

Emerging Wireless Technologies

Enhanced 911—Enhanced Wireless Emergency Communications

Foreword: The Public Safety Wireless Network (PSWN) Program is conducting an ongoing assessment of advancements in the wireless communications industry. The scope of this assessment is to identify emerging wireless services and technologies for potential public safety use in the near future and beyond. This document is the fifth in a series of studies on emerging wireless technologies. This particular study concentrates on Enhanced 911, a wireless emergency communication technology that will be implemented fully over the course of the next four years.



Through a series of orders issued since 1996, the Federal Communications Commission (FCC) has taken action to improve the quality and reliability of 911 emergency services for wireless telephone users. This action is reflected in the adoption of rules to govern the availability of basic 911 services and the implementation of enhanced 911 for wireless services.

Short for Enhanced 911, E-911 is an automatic number identification (ANI) and automatic location information (ALI) technology that the FCC requires of wireless telecommunications vendors and service providers. Phase I of the E-911 mandate is the delivery of ANI with mobile 911 calls. Phase II of the E-911 mandate is the complete E-911 capability of the delivery of both ANI and ALI with mobile emergency calls.

In the past, FCC regulations governing E-911 service only applied to wireline telephones. With the proliferation of cellular/PCS technology, however, the regulations had to be expanded to include E-911 service for wireless telephone users. E-911 technology for wireless telephones will enable emergency dispatch centers to process emergency 911 calls from mobile users that will render number and geographic information for use by public safety service providers. When a person makes a 911 call using a traditional telephone via landlines, the service provider automatically routes the call to the nearest public safety answering point (PSAP), which then distributes the emergency call to the appropriate service(s). The PSAP receives the caller's telephone number and the street address of the telephone from which the call was made.

However, prior to 1996, 911 callers using a mobile telephone had to access their service providers to get verification of subscription service before the provider would route the call to a PSAP. The FCC now mandates that all of the wireless carriers in the United States must have full E-911 service available by December 31, 2005.

Background on Wireless 911

The FCC's wireless E-911 rules seek to improve the reliability of wireless 911 services by providing emergency services personnel with both ANI and ALI. E-911 will enable emergency service personnel to locate and provide assistance to wireless 911 callers much more quickly. To further these goals, the FCC has required wireless carriers to implement E-911 services, subject to certain conditions and schedules. The wireless 911 rules apply to all cellular licensees, broadband personal

communications services (PCS) licensees, and certain specialized mobile radio (SMR) licensees.

The basic 911 rules require wireless carriers to transmit all 911 calls to a PSAP without regard to validation procedures intended to identify and intercept calls from non-subscribers. Under these rules, therefore, both subscribers and non-subscribers can dial 911 and reach emergency assistance providers without subscription validation. It is important to note that people who are not victims, but rather are just “good Samaritans” reporting traffic accidents, crimes, or other emergencies, make many wireless 911 calls. As a result, rapid delivery of these and other wireless 911 calls to public safety organizations benefit the general public by promoting safety of life and property.

Industry Addresses E-911

Industry leaders are continuing their efforts to address their concerns regarding E-911. For example, SiRF Technology, Inc. develops and markets semiconductor and software products that are designed to enable location awareness in high-volume mobile consumer devices and commercial applications. The SiRFLoc architecture, with multi-mode, client-server capabilities, is designed for the wireless carrier deployment of GPS enabled location technology.

Additionally, Xmarc, Inc. and Lucent Public Safety Systems (LPSS) recently announced a complementary technology agreement to develop PSMaP, a centrally based mapping service for wireless E-911. PSMaP will deliver reliable and accurate maps to the nation's public safety call centers or PSAPs assisting them in meeting the challenges of responding to wireless E-911 calls. LPSS plans to offer PSMaP to public safety call centers nationwide beginning in 2001. With the availability of this technology, PSAPs will

be afforded one more solution to accept and process location data for E-911 calls.

Location Methods for E-911 Phase II

There are several methods for locating a wireless E-911 call—the wireless telecommunications industry is currently examining solutions that are either handset based or network based. Several factors influence the selection of the appropriate technology. Obviously, the decision is strongly influenced by the need to comply with the FCC E-911 Phase II mandate. In addition, technical feasibility, capital and physical space requirements, along with network requirements, play a large role in the decision process. Finally, although the ability to market other location-based services in the future also dictates the ultimate solution, the deadlines associated with the Commission’s mandate may ultimately drive the direction in selecting a location technology a particular wireless provider follows at this time.

