Establishing and Maintaining Phase II E911 Location Quality of Service (QoS)

White Paper

TechnoCom™
Wireless Location Leaders™

Introduction

The E911 Post Deployment Location Quality of Service (QoS) Problem

More than 30 million AGPS enabled handsets have been sold to wireless subscribers for the delivery of E911 location. Nearly 20,000 GSM and TDMA cell sites have been deployed with network based TDOA location systems providing E911 location to millions of subscribers throughout the United States. Hundreds of markets are now operational with E911 location infrastructures. By some estimates at least 50 per cent of all wireless subscribers will be Phase II E911 ready by the end of 2004. Billions of dollars have already been spent or committed to by carriers and public safety agencies to ensure the availability of Phase II E911 location systems nationwide. But now that these deployments are well underway several new issues have emerged. How well are these location systems working in terms of accuracy and reliability? How will they be maintained to ensure that the QoS for Phase II E911 meets the needs and expectations of public safety and wireless consumers?

Why is Phase II E911 location service assurance so vital today? Carrier operations organizations have been given responsibility for highly complex and now widely deployed location systems that provide life saving E911 services to wireless subscribers and public safety agencies. Yet today no one knows if the wireless E911 location system is delivering on its service promise until the emergency actually occurs. Unlike voice systems, location networks are unique in that they provide no natural loop- back mechanism to help identify performance problems before they impact the integrity of the Phase II E911 location service. Historically, voice and data subscribers have been able to report coverage problems, dropped calls and poor connections to a carrier's customer service organization. These customer driven trouble tickets are often the basis for both system-wide and market-by-market troubleshooting and

problem resolution Wireless E911 on the other hand is an exception based emergency service that is rarely used by an individual subscriber. When used, subscribers expect an extremely reliable, high quality user experience. For both consumers and public safety, there is little room for acceptable error. Customer tragedies are the *last* way to discover problems.

Regardless of the type of location technology deployed (AGPS, TDOA/AOA or Radio Signature), the air interface (CDMA, GSM, TDMA or iDEN™), the size of the carrier (Tier I, II or III) or the environment (urban, suburban, or rural) the challenge of location service assurance is both real and daunting for all E911 stakeholders including public safety, wireless carriers and consumers. The following questions will need to be addressed:

- How does a carrier and public safety know if the location system's Phase II E911 QoS metrics are being met post deployment?
- What specific Phase II E911 service performance metrics should be available to carriers and public safety?
- Is the location system providing the required level of E911 QoS on a day-to-day basis? If not, why? Where is the problem? And, how quickly will it be resolved?
- What is the impact of location system degradation on wireless customers or those public safety agencies that rely on the accuracy and reliability of the E911 service?

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What is Phase II E911 Location QoS?

Quality of Service (QoS) can be defined as the proactive establishment of measurable performance factors along with management methods that monitor and alert carriers so that necessary actions can be taken to bring any divergent performance into compliance with agreed to service metrics. This general description of QoS applies to wireless carrier's management of location as well as their voice and data services.

Phase II E911 QoS may be measured by five specific metrics:

Location Accuracy

The *key* component of any E911 location service is the accurate identification and representation of the subscriber's location. If the location information is not accurate it could delay the delivery of emergency services to the subscriber and reduce the efficient utilization of public safety resources.

Location Latency

Another key component of E911 location service is latency, the time it takes to identify the location of a subscriber for a requested service. A location that is not delivered in timely manner may significantly impede the ability of public safety to promptly dispatch emergency vehicles.

Routing of Location Calls

Proper routing of the voice call is essential to the successful completion and subsequent location of the caller. If the call is routed to the incorrect Public Safety Answering Point (PSAP) significant delays in the dispatch of emergency services may occur.

Yield or Phase I Default Percentage

Yield is a metric that identifies the percentage of all E911 calls that should have been handled as a Phase II call in terms of delivering a precise geographic

location but for some reason were not and defaulted to a Phase I cell sector based location.

