Next Generation 9-1-1 and Your GIS

Keith W. Cunningham, PhD
kwc@mobile-map.com

Next Generation 9-1-1 will have an impact on the structure, maintenance, and sharing of GIS data for local governments. The greatest impact on your GIS will be the necessary synchronization with telephone databases. There will also be the need to standardize GIS data to enable regional data sharing and the densification of GIS geography to assist in location determination. Besides the technical aspects of the synchronization, standardization, and densification are the administrative issues involving data sharing agreements, edge matching of neighboring data sets, and methods of change detection to resolve GIS data discrepancies.

Why Next Generation 9-1-1

Next Generation 9-1-1 is the next step in the evolution of emergency dispatch. Emergency dispatch has always required a location component, providing dispatchers with information regarding the location of the emergency.

With Basic 9-1-1, the dispatcher can determine the telephone number of the caller, but the caller has to tell the dispatcher where they are located. If their location is not an address, such as a road intersection, then verbal directions are given. In these early days of 9-1-1, a GIS was not required to locate a caller. But wall maps and more detailed map books were typical tools of the trade.

Enhanced 9-1-1 utilizes a database linked to the telephone number and this database includes the physical address for the telephone number. This database automatically provides the emergency dispatcher with the address of the caller. GIS became common with Enhanced 9-1-1 dispatch because the address could be automatically geocoded to a street centerline, giving the dispatcher a good idea of the location of the emergency. When the 9-1-1 database did not perfectly match the GIS centerline, the dispatcher could manually geocode the call in the dispatch mapping software.

This approach had to evolve with cellular telephones and wireless 9-1-1. At first, wireless 9-1-1 required the caller to relay their location using verbal directions. Later, technology in the cellular network or GPS on the cellular handset was used to determine an approximate location of the caller on a map via a coordinate. This coordinate could be automatically mapped with the GIS. As a fall-back, if a coordinate cannot be determined, the cell tower antenna face could be displayed to indicate the general region of the caller. In all cases, the GIS became integral to the emergency dispatch system.

Today, emergency telecommunications must soon support instant messaging and the emailing of images and videos from cell phones during an emergency. Next Generation 9-1-1 uses an IP network to handle this new form of emergency telecommunications. GIS again is the key to locating the emergency. In the case of Next Generation, the GIS has to be more closely interfaced to telecommunications technology and databases. And to support IP data networks, more detailed GIS data will be required to assist dispatchers in locating persons sending non-voice messages.

9-1-1 Telephone Data Synchronization

The first step in preparing your GIS data for Next Generation 9-1-1 is the complete synchronization of the GIS data with the telephone company 9-1-1 data. The largest decision to make is which database will be the standard for road naming and addressing. Most communities opt to make the GIS database the standard, because the telephone company records may have variability in road naming and abbreviation use. For example, it was standard policy to omit "ST" if the road name was a "street." In this paper, we will assume that the 9-1-1 data will be updated to match the GIS data, but in many cases, the GIS may also have to be updated.

There are two primary databases used by telephone companies to build and maintain a 9-1-1 system. They are the Master Street Address Guide (MSAG) and the Automatic Location Information (ALI) database. Records in both of these databases will need to be edited to ensure that road names and addresses agree with the attribution in the GIS street centerline. Along with modifying the MSAG, every customer service record contained in the telephone company's Automatic Location Information (ALI) databases needs to be updated with the standardized addressing.

Road Name	Low Address	High Address
Academy		
Academy	0	99999999
Academy Rd		
Academy Rd	0	99999999

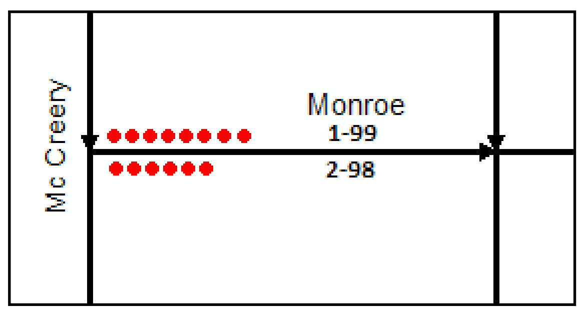
Figure 1 – MSAG Duplications

While all 9-1-1 records will have to be inspected, most will not require any editing. Automated tools are available to assist with the completeness and accuracy checking of the 9-1-1 databases. Ultimately, all telephone company records will have to be synchronized with the GIS data.

Historically, telephone companies have resisted modifying the 9-1-1 databases to match the GIS, thus the GIS may have been loaded with the spellings and abbreviations used by the telephone companies. This included alternate road names and occasional misspellings. The telephone companies were reluctant to change their address information because of the ripple-effect through their customer billing records. Thus changing one persons address to fix a spelling or abbreviation meant also changing billing data, which is very sensitive to the telephone companies. Today, telephone companies realize that standardizing their databases is not only required for Next Generation 9-1-1, but also promotes the accuracy of their internal records.

