

Cruden motion simulators for vehicle development and testing

Increasing numbers of automotive OEM departments, their suppliers and automotive research institutes are working with Cruden to significantly reduce vehicle development cost and time.

Cruden 6-DOF, driver in the loop, motion-based simulators are trusted for their realism and accuracy, and relied upon to deliver unlimited repeatable virtual vehicle testing.

Simulators for various automotive applications

Traditionally, the use of driving simulators has been limited to large OEMs and research institutes. Extremely powerful PC hardware has driven the development of accessible software tools for simulation to new levels. Now, simulators play a significant role in automotive engineering, at departmental level and across geographies, at automotive suppliers, academic organizations and OEMs.

Virtual vehicles can truly be used as test mules long before the first prototypes are built. For the subjective assessment of new developments, or when a driver plays a vital role in the control loop, driving simulators are a valuable step between desktop simulation and actual prototypes.

Cruden has recognized the potential of driving simulators since the late 1990s and has developed an extensive software suite that either integrates with existing engineering environments or serves as a starting point for newcomers. Simulators by Cruden are well known for their flexibility, durability and performance. Over 100 motion based simulators have been installed and are being used for various automotive applications:

- **Vehicle dynamics**
- **Autonomous driving**
- **Ride & comfort**
- **Driver training**
- **HMI**
- **ADAS**
- **NVH**
- **Audio**

What to buy?

When acquiring a simulator, there are many questions. While there is no “one size fits all” solution, the engineering application will decide the configuration, motion system, top platform and other fundamental components. Next, the budget, timing, facility and the level of customer experience with DIL simulators are important factors to consider.

Cruden technology is open, meaning an array of different simulators can be put together for different applications. Our experts will help you choose the right solution for your situation.

Cruden backs up its installations with maintenance, support and consultancy contracts. This can vary from responding to occasional phone and email queries, to providing remote online support, maintenance visits and full support and consultancy contracts.



Products: standard or customized

Cruden makes standard as well as bespoke simulators to customer specification. Below are three standard simulators that are commonly specified for the automotive market.

A646-D3C

Base product for automotive applications

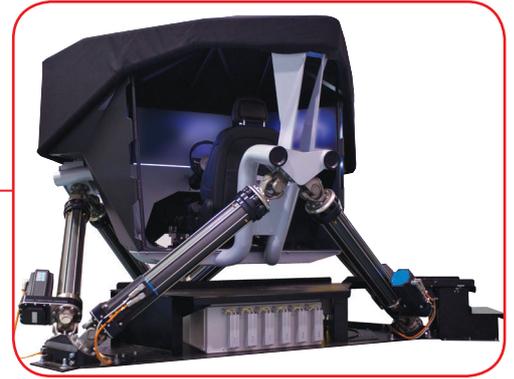
Compact, affordable and flexible, it ships in one piece and fits in a space of 5.5 m x 5 m x 3.5 m. Customers can be up and running within three to four months.

Hardware

- 6-DOF, 640 motion base
- Control loading / force feedback steering system
- 3 x 42" displays
- Recessed top frame with passenger car seat, steering wheel and pedals
- Canopy

Software

- Panthera Master
- Panthera ePhyse (external vehicle model integration)
- Panthera Set-Up Tool
- Panthera Data Logging
- Panthera Spectator view
- Panthera GPS Tracker
- Content: Skid pad and Endless highway



Typical applications

- Vehicle dynamics
- Autonomous driving
- Driver training
- HMI
- ADAS

A646-N3

Simulator with on-board projection and screen

A compact solution for when a mock-up or partial vehicle is required and more advanced visuals. Fits into a space of 8 m x 7 m x 5.5 m.

Hardware

- 6-DOF, 640 motion base
- Control loading / force feedback steering system
- On-board conical carbon fibre screen with a viewing angle of 180°
- 3 Barco F50 projectors (120 Hz @ WQXGA - 2560 x 1600 resolution)
- Top frame with interface on which a mock up or partial vehicle can be mounted
- Interchangeable Driver Cell (IDC) optional (see page 4).

Software

- Panthera Master
- Panthera ePhyse (external vehicle model integration)
- Panthera Set-Up Tool
- Panthera Data Logging
- Panthera Spectator view
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- Content: Skid pad and Endless highway



Typical applications

- Vehicle dynamics
- Autonomous driving
- Driver training
- ADAS
- NVH
- Audio
- HMI

A646-F5

High immersion simulator with off-board projection and screen

This system requires a 9 m x 6.5 m x 5 m simulator room.

