How Law Enforcement Agencies Can Make Geographic Information Technologies Work for Them

By Mark Leipnik, Donald Albert, Dennis Kidwell, and Alberto Melis

A geographic information system (GIS) is a powerful technological tool for municipal police departments and other law enforcement agencies. Typical GIS users in law enforcement include crime analysts, computerized crime records management personnel, police executives, shift supervisors, patrol sergeants, and even patrol officers. All current and potential users of GIS can benefit from a better understanding of what GIS is and what makes GIS special and different from other information technologies such as databases, computer aided dispatching, and computer aided design.

This article reviews the basic concepts and applications of GIS in law enforcement activities. A case study illustrates the real-world use of GIS within a medium-sized police department. Further, a short list of crime mapping resources and a glossary of terms, which appear at the end of the article, complement this discussion. The list provides some readily available current information on crime mapping. The glossary of terms may assist map readers to better describe and analyze the distribution of crime patterns.

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What Is GIS?

GIS is an abbreviation for geographic information systems. Defining GIS is often elusive because there is no universal definition; however, there is general agreement that GIS is a powerful tool for examining spatial data (points, lines, and areas). GIS is a computer-based system that captures, stores, manipulates, analyzes, and displays and queries geographic data.

Implementing a GIS requires people (officials, managers, technicians), data, software, hardware, and procedures. Overarching these components should be the application of sound geographic reasoning that involves asking geographic questions, acquiring, organizing and analyzing geographic information, and answering geographic questions. Therefore, geographic reasoning and GIS provide crime analysts an effective one-two punch in maximizing the potential benefits of crime mapping.

GIS supports four groups of spatial functions:

1) general operations such as the retrieval, classification, and measurement of spatial data
2) overlay operations that involve adding, removing, or reordering map layers
3) neighborhood operations that count points or lines contained within polygons
4) connectivity functions that generate buffers around points, lines, and areas

Space limitations prevent further elaboration; however, readers might examine Geographic Information Systems: A Management Perspective, by Stan Aronoff, for a more detailed discussion of GIS functions.

Characteristics of Law Enforcement GIS

Examples of spatial data relevant to law enforcement include point (crime locations), line (streets), and area (precinct boundaries) features. These geographic features are often separated into overlapping thematic layers (schools, parks, political boundaries, criminal offenses, traffic, and 911 calls, to name a few examples). GIS provides users the flexibility to combine or separate data into as many or as few layers as needed. All layers in a GIS have a common coordinate system, frequently either Universal Transverse Mercator (UTM) or State Plane Coordinates in the U.S. A GIS can manage multiple-coordinate systems and projections and support cartographic transformations of the data so that data can be imported in another format and included into the GIS.

A GIS can also usually accept data that is in a raster format including scanned images of maps, digital aerial photography, or remotely sensed imagery. Although a GIS can bring this data in as a new layer, it will not have the same information content as existing data stored in a vector format. Examples of typical vector-based data sets are the street centerline data most departments use to serve as a base-map for crime mapping.

Tables are used to store attribute data in a GIS. These tables have a series of records that are linked to the map features, such as points representing crime incidents, lines representing street segments, or polygons representing precincts. This attribute data can be extracted, revised, and managed separately from the spatial data and, in many cases, is of greater importance than the spatial data. A common approach in law enforcement is to collect the attribute data from crime incident reports entered into a

stand-alone database and then selectively extract incident data for insertion into the GIS. Often this requires geocoding of the location of an incident. Usually, the street address of an incident is compared to a database linked to the GIS that contains street names and address ranges for the right and left sides of every city block. This data is a challenge to create for a police department; fortunately, the U.S. Census Bureau has, since 1990, created just such a data set. It is called TIGER (Topologically Integrated Geographic Encoding and Referencing) and is available to the public nationwide. This TIGER street data serves as the basis for most crime incident geocoding and hence for most crime mapping at present. More recently, global positioning systems (GPS) have become a viable alternative for determining the location of incidents for inclusion in a GIS. This is particularly true of incidents that occur where street addresses are unavailable or do not tie the incident to a limited area.

