Ten Factors to Consider when Testing New GNSS Chipset Designs

A Spirent eBook

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Introduction

Satellite navigation and positioning technologies have been with us for many years, but so far they've only scratched the surface of what's possible. Now, several developments are contributing to an explosion in innovation in consumer, civilian and military markets, opening up huge opportunities for designers of GNSS chipsets.

The introduction of new satellite constellations and the increasing sophistication of alternative positioning technologies are driving advances in GNSS receivers, software applications and device form factors. The result is a booming market for location-based services, ranging from basic photo geotagging to ultra-high-precision positioning for automotive, aerospace and military use.

These are exciting times for GNSS chipset designers, with lots to gain for those who are first to market with high-quality, innovative products. Testing is a critical part of the development process, whether you're working in a commercial R&D team or an academic research lab. But testing can also hold up the process for weeks or months, tying up time and resources and delaying market entry.

This ebook is about how to make the testing process as fast, efficient and cost-effective as possible, without sacrificing any of the rigour that goes into developing an outstanding new product. It covers 10 factors that a GNSS chipset design team should consider when setting out to test a prototype, and considers ways in which those factors can be addressed simply and affordably.

Ten Key Considerations

Drawing on our 25 years as the market leader in GNSS testing, we've identified 10 key factors to consider when testing the performance of a new chipset design or prototype at the R&D stage:

1. **Live sky testing vs simulation:** best practice in testing approaches

2. **Basic performance tests:** the nine key tests of receiver performance

3. **Application-specific performance:** ensuring the chipset functions in the intended application

4. **Multi-GNSS support:** future-proofing designs as new constellations come onstream

5. <u>Hybrid positioning</u>: how to test for **"accuracy everywhere"**

6. <u>Interference</u>: understanding how different kinds of interference may affect receiver performance

7. <u>Real-world verification</u>: techniques to increase the speed and efficiency of field testing

8. <u>Preparing for certification</u>: using testing to accelerate the submission process

9. <u>Increasing sales to OEMs</u>: using test data to demonstrate quality and accelerate the sales process

10. <u>Choosing the right equipment</u>: making sure you have the kit you need

1. Live Sky vs Simulation

Since the early days of GNSS, there have been two alternatives available to those wishing to test a navigation system: field test and laboratory simulation.

While GPS was the only GNSS available for the majority of applications, live sky testing was a viable (if expensive and flawed) option. Today, the switch from simple GPS navigation to the use of multiple satellite systems means live sky testing for new designs is no longer an option.

Firstly, designers now need to test receiver performance with GNSS systems that are either only partially live (such as Galileo), or not yet live at all (such as Compass).

Secondly, the emergence of multiple additional positioning technologies, such as Wi-Fi, cellular, satellite augmentation systems and sensor-based systems, means designers need to test chipsets in environments that present a mixture of signals, which is extremely difficult to do in the real world.

Thirdly, designers of today's high-precision receivers need to understand how the chipset performs in a wide variety of conditions, including extremes of temperature and pressure, and how it handles multiple types of interference, some of which may be extremely rare (but still critical to test).

For these reasons, best practice indicates that the majority of tests are done under controlled, repeatable conditions in a secure laboratory using one or more RF simulator units. This not only provides the accuracy that designers need, but also simplifies testing in four key ways:

1. It's faster: much of the testing with RF simulation can be automated, meaning tests can run constantly, including overnight, with no human intervention. It's also much quicker to get going in the lab than it is to transport vehicles, staff and equipment to and from field test locations.

2. It's cheaper: RF simulation removes the logistical cost of field testing, and its high level of automation means it requires fewer man-hours and can be completed with smaller testing teams.

3. It's more accurate: in contrast to the live sky environment, which is constantly changing, simulated scenarios can be repeated again and again. This enables accurate comparative testing (e.g. of different chipsets during the vendor selection process) and removes any uncertainty around whether changes in performance are due to the signal environment or the product design.

4. It's more flexible: lab simulation lets you generate any combination of signals and conditions that you need to test. You can model constellations and signals that do not yet exist in the real world. You can also easily test hybrid positioning capabilities by modelling combinations of satellite, Wi-Fi and sensor signals.

For more about the benefits of RF simulation, read our eBook: The risks and limitations of GNSS live sky testing

2. Basic Performance Tests

No matter what the intended end-user application, every new receiver needs to be able to conduct a number of basic tasks effectively, from quickly acquiring an initial fix to coping adequately with common types of interference such as multipath effects and signal obscuration.

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.

While a receiver's desired capabilities will vary depending on its intended use, Spirent recommends nine basic tests to assess and verify the performance of any GNSS receiver design or design iteration.

