Choosing a GNSS simulator?

Getting it right. Why all simulators are not the same

SPIRENT®

Getting it Right

Product designers, manufacturers and system integrators involved in GPS development have used GPS simulators for R&D, integration, verification and production testing for years. But with the proliferation of GPS applications coupled with the commercialisation of GLONASS, the development of future Global Navigation Satellite Systems (GNSS) and the integration of these systems, GPS and GNSS testing has become more mainstream.

If this is new to you, don't worry, we can help you as all GNSS simulators and test approaches are not the same. You need to understand what these devices can do and how they can benefit your particular needs.

The case for RF simulation

The case for using a *GNSS simulator* when designing any form of location aware equipment is a compelling one. The ability *to control test conditions*, to simulate new satellite systems long before they go “live” and *the ability to precisely repeat tests* time and time again is a key application of simulation that cannot be achieved through using live satellites for testing.

There is however, a case where capturing the richness of live sky signals to playback later in the lab complements simulation as a source of GNSS signals for test. But more of that later.

What is a simulator?

An RF Constellation Simulator reproduces the environment of a GNSS receiver on a dynamic platform by modelling *vehicle and satellite motion*, signal characteristics, atmospheric and other effects, causing the receiver to actually navigate according to the parameters of the test scenario.

GSS6300 Multi-GNSS Signal Generator

GSS6700 Multi-GNSS Constellation Simulator

GSS7735 Multi-Channel GPS L1/L2 production test simulator

However, during the past decade, a number of alternative devices have emerged that claim to offer a complementary or alternative to GNSS simulation in a number of different ways.
The mix now includes (in no particular order):

- Live sky
- Pseudolites
- RF record and playback systems (RPS)
- Single-channel RF simulators
- Multichannel RF constellation simulators

So where would we use these devices and how do I decide what's right for me? Well that all depends on your test requirements as all approaches bring with them a mix of pros and cons.

The tests required

Laboratory testing of any GNSS receiver design *will require a range of standard tests* in order to exercise the *full functionality* of the receiver under both “normal” and “special” operating conditions. These tests,* which might be carried out individually or combined, will comprise:

- Time to first fix
- Acquisition sensitivity
- Tracking sensitivity
- Reacquisition time
- Static navigation accuracy
- Dynamic navigation accuracy
- Radio frequency interference

So how does each solution stack up against requirements?

* More information on GNSS Receiver testing can be found by downloading the eBook ‘Simulation Versus Real World Testing’