Another GIS impact to consider is the inclusion of more detailed address geocoding information. Instead of "potential" address ranges, rounded off to the nearest 100 block in cities and towns, the actual address ranges for road centerlines can be considered. This will remove the excess address range data typically found in most centerline files, causing the geocoding of addresses to "bunch-up" and the lower end of the address range.

Figure 2 – Centerline Geocoding



Point address layers will also become standard in emergency dispatch mapping. Software will first attempt to geocode to the point address layer and only revert to the centerline if a specific point address cannot be matched. Thus the database synchronization process extends to other GIS addressing layers such as a point layers containing situs addresses.

In the background with the data synchronization step will be the management decision to migrate the simple, flat-file database structure of most GIS geocoding databases to a more sophisticated GIS data model utilizing relational databases. One of the tables in the relational database will be used to store the official road names and standardized abbreviations. Then point and centerline addressing will be indexed to the master road naming table. This will prevent the use of non-standardized road naming and prevent spelling errors. For larger communities with numerous GIS data users, the migration to a relational database will be integral to their planning, including enterprise GIS. But rural communities with simple GIS needs are not required to overhaul their database structure.

GIS Standardization

Synchronization of the GIS data with the telephone databases requires standards. This at a minimum includes standardized road naming and abbreviations. Along with scrubbing the telephone company data, nearly every record kept at local government databases should also be considered for standardization with the GIS. These include the assessor, voters' registration, school records, etc. Other databases are more complex, such as water, sewer and trash which include a billing address, a service address, and other location information.

A starting point for your standardization should be Publication 28, from the US Postal Service. The Census Bureau, Urban and Regional Information Systems Association (URISA), and the National Emergency Number Association (NENA) also publish addressing standards. They all publish their recommendations on field naming, record length, and even innovative issues such as the National Grid.

Data standardization is most easily solved with relational databases. As mentioned in the previous section, one database table can store all official, standardized road names, another table holds the allowable road feature types, and another keeps the accepted abbreviations. These database tables would thus constrain the options available for database users, forcing standardized spellings and abbreviations as they enter and edit data. Adopting a relational database then means that the older GIS databases based on "flat" tables will have to be migrated into more sophisticated GIS data models.

Key to standardization is going though the process and deciding what is acceptable and what will not be part of the standard. This process can become politicized due to having to agree on many details with different data owners and users and having to adhere to new standards. The process will also require holding to the standards after they are set. So some habits and group interactions may have to change as part of the standardization process.

The standardization process should extend to data users in local and neighboring communities. This means addressing database standards at the county level should be shared and adopted with local governments. This process will ultimately help with the regionalization of the GIS datasets allowing first responders and other outside responders to more easily utilize your consistent GIS data. Standardization is part of the regionalization and sharing of GIS data.

Regionalization

Next Generation 9-1-1 will permit neighboring dispatch centers to more easily assist and back up neighboring communities. By sharing its GIS data, each dispatch center can be part of a regional emergency management system. Regionalization of GIS data for emergency dispatch requires two GIS processes to be developed: edge matching and change detection.

Road centerline features are typically broken into linear segments in the GIS. These segments ending at community boundaries need to be connected, or "snapped" to neighboring GIS road centerlines. A procedure for inspecting the snapping and attribution with neighboring GIS data is required and this is called edge matching.

And before a line feature from a neighbor's data is edited, or even discarded, you must determine if their data is different is some way since the last time it was shared. Your data or the neighbor's data may have updates and you have to determine if their updates somehow impact your data, and vice versa.

This process is called change detection and the GIS industry is now learning to administer this process. So you will likely have to use some creativity to implement a successful change detection process.

Many GIS centerlines used in 9-1-1 dispatch may have accurate and complete attribution, such as road naming and address ranges, as well as snapped vertices. But they may not have clean topology . The standardization and regionalization process, along with the adoption of relational databases, is also an opportunity to implement a "clean" network topology. This means possible new GIS tools, methodologies, and procedures to ensure that topology can be maintained. Don't forget that part of the process for setting standards is agreeing on topology rules and relationships among datasets.

Spatial MSAG

The outcome of this synchronization and standardization process is that the traditional MSAG database table is now a spatial database. The GIS has become the MSAG, or another way of thinking is the GIS now "hosts" the MSAG. With the GIS acting as the MSAG, new spatial routing technology based on coordinates and GIS layers is enabled. Traditional routing tables created for Enhanced 9-1-1 and Wireless 9-1-1 systems can be replaced with spatial GIS databases capable of routing telephony based on geography and coordinates. This means more detailed and responsive dispatch geography that is more meaningful to first responders.