When a new incident is entered into a GIS, a point is inserted at the corresponding location, a database table is opened, and a new record is inserted into this table. In general, a special symbol is used to denote each class of incident. Thus, "part-one" incidents might be subdivided into burglaries, robberies, and assaults with a unique symbol associated with each. Some departments choose to use connotative symbols. For example, symbols in the shape of a gun, knife, running person, or tombstone might be used to represent, the location of, respectively, a robbery, assault, burglary, and homicide. Most departments choose to use geometric figures (squares, stars, circles) of various colors to denote different types of crimes or crimes occurring at differing time periods.

Aiding Crime Analysis

The most common approach is to have a crime analyst use GIS to analyze the spatial and temporal factors associated with a series of crimes or to detect patterns, trends, and exceptions. In most police departments, crime analysts view GIS as an important but non-essential tool. They may generate reports on only selected crimes or create crime maps occasionally in response to particular types of incidents such as serial robberies or rapes. The reason that many departments use GIS selectively is that it is a relatively new technology in policing. Further, geocoding all crime incidents or even all major crimes is a laborious task and in many departments adequate resources have not been provided to support maintenance of a GIS. Thus, crime analysts are often assigned the additional task of crime mapping using a simple GIS program and a less-than-perfect street data set from TIGER with which to work. This is not to say that the crime maps produced periodically are not useful, or that crime mapping of specific incidents or types of incidents is not valuable. Examples of serial rapists, murderers, and robbers caught through the use of deployment and response strategies -- analyzed and generated with a GIS -- exist for many cities. The Federal Bureau of Investigation occasionally uses GIS; the Royal Canadian Mounted Police (RCMP) do so routinely. The RCMP, in conjunction with Dr. Kim Rossmo of Vancouver, has developed its own GIS software, geared toward spatial analysis of serial crime patterns.

In addition to helping to solve crimes associated with a particular perpetrator or gang, many crime analysts use GIS to examine crime patterns associated with a particular locality, say, a liquor store or a motel, that may see a significant number of crimes. Sometimes, it is difficult to identify locations that for whatever reason seem to act as crime magnets. Frequently, the incidents may not actually be on the premises of a liquor store or motel, but crimes such as an assault, prostitution, and drug dealing may be concentrated in close proximity to the offending establishment.

A function standard to all GIS programs, "buffer zone generation," allows an analyst to generate a zone (often a circle with a specified radius) centered on the location of interest and then extract all incidents within that zone. These incidents will appear in a different color on the screen, and the corresponding records from the database can automatically be extracted from the entire mass of records. For example, all incidents within 500 feet of a particular liquor store can be easily identified. The San Diego and Charlotte-Mecklenburg police departments are using this approach to identify motels and liquor stores that have an unusually large number of crime incidents in close proximity. If it is established that there is a link between a motel and prostitution and drug dealing, or a liquor store with assaults, vagrancy, and petty theft, enforcement actions are directed at the establishment in question. These actions are not necessarily geared toward proving criminal activity on the part of the business. Rather, civil enforcement actions or removal of liquor licenses are the most common responses. In some cases, the police department cooperates with city building inspectors, fire marshals, planning officers, and district attorneys to rid the community of these magnets for crime. GIS has not only helped identify these establishments, but also has been used in evidence in court and liquor control board proceedings as graphic (and geographic) proof of the localized crime all too frequently associated with a small but distinct minority of businesses in the community.

Improving Command-Level Decision Making

Command-level executives within police agencies are now using GIS to help decide how to deploy resources and where to locate facilities. Perhaps most visibly, the New York City Police Department has made GIS an essential component of the COMSTAT process. COMSTAT stands for computerized statistics, but the crime statistics that are analyzed on a monthly basis by decision makers in order to better deploy resources and target specific problems are displayed and analyzed using a GIS in these monthly staff meetings. The GIS helps commanders see crime patterns graphically in relation to community features and precinct boundaries. In particular, clusters of incidents become very visible.

