White Paper

A-GNSS Over-the-Air Test Methodology

Antenna Performance for Location-Based Services

Introduction

With the huge growth in usage of Location-Based Services (LBS) and the need to meet E911 requirements, the number of wireless devices supporting the Assisted Global Navigation Satellite System (A-GNSS) is steadily on the rise. As one of the enabling LBS technologies, A-GNSS offers its customers higher position accuracy, quicker location fixes, and improved coverage of service in difficult locations, such as urban environments. As a result, wireless operators and device manufacturers are looking for testing choices that quantify and benchmark real-world A-GNSS performance.

Initially, all industry-defined positioning test methodologies focused on testing the performance of a device over a cabled RF connection, bypassing the GNSS antenna and associated circuitry. This approach does not give the complete picture of real-world device performance and its impact on the end-user experience of LBS applications. If A-GNSS testing is performed using a cabled RF connection, devices that pass all tests in the existing conformance standards may perform poorly in the real world, resulting in an inferior user experience. To achieve the complete picture, GNSS performance testing needs to include all relevant components, and the Over-the-Air (OTA) test methodology is the best solution to address this need.

OTA testing is performed in a controlled radiated environment, called an anechoic chamber, using specialized equipment to provide a known signal to the device under test (DUT). A key aspect of this testing is that all signals are transmitted and received wirelessly, as they are in the real world. This ensures that all interaction factors between the radio and the rest of the wireless platform, including radiation pattern and platform interference, are taken into account when determining overall wireless performance.

In 2011, industry organizations such as the CTIA standardized A-GNSS test procedures for OTA testing in their OTA test plan currently-entitled *CTIA Test Plan for Wireless Device Over-the-Air Performance*[1]. This white paper is focused on CTIA's foundation of test methodologies for testing GNSS antenna performance, including key aspects of the antenna pattern, different forms of radiated sensitivity, and cellular antenna interference.

Industry organizations are not the only ones mandating A-GNSS OTA requirements. Many network operators believe this testing is very important and already have A-GNSS OTA test programs in place. Typically, many of these network operators adopt the methodology in the CTIA OTA specification to help ensure the performance of the A-GNSS-capable devices they offer their customers.

About CTIA

CTIA - The Wireless Association, originally known as the Cellular Telephone Industries Association, is an industry consortium representing the international wireless communications industry. Founded in 1984, this organization represents network operators, device manufacturers, wireless data/networking companies, and other contributors to the wireless sector. In addition to lobbying the U.S. Congress and FCC on behalf of the wireless industry and operating one of the industry's largest trade shows, the CTIA maintains a device certification program intended to ensure a high standard of quality for consumers.

1 *http://www.ctia.org/policy-initiatives/certification/certification-test-plans*

A-GNSS OTA Test Methodology

This section gives an overview of the A-GNSS OTA test method for basic GNSS antenna performance. A-GNSS OTA testing requires specialized equipment beyond that required for conducted testing over an RF cable. The test method described in this section applies to UMTS, GSM, CDMA, LTE, and 5G NR devices.

Test Procedure and Interpretation of Results

Since the GNSS radio is receive-only, interest centers on evaluating receiver sensitivity from various directions around the device. The resulting Effective Isotropic Sensitivity (EIS) pattern is then used to determine the average radiated receiver sensitivity across the entire sphere around the device, referred to as Total Isotropic Sensitivity (TIS), or across a portion of the sphere. In addition to determining the baseline radiated sensitivity of the GNSS receiver, the effect of cellular communication on the GNSS receiver is evaluated to ensure that the GNSS receiver performance is not degraded due to interference from the wireless phone transmitter or any other internal desensitization effects.

Traditionally, a TIS measurement (the measurement of an EIS pattern) is determined by performing a sensitivity search at each point around the device. The signal level transmitted to the device is lowered until a target error rate is reported by the device. That defines the limit of the device's receiver sensitivity for that direction; the compilation of these limits results in a contoured radiation pattern.

Determination of the TIS for an A-GNSS device is complicated by the time involved in determining a "good" versus "bad" result. A single A-GNSS fix can take over 20 seconds, and repeated fixes are required as the power is lowered and also to obtain a level of statistical confidence that the appropriate sensitivity level has been determined. To do this from all directions around a device would result in a test methodology where the total test time was not feasible. As an alternative, a method was developed to record measurements from the A-GNSS device to help determine the radiation pattern of the device. The resultant pattern is then normalized to a single EIS sensitivity search to determine an estimate for the entire EIS pattern.

The test procedure consists of recording and analyzing five sets of measurements:

- Antenna pattern
- Linearization
- Radiated sensitivity
- TIS, Upper Hemisphere Isotropic Sensitivity (UHIS), and Partial Isotropic GNSS Sensitivity (PIGS) calculation
- Intermediate channel degradation

In addition to understanding the test method for A-GNSS OTA, it is very important to understand the significance of each measurement and how it is used to quantify the A-GNSS performance of devices. This in turn allows device manufacturers to make better-performing devices and network operators to ensure that devices launched on their network perform well.