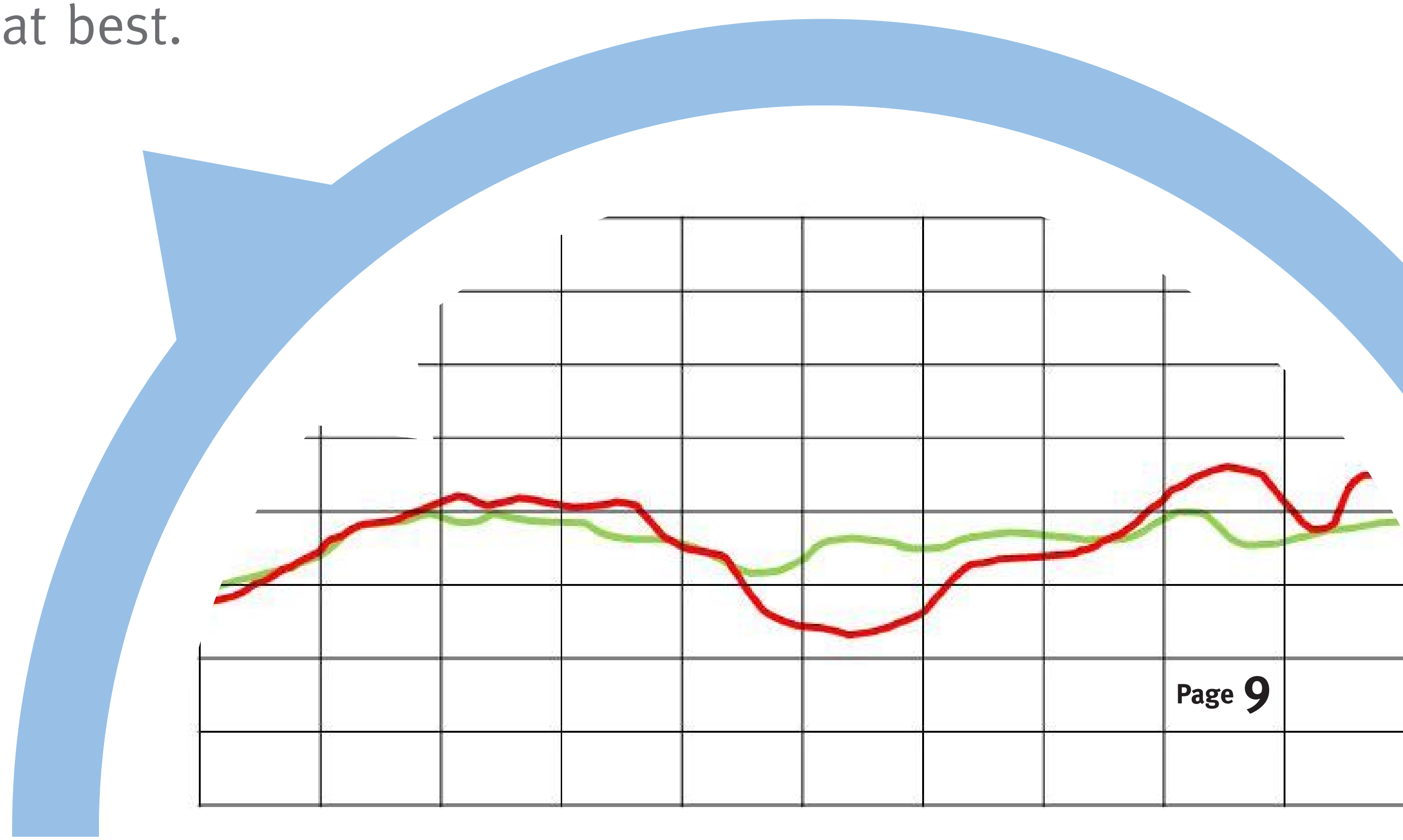
Live sky

The first obstacle that will be encountered *in integrating GNSS* receiver testing into *a production test setup* is pretty obvious. As such tests are performed at the end of the production line, they are inevitably performed indoors.
And regardless of whether the equipment is designed to work indoors or outdoors, the roof and walls of the building will introduce variables into the test that will negate its effectiveness.
So-called “live-sky” testing is therefore impossible without relaying the GNSS signals from outdoors to the production tester.

It is a relatively simple exercise to capture live GNSS signals and re-radiate them within the production test environment. However, this comes with its own set of shortcomings.

First, radiating any signal in such an environment might have unforeseen consequences on other tests that are performed on the product; and conversely, other RF signals and noise within the production test area may well impact on the integrity of the GNSS signals.

More importantly, though, the inherently dynamic nature of GNSS signals means that while each unit may well be tested in the same physical location (i.e. in the production test fixture), the relative positions of the GNSS satellites and the signal pertubations and errors due to propagation conditions will be different for every unit tested. And, not surprisingly, this makes direct comparison between results unreliable at best.



Real-world, live-sky testing does have some advantages e.g. you’re testing real signals and at the very basic level, it’s inexpensive but it has some significant drawbacks which, in practice, preclude controlled testing.

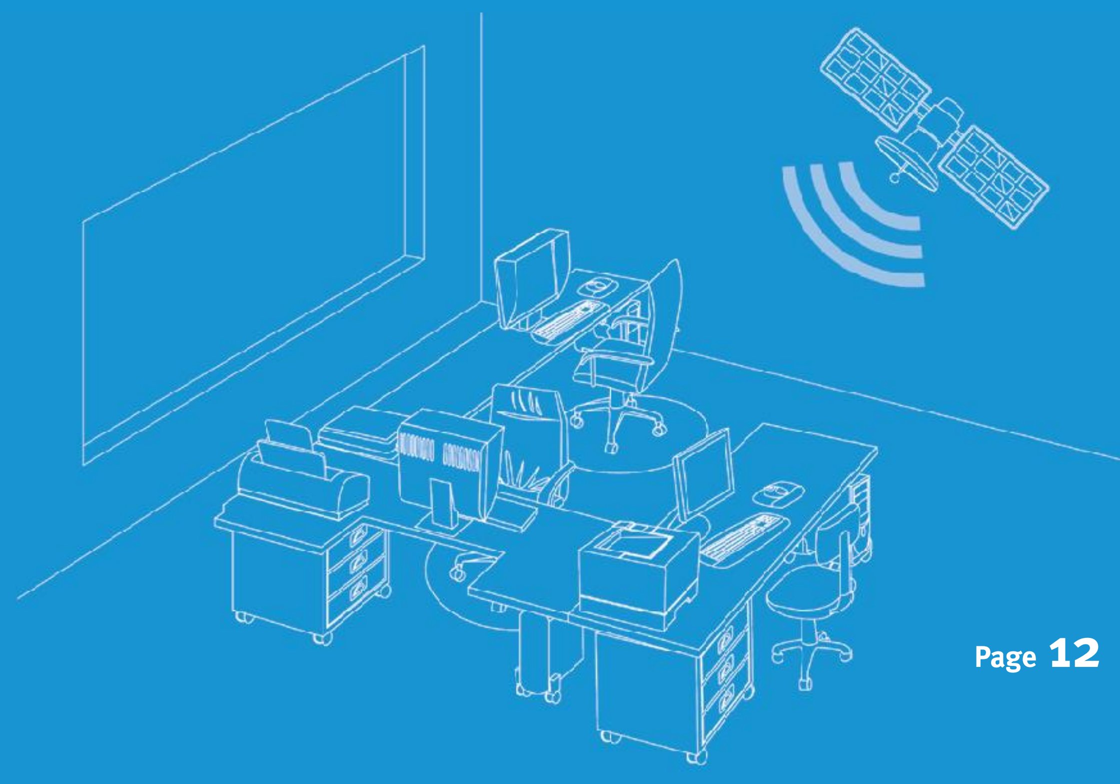
Key points:

- Testing using real signals
- Can be inexpensive
- An end user or test site cannot have any control over the GNSS signal being transmitted
- The signals seen incident to the GPS receiver antenna are constantly changing as the GPS system constantly changes (precesses)

- There are occasional signal errors, often unknown to the receiver at the time
- *Atmospheric conditions* change significantly and have a significant impact on single frequency systems
- Testing at multiple geographic locations proves to be expensive

Pseudolite

A pseudolite (or pseudo satellite) is simply a device used to *emulate the role of a satellite*, and as such can be thought of as a simulator. This class of devices includes transmitters used to augment indoor coverage as well as those used to simulate future satellite constellations before launch.



Key points:

- Pseudolites are not for testing
- They can be used to augment GNSS, but major issues are:
    - *Synchronisation*
    - *Modified receiver needed to cope with high power signals and stationary transmitters*
- Mostly used for professional applications
    - *E.g. mining or use in container ports*

RF record and playback system (RPS)

A GNSS RF RPS does exactly as the name suggests. In simple terms, the whole RF spectrum in a specified bandwidth is downconverted, digitised and stored as samples on suitable storage media.
For playback, the samples are converted back to an analogue signal, up-converted and output at the original RF frequency.

All RF energy in the specified bandwidth is recorded. In addition to the GNSS signals interference is also recorded. This may be from many sources such as other RF communications, broadband interference from electrical systems (vehicle ignition etc.), and even radiation from solar activity. Noise is also inevitably added by the *recording and playback process*, but with appropriate low-noise gain at the start of the process this can be minimised.

In terms of the recorded GNSS signals, these will be as they arrive incident upon the recorder's antenna so they will include the effects of the propagation environment and the satellite and observers' motion, this includes multipath in its full richness, fades, signal loss and carrier phase/signal group delay due to atmospheric influences.

Key points:

- An RPS gives you the power and flexibility of performing one field test and repeating it many times in the lab.
- Records all signals in band
- Record real world environments and effects
- Can be a cost effective solution

- RPS is complementary to GNSS simulation and is important for the verification part of a complete GNSS test plan, where precise knowledge of the test signal is not important, but precise repeatability of the signal 'richness' of the real world is
- You can't test future signals e.g. Galileo
- Results can be difficult to interpret
- RPS has limited control
- Ideal for testing in complex environments, where recreation of signal and fading effects in a simulator is a major challenge

Single channel RF simulators

On the face of it, a simple single channel RF simulator would appear to be suitable for GNSS receiver testing. However, many of the range of tests required (see page 2) are not possible. Single channel units are widely used for *production testing* where "stimulation" of one receiver channel as a Go/NoGo or sensitivity test is enough to determine the circuitry works. For R&D testing a single channel can help with simulating the receiver RF and enabling single channel tracking and sensitivity measurements. However, there is more to testing a GNSS receiver than simply producing a signal at the correct frequency.

Key points:

- Without the ability to simulate a full satellite constellation a receiver cannot be fully tested for its primary function
- As future receiver tests will include more than just GPS L1 C/A code, a single channel RF simulator should have the capability to test GLONASS L1 and Galileo L1 either out of the box or through a field upgrade
- RF power level accuracy and stability are important to ensure valid results

Multichannel RF constellation simulators

There is, however, one solution that is capable of handling all of the tests necessary for designing, developing and integrating GNSS receivers in the laboratory.

The multichannel GNSS constellation simulator is capable of running all seven standard tests of GNSS receiver performance, together with their individual variations.

What's more, today's simulators can be used to produce signals from satellite constellations that do not yet exist in the real world, allowing *developers* to create multi-GNSS designs that will work reliably with GPS, GLONASS, Galileo and Compass systems.

This type of equipment is widely used for R&D, integration, validation, production and post sales testing.

