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October 29, 2004

Marlene H. Dortch, Secretary
Federal Communications Commission
Office of the Secretary
445 12th Street, SW
Washington, DC 20554

Re: CC Docket No. 94-102

Dear Ms. Dortch:

The Emergency Services Interconnection Forum ("ESIF") hereby submits the attached document for inclusion in the record in CC Docket 94-102. In its Third Report and Order, the Commission established accuracy requirements for network and handset based location solutions for Enhanced 9-1-1 emergency call services.[1] As a result, the ESIF identified the need for industry-accepted requirements for testing the accuracy performance of Wireless E-9-1-1 Phase II systems, and developed **ESIF Technical Report - ATIS-050001: High Level Requirements for Accuracy Testing Methodologies (7/23/04).** This document provides a common frame of reference that individual stakeholders may use to validate the accuracy methodology of 9-1-1 location technologies.

If you have any questions or concerns, please direct them to me at (202) 434-8830 or via email at thaddix@atis.org.

Sincerely,

Toni G Haddix

Toni Haddix
Staff Attorney

Attachment: ESIF Technical Report – ATIS 0500001
High Level Requirements for Accuracy Testing Methodologies

[1] In the Matter of Revision of the Commissions Rules to Ensure Compatablity with Enhanced 911 Emergency Calling Systems, CC Docket 94-102, Third Report and Order, (September 15, 1999).

Alliance for Telecommunications Industry Solutions

ATIS Standard

ESIF TECHNICAL REPORT

ATIS-0500001

High Level Requirements for Accuracy Testing Methodologies

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REVISION HISTORY

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High Level Requirements for Accuracy Testing Methodologies

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1 INTRODUCTION

The United States Federal Communications Commission has established accuracy requirements for network and handset based location solutions for Enhanced 9-1-1 emergency call services. These requirements can be found in the Commission's Third Report and Order, adopted September 15, 1999.

The Emergency Services Interconnection Forum (ESIF) identified the need for industry accepted requirements for testing the accuracy performance of Wireless E-911 Phase II systems.

This document neither recommends, nor imposes a specific test methodology, but rather provides a common frame of reference that individual stakeholders can use to validate the accuracy methodology of 911 location technologies. This document provides a set of minimum requirements individual test methodologies should comply to.

Every possible effort has been made to ensure that these requirements remain technology neutral.

Per current ESIF Operating Guidelines, due process has been followed in the creation of this document, and development has been open for participation within the bounds of ESIF.

Scope

This document focuses on providing a set of minimum requirements for the "Accuracy Testing" phase of a typical network deployment of positioning technologies for Wireless E-911. Other testing phases are beyond the scope of this document.

This document addresses the technical aspects of accuracy testing. Testing and carrier compliance reporting are two distinct and separate issues. The application of this methodology to compliance reporting is beyond the scope of this document.

Acknowledgements

Study Group G would like to thank individual members for their active participation and contribution to the creation of this document.

References

[1] Guidelines for Testing and Verifying the Accuracy of Wireless E911 Location Systems (OET Bulletin No. 71)
Federal communications Commission, USA
April 12, 2000

[2] CDG Test Plan Document for Location Determination Technologies Evaluation
CDMA Development Group
2000

[3] Enhanced Wireless 9-1-1 Phase 2
J-STD-036-A
Telecommunications Industry Association and Alliance for Telecommunications Industry Solutions
June 2002

2 DEFINITIONS

This section offers a few definitions found to be important to maintain a common vocabulary throughout the creation of this document.

Accuracy Testing

Accuracy testing, whether through empirical and/or predictive test methods, consists of generating location data to gauge the accuracy performance of the system. Location data, typically significant in volume, involves the location infrastructure of the carrier's network. The primary objective is to verify location accuracy and correct any location system errors. Limiting the test to the carrier's location network minimizes impact to the rest of the Phase II network and maximizes the capability of the carriers to optimize their system.

Functionality Testing (End to End)

Functionality testing consists of testing the delivery of the location data from the carrier to the PSAP. The objective of this testing activity is to ensure interoperability between the carrier and the Emergency Service Network. This testing activity requires tight coordination among the involved parties, which normally includes the Emergency Service Network, the carrier and the technology vendors.

Maintenance Testing

Maintenance testing may be conducted after a system has been turned up with the Emergency Service Network. Like all network systems, maintenance testing will be conducted as needed to ensure functionality and performance. This testing activity may include functionality and/or accuracy testing and the participation of the Emergency Service Network may or may not be required. Maintenance testing can be a condensed version of the original accuracy and functionality testing.

Empiric Testing

An empirical location accuracy test consists of measuring the difference between a location established by typical surveying techniques or by a differential GPS receiver or similar means and the location estimate provided by the wireless carrier.

Predictive Testing

A predictive test method consists of utilizing a predictive model to compute the expected accuracy of a location determining technology within a wireless carrier's service area. The predictive model takes into account the physical elements of the location determining system for network or handset based solutions as well as the relevant terrain and RF propagation characteristics.

