Testing Multi-GNSS in an R&D Environment

From GPS to Multi-GNSS

SPIRENT®

A host of benefits

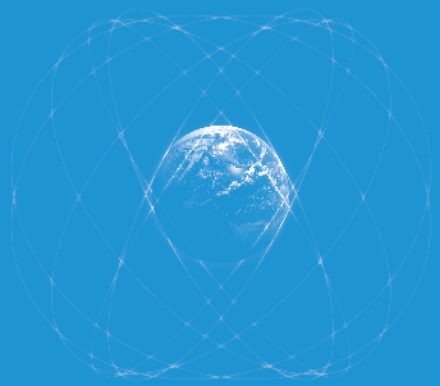
The shift from individual satellite navigation systems using GPS to next-generation receivers capable of exploiting multiple global navigational satellite systems (Multi-GNSS) offers a host of benefits in terms of improved coverage and accuracy and in new services.

However, this switch to *Multi-GNSS* dictates that manufacturers take a different approach to testing their products to ensure that they will function as desired, regardless of which satellite signals can be acquired at any given time. And that new approach has to start at the beginning of the product development process – in the research and development lab.

So many systems

The problem is that while systems such as *GLONASS*, *Galileo*, the soon to be upgraded *GPS* and *Compass* are functionally similar, there are major differences in the way they go about their respective tasks.

Different constellations broadcast on different frequencies. Modulation schemes differ. Timebases differ. Different systems even use different mathematical models for ionospheric modelling.



As a result, the range of tests required in the *R&D laboratory* is considerably wider than those traditionally used in the development of *"vanilla" GPS receivers*.

The simulation solution

A Multi-GNSS simulator provides an effective and efficient means to test GNSS receivers and the systems that rely on them. With a Multi-GNSS simulator, every time a test scenario is run, the signals produced are identical. The *scenario* will start at the same time and on the same date, and the satellite positions will be identical – even down to the relative phase offsets between the different signals.

In this way you can guarantee that the receiver is being simulated with exactly the same signals every time the test is run. Only this way can you fully determine any improvement (or otherwise) the design alterations have made.

What's more, a suitable simulator will be *capable of upgrading* to simulate other GNSS signals as soon as they have been defined by the system operator.

The tests required

In the development process of any GNSS receiver, there are two distinct levels of tests that will be applied.

Basic tests are those that exercise the simplest underlying functionality of the receiver.

Advanced tests cover those that recreate “unusual” situations and also those that exploit novel applications outside the basic functionality of the receiver.

Basic R&D testing

In testing the underlying functionality of any GNSS receiver design in the laboratory, it is essential that the equipment is subjected to a known and repeatable stimulus so that the correct response can be assessed and the performance can be adjusted accordingly.

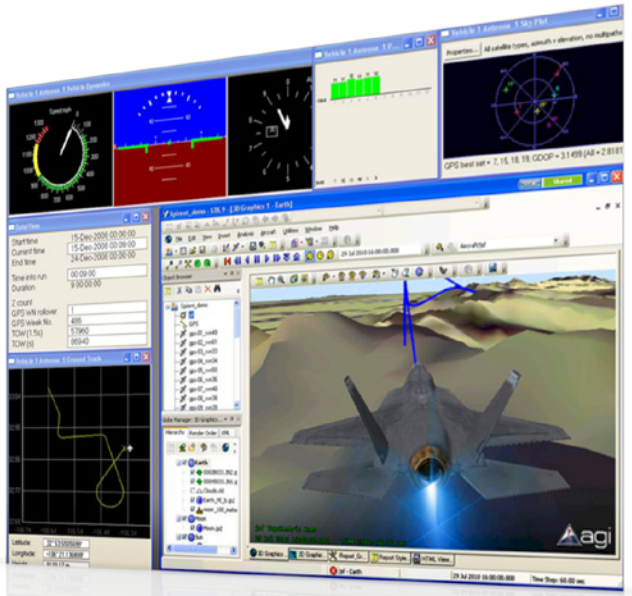
At the simplest level, the receiver is supplied with a reference signal with a navigation message consistent with the relevant ICD or interface control document. This allows the designer to verify the receiver's algorithms for decoding the messages and recovering time synchronisation. It also allows the designer to optimise the accuracy and sensitivity of the receiver.