Hardware

- 6-DOF, 640 motion base
- Control loading / force feedback steering system
- Off-board, 8 m diameter, conical, 210° viewing angle screen
- 3 Barco F50 projectors (120 Hz @ WQXGA - 2560 x 1600 resolution)
- Top frame with interface on which a mock up, partial or full vehicle can be mounted
- Interchangeable Driver Cell (IDC) optional (see page 4).

Software

- Panthera Master
- Panthera ePhyse (external vehicle model integration)
- Panthera Set-Up Tool
- Panthera Data Logging
- Panthera Spectator view
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Typical applications

- Vehicle dynamics
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Hardware

Cruden's driving simulators are built around motion systems with direct drive force feedback steering systems. From there, a choice of standard top platforms is available, but custom configurations can also be specified by the customer using Cruden's technology building blocks.

Motion base

Cruden uses various motion bases for its simulators. Its standard industrial 6-DOF systems – with either 400 or 640 mm actuator stroke – are used in professional automotive, motorsport and military applications around the world.

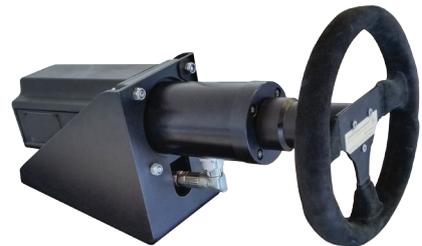
The hexapod platform is a renowned and excellent solution for motion systems:

- The parallel kinematic structure and closed-loop system make it very stiff.
- Excellent high dynamic behaviour.
- No accumulation of positions errors, as with cascaded structures.
- Small package with a simple mechanical design, using six identical actuators.
- No moving cables and cable chains.



Control loading / Force feedback

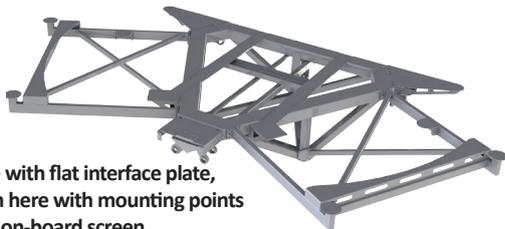
Cruden uses direct drive force feedback systems. These are purposely designed, single or multi-turn actuators for high-fidelity steering wheel applications, featuring double loop control. The tunable inner loop controls the servomotor and the outer loop uses a load cell, to optimally recreate the torque demanded by the vehicle model. This also allows the user to request features such as friction, damping and soft-stops. At a bandwidth exceeding 50 Hz, the maximum peak torque is 30 Nm, the nominal maximum torque is 20 Nm and the maximum velocity is 4500 deg/s.



Top platform

Cruden standard simulators come with either a recessed-seating frame or interface frame on which a mock-up, cockpit or partial/complete vehicle can be mounted.

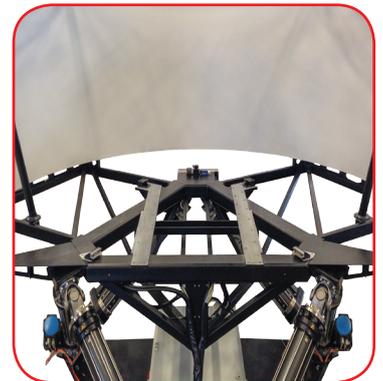
The Interchangeable Driver Cell (IDC) option allows for different mock-ups to be fixed to the top platform, with a changeover time of less than 20 minutes.



Frame with flat interface plate, shown here with mounting points for an on-board screen.



Recessed frame



Interchangeable Driver Cell (IDC) platform

FREQUENCY RESPONSE

The bandwidth (-3 dB point) of Cruden's motion bases exceeds 20 Hz in all 6-DOF. The bandwidth for heave and rotational degrees of freedom goes beyond 40 Hz. The control loader bandwidth exceeds 50 Hz.

LATENCY

Full round-trip latency (from driver input to visual change from full white to full black) is just below 30 ms of which 19 ms is due to the projectors. For motion (heave, roll, pitch and yaw) it is 10 ms. Surge and sway are below 20 ms. The end-to-end latency from the driver generating an input to the driver receiving feedback on the control loading is only 7 ms. Audio latency is as low as 8 ms.

Vehicle components

Cruden has many years' experience integrating complete or partial vehicles, mock-ups, cockpits and original vehicle components e.g. shifting devices, pedal boxes, steering wheels or complete dashboards. Company know-how of CAN-bus and other automotive protocols enables interfacing with virtually all automotive hardware and software.