Two techniques that have the capability to find the locations of wireless users are location pattern matching (LPM) and time difference of arrival (TDOA). Both of these methods meet the requirements of the Phase II mandate and are networked based. Illustrated in Figure 1 is an example of LPM.

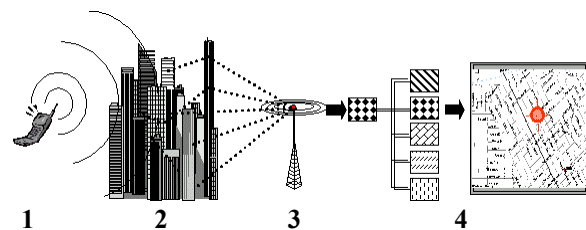


Figure 1

1. A user places a call from a mobile telephone, which emits radio signals.
2. The signals bounce off buildings and other obstacles, reaching their destination (the base station) via multiple paths.

3. At the base station, the system analyzes the unique characteristics of the signal, including its multipath pattern.
4. The system compares the signature pattern with a database of previously identified locations and their corresponding signature patterns, and makes a match.

The LPM technique shown is considered a network-based solution for E-911 Phase II location determination. A handset's signal is received at various antenna sites. Sophisticated, specialized equipment analyzes the acoustic radio signal and compares it with a database of standard signal characteristics. These characteristics include signal reflections (multipath), echoes, and other signal variances.

U.S. Wireless is constructing a nationwide location information network, utilizing LPM technology, called RadioCamera™. The RadioCamera™ system determines a wireless subscriber's location by measuring the distinct radio frequency (RF) patterns and multipath characteristics of radio signals arriving at a cell site from a single caller. The RadioCamera™ identifies the unique radio frequency pattern of the call and matches it to a similar pattern stored in its central database. With the RadioCamera™ network, subscribers do not need to purchase new telephones to access services, and wireless carriers do not need to make expensive infrastructure investments to offer location-based services – instead, the RadioCamera™ technology is applied to existing infrastructure that is already in place for each provider.

Currently, none of the cellular service providers are using this technique. However, U.S. Wireless, the only supplier for this technique, announced that it has completed tests for the National Emergency Number Association (NENA), confirming that its RadioCamera™ caller location system satisfies the Phase II requirements of

the E-911 mandate of the FCC. NENA represents more than 7,000 public safety workers, most of who manage the 4,300 primary emergency call centers that answer and process 911 calls. NENA also develops and recommends standards and protocols for emergency 911 services.

Following this testing, NENA concluded that U.S. Wireless' E-911 system had demonstrated accuracy within the requirements of the FCC's E-911 mandate, and would not require subscribers to replace their existing handsets to benefit from the emergency caller-location services.

Illustrated in Figure 2 is another network-based location solution known as TDOA. The TDOA technique works by measuring the exact time of arrival of a handset radio signal at three or more separate cell sites. Because radio waves travel at the speed of light (which is a known, fixed rate), by calculating the difference in arrival time at pairs of cell sites, it is possible to calculate curves on which the transmitting device is located. The TDOA technique typically uses existing receive antennas at a cell site. In multipath environments, such as urban areas, it may be necessary to make measurements with four antennas to overcome the multipath effects.

TruePosition, Inc., a leading provider of integrated wireless location products, now provides a TDOA Wireless Location System (WLS) that meets and/or exceeds the E-911 accuracy requirements in varied environments, via multiple air interfaces. Cingular Wireless has selected TruePosition as its location technology provider for its wireless network making it the first deployment contract of its kind. Also, Verizon recently completed a successful test of TruePosition's WLS as it began preparations to meet the FCC E-911 mandate.

