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Technical Bulletin

featuring emerging technologies in criminal justice information management

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ACQUISITIONS

Automatic Vehicle Location for Law Enforcement

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Being at the right place at the right time. Never is this more important than in public safety. One of the most basic necessities of law enforcement is the ability to get the right resources to an incident as quickly as possible. Traditionally, agencies have done this by breaking down the geographic areas they cover and assigning resources to each small area, or beat. When an incident occurs in that area, the resource covering that beat responds. Most of the time, the resource that is used is the closest, with the ability to respond most quickly.

As cities and towns have grown and spread, and resources to serve these communities have become more expensive and scarce, many law enforcement agencies are looking for methods that are more effective than assigning beats. Automatic vehicle location (AVL) of law enforcement vehicle fleets is one method that appears to hold promise in this area.

Many equate AVL with the U.S. Department of Defense's Global Positioning Satellite (GPS) system. But GPS is just one of several means of detecting the geographic location of a vehicle, and location detection is just one of several components of AVL.

To truly utilize AVL, three main components are required:

- The ability to determine the location of the vehicle;
- The ability to communicate the vehicle location to those who need to know (i.e., the dispatch center); and
- The ability to translate the vehicle's location, generally computed in latitude/longitude, into a format meaningful to the dispatcher.

Bureau of Justice Assistance, SEARCH Explore New Technologies

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The *Bulletins* identify, describe and assess new and emerging technologies that have existing or potential application in criminal justice information management. They alert practitioners to the existence of technologies which can benefit their management of information.

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Locating the vehicle

The key component, of course, is the ability to accurately detect the location of a moving vehicle. Several means to accomplish this are available, including dead reckoning, LORAN, and GPS.

- **Dead Reckoning**

In the dead reckoning implementation of AVL, a

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digitally compensated solid-state compass and wheel sensors are installed in each vehicle. These are used to measure heading (direction) and distance to "dead reckon" a new position from a previous position. The vehicle's starting position is plotted when the sensors are first mounted in the car. The system determines a new position for the vehicle by using the previous position and "drawing a line" to the new position based on the vehicle's heading (determined by the compass) and the distance it has traveled.

A good dead reckoning system can do this with only a 1 or 2 percent error rate. This may seem acceptable, until you consider that for every mile driven, the location can be off by up to 100 feet. Drive 50 miles, and the location derived by this system can be blocks away from the vehicle's actual position.

Some companies, such as Etak, Inc. of Menlo Park, California, have improved upon the dead reckoning method by adding logic that Etak calls "map matching." According to Walt Zavoli, Vice President for Business Development in Etak's Commercial Solutions Group, "map matching is logic that takes dead reckoning and constantly compares it to an on-board copy of a map."

In a simple case, if the compass says the vehicle is heading due east, but the map shows only a road heading a bit off due east, the map matching logic will correct the location of the vehicle to the road. If this correction is performed often enough, every 1 to 2 seconds, it can eliminate the small errors that will occur in the dead reckoned position over that short time frame. The map matching system also recognizes the fact that the vehicle is not always on a road, and takes this into account when making corrections.

Dead reckoning used in combination with map-matching is more accurate than dead reckoning by itself, but it can still get off track — and stay off track — until someone in the vehicle takes some action to correct it. This is not always possible, nor desirable, and so some AVL implementations combine dead reckoning, map matching and GPS: dead reckoning with map matching to keep the vehicle's location matched to a map, and GPS to correct the occasional errors. This is an excellent solution, but of course is more costly than dead reckoning alone.

• LORAN (Long Range Navigation)

Another method to determine a moving vehicle's location is via LORAN. LORAN is an existing network of high-powered, land-based transmitters, owned and maintained by the United States Coast Guard. It is a low-frequency (100KHz) system originally designed to provide navigation capability to ships operating around the coast of the continental U.S. and on the Great Lakes. The signals cover more than three-quarters of the U.S. land area.

