

# OET71 Compliance Testing

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**Abstract: Recent FCC regulations have caused wireless operators to introduce new technologies into their networks for E911 compliance. This paper focuses on what these new regulations mean to wireless operators, LCC International's position on testing and compliance, and the cost benefit of various testing methodologies.**

## I. Introduction

Beginning in 1996, the Federal Communications Commission (FCC) began publishing a series of orders to improve both the quality and reliability of 911 service in the United States for subscribers of cellular service. The rules adopted seek to provide emergency service personnel as much information as technically feasible about the caller's location, for the purposes of public safety. Today, wireless 911 rules apply to all cellular and PCS licenses, and certain specialized mobile radio (SMR) licenses.

At a high level, compliance with FCC guidelines has been segmented into two phases. The first phase requires that the wireless service provider locate callers based on cell site and sector identification. Phase II compliance requires that the wireless service provider locate callers with a greater degree of accuracy.

This white paper addresses OET71 compliance testing in conjunction with E911 Phase II requirements. This article addresses major over the air technologies (TDMA/GSM, iDEN, AMPS & CDMA) from a compliance and solutions standpoint, and LCC's methodology of compliance testing.

## II. Technologies

To meet the requirements of Phase II, wireless operators need to make modifications to their existing network equipment, and depending on system design, to deploy special geo-location technology equipment used to provide tighter measurement accuracy (Figure 1.1). Geo-location technology can be integrated into the network, or added as an overlay/adjunct to the wireless communications system.

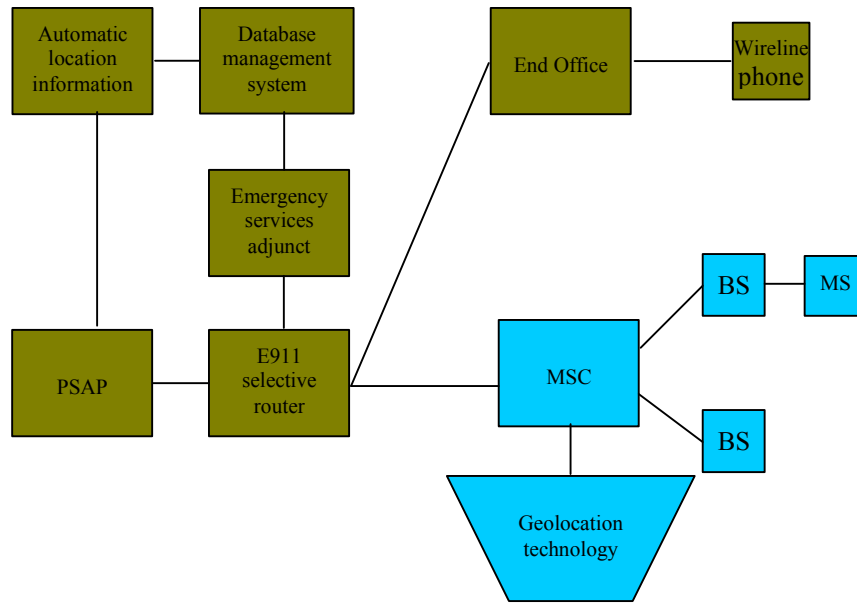


Figure 1.1 Location System Architecture

A variety of basic technologies are available for accurate position location. These technologies may be grouped into handset-based technologies such as the Global Positioning System (GPS) and network-based technologies that capitalize on the cellular infrastructure to obtain geo-location information.

### Network-Based Technologies

#### *Time Difference of Arrival (TDOA)*

Hyperbolic location systems, often referred to as time difference of arrival (TDOA) systems, locate a handset by processing signal arrival-time measurements at three or more separate cell sites. The arrival-time measurements at two stations are combined to produce a relative arrival time that restricts the possible transmitter to a hyperboloid with the two stations as the foci. Transmitter location is estimated from the intersections of two or more hyperbolas determined from three or more stations (see Figure 1.2). The TDOA technique typically uses existing cell site receive antennas.

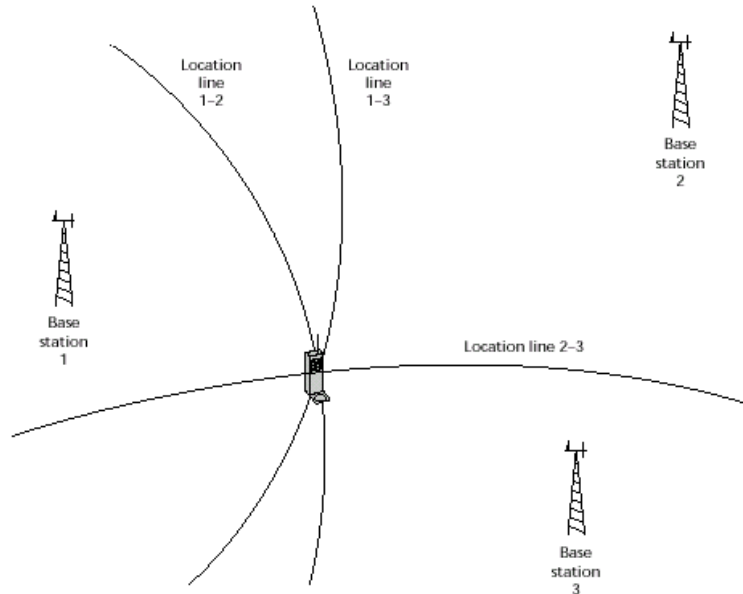


Figure 1.1 TDOA Positioning Diagram

*Angle of Arrival (AOA)*

The AOA technique determines the direction of arrival of a handset's signal at the cell site. The phase difference of the signal on elements of a calibrated antenna array mounted at the cell site provides the angle of arrival. The intersection of the angles from two or more sites provides the location (see Figure 1.2).

