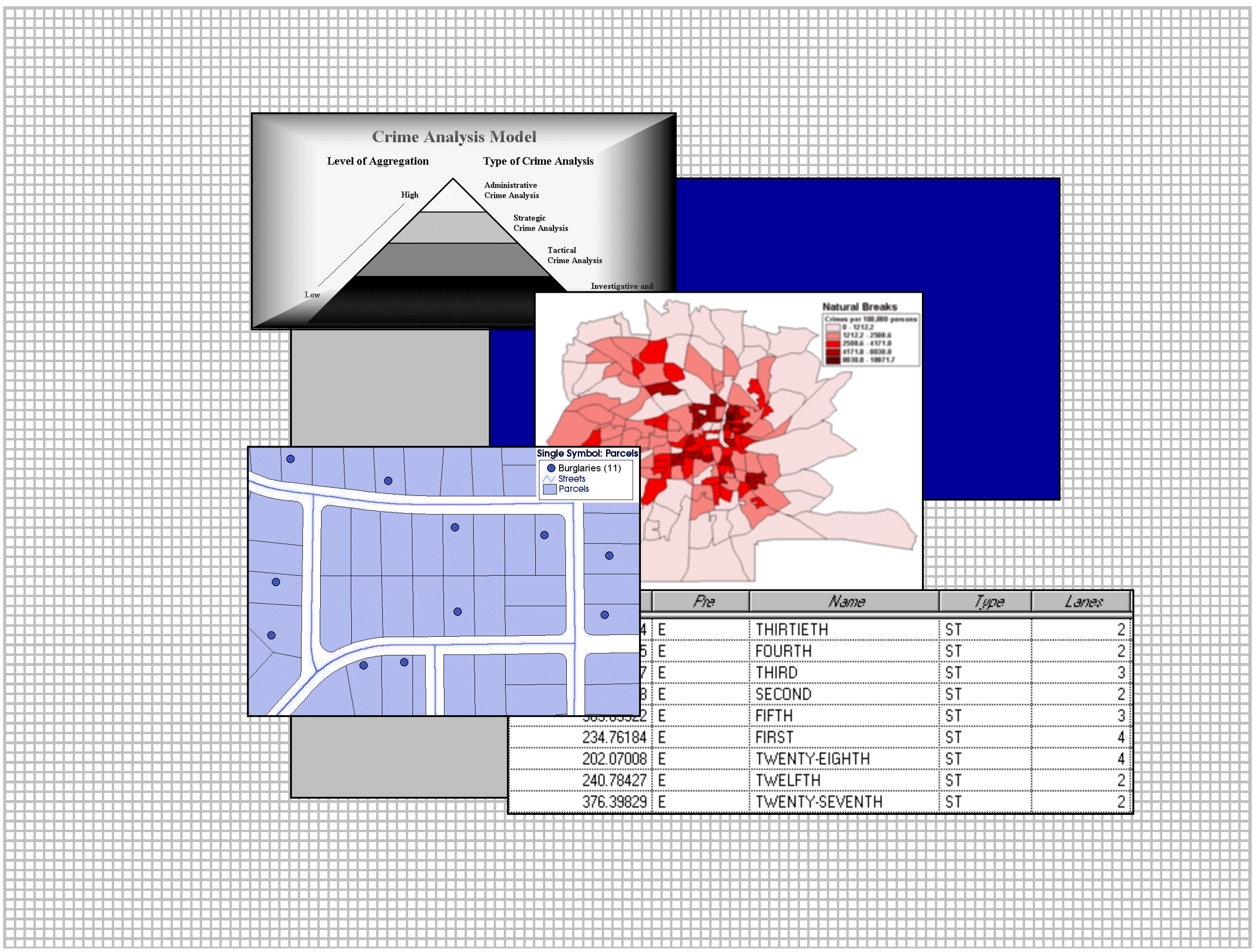
COMMUNITY ORIENTED POLICING SERVICES
U.S. DEPARTMENT OF JUSTICE

INTRODUCTORY GUIDE TO CRIME ANALYSIS AND MAPPING



Introductory Guide to Crime Analysis and Mapping

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November 2001
Report to the Office of Community Oriented Policing Services
Cooperative Agreement #97-CK-WXK-004

The opinions, findings, and conclusions or recommendations expressed in this document are those of the authors and do not necessarily represent the official position or policies of the U.S. Department of Justice.

Acknowledgements

The author would like to thank Kristin Quayle for transcribing our training session during her summer here at the Police Foundation, as well as Mary Velasco and Erin Lane, Research Associates at the Police Foundation, for their careful review and comments.