2.1 Acronyms

AFLT	Advanced Forward Link Trilateration
AGPS	Assisted GPS
ALI	Automatic Location Identification
ANSI	American National Standards Institute
AOA	Angle of Arrival
E-911	Enhanced 911 Emergency Service
ESME	Emergency Services Messaging Entity
ESNE	Emergency Services Network Entity
GMLC	Gateway Mobile Location Center
GPS	Global Positioning System
GSM	Global System for Mobile Communications
MPC	Mobile Positioning Center
MSC	Mobile Switching Center
PDE	Position Determining Equipment
PSAP	Public Safety Answering Point
RF	Radio Frequency
S/R	Selective Router
SMLC	Serving Mobile Location Center
TDOA	Time Difference of Arrival

U-TDOA	Uplink TDOA
WAAS GPS	Wide Area Augmentation System GPS

3 GENERAL TEST REQUIREMENTS

3.1 Introduction

This section on General Test Requirements serves the following purposes:

1. It lists a set of basic, concise and broad requirements for the methodology addressed in this document to test and validate the accuracy of an E911, Phase II location system as it is implemented in a given wireless service provider's network.
2. It introduces the framework for this methodology, which consists of related, cohesive elements (described in the remaining chapters of this document) that form the basis for the test methodology.
3. It defines the context for the "system under test" to which this methodology is applied. For reference, there is a system diagram for the location network being tested that identifies interface points for accuracy testing within ANSI 41 and GSM MAP networks (Figure 3-2and Figure 3-3).

3.2 Basic Testing Requirements

In general, the following basic requirements will be satisfied as part of the ESIF Accuracy Testing:

- Accuracy testing shall be accomplished in a manner that minimizes its impact on the wireless network, including the air interface, the location technology, and all other elements involved in E911 call processing.
- Accuracy testing results shall be representative of the location information that will be delivered to the Emergency Services Network.
- Accuracy testing shall be performed in a manner minimizing or not interfering with PSAP operations.
- Accuracy testing shall be consistent with the spirit and overall objectives of OET Bulletin 71 Guidelines.
- Accuracy testing shall aim to satisfy the diverse objectives of the wireless E911 stakeholders.
- Accuracy testing shall be documented for purposes of review and maintaining an accurate record of test results.
- The test objectives shall be clearly defined and understood by all involved parties. A pass or fail criteria shall be clearly stated prior to any test activities.

3.3 General Testing Framework

The ESIF testing framework identifies all the critical and interrelated elements required to perform accuracy testing of an E911 Phase II location system. Figure 3-1 depicts this framework. It starts with requirements for testing equipment, test area definition and description, actual testing methods (both empirical methods and predictive modeling with empirical verification) and analysis and summary reporting. The sections within this document follow this sequence reflected in Figure 3-1. Each is concisely outlined below.

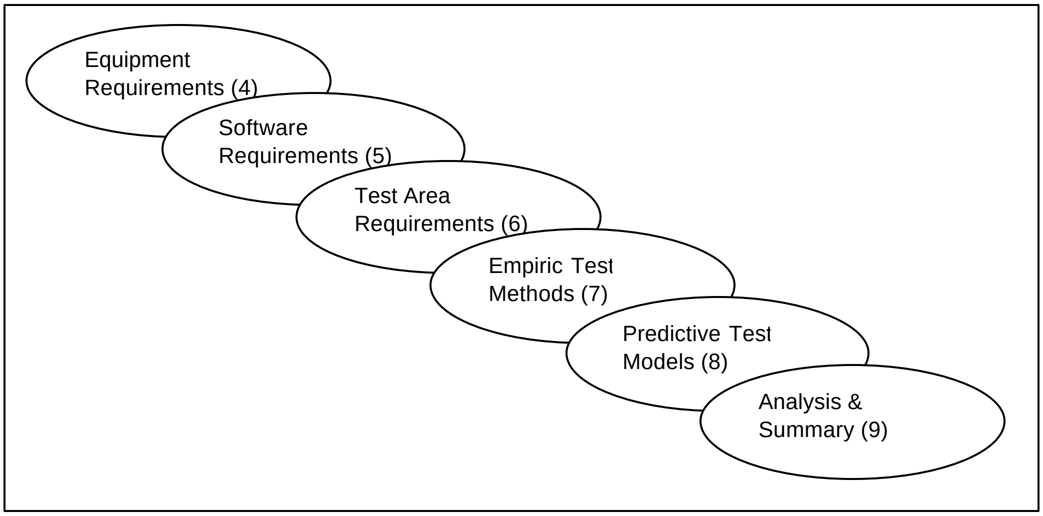

Figure 3-1: Accuracy Testing Methodology Framework

Equipment Requirements: Accuracy testing shall include test equipment that is capable of identifying and recording independent "ground truth" location that becomes the reference for comparison to test location measurements. Accuracy testing shall include but not limited to equipment identified in Section 4 that can record test and reference data.

Test Area: In order to correctly assess location accuracy, testing shall be conducted in an established test area. The factors described in Section 6 shall be considered in determining the requirements for the test area.

Empirical Test Methods: Measurements performed in the field are employed in determining the accuracy of location systems. Because of the complex and varied nature of the landscape in which wireless networks operate, empirical testing shall be the primary method of accuracy determination. Empirical testing methodologies and their requirements are addressed in detail in Section 7.

Predictive Methods: When applied according to proper requirements and safeguards, predictive models may be used as a viable location accuracy assessment approach that cost effectively augments empirical methods. Since, location prediction, like any RF prediction, is susceptible to modeling inaccuracies and limitations, the predictive modeling techniques used shall be carefully and periodically calibrated with empirical data to ensure their fidelity. The attributes of suitable predictive models, their interrelationship and consistency with empirical methods, and the requirements for their application based on sound engineering practice are described in Section 8.

