"When you pitch down on the front, downforce on the front increases, which upsets the balance at the rear. It was important for us to support the front, which is why we've increased the anti-dive"

Björn Racky, project manager of suspension and vehicle dynamics for the GT model line

Recreating reality

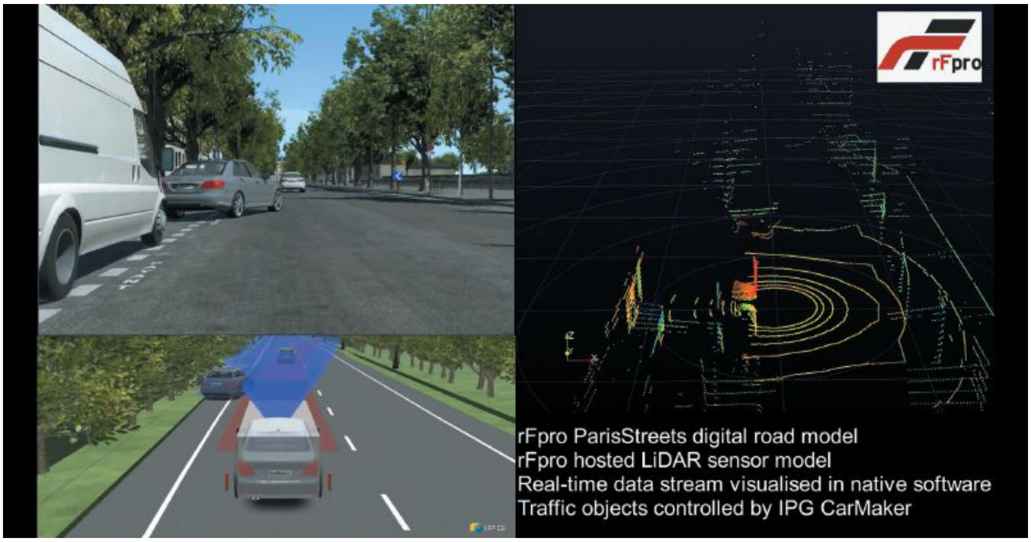
Claytex is adopting a holistic approach to the simulation of autonomous vehicles, explains Theodor Ensbury, one of the company's simulation engineers

Reality is but a construct of millions of interdependent phenomena. As humans, we use five main senses – sight, sound, smell, touch and taste – to observe the world around us and relay that information to our brains. We are often fooled though. A pungent smell can overpower other odours, while something soft can dull something sharp. Autonomous vehicles exist in the same reality, with their sensors equally fallible.

The RAND corporation estimates that some five billion miles need to be covered by an autonomous vehicle to have 95% confidence in its safety versus a human driver. It is clear, therefore, that simulation will play a central role in bringing autonomous vehicles to market. A holistic approach to recreating autonomous vehicles, and the conditions they experience, is imperative in order to truly recreate reality in a digital twin. Three areas need to be addressed for this to be achieved: the sensor, the environment and the vehicle.

Sensor models must behave in precisely the same way as their real-life counterparts. Optical effects such as lens distortion and field of view, for instance, must be correctly recreated from the real camera, with the deliverable signal formatted exactly how the control algorithm expects. LiDAR sensor models need to spin at the same rate as in real life, and be able to measure the distance and intensity of the reflection to each point in the environment. Weather effects, such as the reduction of effective range with higher humidity, or the beam 'scatter' effect from raindrops on LiDAR sensor performance, need to be incorporated. Radar sensors also need to recreate the reflection from the environment. Noise also needs to be accounted for. In all cases, the data output from the sensor model must be the same as from the real unit.

