Quantum leaps

Simulators are fast becoming an indispensable tool in vehicle design and development. ATTI presents some of the latest software and hardware advances in the field

WORDS BY RACHEL EVANS

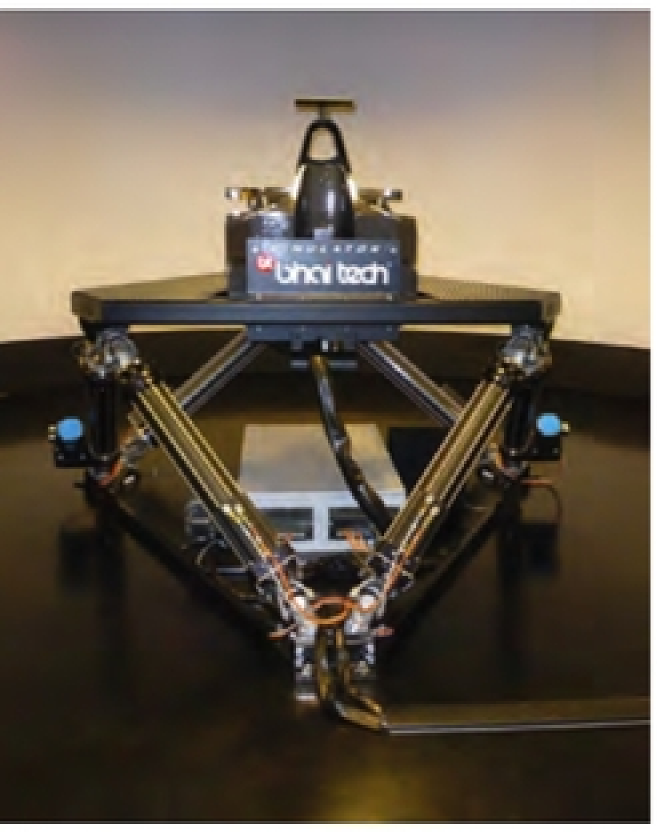
VI-grade's Driver-in-Motion system is currently in use at facilities including Ferrari, Porsche Motorsport, Volvo and Danisi Engineering and is being installed at several other automotive OEMs

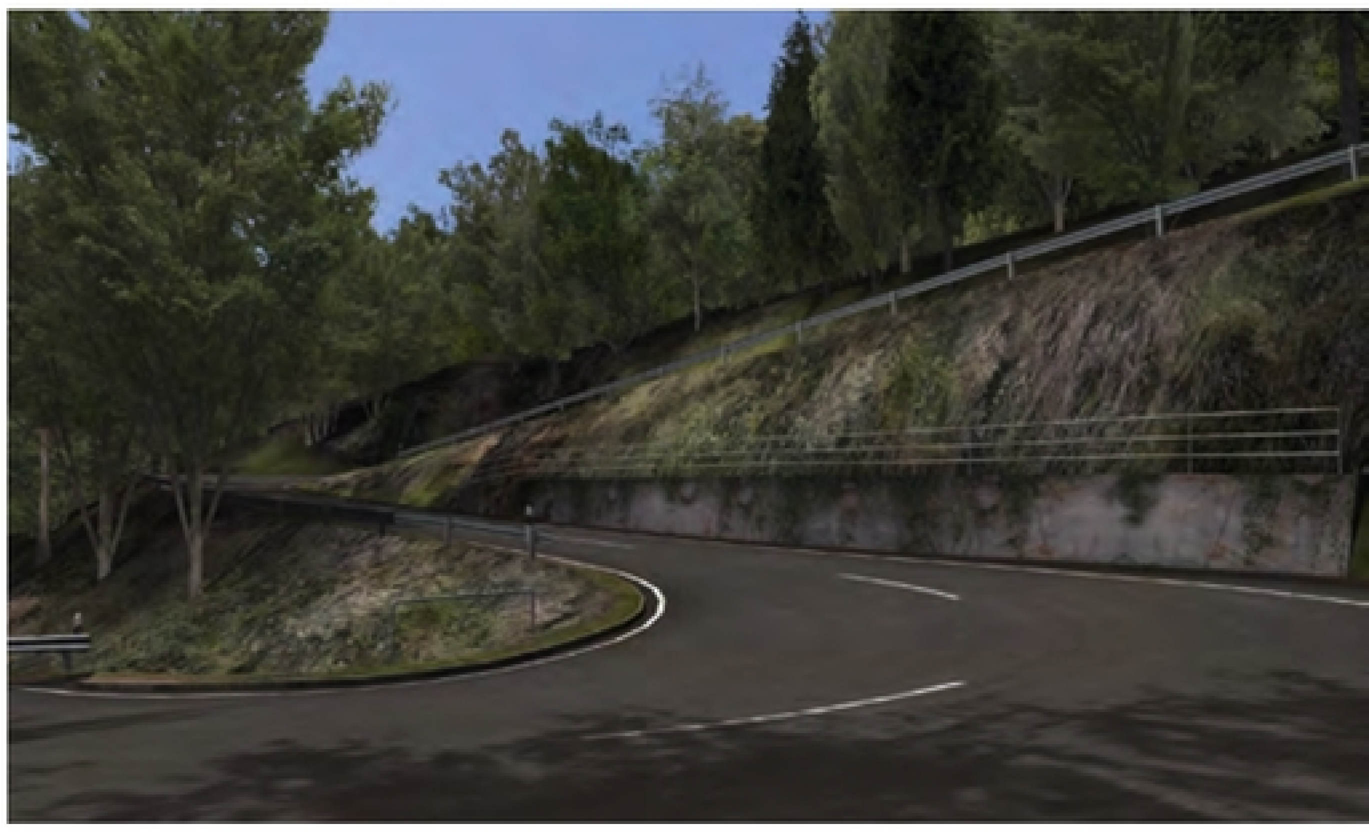
In recent years the need for more testing earlier in a product's development, coupled with the increase in ADAS and autonomous vehicle technology, has fueled the demand for more complex, application-specific driving simulators. There is also a requirement for more detailed road models and incorporation of mechanical hardware-in-the-loop (mHIL) technology. From a supplier standpoint, companies have had to keep pace with both hardware and software advances, which has thrown up a mass of R&D challenges.

