Certification Processes and Testing of A-GPS Equipped Cellular Phones

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Assisted-GPS designs have gotten a lot of attention in recent years as manufacturers try to build high-sensitivity receivers that works indoors or in other challenging environments. Interest has surged as wireless carriers and mobile handset manufacturers have adopted GPS technology. But how do carriers and end users know that their A-GPS products will work? This article describes the standards, processes, and test procedures that lead to certification of devices incorporating A-GPS.

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More and more GPS-enabled devices are entering the consumer marketplace, many incorporating assisted-GPS (A-GPS) technology. These include not only cellular phones, but laptop datacards, PDAs, and other mobile equipment.

Increasingly, GPS devices that were previously standalone now incorporate a cellular modem for such applications as mapping download or live traffic alerts. The proliferation of GPS in the consumer space can also be seen in the availability of GPS automotive navigation systems in local supermarkets or large grocery stores.

Those who purchase these products expect the technology to function everywhere, continuously, be simple to use and to always have the most obscure address in its database.

To help ensure the successful deployment of this concept in cellular devices, the telecommunications industry's standards and certification bodies have been working diligently on a standardized approach to A-GPS certification.

In recent years, the subject of A-GPS, its purpose, and operation, has gotten a lot of attention in the technical and trade media. The authors of these various sources have focused on either the technical details or on the performance of the technology in the areas for which it was or was not primarily designed.

For example, performance in urban canyons and indoor environments or development and testing by manufacturers, cellular network operators or research organizations of products using this technology.

In contrast, this paper focuses on how a mobile device that incorporates A-GPS technology gains certification for use on a 2G or 3G (GSM or UMTS) cellular network.

Standards Bodies

The 3rd Generation Partnership Project (3GPP) is a collaboration agreement, bringing together a number of telecommunications standards bodies such as the European Telecommunications

Standards Institute (ETSI), the Alliance for Telecommunications Industry Solutions (ATIS), China Communications Standards Association (CCSA), and others.

The 3GPP's role is to prepare, approve, and maintain the necessary set of technical specifications and reports for an evolved third-generation and beyond mobile system. Under this remit the 3GPP resolved to prepare and approve a set of standards for testing A-GPS in cellular devices from both a signaling and RF minimum performance perspective.

The Open Mobile Alliance (OMA) is a parallel standards organization that concentrates on developing the necessary specifications for so-called "application enabler" protocols. These protocols sit on top of the radio bearer protocols specified by 3GPP and allow the various applications that may now be running on cellular devices to work correctly.

To achieve the "assessment compliant" status a manufacturer must test, or have a third party test, their [mobile phone] product against the specifications.

Examples of OMA application enabler protocols include those for multimedia messaging services (MMS), digital rights management (DRM), push-to-talk over cellular (POC), broadcasting (BCAST), and so forth. In particular, the OMA has developed an application enabler protocol for location-based services (LBS) called secure user plane location (SUPL), which can be used in conjunction with the standard 3GPP signaling protocols for LBS. The OMA has also developed a standard for the testing of this SUPL protocol.

Certification Organizations

The output of the standards bodies has been adopted by organizations such as the Global Certification Forum (GCF), which developed an independent certification scheme for terminal manufacturers and operators to ensure interoperability. In North America this role is performed by a similar body, the PTCRB, the certification forum for 850/1900 MHz North American cellular operators.

Terminal or device manufacturers are responsible for having their product certified or not, depending on the intended market. For those who do so, the GCF and PTCRB schemes are similar, and in some cases identical. In the GCF, for example, the process is quite straightforward, providing a company is already a member:

- A vendor must achieve a "quality qualified" status, which involves a self-declaration that the company has a recognized quality assurance program in place for its design, development, and manufacturing processes.
- The vendor must also demonstrate an "assessment compliant" status, which demonstrates that "they possess, or have subcontracted for, the skills and means of test to perform the self-assessment of their new product's conformity with the relevant GCF certification criteria." (Taken from http://www.globalcertificationforum.org/Application/admininfo/faq/#FAQ109.)

Certification & Registration. Once a new product has successfully met all the relevant GCF certification criteria, the manufacturer is then able to declare it as having achieved the "terminal certified" status. The company can then submit the product to the GCF for registration as a certified terminal meeting the agreed standards, which enables the vendor to market and promote it as an approved terminal device to customers such as network operators.

