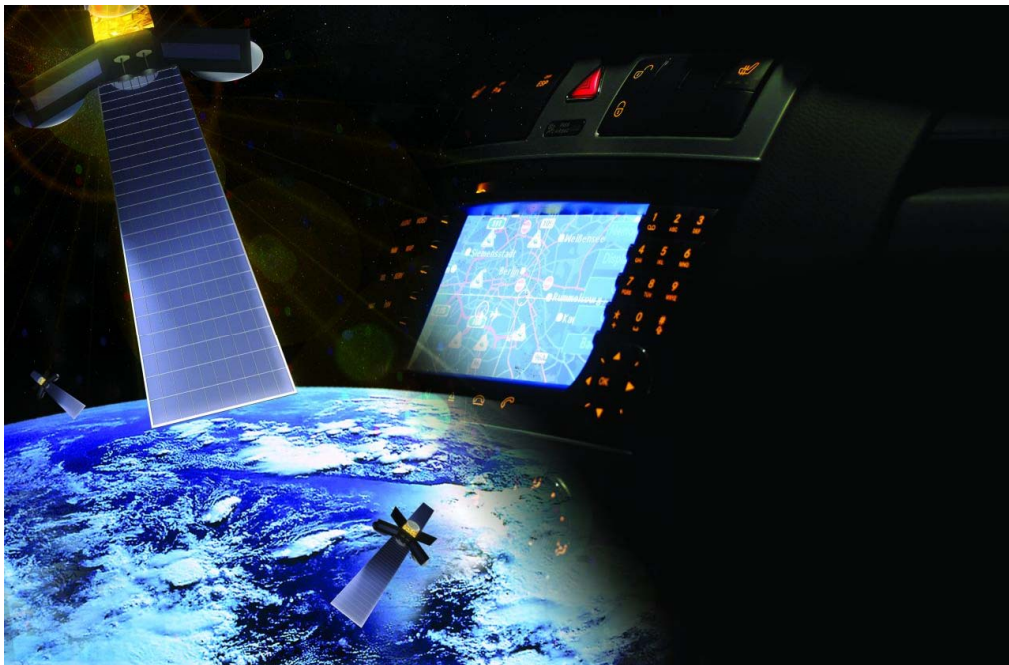


# Functional A-GPS Receiver Test using 8960 Wireless Communications Test Set and E4438C ESG Vector Signal Generator

Application Note



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## **Introduction**

Assisted GPS (A-GPS) is an enhanced position location method that uses the satellite-based global positioning system (GPS). A-GPS allows much faster position location by using more precise positioning information obtained from base stations that monitor GPS satellites constantly. This information is called Assistance Data and allows the mobile to determine and report back to the network its exact location within seconds as opposed to minutes using unassisted GPS techniques. Its development was driven by the U.S. Federal Communication Commission (FCC) E911 requirement for quickly providing the location of a cell phone to emergency call dispatchers.

In addition to emergency-related position location, more mobile device applications are emerging that use GPS technology. Some examples are mapping, voice navigation, etc. More service providers around the world are implementing A-GPS in their networks to meet emergency and customer-convenience needs. As a result, more A-GPS capable devices are being introduced into the marketplace. It is important to service providers that A-GPS operation does not interfere with cellular phone calls, especially emergency calls. As a result, service providers require their mobile phone suppliers provide proof of correct operation prior to accepting these phones on their networks.

This application note describes a test system that uses an 8960 Wireless Communications Test Set in conjunction with an E4438C ESG Vector Signal Generator with GPS Personality to perform the types of functional testing needed to meet service provider proof requirements.

## **Satellite information and location calculation methods**

The satellite information provided to the wireless device in the assistance data includes both ephemeris data and almanac data. Satellite ephemeris data is information with exact location data of satellites at a particular time, which enables GPS-capable devices to determine their own location. Almanac data are used to determine which satellites are going to be visible at a given location so that a GPS receiver can search for satellites within range and exclude satellites below the horizon from its search. Almanac data is not highly accurate, but does not need to be frequently updated. The assistance data sent from the network to the wireless device includes both almanac and ephemeris data.

There are two types of A-GPS techniques specified in the standards: Mobile Station Assisted (MSA) and Mobile Station Based (MSB). With the MSA method, the position location calculation is performed in the network by a network processor or location server. This server approximates the position of the wireless device based on the raw satellite data sent by the device back to the network. The MSB approach utilizes the processing power of the wireless device to complete the location calculations. The device then reports back its longitude and latitude to the network rather than the raw satellite data. This technique uses more of the device's memory and MIPS and requires more precise ephemeris data. However, this ephemeris data is valid for a number of hours, so it does not require frequent updates.

