ON THE ROAD TO Geocodes

GPS/GIS build county E-911 databases

By Bill Elliott

As county public safety agencies across the United States progress toward implementation of Enhanced 9-1-1 call centers, the technologies of GIS and GPS have moved center stage as main characters in the collection of data needed for E-911 and as integral elements of E-911 system databases. Since the introduction of Basic 9-1-1 service in 1968, call center technology has undergone a transition from analog communications and address cards to fully digital database systems (Enhanced 9-1-1) providing Automatic Number Identification (ANI) of incoming calls, Automatic Location Identification (ALI) of caller street addresses, and automated routing of emergency calls to proper emergency service providers based on the 9-1-1 caller’s street address.

As non-spatial, database-oriented Enhanced 9-1-1 / Computer Aided Dispatch (CAD) systems come on-line at a record pace, another, less visible technology transformation is underway. Two newcomers, GIS and GPS, have awakened the industry to the inherent geospatial nature of E-911 information. This realization, coupled with a fast approaching deadline for implementation of the Federal Communication Commission (FCC) mandate requiring public safety call centers to provide wireless E-911 service, will move GIS and GPS to the forefront of E-911 / CAD system implementations in the near future.

Rural Delivery and Public Safety

The majority of the U.S. population lives and works in urban or suburban communities. For the most part, buildings in populated areas are addressed sequentially by street blocks, odd numbers on one side of the street, even numbers on the other side. Most urban/suburban residents give little thought to this “municipal style” addressing system, assuming it is in place everywhere. In much of rural America, however, logical addressing systems do not exist, and in many areas, public roads have yet to be named and marked with signposts. Additionally, many rural homesteads have no assigned street address or visible address marker. Mail is typically delivered to a numbered mailbox on the side of a nearby public road with postal delivery routes meandering through the countryside from one numbered box to the next.

Postal route box numbers and unnamed roads offer little help in emergency situations when police or fire vehicles are dispatched to rural residences. The lack of posted road signs, logical street address schemes, and address markers, coupled with incomplete maps of structure locations, make implementation of effective E-911 services in rural areas very difficult. Consequently, mapping and addressing projects have become a critical prerequisite to bringing E-911/CAD systems on-line in rural counties.

E-911 Alphabet Soup

For the uninitiated, E-911 systems can be quite intimidating due to the heavy use of acronyms in the industry. In its simplest form, a caller dials 9-1-1 and the call is routed through the telephone company’s Central Office (CO) and to the E-911 Public Safety Answering Point that is taking emergency calls for an area (typically a county). The PSAP has several automated databases that automatically display the caller’s phone number (Automatic Number Identification or ANI) and the caller’s address (Automatic Location Identification or ALI). The ALI is typically a tabular record of the resident’s name and street address linked to the call-in Telephone Number (TN) location. “E-911 Equipment” typically performs the ANI/ALI task.

The second major component of a PSAP is the dispatch operations, performed typically with the aid of a Computer Aided Dispatch (CAD) system. CAD systems have traditionally been tabular in nature, but are increasingly becoming map-based as GIS and GPS tools are made available. E-911 call centers receive the ANI/ALI information from the E-911 equipment, pass it off to the CAD system where it is used to query a combined database commonly referred to as a Master Street Address Guide. MSAGs are created and kept updated in close coordination with the local telephone company and the U.S. Postal Service.

Tabular MSAGs

The MSAG tabular database is indexed by street names and address block ranges. It is used to identify which Emergency Service Zones (ESZs) serve the caller’s area. An ESZ is a bounded area of responsibility served by a single fire, police or emergency medical district or station. Most often, each public safety entity (e.g., fire, police, and emergency medical) has its own uniquely

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**SUMMARY**

Geographic Information Systems and Global Positioning System technologies are providing new tools for improving rural emergency response 9-1-1 databases.

**GeoTechnologies Discussed:**
- GPS
- GIS
- CAD

**Benefit:**
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bounded ESZs. Hence, residents served by a particular police precinct may not all be served by the same fire district. The MSAG contains Emergency Service Numbers (ESNs) that describe the unique combinations of emergency service agencies that serve a particular street address range.

The purpose of the MSAG is to dispatch the responsible public safety entity to the caller’s location based on the type of emergency reported and the caller’s street address. Most PSAPs provide both telephone and digital dispatch notification to the designated emergency responder(s). Additionally, many CAD systems contain ancillary databases that provide written directions to a landmark near the caller’s location and alert information about the resident or property that might be important, such as the presence of hazardous waste on the property or a history of domestic violence by property occupants. This information is also relayed to the designated emergency responder. The whole process occurs in a matter of a few minutes after the caller dials 9-1-1.

Going Geospatial

E-911 / CAD databases, and particularly MSAGs, are inherently geospatial in nature. Structures are dispersed across a geography, and each structure’s unique geographic location determines the form of the E-911 response. This fact has not been widely recognized until recently when GIS software came into common use. The ability to map street block centerlines with address range attributes, geocode address locations to create structure nodes, and digitize Emergency Service Zone (ESZ) boundary polygons into a GIS, provides new capabilities for automating the creation and update of MSAG databases. Use of GIS spatial analysis tools, such as points-in-polygon, lines-in-polygon and polygon overlay can be used to full advantage for E-911. Structures and street address blocks can be spatially related to assess (i.e., points-in-polygon, lines-in-polygon) while unique Emergency Service Numbers (ESNs) for address blocks can be automatically created using polygon overlay.