Antenna Pattern

The first part of the A-GNSS OTA Test Plan calls for measurement of the GPS antenna pattern.

An antenna pattern can be represented visually to identify the wireless device's ability to effectively receive signals from different directions. Imagine the antenna at the center of the shape in Figure 1; the areas with large peaks signify the directions from which the antenna will receive most effectively.

Antenna patterns help quantify the true performance of GNSS antennas in wireless devices; for these devices to deliver a good user experience for location-based applications, the GNSS antenna pattern should be compromised as little as possible. Antenna performance can be affected by device form factor, location of the GNSS antenna in the device, and the presence of a human head and/or hand near the device.

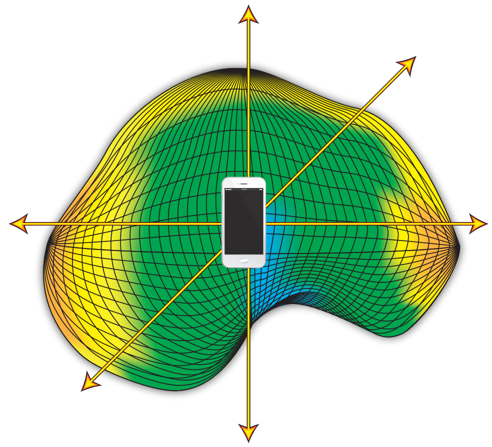


Figure 1: Typical GNSS antenna pattern.

Per the CTIA A-GNSS OTA test plan, antenna pattern measurements are made by radiating a known GPS signal power level and obtaining full spherical coverage around the device. By recording the GPS power levels that the DUT measures at different points, it is possible to plot how well the device receives GNSS signals at different angles of arrival. Due to the proximity of GPS, GLONASS, and Galileo, the antenna pattern found using the GPS signals is used for the evaluation. The exception is GPS L5, which has a different frequency, 1175 MHz, so the antenna pattern is measured separately. A-GNSS OTA testing involves establishing the antenna pattern by radiating a signal at a particular value of Carrier-to-Noise ratio (C/N_0) through a Measurement Antenna (MA) and measuring the reported value of C/N_0 by the device. For CTIA-defined tests, the C/N_0 ratio of the GPS signal is determined at 60 discrete positions along two orthogonal antenna polarizations, for a total of 120 measurements. A specified number of GNSS satellites are simulated during the antenna pattern measurement. The C/N_0 ratio is measured by the device under test for each individual satellite, and the average C/N_0 is used as the metric for each discrete antenna pattern measurement.

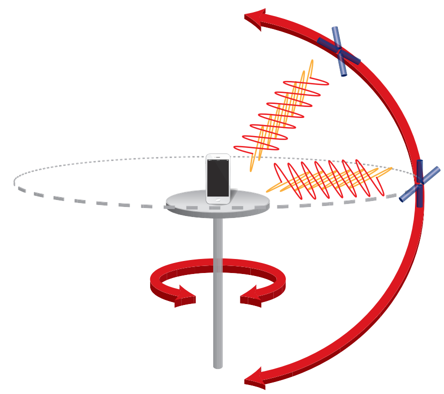


Figure 2: Dual axis rotation with two antenna polarization.

Linearization

The antenna pattern, consisting of discrete measurements of the average C/N_0 ratio, is computed using the device itself as a measurement tool. However, the DUT by itself is not a measurement device that has a traceable calibration and hence cannot be solely relied upon to provide absolutely accurate values. In order to provide that traceability, the pattern measured by the DUT needs to be corrected to eliminate any non-linearity introduced by it. By mapping the average C/N_0 report from the DUT back to a range of signal levels generated by the calibrated signal source (i.e., GNSS simulator), a set of corrections for the pattern data can be obtained, essentially transferring the traceability of the signal generator to the DUT. This linearization process results in antenna pattern data that is much more accurate.

Radiated Sensitivity

Another important test step is to measure the radiated sensitivity of the device. As mentioned earlier, average GNSS signal levels in clear sky conditions are very low, typically -130 dBm, which are much lower than cellular signal levels. It is therefore very important for a GNSS-enabled mobile device to be able to receive in a low-signal environment. A device's GNSS sensitivity reflects, to a great extent, the ability of its antenna to receive low-powered signals.

The GNSS performance of wireless devices is closely correlated with the user experience of location-based applications. When using a device indoors, or in areas where the sky is obstructed by trees or other obstacles, the already-low GNSS signal levels are further attenuated. As a result, devices with good GNSS sensitivity will work in many situations where others with poorer sensitivity will not. Some devices on the market today can use GNSS signal levels below -150 dBm.

