Cruden Panthera simulator software suite

Automotive OEM departments and first tier companies, motorsport teams, universities and research institutes use Cruden simulators to significantly reduce the cost and time of vehicle development and race preparation.

Alongside simulator hardware and content, Cruden has created the open architecture Panthera simulator software. It can be used with any desktop, static or motion simulator, in automotive or motorsport applications, and in conjunction with any vehicle model.
**What is Panthera?**

Panthera is Cruden’s stand-alone, open architecture software for use with any existing or new simulator and with all vehicle models. It has a flexible, modular setup and a strong focus on image generation and the centralized control of simulator components, including:

- Motion & control loading
- Visuals
- Vehicle dynamics
- Audio
- External hardware and I/O
- Real time platforms for HIL and RCP
- Safety

The modular framework guarantees maximum flexibility; interfaces between Panthera’s modules are open, to avoid users being tied to a single supplier for all simulator components whilst maintaining the lowest achievable latencies and highest possible bandwidth plus image quality.

Panthera is scalable, making it easy to run any kind of driving simulator, from a free desktop application up to a complex multi-‘degree of freedom,’ motion-based simulator with a multi-channel projection system. Simulators can be linked and thus driven concurrently in a joint scenario.

**Panthera within the simulator environment**

To the right is a graphic schematic of a typical driving simulator running Panthera. The outer layer represents the simulator hardware. Within the software framework, is the inner-most section, the ‘core’, which features all software components that are optimized specifically for high communication rates. At the most basic level, the simulator starts with the Panthera Master module (the main simulation engine), a vehicle model, controls, audio, and video.

The ePhyse environment is the heart of the simulator where all elements are optimized to run and communicate, often bi-directionally, at a rate of at least 1 kHz. This is also where you will find the vehicle model and the steering wheel force feedback system (control loader), running in closed loop. Additional interfaces to several open loop cueing devices are available, such as motion systems, seat belt loaders, vibration actuators and other control loading systems. ePhyse also interfaces to the virtual road and (simulated) ECUs. It runs either on Windows in soft real time or on a variety of hard real time platforms.

Software elements that run and/or communicate at a lower rate and that are predominantly uni-directional are placed outside the ePhyse environment.
1. Core elements to run a simulator

At the heart of Panthera is an essential collection of the fundamental modules required to run a simulator. It contains Panthera Master, Panthera Session Manager as well as other key modules. At the most basic level, all that would be needed to drive a simple desktop simulator is Panthera Master, Session Manager, a vehicle model, video, audio and controls.

**Panthera Master**

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

**Panthera Session Manager**

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. During a run, Session Manager provides status feedback and allows for interaction with the session, for example, to change the time of day or affect the weather conditions.

2. The Panthera ePhyse environment

ePhyse is the generic interface package that enables the use of (custom-built) simulation models over a network. This interface can theoretically link any Real-Time code to the simulator environment. A variety of real time platforms are supported, amongst which are dSPACE, CCUR iHawk, ETAS and Speedgoat.

The default implementation is based on Simulink library extensions to control the configuration and state of the vehicle model that resides on the real time platform. During execution, time critical communication is setup directly between the relevant modules to minimize delay whereas status and control signals are handed over to the Master.

Alternatively, a soft real time Windows solution is offered by Panthera Simulink blocks, through which the vehicle model is both timed, as well as linked to the Master and simulator hardware. Third party vehicle models or in-house developed Simulink code may run natively, in co-simulation, through their S-functions allowing partner-supplied Simulink libraries to be used without the need for object- or source code.
**Third party vehicle dynamics package integration**

Integrating dedicated vehicle dynamics packages, such as VI-CarRealTime, IPG Carmaker, CarSim, SIMPACK, VeDYNA, dSPACE ASM, AVL VSM and Dymola-based models is performed through the ePhyse module. If the vehicle model is Simulink based, Panthera Set-up Tool (see page 7) can be used in combination to alter parameters at runtime; otherwise, modifications must be made using the third party’s front end.

**Panthera CSVM**

Cruden’s Simulink Vehicle Model (CSVM) is a highly detailed, open architecture, multi-body vehicle model created in MATLAB Simulink, in close cooperation with Cruden’s motorsports clients. Model parameters can be modified using Panthera Set-up Tool both during preparation as well as at runtime.

Panthera CSVM runs Pacejka 6.1 based tire models and has many features, such as aero-mapping, a multi-point skid plate and the ability to add items such as ERS and DRS.