Once commanders recognize problems, either in terms of spatial or temporal "hot spots" of crime, the COMSTAT process focuses resources on combating these problems. If displacement of crime results, the next monthly meeting can observe that trend and make necessary adjustments in deployment. In particular, the use of GIS in this process has helped the department identify crime hot spots that cut across precinct boundaries. Before the advent of COMSTAT, for example, an area where street crime associated with crack cocaine dealing was near the convergence of three precincts likely to go unnoticed by all three precincts. GIS can help the involved precincts to recognize the problem by displaying both crime incident locations and precinct boundaries. Then, resources within and among precincts can be reallocated appropriately. (Inevitably, GIS users discover a time-tested law of cartography that every interesting cluster lies at the convergence of four map sheets or, in this example, three precincts).

The GIS also helps the New York City police perform both spatial and temporal analysis simultaneously. In this way, incidents occurring at a particular time of day or on the weekends will be displayed on a crime map; thus, the technology will highlight an area with high rates of street crime on Friday and Saturday nights, for instance, or an area with daytime workweek residential burglaries. The relevant commanders can then make changes in scheduling and, if necessary, approve overtime. Many departments are using GIS to assist deployment, though few use it as systematically as the New York City Police Department.

Authorities can use GIS to determine the best location for new facilities, as well. Numerous fire departments and other agencies involved in emergency response have used GIS to locate facilities. As GIS becomes more prevalent and accepted in

law enforcement, police departments will find it a useful tool to locate community outreach "storefront" offices, new substations, and, ultimately, new headquarters and other facilities.

Assisting Patrol and Community Outreach Activities

GIS can be a great help to individual patrol officers and officers working in community-oriented policing programs. A number of departments routinely generate crime maps that are attached to tabular lists of specific incidents for a given period (frequently a month or week). These bulletins are copied and distributed at briefings or even at the beginning of every shift. In several departments that provide a computer (desktop or laptop) to most officers, an effort is underway to use internal local area networks to make this data available digitally. Several other police departments, including those in Chicago, Houston, and Charlotte have copies of a GIS program in every precinct or district office. At any rate, the effort to disseminate the results of crime incident mapping and spatial analysis of crime down to the level of the patrol officer is underway. Since a GIS can focus on the beat, precinct, or community, the maps can focus on issues pertinent to particular patrol officers. Creating incident maps for all possible types of crimes on a routine basis is a significant effort. In particular, getting the incident reports into a GIS in a timely and accurate manner requires a special effort.

An example of a department that has done an outstanding job of disseminating information down to the patrol level is the Chicago Police Department. This department puts many categories of crime incidents into its GIS on a daily basis and has achieved a remarkable 99.8 percent success rate in geocoding these incidents by systematically making sure that addresses recorded in crime reports are consistent with the street names and address ranges stored in the GIS. This involves laboriously checking the street map in the GIS for accuracy and removing glitches such as missing streets or streets with out-of-date names or address ranges. More importantly, Chicago has impressed on its officers the need to accurately record the street addresses of incidents and make an extra effort to correctly spell street names. This effort was rewarded with crime incident bulletins and on-line crime incident maps that are current as of the preceding day and, in some cases, the preceding shift.

Which Departments Are Using GIS?

Generally, in the U.S., metropolitan police departments with at least 100 sworn officers have been the early adopters of this proliferating technology. GIS use is rapidly growing, particularly in states such as California and Massachusetts. Even in a less technology-oriented state like Texas at least 24 departments use GIS. However, probably fewer than 10 percent of all the 17,000 or more U.S. police departments have adopted GIS technology. Among the departments that are actively using GIS, most tend to be in larger cities with populations over one million. Cities such as New York, Los Angeles, Chicago, and Houston all have GIS, as do San Francisco, Oakland, San Diego, Portland, Seattle, Salt Lake City, Albuquerque, Dallas, San Antonio, Miami, Atlanta, Boston, Minneapolis, Saint Louis, and several jurisdictions in the Washington D.C. area. Mid-sized police departments in cities such as Charlotte, Tacoma, Richmond and many others have GIS as well. Many smaller but affluent cities such as wealthy suburbs of Dallas (Plano), Los Angeles (Beverly Hills), and Phoenix (Scottsdale), or wealthy suburban areas such as Stonington, Connecticut, and Cathedral City, California, use the technology. Relatively few sheriff's departments use GIS, and they tend to be in large urban areas such as Los Angeles County or wealthy counties such as Santa Barbara County, California, and Prince George's County, Maryland.