Analysis and Summary of Results: After data has been collected from empirical methods or predictive models, specific analysis shall be used in determining the test results. Analysis techniques meeting the requirements described in Section 9 shall be the basis for determining the location accuracy statistics reported.

3.4 System Diagram for Location Network Testing

Figure 3-2 and Figure 3-3 show the network diagrams for "location network under test" for purposes of location accuracy testing. The purpose of this diagram is to identify the interface points where data collection shall take place. These interface points for the collection of voice and data information shall not impact the processing of both test and actual, i.e., "live" 911 traffic. The position of interface points in the wireless network is optional, but shall provide the same location data that would be delivered to the

Emergency Services Network. The interface points shall provide E911 location data whether they are Phase 1 or Phase 2 based.

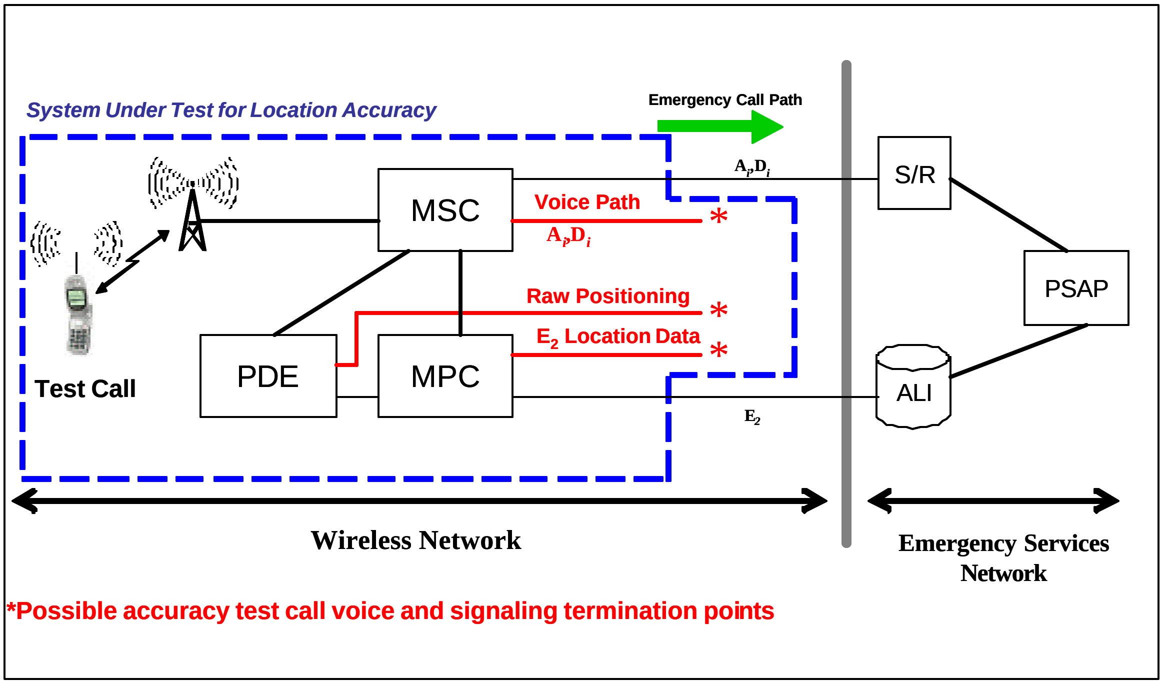

Figure 3-2: System under Test Boundary for Location Accuracy (ANSI-41 Networks)