In terms of power, the two most computationally demanding components are the physics modeling and graphics rendering, and these will benefit the most from frequent hardware updates. Chris Hoyle, technical director at rFactor Pro (rFpro), a driver-in-the-loop (DIL) simulation supplier, says, "We've seen that GPU [graphics processing unit] hardware is still roughly following Moore's law, meaning the number of transistors in circuits is doubling every two years.

"We therefore encourage customers to upgrade their GPU boards every two years and that enables us to regularly raise the standards in our digital road models. We're able to increase the amount of memory dedicated to images that are being mapped onto models. We're also able to continuously increase the polygon count of our models – the actual detail that goes into the 3D model – and we're able to add more shaders, which helps create realism for specific materials."

Hoyle believes that the push toward more detail and higher quality digital road models won't stop until complete photo reality has been achieved.





Creating digital content for testing ADAS and autonomous systems – which is also requiring more test route miles to be modeled – can be a demanding process. rFpro has invested considerable R&D effort into automating much of this process, and has pushed for improvements in the technology used for scanning road surfaces.

However, a further challenge presents itself: "It's easy to imagine how we create a digital model for humans to look at, but we also have to provide the raw data for the customer's sensor models," explains Hoyle.

"That has meant we've had to add post-processing stages, so it's almost as if we're rendering the scene two or three times now – once to provide that high-definition video for the human driver, and then again to feed the raw data required for the sensor models. For example, feeding depth maps, point clouds or normal maps, created in real time from the same digital road model, as required."

Meanwhile, improvements in CPU performance have also encouraged simulator suppliers to increase the number of cores and achieve higher clock rates.

Martin van Donselaar, vehicle dynamicist and CEO at Cruden, a manufacturer of simulator platforms and software, says, "This has an influence on how we develop, because if the clock rate of the CPU goes up, the performance of our software goes up and we can have more detailed simulations.

"And theoretically, if a new CPU had double the number of cores and therefore double the processing power, we would have to ensure we

ABOVE: A Cruden simulator inside the Bhai Tech facility in Italy. It features a 210°, 8m diameter curved screen and rear view visuals, and five off-board projectors. According to rFpro's Chris Hoyle, higher brightness simulation-quality projectors have enabled a steady uptake of passive stereo, to the extent that a 5+5ch stereo system has almost become entry level

RIGHT: The recently opened Ansible Motion R&D center in Hethel, Norfolk, UK. Housed there is one of the company's Delta series simulators, which will be used as a demonstrator to new customers and for developing new technologies

LEFT AND BELOW: rFpro's graphics rendering software is used by many OEMs in the development of ADAS and autonomous vehicle systems. This has required greater detail and accuracy in the modeling of the scenery, including elements such as gantries and road signs

distribute our computing need across those cores. But parallelizing without introducing delays in the communication between the modules is crucial – it's a fine art splitting up the code so that it can run on multicore systems."