As mentioned earlier, to achieve the "assessment compliant" status a manufacturer must test, or have a third party test, their product against the specifications. For manufacturers working under GCF guidelines, a company has a duty of trust to ensure that the testing facility is capable of performing the tests and that the products pass the tests. With the PTCRB, the organization itself accredits laboratories and gives approval for them to perform the testing.

Many manufacturers prefer to use a third-party laboratory for this testing as it can provide an independently accredited quality framework in which manufacturers can achieve certification without the need for substantial capital expenditures.

A-GPS Specifications

The specifications drawn up and approved by 3GPP for A-GPS are separated into two technology areas, with each one further subdivided into signaling (protocol) conformance and RF minimum performance specifications.

UMTS and GSM have separate specification document schemes. A-GPS has been incorporated into these schemes rather than having a completely separate certification track. Signaling conformance essentially involves testing the protocol messages passed between the mobile terminal (wireless handset) and the network to ensure that various scenarios are handled correctly by the terminal and that it responds to stimuli in the appropriate manner. RF minimum performance establishes whether an A-GPS device can meet minimum performance criteria under a range of different scenarios.

For the purposes of this article, testing for GSM and UMTS can be considered equivalent, as the differences in the testing methods for both signaling and minimum performance are small; therefore, UMTS will be used as the reference for this article.

UMTS. The 3GPP specification documents for UMTS (A-GPS related), TS (Technical Standard) 34.123 and TS 34.171, are conformance specifications for signaling and RF minimum performance, respectively. When used together, these cover the full range of both signaling and RF minimum performance certification needs for UMTS User Equipment (UE) operating in the FDD (Frequency Division Duplex) mode of UTRA (UMTS Terrestrial Radio Access).

UE in this context refers to the entire terminal or mobile handset, not the GPS receiver itself. The test looks at the output from the terminal and its ability to communicate with the network as well as everything else, including the GPS receiver function.

GSM. The relevant publication for GSM is entitled 3GPP TS 51.010, a single set of specifications covering both signaling and RF minimum performance requirements in a single document for both GSM and the Personal Communication Systems (PCS) technology operating in the 400 MHz, 700 MHz, 810 MHz, 850 MHz, 900 MHz, 1800 MHz, and 1900 MHz bands.

A subset of these tests is also referenced in the GSM Common Technical Regulations (CTRs) and used for regulatory conformance testing according to the EEC (European Economic Community) procedures for telecommunications terminal equipment (TTE) type approval (European Commission Directive 1999/5/EEC; also known as the "Terminal Directive" or "Second Phase Directive"). (Refer to 3GPP TS51.010 for complete description.)

The test scenarios do not need to and should not be modified for conformance testing. If they are modified then they are not performing a certified (validated) test by which to achieve conformance. In practical terms, however during development tests can be modified and, indeed, manufacturers and operators can write their own acceptance tests, which may be more stringent than the validated tests.

Moreover, the architecture of the user equipment — for example, whether a dedicated CPU or hosted microprocessor is used to handle the GPS/GNSS signals — doesn't affect the test or testing procedures. In practical terms, the mode of operation (e.g., MS-based, MS-assisted, autonomous) is more important for conformance certification.

In the case of the OMA and the SUPL, a single set of testing requirements exists titled the SUPL Enabler Test Specification (ETS). The SUPL ETS contains (among other things) the signaling conformance process approved by the OMA for testing SUPL in a cellular device.

As most application enablers are essentially agnostic regarding the radio technology in use (for example, GSM

The test looks at the output from the terminal and its ability to communicate with the network as well as everything else, including the GPS receiver function.

Test Category	Scenario
Network Induced	Verification that the UE supplies UE positioning method capability and positioning method(s) when requested
	Verification that when a network instigates the positioning procedure during an emergency call, the mobile responds with location estimate
Mobile Originated	Verification that the UE correctly invokes a self-location request by sending the network a set of specific protocol messages, which are processed and returned by the network including assistance
	Verification that the UE invokes a transfer of its own location to a third party client by sending the correct messages to the network
	Verification of the UE ability for error handling when processing location information.
Mobile Terminated	Verification that the UE returns location information when requested by the network
	Verification of the correct operation of the privacy functions of the UE in handling location information
	Verification of the UE ability for error handling when processing location information
Conventional GPS (Tested in GSM Only)	Verification that a UE fitted with conventional GPS (Not Assisted) responds correctly with location information when requested by the network, in an emergency call