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I. Introduction

The following guide was developed from the curriculum for the "Introduction to Crime Analysis Mapping and Problem Solving" training course conducted by members of the Police Foundation's Crime Mapping Laboratory in 2001 and funded by the Office of Community Oriented Policing Services (COPS). The purpose of this document is to convert the information presented in the training into a succinct and readable report that makes it available to a larger audience than was reached through the training sessions. It is not intended to be a comprehensive document on crime analysis, crime mapping, and problem solving, but rather a "starter" guidebook for someone just entering the field or a reference manual for current crime analysts or other law enforcement analysts. The format of the document follows the format of the training slides loosely, but it is not necessary to read them together. This document stands on its own. For further reading on crime analysis and mapping, see other relevant documents written by the Police Foundation at www.policefoundation.org or www.cops.usdoj.gov.

II. Introduction to Crime Analysis

As an introduction to crime analysis, this section provides the definition of crime analysis as a general concept as well as definitions of five types of crime analysis. These definitions are used in the Police Foundation's "Introduction to Crime Analysis Mapping and Problem Solving" course and have been created to synthesize current concepts and ideas in the field of crime analysis. These definitions are meant to enhance the understanding of crime analysis and to help create commonly understood terminology. The latter part of this section includes a hierarchical model by which all five types of crime analysis are related to one another.

Definition of Crime Analysis

> *The qualitative and quantitative study of crime and law enforcement information in combination with socio-demographic and spatial factors to apprehend criminals, prevent crime, reduce disorder, and evaluate organizational procedures.*

Qualitative and quantitative*.* Crime analysis uses both qualitative and quantitative data and analytical techniques. Qualitative data and analytical techniques refer to non-numerical data as well as the examination and interpretation of observations for the purpose of discovering underlying meanings and patterns of relationships. This is most typical of field research, content analysis, and historical research. Quantitative data are data primarily in numerical or categorical format. Quantitative analysis consists of manipulations of observations for the purpose of describing and explaining the phenomena that those observations reflect and is primarily statistical. Crime analysis employs both types of data and techniques depending on the analytical and practical need. For example, crime data can be used in various ways, both quantitatively and qualitatively. The information such as date, time, location, and type of crime is quantitative in that statistics can be used to analyze these variables. On the other hand, narratives of crime reports are considered qualitative data in that a large number of narratives are nearly impossible to analyze statistically and are primarily examined to determine general themes and patterns.

Study*.* Study is a systematic way of looking at crime and law enforcement information. That is, crime analysis is not examining information haphazardly but rather is applying formal analytical and statistical techniques as well as research methodology to law enforcement information according to the rules of social science.

Crime. In a law enforcement agency, the central focus is crime, both those reported to the police and those that are not. Thus, the central type of data analyzed is crime and the information surrounding it, such as arrests, offenders, victims, property, and evidence.

Law enforcement information. In addition to crime, law enforcement agencies address many other issues and thus collect many other types of data. Examples of law enforcement data that are often available for crime analysts are calls for service (e.g., noise complaints, burglary alarms, suspicious activity), traffic information (e.g., accidents and citations), citizens' perceptions (e.g., fear of crime, crime prevention behavior, satisfaction with the police), victimization, probation records, and parole information.

In combination with… This phrase refers to identifying patterns and studying relationships of crime and law enforcement data with other types of information, such as those listed below.

Socio-demographic. This type of information refers to characteristics of individuals and groups such as sex, race, income, age, and education. On an individual (micro) level, socio-demographic information is used in law enforcement to search for and identify crime suspects. On a macro level, socio-demographic information is used to determine the characteristics of groups and how they relate to crime. For example, the information may be used to answer the questions, "Where can we find the suspect who is a white male, 30-35 years of age with brown hair and brown eyes?" or "Can demographic characteristics explain why one neighborhood has a higher rate of crime than another?"

Spatial. The location where crimes or activities occur and the relationship of those places to one another and to other information is an important factor in the analysis of crime. It is not only important where a crime takes place but also the characteristics of those places and the environment in which the crime occurs. Thus, examination of spatial data such as streets networks, parcel information, orthophotographs, school locations, business and residential zoning, among others, is imperative for effective crime analysis.

The last four key points describe the four goals of crime analysis.

Apprehending criminals. The main function of crime analysis is to support law enforcement endeavors. One of the primary goals of law enforcement is the apprehension of criminals; consequently, one of the primary goals of crime analysis is to assist in the apprehension of criminals. For example, a detective may have a robbery incident in which the suspect has a snake tattoo on his left arm. The crime analysts may assist by searching a database of field incident cards to identify individuals with such a tattoo. Also, a crime analyst may conduct a time of day/day of week analysis of burglary incidents that would assist officers in surveillance of an area to catch offenders.