Coverage

Although Phase II E911 location is theoretically available wherever voice coverage exists, in practice location service availability varies significantly across a carrier's service footprint. Unlike voice and data systems where only a connection to a single cell site needs to be established, all location solutions require a relatively unobstructed view between the handset and ***multiple*** (at least 3) satellites or cell sites. Because this is sometimes not possible, location performance will vary significantly in different environments and topographies including urban, dense urban, suburban, rural as well as both in-door and outdoor scenarios.

How can Phase II E911 Location System QoS be degraded?

Both handset based location technologies (e.g., AGPS) and network based solutions (e.g., TDOA-AOA and Radio Signature) face the inevitability of performance degradation. Location technology performance is impacted by a variety of environmental and engineering factors which if left undetected and uncorrected can dramatically reduce location QoS performance delivered to E911 users and public safety call takers.

Like the voice and data networks currently operated by wireless service providers, E911 location networks are complex aggregations of systems, location measuring equipment and software applications installed at the cellular base stations or embedded within the handset and the interconnecting components. Each element in the Phase II location infrastructure -- software in the handset, TDOA equipment in the cellular base station, location determination (PDE), MPC/GMLC middleware servers, database service bureau, and the LEC -- contributes to the system's overall functionality and robustness as well as providing a point of potential failure. Each element may also discreetly contribute to the overall degradation of the Phase II E911 service. In combination the failure or degradation of these various elements can dramatically impact the Phase II E911 QoS delivered to consumers and public safety. How serious will this Phase II E911 QoS degradation be? Will it affect the very integrity and credibility of the E911 location service? Most importantly, what can be done to prevent and resolve either a gradual or dramatic deterioration in Phase II E911 QoS?

The fact that location systems and their respective elements can and will degrade or even fail altogether is not surprising. Such degradation is a technical and operational fact of life for any wireless system. What is different about such failures or degradation in the performance of the Phase II E911 location system is the criticality of the service being delivered (often a matter of life or death) and

the inherent limitation of the system to provide a daily feed back mechanism in which wireless subscribers and public safety users can routinely verify location QoS.

All location systems are impacted by five distinct types of potential problems: Provisioning errors (both initial and on-going); Database errors; Network element errors; RF Environmental anomalies and Interconnection errors. The following is designed to illustrate both the potential error sources and their potential impact on the QoS of Phase II E911 location for both AGPS and network based TDOA/AOA location systems. This does not suggest that any or all of the potential error sources may have an immediate impact on E911 QoS. Rather, it is designed to outline the type of issues that both carriers and public safety will need to be aware of during their day-to-day operation of these Phase II E911 location networks.

Potential Location System Error Sources

Provisioning Errors

- Incorrect Site Survey
- Inadequate or outdated calibration
- Data entry errors
- Changes to site equipment
- Improper network planning

Database Errors

- Data input error
- Missing sites or site data (new and modified)
- MPC database errors
- Changes to network deployment without associated database updates

Network Element Errors

- MPC software
- PDE software errors

- MSC software errors
- PDE algorithm anomalies
- Defective or impaired backhaul network

RF Environment Errors

- RF signal fade
- Marginal data link performance (AGPS)
- Satellite RF signal fade (AGPS)
- RF multi-path
- RF Interference
- RF Traffic levels

Interconnection Errors

- PDE-MPC errors
- MPC-MSC errors
- ALI-PSAP errors
- MPC-ALI errors

What is the impact on E911 QoS if the location system is allowed to degrade?

Over the past decade both AGPS and network based TDOA location solution providers and wireless carriers have made dramatic improvements in location system accuracy, cost reduction and widespread market availability. Despite these advancements, location systems cannot avoid the natural process of system level degradation without on-going performance monitoring, real world testing and the adoption of comprehensive service assurance processes and systems. The following outlines the ways in which these problem areas can impact the quality of E911 location service delivered to wireless subscribers and public safety call takers.