Add-ons such as an active brake pedal, seat belt loaders and vibration devices create a fit-for-purpose engineering tool. Cruden has a standard canopy to improve the immersiveness of its recessed low-seating platform.



Display and audio

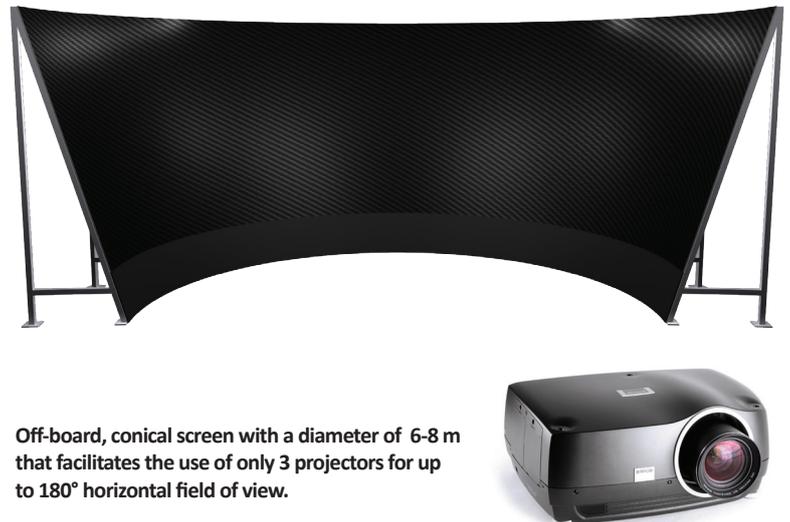
Cruden makes systems with integrated TFT displays as well as on- and off-board projection systems with both mono and stereo projection using various technologies available on the market (Infitec, active shutter glasses and more). All simulators come with digital audio.

TFT displays



Cruden produces its own 42" vibration isolated, industrial displays.

Projectors



Off-board, conical screen with a diameter of 6-8 m that facilitates the use of only 3 projectors for up to 180° horizontal field of view.

PC hardware

The rendering engine and peripheral software run on high-end COTS Windows PCs. The vehicle model runs either on Windows in soft real time or on a variety of hard real time platforms, such as CCUR iHawk, dSPACE or SpeedGoat. RT Linux is used to control the motion and control loading hardware.

Software

All Cruden simulators run on the Cruden Panthera software suite, which includes various modules, depending on the application. Panthera integrates perfectly with existing simulator hardware and is also available as a stand-alone desktop application.

Panthera

Panthera Master is the main module of the simulator system. It times and controls the simulation, performs several monitoring tasks and executes interface liaison tasks for and between modules.

Session Manager is the main GUI for operating the simulator. Operators can set up a simulation by selecting a car, road and vehicle set-up. Once configured, a session can be controlled with a single mouse click for all hard and software modules involved.

Vehicle modelling / ePhyse

Through Panthera ePhyse, external vehicle model packages such as Vi-Grade, IPG CarMaker, veDYNA, CarSim, Dymola, dSPACE ASM or SIMPACK can be integrated into a Cruden simulator. The models run natively, in co-simulation, through their Simulink S-functions or are compiled through Simulink Coder and then run on the Master PC.

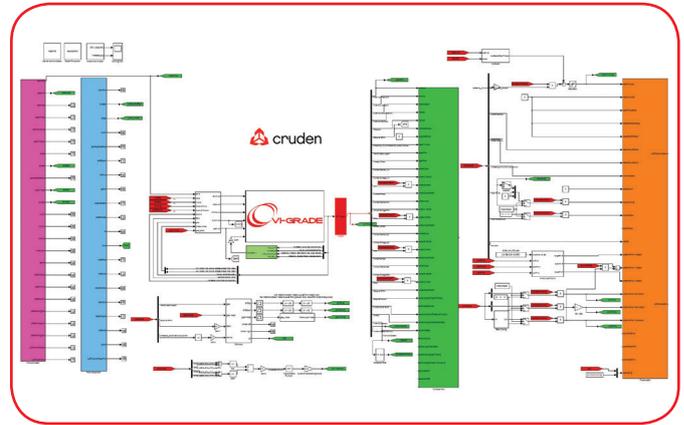
Alternatively, Cruden has developed its own highly detailed Simulink Vehicle Model, CSVm, which is an option on every simulator. For start-up, CSVm-Light is available.

Data logging

Data logging is an SL-block that writes real-time vehicle data to a Cruden proprietary file format. This data can subsequently be converted to either Matlab or ASCII, but can also be read, analyzed and/or post-processed by Panthera's Telemetry Analyzer.