Prevent crime. Another primary goal of law enforcement is to prevent crime through methods other than apprehension. This goal lends itself particularly well to assistance from crime analysis. For example, members of the police department are conducting a crime prevention campaign about residential burglary and would like to target their resources in the areas that need it the most. Crime analysis can assist in planning community education and patrol response tailored to the problem by providing spatial analysis of residential burglary, analysis of how, when, and where the burglaries occurred, and analysis of what items were stolen. This information could be used to develop crime prevention suggestions such as closing and locking a garage door.

Reduce disorder. Many criminologists contend that social disorder can lead to crime; that is, blight and other indicators of social decay left unchecked can attract crime and accelerate further decay. Thus, reducing disorder is a law enforcement objective and, by extension, one for crime analysis as well. Crime analysis can assist with these efforts by providing research and analysis of disorder indicators such as traffic accidents, noise complaints, or trespass warnings that can assist officers in addressing these issues before they become more serious problems.

Evaluate organizational procedures. The fourth goal of crime analysis is assisting with the evaluation of organizational procedures. Several examples include resource allocation, the assessment of crime prevention programs, realigning geographic boundaries, forecasting staffing needs, and developing performance measures for the police department.

Types of Crime Analysis

The following are five types of analysis that fall under the umbrella of crime analysis. As you will see, each contains characteristics of crime analysis in general, but each is specific in the type of data and analysis used as well as in its purpose.

Intelligence Analysis

> *The study of "organized" criminal activity, whether or not it is reported to law enforcement, to assist investigative personnel in linking people, events, and property.*

The purpose of intelligence analysis is to assist sworn personnel in the identification of networks and apprehension of individuals to subsequently prevent criminal activity. A related goal is to link information together, prioritize information, identify relationships, and identify areas for further investigation by putting the analysis in a framework that is easy to understand. Much of the information analyzed in the field of intelligence analysis is not reported to the police by citizens but is gathered by law enforcement. Examples of data collection methods include surveillance, informants, and participant observation. In addition, the type of information is not limited to criminal information but can include telephone conversations, travel information, financial/tax information, and family and business relationships. Intelligence analysis has traditionally focused more or less on organized criminal activity, which includes drugs and prostitution syndicates. The data analyzed are plentiful and primarily qualitative, and thus are usually analyzed through qualitative methods. In light of the events of September 11, 2001, intelligence analysis has most recently begun to focus on terrorist activity at the local level as well.

Criminal Investigative Analysis

> *The study of serial criminals, victims, and/or crime scenes as well as physical, socio-demographic, psychological, and geographic characteristics to develop patterns that will assist in linking together and solving current serial criminal activity.*

This type of analysis has also been called "profiling," which is the process of constructing a "profile" of an unknown offender based on the nature of the crime, the facts of the case, and the characteristics of the victim. As with intelligence analysis, this type of analysis focuses primarily on qualitative data surrounding serious serial crimes such as murder and rape. Data are collected and analyzed on an individual level for those persons primarily or peripherally involved with the incidents. The spatial nature of the incidents and related locations such as the body dump sites or the encounter sites is also considered. The primary purpose of criminal investigative analysis is to develop patterns of serial crimes crossing city, state, and even national boundaries by linking behavior and evidence within and among incidents in order to catch the offender and/or clear cases. This is a very specific type of crime analysis that is primarily done on the federal law enforcement level since these types of crime occur infrequently and cross jurisdictional boundaries.

Tactical Crime Analysis

> *The study of recent criminal incidents and potential criminal activity by examining characteristics such as how, when, and where the activity has occurred to assist in problem solving by developing patterns and trends, identifying investigative leads/suspects, and clearing cases.*

Tactical crime analysis focuses on information from recent crimes reported to the police. "Recent" can refer to the last few months or longer periods of time for specific ongoing problems. Tactical crime analysis also focuses on specific information about each crime such as method of entry, point of entry, suspects actions, type of victim, type of weapon used, as well as the date, time, location, and type of location. Field information such as suspicious activity calls for service, criminal trespass warnings, and persons with scars, marks, or tattoos collected by officers is also considered in the analysis. Although quantitative analysis is often conducted once a pattern has been identified, qualitative analysis, (i.e., critical thinking and content analysis) is used to identify patterns and trends initially. Three purposes of tactical crime analysis are 1) linking cases together and identifying the notable characteristics of the patterns and trends, 2) identifying potential suspects of a crime or crime pattern, and 3) clearing cases. The focus of tactical crime analysis is examining data daily in order to identify patterns, trends, and investigative leads for recent criminal and potential criminal activity. Once a crime pattern, suspect, or investigative lead is identified, the information is compiled and disseminated to patrol officers and detectives.

