



Constellator™

Hardware-in-the-loop GNSS Simulator

A hardware-in-the-loop setup allows the test of an entire navigation system (software and hardware) in the controlled environment of a laboratory.

Constellator allows hardware-in-the-loop GNSS simulation at high-fidelity, even under very-high dynamics, with zero effective latency.

It allows **safe** and controlled tests while **saving time, budget and efforts**.

Key Simulator hardware-in-the-loop features:



- ▶ Any iteration rate from 1 Hz to 1 000 Hz allowing high fidelity tests from low to extreme dynamics



- ▶ Zero effective latency even at 1 000 Hz



- ▶ Multi-constellation & up to 3-frequency simulation with 660 L1 C/1 equivalent signals even at 1 000 Hz



- ▶ 6-degree of freedom trajectory and dynamics inputs for the high-fidelity simulation of any trajectory



- ▶ Simple hardware setup, including for multi-antenna tests, multi-receiver setup
Interfaces: 10 MHz Clock reference (IN & OUT), triggers, PPS IN & PPS OUT



- ▶ Simple control and integration
Simple graphical user interface for local and remote access, remote control via commands, and CCSDS integration.



- ▶ Extensive testing reports
Leverage 25+ environment variables and 20+ variables per satellite in view with a source of truth data in realtime at 10 Hz



- ▶ No duration limit in simulation
Feel free to have it run for weeks, continuously, or more!



- ▶ Extensive documentation, examples available & local support
User guide, HWIL interface documentation, CCSDS Protocol documentation, Python script examples & .xls tools for data structure

Customers include:

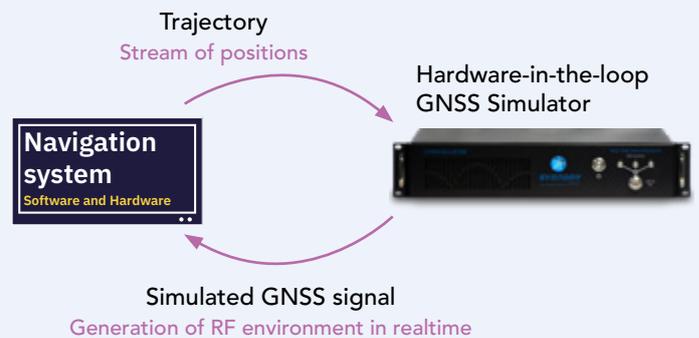


The flexibility of hardware-in-the-loop tests

What is hardware-in-the-loop?

Hardware-in-the-loop is a setup allowing testing in a closed-loop of both the hardware and the software of a navigation system.

GNSS RF signals are generated in realtime from a stream of 6 degrees of freedom trajectory input.



The great thing about hardware-in-the-loop is the ability to test control guidance systems and to define complex user-defined trajectories (phone in hand, tumbling satellite...).

Compared to a real-life outdoor test setup, hardware-in-the-loop simulation allows to check as many times as wanted, how the unit under test performs. It creates a safe and repeatable environment.

Pinpointing and tackling potential design issues early on lead to massive time, budget and effort savings, this is why it's now an industry standard. The same applies to integration and tests at the system-level. This way of testing allows product development at a much faster pace.

Hardware-in-the-loop main benefits:

▶ Repeatable

The biggest strength of hardware-in-the-loop test is the ability to run the exact same scenario over and over. This is particularly helpful while developing new features or fixing bugs. It can also be used in production.

▶ Simple

Hardware-in-the-loop can be easy to setup, connecting together a computer, a Constellator and a receiver. Real life test on the other hand, involves a lot of staff and logistics. In some environment such as in space, real-life testing is just impossible and hardware-in-the-loop represents a great alternative.

▶ Cost Efficient

Real life tests are very expensive as it requires moving hardware around the world to test any edge case. While hardware-in-the-loop test can replace most of real-life tests and speed up development, saving money.