Key points:

- A multichannel GNSS constellation simulator should provide the capability to recreate the GNSS RF signal in such way that it should be fully representative of the real signal expected by a receiver
- It should allow a user to control the simulation environment and all parameters of the signal should be known to the user
- A multichannel GNSS constellation simulator should enable the provision of complete repeatability in the signal creation
- Results are easily interpreted, quantifiable and certifiable
- You’re not testing real world signals

To complement simulation testing at the verification stage, the expense of field trials can be dramatically reduced by bringing the real-world back to the Lab with a Record & Playback System (RPS).

Conclusion

While the majority of the simulation options offer some of the attributes required for testing GNSS receivers, many of these instruments also have their shortcomings but as mentioned previously, it depends on your test application.

The key point to note is that the markets we operate in are changing fast. The GPS system is being modernized, GLONASS is almost at full strength, Galileo and Compass signals will be coming online over the next few years. *Augmentation systems* such as EGNOS, WAAS and the soon to be GAGAN and QZSS systems add to the mix of signals and technologies available to those developing GNSS.

Any system you are looking to purchase must be able to support these signals now or have a defined roadmap of when that support will be available.

At Spirent we advocate a progressive approach to testing, incorporating simulation, Record & Playback with final confirmation using real world signals:

Progressive testing approaches

Simulation

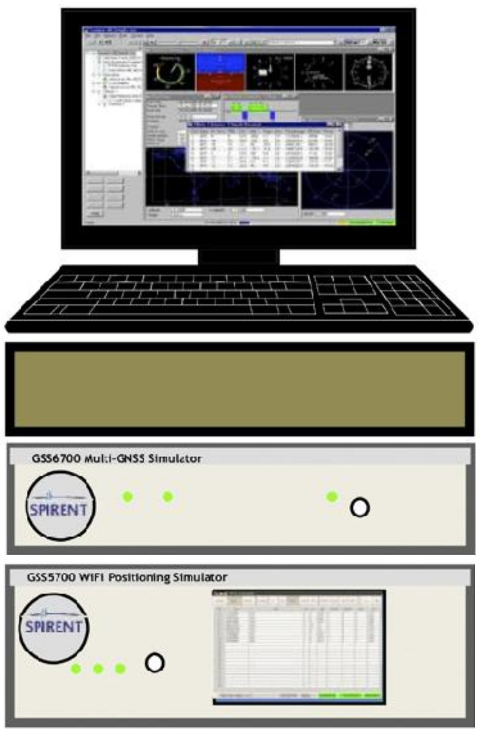
Performance evaluation

Threat modes

Failure modes

Safety cases

Statistical results analysis



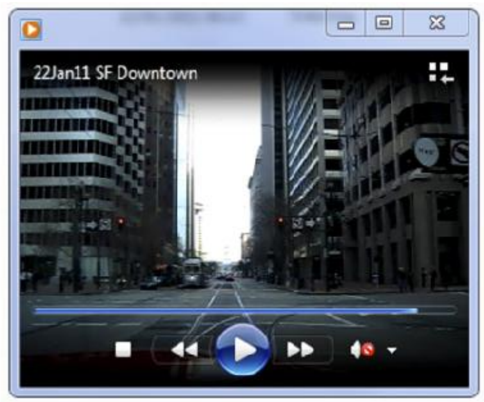
Record & Playback

Environment capture

Performance tuning

Known problem areas

Optimisation



Live Drive Testing

Final confirmation

The Spirent GNSS and Wi-Fi Solutions

Spirent is the industry leader for GNSS simulator products. Digital RF signal generation techniques patented by Spirent have led to the development of high-fidelity, world-leading GNSS RF Simulation Systems.

Spirent offers several different models of GNSS simulators that support a variety of different applications and cover the full spectrum of civilian and military GNSS testing needs.

Spirent products range from basic single-channel simulators, suitable for simple production testing, through multi-channel, multi-constellation simulators, suitable for the most demanding research and engineering applications.

For more comprehensive testing, Spirent also offers products that simulate additional system elements simultaneously with the GNSS constellation signals, such as inertial sensors, various automotive sensors, Assisted GPS (A-GPS) + Assisted GLONASS (A-GLONASS) data, SBAS and GBAS augmentation system signals, interference signals, GNSS Record & Playback and Wi-Fi Positioning.

Spirent GSS8000
Multi-GNSS Constellation Simulator

Spirent GSS6700
Multi-GNSS Constellation system

Spirent GSS6300
Multi-GNSS Signal generator

Spirent GSS6400
Record & Playback System

Spirent GSS5700
Wi-Fi Access Point simulator

If you found this **Spirent Choosing a GNSS simulator** E-Book of interest, we think you'll definitely like the Spirent Application Note: **Multi-GNSS benefits, challenges and test considerations**. Download it here.

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