CSVM-Lite is a ‘light’ version of the Cruden Simulink Vehicle Model, provided free of charge as an implementation example.

**SISTer**

Cruden has developed a separate module for the tire road interaction: SISTer (Server for Interaction with Surfaces and Terrains). Interaction between the car (tire, skid plate etc.) and the road (Lidar triangles, Lidar points, OpenCRG etc.) is handled in one or more separate threads, at rates of 1 kHz or more.

This can be done either by multisampling with up to 49 intersection queries per wheel or skid plate, or by driving directly on a dense point set with a spatial density down to 10 mm. Highly accurate road representations can be loaded and processed outside the vehicle model itself, freeing up valuable computational resources for vehicle dynamics, whilst increasing road interaction fidelity.
Panthera Motion
Panthera Motion interfaces with the motion system providing all necessary data on platform level. Actual position and orientation data of the driver with respect to the visual system is fed back to Panthera IG for off-platform visualisation. Optionally, an additional Simulink-based cueing algorithm can be added on top of the standard cueing algorithm.

Additional cueing
Panthera may generate a variety of additional cueing signals to enhance driver immersion. For instance, vibration actuators can be installed at various places on the simulator to create high frequency vibrational feedback. Additional control loading can be used on, for example, seatbelts, to provide the driver with sustained deceleration cues or on pedals, to create active feedback from brake and/or accelerator. Seat deformation due to air pressure or movable parts can also be a means of providing the driver with sustained cues.

Panthera IG
Panthera IG renders the scene at resolutions up to WQXGA at 120 fps with native support for projection surfaces that are not flat, for stereoscopic 3D and head-tracking. Latency is kept extremely low by our in house developed engine whilst image quality outperforms any other engineering simulation package.

Panthera Control Loading
Panthera Control Loading interfaces with force feedback steering systems. A force setpoint is sent in combination with parameters for effects that may be realized on the force feedback units locally like friction or hard stops. Measured steering wheel angle and velocity are received in the return path. To prevent low frequency oscillation at cruising speeds or high frequency rattle due to numerical instability, delays are kept to the minimum possible.

Controls and instrument interfaces
The Panthera software suite can integrate a wide variety of (OEM) controls and HMI devices, such as pedals and instrument clusters through CAN or similar networks.

HIL
To include the actual vehicle’s ECU as hardware in the loop or integrate a testbench to substitute parts of the simulation model with the actual hardware, Panthera’s ePhyse supports a broad range of real time platforms.

3. Outer layer software modules

Panthera Mesh
Panthera Mesh 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. W&B is integrated in the core of the rendering engine performing instantly without introducing addition delay or compromising image quality. It also means you do not need to add third-party software or warp & blend boxes.

Panthera W&B
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Panthera Set-up Tool

This module is used to adjust the setup of Simulink based vehicle models. Using this tool, setups can be created, saved and loaded. Set-up Tool has a comprehensive visual feedback. A sample screenshot is shown. Additionally, Set-up Tool enables live adjustment of various car parameters i.e. the vehicle set-up can be changed on the fly, whilst the simulator is in use. This saves valuable time as the simulator does not have to be stopped and started each time a change is made.

Panthera Data Analyzer

The Data Analyzer module has multiple functionalities.
- It can be used to monitor and analyze the recorded vehicle data. Some signals that are in the vehicle model can be viewed, others can be programmed as an option. Viewing is distance- or time-based;
- It can be used to load previous runs that were created and stored by the Data Logging module, e.g. to compare the current run with previous sessions;
- An interface to commercially available packages (such as, Bosch Windarab, Magnetti Marelli Wintax, Pi Toolbox, MoTeC or Atlas) is available.

Panthera GPS Tracker

This module is the live timing package for motorsport customers and shows a track map with the driver's position on the virtual track, as well as a list of times during this run. Each line in the lap time table represents one lap and shows three sector times and the total lap time. The best time in each sector is shown in purple. At the top of the table, the best lap is shown, as well as the best three sector times combined.

Panthera ADAS

For the development and evaluation of Advanced Driver Assistance Systems (ADAS), Cruden is currently working on new features for traffic, sensor-simulation and the possibility to implement ADAS control algorithms as software in the loop (SIL) or actual controllers as hardware in the loop (HIL). Panthera supports ideal sensor simulation natively. PreScan or Vires may be used if the inherited error-prone detection characteristics of real ADAS sensors need to be simulated. ADAS sensory information is made available over the ePhyse interface such that control algorithms can be prototyped in Simulink or run on the actual ECU.
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 image generation.