Radiated sensitivity is measured by lowering the GNSS signals until the DUT is unable to meet the specified performance requirements. The test is performed at the device orientation and MA polarization that resulted in the highest C/N_0 measurement in the upper hemisphere.

This test is in line with the corresponding wireless standards specified in the 3GPP and 3GPP2[2], which specify that device performance is declared either a pass/fail depending on a particular measurement accuracy threshold; only in this case, the actual sensitivity level is determined.

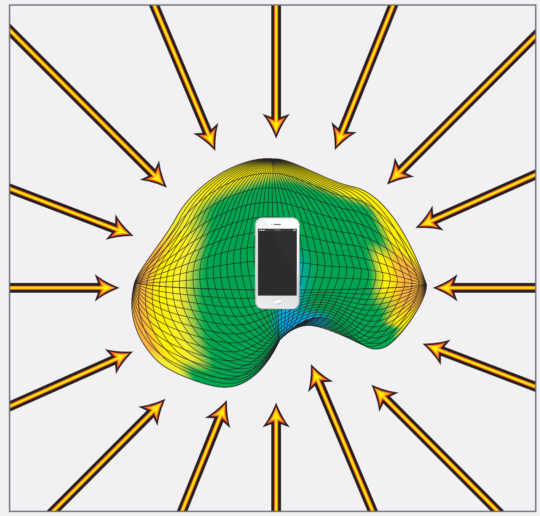


Figure 3: TIS measurement scope of a typical antenna pattern.

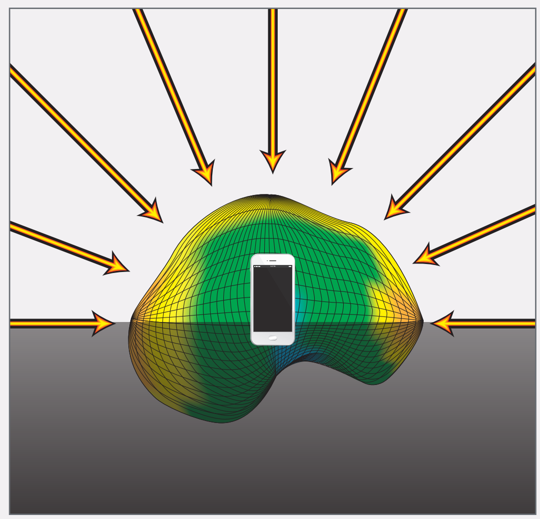


Figure 4: UHIS measurement scope.

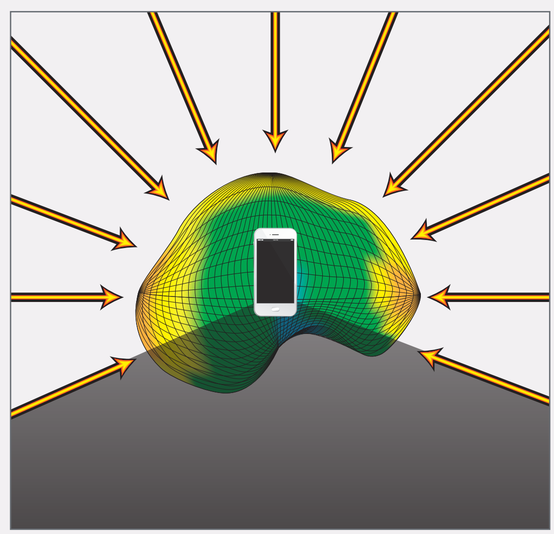


Figure 5: PIGS measurement scope.

TIS, UHIS, and PIGS Calculation

Once the antenna pattern and radiated sensitivity is determined, the TIS, UHIS, and PIGS–metrics which provide an overview of device A-GNSS performance–can be calculated.

TIS is a metric that represents the overall sensitivity of a device in a radiated environment. TIS is effectively the lowest signal level that the device would be able to operate with if it received the same signal from all directions in a 360-degree sphere. TIS is convenient because it is a single metric that represents the overall radiated sensitivity performance of the device, making it easy to benchmark devices against each other. For TIS, the entire 360-degree antenna pattern is used.

Another important metric is UHIS, which represents the radiated sensitivity performance of a device in the "upper hemisphere" (effectively above the device's horizon). It is calculated by the partial summation of the EIS pattern over the upper hemisphere.

PIGS is also a useful and realistic metric, as it takes into account an incremental 30 degrees of reflection from the bottom hemisphere of the phone, in addition to the radiated power calculated from the UHIS, as described above. It can be viewed as the sensitivity level of the DUT if an equal amount of GNSS power was received from all directions in the upper horizon and from a limited set of reflections from the ground.

2 The 3rd Generation Partnership Project (3GPP) is a collaboration between groups of telecommunications associations from Asia, Europe and North America that creates standards for radio, core network and service architecture.