The advantages of using a GIS approach to MSAGs are quite stunning when one considers the time-consuming task of maintaining an MSAG as ESZ boundaries change and new streets, subdivisions and homes are built in a community. The movement of a single ESZ boundary line, adjusted perhaps to better allocate available resources, requires the regeneration of unique ESNs for every street address block in the effected area. This task can be automated using off-the-shelf GIS tools, compared to updating individual records manually in a tabular database. In fact, using a map-based E-911 / CAD approach (read: GIS), geospatial operators can be used to generate the majority of the reports and tabular databases needed for E-911.

GPS/GIS as Database Builder

One of the major obstacles blocking early use of GIS for E-911 / CAD is the critical shortage of available geospatial data, particularly in rural counties. Since one goal of municipal style addressing schemes is to accommodate “fill-in” of address numbers as new structures are built, county addressing ordinances typically specify a unique, sequential street address every 10.56 feet on each side of the road (1,000 address number possibilities per mile, 500 to a side). Mapping structure locations (GIS nodes) at this accuracy requires map scales of 1” = 100’ or 1” = 200’. Geographically referenced maps at these scales showing building locations are rarely available for rural areas.

GPS/GIS provide excellent capabilities for economically building E-911 / CAD maps in the field. These systems integrate GPS positioning, feature and attribute entry, and background reference maps in easy-to-use field system units that can be used both on foot and in a vehicle. Most GPS/GIS field mapping projects for E-911 involve capturing GPS road centerlines, recording signed road names from posted signs, assigning IDs to unnamed roads, creating GIS nodes at this accuracy requires map scales of 1” = 100’ or 1” = 200’. Geographically referenced maps at these scales showing building locations are rarely available for rural areas.

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Required Address Updates

Once new road names and unique addressing anomalies are approved by county stakeholders, re-addressing is performed using software to assign each structure node a new address based on distance down the road in its address range block. In a typical scenario, re-addressing efforts are approved at public hearings, new address notification letters are printed and mailed to residents, road signs are posted and address markers are placed on each property. With E-911 databases, post office and telephone company records are updated with each new address.

Advanced GPS/GIS systems such as the GeoLink( GPS/GIS Field Mapping System, developed by GeoResearch, Bethesda, Maryland, allow structures to be located with GPS at the same time road centerlines are being mapped. Used in a vehicle,
GeoLink Power Trak combines vehicle tracking and GIS/GPS data collection features.

GeoLink records the road centerline track while the operator maps roadside structure locations. Hot keys, data entry forms and pick lists support the rapid entry of road names, structure types, current addresses and other observed information in a format that can be loaded directly into a GIS. Digital background maps can be loaded into GeoLink and used for navigation and reference purposes during field data collection. Integrated laser rangefinders can be used to precisely measure offsets, and digital camera options support linking structure photographs to each structure record. With all this capability, it is no surprise that GPS/GIS technology has quickly become the preferred method for creating the geospatial databases needed for E-911/CAD.

The Wireless Nemesis

Most of the E-911/CAD systems going “on-line” today are highly automated, yet tabular. When geospatial information is needed, incomplete and out-of-date paper wall maps and/or map atlas books are typically used. For many call centers, this approach is working satisfactorily. Why should an operational E-911 call center with a tabular-based CAD system consider changing to a GIS-oriented system? This question can be answered in one word — WIRELESS. The number of E-911 calls made from cellular telephones is increasing exponentially. Studies and experience have shown that a significant percentage of wireless E-911 callers cannot adequately describe to call takers the location of the emergency they are reporting.

Increasingly, a single traffic accident or roadside incident is being called into the E-911 call center by several wireless callers, creating confusion as to which incident is being reported. In an effort improve the situation, the FCC has mandated that by the year 2001, wireless carriers must provide the capability for E-911 call centers to locate wireless caller locations within 125 meters 67% of the time. As wireless providers begin to provide E-911 locating services, either with GPS or other technologies, E-911 call centers will need to “map” wireless caller locations on computer screens in near real-time.

Map-based E-911/CAD systems are ideally suited to support this requirement. Tabular systems do not provide capabilities to geocode incoming wireless caller coordinates in near real-time. GIS-based systems automate this function and display wireless caller locations on a digital map display. Once the wireless caller location is geocoded, the GIS can generate an ESN automatically through points-in-polygon operations. The FCC mandate has created a new awareness of the benefits of GIS, resulting in a flurry of activity in the development of GIS-based E-911/CAD systems.

Toward Map-based Dispatch

The inherent geospatial nature of E-911/CAD applications and the approaching deadline for locating wireless calls provide strong incentives for GIS and its supporting technology, GPS, to become the centerpiece of E-911/CAD systems in the future. However, there is another potential advantage for adopting GIS on the dispatch side of the E-911 equation. Accurate digital maps, created with GPS and used to locate E-911 calls, will facilitate the real-time tracking of public safety vehicles as Automated Vehicle Location (AVL) technology is implemented in the fleet. By adding AVL capabilities to the E-911/CAD systems, dispatchers will be able to visually determine which response vehicle is closest to an emergency, track the dispatched vehicle as it moves toward the emergency, and verify its arrival at the incident site. The maturing technologies of GIS, GPS and AVL are poised to boost E-911 and public safety applications to new levels of automation, efficiency and responsiveness in the future.

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