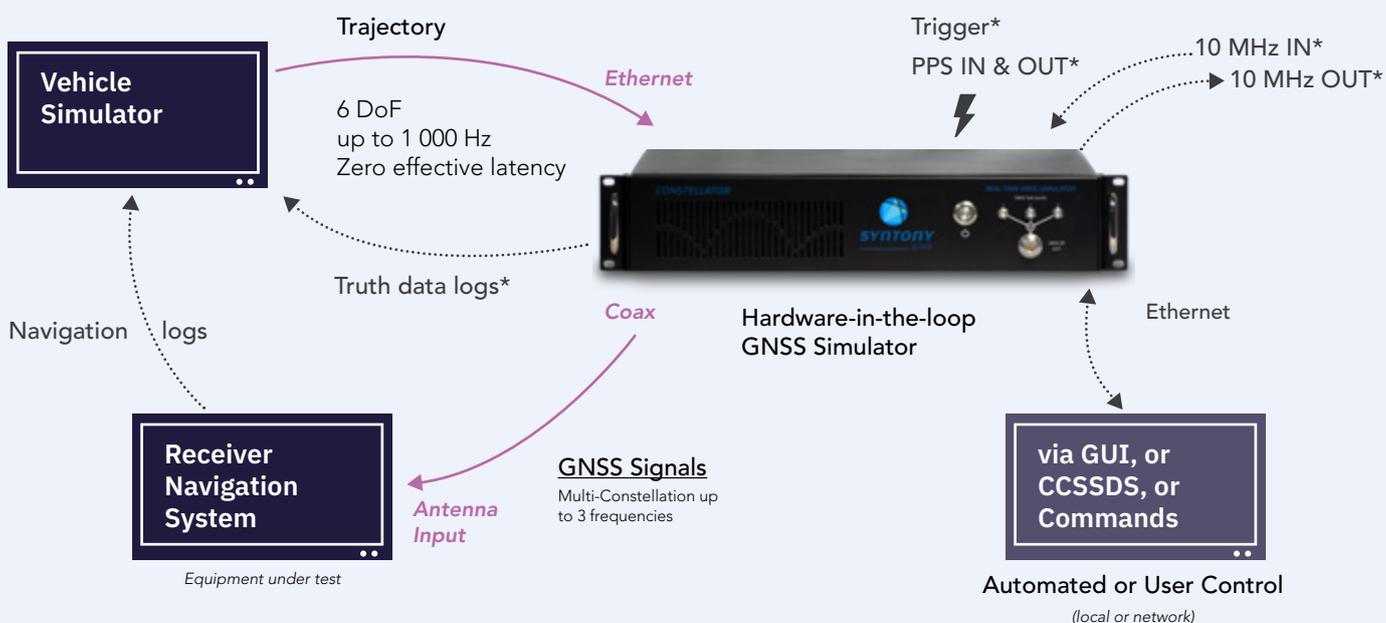
▶ Safe

In real-life test, the hardware is moving in a real electromagnetic environment. In hardware-in-the-loop, the electromagnetic environment is generated around a static hardware. Because it is inside a laboratory, there is no risk of losing, damaging equipment or hurting someone.

▶ Global

Hardware-in-the-loop makes it possible run high-fidelity tests representing any environment anywhere on earth or in space from a laboratory.

Typical Setup



*available by default on all Constellator™ units but not required for a hardware-in-the-loop test

Market Benchmark

Constellator offers the **best hardware-in-the-loop GNSS simulation** on the market, specs are listed below:

	Syntony GNSS Constellator™	Second best on the market	Third best on the market
Hardware-in-the-loop mono-frequency	Up to 1 000 Hz	Up to 1 000 Hz	Up to 1 000 Hz
Hardware-in-the-loop multi-frequency (single unit)	Up to 1 000 Hz	Only up to 100 Hz	Up to 1 000 Hz
Latency with offset	Zero effective latency & no need for offset	~10ms	~100ms
Latency without offset	Zero effective latency & no need for offset	~40ms	Longer than 100ms
Simulation duration limit	None	Days	Days
Appliance Cost	\$-\$-\$	\$-\$-\$-\$-\$-\$	\$-\$-\$



Constellator™

Hardware-in-the-loop

Achieving zero latency while ensuring position accuracy

Historic solutions waste a non-negligible amount of time to process the input trajectory and generating GNSS signal. This used to generate significant latency inducing errors ranging from meters to much more depending on the use-case.

To avoid such impact, Constellator™'s Propagation Engine computes the best estimation of the position at the current simulation time, based on the hardware-in-the-loop data.

Constellator™ does not only achieve zero effective latency, it also ensures the accuracy of the position simulated, even under expected or unpredictable very-high dynamics.