1. **Cold-start time to first fix:** starting a receiver from scratch – the first experience a user will have

2. **Warm-start time to first fix:** as above, but with the time and almanac in the receiver's memory

3. **Hot-start time to first fix:** re-starting the receiver with time, almanac and ephemeris data, within 100km of the last fix

4. **Acquisition sensitivity:** the minimum received power level at which the receiver can obtain a fix

5. **Tracking sensitivity:** the minimum power level at which the receiver can maintain lock

6. **Reacquisition time:** time taken to reacquire the signal after passing through an obstacle

7. **Static navigation accuracy:** taking into account the many internal and external variables that can affect receiver performance

8. **Dynamic navigation accuracy:** accuracy while the receiver is in motion on one, two or three axes

9. **Radio frequency interference:** susceptibility to incidental or intentional ('jamming') radio interference

Conducting these nine basic tests as standard, using an RF simulator to guarantee that the test scenario and parameters are identical each time, removes significant amounts of time, effort and uncertainty from the testing process.

For more information, read our ebook:
Simulation versus real world testing

3. Application-specific performance

In addition to the nine standard tests mentioned above, designers will also want to conduct a raft of more specific tests relating to the intended end-application of the receiver. These might be automotive-specific, avionics-specific (which might involve, for example, the receiver and its antenna being at any range of angles depending on vehicle manoeuvres) or space-specific.

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 GNSS receiver will be expected to perform reliably under all possible conditions.

In each case, using a GNSS simulator will accelerate and simplify the testing process either by providing suitable ready-written tests, or by storing custom-coded scenarios that can then be replayed with absolute repeatability, time and time again.

For more information, read our ebook: Testing GNSS-Enabled devices for industry: Chip selection

4. Multi-GNSS Support:

The vast majority of new chipsets being developed today are capable of receiving and processing signals from more than one satellite system, and multi-GNSS support is now a key consideration in almost every GNSS chipset R&D lab.

As new constellations go live, there are many opportunities to enhance coverage and positioning accuracy, and open up new geographical markets, by including support for new GNSS such as GLONASS, Galileo and smaller regional and augmentation systems in addition to GPS.

Designers with an eye to future-proofing receivers will also want to include automatic upgrades for forthcoming constellations such as Compass 2 (Beidou) and planned additions to Galileo. That means ensuring the receiver performs as intended with signals that are not yet available in the live sky.

The problem is that while these systems are functionally similar, there are major differences in the way they go about their respective tasks. Different constellations broadcast on different frequencies, have different timebases, and take different approaches to modulation and 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.

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, so you can guarantee that the receiver is being stimulated with exactly the same signals every time the test is run.

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.

A suitable simulator will also be capable of upgrading to simulate other GNSS signals as soon as they have been defined by the system operator.

For more on using Multi-GNSS simulators to increase testing efficiency and accuracy, download our eBook Multi-GNSS for technology developers.

5. Hybrid Positioning

As demand for continuous positioning and indoor location accuracy increases across a broad spectrum of industries, OEMs and integrators are looking for solutions that can also process signals from alternative sources to GNSS.

There is a rapidly growing market for hybrid receivers that can combine positioning information from sources such as Assisted-GPS, Assisted-GLONASS, mobile/cellular networks, Wi-Fi access points and inbuilt motion sensors. These signals can be used to maintain positioning data in areas where GNSS signals are weak or unavailable, such as inside buildings and malls and in urban canyons.

The hybrid positioning market is predicted to be huge: ABI Research estimated in 2009 that hybrid receivers will represent 25% of all positioning solutions by 2014. However, the challenge for chipset designers is creating the best combination of inputs to deliver the kind of positioning accuracy required by the end-application.

Getting an effective product to market will require careful development and a test environment that provides total control over multiple, coherent sources to facilitate iterative improvement. The ability to apply rigorous, iterative performance testing to new hybrid receivers and boards will be critical to success in this booming market.

For more about testing hybrid positioning technologies, download our companion eBook: Hybrid Positioning.

6. Interference

GNSS signal interference may take many forms, some common and some extremely rare. A good R&D team will want to understand how the receiver copes with all kinds of interference, from simple multipath effects to intentional and unintentional signal jamming, interference from services operating in nearby frequencies, and ionospheric effects such as solar flares.

The key to successful testing for interference 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 some conditions may be unlikely to occur in real life, a reliable Multi-GNSS receiver will be expected to perform reliably in all possible circumstances.

An RF simulator with a fully-featured software platform can model all kinds of interference including multipath, obscuration, signal jamming and ionospheric effects. To save time writing custom code for different scenarios, and to increase the efficiency of the testing process, look for software that has a broad range of test cases already built.

For more information, read our ebook: Testing GNSS System Errors.