In terms of motion control technology, hardware advances have remained steady, but the software is evolving constantly – so much so that updates are recommended throughout the year. Experts at Cruden recently developed a new approach to motion cueing that combines vehicle side-slip angle and dynamically varying yaw pole. Adding vehicle side-slip angle and dynamically varying yaw pole to existing motion cues is said to overcome the limits of conventional acceleration cues, and is particularly useful when it comes to providing a realistic feel for oversteer and understeer.

Van Donselaar explains further: "Instead of cueing these combined lateral and yaw motions, we cue the side-slip angle of the car, which is a very well-defined signal from the simulation that gives you a perfect feel of slipping round a pole. If the side slip appears in an oversteer situation then the pole of that motion is more toward the front. If you are understeering then the pole moves toward the back. That's not easy to get into the vehicle dynamics simulation and it can be deterministically cued."

Last year Cruden also introduced enhancements to its ePhyse external physics package. With the ePhyse add-on, customers are able to bypass the standard cueing algorithms and command direct platform set points from within the Simulink environment; the motion-base software continues to manage the system's inverse kinematics, workspace and safety aspects. This opens up opportunities for advanced cueing techniques such as model predictive control or prepositioning.

Typically, vehicle component and subsystem testing happen separately and often problematic interactions are not highlighted until later in the design cycle when they become apparent at the prototype stage. DIL simulator testing, coupled with mHIL testing, enables manufacturers to gain insight into these problems far earlier in the vehicle development process.

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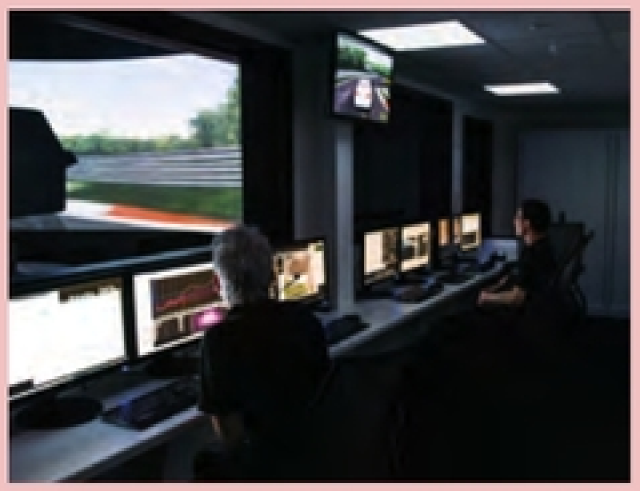
More and more, modern simulators are being designed to also accommodate mHIL technology,

No easy answer

The extent to which simulators can be used to test tires has long been a subject of debate. Ansible Motion's technical liaison, Phil Morse (pictured right), believes the misapplication of tire models has been a large influencing factor in this debate.