Figures 6 and 7 illustrate the importance of UHIS. The devices in both images show the same antenna pattern, but the one in Figure 7 is inverted. In spite of identical TIS values, the device in Figure 6 will yield a better UHIS and have better performance in an environment with partial clearance where only the overhead sky is unobstructed.

Figure 8 illustrates the PIGS advantage, which considers the fact that the device will not be held in a completely vertical orientation with respect to the ground. Because devices often receive signals that are reflected off the ground, for example while the user is standing indoors next to a window, the usefulness of PIGS becomes apparent.

Intermediate Channel Degradation (ICD)

Another key factor that needs to be taken into consideration while evaluating A-GNSS performance is intermediate channel degradation (ICD), which is the device's active cellular subsystems interference with the GNSS receiver. The presence of cellular antennas at close proximity to the GNSS antennas can result in self-jamming and performance degradation. In particular for 5G NR NSA and SA dual connectivity modes, the device transmits LTE as well as NR signal simultaneously. These two signals create significant intermodulation and different orders of harmonics, which can fall on GNSS frequency bands and cause severe interference problems for the GNSS receiver. This will greatly impact GNSS receiver performance. The frequency of interference and severity depends on the cellular band combinations. Therefore, it's necessary to test all band combinations supported by the device to evaluate the impact of the interference.

ICD measurement can reveal how severely user experience can be impacted when GNSS performance degrades due to the use of cellular frequencies on a specific network. Even if a device is targeted for one network operator market and its associated frequencies, users will likely roam to other networks, especially when traveling.

This is an area where OTA testing can bring key performance issues to light, as conducted testing may shield the interfering cellular signal from reaching the GNSS receiver. The ICD procedure tests the A-GNSS performance across a variety of wireless operating channels (referred to as intermediate channels). To test ICD, a C/N_0 measurement is performed at the "mid-channel" frequency in a particular wireless operating band at the same pattern peak used for the GNSS sensitivity

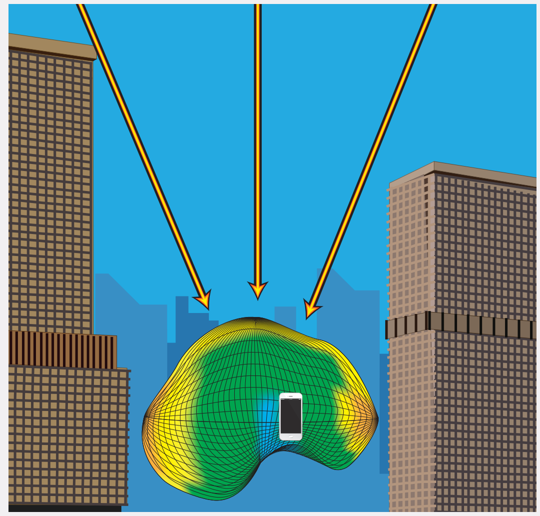


Figure 6: Good UHIS performance.

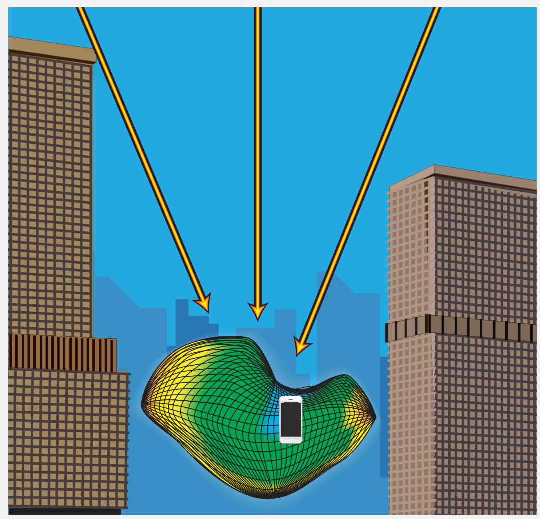


Figure 7: Poor UHIS performance.

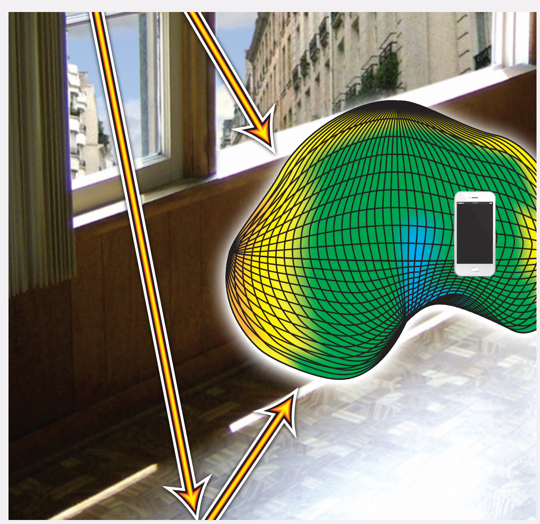


Figure 8: Indoors with reflections from floor.

measurement. The same C/N_0 measurements are repeated at various intermediate channels for that particular operating band. The final ICD measurement is defined as the difference between the C/N_0 measurement at the mid-channel and the lowest C/N_0 at any intermediate channel (including the mid-channel).