Strategic Crime Analysis

> *The study of crime and law enforcement information integrated with socio-demographic and spatial factors to determine long term "patterns" of activity, to assist in problem solving, as well as to research and evaluate responses and procedures.*

Strategic crime analysis consists primarily of quantitative analysis of aggregate data. Monthly, quarterly, and/or yearly compilations of criminal and non-criminal information such as crime, calls for service, and traffic information are analyzed in aggregate form. That is, general categories such as date, time, location, and type of incident are analyzed instead of qualitative data such as narrative descriptions of incidents. Variables including race, class, sex, income, population, location, and location type are examined along with law enforcement information in the analysis process. The two primary purposes of strategic crime analysis are 1) to assist in the identification and analysis of long-term problems such as drug activity or auto theft and 2) to conduct studies to investigate or evaluate relevant responses and procedures. Both of these purposes correspond very well to the problem solving process (see

Section IV for a discussion of crime analysis and problem solving specifically). These types of studies include evaluation of crime prevention programs, in depth examination of a particular crime problem, and implementation of a survey of citizens' perceptions of crime and the police. They incorporate pre- and post-measurement as well as both impact and process evaluation methodology. Procedures examined include such activities as deployment and staffing, redistricting of beats or precincts, data entry and integrity, and the reporting process. In sum, strategic crime analysis uses statistical techniques and research methods to investigate long-term problems and evaluate organizational procedures. Analysts who primarily conduct strategic crime analysis are also called problem or research analysts.

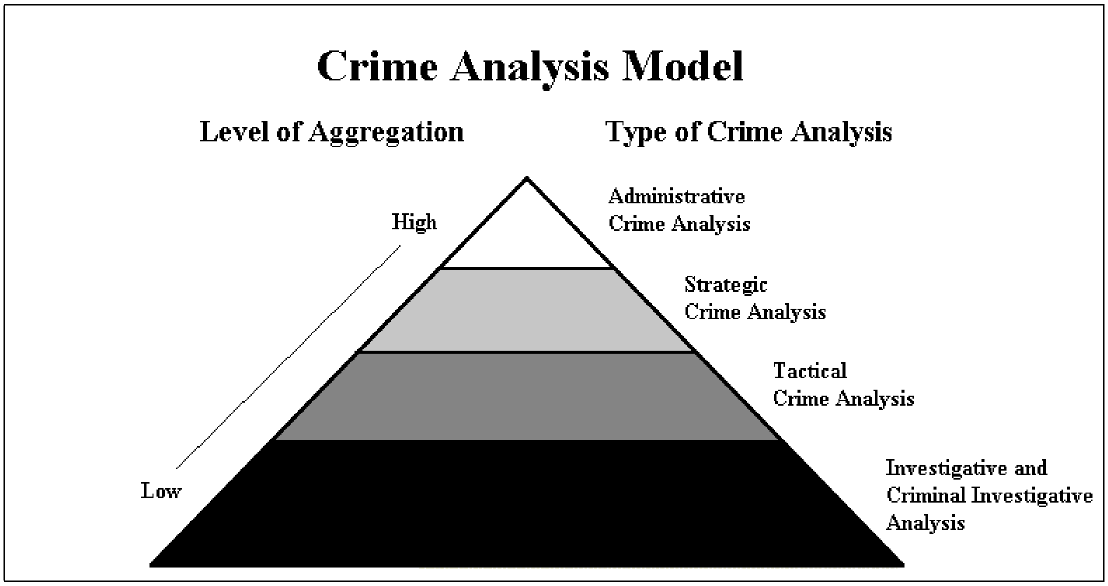
Administrative Crime Analysis

> *The presentation of interesting findings of crime research and analysis based on legal, political, and practical concerns to inform audiences within law enforcement administration, city government/council, and citizens*.

Administrative crime analysis is different from the previous types of analysis in that it refers to presentation of findings rather than to statistical analysis or research. The decision of what and how to present information is the primary focus of administrative crime analysis. Often, the type of information that is presented represents the "tip of the iceberg" of all the work and analysis that has previously been done, for example, an executive summary of a report. The purpose and the audience of the information determine "what" is presented along with legal (e.g., privacy and confidentiality), political (e.g., union issues, election concerns), and practical concerns (e.g., complexity of the information presented). The primary purpose of administrative crime analysis is to inform audiences. These audiences may vary from one situation to the next, which is why the type and quantity of information should vary as well. Audiences can be police executives, city council, media, citizens, and neighborhood groups or a combination. An excellent example of administrative crime analysis is the use of the Internet to provide information to the general public. Audiences of a police Internet site include citizens, police personnel, businesses, victims, criminals, and media—essentially everyone; therefore, the type of information published should be appropriate for an array of diverse customers. The information provided should be simple, clear, and concise and should not disclose sensitive information. One rule of thumb would be to only publish information that one would be comfortable seeing on the evening news.