TABLE 1. Summary of Signaling Tests

Parameter	Detail
Time/Date of Simulation	12th September 2003 21:30:00
UE and Reference Location	Static at latitude: 35°40' N, longitude: 139°45'E, (Tokyo), height: 50m
Number of Visible Satellites	6 (PRNs: 4, 6, 9, 10, 13, 22)
Nominal Signal Level for satellites	-125dBm ± 6dB (considered suitable)
GPS TOW	509 400 (Week 211)
Accuracy of TOW assistance	± 2s relative to the GPS time in the GPS Simulator

TABLE 2. GPS Simulation Requirements in Signaling Tests

Step	Detail
1	The UE initiates a call independent supplementary service request to set up the conditions for making the position measurement
2	The UE invokes a mobile originated location request (MO-LR) request using the correct messaging sequence. The MO-LR request is of type "locationEstimate."
3	The network orders an A-GPS positioning measurement using specific control messages, including assistance data. The UE may request additional assistance data which, if requested, is provided over one or more messages.
4	The UE then initiates periodic GPS position measurement reporting which involves position determination and reporting to the network.
5	After receiving the measurement reports from the UE, the network responds in a specific manner
6	If the message sequence is correct the UE terminates the sequence and the test ends

TABLE 3. Typical Signaling Test Method

or WCDMA), only one set of tests is specified, which apply to either GSM or WCDMA without distinction.

UMTS Signaling Conformance

Section 17.7 of 3GPP TS 34.123-1 covers the tests for A-GPS signaling and these tests describe various scenarios as outlined in Table 1.

Test Method. The testing is carried out using industry-standard test equipment, which has itself been validated by the GCF/PVG (PTCRB Validation Group) as equipment capable of performing the test to the relevant specifications.

A list of validated equipment is held by these organizations and manufacturers can approach vendors of such equipment for purchasing, as part of the requirement to hold the validated status is that the equipment must be commercially available. Many manufacturers, however, prefer to contract a test laboratory to perform these activities, as these laboratories would already have validated equipment available.

The default conditions for the testing are described in generic terms in another document, 3GPP TS 34.108, where the UTRA conditions for the tests are defined. The A-GPS environment for the testing is simulated with GPS simulators. During A-GPS tests the simulator must generate satellite signals as described in this TS 34.108 (section 10) document. These requirements are summarized in Table 2, while Table 3 outlines the process of a typical signalling test.

Results. As the purpose of these tests is to test conformance to a signaling specification, the actual position measurements are not assessed for accuracy. Rather, the manner in which the information is transferred is the subject of the test.

Many manufacturers implement test script automation for the test process. Therefore, a PASS/FAIL result can be easily generated as part of the automation process, with a failure flagged to the test operator for further investigation. An overall PASS is achieved by the UE responding correctly to the sequence of protocol scenarios.

Figure 1 shows the results of a sample UE having performed the signaling tests, the tests performed, and the test process.

UMTS RF Performance

Another 3GPP specification, TS 25.171, determines the set of minimum performance requirements for a UE with A-GPS capability. As expected, these minimum performance requirements test the GPS performance of the device against a set of minimum achievable standards.

The UE is tested by exposing it to a number of different GPS scenarios designed to test the specific parameters in turn. This means that the UE is tested a number of times, each test looks at a different aspect of UE performance. Table 4 summarizes the A-GPS performance criteria.

To meet the requirements laid out in TS 25.171, two further specifications are used by test organizations and manufacturers: TS 34.108 and TS 34.171. TS 34.108 defines the common data for all test scenarios and, as stated previously, TS 34.171 outlines the actual test measurement procedures to establish conformance with the requirements in TS 25.171.

UMTS A-GPS Test Method

The performance tests consist of five separate test scenarios (six, counting one test that is split into two), each one evaluating a specific condition and performance factor. These are the *sensitivity* (both coarse and fine), *accuracy, dynamic range, multipath* and *moving* scenarios.

Each scenario consists of a complex set up of test environments, multiple positions, sequences of time shifts, and numbers of GPS fixes. With a well-implemented test system, the operator does not need to be fully versed in the fine detail of these tests as they are generally executed in an automated manner.

With the exception of the moving scenario each test scenario consists of the following test conditions

- the simulation of two separate and discrete GPS environments
- the simulation of randomized UE locations
- swapping between the two locations in a controlled manner, but using a different time of simulation for each iteration

This process is detailed in **Table 5**, assume that the two discrete GPS environments are called scenario #1 and scenario #2.

