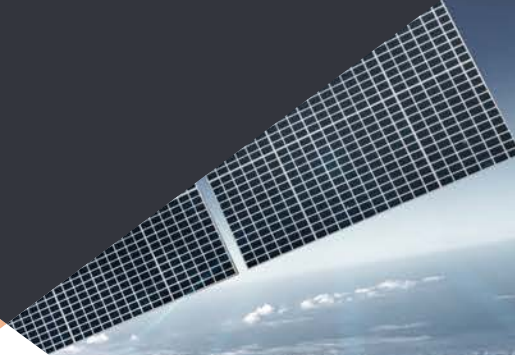


GNSS Simulation

A Guide to Testing



A guide to the terms and techniques used to
successfully simulate GNSS RF signals



Time To First Fix (TTFF)

What is Time to First Fix?

When a GNSS receiver is turned on, it searches for satellite signals and this process is called acquisition. Once it has acquired signals it tracks them to calculate its position, or fix. The time taken from switch on to a valid location fix is known as Time to First Fix or TTFF.

In order to calculate a valid location fix, the GNSS receiver requires almanac data and ephemeris data in addition to the GNSS satellite signals.

Almanac Data

Almanac data contains coarse orbital and status information for all satellites within a constellation. Every satellite broadcasts the almanac data for the whole constellation so that a receiver can approximate the locations of all satellites and determine which it should track. By only focussing on those above the elevation mask, the receiver narrows its search and saves time on acquiring a position fix.

Ephemeris Data

Ephemeris data contains very precise data on the orbital path and position of each satellite, including clock correction data. This allows a receiver to accurately locate an individual satellite at any time. Each satellite only broadcasts its own ephemeris data.



When conducting TTFB testing, there are three conditions that should be tested: Cold Start, Warm Start and Hot Start. These simply refer to what data is available to the receiver when it is turned on.

Cold Start



A cold start state usually occurs when a receiver is turned on for the first time, has intentionally undergone a factory reset or has been manually cold started. After a cold start, the receiver has no time, position, almanac or ephemeris data available to it and must therefore complete a full search of the sky for satellites.

Warm Start



A warm start state usually occurs when a receiver has been switched off for a day or two or has moved up to 100km from its last known position. It will know the approximate time and position, and will have retained valid almanac data, stored from the last time it was on. However, it will not have any ephemeris data as this either was not stored or will be outdated.

Hot Start



A hot start state usually implies the receiver has been off for only a few hours. It will have retained its approximate time and position, and valid almanac and ephemeris data. In this condition, the receiver can quickly locate and track satellites that are overhead and Time to First Fix should only take a few seconds.

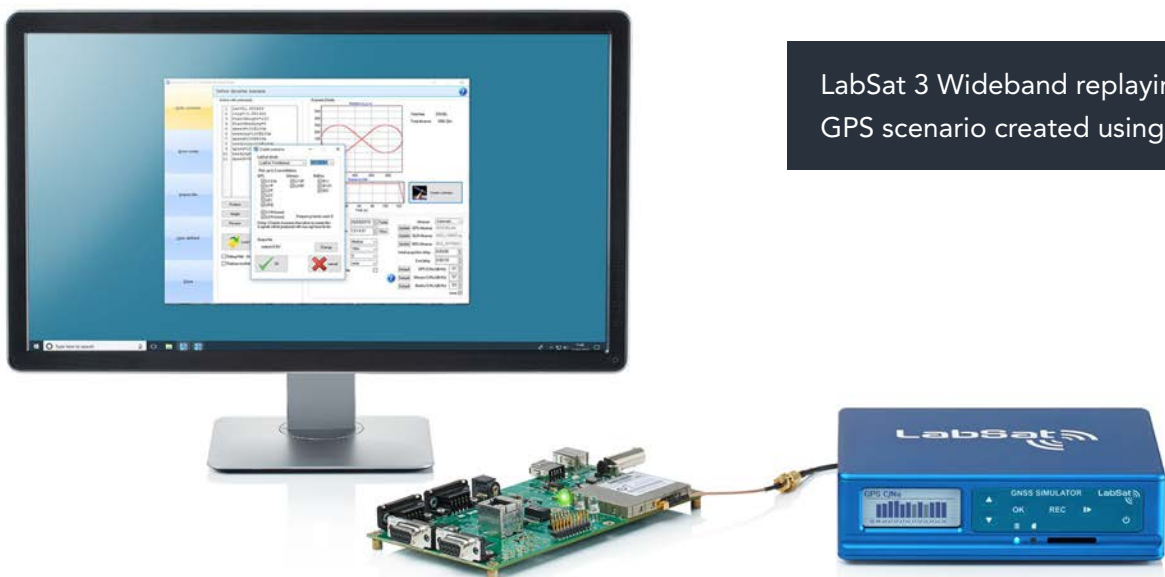
Why Test Time to First Fix?