Other basic tests at this level include the receiver's one pulse per second (1PPS) performance, together with *static* and dynamic accuracy and time to *first fix (TTFF)*.

Advanced R&D testing

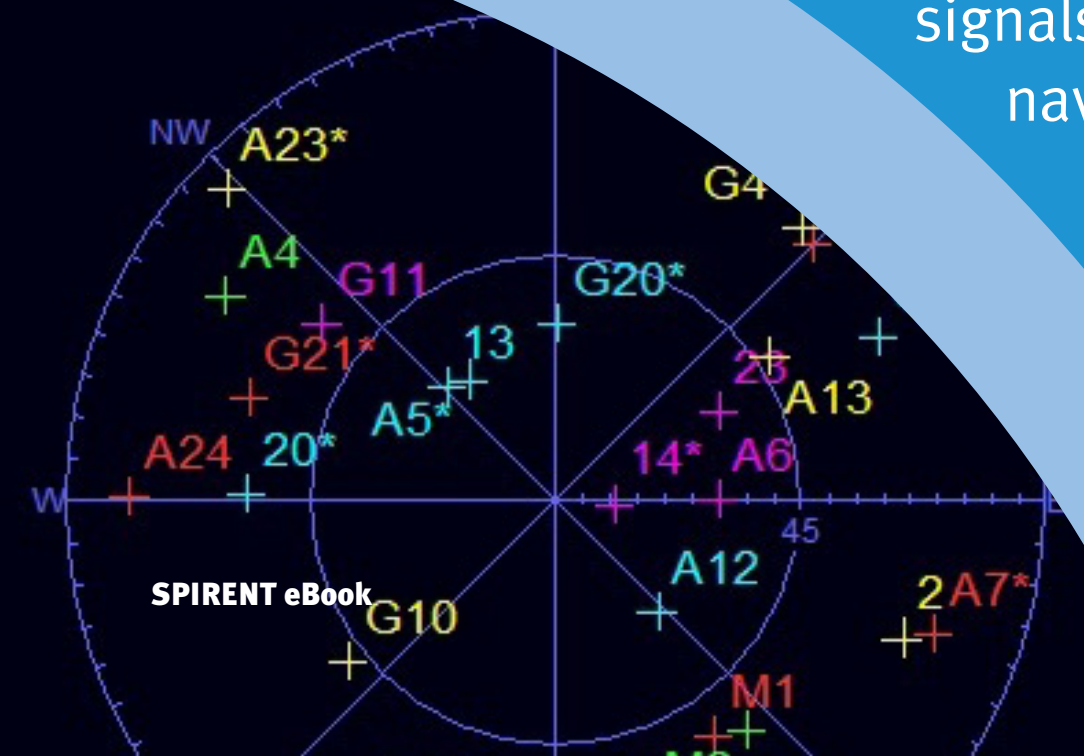
The key to any advanced R&D testing is the ability to simulate a specific scenario with absolute repeatability so that adjustments can be made and the test can be re-applied. These scenarios can be of almost any nature, and while each one may be unlikely to occur in real life, a reliable Multi-GNSS receiver will be expected to perform reliably under all possible conditions.

Clearly, because these scenarios are unlikely, it is impossible to "create" them in real life without a simulator (let alone recreate them for a second test). The simulator enables easy creation of a library of performance tests ready to apply to the receiver.
These tests can then be combined and enhanced to create ever more complex test scenarios that can be saved and used over again with absolute repeatability.