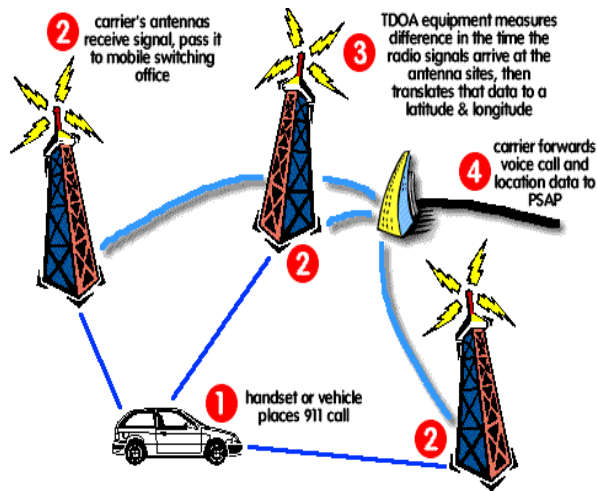


Figure 2

Another location determination method is the Assisted Global Positioning System (A-GPS) handset solution shown in Figure 3. In a handset-based solution, a handset that has been specially equipped with a GPS receiver determines its location based upon signals received from the GPS. The location is then forwarded to the PSAP during a 911 call. This basic location determination can be improved upon by implementing the assisted portion of the A-GPS technique. This assistance comes from the use of a GPS reference receiver or network of reference receivers, which in turn report all gathered navigation messages and differential correction data for the GPS satellites in view to a location server. The location server then provides data to the handsets during an E-911 call.

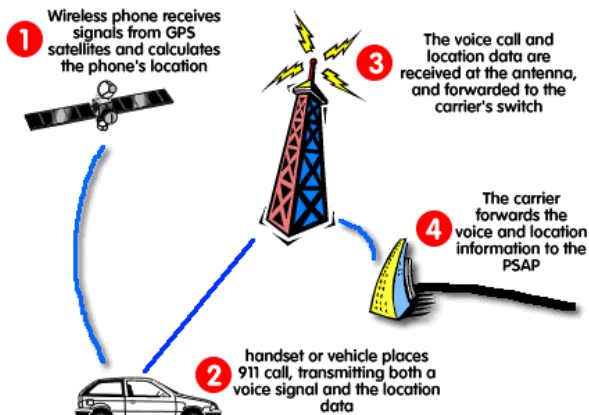


Figure 3

Yet another handset solution is Enhanced Observed Time Difference (E-OTD). This technology was developed for the Global System for Mobile communications (GSM) wireless networks. E-OTD is a triangulation-based technique for ALI. This technique requires either new handsets with E-OTD software or upgrading existing software in current handsets. It does not, however, require any GPS capabilities in the handset.

In GSM networks, handsets must synchronize with each base station to register and secure a talk-channel. To do this, base stations send regular synchronization bursts. The handset must monitor all synchronization bursts from serving and neighboring cells. This "primes" the handset so that synchronized handover across cells can be achieved. In this manner, the handset can roam from cell to cell and maintain a call. E-OTD builds on this inherent feature of GSM networks.

In E-OTD, the handset receives the synchronization bursts sent out by the base stations and records the time of arrival of each. From there, the mobile can triangulate its position by comparing the timing differences between the synchronization bursts from each base station, and applying that data to the known coordinates of the actual base stations. These position calculations require precise measurements of the time of arrival of each of the synchronization bursts; therefore, new, sophisticated handset software is needed to use E-OTD technology. No other costly physical changes are required for existing handset to use E-OTD, just software upgrades. E-OTD is illustrated in Figure 4.

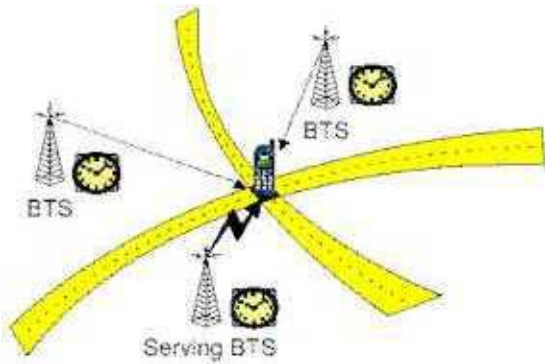


Figure 4

Wireless Enhanced 911 Service

After successful negotiation of a Consensus Agreement between wireless carriers and public safety representatives, the FCC divided enforcement of the 1996 rules into two phases. In 1998, Phase I rules required that mobile telephone carriers, subject to certain conditions, provide PSAPs with the telephone number of the originator (i.e., ANI) of a 911 call and the location of the cell site or base station receiving a 911 call. This information assists in provisioning timely emergency response by providing some information about the general location from which the call is being received and by permitting the emergency caller to reestablish a connection with the caller if the call is disconnected.

As of October 1, 2001, Phase II rules required that each mobile telephone company conducting business in the United States offer either handset- or network-based location detection capabilities. Consequently, the caller's location is determined by the geographic location of the cellular telephone to within 100 meters, not the location of the tower transmitting its signal. This capability satisfies the FCC's requirements for providing location information (i.e., ALI).

