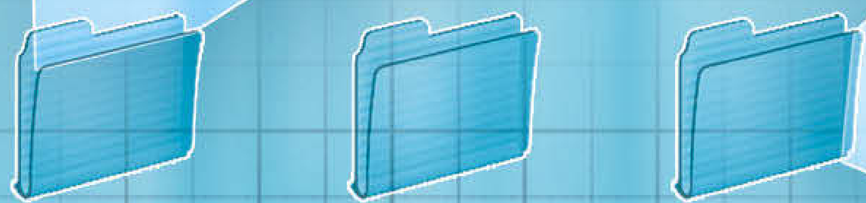


Screen star



As computing power increases, electric vehicle manufacturers are finding virtual prototyping and simulation testing technologies to be the perfect fit for their development programs as they bid to get more EVs to market in less time

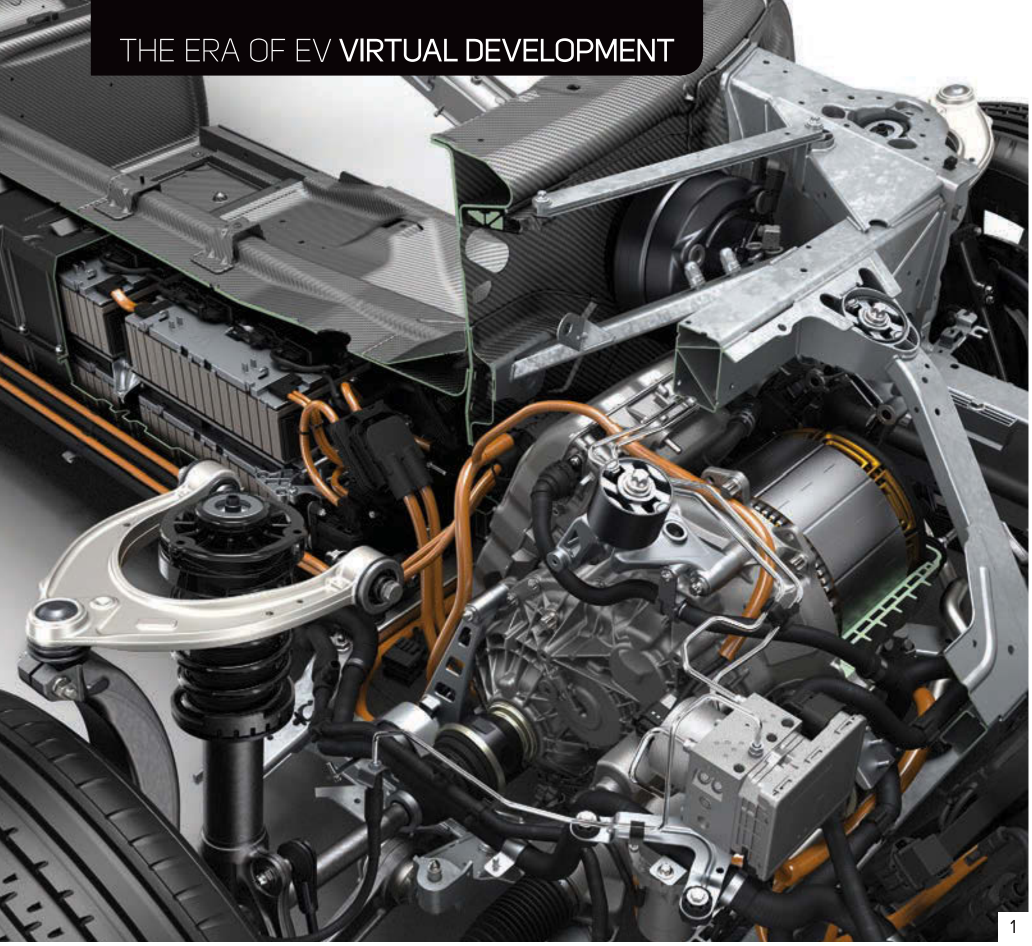
WORDS: **SAUL WORDSWORTH**



"If you talk to any OEM they will agree that powertrain testing will increasingly be done virtually. For many years there has been the dream of eliminating the need for prototype vehicles"

Mike Dempsey, managing director, Claytex

Image: dSPACE



1

It is accepted by nearly all in the automotive industry that the arrival of electric and hybrid vehicle technology – at least in a true, mass-market sense – marks a new paradigm for powertrain engineers. And the fact that battery packs and e-motors have arrived just as advanced and reliable virtual testing techniques and systems are being honed and fully integrated by all R&D departments makes for an incredible opportunity for the next five to 10 years.

"If you look to the future, everyone believes that virtual testing will become an increasingly important part of the electric vehicle design mix," states Steve Hartridge, director of electric and hybrid vehicles at CD-adapco, a leader in CFD-focused solutions. "Competitive pressures are forcing OEMs to come up with new vehicles at a terrifying rate, in particular in their electric and hybrid product lines. The only way the manufacturers will have the confidence to deliver is via virtual testing. The product diversity on offer today undoubtedly means growth in virtual testing."