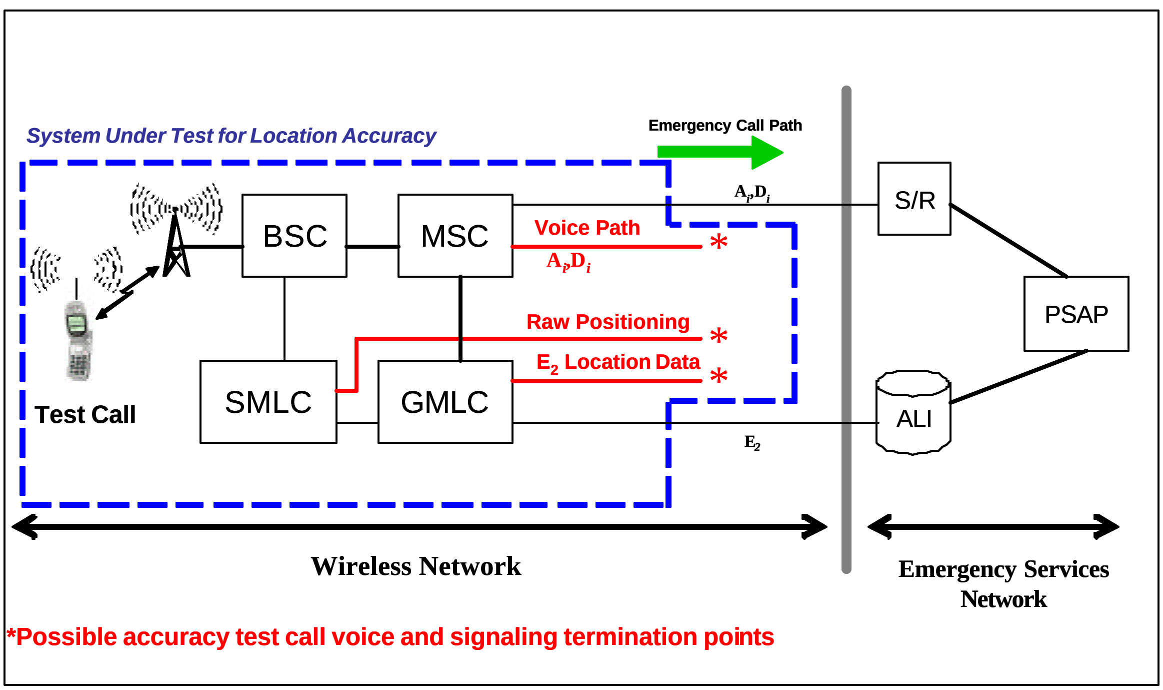

Figure 3-3: System under Test Boundary for Location Accuracy (GSM MAP Networks)

It must be noted that these figures are representations of functional entities, and not necessarily physical node implementations. If an MPC or GMLC alters the location information then that functional component shall be considered part of the location platform.

4 EQUIPMENT REQUIREMENTS

This section describes the equipment and tools typically used to conduct accuracy testing. Depending on specific methodology needs, some of the equipment listed in this section may be optional.

4.1 Test Phones

Test phone equipment must be available and representative of the Radio Access and Location Technologies in use by the Wireless Carrier. The capability to initiate test calls autonomously is acceptable.

4.2 Equipment to Establish Ground Truth

GPS Receiver

A Differential GPS (D-GPS) or Wide Area Augmentation System GPS (WAAS GPS) Receiver may be used as a tool for establishment of Ground Truth.

GPS Survey Equipment

Equipment used to generate Ground Truth to survey accuracy precision as desired.

Inertial Navigation Systems

An Inertial Navigation System may be needed in situations where GPS reliability needs to be augmented, such as dense urban locations or indoors.

Notice that many high-end commercial surveying and navigation tools integrate GPS (Differential or WAAS) with Inertial Navigation devices, such as Gyroscopes and Accelerometers.

Portable Computer or Comparable Recording Device

May be used on the field to record and/or transmit test call data, such as ground truth, and assist with test execution.

Wireless Modem or RF Relay

A communications device may be used to transmit, receive and process field data to aid in the measurement of Ground Truth.

4.3 Data Recording Device

Computer or Comparable Recording Device

Such device may be used centrally or on the field to record test call data to provide automation and efficiency in the recording of data.

5 SOFTWARE REQUIREMENTS

GPS Reference Database

These reference points may be used in stationary call cases. Typically it may take the form of a software based collection of known geographic reference points, within the test area, including Latitude – Longitude (and possibly altitude) readings and descriptions.

Mapping Software

Mapping software running on a mobile test station laptop may be used as an interface to the D-GPS receiver. It makes it possible to identify, set-up, and navigate stationary test points, and drive test routes.

Data Recording Software

Software may be used to record, log, transfer, and receive test data, call information, routing information, timing data and other relevant information required.

Data Processing Software

Software may be used to automatically process the location accuracy when compared to ground truth and provide analysis and reporting to provide accurate and efficiently processed results.

6 TEST AREA

6.1 Definition of Test Area

Test area is the geographical area designated by the Test Entity for performance of the Phase II positioning technology testing and verification.

Any required network hardware or software modifications necessary to enable the Phase II location technology will have been previously completed for the area defined.

The definition of each ‘test area’ shall be determined and clearly documented by the Test Entity. Areas delineated for compliance testing should not overlap.

The test area should be a polygon selected from the portion of the wireless network to be tested, where Phase 2 E-911 service is available, regardless of PSAP boundary.

7 EMPIRICAL TEST METHODS

7.1 General

This section describes the requirements for the planning and conduct of empirical testing of location accuracy within a wireless location network used for Phase 2 E911. It describes the conditions under which this accuracy testing would be consistent with sound engineering practice and can therefore be used to establish compliance with related mandates. The following sections outline the testing requirements and do not mandate a testing methodology.

7.2 Test Locations

A set of test locations shall be selected and defined prior to the start of any empiric testing. The test point selection shall be determined using a random process or mechanism that provides statistical independence between each test location. Such a process or mechanism shall be sufficiently documented in the testing methodology used and shall also be verifiable. Such independence shall apply to all test locations whether they apply to static or dynamic testing. Applicable factors may be applied to reflect “real world" E911 call volumes if such factors are documented and are technically justified in the test methodology used.

The selection of such test scenarios shall take into account the practical logistical aspects of field test execution such as route drivability, fixed point accessibility, and crew safety. Furthermore, to ensure the public accessibility of test points, there shall be no explicit requirement to conduct test calls at any arbitrarily determined fixed point(s), such as might be required by a statistical grid square or centroid of any cell sector. The methodology shall allow for flexibility if such a fixed point selection is employed.

Depending upon the specific test area concerned, test locations may be classified by environment (i.e., rural, suburban, urban, highway, etc.). This shall not however, interfere with the random process or mechanism applied to test location selection within each classification.