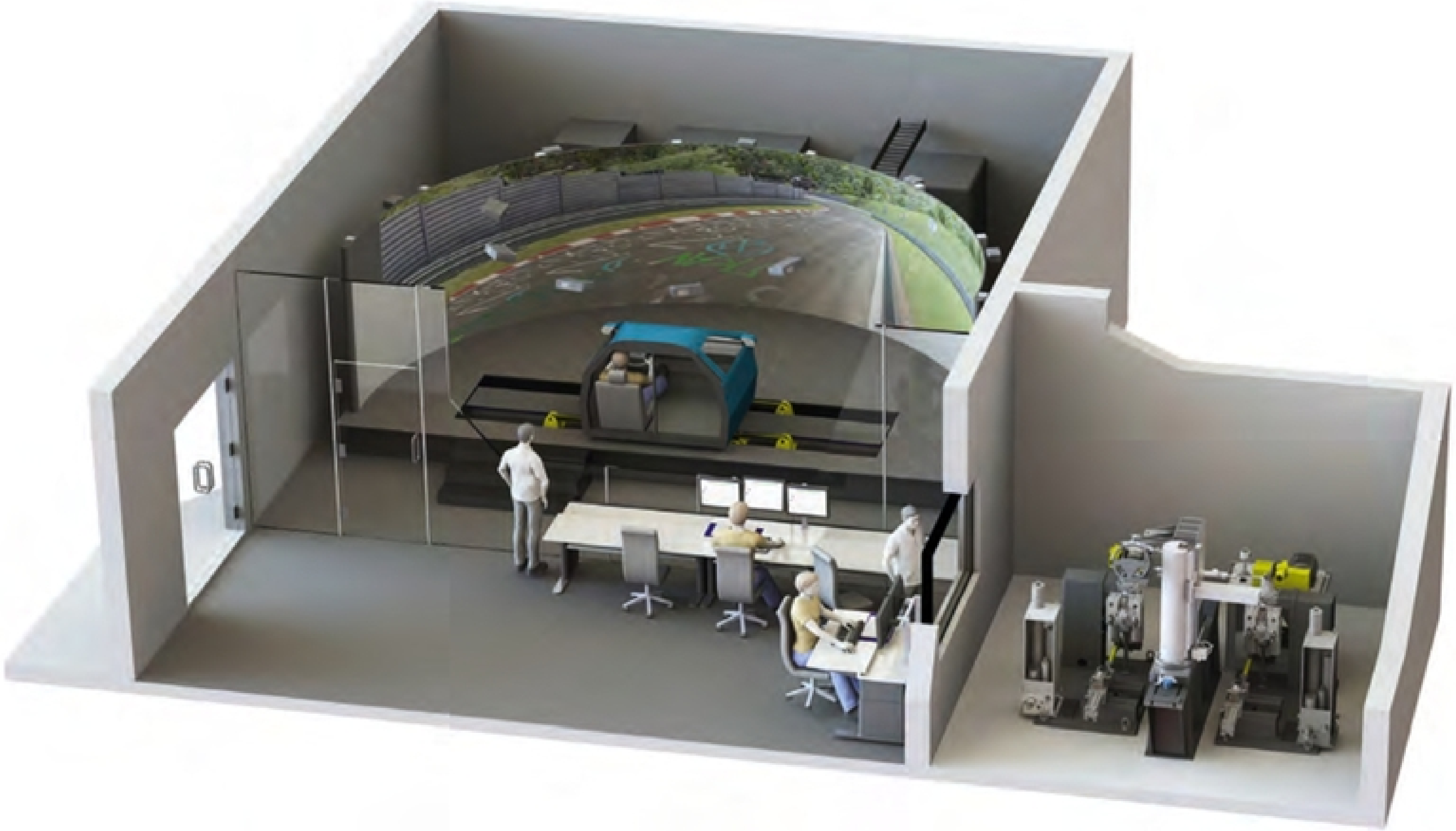


He says, "The type of model used has to fit the experiment being conducted, so if you're interested in steering feeling or EPAS system development, the tire model used and road surface texturing used would be different than if you were interested in limit handling performance around a race track, or in understeer and oversteer behavior.

"Vehicle manufacturers provide limited vehicle models and tire companies provide limited tire models to one another, so it's a co-development process," Morse continues. "Inject into that something like DIL, where you can quickly assess multiple rounds of tires in the simulator – many more than you could in real-world testing – and you instantly have a big advantage."

Simulators can also be beneficial for developing tire models, as MTS's Mark Gillan notes. "Certainly in motorsport, with a high fidelity DIL simulator, your ability to develop the tire model is greatly enhanced. Most F1 teams have very detailed thermal tire models that can predict for thermal degradation, and that's come from tight integration with the track and simulator.

"From an OEM perspective, thermal modeling may be overkill but tire models are still the weak point of any vehicle model," he says. "That's where a DIL simulator can help in giving feedback to the OEM, or the tire maker, to help accelerate the tuning and optimization of their tire models."



LEFT: The MTS VDS and Steering Test System incorporated. The simulator combines an electric dynamic motion platform, lightweight driver chassis, low-latency sensory cueing and adaptable virtual environment featuring rFpro graphics rendering

which enables the real-time integration of vehicle components and systems – including tires, dampers, hybrid powertrains and steering systems – directly into simulations.

"Being able to actually test drive physical components early on in the design cycle is the future and where we'll see maximum benefits in simulator usage," comments Professor Mark Gillan, director of the motorsports technology group at MTS Systems, a supplier of test systems and industrial position sensors.