The Multi-GNSS angle

Even at the most basic level, it is important to test the Multi-GNSS capabilities of the receiver. The basic tests of signal and truth data references should be repeated for each GNSS with which the receiver is intended to operate. So (currently) this will mean applying GPS, GLONASS and *Galileo* reference signals and decoding their respective navigation messages.



This multiple signal testing will also exercise the frequency agility of the receiver design. For while both GPS and Galileo broadcast their L1 civilian signals in a band centred on 1575.42MHz, the GLONASS civilian signal is broadcast in a band from 1598MHz to 1605MHz.

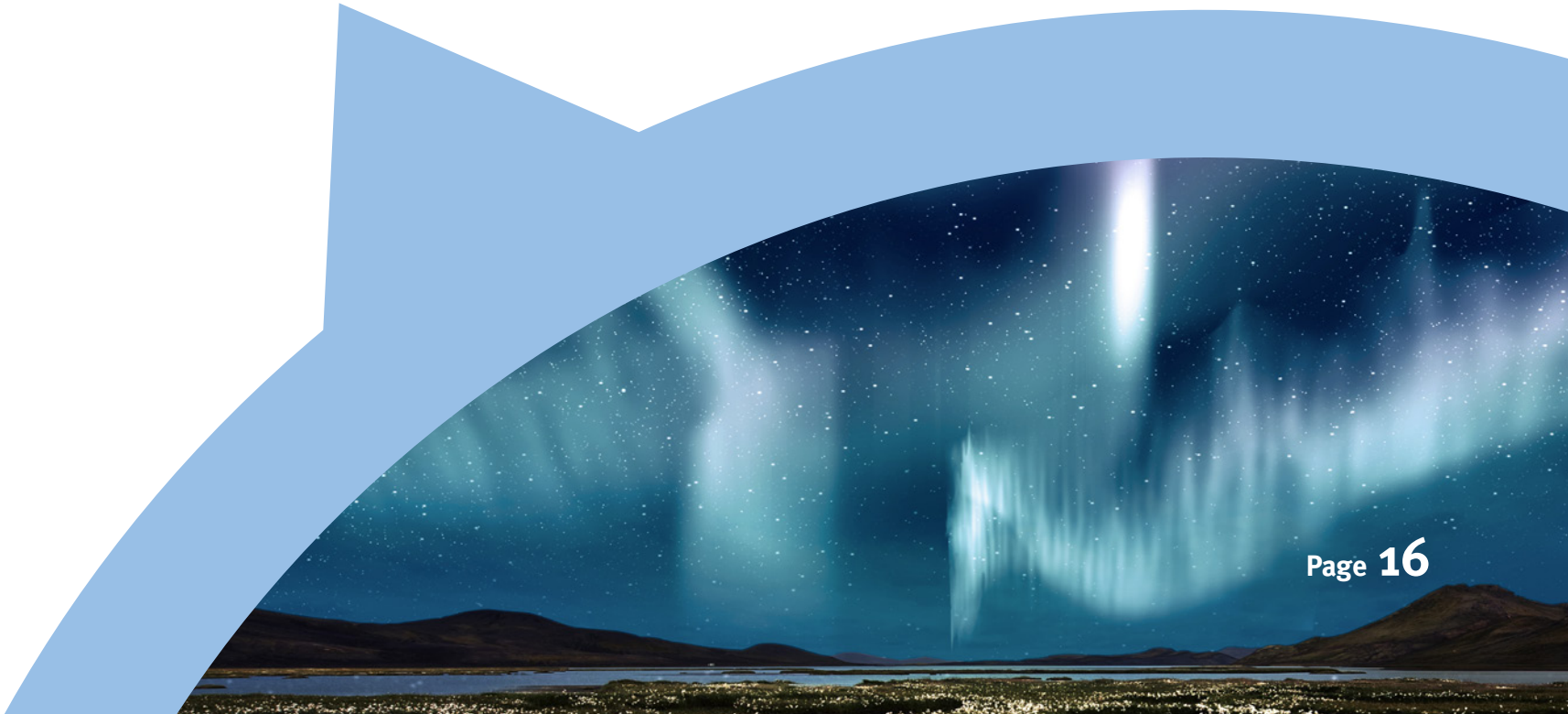
And the ability to apply all these tests from the same simulator will remove a number of potential error sources from the test setup.