During test location selection, ground truth determination methods shall be sufficiently tested to ensure the attainment of the required accuracy of reference for each test location. In general, for both network based and handset based location systems, a ground truth reference location error of less than 10 meters is acceptable.

7.3 Static/Dynamic Testing

Test point locations and accuracy testing shall include points for either static testing or dynamic testing or a combination of static and dynamic testing as long as the samples taken during empiric testing are of a statistically significant nature.

Static Testing

For static testing, the test point selection shall be defined by using sufficient detail, such that it is readily accessible by any test personnel. The reference accuracy of the static test point shall be determined by one of several means described in Section 4. Ground truth accuracy shall be such that ground truth errors do not contribute significantly to the statistics of the location error. Test points shall be sufficiently documented and the test methodology shall be sufficiently described such that any static testing is repeatable.

Dynamic Testing

For dynamic testing, the test route shall be defined with sufficient detail and the test methodology shall be sufficiently described such that testing is repeatable. The reference accuracy of the dynamic test route shall be determined by one of several means described in Section 4. Ground truth accuracy shall be such that it does not significantly impact the statistics of the location error.

Drive Test routes should be designed prior to any dynamic test execution. The routes should aim to involve as many cell sites in the test area as practical. Various routes can be defined within a test area, for execution simplicity and efficiency. Consideration must be given to factors that may affect the performance of drive test tools. For example the ground reference equipment must have consistent access to GPS signals, and a data backhaul be available as needed. It is a good practice to document the drive test route when results are recorded.

The routes shall be driven enough times to ensure a statistically significant number of test calls are made for the test area (See the example in ANNEX B).

For dynamic testing, care shall be exercised and sufficient instrumentation shall be employed to ensure the proper correspondence between ground truth and the location where the fix attempt for the test call takes place. Hence, for dynamic testing there should be: (1) a common time system employed, (e.g., GPS time) and (2) location system messages with time of fix, so that test call positioning attempts can be aligned to the corresponding ground truth reference points. If a GPS receiver is used to establish ground truth, periodic GPS samples must be taken while in motion (e.g., every second, with adequate number of satellites in view). Interpolation between GPS samples may be necessary to achieve consistent results.

The methodology shall guarantee that samples taken are statistically independent during the course of such mobile testing.

Other ground truth establishment techniques should be used as an alternative, or to augment GPS if its performance is not considered adequate within the test area (See section 4.2 Equipment to Establish Ground Truth).

7.4 Indoor/Outdoor Testing

There shall be a portion of the total test points selected for testing in indoor environments. In general, the number of indoor test calls shall be based on a good faith estimate of indoor wireless 911 calls in the test area. Indoor environments are defined as permanent structures. Inside the vehicle testing, in an open sky environment shall be considered outdoor testing.

7.5 Handset Test Equipment

Handsets used for testing shall be representative of the commercially available equipment provided by the wireless service provider. Any external or special modification to the handsets used for testing shall not enhance or modify the overall handset or location network performance. Care shall be taken and handsets should be monitored for proper functioning during all testing. In cases where test calls may reach the PSAP, handsets shall be capable of voice communications.

7.6 Test Conduct

Test Calls

Test personnel shall perform testing with handsets that utilize scenarios that are representative of current “real world” user behavior. This testing shall reflect consistency with user behavior, such as handset orientation, handset placement in a vehicle (for vehicular scenarios), etc. RF enhancements (e.g., external antennas or signal boosters) shall not be used. Additional guidance on testing is provided in Section 4, Equipment Requirements.

Sufficient test calls shall be made to accumulate statistics of the wireless location network (e.g., ANNEX A and ANNEX B). Accuracy test data shall be reflective of the performance of the wireless location network as described in Section 3.4, System Diagram for Location Network Testing,

The wireless network or handset shall not make use of any location assistance information, or positioning knowledge related to a previous attempt, which may be available prior to the initiation of a new location attempt.

During the course of empiric testing, any test data resulting from calls that are dropped prior to prescribed wireless location network timing requirements may not be used as part of the data collection and data analysis process. See Section 9, Analysis and Summary of Results

Positioning information used for accuracy determination shall be obtained within 30 seconds of test call initiation, consistent with OET-71.

Non Interference with “Live 911” Traffic

Testing shall be conducted such that any voice and data routing throughout the wireless location network does not interfere with the service providers’ ability to process actual Phase 1 or Phase 2 E911 calls as part of their normal service.

It is generally an objective that the PSAP Emergency Services Network not be utilized for accuracy tests. However, if desired by the testing entity and cleared by the PSAP, test calls may be made such that both voice and location data are sent to the PSAP. Regardless, the accuracy shall be based on data collected within the Wireless Location Network as described in Figure 3-2 and Figure 3-3 in General Test Requirements (Section 3).

Location Network Configuration

The wireless location network configuration should, as a goal, not be modified during the course of testing. If necessary, any modifications made during the period of test conduct shall be minimized so that all test calls made utilize the same critical handset or network location processing functions. Any changes made during testing shall be adequately documented, and if necessary a re-test shall be scheduled for the affected portion of the network.

Sample Size

Whether testing is conducted on network or handset based location networks, an adequate number of test locations or test call attempts shall be used to provide for a statistically significant result. The test methodology used for such accuracy testing shall provide adequate and verifiable justification for such test sample and location selections. A 90% confidence level shall be used with a meaningful corresponding confidence interval. Examples of such test sample sizes or number of test calls which clarify these statistical criteria are provided in ANNEX A and ANNEX B.

