Wireless 9-1-1 Geolocation: A new way to save lives NOW

By Jim Kauffman

Unless you've been there, there's no way to describe what it's like to answer a 9-1-1 call.

"9-1-1, what is your emergency?"

With that greeting, 9-1-1 call-takers dive in where few are trained—one human intimately connected to another, trying to send help when seconds count. It happens over 400,000 times a day in the United States.

When Seconds Count, Location Matters

Call-takers are trained to extract the important facts from the rest of the caller's story and start help on its way. But callers start from a highly emotional state and often slip further from coherence as they communicate with call-takers.

Any parent who has tried to make sense of their sobbing child's story of "what happened" will begin to understand what it's like for 9-1-1 call-takers every day. That's why automatic location is so important.

Without Location, Nothing Else Matters

A 9-1-1 call-taker's biggest challenge is to get an accurate location from the screams of disoriented, incoherent, or panicky callers. Our 9-1-1 personnel can start units rolling to the scene—if they know where to go—even before all the details of an incident are known. That can shave seconds and minutes from response time; that can save lives.

Some Say We're Sliding Backward

Ten years ago, 9-1-1 centers equipped to receive "enhanced 9-1-1" (E9-1-1) service were able to display the telephone subscriber's name, address and phone number on the call-taker's screen. Call-takers knew the caller's location close to 100% of the time.

Today, 30 to 60% of 9-1-1 calls come from wireless phones, and the number is climbing rapidly. Current wireless phone systems cannot accurately locate a caller, so our ability to locate 9-1-1 callers has been reduced significantly. Some say we're sliding backward.

In its June 1996 Report and Order, the Federal Communications Commission laid out a blueprint for this to change.

Wireless 9-1-1 Location Technology is Available Now

The FCC's 1996 mandate ultimately requires wireless carriers to send the "x/y" (latitude and longitude) coordinates and the wireless phone callback number of wireless phone users who dial 9-1-1. Technologists have spent years and hundreds of millions of dollars getting ready to implement this mandate.

2001—The Beginning of Location Accuracy

Wireless location accuracy was mandated in two phases. Phase I capability requires wireless carriers to deliver to the 9-1-1 call-taker a "neighborhood" location based on the area served by a particular cell site sector. Phase II requires that the specific location information, based on x/y coordinates, of the wireless caller be delivered to the call-taker's screen. The FCC mandate requires wireless carriers to provide Phase II service by October 2001 to those 9-1-1 centers that request it.

The number of 9-1-1 centers that have upgraded their equipment to receive this lifesaving location information is growing rapidly. But supplying this data to 9-1-1 centers requires wireless carriers to select and implement a Phase II solution. The sooner this happens, the more lives will be saved.

Location Technology Choices for Wireless Carriers

Wireless carriers have their choice of several location technologies. These technologies use different methods to determine caller location. The following table summarizes some of these, and more are under development.

Today's Location Technologies

	TDOA	AOA	GPS and Assisted-GPS*	Location Pattern Matching
Can Use Existing Mobile Handsets	Yes	Yes	No	Yes
Cell Site/Satellite Coverage Required	Minimum 3 cell sites	Minimum 2 cell sites	Minimum 3 satellites in view*	Minimum 1 cell site. 2 or more preferred.
Line of Sight Requirements	Yes	Yes	Yes	No
Calibration Requirements	Timing calibration at all cell sites	Calibrated antenna arrays required	None	Covered areas must be driven periodically

*Technologies are currently in development that require fewer than 3 satellites to be in view when supplemented by carrier network data.
TDOA=Time Distance of Arrival
AOA=Angle of Arrival
GPS=Global Positioning System

The various technologies offered as E9-1-1 geolocation solutions include Location Pattern Matching, Angle of Arrival, Time Difference of Arrival, and Global Positioning System. In the industry that is developing around the FCC's wireless E9-1-1 mandate, these technologies are operationally grouped into two separate categories: *network-based* systems and *handset-based* technology.

Network-based systems do not require the addition of any new equipment to wireless handsets. They work with all existing handsets, relying solely on the wireless network for the geolocation process, and accommodate 'roamers' traveling between wireless networks. This is important because it serves those who buy a phone primarily for safety and security, keep it in their glove box and seldom think about upgrading it. Roamers are also the least likely to be capable of describing where they are in an emergency.

Network-based location systems include Angle of Arrival (AOA), Time Difference of Arrival (TDOA) and Location Pattern Matching (LPM). Both AOA and TDOA techniques rely on triangulation from multiple points of reference to determine the location of a wireless device. The AOA system requires a minimum of two points of reference, and TDOA requires a minimum of three points of reference.

Location Pattern Matching, also referred to as the RadioCamera™ system, was developed by U.S. Wireless Corporation to address the challenges associated with geolocation in dense urban and sparse rural environments. Triangulation techniques rely on line-of-sight between the transmitter (wireless phone) and multiple points of reference (base stations). Urban environments (where line-of-sight is blocked by buildings and other obstacles) have proven difficult for technologies relying on triangulation. In less populated rural environments, base stations are often sparsely distributed, resulting in insufficient numbers of reference points to complete the process of triangulation.