## Test equipment

### **8960 wireless communications test set**

Control plane A-GPS involves the transmission of GPS assistance data from the network to the UE using 3GPP specified signaling messages. Assistance Data Deliver message (ADDM) and Measurement Control message (MCM) are defined for this purpose. The Measurement Report message (MRM) is used to return A-GPS measurement results from the UE to the network.

For testing 2G (GSM/GPRS/EGPRS) A-GPS capable devices the following test set configuration is required:

- E5515C (Wireless Communications Test Set) with
  - E5515C-002 (2<sup>nd</sup> RF Source)
  - E6701F (GSM/GPRS Lab Application)

For testing 3G (W-CDMA/HSPA) A-GPS capable devices the following test set configuration is required:

- E5515C (Wireless Communications Test Set) with
  - E5515C-003 (CDMA base station emulator)
  - E6703E (W-CDMA/HSPA Lab Application)

If you will be testing either 2G or 3G UMTS A-GPS capable mobile devices, then the following 8960 test set configuration is required:

- E5515C with Options 002 and 003
- E6703E/F for W-CDMA/HSPA
- E6701F/G for GSM/GPRS/EGPRS

For testing cdma2000® A-GPS capable devices the following test set configuration is required:

- E5515C (Wireless Communications Test Set) with
  - E5515C-003 (CDMA base station emulator)
  - E6702C (cdma2000 Lab Application)

### **E4438C ESG vector signal generator**

The GPS signals are created by the E4438C ESG vector signal generator with Option 409 GPS personality. The E4438C is a high performance, general-purpose RF signal generator capable of providing comprehensive support for today's wireless signal formats. The GPS personality provides up to eight real-world GPS satellite signals that are developed based on pre-configured scenario files. These signals, including Doppler shifts, are synchronized with the actual satellite orbits so that they are consistent with the navigation message contained in the satellite signals.

This GPS signal simulator provides the following capabilities:

- Multi-satellite GPS configuration (maximum eight satellites)
- Simulation of real-world scenarios (multiple scenarios available)
- Real satellite data (synchronized satellites with Doppler shifts and navigation messages)
- Adjustable number of visible satellites between one and eight
- Automation of signal generation through SCPI commands

The following E4438C configuration is needed for GPS signal generation required for the mobile device A-GPS test system:

E4438C ESG Vector Signal Generator with

- E4438C-005 (6 Gbyte hard drive)
- E4438C-409 (GPS personality)
- E4438C-502 (250kHz to 2 GHz frequency range)
- E4438C-601 or -602 (Internal baseband generator)

Note: a special [GPS Scenario](#) file is required for this test setup. This file can be downloaded from the following location: [www.agilent.com/find/msggps](http://www.agilent.com/find/msggps)

This GPS scenario file simulates the location information for *GPS Scenarios* as required by 3GPP TS 34.108 clause 10.1.2.1. The assistance data provided with this scenario is defined in 3GPP TS 34.108 clause 10.6

### PC Control Software

#### GS-9000 (recommended)

Software is required to control the test equipment, generate assistance data, encode and decode protocol messages, calculate position location, and return test results. Agilent's GS-9000 test system is a scalable solution that includes software with predefined test cases that conform to individual technology standards. These tests can be configured or modified to fit specific design verification needs and accurately emulate A-GPS operation on a real network. See the Test Setup section for more details on the PC Control Software.

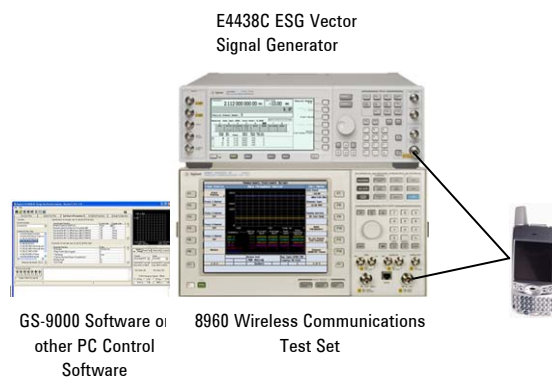
#### E6584A wireless protocol advisor (WPA) software (optional)