Data Collection

Data shall be recorded accurately such that any verification or audit of results is easily achievable. Data collection may use one of the recording mechanisms listed in Section 4, Equipment Requirements. Data shall be stored in accordance with the established guidelines of the individual company or organization responsible for the testing.

8 PREDICTIVE TEST METHODS

This section describes the attributes of the models suitable for use in predicting location accuracy for E911 Phase II compliance and the conditions under which their use would be deemed consistent with sound engineering practice.

8.1 Objective

In the context of E911 Phase II accuracy testing, the objective of using predictive tools and models for location accuracy determination is to augment empirical methods and to reduce the reliance on resource-intensive, repetitive field-testing.

8.2 Attributes of Suitable Modeling Tools

Predictive modeling tools that are appropriate for use in predicting location accuracy for E911 Phase II purposes must be capable of modeling the behavior of the location technologies and underlying wireless network for the target area of prediction. The predictive methods shall be able to reflect the physical mechanisms that influence the performance of the location technology or technology combinations in use as well as the dependence they may have on the underlying wireless network.

These models can rely on empirical or theoretical modeling techniques or a combination thereof. However, the models shall provide results that can be verified through empirical testing and must be able to incorporate such results back into the models to refine them and deliver final results that are within acceptable limits of difference from actual field measurements. The model shall provide outputs as the expected positioning error and its statistics (particularly the 67th and 95th percentiles) to determine the accuracy over the entire area of interest.

8.3 Relationship between Predictive Modeling and Empirical Methods

Validated predictive modeling techniques may be used for initial as well as ongoing E911 Phase II accuracy determination. In especially challenging settings such as dense urban areas, hilly terrain, adjacent to water bodies, or areas of high wireless interference, the ability to adequately match the predictive results to the empirical ones is key to a successful and acceptable prediction tool for E911 Phase II performance verification.

Therefore, the following relationship between predictive modeling and empirical methods shall exist as a minimum:

1. The use of predictive modeling in a test area shall be contingent upon the availability of applicable benchmarking empirical data.
2. A benchmark is a set of empirical data measurements that provides expected location accuracy with 90% confidence in the various environments within a given area. Empirical data used to either calibrate and/or tune any predictions shall be sufficiently diverse to reflect the set of environments within the benchmarking area.
3. A benchmark of the performance of the location system/wireless network shall be required in the same or similar area (i.e., similar topography, urbanization, and location technology deployment).
4. Empirical data within the benchmarking area shall be used to either calibrate and/or tune any prediction model for the wireless network coverage and location technology error and resulting accuracy.
5. Benchmarking shall be updated or verified periodically as major changes to the network and/or the location technology are made (e.g., change of handset characteristics, substantial retuning of the wireless network, etc.)

8.4 Consistency of Predictive and Empirical Results

Results of predictive models shall be provided in the form of expected location accuracy for the test area (e.g., polygon). The predicted location accuracy shall be consistent with the empirical testing results when applied to the same benchmarking area.

Any empirical results used for benchmarking are subject to certain confidence levels depending on the size and nature of the test samples used[1]. The confidence level for benchmarking shall be 90%. For a valid prediction, the mean predicted location error shall fall within the same confidence interval associated with the 90% confidence level for the baseline empirical sample[2].

8.5 Requirements for Using Predictive Modeling in E911 Accuracy Determination

1. Prediction methods or models shall reflect the nature of both the operational wireless network and the location technology used.
2. The model shall use information that accurately describes the network infrastructure and the location technology. Examples include site locations, antenna types, heights, and orientations, Effective Radiated Power (ERP), receiver sensitivities, timing and/or angular errors, handset measurement limitations (if applicable), and

[1] For example, the average positioning error based on a certain set of field measurements may be 35 m +/- a confidence interval Δ (e.g., 30%) with 90% confidence.

[2] If the predictive model indicates an average error that is within the same Δ for 90% confidence (e.g., +/-30%) of the field measurement average, it would be considered a valid prediction result.

rules for the range of positioning modes used in the location system under test/prediction (e.g., TDOA, AOA, AGPS, hybrid, AFLT, other).

3. The model shall first be calibrated and validated in a number of test areas that contain the network and location technology configurations deployed based upon the service providers test area types and characteristics. These areas shall also contain the range of topography and land use that is experienced elsewhere where the model is to be applied. Any calibration data is empirically gathered in the field and may be more than just location accuracy measurement data (e.g., could also include RF propagation measurement data).
4. Any calibration in the benchmark areas shall capture diurnal or seasonal variations and should be repeated upon the occurrence of location performance impacting activities such as extensive changes to the network or the location technology.
5. Following calibration, prediction shall first be applied in the benchmark areas to predict positioning accuracy and continued E911 compliance. If changes to the network or the location technology, which may have impacted the location performance have occurred, these shall be accounted for.
6. Deviation of the end results of the prediction relative to the periodic benchmarking are to be used as a guide in determining the suitability of applying the model without further tuning (after changes to the network or location system have occurred).
7. The predictive model shall be applied to provide positioning accuracy predictions in only those other areas that are similar to the benchmark areas in topography, land use and network and location technology utilization. The predictive model shall utilize periodic spot-checking of prediction results with empirical sampling.