To determine pass/fail criteria a set of statistical rules are used to determine if a UE has passed a particular test or not. These rules are summarized below, using the terms good and bad results to indicate a result outside or inside of the individual test tolerance.

→ 0 bad results, pass the test at ≥77 results, otherwise continue

→ 1 bad result, pass the test at ≥106 results, otherwise continue

→ 2 bad result, pass the test at ≥131 results, otherwise continue until

→ 6 bad result, pass the test at ≥218 results, fail the test at ≤ 42 results, otherwise continue

→ 7 bad result, pass the test at ≥238 results, fail the test at ≤ 52 results, otherwise continue, etc. until

→ 168 bad result, pass the test at ≥2,751 results, fail the test at ≤2,747 results, otherwise continue

→ 169 bad result, pass the test at ≥2,765 results, otherwise fail

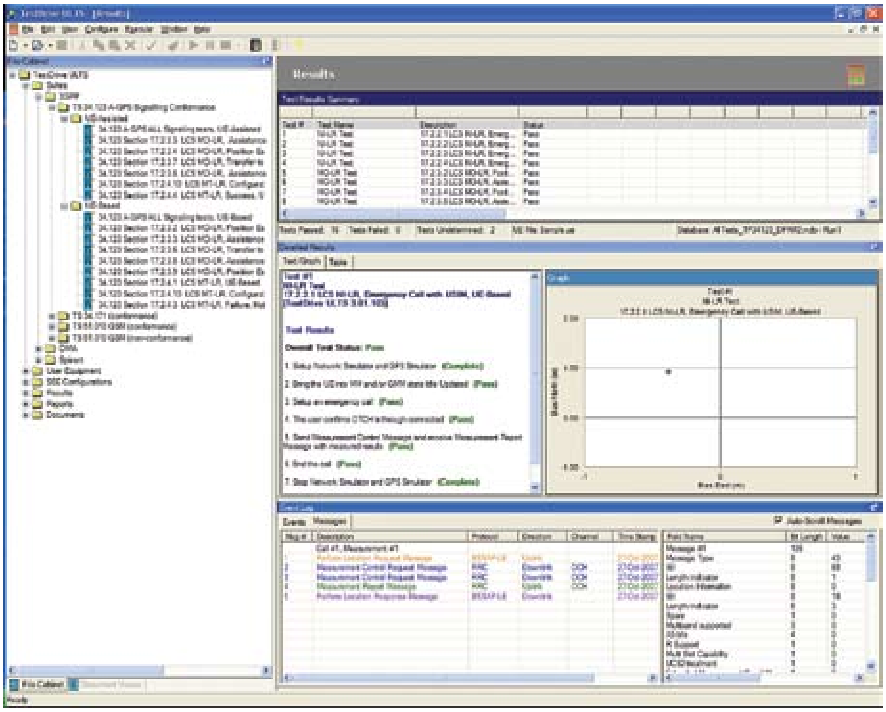

FIGURE 1 UMTS Signaling Testing

Parameter	Comment
Response Time	Response time is defined and maximum values are given for a UE to achieve.
Time Assistance	Two types of timing assistance are available, both with the relevant test parameters however one type (fine) is optional only
Sensitivity	A UE must meet a minimum sensitivity value
Horizontal Position Accuracy	A UE must meet a minimum accuracy value but the parameters of measurement are defined separately for UE-assisted and UE-based measurement types
Dynamic Range	A UE must meet a performance requirement when visible satellites have rather different signal levels from each other
Multi-path Performance	A determination of the tolerance of a UE to multipath effects
Dynamic Performance (Moving)	A UE must meet certain tracking performance requirements (accelerations, turns, etc.) and produce GPS measurements or location fixes on a regular basis

TABLE 4. 3GPP TS 25,171 Summarized Performance Criteria

Step	Detail
1	Start scenario #1 with the UE at a randomized location around the specified reference point.
2	Initiate UE connection, reset UE, and initiate positioning measurement procedure (UE based or UE Assisted)
3	UE should return a result within the response time specified for the test. If not, record a positioning error (bad result)
4	Evaluate UE result against simulated random position to determine 2D position error and evaluate this error as a good or bad result for the fix
5	Drop connection and repeat steps 1 through 4 using scenario #2
6	After completion of scenario #2, repeat again using scenario #1 and #2 as above but advance the time into the current scenario by two minutes each run through, restarting the scenario from the beginning of its set duration if necessary, until such time as the necessary statistical result analysis requirements are met