Time to First Fix fundamentally measures the time taken from when a device is switched on, to when it has gained a position fix so that GNSS capabilities can be used. It is a key performance metric for any receiver or GNSS device. Almost all GNSS device users want their device to be operational as quickly as possible, making TTFB one of the most popular GNSS receiver tests and standards.

Why Use a Simulator to Test TTFF?

Generally, when testing TTFF it is advisable to use a GNSS simulator to conduct the testing. The use of a simulator is preferable to live-sky testing as it is quicker, more convenient and allows for exact and consistent signal parameters including signal stability and noise levels.

When using a LabSat simulator you have the choice between recording a live-sky scenario and replaying this as your test RF signal, or create a bespoke scenario at the time, date and location of your choosing by using the SatGen simulation software. Both methods allow complete control over the scenarios for repeatable and consistent testing.



LabSat 3 Wideband replaying a GPS scenario created using SatGen

LabSat's Application Programming Interface (API) provides additional control and testing automation as scenarios can be programmed to automatically repeat or play in a set order. This improves efficiency by allowing significant testing programmes to be run continuously, without the need of human supervision.

Further efficiency can also be gained by testing multiple devices at once with a single LabSat. Adding an RF splitter into your test set-up allows multiple devices to receive the same test signal.

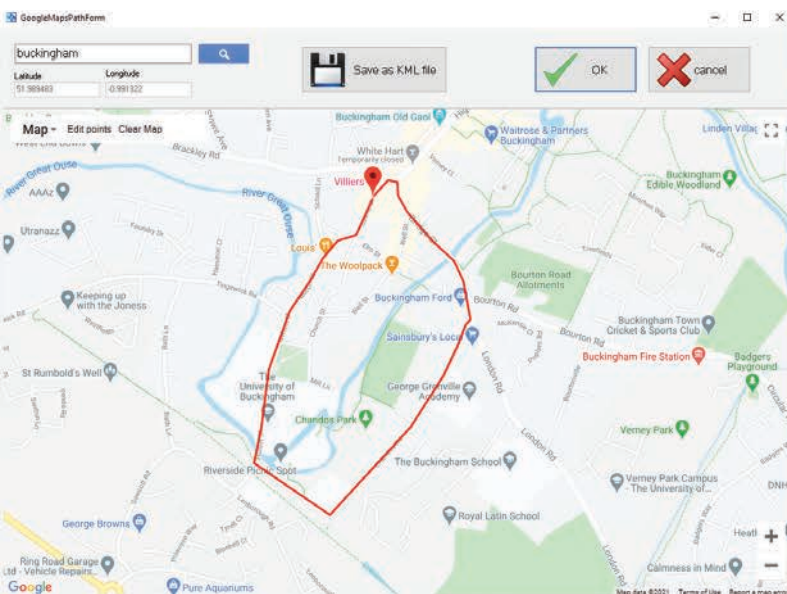
The level of control afforded by a LabSat Record & Replay simulator extends to the ability to test individual or combinations of constellations and signals. This is ideal for testing multi-constellation receivers, the use of which is increasing across most sectors.

How to Test Time To First Fix?

When conducting your TTFF test there are a range of parameters that you should consider and select based on the technical capabilities of your product and its realistic, intended use by the end user.

Type of scenario

The scenario that you record or create for your test should be based on a likely user case. Is your product intended to be used in a static or dynamic manner, is it likely to encounter multi-path or other inference? There is little point in using a static scenario set in an open field if your device will be used in an urban environment while moving.