9 ANALYSIS AND SUMMARY OF RESULTS

This section describes the requirements for the analysis of test data using tools and software for analysis, summary and report creation for E911 Phase II accuracy testing in accordance with sound engineering practice. These requirements shall be consistent with the spirit and intent of the OET Bulletin 71 Guidelines.

9.1 Objective

In the context of E911 Phase II system accuracy testing, the objective of this section is to use statistically sound and acceptable practices for data processing, data analysis and summarizing of results from accuracy testing.

9.2 Data Format

The data coordinates used for analysis shall be logged and formatted in units of latitude and longitude using decimal degrees with sufficient decimal places for sub-meter level resolution (e.g., 35.123456, -110.123456). Geodetic reference frame shall be recorded in accordance with J-STD-036; i.e., WGS-84 or more recent. Ground truth accuracy shall be as per the requirements in Section 7, Empirical Test Methods (Paragraph 7.3 Static/Dynamic Testing). Vertical dimensions may be included, but are not required.

9.3 Data Analysis Tools and Software

Data analysis tools including Data Recording Software, Data Processing Software described in Section 4 Equipment Requirements (Paragraph 5 Software Requirements) may be used to automate the analysis, enhance the efficiency and increase the reliability of calculations of location error. Data tools shall be adequately described and documented as part of any accuracy test plan.

9.4 Processing of Test Call Data

During the testing process, all calls shall be documented and classified according to their results. Calls shall be categorized and results documented in accordance with the OET 71 guidelines.

Failed or Dropped Calls

Any failure to complete a test call or any dropped test calls shall be documented as part of the data summary. Such incidents shall be documented, but not be included as part of the accuracy statistics and their associated results.

Systematic Errors

Any systematic errors that are determined as a result of data analysis shall be reported as part of the summary.

The processing of outliers (an instance of large errors or locations where no Phase 2 fixes are obtained) shall be handled consistent with the OET Bulletin 71 Guidelines and included in the data analysis and processing.

Weighting of Data

Weighting of data is a method to take into consideration such factors as the likelihood that a wireless 911 call (or any wireless call) will be made from a particular location. OET 71 provides a general discussion of call weighting.

As a goal any weighting should be conducted as part of test planning and test point selection so as to minimize any subjective, post data collection filtering. If used, weighting criteria shall be established during test planning, and may either be applied in the test site selection, or in post test analysis, but not both. Data shall be weighted only in accordance with a justifiable, verifiable and statistically valid methodology. No arbitrary portion of the data collected shall be removed during data analysis.

<u>Examples of Weighting of Data</u>

Examples of weighting of data include, but are not limited to the following (other examples may be acceptable to the FCC):

1. One weighting method is to first gather accuracy test measurements essentially uniformly and randomly over the entire test area. Next, weight each of those test measurements (i.e., the measured positioning error) by a ratio of the number of wireless 911 calls placed via the cell site covering the location of each test call, relative to the total number of wireless 911 calls placed in the entire test area, over a period of time.

   The number of wireless 911 calls placed in the test area should be measured over a significantly long interval of time, for example 1-3 months. (The intent is that the period be long enough to ensure capturing adequate 911 statistics yet short enough so that substantial changes to the network will not have occurred.)

   The weighting ratio for cell sites which received no wireless 911 calls during this measurement time period could be established as the average ratio of wireless 911 calls made per cell site over the entire test area during that time, or some other suitably small, yet non-zero ratio. This step would ensure that no test results collected are completely eliminated from the subsequent statistical computations due to 911 call weighting. This redistributed (911 call-weighted) data is then used in the subsequent statistical computations for the test area.

2. Final test area accuracy performance is determined by weighting accuracy performance according to (1) the percentage of actual wireless 911 calls in a given

sector relative to the test area, or, if wireless 911 call data is not available, (2) the percentage of actual total wireless calls originating in a given sector relative to the test area.

Pass – Fail Criteria

The pass - fail criteria for accuracy testing of the positioning technology deployed for Wireless E911 shall be developed and documented as part of the test plan being implemented. While the criteria may vary according to the objectives and requirements of the test being performed, they shall be applied in accordance with the methodology and practices outlined in this document.

Resulting Statistics

Sufficient amounts of data shall be collected, analyzed and reported so that the 67% and 95% error points are calculated with at least 90% confidence.

9.5 Data Summaries and Reports

This section includes a list of what ESIF considers to be a reasonable set of accuracy test-related data to be collected, organized, and stored by the individual company or organization responsible for the testing. While this collection of data is deemed essential to sound engineering practice for accuracy testing, reporting of test data shall be based upon mutual agreement between the requesting company or organization and the company or organization performing the test. Note that reporting to the FCC is addressed elsewhere (outside the scope of this document) and as such is not the subject of this section

Data summaries/reports including all statistics, pre-processed and post processed data shall be stored on a standard commercial media in accordance with the established guidelines of the individual company or organization responsible for the testing. Data summaries and reports shall include as a minimum

1. Description of the testing objectives
2. Description of the location technology and air interface tested.
3. Description of the test configuration used (Including the test versions of each location network element and handsets used (e.g., GMLC Version XYZ).
4. Description of test area(s) used, including a graphical representation.
5. Description of test point locations, test route selection method, test routes used, and test route identification.
6. Description of “ground truth” or reference locations used.
7. Description of any data recording equipment/software and data analysis equipment/software used.
8. Description of any predictive modeling used to support the location testing. Description of the available baseline used as a basis for the predictive modeling and the applicability of the baseline to the test area for which this predictive modeling has been applied.
9. Description of the “Pass-Fail” criteria.
10. Description of any systematic errors that occurred during testing, if applicable.
11. Description of any failed or dropped calls, if applicable.
12. Description of any weighting used and the statistical justification.

