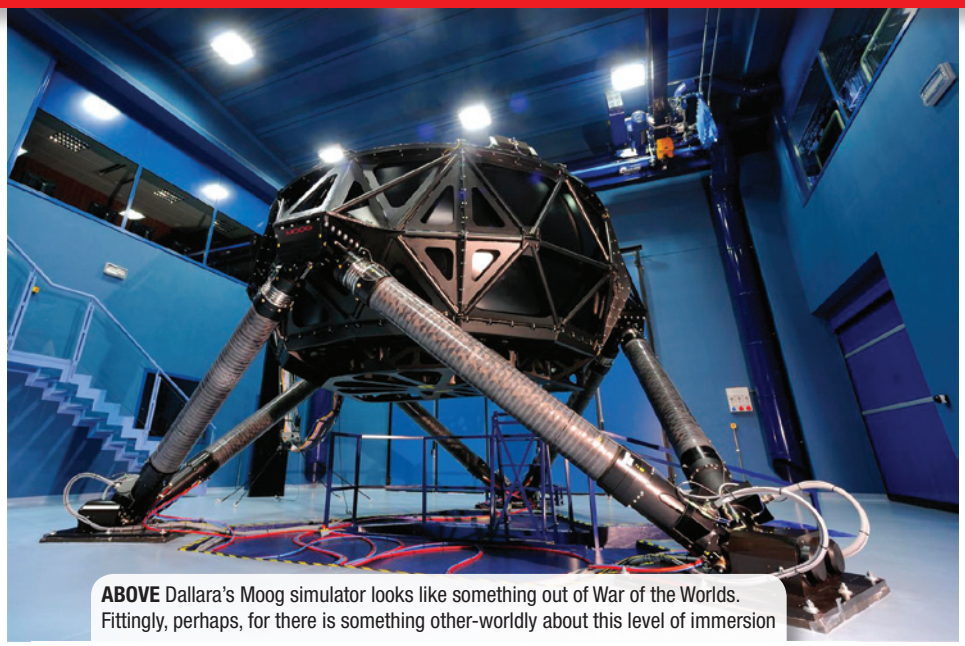


ABOVE Dallara's Moog simulator looks like something out of War of the Worlds. Fittingly, perhaps, for there is something other-worldly about this level of immersion

THE REALITY OF SIMULATION

Alan Stoddart finds the benefits of simulation stretching from the dentist's chair to the Dunlop bridge at Le Mans

MOTORSPORT is not usually the first thing that pops into the head while sitting in the dentist's chair, given that there are plenty of other things that tend to preoccupy the mind. For those of strong resolve however, it may be a particularly prudent time to ponder one of the ways Moog helps train future dentists.

The trainee dentists don a pair of glasses through which they are able to see a three-dimensional mouth which is entirely virtual: there is nothing physically there. They then use tools on ligaments to perform procedures on teeth that don't really exist.

What is remarkable about this however is that the tools actually provide haptic feedback to let the trainee dentist know precisely what he or she is doing. As it would if drilling a real tooth, the tools feel different depending on what layer of the tooth is being drilled, and actually give the trainees feedback through the fingers allowing them to be better prepared for when they are actually let loose on a mouth that exists.

The principles and techniques which achieve the immersion and transferable experience for dentists are the same as those used by Moog to convince drivers using one of the company's simulators that they are driving a real racing car. When the driver is in the simulator it is imperative that the controls feel authentic. This is similarly achieved by the clever use of force feedback and haptic feedback, but instead of behaving differently because of differing hardnesses of tooth enamel, the steering reacts according to other environmental factors. As in a real car, the steering weights up under fast, high downforce corners, it lightens as the simulator driver summits a simulated crest and the front axle unweights, and tugs and rhythmically thrums as the driver roughly monsters a kerb before washing wide and kissing the rumble strip at the track's edge.

Importantly, this means the driver can practice driving an unfamiliar car or an experimental setup using real granular feedback to know what the car is doing, and how it is responding to his inputs without just relying on visuals, exactly as he would do in a real car. It is even able to replicate dynamic aspects of the feel of a car, such as changes in the tyres' traction as they wear or change temperatures. This fidelity through the wheel is complemented by Moog's 6-dof Hexapod Motion Bases, which subject the driver's whole body to realistic forces. This however presents more of a problem than sending forces through the steering wheel.

The steering wheel in a simulator can have both the same range of movement and the same level of torque as a real racing car's steering wheel. However, the simulator platform itself obviously cannot reproduce the sustained full level of acceleration experienced by the driver in real life. In order to address this limitation, Moog has had to rely on some innovative techniques.