Required Equipment and Setup

The goal of OTA testing is to obtain a "snapshot" of the performance of the DUT in all directions around the device. For reference, imagine the requirement to compare the amount of light emitted from a light bulb in all directions around a room. It would be necessary to look at the light bulb from every direction in order to measure and compare the results.

A typical test solution for A-GNSS OTA will consist of the following components:

- Anechoic chamber with specialized chamber equipment such as device turntable/positioner, measurement antenna, cellular antenna, phantom head/hand or low-dielectric pedestal for free space testing configurations, and RF switch matrix
- Network emulator
- GNSS simulator
- Positioning controller
- LMF (5G NR), E-SMLC (LTE), SMLC (UMTS) or PDE (CDMA) software server for A-GNSS capability
- Automation software to control equipment, automate test procedure, and present results

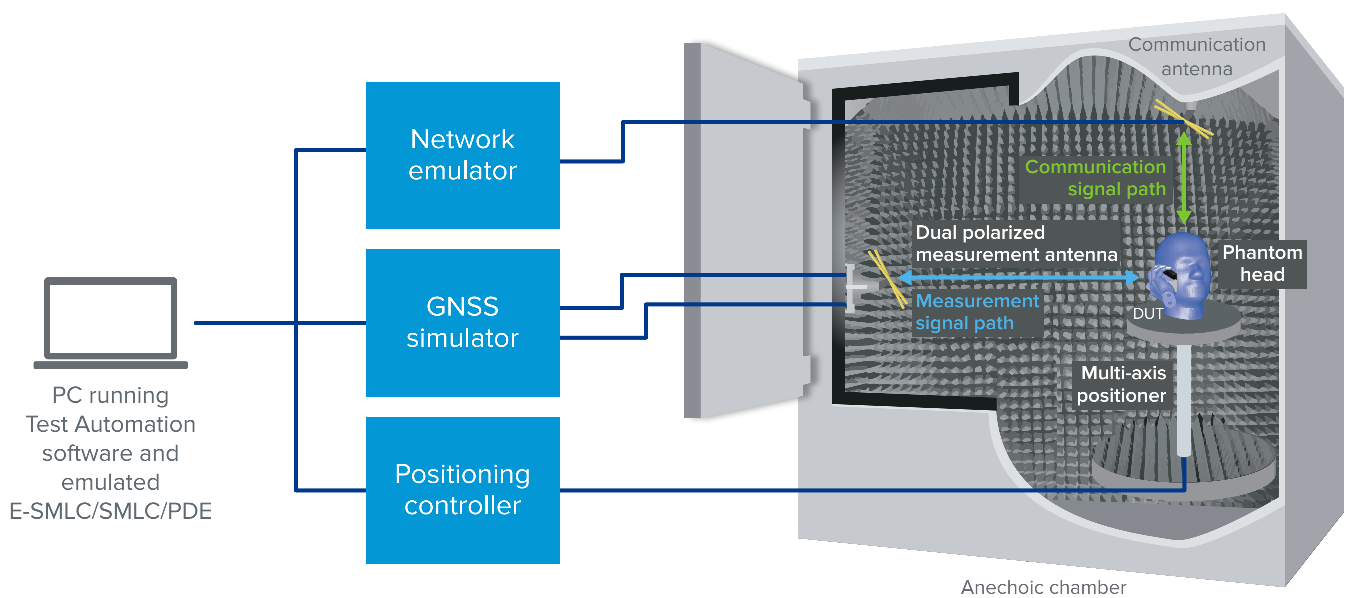
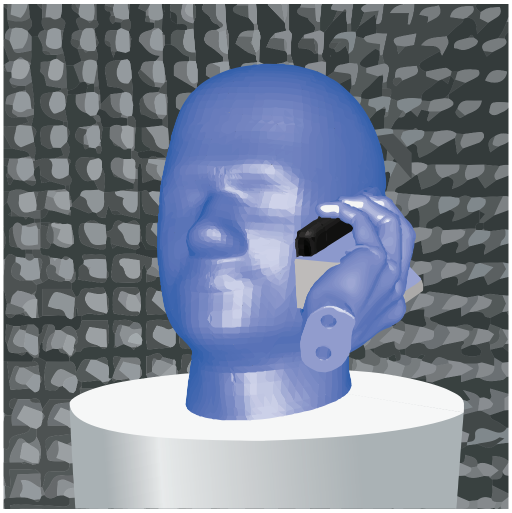


Figure 9: Typical A-GNSS test configuration.