13. Location error statistics for 67% and 95% of the total samples collected and processed and the level of statistical confidence with which these percentiles have been determined. Other statistics may be presented based upon the test plan objectives.
14. Description of any remaining problems and plan for resolution (e.g., re-test plan).

ANNEX A: On Confidence Intervals and Levels for Location Testing

Confidence intervals and confidence levels are interrelated elements in the estimation of certain statistics of a sample. To illustrate the terminology, if we are estimating the mean positioning error, the confidence interval is the interval around the sample average in which we expect this mean to fall with a certain probability, e.g., 0.9, called the confidence level.

The approach discussed here falls under the so-called distribution-free confidence intervals, i.e., intervals that do not depend on a priori knowledge of the distribution of the variable being estimated, which in our case is the location or positioning error. This is a robust approach that does not entail significant assumptions about the error, and primarily depends on a sample that is large enough.

At a given test location when an adequate number of independent calls is placed, then although the error for each individual call is not normally distributed, the average error for the sample quickly approaches a normal distribution. The number of calls at the test location does not have to be quite large for this Central Limit Theorem application to hold. As long as the location system is not providing totally inconsistent results from call to call resulting in a very large variance, which is a very reasonable assumption for calls placed from the same location, then a sample "N" of 20 or more calls (but sometimes less) would be adequate. We can then apply the simple rules of the normal distribution to determine the confidence interval and level associated with the measurement as follows.

N is the sample size
X is the location error (a random variable)
Xav is the sample average for the error observed
μ is the mean error at the test location
σ is the standard deviation of the error

Thus, the 90% confidence interval associated with the measurement or estimation of the mean error at the test location is:

$(X_{av} - \delta,\ X_{av} + \delta)$

Where $\delta = 1.645\ [\sigma / (\sqrt{N})]$. The number 1.645 corresponds to the probability of 0.9 from the Normal curve.

Another way of stating the above is that the probability is 0.9 (90%) that the mean location error μ is within the confidence interval

$(X_{av} - \delta,\ X_{av} + \delta)$

For a 95% confidence interval, i.e., a confidence interval with a 95% confidence level, the number 1.645 would be replaced by 1.96, and similarly for other confidence levels.

A convenient way to choose or express δ is as a percentage of the observed average error.

<u>Example</u>:

If 20 calls are placed at a single test location and the observed X_{av} and σ are 50 m and 25 m, respectively. Then the 90% confidence interval in measuring the mean error is 50 m +/- 9.2 m or 50 m +/- 18.4%.

ANNEX B: Example of using the 90% confidence interval to obtain a statistically significant sample size.

The following example demonstrates a technique to determine the number of samples needed to demonstrate accuracy compliance with a 90% confidence interval in a contiguous deployment test area. This technique requires a prior understanding of the underlying radial position error behavior specific to the location technology being tested. It also requires the actual test area deployment to behave predictably according to this distribution.

This specific example is applicable to a Network Based U-TDOA location system. Through a significant level of field-testing, it has been determined that the statistics of the radial position error of this U-TODA system closely match that of a Rayleigh distributed random variable. Assuming a Raleigh distribution for the error statistics, a 90 percent confidence interval can be determined for both the 67th and 95th percentile accuracies as a function of the number of test calls. This technique can be used to determine the number of test calls required to achieve a given measurement accuracy.

It should be noted, however, that once a Rayleigh distribution is assumed, a selection of a specific number for the 67th percentile implies the associated number for the 95th percentile. So if the 67th percentile is taken to be 100 m then this implies that the 95th percentile is 164 m. Similarly, if the 67th percentile is taken to be 50 m, the 95th percentile becomes 82 m. Thus, it is important for the user of this approach to ascertain that the distribution of errors observed in the field is consistent with this relationship between those percentiles. If it is not, then a more general distribution needs to be fitted to the data and applied. If this more general approach is found to be unwieldy, then a distribution free approach, such as the one discussed in ANNEX A, can be used.

In the table below the Rayleigh distribution of error is assumed. The table shows the 90% confidence interval for both the 67th and 95th percentile accuracies for 2 example systems with 67th percentile accuracy performance of 50m and 100m.

67% = **50**
95% = **82**

	90% CI of 67% Error		90% CI of 95% Error	
N	Low	High	Low	High
100	46.1	54.4	75.8	89.4
500	48.1	51.8	79.1	85.1
1000	48.6	51.2	79.9	84.2
2000	49.0	50.8	80.5	83.5

67% = **100**
95% = **164**

	90% CI of 67% Error		90% CI of 95% Error	
N	Low	High	Low	High
100	92.2	108.8	151.6	178.8
500	96.2	103.6	158.2	170.3
1000	97.2	102.4	159.9	168.4
2000	98.0	101.6	161.0	167.1

Note that in the case of a Rayleigh distribution of error, for just 500 calls, the confidence intervals are less than +- 5%, showing that 500 calls provides a sufficiently tight 90% confidence interval.