When it comes to advanced hybrid vehicle development, the first engineering challenge that most OEMs face is assessing and optimizing the interplay between the electric motor, battery pack and the traditional diesel or gasoline IC powerplants. At any time, these three crucial subsystems might be either sourcing or sinking power, and managing this flow can be difficult. As a result, this complex setup requires more and better testing to ensure that the controller behaves as expected in all driving conditions. Similarly, this means that the automation of the test process has a higher value in the development cycle as it can greatly speed up testing. With just a few clicks of the mouse while running a state-of-the-art simulation package, changes in the base control algorithms can be run through a pre-prepared suite of tests, thus ensuring that those alternations have not broken something else in the algorithm.

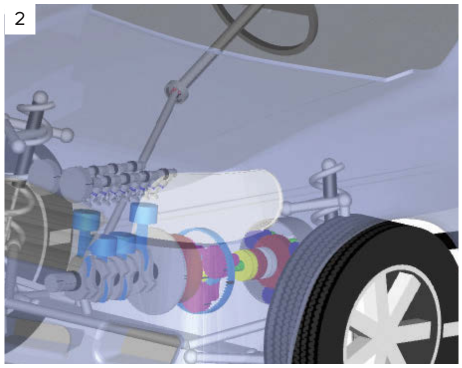
"More fundamental to the power electronics component of the controller test is the fact that the real-time simulations of the inverters and motors connected to the ECU must run incredibly quickly," explains Ben Black, development manager for real-time testing at National Instruments (NI). "The pulse-width modulation (PWM) signals generated by the ECU must be measured at least 100x the base frequency to ensure a numerically accurate simulation. A simulation running 100x faster yields a measurement error of up to 2%, which is barely acceptable. The state of the industry currently falls somewhere in the 8-20kHz range for the PWM frequency, which in turn means that the real-time simulations of the inverter and motor are only barely acceptable at 80-200kHz. The NI solution to this is to shift the simulation from a traditional CPU-based computing node into a field-programmable gate array (FPGA) for computation."

Striving for accuracy

Accuracy in virtual testing should probably be thought of on a continuum that matches up with the complexity of the test. For simple functional assessments of a controller, a very simple model might be enough to validate the basic functionality. However, as the complexity of the test increases, so should the complexity of the model, and the more sophisticated the model, the more realistic the behavior of the e-powertrain component in a simulation package will be, ultimately leading to greater fine-tuning opportunities that can be done in a simulated environment.

"To some extent, modeling is always an approximation of the real world," says Mike Dempsey, managing director of Claytex, a specialist in system engineering that deploys Dassault Systèmes DYMOLA technology. "An experimental test will always give you some variation. People talk about the ideal model accuracy being within 1-2% of a test, but your experimental spread is always at least that. With the models you put together, you need to be able to tailor the level of detail that goes into each of the simulated tasks you're doing. We have very strong concepts for defining an architecture for the system rather than being able to plug in the different levels of detail to all the parts of the powertrain for a particular test."

2



1. Simulation is vital for engineers developing e-powertrains for mass-market applications. Vehicles such as BMW's plug-in hybrid i8 have greatly benefited from advanced virtual testing techniques, which are now becoming an integral part of modern car development

2. Virtual models and the tests run upon them are constantly increasing in complexity. Simulation also allows designers and engineers to tailor the level of detail in a particular model, adapting the virtual system in question according to the nature of the individual application

Simulation allows for a drastic reduction in the time and cost required to undertake a host of physical tests. Manufacturers such as Subaru are utilizing such techniques to simulate scenarios that are virtually impossible to recreate physically. A model to simulate a vehicle accelerating and hitting a patch of ice allowed Subaru to reduce a 2,300-hour validation to just 118 hours

VIRTUAL BENEFITS

Subaru recently cited an example of a test where the car maker's powertrain engineers wanted to simulate a vehicle accelerating and hitting a patch of ice. In this situation, the motor applies power to the ground but the wheels lose traction. As such, the ECU needs to handle the setup cleanly so that the powertrain's rpm levels don't spike. Such a scenario is incredibly difficult to test on the track and physically impossible on a dynamometer, but on a HIL system it can be simulated easily by changing a parameter.

Testing against a simulation enables the engineers to test a huge number of corner cases that are either expensive or impossible to reproduce in a physical test, and it does so in a way that's automated and repeatable. Changes in control code can be quickly validated against the full suite of tests without having to set up any hardware.

"In the case study from Subaru, the engineer very directly voiced the same feedback we have been hearing from all of our customers in this space," says Black at NI. "The HIL system enabled them to produce a better, safer, more economical vehicle more quickly than they would have been able to do with physical tests alone. They estimated that it would take 2,300 hours to complete their validation with physical testing alone, but the HIL system allowed them to complete it in 118 hours. That's nearly 20 times faster."