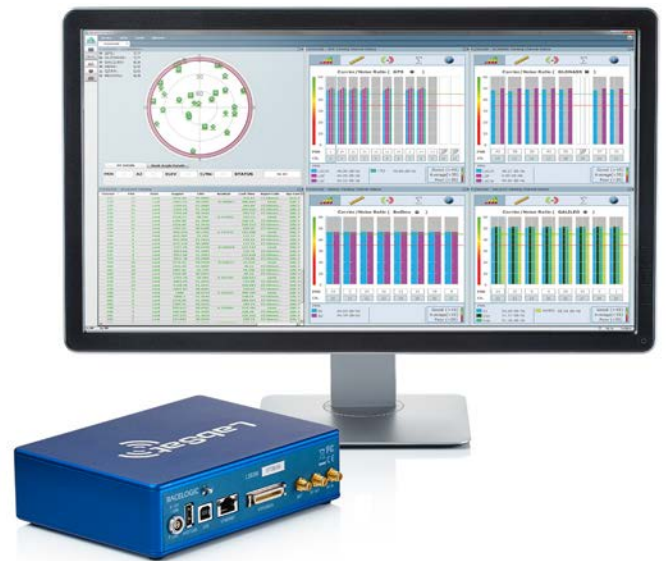
Create GPS RF scenarios which replicate real world conditions

Range of scenarios

It is advisable to complete the tests using a range of scenarios that represent different user cases. These might represent vast differences in environment on a global scale or they could represent micro-differences within a specific environment. By performing tests using a range of scenarios you will gain more accurate results on performance and prove robustness.

Range of constellations and signals

If your device can track multiple constellations or multiple frequencies, then this should be included in your testing. The testing of individual and combined constellations and signals should be completed across the scenarios already defined by type and range (see above). This will ensure that all are functioning within expected limits and that any issue with a particular constellation or signal is not being masked by operational ones.