Crime Analysis Model

The following figure displays how all of these types of crime analysis relate to one another in terms of the level of aggregation of the information. That is, types with low levels of aggregation focus on individual cases and used qualitative data and analysis techniques and those with high levels of aggregation focus on a limited scope of larger amounts of data and information. At the top of the figure, criminal investigative analysis and intelligence analysis utilize the least aggregated and most qualitative data. The data consist of information about informal networks of criminals and their non-criminal acquaintances and relatives as well as where individuals live, work, and "play." The focus here is on the specifics of criminals, the nature of their crimes, their relationships, and their lives in general.



Tactical crime analysis utilizes only crimes and activity reported to the police so the data are more aggregate and somewhat less abundant than those used for criminal investigative and intelligence analysis. Tactical crime analysis is primarily qualitative in nature but depending on the data, quantitative techniques can be used to describe characteristics of a given pattern such as the most common time the crimes occur (time series) or where the crimes are located in relationship to one another.

Strategic crime analysis utilizes large amounts of data that are even more aggregated than tactical and investigative data. For example, information used in tactical crime analysis is primarily made up of crime incidents but includes such information as date, time, location, methods of the crime, and detailed description of the crime. Strategic crime analysis focuses only on those variables that can be easily quantified, such as date, time, location, type of location, type of crime, and priority. Thus, the type of analysis is more quantitative and the large amount of data calls for statistical operations instead of reading and examining each case individually.

Finally, administrative crime analysis in this figure is literally the "tip" of the triangle in level of aggregation. The focus is presenting the most aggregate or summary information to a variety of audiences.

Overall, these types of analysis fall under the general definition of crime analysis in that each one contains some of the key components of crime analysis. For the purposes of the rest of this report, we will focus on examples of the last three types of analysis, tactical, strategic, and administrative, as they are the types of analysis that are most likely to be conducted on a regular basis by a crime analyst in an average law enforcement agency.

III. Introduction to Crime Analysis Mapping

Historical Overview

The following chart is a brief outline of the history of crime mapping (taken from Weisburd and McEwen, 1997; and Harries, 1999). Mapping itself has a long history, but crime mapping specifically can be traced back to the early 1800s when social theorists began to create maps to illustrate their theories and research about crime. In relation to crime and policing, maps initially were used to examine issues like poverty or demographic characteristics and crime. One of the first police departments to use mapping was New York City in the 1900s. The maps consisted of simple wall maps in which “push pins” were used to indicate crimes that had occurred. During the 1920s and 1930s, sociologists at the University of Chicago used mapping to examine crime and delinquency, specifically juvenile delinquency and related social characteristics. In the 1960s and 1970s, the first computer-generated maps of crime were created. (See Weisburd and McEwen, 1997 for more information).

Early 1800s: Social Theorists: Single symbol point and graduated area maps

1900s: New York City Police Department and others: Single symbol point maps, “pin maps”

1920s-30s: Urban sociologists at the University of Chicago: Graduated area maps of crime and delinquency

1960s-70s: First computer generated maps of crime

1980s: Desktop computers available for mapping, but with limited quality; Environmental Criminology theory

1990s: Desktop GIS and integration with law enforcement systems and data; government funding, etc.

In the 1980s, more advanced technology and desktop computers became available, and more widely used. However, the quality of computerized mapping at that time was limited because of slow processing speeds and poor printing quality. At the same time, environmental criminology theory began to emerge, and academics began to examine the spatial characteristics of crime as well as how location characteristics might contribute to criminal activity at particular locations over others. In the 1990s, desktop geographic information systems (GIS) became widely available, and in the late 1990s, they began to be generally used by law enforcement agencies and criminologists.

Most recently in the late 1990s, Federal programs such as the Crime Mapping Research Center (National Institute of Justice) and the Crime Mapping and Analysis Program (National Institute of Justice, National Law Enforcement and Corrections Technology Center) were established. As part of its $1 billion Making Officer Redeployment Effective (MORE) program, from fiscal years1995-1998 and in fiscal year 2001, the COPS Office provided funds to law enforcement agencies to acquire crime mapping software and hardware. As with all MORE funded technology, the purpose of this software and hardware was to enhance community policing activities through timesavings and increased officer effectiveness. Since 1995, the Police Foundation's Crime Mapping Laboratory has been funded by COPS to assist police agencies in incorporating crime mapping into their practices. In addition, universities and colleges have begun to offer undergraduate and graduate courses in crime analysis and crime mapping.

