TOP SPEED

Getting vehicle dynamics right is an engineering specialisation all of its own. Brian Tinham talks to one of the best known simulation specialists about how to get from concept to reality faster

For the first time, a commercial vehicle manufacturer has been able to simulate vehicle dynamics in real time – and with sufficient realism – to massively speed up testing of chassis control, handling and safety systems, using a human driver. It happened earlier this year in Spain, when Hyundai commissioned a team from vehicle dynamics and engineering consultancy Applus Idiada, using simulation software from British specialist rFpro to deliver the virtual environment.

Idiada's chassis development and vehicle dynamics simulation manager Guido Tosolin says his team was able to evaluate some 25 vehicle configurations using three professional drivers within just 10 days. "More importantly, because of the high fidelity visual cueing, using rFpro, driver immersion was very convincing. That led to good correlation between their subjective ratings and the objective data."

So what's this about? Chris Hoyle, technical director at rFpro, explains that previous simulators were too slow, so their use was restricted to studies around human factors and ergonomics – certainly not chassis development.

MASSIVE ACCELERATION

His organisation has its roots in Formula 1. Back in 2007, rFpro started developing simulation software to "wrap around" F1 car mathematical models. The goal was to massively accelerate the teams' ability to test chassis and body developments aimed at improving, for example, aerodynamics or tyre adhesion – by doing so in the virtual world.

Early success saw rFpro being adopted not only within F1, but also most of the NASCAR community and the high-budget sports car teams competing at the likes of Le Mans. So, what to do next? "We could either remain a small specialist serving the top 18 motorsport organisations, or grow and address the wider automotive market," says Hoyle. "So we decided to dip our toes in that side – and very quickly discovered just how different this world is."

The result was a two-year development project, during which rFpro tuned its modelling and simulation software to handle a much wider range of parameters. Hoyle cites everything from primary and secondary ride to NVH (noise, vibration and harshness), stability control, ABS braking and ADAS (advanced driver assistance systems).

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your axles, you affect the longitudinal balance of the vehicle, especially during manoeuvres. More conventionally, with drivetrain controls, designers need to go through longitudinal compliance evaluation. So there's far more to consider when you're simulating road-based chassis."

But by 2012 that job was done, and since then rFpro has been adopted by most top car OEMs – but not truck manufacturers. Until Hyundai.

DRIVER IN THE LOOP

"Idiada had been commissioned by Hyundai to design the complete chassis and suspension systems for a commercial vehicle range. Using our software, they were able to take advantage of 'driver in the loop' simulation to accelerate testing. Instead of spending weeks at a proving ground, they spent days at a full-scale driving simulator facility. They plugged Hyundai's CarSim models into our virtual vehicle dynamics proving ground and, for the first time ever, recorded sufficient test data to apply statistical methods. And that was with 25 virtual permutations of the chassis – around kinematics, springs, dampers, anti-roll bars, etc – and three drivers."

Hoyle explains that, unlike with conventional testing – where real chassis have to be removed from the track and modified between tests – there was no downtime. "We just warn the drivers that we're switching between chassis controls when they're on the straight, and they carry on driving."

In fact, Idiada's simulation exercise took place at the eight-degrees-of-freedom Sim IV platform, housed at the Swedish National Road and Transport Research Institute, using a lightweight cab matching the new vehicle (see panel). "Our software is based on closing the loop as quickly as possible by providing very high bandwidth video and audio feeds to the driver, and high bandwidth road surface detail to the vehicle model," explains Hoyle. "This provides the realism necessary to achieve good correlation between driver perceptions and actual changes to the vehicle dynamics." (See images.)

So, what about developments at the heavy-duty truck OEMs? Hoyle believes there's no reason why they

Simulator scene

Despite the fact that trucks weigh in at several thousand kilograms, a simulator cabin must be as light as possible. Yes, the builder will accurately replicate sightlines, driver position and the controls but that's as far as it goes. "Remember that drivers will be sitting on a simulator machine, and we need to transmit as wide a frequency response as possible so they feel what's happening," explains rFpro technical director Chris Hoyle (below).

"Gross manoeuvres involving, for example, braking ahead of roundabouts, are low frequency events. But as drivers initiate lane changes, the response moves up from 1Hz to maybe 5Hz," he continues. "Then secondary ride characteristics, as the vehicle experiences potholes for example, are in the 50–70Hz range. So the simulated cabin has got to be nothing more than a few hundred kilograms."

Beyond that, simulators themselves are typically surrounded by semi-circular, cylindrical projection screens. Drivers wear stereo glasses to enhance the realism as different scenarios are projected on to the screen. That is particularly important in low-speed manoeuvring and urban situations where achieving full immersion is optically more challenging.

As for movement itself, because there can be no sustained g forces in a simulator – so no velocity – the main queues are acceleration, deceleration, lateral roll, yaw and the ride inputs. "So drivers will feel the jerk effect of depressing the accelerator, and the same again as the simulated vehicle moves up through the gears. But, with the high-definition visual and audio surround, that is enough to achieve near perfect realism."

can't take advantage, too. "Human drivers can affect dynamics in any vehicle, so you need to include them in your development process." That may be around how ADAS safety systems function in 'real' emergency situations. Or it may be about understanding the impact on drivers of heavy-duty hybrid or electric vehicles with drivetrains and suspension re-engineered to allow for the lower centre of gravity.

"Allowing people to get involved in simulated testing of expensive vehicles two or three years before a prototype is even available can shave huge costs and time off a project. The quality of major design decisions in the early stages of a new vehicle programme can be greatly improved by supplementing engineering data with subjective human 'feel'. Using a driving simulator allows vehicle manufacturers to pull forward this activity, even though no physical prototypes exist." TE