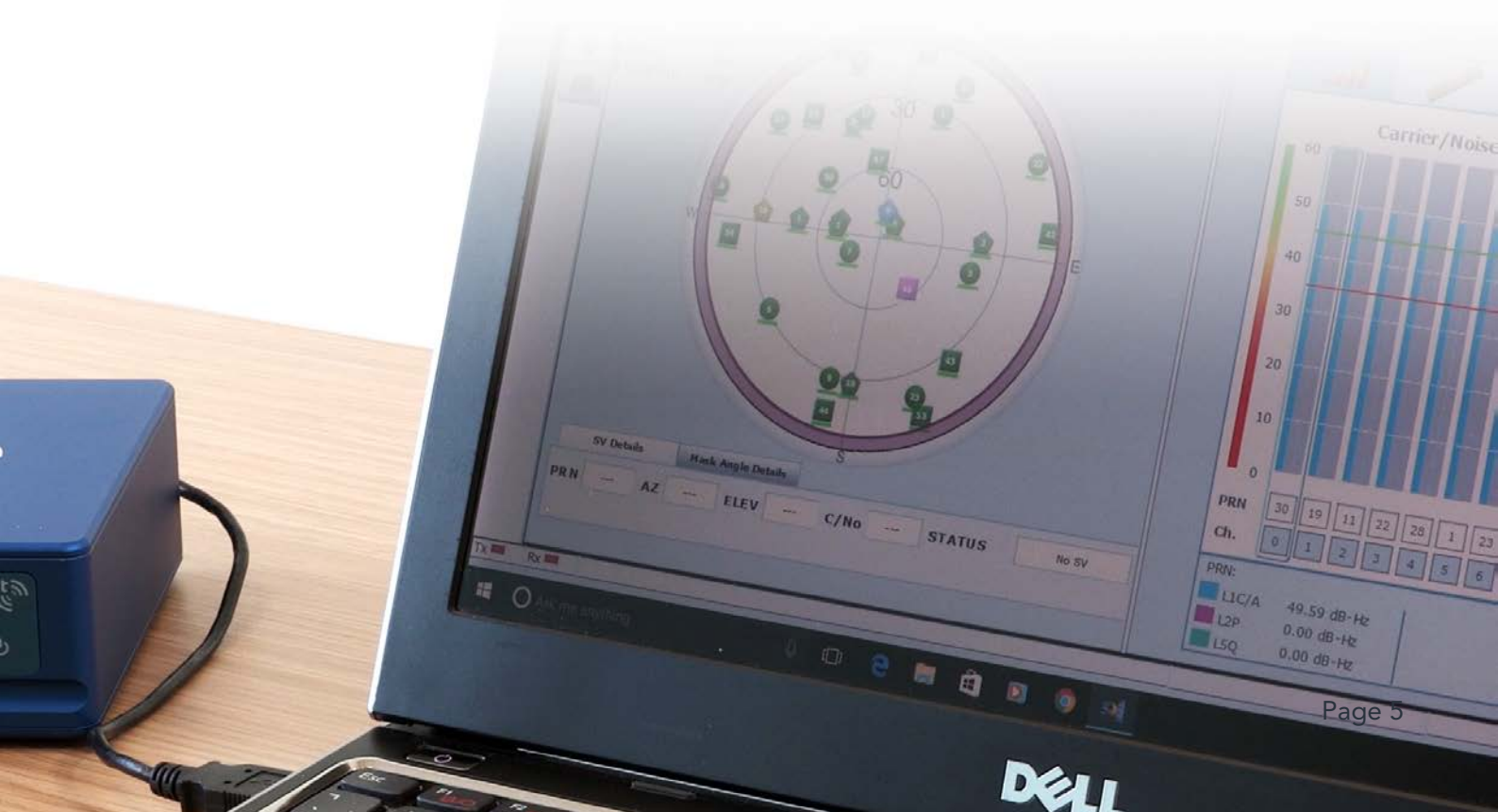


Cold, warm and hot starts

It is important to test that your device performs adequately in all three starting states as poor performance in any state could lead to user dissatisfaction.

Repeatability

As with any test, it is essential that the test parameters are accurately repeatable to ensure robust results. For the most accurate results, it is advisable to repeat the tests multiple times and take an average time. Using a simulator is an excellent way of ensuring accurate repeatability.



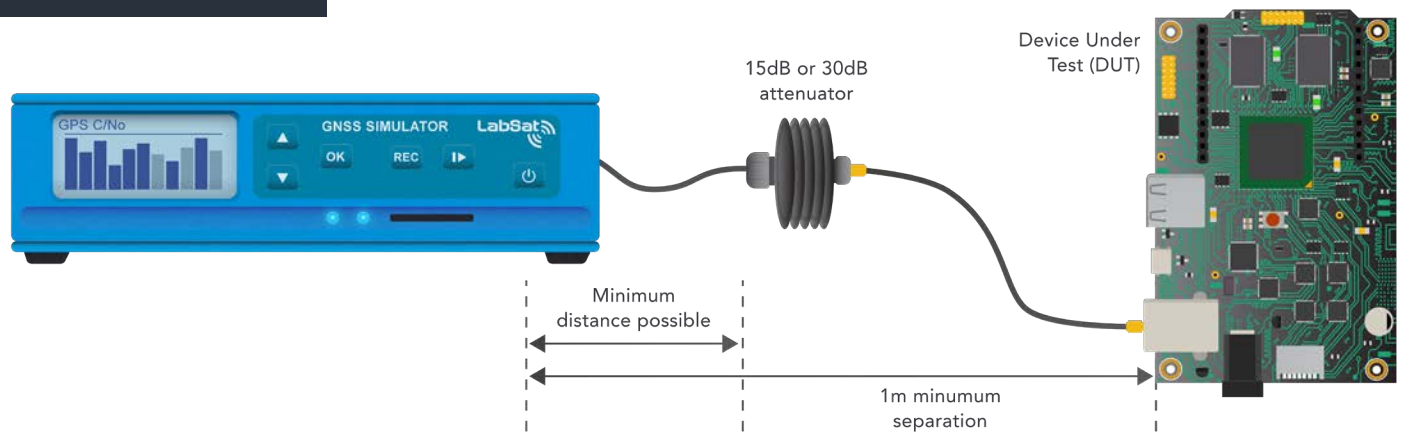
Conducted or Radiated Testing?