A LORAN receiver on a vehicle makes time measurements of the signals transmitted from at least three locations. These measurements determine how far away the vehicle is from the fixed locations transmitting the signals. Applying the fixed location of the transmitters from which the signals were received, the receiver uses triangulation to calculate the vehicle's latitude and longitude. Triangulation uses the distance from each of three known points to calculate the one point on earth where you can be.

LORAN signals are susceptible to electromagnetic distortion by power lines, neon signs, railroad tracks, etc. Because of this distortion, it is not certain that this method would be reliable in a major metropolitan area.

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the officer's location and send backup units.

In a second incident, an officer at a traffic stop hit his emergency button before being incapacitated. Using the AVL-supplied location in conjunction with the officer's last radioed location, support was quickly provided for the officer.

Initially, beat officers were concerned about the potential for "Big Brother" to abuse the system. Some officers even devised clever schemes to "test" the system, including unplugging the GPS units from the MDT. But officer acceptance has steadily increased, and the officers realize that the system gives them greater safety and helps the force service the community more effectively.

The Michigan State Police are experimenting with AVL technology in a prototype law enforcement vehicle they have developed. They are also using the Trimble GPS receivers as well as Trimble's StarView graphical mapping package. They have "piggy-backed" their AVL data transmissions on their existing 800MHz voice radio. Although they are only collecting AVL data from the vehicle every 5 seconds or at each transmission, they are pleased with the accuracy of the system.

The Michigan State Police see many potential benefits for AVL, the primary one being officer safety. The State Police would also like to be able to include graphical mapping capabilities in the officers' vehicles so each officer could see where he is in relation to a given incident. In addition, the State Police may use the system to locate precisely where traffic enforcement is most effective so that they may more effectively deploy their resources.

Another law enforcement agency experimenting with AVL is the California Highway Patrol. The CHP, in conjunction with the Bay Area Metropolitan Transportation Commission (MTC) and the California Department of Transportation (Caltrans), have implemented a Freeway Service Patrol (FSP) on major segments of the freeway system in the San Francisco Bay area. The central mission of the FSP is to rapidly remove disabled vehicles or those involved in minor traffic accidents from the freeways. The FSP Communications System uses AVL and provides CHP dispatchers with the means to monitor and supervise the FSP tow trucks and to assist them in responding to freeway incidents.

The FSP AVL system was implemented by Ball Systems and uses Coded Communications GPS receivers and communications equipment. A 900MHz radio network was implemented for both voice and data communications between the tow trucks and the dispatchers.

According to Mr. Jerry Hamm, Communications Supervisor, CHP, the AVL is working well and has provided location accuracy of 200 to 300 feet. However, because the AVL is not integrated with the CAD system, dispatchers have to look at the graphical map and see which tow truck is closest to the incident.

Potential benefits

It is clear that AVL can help achieve decreased response times to incidents and increased officer safety, but AVL has the potential to achieve less obvious tactical and strategic benefits. Tactical benefits might include:

- Support of hazardous situation management, such as hot pursuit, multi-unit operations, stakeouts, etc., with a reduction in confusion over unit placement or the availability of assets;
- Dramatic reduction in voice radio usage in the dispatch process, freeing channels for tactical and MDT usage; and
- Documenting the sequence of events that occur in an incident to augment the testimony of law enforcement officials.

From a strategic standpoint, AVL can help larger fleets increase the efficiency in their vehicle usage. The AVL data can help point out beats which are quieter than average over time, and which beats are busier. These data can be analyzed to determine the most efficient beat lines to draw or where changes in the number of vehicles covering a beat are needed. In some instances, properly distributing existing vehicles based on need can help departments forego the purchase of additional vehicles.

This report was written by Meg McLaughlin of Andersen Consulting. Points of view or opinions are those of the author and do not necessarily represent those of SEARCH or the SEARCH Membership Group.