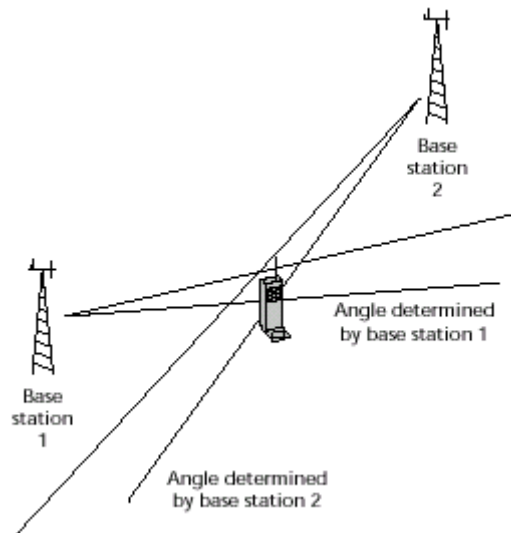


Figure 1.2 AOA Positioning Diagram

*TDOA + AOA*

In this approach, TDOA sensors are augmented with AOA capability to improve coverage and accuracy. One example of this is the coverage of a rural highway where the

cell site arrangement often is in a line along the highway, making the TDOA-only approach non-workable or less accurate due to signals received from a fewer number of cell sites.

#### *Multipath Finger Print*

The base station (BS) compiles the unique signature pattern (Multipath Fingerprint) of the mobile station. The signature pattern is compared to a database of previously identified locations and their corresponding signature patterns, and a match is made.

### **Handset-Based Technologies**

#### *GPS*

GPS uses a network of satellites to provide TOA-based localization at the terrestrial based receiver. The receiver typically records the coordinates and transmitted time determined by triangulation using received signals from at least four satellites. Many GPS-based systems integrate GPS devices with terrain-navigation technologies in a single, complex, processor-based approach.

#### *Assisted GPS*

This is a distributed approach to GPS. The handset takes a "snapshot" of the GPS signal, calculates its distance from all satellites in view and sends this information back to a location server. The server software performs complex error correction and calculates the caller's precise latitude, longitude and altitude.

#### *E-TDO*

In this approach, the TDOA solution is calculated in the handset. The location solution is based on apparent arrival time differences between pairs of cell sites as well as from knowledge of the geographic position location information of the cell sites.

### **III. Phase II Compliance**

The guidelines for wireless carrier enhanced 911 (E911) service in CC Docket No. 42-102, Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling System state:

- For network-based solutions, error in location accuracy must not exceed 100 meters for 67 percent of calls, and 300 meters for 95 percent of calls. For testing purposes, uncompleted calls should be documented, but not included in calculating statistical accuracy.
- For handset-based solutions, error in location accuracy must not exceed 50 meters for 67 percent of calls, and 150 meters for 95 percent of calls. For testing

purposes, uncompleted calls should be documented, but not included in calculating statistical accuracy.

- For either solution (network or handset based), location information must be routed to the appropriate PSAP within a reasonable amount of time to be effectively used by an emergency crew. Additionally, when Phase II accuracy cannot be provided, Phase I accuracy must be, i.e., cell site or sector from which the call was received.
- Any Automatic Location Identification (ALI) system should continue to remain effective whether calls are generated from stationary points or vehicles traveling at highway speeds. The commission recognizes that there is a limitation with respect to technology, and reserves the right to modify operational requirements based on accuracy requirements with respect to motion.
- For testing and compliance reporting, a biannual validation of accuracy is required to ensure system performance in conformance to stated accuracy targets. The methodology for biannual validation should include a random selection of sites such that the service provider can provide a 90% confidence level of required accuracy. Sites chosen should be random, but be based on sites most likely to initiate a 911 call based on a Monte Carlo or other equally viable methodology.

#### IV. LCC Test Point Selection Methodology

The FCC requires that a representative sample of test points be randomly selected for a market and tested bi-annually based on the above criteria such that a 90% confidence level of success is met. As a guideline, this requires that sites selected for testing not only represent the entire market, but be chosen in a random fashion to ensure statistical accuracy.

Balancing the right number of test points to save costs while ensuring that the entire market and/or network has been tested sufficiently enough to minimize risk is the challenge. For clarity, the commission has published Table 1 in Appendix A of OET71 to provide a guideline for wireless carriers in selecting an appropriate number of test points, and the allowable failures possible in either the 67% or the 95% range, or both, depending on the number of test points..