Phase II Framework of E-911 Services

Under Phase II of the FCC's wireless E-911 rules, wireless carriers must provide the location of wireless 911 callers, i.e., the

ALI component. In establishing those rules, the Commission sought to be technologically and competitively neutral, allowing use of any location technology that could comply with the specified accuracy, reliability, and deployment schedule requirements. For example, the rules state that handset-based location solutions must provide the location of wireless 911 calls with an accuracy of 50 meters for 67 percent of calls and 150 meters for 95 percent of calls. Carriers using a handset-based solution also must begin to offer one entry-level model with location capability no later than October 1, 2001, and must ensure that 95 percent of their customers have location-capable handsets no later than December 31, 2005.

For carriers choosing a network-based solution, the rules provide that the technology must report the location of the wireless 911 calls with an accuracy of 100 meters for 67 percent of calls and 300 meters for 95 percent of calls. Under the FCC rules, a carrier using a network-based solution must provide ALI to 50 percent of its coverage area, or 50 percent of its population, beginning on October 1, 2001, or within six months of a PSAP request, whichever is later. Further, a carrier using a network-based solution must provide ALI to 100 percent of callers within 18 months of a PSAP request or by October 1, 2002, whichever is later. The FCC directed wireless carriers subject to the rules to report their Phase II plans, including the technologies they plan to use, by November 9, 2000.

FCC's Action on Wireless Carriers

The FCC has taken action in response to requests from several wireless carriers regarding the timely deployment of wireless E-911 services. The Commission has conditionally approved, with certain modifications, the compliance plans of six nationwide carriers, along with actions approving plans to implement E-911 Phase

II for those six wireless carriers. The six wireless carriers are Nextel, Sprint, Verizon, the Global System for Mobile Communication (GSM) portions of AT&T Wireless and Cingular's networks, and VoiceStream. These six carriers together serve more than 75 percent of all wireless telephone subscribers in the United States.

Specifically, the FCC has taken the following actions to approve implementation plans for Phase II of E-911 for the different carriers. Acknowledging that equipment procurement was a concern for Nextel, Sprint, and Verizon, the FCC will allow the three major carriers to implement Phase II E-911 according to a modified schedule for some of the initial 2001 and 2002 deployment milestones. The FCC intends to adhere strictly to enforcement of this modified schedule and completion of the E-911 deployment by 2005. A summary of the deployment plan for each of the primary carriers is described below:

Nextel. The FCC granted Nextel's request to deploy A-GPS technology for its iDEN¹ networks, subject to compliance with the specific conditions described in the order. Nextel must comply with the following timeline with respect to its A-GPS-capable handsets:

Date	Action Required
10/01/02	Begin selling/activating A-GPS-capable handsets and ensure availability of one entry-level A-GPS-capable handset
12/31/02	10 percent of new handsets activated nationwide must be A-GPS capable
12/01/03	50 percent of new handsets activated nationwide must be A-GPS capable
12/01/04	100 percent of all new digital handsets activated must be A-GPS capable
12/31/05	95 percent of all subscriber handsets in service nationwide must be A-GPS capable

¹ iDEN (Integrated Dispatch Enhanced Network) is a high-capacity digital trunked radio system providing integrated voice and data services to its users.

Sprint PCS. The FCC granted Sprint's request to deploy A-GPS technology for its code division multiple access (CDMA) network, subject to compliance with the specific conditions described in the order. Sprint must also comply with the following timeline with respect to its A-GPS-capable handsets:

Date	Action Required
10/01/01	Begin selling/activating A-GPS-capable handsets and ensure availability of one entry-level A-GPS capable handset
7/31/02	25 percent of new handsets activated nationwide must be A-GPS capable
12/31/02	100 percent of all new digital handsets activated must be A-GPS capable
12/31/05	95 percent of all subscriber handsets in service nationwide must be A GPS capable

Verizon Wireless. The FCC granted Verizon's request to deploy A-GPS/AFLT² technology for its CDMA network, subject to compliance with the specific conditions described in the order. Verizon must also comply with the following timeline with respect to its A-GPS-capable handsets:

Date	Action Required
12/31/01	Begin selling/activating A-GPS capable handsets and ensure availability of one entry-level A-GPS-capable handset
7/31/02	25 percent of new handsets activated nationwide must be A-GPS capable
3/31/03	50 percent of new handsets activated nationwide must be A-GPS capable
12/31/03	100 percent of all new digital handsets activated must be A-GPS capable
12/31/05	95 percent of all subscriber handsets in service nationwide must be A-GPS capable

AT&T. For AT&T, which submitted E-911 compliance plans for the GSM portion of its wireless network, the Commission provided similar relief, also conditioned on strict FCC enforcement of a new schedule. The FCC