The WPA software is a good debug tool to show the protocol messages being sent between the 8960 and the wireless device under test. This tool can be used to verify that the correct assistance data is being sent to the wireless device and that the results returned from the device are correct.. An example of this can be found in the [.tol file](#) downloaded from:

[www.agilent.com/find/E6584A](http://www.agilent.com/find/E6584A) >> **Technical Support >> Drivers & Software**

## Test setup

### Setup diagram



**Figure 1. Connection diagram for mobile device A-GPS test system**

Figure 1 shows the connections required to set up the mobile device A-GPS functional test system. Both instruments (8960 and E4438C) are connected to the PC controller via GPIB. The PC control software is installed on an external PC. The device under test (DUT) is coupled to the instruments either via RF cables or antennas connected at the RF ports of each of the 8960 and E4438C.

### **E4438C setup**

The special GPS Scenario file should be transferred to the USERS/GPS directory on the E4438C hard drive. The procedure to accomplish this is found on the Scenario Files webpage [www.agilent.com/find/msggps](http://www.agilent.com/find/msggps)

### **PC Control Software setup**

- The PC should be connected to the 8960 and E4438C over GPIB in order to control the instruments.
- Select the GPS scenario for the ESG
- Generate the assistance data based on the GPS scenario selected
- Encode the assistance data to be sent from the 8960 to the wireless device. For GSM/GPRS/EGPRS devices, the assistance data is exchanged via RRLP (Radio Resource Location Services (LCS) Protocol). For W-CDMA/HSPA devices, the assistance data is sent using the RRC (Radio Resource Control) layer. For cdma2000 devices, TIA-801 messages are used to send the assistance data.
- Send the assistance data and measurement request messages to the 8960 over GPIB ("CALL:PPR:PME:PIPE:DATA:TX 'XXXX'" in GSM/GPRS/EGPRS)
- Execute GPIB command to send the assistance data and measurement request messages from the 8960 to the wireless device ("CALL:PPR:PME:PIPE:SEND" in GSM/GPRS/EGPRS).
- Query the 8960 over GPIB to determine if a response from the wireless device has been received. ("CALL:PPR:Procedure:PMEasurement:PIPE:DATA:RX:AVAILABLE?" in GSM/GPRS/EGPRS)
- When a response from the wireless device is available, query the 8960 to return the raw data from the last message received from the wireless device ("CALL:PPR:Procedure:PMEasurement:PIPE:DATA:RX?" in GSM/GPRS/EGPRS)

### **Test results**

The test results detailed below can be obtained by analyzing the results reported back by the wireless device. This analysis can be performed either by decoding and analyzing the data returned to the 8960 by the wireless device or by using Wireless Protocol Advisor to view the protocol messages. The raw data returned to the 8960 by the wireless device can be queried over GPIB and returned in hexadecimal form. For example, a return of

```
"800000010221F8AF76D8AF38B49C6C00328875CA4DFB5B34E83ACD253E1942911D5292565185558EA34933B2FA910741A55E14724B83A4D2AEF38A8201D429479BCF4F80E8"
```

includes data on 8 satellites that were found by the wireless device as well as some measurement report header information. This hexadecimal data can be parsed and viewed in Wireless Protocol Advisor (WPA) or analyzed by your PC software. Agilent's GS-9000 software uses this data to calculate and report the following results.

### **Raw Satellite Data**

The following results apply to devices using the Mobile Station Assisted technique:  
Satellite Identification (ID) Number: Each GPS satellite has a unique identification number assigned to it and is the GPS receiver's primary means of identifying individual GPS satellites.

Carrier to Noise Ratio (C/No): This is the ratio of the received carrier power and the noise power in a given bandwidth, expressed in dB. The higher the C/No-value, the better is the strength, and therefore the quality of the received signal.

Pseudorange RMS Error: These values are used to compute a weighting matrix that is used in the WLS (Weighted Least Squares) positions solution (as defined in 34.171).

Doppler: This is the Doppler shift as measured by the GPS receiver. This information is used to calculate the 3D velocity of the mobile.

Whole and Fractional Chips: These parameters represent the code-phase measurements as reported by the mobile. Code-phase can be used to calculate the observed pseudorange between the mobile and a satellite.

### **Latitude and Longitude**

Mobile Station Based capable devices can determine their own longitude and latitude and will report it back to the 8960 in the form of hexadecimal data.