The DUT is configured for typical use cases. For devices such as smartphones, this includes use of a phantom head and hand to simulate the effects of the device being held against the human head. For hand-held applications such as personal navigation using A-GNSS, a phantom hand is used to hold the device in the same way a user typically would. Thus, the RF shadows and near field effects caused by the proximity to these phantoms can be taken into account when determining the device performance. For laptops, tablets, or M2M devices, a Styrofoam column or fixture composed of a low dielectric material simulates a flat surface where the device would normally rest.



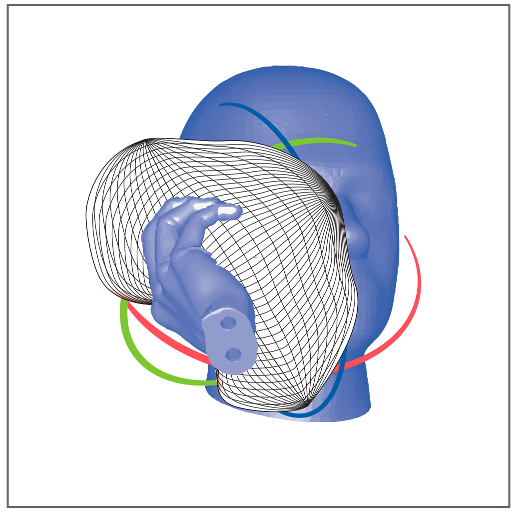


Figure 10: Typical phantom head/hand configuration and resulting antenna performance.

The radiated receiver sensitivity of the DUT is measured by placing an MA a fixed distance away from the device. Since the DUT can be randomly oriented with respect to the MA, a dual polarized measurement antenna is used to measure two orthogonal polarizations, thus allowing for the total radiated receiver sensitivity to be determined irrespective of the relative orientation.

In all likelihood, the device will be operating in a highly scattered environment when operating near the limit of its sensitivity. In this case, the device will not favor any particular polarization. The test methodology for A-GNSS OTA testing utilizes an MA with linear polarization as opposed to circular polarization to remain compatible with the existing CTIA OTA Test Plan.

To cover all points on the surface of a sphere surrounding the device, it is necessary to be able to move the MA relative to the DUT in two orthogonal axes. Imagine looking at a globe of the Earth and wanting to ensure that you have observed every part of its surface equally. You would have to move north and south, as well as east and west, to eventually cover the entire globe. This movement of the MA relative to the DUT requires some form of positioning system.

There are two common ways to achieve this. The first is to mount two orthogonal positioners, one on top of the other, to rotate the DUT in two axes. In this combined axis scenario, the MA remains fixed, while the DUT rotates in two axes. The second involves placing the DUT on a turntable and using a separate positioner to move the MA up and down around it. In either case, from the viewpoint of the DUT, the MA moves north/south (theta axis) and east/west (phi axis) around it, resulting in full spherical coverage.

To avoid unwanted interference from outside signal sources, as well as to prevent interference with other communication systems, the DUT and MA must be shielded from the outside world. This is done by placing them inside a shielded room. However, while the shield reflects external energy away from the DUT, it also reflects energy radiated from the DUT back towards the MA and vice-versa. This can result in that energy being measured more than once, since it may be measured directly from the DUT as well as after reflection off the walls of the shielded room. To avoid this, the room must be lined with RF absorbing material to reduce the unwanted reflections. The result is a fully shielded anechoic chamber, where all walls, floor, and ceiling are lined with RF absorber.

Outside the chamber, the measurement antenna is connected to transmit signals at a known level to the DUT in order to determine its receiver sensitivity. The path loss associated with all cabling, the measurement antenna gain, and the range path loss must be applied to correct the test equipment reading to correspond to what is actually occurring at the DUT. To determine the GNSS receiver sensitivity of the DUT, a satellite simulator provides the known downlink signal.

Depending on what test instrument must be connected to the MA, it is often not practical to maintain the communication link to the DUT through the MA. Thus, a separate communication antenna is typically used to provide a dedicated communication path between the cellular Network Emulator (NE) and the DUT. This can be used to provide a low loss path for the cellular wireless connection when the MA is used for downlink-only tests. Since most communication test equipment is designed for conducted testing, additional signal conditioning components are usually required to adapt the Over-the-Air signals to the available dynamic range of the instrumentation. An RF switch matrix is used to provide all of the necessary routing between the component parts of the system, and a PC running test automation software is used to control the positioning system and capture the desired measurements from all orientations around the DUT.

Typical Test Components

Anechoic Chamber

The anechoic chamber is a critical piece of equipment for OTA testing, and it serves two purposes. First, it isolates the DUT from outside signal sources that could interfere with radiated measurements. Second, special RF absorbing material inside the chamber prevents signal reflections inside the chamber from corrupting measurements. Most anechoic chambers are quite large, extending at least 4 meters in all dimensions. The primary requirement in all cases is to provide enough distance between the DUT and the MA to ensure that the far-field antenna region is included in testing.