Types of Mapping

Manual Pin Mapping

Wall maps have long been a simple and useful way to depict crime incidents or hot spots. Many police departments still have large maps tacked to the wall of the briefing room with the most recent crimes represented by pins. Although useful, manual wall maps, offer limited utility because they are difficult to keep updated, keep accurate, make easy to read, and can only display a limited amount of data. For example, although different colored pins could be used to represent different types of crime, date and time of incidents, the nature of incidents, and other information cannot be displayed easily. In order to update a manual wall map, for example, the pins must be removed each month. Unless a photo or some other mechanism is used to record the previous month's map, the information illustrated on the map is lost. Thus, comparison is difficult, if not impossible, from one month to the next. Finally, the maps become unreadable when they display large amounts of data because of the numerous pins and/or holes.

Computer Mapping

The following is an example of a computer map. It has been taken from MapQuest©, an Internet mapping program, where an address is entered and a map of the surrounding area appears with a pin to locate the address.

Even though it is possible to zoom in and out of this type of map, the geographic features (e.g., locations, streets, parks) are static and cosmetic only. In essence, a computer map is similar to a wall map, in that the computer is used to place a point at a specific location just as a person would put a pin on a wall map. Thus, computer maps have limitations similar to wall maps. For instance, when using MapQuest© to map an address, clicking on a point will not provide information behind that point, such as the specific address. While visually appealing and easy to use, computer mapping does not allow any more effective analysis than manual pin mapping.

Geographic Information System (GIS)

> *A geographic information system (GIS) is a set of computer-based tools that allow a person to modify, visualize, query, and analyze geographic and tabular data.*

A GIS is a powerful software tool that allows the user to create anything from a simple point map to a three-dimensional visualization of spatial or temporal data. A GIS is different from manual pin maps and computer maps in that it allows the analyst to view data behind the geographic features, combine various features, manipulate the data and maps, and perform statistical functions. There are many different types of GIS programs, which include desktop packages (e.g., ArcView®, MapInfo®, GeoMedia®, Atlas GIS®, Maptitude®) as well as professional software (e.g., ArcInfo® and Intergraph®).

Crime Analysis Mapping

"Crime mapping" is a term that has been used for the past few years to refer to research analysis using GIS in a law enforcement setting. In this report, the term crime analysis mapping is used to describe this process because using a GIS to analyze crime is not just the act of placing incidents on a map but also of analysis. Consequently, "crime analysis mapping" is:

> *The process of using a geographic information system in combination with crime analysis techniques to focus on the spatial context of criminal and other law enforcement activity.*

GIS Components

The following is a description of the major components of a GIS, which include data representation, data features, visualization, scale, and querying.

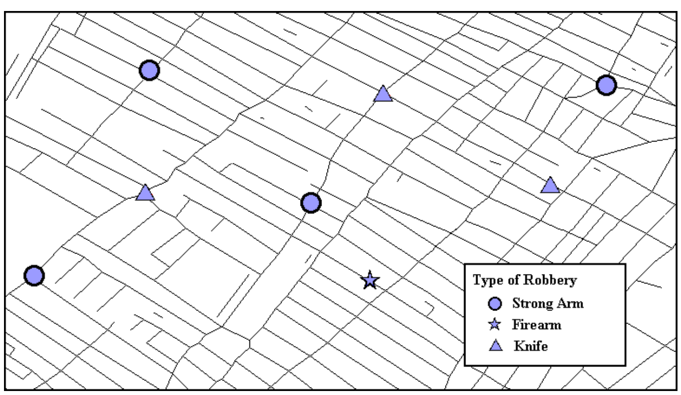
Data representation

Real world data are represented by one of four features in a GIS. They include point, line, polygon, and image features.

Point feature

> *A point feature is a discrete location that is usually depicted by a symbol or label.*

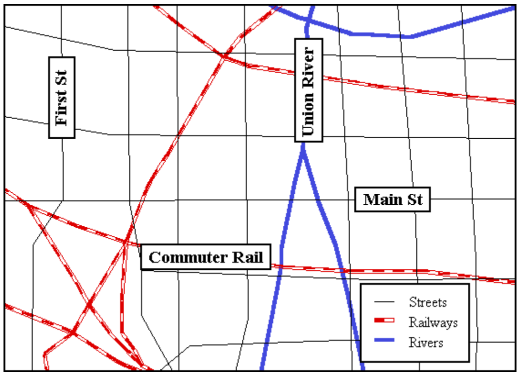
A point feature in the geographic information system is analogous to a pin placed on a paper wall map. Different symbols are used to depict the location of crimes, motor vehicle accidents, traffic signs, buildings, beat stations, and cell phone towers. The following map shows a robbery point map.