Advanced Multi-GNSS testing

One critical difference in testing a Multi-GNSS receiver compared with one destined for use on a single system is in its ability to handle all the various different models used by each satellite system. And while GPS, Galileo and GLONASS use the same co-ordinate frames, GPS has its own timebase, which differs from the other two systems, which are tied to the global *UTC time system*.

Similarly, while GPS uses the *Klobuchar model* to correct for errors induced by ionospheric effects, Galileo will use the NeQuick model.

Fortunately, a Multi-GNSS simulator can account for these differences, and will supply the signals exactly as they would appear to the receiver in the real world, allowing R&D testing to predict real-world performance way in advance of the “real” signals being available.



Mixed messages

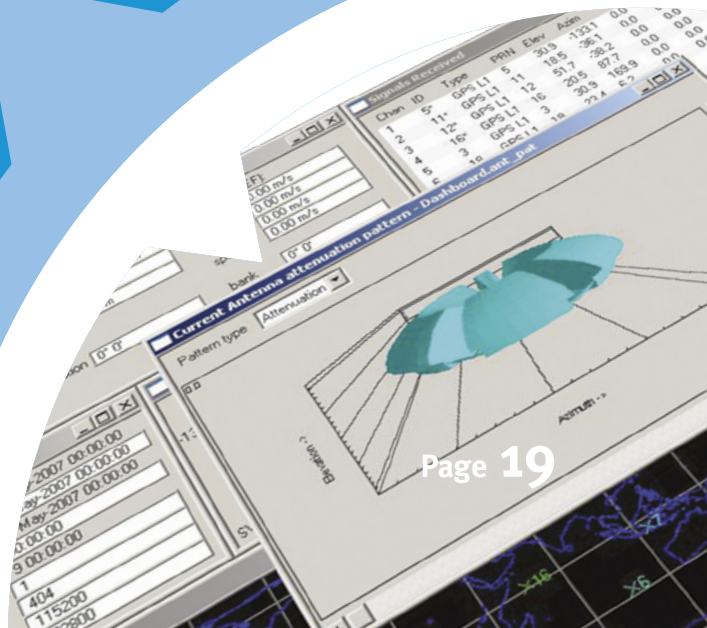
So while the designer will want to assess any new receiver design for its performance against all the standard GNSS tests, it is essential that these tests are run for each GNSS for which the receiver is designed.