Within the chamber, a device turntable/ positioner allows three-dimensional measurements to be made at discrete points (usually 30 degrees apart for sensitivity measurements). The device turntable has a positioning controller that typically operates via test automation software, allowing automated testing of the A-GNSS OTA procedure.

The GNSS signal is applied to the MA, which is located within the chamber to transmit the radiated signal to the DUT. For CTIA-defined A-GNSS OTA testing, this must be a linearly-polarized antenna that is able to transmit two orthogonal polarizations. In addition to the GNSS antenna, at least one cellular antenna is needed to wirelessly transmit the GSM, WCDMA, CDMA, LTE, or 5G communication signal. This is typically accomplished using the communication antenna described earlier.

Lastly, the head and/or hand phantom is used for testing mobile devices to simulate the impact of having the phone next to a human ear as when making an emergency call or in a human's hand as when browsing the internet. There is also a configuration for a "free space" scenario that applies to devices that sit in open air or on a flat surface (such as laptops, tablets, or M2M devices). In this case, the DUT rests on a Styrofoam column or fixture composed of a low dielectric material during the OTA test. The CTIA has specific requirements for the characteristics of head and hand phantoms, as well as the free space fixture.

The RF switch matrix is required outside the chamber in order to connect the test equipment to the appropriate antennas inside the chamber. In addition to switching the correct RF signals, the switch matrix enables automated switching of GNSS antenna polarization.

Network Emulator

Since A-GNSS requires a wireless radio communication link in order to operate, a cellular network emulator is a required component of this solution. This instrument emulates all network components required to establish mobile calls, exchange necessary messages for A-GNSS sessions, and retrieve GNSS C/N_0 measurements from the phone.

The CTIA OTA Test Plan applies to all cellular devices, whether they are UMTS, GSM, CDMA, LTE, or 5G. All frequency bands supported by a device must be tested. For this reason, it is desirable that the network emulator is able to support all of the frequency bands supported by the device under test.

Additionally, a high level of synchronization is required between the cellular network emulator and GNSS simulator to meet the timing requirements of the 3GPP specification. Specific timing requirements include coarse time accuracy delivery (<200ms uncertainty) and calculation of time-to-first fix (accuracy <300ms uncertainty). The bar is set even higher for CDMA solutions, which require nearly perfect synchronization. The minimum requirement is <30ns, but any timing uncertainty will result in degraded device performance. It is therefore critical that timing synchronization accuracy in A-GNSS OTA test solutions is high enough to prevent unnecessary device performance degradation.

GNSS Simulator

Simulation of the GPS, GLONASS, GPS L5, and Galileo satellite constellations is a requirement in this solution. The CTIA OTA Test Plan requirements vary per satellite constellation and network technology, as follows:

Test Parameter Description	A-GPS	A-GLONASS	A-GPS L5	A-Galileo
Number of satellites	8	6 (3 GPS and 3 GLONASS)	6 (6 GPS L1 and 6 GPS L5)	6 (3 GPS and 3 Galileo)
HDOP range	1.1 to 1.6	1.4 to 2.1	1.1 to 1.6	1.1 to 1.6
Propagation conditions	AWGN			
GPS time assistance	Coarse, ± 2 s	Coarse, ± 2 s	Coarse, ± 1.8 s	Coarse, ± 1.8 s
Phone response time	20 seconds for LPP 16 seconds for RRLP	20 seconds for LPP 16 seconds for RRLP	20 seconds	20 seconds
Acceptable response time to network	20.3 seconds			
Success rate	95 successful fixes with the necessary accuracy out of 100 attempts (95%)			
Position accuracy	101.3 m			

LPP and RRLP are supported as options for LTE since A-GNSS testing for LTE utilizes user plane testing over SUPL 2.0, which allows for either positioning protocol to be used. The GNSS simulator must accurately broadcast the required number of satellites for each constellation simultaneously as well as control the power level of each satellite.

Other satellite constellations are on the way, such as the Galileo E5 and India's IRNSS, as well as regional systems such as QZSS (Japan). As more mobile devices support these additional technologies, the ability of a satellite simulator to emulate these multiple constellations will be increasingly important.

E-SMLC (LTE), SMLC (UMTS) and PDE (CDMA) Software Server

The Evolved Serving Mobile Location Centre (E-SMLC) is an LTE network entity that manages several important tasks for A-GNSS positioning. The E-SMLC captures assistance data from a network of GNSS reference receivers and delivers this data to the mobile device during a positioning session. Secondly, the E-SMLC helps to calculate position accuracy during MS-assisted positioning sessions.

The E-SMLC software server must work in conjunction with the satellite simulator and network emulator to provide the required assistance data in the correct way. The CTIA OTA Test Plan defines very specific assistance data parameters and it is important that the E-SMLC server complies with this.