Panthera SISTer

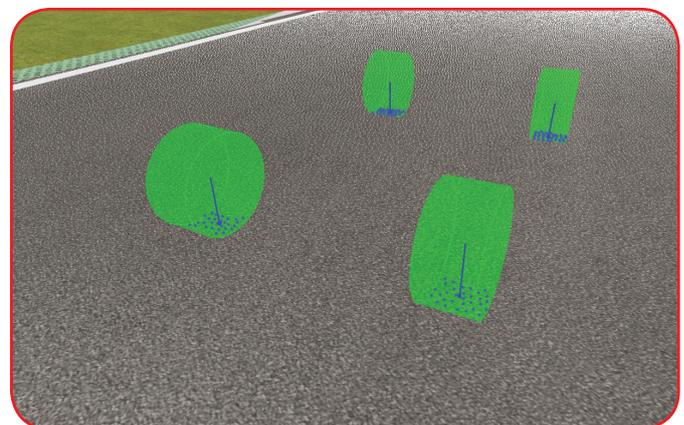
Panthera SISTer (Server for Interaction with Surfaces & Terrains) determines how the tire contact patch interacts with the road. This can be done either by multisampling with up to 49 intersection queries per wheel, or by driving directly on a dense point set with a spatial density down to 10 mm. This is done at a frequency of 1000 Hz or higher. This method provides highly improved input to the tire model, resulting in detailed and precise forces and moments plus road-normal calculations, without additional computational costs to the vehicle model. The interaction between the vehicle model and Panthera SISTer has a latency of less than 2 ms.



Vehicle modeling



Set-up Tool



Panthera SISTer

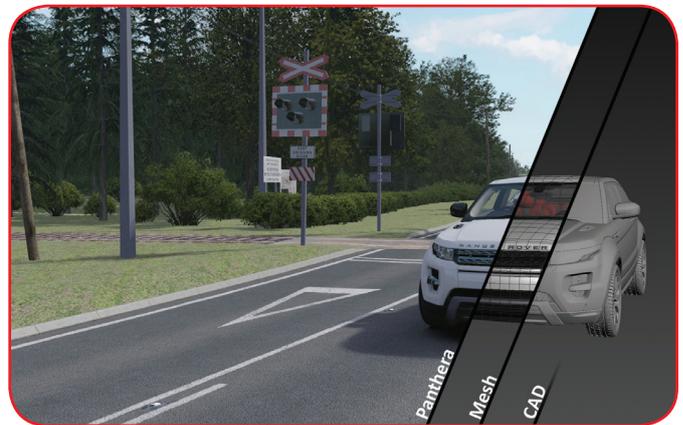
Platform tracking

For off-board projection, Panthera tracks the motion platform position and orientation and adjusts the projected images accordingly. This can also be combined with head and/or eye-tracking.

Warping & Blending

The Panthera software includes a post processing step that allows projecting on arbitrary shaped surfaces. The virtual world is rendered such that it is compensated for the deformation that typically occurs when projecting on non-flat surfaces. The compensation is derived from physical properties of the projectors, the shape of the projection screen as well as the dynamic position and orientation of the driver's head.

At the same time, an edge blend will be performed to smoothly blend the area where two projections overlap. This results in a seamless image generated by multiple projectors



Content

Roads, cars, tracks, environment

Cruden creates content, ranging from skid pads, endless highways and test tracks up to full Lidar scanned public roads. It also models customer vehicles from 3D CAD data.

The use of full Lidar scanned data provides the most accurate representation of the road surface and environment, from a reassuring bump in the track to the tree that signals a driver's braking point.



Integration

Engineers value Cruden above all, because of its expertise in system integration and overall system know-how. A simulator is a complex mechatronics system, consisting of mechanical, electrical, electronic and sometimes hydraulic components, as well as several software packages. Cruden designs the complete simulator architecture, including all the components that are integrated into a simulator. This integration, both in the design as well as manufacturing and commissioning phase, is one of the most important and often underestimated factors.



Cruden's founders have been developing professional motion simulators since the early 1990s. The company started developing products for the aerospace industry and helped lead the technology transfer into the marine, automotive and motorsport industries.

As a result, Cruden has the world's leading experts in the complete array of technologies required for a simulator.

Cruden's team of vehicle dynamicists, software developers, mechanical engineers and project managers is based at its global headquarters in Amsterdam. The building houses all functional teams covering the mechanical design of all the company's components and systems; hardware assembly and integration; its Content & Design Studio which makes all the content for the simulated environment e.g. tracks, vehicles, cars, and scenery; the design of motion-cueing algorithms and associated software; simulator operating software and professional image generation.



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