Location Pattern Matching does not rely on line-of-site triangulation, and is effective in dense urban and sparse rural environments. Location Pattern Matching recognizes the distinct patterns, or "signatures", of incoming radio frequency (RF) signals, and associates them with the specific locations from which they originated. Radio frequency characteristics that define the signature include relative power, direction of arrival, number of dominant reflections, and multipath phase and amplitude. The RadioCamera™ system learns the signature patterns and logs them into a reference database, thereby identifying calls coming from the same location by their similar signatures.

Handset-based technology (also referred to as "subscriber-assisted") places location technology in the handset and therefore requires the replacement of existing handsets or the addition of a dedicated piece of equipment to allow the geolocation process to function. The best known of the handset technologies is the Global Positioning System (GPS). GPS technologists are attempting to integrate GPS information processing into wireless handsets, allowing a government constellation of GPS satellites to triangulate with the receiver to establish its location. This location information would then be transmitted to the network via the cellular link.

An alternative to GPS is *Enhanced Observed Time Difference* (E-OTD), where the handset is responsible for making time measurements of signals arriving from multiple base stations in order to compute handset location. This is part of VoiceStream's proposed solution and has become part of the GSM standard. In their April 2, 2001 progress report to the FCC, VoiceStream's experimental handsets were achieving accuracies of within 75 meters 67% of the time.

Real World Testing
For wireless location providers, moving from the lab to commercial deployment has meant shifting focus from technology issues to real world issues of integration and functionality.

In 1998-1999, the State of Montana sponsored an end-to-end evaluation of wireless location capability. There was concern in Montana that the location technologies tested in other areas of the country would not work well in that State's rural areas.

In the Montana trial, a Location Pattern Matching system provided by U.S. Wireless Corp. identified a caller's mobile phone number, location coordinates, and nearest street address. The information was then sent to the appropriate 9-1-1 center and displayed on a screen at a 9-1-1 call-taker's workstation. The system continuously updated the location information, enabling the 9-1-1 call-taker to monitor the caller's location throughout the call. The demonstration marked the culmination of a five-month development effort involving the State of Montana, the local Billings 9-1-1 center, U.S. Wireless Corporation, and six telecommunications organizations.

The State of Montana's full report is available online at:
http://www.uswcorp.com/Montana Wireless E911 Final Report.pdf

Latest Trial Requested and Monitored by NENA
As part of NENA's effort to assess the state of available location technologies, the most recent trial of wireless location was held in Seattle, Washington in March 2001.

A Location Pattern Matching System provided by U.S. Wireless Corp. was again used. The network-based system, using existing handsets, demonstrated accuracy within 61 meters (half a city block) two-thirds of time and within 50 meters 60% of the time.

The NENA-requested trial of the U.S. Wireless 9-1-1 caller location solution was conducted over nine days in a test area that included dense urban, residential, light industrial, waterfront, and highway environments. Over 16,000 location "fixes" were evaluated from 18 stationary test points and over nine mobile test routes, encompassing a wide range of test environments.

The full report of the NENA-requested Seattle trial is available from the U. S. Wireless FCC filing which can be found online in two parts at:

http://svartifoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6512564818

And at:

http://svartifoss2.fcc.gov/prod/ecfs/retrieve.cgi?native_or_pdf=pdf&id_document=6512564819

(For more information about the NENA/U.S. Wireless Trial from the perspective of a PSAP manager, please see Rick Jones' article "Is Wireless Location a Dream?" from Summer 2001 *NENA News* magazine.)

Currently Available: A Range of E9-1-1 Solutions

Many other trials have been performed with major wireless carriers using several types of location solutions. In addition to U.S. Wireless Corporation, companies such as SnapTrack, TruePosition, SigmaOne Communications, and Allen Telecom's Grayson Wireless division have announced successful trials with major wireless carriers in the United States.

The 9-1-1 centers throughout the U.S. have and are requesting Phase II E9-1-1 automatic location identification capability from their local wireless carriers and are gearing up to receive this life-saving, mission-critical information. As the FCC's October 2001 deadline for implementing Phase II draws near, wireless carriers need to quickly select E9-1-1 geolocation vendors if they are to meet the deadline.

Jim Kauffman has spent 21 years at the National Fire Protection Association helping the fire service and public safety community use technology more effectively. After leaving the NFPA, he was appointed the Massachusetts State Fire Marshal.

He has served on the standards committee of the Massachusetts Statewide Emergency Telecommunications Board charged with implementing statewide Enhanced-9-1-1 and he has assisted communities in implementing and optimizing their emergency communication centers.

Nine months ago, Jim moved to California to join U. S. Wireless, where he has been working to ensure that their ability to locate wireless 9-1-1 callers meets the needs of the public safety community.