² A-GPS/AFLT - assisted global positioning system/advanced forward link trilateration.

granted AT&T Wireless' request to deploy E-OTD technology for its GSM network, subject to compliance with the specific conditions described in the order. Because E-OTD requires handset modifications to be effective, AT&T will be subject to all the requirements applicable to handset-based technologies, except as specifically waived or modified in the FCC's order. To the extent AT&T cannot comply with these accuracy requirements, AT&T must use another ALI methodology that conforms to the accuracy requirements of the Commission's rules. AT&T must comply with the following implementation timeline:

Date	Action Required
10/01/02	E-OTD-capable handsets must provide ALI with an accuracy of 100 meters/67 percent of calls and 300 meters/95 percent of calls
12/01/03	E-OTD-capable handsets activated on or thereafter must comply with an accuracy of 50 meters/67 percent of calls and 150 meters/95 percent of calls

Cingular Wireless. For Cingular Wireless, which submitted E-911 compliance plans for the GSM portion of its wireless network, the Commission provided similar relief, again conditioned on strict FCC enforcement of a new schedule. The FCC granted Cingular Wireless' request to deploy E-OTD technology for its GSM network, subject to compliance with the specific conditions described in the order. Cingular will be subject to all of the requirements applicable to handset-based technologies except as specifically waived or modified in this FCC order. Cingular must comply with the following implementation timeline:

Date	Action Required
10/1/01	Begin selling/activating E-OTD-capable handsets and ensure availability of one entry-level E-OTD capable handset
12/31/01	25 percent of new handsets activated nationwide must be E-OTD capable
6/30/02	40 percent of new handsets activated nationwide must be E-OTD capable
3/31/03	65 percent of new handsets activated nationwide must be E-OTD capable
12/31/03	100 percent of all new digital handsets activated must be E-OTD capable
12/31/05	95 percent of all subscriber handsets in service nationwide must be E-OTD capable

The Commission also noted that although AT&T and Cingular had submitted compliance plans for the time division multiple access (TDMA) portion of their networks, the timing of those submissions did not permit Commission consideration. Accordingly, these carriers and FCC Enforcement Bureau staff have initiated discussions concerning possible consent decrees with the Commission to resolve this compliance issue.

To efficiently track carrier compliance with the revised schedules, the FCC imposed specific reporting requirements on the carriers regarding the implementation of both Phase I and Phase II wireless E-911. Beginning next year, the carriers must file Carrier Quarterly Progress Reports on February 1, May 1, August 1, and November 1. The FCC will conduct an ongoing inquiry on E-911 technical issues, including evaluation of reports and submissions by technology vendors, network equipment and handset manufacturers' and carriers' technology standards issues, development of hardware and software, and supply conditions.

Summary

The impacts of E-911 to public safety are very apparent. When both phases of E-911 are implemented, responses to emergency calls placed via a commercial wireless phone will be more efficient and

more accurate. E-911 technology will deliver PSAPs the emergency caller's phone number and location, even if the caller is incapacitated and unable to speak. These capabilities will undoubtedly help emergency responders get to the scene easier than ever before (when the emergency call is placed from a commercial wireless phone).

This article is intended to give the reader an understanding of the regulatory landscape of E-911 as well as techniques and technologies that the wireless industry is considering for their E-911 offerings. Currently, all commercial wireless services providers adhere to the Phase I rules of the E-911 mandate. Phase I states that ANI must be delivered to the PSAP. The main challenge of the E-911 mandate lies in Phase II, which states that both ANI and ALI must be delivered to the PSAPs. Compliance to Phase II of the E-911 mandate is required by December 31, 2005.

To comply with the ALI portion of the E-911 mandate, service providers and vendors are exploring two types of solution: network-based and handset-based. Among the network-based solutions being explored are LPM and TDOA. Among the handset-based solutions being explored are A-GPS and E-OTD. Regardless of the technology or technique chosen, the wireless service providers and vendors have made significant advances to location position finding in the mobile environment.

When fully implemented, E-911 will prove to be a significant step forward in public safety. The benefits of E-911 much outweigh the challenges to develop E-911 compliant solutions. E-911 will have a lasting, positive effect on public safety response by increasing the ability of responders to protect lives and property.

Postscript: The purpose of this article is to further educate the reader regarding the technologies and FCC regulations designed to improve the quality and reliability of 911 services for wireless telephone users through the implementation of Enhanced 911. In the final article in this series, developments in the emerging wireless technology of wireless priority access services will be presented.

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