Line feature

A line feature is a geographic feature that can be represented by a line or set of lines.

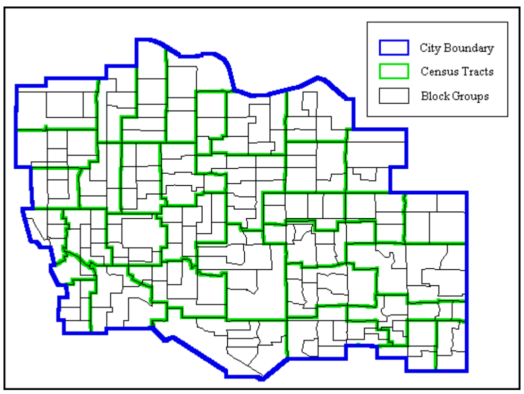
The following map shows how different types of geographic features such as railways, streets, and rivers can be represented by a line in a GIS. Additional examples are streams, streets, power lines, bus routes, student pathways, and lines depicting the distance from a stolen to a recovered vehicle.



Polygon feature

A polygon feature is a multisided figure represented by a closed set of lines.

In the following map, the largest blue polygon represents the city boundary, the green are census tracks, and the black are census block groups.   Other examples of polygon features used in law enforcement would be patrol areas, beats, neighborhoods, or jurisdictions.   Polygon features can represent areas as large as continents and as small as buildings.



<u>*Image feature*</u>

> *An image feature is a vertical photo taken from a satellite or a plane that is digitized and placed within the geographic information system coordinate system so that there are -x and -y coordinates associated with it.*

The following image is an example of an aerial photograph. Note that details of the streets, buildings, and environmental features such as landscaping are visible.

There is a distinction between aerial photography (just the image) and digital orthophotography (the image combined with geometric qualities of the map). Because orthophotographs are located within the geographic information system, they can be viewed with other layers such as street or parcel information. The following image depicts a digital orthophotograph with the corresponding street network and parcel boundaries.

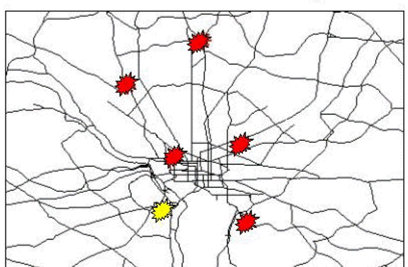
Data of geographic features

Each type of feature has “attributes” or a table of data that describe it. All the attributes for three of the four types of features (point, line, and polygon) are stored in a GIS as a data table (Note that a digital orthophotograph has an –x and –y coordinate but does not have an associated data table worthy of analysis). The ability to view, query, relate, and manipulate data behind these features is the true power of a GIS. A manual pin map and a computer map depict points, lines, and polygons but do not have data associated with the features and are not easily manipulated. In a GIS, simply clicking on a point, line, or polygon can produce the data table associated with that particular feature.

<u>Point data</u>

The following is an example of point data taken from a GIS. The highlighted point has a corresponding data table, which describes the features. For instance, the yellow point is a robbery that occurred at 6:52 pm on January 1st, 1999. In this case, each line of data describes a different point on the map and each variable describes something about that point.

Point Data Example

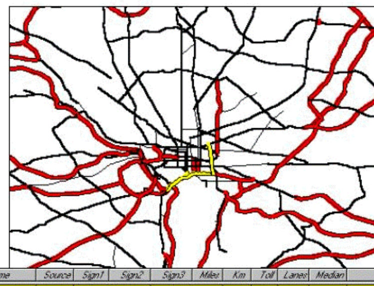


Report Date	Date of Occurence	IBR code	Type of Crime	Hour of Occurence	Beat
19990103	19990103	0300	ROBBERY	1852	220
19990104	19990104	0300	ROBBERY	0056	430
19990114	19990114	0300	ROBBERY	1238	330
19990118	19990118	0300	ROBBERY	2103	340
19990119	19990119	0300	ROBBERY	2054	240
19990120	19990120	0300	ROBBERY	2326	220

Line data

The following is an example of line data. The table describes the street segments (e.g., the miles, the length of that street segment, and the name of the street). The yellow street segment corresponds to the case highlighted in yellow in the data table. The GIS knows which line corresponds to each case in the table.