Hardware-in-the-loop 1 000 Hz iteration rate	<u>Expected 5g acceleration</u>	<u>Unpredicted 5g acceleration</u>
Hardware-in-the-loop mono-frequency	< 1mm <i>no effect on the receiver's ability to compute its PVT</i>	< 1cm <i>no effect on the receiver's ability to compute its PVT</i>

Even if within 1ms, the trajectory faces an unpredicted 5g acceleration, the error in position of the GNSS signals generated would be less than 1 centimeter. For civilian applications, the bias would never be greater than 1mm.

To put things in perspective, it simulates ~100x higher position accuracy than any high-end GNSS receiver.

Hardware-in-the-loop: Syntony's Propagation Engine

Syntony's exclusive Propagation Engine is the key component allowing zero effective latency simulation in hardware-in-the-loop.

This software engine is self aware of its computing and signal generation delay.

It also leverages the timestamps and dynamics data to ensure Constellator™ broadcasts the exact position at the right time without latency.



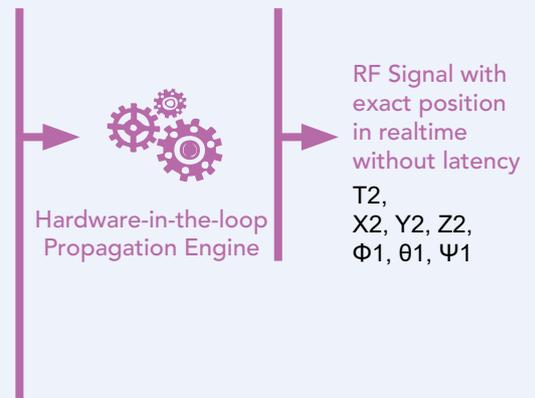
Timestamp
T1



Position
& Attitude
X1, Y1, Z1,
Φ1, θ1, Ψ1



Current
dynamic
Velocity
Acceleration
Jerk



Constellator™'s hardware-in-the-loop is therefore plug and play as it will always ensure the GNSS signals are exactly on time and generate the exact trajectory described in input.

There is no need to offset the stream of positions to artificially compensate for delays. Constellator™ provides zero effective latency by default.

Input: your trajectory

You can get started by feeding the position (ECEF coordinates). See below for fine tuning of the trajectory.

The external simulator sends to Constellator™ (specific IP address and port number) a structure that combines the different necessary elements to describe the mobile trajectory at a Time of Applicability (TOA):

- The position; (ECEF coordinates)
- The velocity (ECEF coordinates)
- The acceleration (ECEF coordinates)
- The jerk (ECEF coordinates)

As well as the elements to describe the mobile orientation angles and their evolution over time:

- Heading (value at TOA, velocity, acceleration and jerk)
- Elevation (value at TOA, velocity, acceleration and jerk)
- Bank (value at TOA, velocity, acceleration and jerk)

Output: your source of truth data (optional)

As output and on top of the generated signal, Constellator™ provides, in the log files, at up to 10 Hz, information related to the position, attitude and dynamic of the receiver, and information related to the GNSS constellations and signals.

Dynamic of the receiver:

- The antenna position, velocity, acceleration and jerk, in ECEF
- The Center of Gravity position and velocity, in ECEF; this may be useful if a lever arm is configured
- The antenna position in geographic coordinates (Latitude, Longitude & Altitude)
- The antenna orientation and its first-time derivative
- Information relative to the simulation time, the traveled distance, and the obscuration

Constellation:

- GDOP, PDOP, HDOP & VDOP
- Number and list of visible satellites

Satellite:

- Position and velocity of the GNSS satellite, in ECEF
- Azimuth and elevation of the satellite in the local ENU reference frame of the receiver
- The geometric range between the satellite and the antenna
- Satellite clock error
- Ionospheric delay at the L1 frequency
- Tropospheric delay
- Number and list of generated signals
- Signal
- Doppler
- RF Power level at output of Constellator™
- Per signal pseudo-range

The logs related to the receiver can be compared to the logs generated by the receiver. This consistency check is included in our validation test plan.

Please note that we have tools to help you structure your data and facilitate the interface.



Feature reference for your Constellator

■ Hardware-in-the-loop
Up to 100 Hz
Ref. RTGS4_HWIL

■ Hardware-in-the-loop
Up to 1 000 Hz
Ref. RTGS4_HWIL_Ext

Contact us



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