Making the location meaningful

Finally, in order for a dispatcher to be able to effectively utilize AVL, the system must have the ability to translate the vehicle's location, generally computed in latitude/longitude, into a meaningful format. This is usually done by placing it on a graphical map or by using a geographic database, or geofile, to translate it into a text street block, intersection, or highway mile marker.

Often it is easiest for a law enforcement agency to implement mapping first, to identify beats in a visual manner and display incident and vehicle locations as entered by communications operators into the computer-aided dispatch (CAD) system. AVL can then be implemented later and integrated into the CAD and mapping systems.

Operational experiences

The Schaumburg, Illinois, Police Department has been operating the first law enforcement GPS AVL installation since January 1992. Schaumburg, a residential suburb of Chicago, covers 24 square miles and 70,000 residents. Over 130 officers, 100 civilian support personnel, and 19 dispatchers handle the roughly 50,000 calls per year received by the department.

Prior to the implementation of CAD and AVL, dispatching was done solely by voice radio, with dispatchers assigning incoming calls to the nearest beat car. In order to do this, however, dispatchers had to constantly monitor vehicle locations by voice and try to keep a large amount of location, heading and estimated time of arrival information in their heads.

Because of these inefficiencies, dispatch assignments and officer safety were not always optimized. The two stated objectives for Schaumburg's AVL system were to improve response times to calls and to increase officer safety. By automating the process, each vehicle's location would be more readily available, current, and accurate.

Schaumburg's original plans in 1989 included the use of LORAN for vehicle location data. However, Schaumburg's evaluation team found that other nearby LORAN AVL systems were prone to large positional errors, as well as extended times and areas where position reports were not available. So the department made the decision to use a GPS AVL system instead.

Of the department's 65 vehicles, 40 are designated as critical response units and are outfitted with AVL receivers and mobile data terminals. Each vehicle has a Trimble Navigation "Placer" Series GPS receiver/antenna permanently mounted on the trunk, just behind the windshield. The receiver constantly receives GPS satellite signals and converts them into the vehicle's geographic latitude and longitude. This information is updated within the GPS receiver once every second and made available to the vehicle's MDT.

Within the MDT, the latitude/longitude is converted into a standard "MDT message" so that the CAD system can accept the data as it would any other MDT message. The fleet uses Motorola MaxTrac radios over a single, dedicated data channel and uses separate radios for voice transmissions over the other available trunked channels.

Schaumburg elected to utilize "standard mode" AVL, which provides accuracy of better than 100 meters, rather than the more costly and complex "differential mode," which achieves an accuracy of 10 meters or better.

Vehicle location data is available to dispatchers in two ways: on a graphical map that can be displayed on individual CAD screens or on a centralized, 35-inch map display terminal in the dispatch facility. The large display shows a "bird's eye" view of the city with color-coded icons and key streets, and it can be manipulated by "zooming" in and out. The dispatch display on all CAD-capable workstations in the communications center can be toggled with a single keystroke between CAD information and the customized AVL map screen. Each dispatcher can manipulate the map as needed on his/her screen.

No quantitative study has been performed to determine how much GPS AVL has actually reduced response times in Schaumburg. However, AVL is considered an integral part of the operation and has definitely played a role in officer safety.

In one case, an officer making a traffic stop requested backup but, in the stress of the moment, failed to state his location. Dispatchers used the AVL map to identify

• GPS

GPS is the most widely known form of detecting a vehicle's location. GPS is the U.S. Department of Defense's network of NAVSTAR satellites, which orbit the earth at very high altitude. The satellites are high enough that they can avoid the problems encountered by land-based systems. These satellites transmit their orbital location along with a code for timing purposes (to calculate how far the receiver is from the satellite). When received from at least three satellites by a GPS receiver, this information can be used to calculate location by triangulation, much like LORAN.