7. Real-World Verification:

While the bulk of testing can now be done more easily, more accurately and more cost-effectively in the lab, you will still want to do some live sky testing to verify the performance of the receiver in the real world.

Live sky testing can be made much faster and simpler by recording the real-world signals on an initial field trip, and then replaying them in the lab. Record and playback systems reduce testing, trials and travel costs substantially recording real-life GPS, GLONASS or QZSS signals (including real world fades, multipath and interference) on to the internal hard drive of the unit.

These signals can then be replayed limitless times in the lab, giving you the repeatability you need to accurately compare the performance of different designs or design iterations.

For more about cost-effective live sky testing in the lab, read our eBook An introduction to GNSS RF Record & Playback Systems Pt2

8. Preparing for certification

Before a new GNSS or hybrid chipset design can be commercialised, it may need to be certified by a relevant authority as being of a sufficient standard for the intended end-application.

Depending on the intended use, standards and certification authorities can range from the 3GPP consortium for mobile devices, to the International Maritime Organization for maritime navigational aids and Cospas-Sarsat requirements for GNSS-enabled distress beacons.

The certification process can be a lengthy one, especially if the design is rejected by the standards authority and requires further work in the lab. Months or even years can be lost in the process, during which commercial opportunities and competitive advantages can be lost.

Rigorous testing can help to speed up the certification process, especially where the same test equipment, test cases and scenarios used by the certification authority can also be used for testing in the lab prior to submission. Subjecting the design to the same tests, and producing meaningful reports demonstrating that the receiver passes those tests, can lead to faster certification and greatly increase the likelihood of passing certification first time.

For more information on Chipset Certification, please download our NEW Application Note: Testing GNSS-Enabled devices for industry certification with TestDrive-GNSS.

9. How can I increase sales to OEMs?

OEMs are under pressure to bring new products to market faster than ever, so anything that receiver designers can do to speed up the chipset vendor selection process will be welcome.

Providing evidence of rigorous testing for all capabilities and conditions, together with meaningful, readily-understood reports documenting the results of the tests, can help OEM and integrator partners to understand the receiver's performance quality faster.

Similarly, sharing details of the test cases, scenarios and testing equipment used in the lab can provide valuable guidance to the OEM in setting up their own tests and test environment.

Finally, in applications where there is currently no industry standard or certification authority for receiver quality, R&D organisations that specify and publish a standard set of tests will be better able to demonstrate product quality to prospective OEM partners and their customers.

For more information, read our ebook:
Fundamental GNSS Receiver Characterisation.

10. What's the best equipment for my needs?

Choosing the right equipment – without over-investing in software and hardware that you don't need – is the key to efficient, accurate and cost-effective testing in the lab.

Spirent offers a wide range of equipment that's used in R&D laboratories across the world to accelerate and streamline the testing process. Some of our key products for chipset R&D teams include:

Hardware

Spirent GSS8000 Multi-GNSS Simulator: A comprehensive, highly adaptable tool, designed to meet the simulation requirements of the world's most demanding and pioneering R&D teams. It provides GPS/SBAS, GLONASS and Galileo signals in a single unit. GPS configurations can also support QZSS and SBAS. Classified signals and various options are also available.

Spirent GSS6700 Multi-GNSS Simulator: A powerful, flexible platform for Multi-GNSS development, integration and verification testing. Multi-GNSS Simulation System offers multiple channels of GPS/SBAS, GLONASS and/or Galileo L1 signals.

Spirent GSS6400 Record and Playback System: a complete, standalone system for capturing live GNSS RF data in the field and replaying it with optimal fidelity and performance back in the lab.

Spirent GSS5700 Wi-Fi Simulator: a practical, intuitive instrument for testing Wi-Fi positioning technology in the lab – either as a standalone solution, or in tandem with Spirent's Multi-GNSS simulation systems. (Simulators for individual constellations, regional augmentation systems and hybrid positioning are also available – see the Solution Directory for details.)

Spirent GSS6300 Multi-GNSS Signal Generator: The ideal solution for high volume, Multi-GNSS manufacturing environments.

Software

SimGEN™: A fully flexible software suite designed for R&D use. SimGEN™ offers complete, flexible scenario generation capability including control of the constellations, propagation, terrain obscuration, antenna patterns, multipath, vehicle trajectory and a range of error models.

Spirent TestDrive-GNSS: A fully automated performance testing solution for GNSS-enabled equipment. It works with the GSS6700 and GSS8000 series of Spirent Multi-GNSS simulators to create an integrated test solution that enables performance characterisation of GNSS receiver equipment by means of RF simulation. It is compatible with Spirent's SimGEN™ RF simulation software.

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.

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For more information, read our ebook: Choosing a GNSS simulator.

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