For those looking to test A-GNSS OTA beyond the requirements of the CTIA OTA Test Plan, flexibility and programmability of the E-SMLC software server is essential. Fully characterizing the sensitivity of a device in the real world requires different levels of assistance data. Sensitivity when tested with the maximum level of assistance data will be much greater than sensitivity when tested with no assistance data, and there will be a spectrum of performance when tested between those two extremes.

Test time can be minimized by configuring the E-SMLC in a way that reduces the time it takes for devices to return position fixes. With a flexible E-SMLC, test execution time can be reduced by over 60 percent without having a significant impact on the A-GNSS OTA test results.

The Position Determination Entity (PDE) is a CDMA network entity that serves the same purpose as the E-SMLC in LTE networks. The PDE software server must also work in conjunction with the satellite simulator and network emulator to provide the required assistance data in the correct way. Similarly, the SMLC serves this purpose for UMTS networks.

Automation Software

The component of the system that controls the entire solution is the automation software. This software should provide a single user interface for setting up test sessions, executing tests, and analyzing results. At a minimum, the CTIA-defined test method for A-GNSS OTA should be automated in this software. Additionally, this software may allow parameters to be modified for customized test scenarios. A key benefit of good automation software is that it removes the complexities of the test procedures and instrumentation control, making user interaction with the solution intuitive and easy to use.

To save time and cost, the software should control all equipment in the system once a test session is started, reducing the need for user intervention and increasing the repeatability of tests. A major advantage of good automation software is that customized test sessions can be saved and re-tested at any time to understand how device performance changes as hardware/software modifications are made or to understand how performance varies across different devices.

Automation software also stores and recalls results data from the tests that have been executed, providing the ability to view and analyze these results. For A-GNSS OTA tests, it should be possible to carry out all the analyses discussed in A-GNSS OTA Test Methodology Section within the automation software itself. Finally, testing inevitably goes wrong at some point. Whether it is call setup or understanding a particular protocol error, unexpected problems can always occur. Automation software should also allow debugging of unexpected problems. In most cases, this is accomplished by providing tools such as event, instrument communication, and protocol logs.

About Spirent Communications

Spirent Communications (LSE: SPT) is a global leader with deep expertise and decades of experience in testing, assurance, analytics and security, serving developers, service providers, and enterprise networks.

We help bring clarity to increasingly complex technological and business challenges.

Spirent's customers have made a promise to their customers to deliver superior performance. Spirent assures that those promises are fulfilled.

For more information, visit: www.spirent.com

Conclusion

A-GNSS OTA testing is a significant methodology for the cellular industry. Industry bodies clearly recognize the need to test A-GNSS performance in this manner and the CTIA OTA Test Plan has obtained widespread acceptance as the de facto standard for location-based OTA testing. Every step of the test plan highlights a significant aspect of antenna performance that must be measured and understood in order to ensure the best user experience for location-based services for their consumers.

Spirent Communications, which pioneered location performance testing with the Spirent 8100 LTS, has been a leading contributor towards the development of OTA testing methodologies, with industry-leading experts serving on the CTIA OTA Working Group. This expertise has greatly aided the development of Spirent's automated 8100 A-GNSS OTA solution, which integrates with multiple industry-leading chamber manufacturers, demonstrating Spirent's commitment to this key test methodology.

Glossary of Terms

Acronyms	Description
3GPP	3rd Generation Partnership Project
AFLT	Advanced Forward Link Trilateration
A-GNSS	Assisted Global Navigation Satellite System
A-GPS	Assisted Global Positioning System (North America)
C/N_0	Carrier-to-Noise Ratio
CDMA	Code Division Multiple Access
CTIA	Cellular Telecommunications and Internet Association
DUT	Device-Under-Test
EIS	Effective Isotropic Sensitivity
E-SMLC	Evolved Serving Mobile Location Center
FCC	Federal Communications Committee
GLONASS	Globalnaya Navigazionnaya Sputnikovaya Sistema (Russia)
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HDOP	Horizontal Dilution of Precision
ICD	Intermediate Channel Degradation
LBS	Location Based System
LTE	Long Term Evolution
MA	Measurement Antenna
NE	Network Emulator
NR	New Radio
OTA	Over-the-Air
OTDOA	Observed Time Difference of Arrival
PDE	Position Determination Entity
PIGS	Partial Isotropic GNSS Sensitivity
PND	Personal Navigation Device
PTCRB	PCS Type Certification Review Board
QZSS	Quasi-Zenith Satellite System (Japan)
SMLC	Serving Mobile Location Center
TIS	Total Isotropic Sensitivity
UHIS	Upper Hemisphere Isotropic Sensitivity
UMTS	Universal Mobile Telecommunications System (UMTS)
WLAN	Wireless LAN

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