The concept is fairly straightforward, however executing it with accuracy and repeatability has posed several challenges. MTS is currently in the process of building a state-of-the-art vehicle dynamics simulator (VDS), the design of which will enable mHIL technology – for example MTS's Steering Test System rig – to be easily incorporated. The VDS is developed in conjunction with McLaren Applied Technologies and rFpro.

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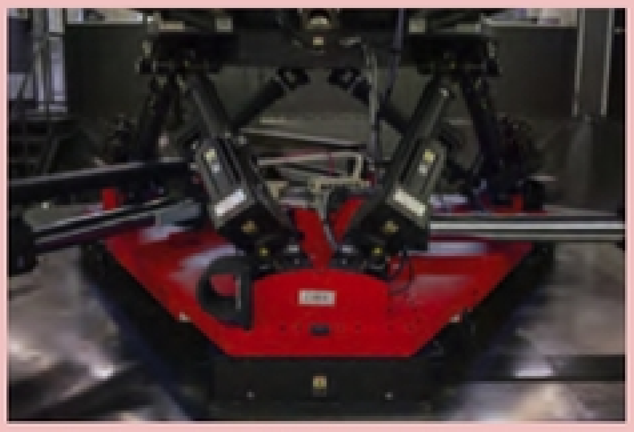
"We're finding mHIL particularly useful for optimizing steering systems. You don't want to get to the prototype stage and find that the steering feel isn't right, which we see with the steer-by-wire systems," Gillan notes. "It's a real steering system with real-time communications coupled to the simulator. And it doesn't have to be located at the test site; it can be in a different building."

Center of attention

To improve the response and behavior of its systems, VI-grade recently set up the VI-SimCenter at its facility in Udine, Italy. The 450m² center includes a driving simulation room, control room, workshop for cockpit preparation and customer debriefing room.

"The center enables us to develop specific features," says Diego Minen, technical manager. "We are now working a lot on traffic simulation and ADAS scenarios. It also enables us to invite both existing and potential customers to come and directly test the simulator's functionalities and dynamic performance capabilities."



Housed inside the VI-SimCenter is one of the company's Driver-in-Motion (DiM) dynamic simulators (*pictured*) alongside a static simulator. DiM is driven by a real-time Concurrent Linux PC, which is also used to run the real-time vehicle model. Several Windows PCs are responsible for image generation, while graphic rendering relies on a Barco projection system. A highly advanced sound system and eye-tracking equipment are also installed.

"The greatest difference between the previous DiM and other commercially available simulators," explains Minen, "is the presence of nine degrees of freedom, which enables us to decouple the low frequency from the mid-to-high frequency behavior while having a very stiff machine with very low latency."

Since its opening in April 2015 the VI-SimCenter has been visited by more than 10 automotive OEMs and motorsport teams.

According to Minen, the company is also working with tire companies to develop tire models for real-time applications in the simulator. "We are developing an active belt system to improve the driving experience, and we are always working to increase the accuracy and the realism of our real-time vehicle models," Minen adds.

Elsewhere, simulation specialist VI-grade recently established a partnership with Danisi Engineering to provide vehicle test and development services to the automotive industry. As part of this, VI-grade is installing a VI-DriveSim static simulator at Danisi's headquarters in Nichelino, Italy, which will be combined with an EPS-assisted steering rack.

"The ultimate goal is to more accurately reproduce steering feedback to the driver by including physical HIL of complicated and difficult-to-obtain software models," says Giacomo Danisi, owner and CEO, Danisi Engineering.

"Thanks to this combined technology, we will be able to perform a set of maneuvers encompassing different driving conditions, matching the results of dynamic simulations with measured data and therefore building a reliable specification framework."

VI-grade's technical manager, Diego Minen, adds, "Steering design, setup and optimization is important for dynamic characterization of a vehicle and for the general feeling of the car. The new test rig will provide a more realistic steering feel especially for on-center handling behavior studies."

The system is being designed by Danisi and will represent an upgrade of the static simulator currently installed on the premises. "The main difference is that in the standard static simulation provided by VI-grade, the calculated steering torque values through the solution of the real-time vehicle model are directly applied to the steering column.

"In the enhanced test rig the simulator will feature a real, complete steering system including column and rack, with all damping and friction effects," explains Minen. ❮