TABLE 5. UMTS A-GPS RF Performance Testing Process

An ideal UE passes after 77 results. The maximum test time is 2,765 results. This is clearly seen in **Figure 2**, which shows the results from a set of mini-

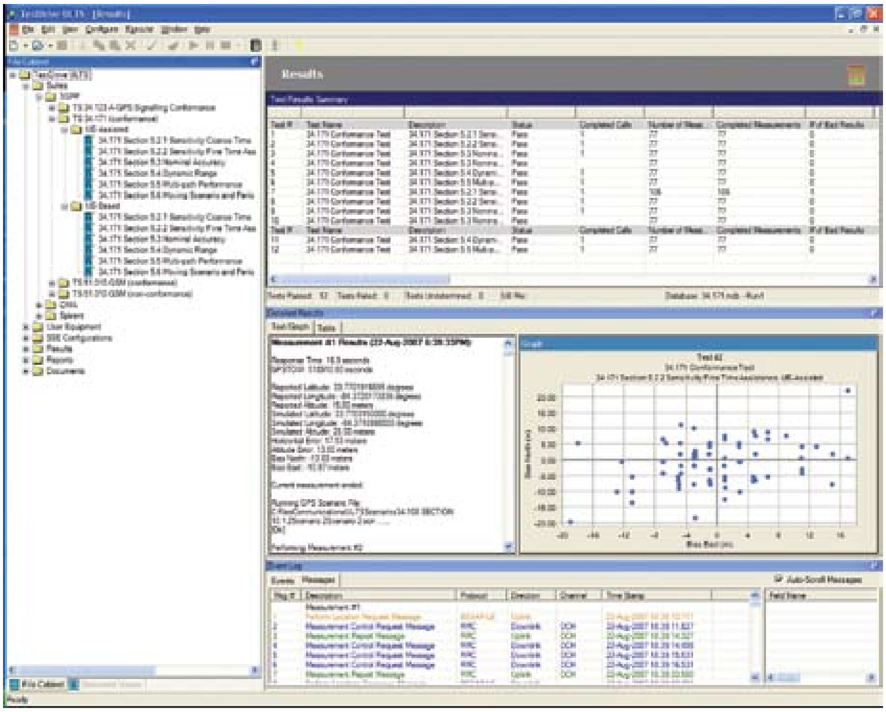

FIGURE 2 UMTS Minimum Performance Testing

Test Category	Scenario
Network Initiated	Verification of basic SUPL functionality
	Verification of correct handling of notification and verification
	Verification of correct choice of positioning method
	Verification of correct handling of various error conditions
SET Initiated	Verification of basic SUPL functionality
	Verification of correct choice of positioning method
	Verification of correct handling of various error conditions

TABLE 6. Summary of SUPL Signaling Tests

mum performance tests on a sample A-GPS device. The 77 measurements for an ideal pass can be seen as being achieved in all but one case.

SUPL Signaling Conformance

Sections 5.1 and 5.2 of the OMA SUPL ETS define the tests for SUPL signaling. In turn, these tests describe various scenarios as outlined in Table 6. Note that for SUPL a cellular device is called a SUPL Enabled Terminal (SET)

The testing of SUPL signaling is carried out in a very similar manner as that for 3GPP signaling; therefore, no further detail is given here.

Certification

Once a UE (or MS in the GSM world) has passed the signaling and minimum performance conformance tests outlined in the relevant documentation, the laboratory or the device manufacturer can use the test results to assist in the submission of a product to the relevant databases for the GCF and PTCRB.

In the case of the United States, certification needs to be approved by the CTIA, the wireless industry association. For the GCF the scheme is voluntary and is described earlier in this article. However the major network operators in Europe require any terminal to have passed the conformance requirements outlined by the GCF, and of course the R&TTE directives are necessary for CE marking.

For the detail of the PTCRB approval this can be found in the Permanent Reference Document NAPRD.03 current version. (Available from <http://www.ptcrb.org>.)

For any manufacturer of an A-GPS–enabled device, certification schemes such as those described in this article demonstrate a level of performance that can be used as a benchmark against their competition. They also assure the manufacturer's customers that its products will operate with a level of generally accepted performance. This also applies to OEM module manufacturers who need to prove to their customers that, once integrated, a device will pass the certification needs for the final product.

Manufacturer

The test equipment used in preparing this article was a Spirent ULTS, A-GPS Test platform from **Spirent Communications Inc.**, Eatontown New Jersey, USA.

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