In addition to helping to solve crimes associated with a particular perpetrator or gang, many crime analysts use GIS to examine crime patterns associated with particular localities.

Given this information, many readers from smaller or less affluent communities may believe that GIS is a technology out of reach for their departments. That this is generally true today is due more to a lack of dissemination of knowledge about the technology than to reasons of cost or technical complexity. In fact, GIS technology is well within the reach of many smaller agencies. The following case study was chosen because it demonstrates that a police department need not be located in a large or particularly wealthy city to successfully use GIS to map and analyze crime.

GIS Use in Waco, Texas

Waco is a moderate-sized central Texas city, far removed from other major metropolitan areas. It is centered in a farming region and features some light manufacturing and a well-known university (Baylor). The population of the city is approximately 109,200. The city has a substantial African-American population (23 percent) and a growing Hispanic community (16 percent). Crime rates are unexceptional. The crime-related issue that most people associate with Waco, the Branch Davidian confrontation, occurred a dozen miles outside of town, and the Waco Police Department had little or no role in it. The Waco Police Department is made up of 201 sworn officers, 74 civilians, and 400 "citizens on patrol."

The Waco Police Department has been using GIS for approximately 10 years and currently is generating crime analysis bulletins for its patrol officers. In general, these bulletins are geared toward property crimes and feature a cover page addressing current crime issues (for example, highlighting the likelihood of burglaries near the university during spring break). Other pages contain citywide and zoomed-in maps that display the incident locations along the boundaries of districts and individual beats. A final section contains the list of actual incidents that relate to the incidents symbolized on the map. The GIS is used to generate such routine reports, which are disseminated by the low-cost method of copying and distribution as paper flyers delivered directly to the hands of supervisors and officers. Alternatively, the GIS can address issues of current interest such as the zoomed-in map of assaults. Close-up maps for particular crimes and the associated tabular data can be easily created for all or part of Waco and for any chosen incident type or period.

The Waco Police Department's GIS system also has the capability of performing several types of spatial and statistical analysis. Specifically, crime density maps can be generated. The system stores seven years of prior incident records that can be used to highlight areas where crimes are likely to occur and these areas can be compared with the location of current incidents. This relatively low-cost system has helped Waco improve its delivery of services to the community.

GIS is a technology that is accessible to any police department with the resources to assign a crime analyst, information specialist, or staff member reasonably competent in the use of computers to the project for a portion of his or her workday. GIS offers law enforcement professionals throughout the department a powerful tool to see and understand spatial and temporal patterns of crime and police responses to these issues in a profoundly new way. GIS applications range from the simple to the highly sophisticated, but the hundreds of cities and many county law enforcement agencies currently using GIS started by gaining an initial understanding of this exciting technology. The resources listed below offer a wealth of information that will be useful to police administrators who are considering

building new systems or maintaining and improving existing ones.

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Crime Mapping Resources

Books

Block, C., M. Dabdoub, and S. Fregly. *Crime Analysis through Computer Mapping*. Washington, DC: Police Executive Forum, 1995.

Goldsmith, V., P. G. McGuire, J. H. Mollenkopf, and T. A. Ross. *Analyzing Crime Patterns: Frontiers of Practice*. Thousand Oaks, CA: Sage Publications, 2000.

Harries, K. *Mapping Crime: Principle and Practice.* Washington, DC: National Institute of Justice, 1999.

La Vinge, N. and J. Wartell. *Crime Mapping Case Studies: Successes in the Field*. Washington, DC: Crime Mapping Research Center and Police Executive Research Forum, 1998.

Weisburd, D., and T. McEwen. *Crime Mapping and Crime Prevention*. Monsey, NY: Criminal Justice Press, 1997.