ABOVE: No autonomous vehicle sensors can be considered separate to the environment, nor to the dynamics of the vehicle

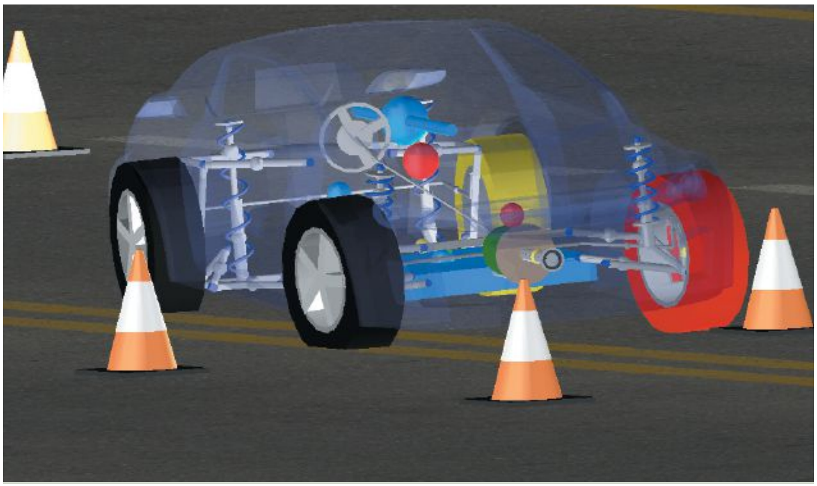


TOP LEFT: AVSandbox advanced sensor models from Claytex fully integrate with the rFpro environment, as well as the high-fidelity vehicle dynamics models from Claytex's VeSyMA suite of simulation libraries for Dymola

TOP RIGHT: Photorealistic graphical quality, allied to differing material properties of surfaces depending on the sensor (LiDAR or radar) viewing them, means rFpro provides a digital twin of real-life locations that AVSandbox sensors can be fully immersed in

Where the sensor model ends, the environment model begins. By building the virtual world from survey-grade LiDAR scans and using physical properties to define the materials, rFpro can capture the environmental impact on sensor performance. Photorealistic images can be produced at frame rates and resolution that match the physical camera. Reflections, from water on the road surface, are achieved through simulation based on physics principles, rather than relying on 'special effects'. The material properties for each object are dependent on the type of sensor viewing them, so that the wavelength of the LiDAR can be considered, and a completely different set of properties used to determine how a radar sees the world. It is not only the sensors the environment interacts with that affect the results produced by the sensors; the performance and fidelity of the vehicle model itself should not be overlooked. After all, the sensors are mounted to a vehicle, travelling through the same environment the sensors are describing to the vehicle's brain.

Surface irregularities such as bumps, kerbs or potholes will cause a pronounced disturbance to the vehicle platform, which in turn can transmit vibrations to the sensor itself. Lateral vehicle dynamics have a similar impact, as the vehicle body is always in lateral motion of some description. No passenger vehicle can exhibit perfect performance in roll and pitch; it's a physical impossibility for a car to have an idealised yaw rate when driving. This means the sensor will not be presented to the environment in a perfectly stable orientation or condition.



LEFT: Full multibody vehicle dynamics models enable dynamic vehicle effects such as roll, pitch and yaw to be experienced by the AVSandbox sensor models in a coupled and representative way

An accurate depiction of the vehicle suspension and tyres is required in order to correctly recreate the behaviour of the vehicle. Multibody models of suspension linkages can achieve this, able to describe the actual motion ratio, suspension kinematics and ride vibration isolation system dynamically, allied to representative tyre model.

The road surface detail found in rFpro virtual environments provides an accurate depiction of real topography, enabling the vehicle to respond to the road in an indicative way. Not only is the vehicle vertical performance accurately described, but the ability to investigate the impact of vehicle platform changes can also be quantified.

A robust vehicle plant model also enables the control algorithm to be trained with an accurate sense of the vehicle's limits of performance, leading to a true appreciation of the total system response and actuator delay.

Using a holistic approach to consider the autonomous vehicle, the simulation can truly recreate reality. Considering not only the sensor model, but also the base vehicle and environment as part of the simulation solution, is a key aspect of this.

AVSandbox from Claytex can fully integrate detailed sensor models, fully immersed in rFpro's virtual environment, with Claytex's specialist Dymola-based vehicle simulation tools accurately capturing the all-important coupled phenomena of autonomous vehicle simulation.

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