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

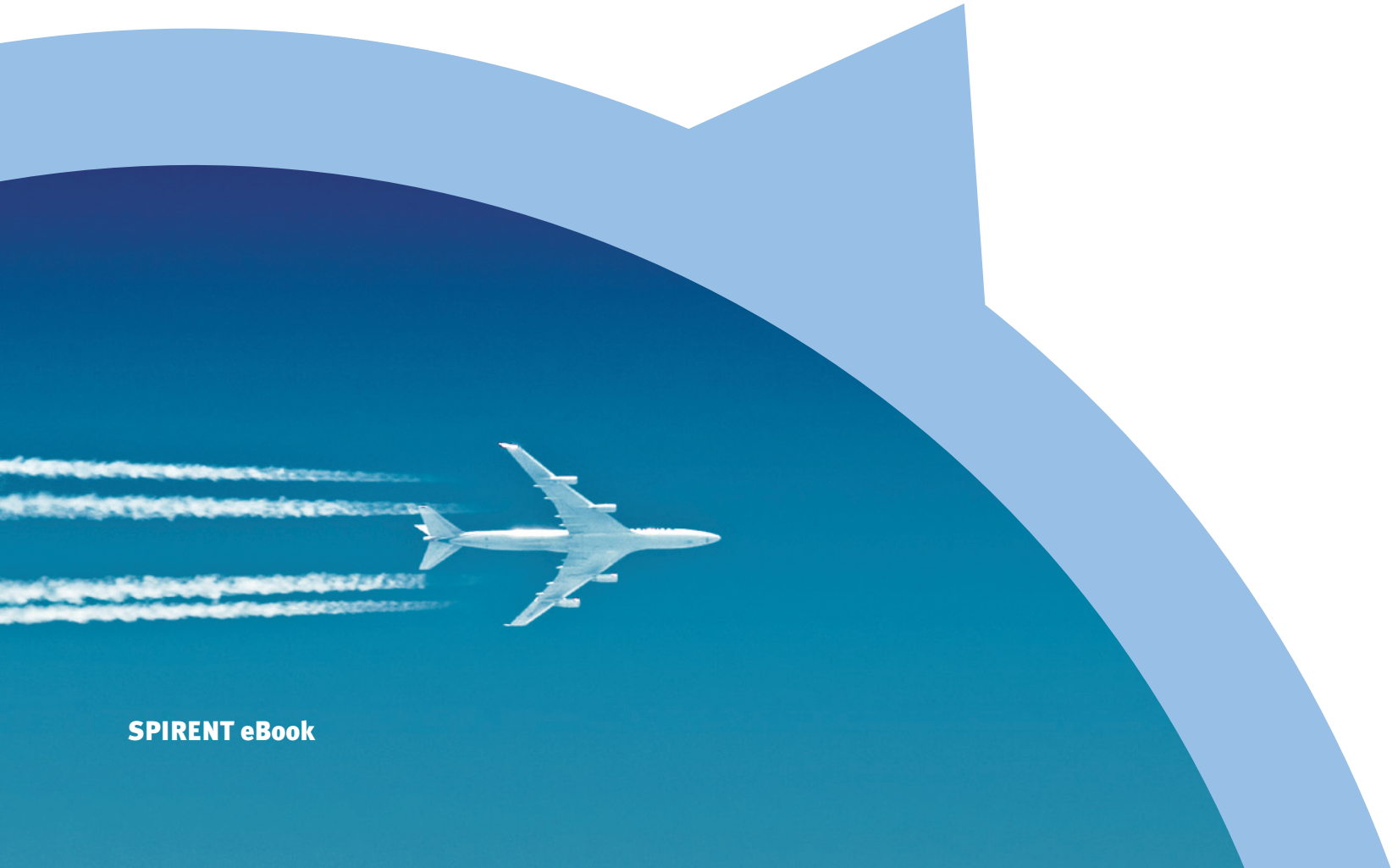
But the true Multi-GNSS receiver should be able to produce workable results even when working with partial signals from multiple systems. It is only by using a multichannel Multi-GNSS simulator that this performance can be readily assessed and the design refined to improve it.

Application-specific testing

Certain tests at this stage will depend on the intended end application of the Multi-GNSS receiver. These might be automotive-specific tests, avionics-specific tests (which might involve the receiver and its antenna being at any range of angles depending on vehicle manoevres) or space-specific tests.



In each case, the simulator will either provide suitable ready-written tests, or can be programmed with the *relevant scenarios*, which can then be replayed with absolute repeatability, time and time again.



State-of-the-art simulation simplifies R&D

The switch from simple GPS navigation to the use of multiple satellite systems is bringing a new set of challenges to *receiver designers*. However, exhaustive testing in the R&D laboratory can give designers the confidence that their new Multi-GNSS receiver designs will perform as intended once they enter service.

The list of tests required is extensive, and "live-sky" testing using "real" signals from "real" satellites is not an option.

A multichannel Multi-GNSS simulator will allow all the necessary tests to be run using signals from single and multiple GNSSs. And the ability to “mix and match” signals from different systems will allow designers to create receivers that can perform reliably anywhere in the world.

The Spirent GNSS and Wi-Fi Solutions

Spirent is the industry leader for GNSS simulator products. 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

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