"It is impossible to reproduce the exact acceleration forces that the driver would experience negotiating a real-life race circuit. However, the simulator's motion system can give the driver an illusion of high levels of sustained acceleration and this technique is called motion cueing," explains Moog Industrial Solutions' business development manager Rick Steele.

"The difficulty with reproducing actual movements is that the sensation of sustained acceleration is limited by the working stroke of the motion system, so we have to resort to other techniques to fool the driver's senses."

THE SPELL OF IMMERSION

The motion system can be used to reproduce short duration acceleration directly on the driver. For a more sustained feel of acceleration, a technique called G tilting is used. This effectively uses the tilt of a platform to simulate directional force. If for example the platform tilts backwards, it puts more weight on the driver's back, and combined with visual cues, convincingly implies acceleration. One of the techniques used to maintain this illusion is called washout. This is bringing the simulator back to a neutral position at a low enough speed that the driver does not perceive the movement.

In a simulator, when the circuit is known, it is expected that the simulated car completing laps will require the same

> *"The experience may be simulated, but the benefits on race day are a reality"*

ABOVE The Ferrari F1 team ranks among the company's high profile customers

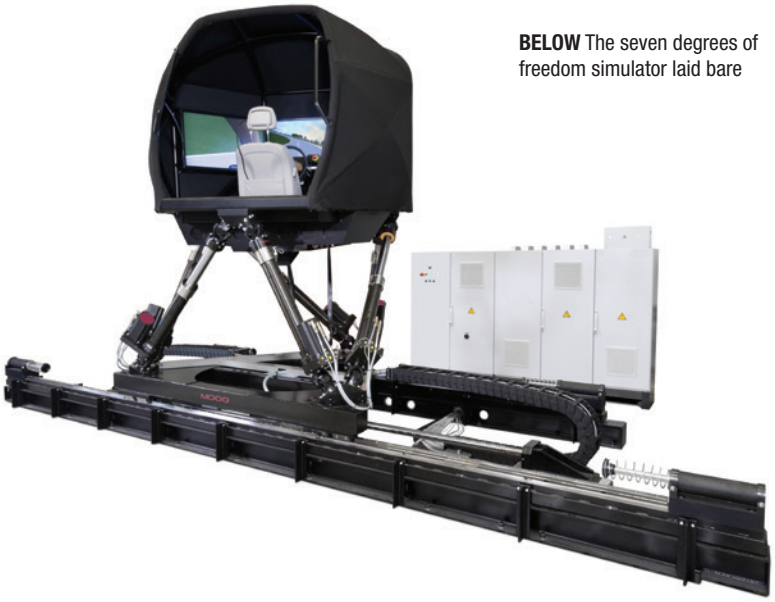
movements to convey the movement of the car lap after lap. In other words, the driver performs predictably. This is called pre-positioning.

Since the simulator can predict the direction of the next manoeuvre, it can be positioned at one extreme movement to allow extended accurate cueing. For example, if there is a long left-hander coming up, the Motion Base can be pre-programmed to move slowly to the right so the movement is imperceptible to the driver to avoid breaking the spell of the immersion. From this position on the right, the simulator can move twice as far left as it would have been able to if it had returned to the neutral position, which is much more effective in simulating a sustained force.

"It's all about the fidelity," adds Steele. "You hear the term driving by the seat of your pants, and that's because you are sensitive to what is happening to you, and we have to fool the brain."

This ability to maximise immersion for any given size of installation means that Moog has won some high-profile customers such as the Ferrari F1 team, Dallara and Mercedes Automotive. Such is the accuracy and fast response of the simulator that it can be used to develop vehicle dynamics as well as for driver training. In order to do this, the simulator can be programmed to reflect the detailed characteristics of the vehicle being driven, with the accuracy of the simulation such that Ferrari, for example, is able to assess improvements to its F1 cars long before they ever see action on the track, while drivers are also able to hone in on ideal setups, and refine race strategies without leaving their headquarters. The experience itself may be simulated, but the benefits on race day are no doubt a reality.

One of the recent demonstrations of the value of this technology comes via Base Performance Simulators at Banbury, which is owned by Aston Martin Racing's Darren Turner who was part of the team that clinched the win in the GTE Pro class at 2017's Le Mans 24 Hours. His training was partially undertaken on a Moog installation. The authenticity of the simulator meant that Turner, like the other drivers that use the Moog system at Base Performance and elsewhere, was able to endlessly hone his skills and test the limits of the car safely, cheaply and repeatedly, with the benefits of an accurately simulated experience becoming an ever more valuable reality for exhausted drivers navigating the Porsche Curves at 130 mph in the heat of a race. RT



BELOW The seven degrees of freedom simulator laid bare