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FEATURE

Using composites to build a better driving simulator

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The use of composites is benefiting automotive R&D, even in the digital domain.

The benefits of composite materials are now widely appreciated in the automotive industry. From city cars to Indy 500 race cars, the unique blend of low weight and high stiffness offered by carbon fiber reinforced polymers (CFRP) and other composites has led to a surge in their use over recent years. But one company is taking this a step further, looking at how the innovative use of materials can enable virtual sign-offs in the digital domain as well.

Developing cars

The life cycle of a car starts long before its release and before it hits the road. The road to market can be a very long one. Development and testing to maturity involves many complicated and time-consuming processes. Car manufacturers and race teams test their cars at company owned proving grounds or test tracks where roads have been designed to replicate real-world conditions. Cars are shipped all over the world to be driven in extreme conditions like the jungles of Brazil or the mountains of New Zealand. If a manufacturer misses the cold weather testing in Europe, cars and entourage are shipped or flown to New Zealand to complete the testing process.

Rise of simulation

Ansible Motion, based just down the road from Lotus Cars in Norfolk, England, designs and builds Driver-in-the-Loop (DIL) simulators that are used by automotive constructors. Founded in 2009, Ansible Motion designs and builds 'Driver-in-the-Loop' simulators that are increasingly used by vehicle manufacturers and motorsport engineers to develop and test vehicles in a virtual world. Ansible Motion focuses on 'engineering-class' simulators that are so advanced they can be used to validate road car safety vehicle systems, sign off vehicle settings and predict how a car will perform before actually creating a physical or real car.

Better than the real world

Done properly, DIL simulation can actually offer a variety of benefits over physical testing of prototype vehicles. However, its effectiveness hinges entirely on a simulator's ability to realistically engage a human driver. That's harder than it sounds, and one of the biggest issues is getting motion systems to be responsive enough to convince a driver that real steering, brake, and throttle inputs are controlling the ''virtual car'' (Fig. 1).

Historically, driving simulators have tended to take their inspiration from those used in the aircraft industries. That provides a ready source of parts and technologies, but the problem is that the range and speed of motion is considerably different for airplanes

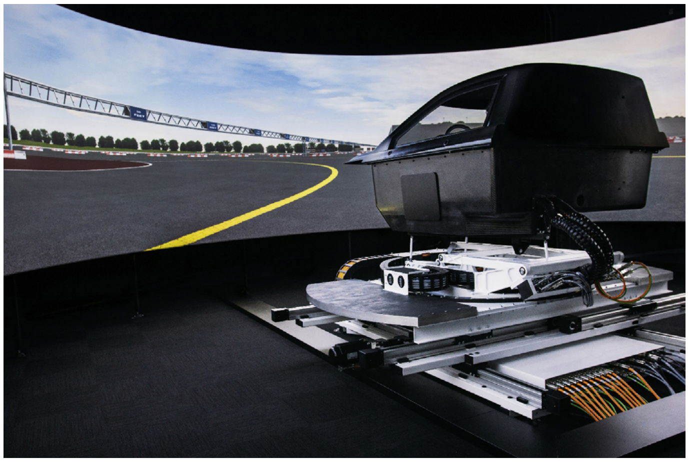

FIGURE 1

Ansible Motion's Driver in the Loop simulator has embraced the use of composites to enhance the value of simulation to automotive developers.

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FIGURE 2
Ansible Motion has created an environment that gives a realistic feeling of being in the car, using composites to replace bulky original items.