GPS can provide latitude and longitude with an accuracy within 100 feet. This accuracy can be improved to within 10 meters if differential GPS is applied. With this technique, one GPS receiver within a system is located at a surveyed site, or known reference point. Because that receiver knows its exact latitude and longitude, it can calculate any errors in location measured by the GPS and then apply that error factor to the locations determined by other receivers to obtain a "corrected" location (the satellites are so high that any errors measured by one receiver will be almost exactly the same for any other receiver in the same locale).

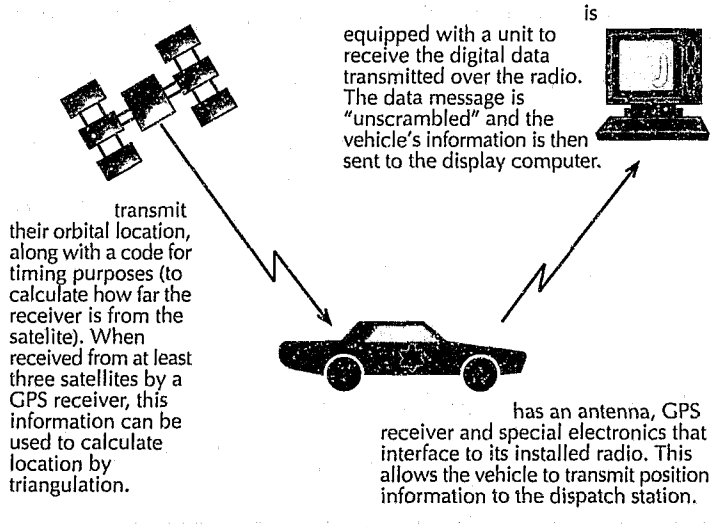
GPS requires readings from at least three satellites. In major metropolitan areas, where skyscrapers are common, or in mountain or canyon areas, this can pose a problem, since the receiver may not have contact with three satellites all the time. For this reason, some users are combining GPS with a second form of AVL, such as dead reckoning. This way, if three satellites are not accessible, the back-up method can be used to keep location information current.

Communicating the location

The second major component of AVL is the ability to communicate vehicle locations to the dispatch center. The most secure and reliable method of doing this is by transmitting the information over radio waves. Microwave and cellular networks could also be used for this link, but microwave is still very expensive and cellular is not secure or reliable enough for agencies to implement for AVL purposes.

The biggest decision to be made regarding the communications link is whether to "piggyback" the location data onto an existing voice or data radio network, or to use a stand-alone network to transmit the location data only. If an existing network is used, delays can be experienced in communicating locations due to the higher volumes of traffic being transmitted. Voice communications can also run into the data, causing the voice communications to be lost. For larger fleets, a dedicated radio link is recommended.

While AVL data tends to be transmitted in very short bursts, it can be frequent. Vehicle location data can be provided to central dispatch either by automatic reporting from the GPS receiver, or by the polling of the receiver by the mobile data terminal (MDT) or the dispatcher. The frequency with which location data is requested is a function of the dispatch operation's need for a given vehicle's location information. For instance, a system could be set up such that critical response units are polled every 15 or 20 seconds, while noncritical units are polled every 60 seconds.



Additional Information

AVL vendors

There are a number of large and small vendors of the different components of AVL. No one vendor supplies the radio, location device and mapping facilities, but several vendors supply more than one of these. The vendors who were contacted during the course of researching this report are:

Trimble Navigation Systems
645 North Mary Avenue
Sunnyvale, CA 94088-3642
(800) TRIMBLE
- GPS Receivers
- Mapping Systems

Motorola
1301 East Algonquin Road
Schaumburg, IL 60196
(800) 367-2346
- GPS Receivers
- Radio Communications

Coded Communications
2375 Camino Vida Roble
Carlsbad, CA 92009
(800) 228-6367
- GPS Receivers
- Radio Communications

Etak, Inc.
1430 O'Brien Drive
Menlo Park, CA 94025
(415) 328-3825
- Map Data
- Mapping Systems

Thomas Bros. Maps
17731 Cowan
Irvine, CA 92714
(714) 863-1984
- Map Data
- Mapping Systems

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