### **GPS Time of Week (TOW)**

GPS time is transmitted by a combination of the current Week Number and the Time of Week. The TOW represents the number of seconds into the week ranging from [0 . . . 604800] seconds and is counted from midnight Saturday/Sunday on the GPS time scale. This is different from Coordinated Universal Time (UTC) in that GPS time is not corrected to match the rotation of the earth (e.g. leap seconds)

### **Number of Satellites**

GPS satellites are arranged in their orbits so a GPS receiver on earth can always receive from at least four of them at any given time. The more satellites the receiver can "see", the better the position location accuracy will be. Buildings, terrain obstacles, electronic interference, or dense vegetation can inhibit signal reception and degrade position location accuracy. Typically four GPS satellite signals are used to compute position.

### **Time to First Fix (TTFF)**

"Time to First Fix" is the time it takes for a GPS receiver to determine its current position. The basic steps are acquiring the GPS satellite signal, tracking the signal, and downloading the navigation information. This process is speeded up using assistance data that is transmitted via the cellular network connection. This value can be calculated by determining the difference in time between when the assistance data was sent from the 8960 to the phone and when the reply is received from the phone by the 8960.

### **2D Error Calculation**

The 2-dimensional error can be calculated based on the difference between the location reported by the wireless device and its expected location.

## **Types of assistance data messages supported**

GSM/GPRS/EGPRS

RRLP (Radio Resource Location Services (LCS) Protocol assistance data messages

W-CDMA/HSPA

RRC (Radio Resource Control) assistance data messages

cdma2000

TIA-801 assistance data messages

## **Summary**

This application note describes how to use Agilent's 8960 Wireless Communications Test Set in conjunction with the E4438C ESG Vector Signal Generator with GPS Personality to perform functional testing of A-GPS performance in cellular devices meant for use on networks that offer this capability.

As more network services are deployed that utilize A-GPS, more cellular device manufacturers will need to test this capability to prove their A-GPS operation does not adversely affect the call performance.

**For more information on the Agilent A-GPS test solutions, go to [www.agilent.com/find/AGPS](http://www.agilent.com/find/AGPS)**

**For more information on the Agilent GS-9000 A-GPS Design Verification Test system, go to [www.agilent.com/find/GS9000](http://www.agilent.com/find/GS9000)**



## Glossary of terms

2G	2 <sup>nd</sup> Generation
3G	3 <sup>rd</sup> Generation
A-GPS	Assisted GPS
CDMA	Code Domain Multiple Access
DUT	Device Under Test
EGPRS	Enhanced General Packet Radio Service
FCC	Federal Communications Commission
FTP	File Transfer Protocol
GPIB	General Purpose Interface Bus
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
HSPA	High Speed Packet Access
ID	Identification
IP	Internet Protocol
Msa	Mega Samples
PC	Personal Computer
RF	Radio Frequency
RRC	Radio Resource Control
RRLP	Radio Resource LCS (Location Services) Protocol
SUPL	Secure User Plane Location
SVN	Satellite Vehicle Number
TIS	Total Isotropic Sensitivity
TOW	Time of Week
TTF	Time to First Fix
UTC	Coordinated Universal Time
W-CDMA	Wideband Code Domain Multiple Access
WPA	Wireless Protocol Advisor

## Reference literature

*GSM/EDGE Radio Access Network; Location Services (LCS); Mobile Station (MS) - Serving Mobile Location Centre (SMLC) Radio Resource LCS Protocol (RRLP)*, 3GPP TS 04.31

*Agilent Customizing the E656XC/N588XA Wireless Test Manager*, application note; literature number 5989-7099EN

*Typical GPS Receiver Verification Tests Using a GPS Signal Simulator*, application note; literature number 5989-8572EN

Axelrad, P., and Brown, R.G. "GPS Navigation Algorithms." Global Positioning System: Theory and Applications, Volume 1. Parkinson, B.W. and Spilker, J.J. American Institute of Aeronautics and Astronautics Inc., 1996.

Grewal, Mohinder S., Weill, Lawrence Randolph, and Andrews, Angus P. Global Positioning Systems, Inertial Navigation, and Integration. Wiley-Interscience, 2007

Guo, Jay Y. Advances in Mobile Radio Access Networks. Artech House, 2004.



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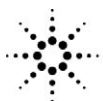
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Revised: October 1, 2008

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Printed in USA, May 14, 2009  
5989-9141EN



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