The choice between conducted or radiated testing will depend on whether your device or receiver has an external antenna connection. With no external connection available, your test signal must be radiated (Radiated Testing) so that the internal antenna can receive the signal. If an external connection is available, then you can use Conducted Testing where the signal is delivered directly via the test set-up.

Conducted testing

Conducted testing can be done where there is a direct antenna connection available on the unit under test. In this case the simulator RF output is connected directly to the antenna input or, in some cases, via fixed passive attenuators to further reduce the signal level.

Wired test setup using attenuator

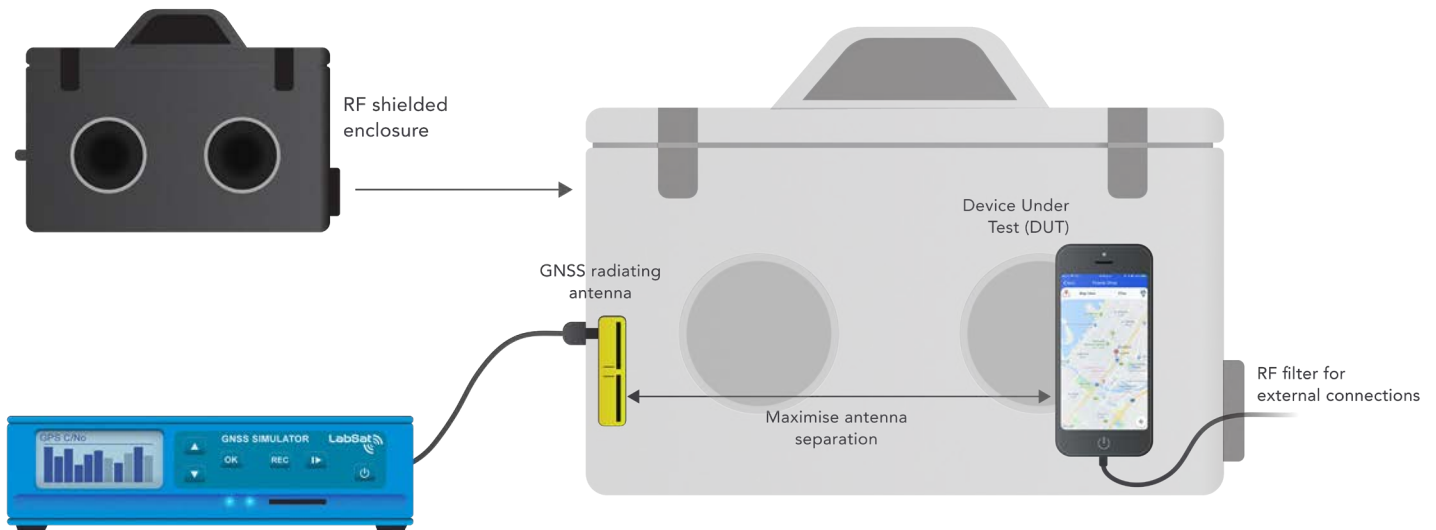


Radiated testing

Testing devices such as smart watches or cell phones with internal antennas is also possible but adds some additional challenges. Radiated Testing introduces the risk of confusion between the test signals and live GNSS signals. This combined with very strict legal restrictions on broadcasting within the GNSS frequency band means that any radiated testing must be carried out within a suitable RF shielded enclosure.

The small separation between the transmitter and receiver imposed by using a chamber in turn means that very small differences in device position or environment can have a significant impact on the received signal strength.

Radiating test setup using RF enclosure



To produce a reliable and consistent test, it is critical that the device under test be consistently located, that the separation distance between the antennas is maximised (this reduces the sensitivity to placement variation) and that any connected cables be as short as possible and routed consistently between tests to minimise the risk of cable placement influencing the test results. If possible, devices should operate without any cables connected.

It is also critical that the RF chamber be closed and sealed for the duration of the test. If user interaction is required, for example to press buttons or read results, then these actions must be performed before or after the test.

Due to losses involved in re-radiating the GNSS signals, the need for additional attenuation may well be eliminated, however, this will be highly dependent upon the physical test configuration and the sensitivity of the equipment being tested.