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Virtual Driver's Seat

In no other type of vehicle is the connection between the driver and vehicle so intense as in a sports car. With the second-generation virtual driver's seat, Porsche has a highly modern development tool to enhance this connection even further.

The simulator enables highly precise tests of the interaction between the driver and the technology in practically every stage of the creation of new vehicles, systems and functions. The application spectrum ranges from the display of virtual reality within and outside of the vehicle to tests with complete vehicles.

Driving simulations in the vehicle development process are the early interface between the human and the machine. They enable "test drives" with virtual vehicles in any digitized environment. Critical situations can be simulated in a risk-free and reproducible manner. And they significantly shorten development times: real components can be swapped in a flash, and virtual elements can be changed at the push of a button.

Porsche put the first virtual driver's seat for the examination of the interaction between the human and the machine into operation in 2007. The second generation of this development tool was designed based on experiences gathered with the first generation model. Some of the concepts from the first system were adopted in the second generation, while others were further developed or completely redesigned from the ground up. The new virtual driver's seat is distinguished in particular by its variability and broad spectrum of application. On the platform of a hexapod, any given payload weighing up to 1,500 kg can be mounted—from simple seats to complex seating bucks and even entire vehicles in which the smaller motion pulses are directed through the front axle. The development engineers distinguish between three basic functions:

- Throne is the name of the mode for pure visualization in which the only hardware is the driver's seat.
- Seating buck is the name of the configuration for interactive driving simulations with complete motion capability for the driver's seat.
- The entire vehicle option enables the incorporation of a real vehicle.

Hexapod with six degrees of freedom simulates accelerations

A core component of the virtual driver's seat is the motion system. It consists of six independently controllable electric actuators and a platform for payloads. This hexapod with six degrees of freedom represents the accelerations that take place in the vehicle. It is installed in a pit in the simulator room and has a motion range of ±40 centimeters in longitudinal, lateral and vertical directions and ±30 degrees of rotation (pitch, roll and yaw) respectively. A specially developed access system to the platform ensures that payloads can be mounted easily without the aid of a crane and that getting into the seating buck does not require stairs or a ladder. In addition to easy accessibility, safety plays a central role in the simulator concept. A fence, surveillance camera and numerous sensors — on the belt buckle and doors — ensure safe operation.

The Porsche Cayenne on the motion platform

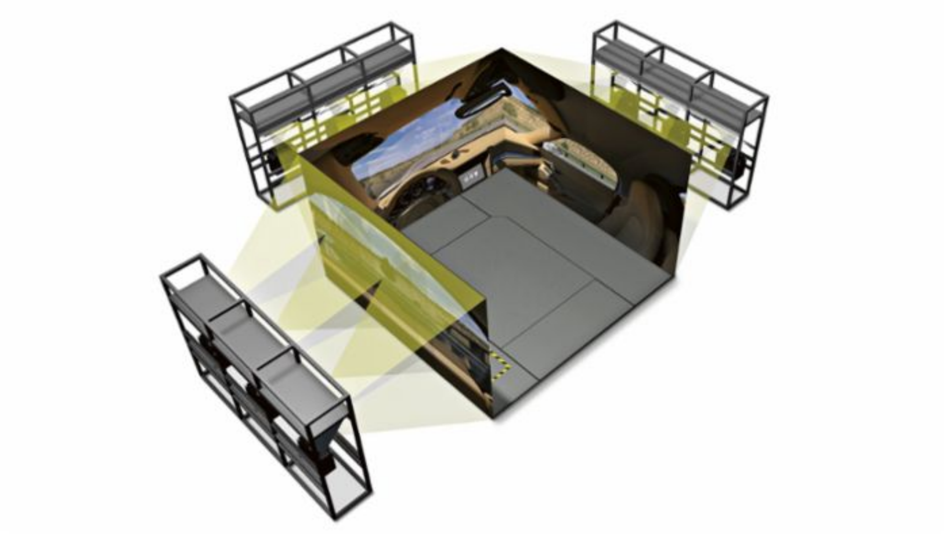
The simulator design makes it possible to replicate longitudinal and lateral acceleration, body roll (for example while driving on inclines or at a transverse angle to the road) and oscillations of the types that can occur on uneven surfaces. The longitudinal and lateral dynamics of a vehicle are represented in the virtual driver's seat in two different ways.