Potential Impact of AGPS Problems on E911 QoS

Potential Impact of Provisioning Errors

- Increased percentage on non-GPS locations
- Delays in AGPS location Fix
- Cell Sector Location Errors

Potential Impact of Database Errors

- Increased delays for AGPS location
- Decreased confidence level
- Decreased AGPS Accuracy (fewer satellites captured)

Potential Impact of Network Element Errors

- Position Determining Entity (PDE) reported result not delivered to PSAP by MPC
- Phase II not recognized location Fix reverts to Phase I
- Sporadic location fix delays in AGPS

Potential Impact of RF Environment Anomalies

- Degraded or Failed AGPS accuracy
- Phase II not recognized location Fix reverts to Phase I
- Data link errors resulting in location failures

Potential Impact of TDOA/AOA Problems on E911 QoS

Potential Impact of Provisioning Errors

- Reduced accuracy, Including increased incidence of wild points
- Failure to obtain location
- Reduced coverage
- Misleading location quality indicator

Potential Impact of Database Errors

- Reduced accuracy, Including increased incidence of wild points
- Failure to obtain location

- Coverage holes/reduced coverage
- Increased incidence of Phase I errors (in addition to reduced Phase II performance)

Potential Impact of Network Element Errors

- Coverage holes/reduced coverage, Including wild points (fixes with extremely high error)
- Reduced accuracy

Potential Impact of RF Environment Anomalies

- High incidence of location failure (unable to locate caller)
- Higher incidence of large location errors / reduced accuracy
- Coverage holes/reduced coverage
- Increased latency (longer time to obtain fix due to increased retries)

Can Phase II E911 QoS be Managed?

Wireless carriers are familiar with QoS measurement and management for their voice and data networks. They use a combination of real time network monitoring for network fault conditions, customer feedback and historical data analysis of network performance or system traffic data for longer term trending and engineering analysis. This network monitoring combined with quantitative drive testing provides the carrier with a clear view of how a network is performing. The management of QoS for E911 location networks will be achieved in similar ways. Carriers will need to implement performance management functionality and processes to accommodate Phase II E911 location metrics and management criteria as they have for their voice and data systems.

In the final analysis, the E911 service assurance process is concerned with the health of the location network and must address three questions: 1) Are the elements of the location system running; 2) How well is the E911 service performing from the users perspective? and 3) Is it meeting its agreed upon QoS metrics?

The E911 location network is today managed by location-specific network management system (NMS) functionality. Fault management systems have been designed to determine the functionality and viability of each network element, to evaluate if they are operating according to spec and to report anomalies.

What is currently missing is an E911 Phase II QoS management system that can identify system level degradation and determine how well the system is performing from the subscriber's perspective. This capability would in turn provide carriers and public safety officials with the necessary information to proactively identify and resolve system level degradation before they impact the integrity of the E911 service. A subscriber QoS perspective for E911 location

can only be obtained through extensive real world end-to-end testing. Delivering E911 location QoS that meets the needs and expectations of consumers requires that carriers and public safety stakeholders work together in identifying key QoS metrics and in diligently testing and monitoring their performance.

Glossary

ALI	Automatic Location Identification
ANSI	American National Standards Institute
AGPS	Assisted GPS
AOA	Angle of Arrival
BS	Base Station
BSA	Base Station Almanac
CPE	Customer Premise Equipment
DGPS	Differential GPS
ESC	Emergency Services Call
E911	Enhanced 911 Emergency Services
FCC	Federal Communications Commission
GMLC	Gateway Mobile Location Center
GPS	Global Positioning System
GSM	Global System for Mobile Communications
IP	Internet Protocol
LAT	Latitude
LONG	Longitude
MPC	Mobile Positioning Center
MS	Mobile Station
MSC	Mobile Switching Center
NMS	Network Management Functionality
PDE	Position Determination Entity
PSAP	Public Service Answering Point
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RF	Radio Frequency
SMLC	Serving Mobile Location Center
SMSC	Short Message Service Center

SS7	Signaling System 7
TDOA	Time Difference of Arrival
TDMA	Time Division Multiple Access
WARN	Wide Area Reference Network