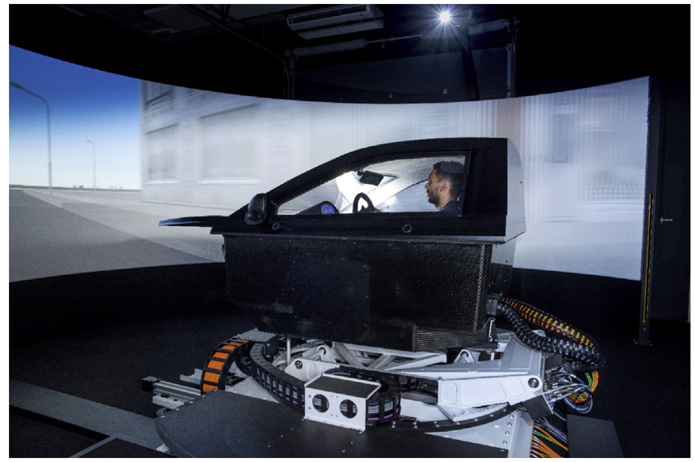

FIGURE 3
The lightweight body enables the sim to remove as much mass as possible.

and cars. Surprisingly, even a high-performance jet aircraft is not nearly as directionally responsive as a mundane family saloon. Consequently, the weight, stiffness and inertia of a ground vehicle driving simulator become even more critical.

Ansible Motion's response was to go back to the drawing board. Instead of using a traditional hexapod motion system derived from aircraft simulation, the company uses an industry-unique 'stratiform' motion system coupled with a control scheme that is cleverly catered to ground vehicles. Ansible Motion's stratiform uses a base X–Y stage that provides lateral and longitudinal movements, while the upper stages generate the yaw, pitch, roll and Z-plane 'bounce' motions. This results in a much lower center of gravity than a hexapod, which means the forces that the actuators have to react to and control are much smaller – and much more direct. In addition, this reduces inertia and unwanted compliance, helping the simulator to react faster and more precisely to the physics demands that are generated by computational models of rolling tires (Fig. 2).

Creating a realistic environment

An equally fundamental question was how to create an appropriate driving environment for a driver, a realistic cabin that gives the impression of a real car. Some automobile manufacturers have looked at mounting complete cars, or cutaway sections with the key cockpit components, on top of motion platforms. At first glance this would appear to be the most logical option, explains Kia Cammaerts, technical director of Ansible Motion: ''There is no question that driving environment immersion details are an important aspect of DIL simulators. It has to look and feel right to create the illusion that you're actually there. And in static simulators – designed for things like human factors research – a real vehicle or cut-away often works very well. In dynamic DIL simulators, however, use of real vehicle components becomes a bit more challenging since they can be quite heavy.''

From a motion system's perspective, a driving environment is simply a ''payload,'' so it becomes wise to place some practical mass and inertia limits on any DIL simulator's driving environment, he points out: ''From a holistic perspective, one might even assert that a lightweight, bespoke cabin structure bounded by a set of specific design constraints would best serve the cause. This is, in fact, exactly the approach we prefer to take at Ansible Motion'' (Fig. 3).

There's also a packaging aspect to consider. Using a real bodyshell would mean that the original parts for that specific car would all fit, but the downside is that new or revised parts would not necessarily do so. What's more, a significant number of electromechanical devices have to be added to a simulator's cabin to provide the driver with feedback – and these are systems that would not be in placer in a real car. These can include force feedback systems for the steering wheel and pedals, high frequency haptic devices to send roadway disturbance content through the structure, and driver-loading systems that apply force to things like the seat belts. Many of these systems are of significant size and weight, hence a bespoke cabin environment that is less massive than that of a real car becomes a more logical solution.

The aim is still to retain the driver's actual contact elements as much as possible, Cammaerts explains, but almost everything else gets a design review, aimed at mass reduction. This has prompted Ansible Motion to think very carefully about its material choices, pinpointing areas where emulated cabin mass can be removed.

Materials make the difference

''Most materials can be made to work in most situations; it is not a certainty that more exotic and expensive materials are the best solution,'' comments Bob Stevens, chief designer at Ansible Motion, and the man behind the mechanical design of the simulator's motion system architecture. ''Depending on the application, we have made use of both conventional engineering materials as well as carbon reinforced composites. The payload for our simulators has been evolving all the time. We have considered many materials, and have used several different construction methods'' (Fig. 4).

Ansible Motion is a company borne out of motorsport. Stevens, along with several of his designers, has a background in Formula 1 racing, so he's no stranger to the use of composites. They're not always the best option, however.

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