- Translation of the platform generates a realistic driving experience. Due to the limited travel paths, however, the accelerations can only be simulated for relatively short periods of time.
- Rotation of the platform gives the driver the impression of a long-lasting acceleration through a slow tilt of the platform. The function makes use of human physiology: The human body perceives rapid rotations as, indeed, rapid rotations, but slow ones as a change in the acceleration acting on the body.

The simultaneous use of both types of motion creates as realistic a driving situation as possible. The represented environment adapts to the motions. The motion of the virtual vehicle is determined on the basis of the real-time-capable calculation models devised and provided by the respective development departments. In addition to the calculation of the position of the vehicle in the virtual environment, the simulator also determines accelerations, roll movements and steering forces. The input from the driver, such as the steering angle and pedal positions, serves as an electronic input signal into the driving dynamics calculations. In a process known as "motion cueing," the calculated accelerations in the vehicle are transmitted to the motion of the hexapod.

Three-dimensional visualization via rear-projection screens

The representation of the environment and the vehicle components that are not physically present is done through projection onto up to six sides of a cuboid. Up to 15 projectors generate the graphics on specially coated rear-projection screens. The cuboid has edge lengths of 4.2 × 4.2 × 2.6 meters. This arrangement is known as a cave automatic virtual environment (CAVE). The projectors generate approximately 3,840 × 2,160 pixels per side, which corresponds roughly to the 4K resolution used in digital cinemas today. Through an active stereo projection method, three-dimensional graphics can be generated that the observer perceives as spatial images through special glasses.



Computer-generated images on three highresolution stereo projectors

An optical tracking system makes it possible to measure the precise position of the driver's head within the CAVE. This information is required by the graphics PCs to represent the physically correct driver perspective. The effect of this is that the driver, depending on their head position, can either see a pedestrian or not because the pedestrian is blocked by the A-pillar, for example. For realistic immersion into this virtual reality, the simulation of sound is also essential. The simulator simulates not only the sounds of the driver's vehicle, but also those of the environment, such as cars driving past.
All systems of the driving simulator are real-time-capable and communicate with each other at very high data rates. The input of a new steering angle, for example, is transmitted via a data bus to the driving dynamics simulation, which calculates the new position of the vehicle in the virtual environment and then sends the coordinates through the network to the graphics PCs, where the 3D visualization is created. This all happens at clock rates from 60 Hz (visualization) to 1,000 Hz (driving dynamics calculation).

Test candidates: rear-view mirrors, luggage compartments, assistance systems

Porsche uses the virtual driver's seat for new vehicle concepts such as the fully electric Mission E as well as for the ongoing development of existing model lines. Among other things, the simulations focus on the two primary points of emphasis: ergonomics and the human-machine interaction (HMI). Ergonomics testing involves elements such as visual examinations of rear-view mirrors, shape and position of the vehicle windows, and camera systems. It also includes testing of active safety functions and vehicle components such as luggage compartment variants. In the HMI area, testing focuses on driver assistance systems and the design of information transmissions — with the aim of arranging the components in such a way that the driver can rapidly receive information and react with commensurate quickness. In order to use real vehicle components as part of the simulation, it is necessary to address the control units — for instance an instrument cluster or button — via CAN bus and ensure functionality through remaining bus simulation.
One elementary component of the simulator is the recording and storage of the relevant data from a virtual drive. The key information pertains not only to the behavior of the simulated vehicle, but indeed the physiological data for the driver in relation to their environment as well. This makes it possible to examine and evaluate influences and reciprocal effects, for example through the position of the simulated vehicles in the vicinity and driver reactions such as eye position or head-turn angle.

Simulator: an effective cross-specialization development tool

The test results from the simulator make it possible to assess the function and effects of the vehicle and components implemented within it at a very early stage in the vehicle development process. The simulation environment is particularly ideal for analyzing systems in which the human interacts with the vehicle. Moreover, Porsche also uses the virtual driver's seat as a platform on which engineers from the various disciplines can test, discuss and present issues in an interdisciplinary context and make decisions on that basis.

The advantages manifest themselves directly in the development process: the results determined in the upstream virtual development cycles with the virtual driver's seat improve the quality of the prototype vehicles produced later in the process and make it possible to make high-impact decisions at an early stage. The virtual driver's seat therefore leads to an overall reduction in development times and more effective use of real testing components.

Info

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