Additionally, for sites that require a solution based on triangulation (E-OTD or AGPS/AFLT), locations selected within buildings can provide challenges due to a lack of GPS signal availability as a reference point. Finally, LCC recognizes that to be truly representative of the market, sites selected should have a high degree of probability of generating a 911 call in a real emergency.

Because RF morphology differs between dense urban, urban, suburban and rural environments, LCC's approach involves segmenting the market based on morphology.

Because RF characteristics differ by morphology, once a given morphology has been tested and found to be compliant within statistically valid measurement techniques, additional test points provide no additional detail.

Based on order statistics, to reach a 90% confidence level as prescribed by the Commission, a minimum of 30 test points must be taken at each morphology, assuming zero errors. Again, Table 1, Appendix A of OET71 provides a guidance of 45 as a starting point, allowing for 5 errors at the 67% accuracy level (within 50m for handset-based location) and no errors at the 95% level (within 150m for handset-based location).

For markets with more densely distributed sites per morphology, LCC believes that the testing procedure should include a minimum of 45 test locations to allow for error most commonly associated with random test points that fall within buildings. So for a market with three morphologies represented, and 500 sites, an operator should plan on testing a minimum of 30 locations in the less dense morphologies, and at least 45 in the more dense morphologies.

While 30 test points is minimum if the accuracy of all points is within 50m for handset-based location (100m for network-based location), it is important to realize that the actual number of test points will depend on the location accuracy statistics in each morphology area (urban, suburban, etc.). The location accuracy will depend on satellite signal visibility for a minimum number of satellites for GPS-based location, and BTS signal visibility for a minimum of three BTS' for handset-based location. The actual number of test points can be better estimated once more information is available on the variability of the level and number of signals received from satellites and base stations, depending upon the type of location system, in each type of morphology area.

For additional testing beyond the current prescribed requirements by the Commission, LCC can weight, by morphology, the number of test points to be taken as a percentage of the area covered. This number can also be checked and verified for independence of morphology, assuming minimum distances between sites, as a check on the practical number of test points. While this practical approach will generally exceed the minimum number of test points as required by the Commission, many operators feel that this approach minimizes risk and public safety is ensured.

Additionally, functional testing should also be performed to include call through testing to either the PSAP, or intercepting the call prior to its termination at the PSAP to check for time of arrival of location based information, proper routing of ALI information, signaling and trunking.

## V. LCC Testing Methodology

The methodology for testing requires that 911 calls be generated from previously designed test points within the network. Close coordination with the PSAP must be completed for a testing methodology through to the PSAP. However, for many cases,

call intercept devices exist which allow for 911 calls to be generated without involving or affecting the normal operations of the PSAP.

When coordination with PSAPs is required, time of day constraints often require that testing be done during non-peak hours. However, when call intercept devices are used, greater flexibility over time of day for the tests can be realized, allowing for testing and measurements of other aspects of the network simultaneously, such as voice and data quality of service.

Each E911 call generated is done so after GPS coordinates are known from the test location. Call detail information is then recorded arriving from the system and compared to actual GPS coordinates during post processing. For A-GPS systems using AFLT, data must be parsed prior to analysis to ensure the appropriate test for accuracy is applied to the call type.

LCC collects and processes E911 call data using custom-made software-based equipment. The software requires input from the E911 system's batch output file for the time period tested, or some other method of obtaining the specific E911 output to the PSAP for each call made.

LCC's collection software ("LocationCollect") is installed on a Pentium III laptop with two serial ports enabled. One serial port is connected to an E-911 ready phone enabled on the network, and for which LCC is provided the data cable, the pin identification and data transfer protocol. The other serial port is attached to a differential GPS. LCC uses a Placer GPS-455 with Dead Reckoning and an input to a CSI MBX-3 differential receiver. The differential (enhanced) GPS is able to switch between the two sources for the best signal.

The methodology for the E911 test can differ dramatically depending upon the purposes of the wireless operator and the scope of the test. Once the quantity and location of points are chosen as representative of the entire market, the call collection procedure is simple. The telephone and software are left in sleep (standby) mode. When it is time to collect a point, the LocationCollect software is initiated, and the technician pushes a button on the telephone set to dial the dummy E911 number automatically. The technician waits to determine whether the call is completed, and if not, the technician repeats the process until the call is completed. Call failures are recorded, but not counted as location failures.

The computer collects the information about the time of the call from the EGPS unit as well as the EGPS location. In some cases it can also be configured to collect the handset's GPS information. After 45 to 60 seconds, the call is manually terminated by the technician, and the computer file is then stopped.

When call collection is completed, the data from the LocationCollect program is output into an Excel table. Meanwhile, the wireless operator must supply a database file of the phone information related to the dummy E911 calls made by the test phone. This

file includes, among other things, such information as the time of the initiation of the call, each latitude and longitude measurement provided during the E911 call, and the time of arrival of each of these latitude and longitude fixes.

LCC will then convert both files into the proper format within LocationCompare to examine the EGPS measurements made at the test call location. LCC's software examines the data call-by-call and determines successes and failures for each call according to FCC guidelines.

#### Reference

1. *OET71*