Government and Educational Organizations

Crime Mapping Research Center
http://www.ojp.usdoj.gov/cmrc

National Law Enforcement and Corrections Technology -- Rocky Mountain
http://www.nlectc.org/nlectcrm/

Illinois Criminal Justice Information Authority
http://www.icjia.state.il.us/public/index.cfm

National Center for Geographic Information & Analysis
http://www.ncgia.ucsb.edu/

Data Sources

Geographic Data Technology
http://www.geographic.com/index.cfm

U.S. Census Bureau
http://www.census.gov/

Software Vendors

The Omega Group (CrimeView)
http://www.theomegagroup.com/

Environmental Systems Research Institute, Inc. (ArcView, ARC/INFO)
http://www.esri.com/

MapInfo Corporation
http://www.mapinfo.com/

Intergraph Corporation
http://www.intergraph.com/

Towards a Lexicon Of Criminology and Geography: 25 Useful Terms

The interaction between criminology and geography has made tremendous contributions to the lexicons of these vibrant disciplines. The fact is that geography must be taken into account when analyzing most human phenomena, including patterns of criminal offenses. This linkage across disciplines requires the development of a unique lexicon through the adaptation of old terms and the coinage of new ones. Some of these terms evolved as criminologists began using computer mapping and geographic information systems to manage and analyze spatial attributes associated with crime data. The following is a collection of 25 useful terms that have found their place in the joint lexicon of criminologists and geographers. This glossary is not intended to be complete or comprehensive, but it does reflect the recent cross-disciplinarian connections that have brought criminologists and geographers together.

Glossary

Activity Space: The area within which offenders move during the regular round of their activities.

Anchor Points: Focus points such as residences, workplaces, criminal markets, and other hangouts that are important to criminals.

Appearance Disorder: The average number of disorders (broken windows, graffiti) per building in a geographic unit (blocks).

Circle Hypothesis: The hypothesis that an offender's home base lies within a circle drawn around a line (diameter) that has as its endpoints the offender's two most distant crime locations.

Commuter Offenders: Criminals who live in one area but "work" in another.

Crime-Gradient: The construction of contour maps where isopleths, or lines, connect points of equal crime rates.

Crime Wave: The spatial and temporal clustering of crime incidents.

Exporter: A criminal who generates a substantial number of offenses outside of his own immediate neighborhood.

Geoforensics: The use of geographic concepts and themes during the analysis of crime patterns.

Geographic Profiling: The geographic analysis of a serial offender's crime locations for the purpose of zeroing in on the perpetrator's neighborhood.

"***Hit" Rate***: The percentage of geographic locations (e.g., ZIP codes, addresses) correctly matched with geographic coordinates.

Hot Spot Area: The place of highest crime density, as revealed through the use of circles, ellipses, or other geometric shapes.

Journey-to-Crime: The distance from an offender's home to the offense location.

Location Quotients in Crime (LQC): The ratio of the rate of crime in a sub-unit to the rate of crime of the complete geographic unit.

Manhattan Distance: The street distance between point a and b that requires going around a corner to reach point b.

Mapless Mapping: Mapping criminal data, using latitude and longitude or some other coordinate system, without reference to geographic boundaries.

Marauder: A rapist who commits offenses in a more or less uniform pattern within a circle encompassing his base of operation. The circle is "domocentric" if that base of operation is the rapist's residence.

Place: The amount of the built environment that can be viewed from a given surface position with the unaided eye.

Safety Zone: The distance between a rapist's residence and the location of his closest offense.

Sphere of Concern: This method uses vectors drawn from the place of abduction to the place of recovered bodies. Individual vectors are aggregated to define a radius that is used to construct a circle or sphere of concern.

Stationary Fallacy: Suggests that when data on offenses are combined over different time periods (i.e., combining daytime and nighttime offenses), possibilities exist for the identification of false clusters. For example, if thefts are a daytime phenomenon and assaults a nighttime phenomenon, aggregating these might produce a cluster representing unrelated crimes.

Target Backcloth: The spatial and temporal distribution of "suitable" crime targets or victims. (The quotations around suitable indicates that this term reflects the perspective of the offender.)

Territorial, Geographic, or Spatial Displacement: The relocation of criminal activities in response to decreasing crime opportunities or increasing chance of apprehension. Area restrictions included within bail and probation orders might also stimulate territorial displacement.

Windshield Wiper or Pie Shape: Describes the locations of criminal offenses that are characterized by a distinct directional pattern.

Wheel Distance: This refers to network distance or the actual distance traveled from points a to b. Wheel distance contrasts with straight-line or Euclidean distance.