The spatial MSAG also means dispatch geography can be dynamically adjusted. This results in easy re-assignments of first responders for special events, such as fairs, concerts, football games, and visiting dignitaries. The spatial MSAG will also better accommodate agencies that on not available every day for 24 hours. Enabling flexible boundaries also permits the simplified assignment of backup and remote dispatch centers and the improved support for multi-jurisdictional response and mutual aid.

An interesting consequence of eliminating the tabular MSAG is the inclusion of more detailed and specific dispatch geography. Because the traditional MSAG is based on customer addresses with postal ZIP Codes, more specific and detailed geography is now possible. Rather than stating only that an address is in a general city ZIP code, the dispatch geography can now succinctly state that the address of an emergency is in a subdivision, state park, ranch, boat marina, interstate rest area and even a small trailer park. The result is a richer, densified geography for emergency dispatchers.

Densified dispatch geography is greatly simplified with the spatial MSAG. The process of creating additional dispatch geography polygons will be determined in part by your regional geography, and it needs the input of the first responders who know places by local place names. NENA standards proposed for NG9-1-1 require both a ZIP Code boundary for resolving duplicate addresses and a 9-1-1 Community boundary to provide more relevant and finely-tuned community place names.

Note that routing telecommunications traffic is not the same as the GIS determining the routing of emergency vehicles using the street centerline.

The National Grid

As emergency dispatch GIS data are shared with those outside of the dispatch center, the need for a consistent, logical and unambiguous location system not based on road names and addresses becomes more apparent.

While physical addresses consisting of a house number plus a road name will be needed by citizens and first responders, they do not always suffice when data is regionalized and integrated. As data is regionalized and integrated into seamless regional data sets, there becomes the possibility of duplicated road names and addresses.

A method to uniquely identify individual situs addresses has been developed called the National Grid. The National Grid is a method of assigning a unique grid coordinate to every address. It is also simple to learn and use.

The National Grid is similar to the UTM grid and the military grid reference system. Based on the UTM grid, it is already supported by off-the-shelf recreational GPS devices. The system has also been adopted by the Federal Geographic Data Committee (FGDC), National Spatial Data Infrastructure (NSDI), Department of Defense (DOD), Homeland Security, and others to support emergency services, especially during disaster recovery.

The method was used successfully during the Katrina disaster when street signs were lost in New Orleans and the normal method of address location using street addresses no longer worked. Dispatching responders by grid map coordinates with GPS proved its value and is now being integrated by several states as part of their emergency planning and preparations.

A perfect, real-world example for using the National Grid occurred in Russell County Kansas. Russell County is a leader among its neighbors in GIS and addressing for 9-1-1. As part of its GIS data sharing to support a regional dispatch system, Russell County encountered all of the issues discussed so far. But there were also some more subtle lessons learned regarding road centerline standards and neighbors' data.

One specific geographic location serves as a perfect demonstration of the issues. In the southeastern corner of the County are borders with two other counties. At one road intersection shared by the three counties, there are three sign posts placed by their respective counties. On each sign post are two street signs for the two roads that intersect here. The surprise is the six street signs all have different road names! Each county assigned their own road names to the two roads, without collaboration with their neighbors.

Figure 3 – Duplicate Road Naming

When each county built their GIS road centerlines, the naming they used was for their county. The nature of a GIS centerline is that only a single, primary road name is stored. Practically no GIS centerline models allow for differing road names for different sides of the road. The same is true for the address ranges because the addresses assigned on one side of the road are in one county, while the addresses on the other side of the road are in the next county. So their situs GIS address point layers reflect the problems with the centerlines.

The interim solution for the duplicated centerlines was to load the Russell centerline as the primary road name, and use the neighbor's road name as an alternate. Though this is not a particularly elegant solution, it is a fair work around with the dispatch mapping software.

An elegant solution is the use of the National Grid to assign unique coordinate addresses to all address points in Russell County and a buffer with the neighboring counties. This solution does not require a road name. Better, the ambiguity of contradictory, duplicate and aliased road names is completely eliminated.

Summary

Next Generation 9-1-1 presents a special opportunity for GIS users. This is a perfect opportunity to leverage your GIS addressing data into not only telephone company records for emergency dispatch but into all other local government databases. This leveraging includes the standardization of addressing and road naming and a more formalized opportunity to share and use GIS data with others.

There is also the opportunity to augment your 9-1-1 databases with densified dispatch geography and National Grid coordinates for every address. Next Generation 9-1-1 essentially ushers in a new level of enterprise GIS, necessary data sharing, and GIS professionalism.

About the Authors

Keith Cunningham has been working with GIS since 1985 and with 9-1-1 systems since 1989. He holds a PhD in Geography from the University of Kansas.