Line Data Example

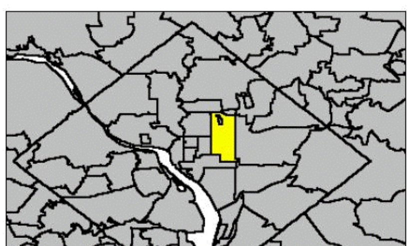


Shape	Name	Source	Sign1	Sign2	Sign3	Miles	Km	Toll	Lanes	Median	Class
PolyLine	14TH ST	D	U1			0.37	0.60	0	4	1	Urban Principal Arterial
PolyLine	14TH ST	D	U1			0.59	0.96	0	4	2	Urban Principal Arterial
PolyLine	14TH ST	D				0.94	1.52	0	4	2	Urban Principal Arterial
PolyLine	15TH ST	D				0.85	1.37	0	1	2	Urban Principal Arterial
PolyLine	16TH ST	D				6.21	9.99	0	4	2	Urban Principal Arterial
PolyLine	17TH ST	D				0.33	0.53	0	2	2	Urban Principal Arterial
PolyLine	17TH ST	D				0.73	1.18	0	4	2	Urban Principal Arterial
PolyLine	23RD ST	D				0.85	1.37	0	1	2	Urban Principal Arterial

Polygon data

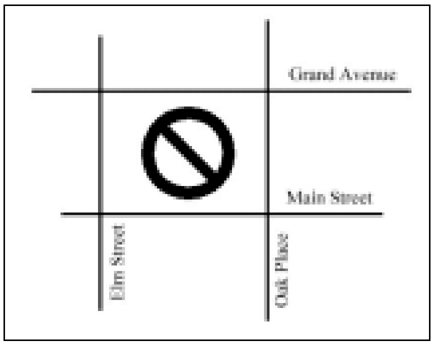
The following image displays the data describing polygons, which are zip codes. The yellow polygon is zip code 20001 in Washington DC with an area of 2.22 square miles and a population of 30,050 in 1990 as is seen in the data table.

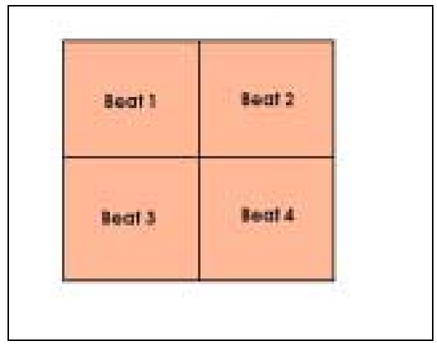
Polygon Data Example



Shape	Area	Zip	Po_name	State	Sumblkpop	Pop1999
Polygon	2.22	20001	Washington	DC	34565	30050
Polygon	5.33	20002	Washington	DC	56756	48412
Polygon	2.58	20003	Washington	DC	24818	21808
Polygon	1.57	20004	Washington	DC	26	36
Polygon	0.53	20005	Washington	DC	9862	8687
Polygon	0.33	20006	Washington	DC	2836	2164
Polygon	3.15	20007	Washington	DC	23233	19535
Polygon	3.26	20008	Washington	DC	26670	22076

Note that the lines themselves only make up the borders of the polygons, rather than being distinct lines with associated data. For example, the image, below left, depicts four intersecting line features that create a square. Each line has associated data; however, the area within the square or polygon that they have formed has no meaning. The image, below right, depicts similar lines; however, these lines are the borders for four separate beats and thus, the lines do not have meaning by themselves, only in relation to the other lines and in the fact that they create a shape.





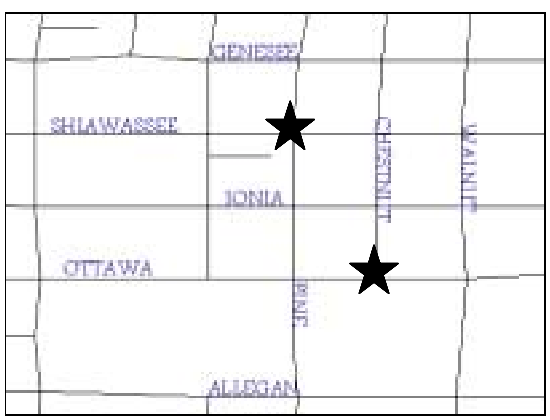
GIS toolbox

The primary advantage of a GIS is its functionality that allows geographic data to be manipulated. The following are some components that enable data to be manipulated.

<u>Connectivity</u>

> *Connectivity refers to streets and other linear features that are represented by segments that connect at intersections.*

As noted above, data are associated with each line feature. However, each segment connects at an intersection, and connectivity is the ability of the GIS to recognize that the two line segments come together to form an intersection.



Thus, connectivity allows intersections such as Shiawassee and Pine or Chestnut and Ottawa to be located on the map, which is particularly important in law enforcement data since accident information (reports and calls for service) usually list an intersection as the location of an accident.

Contiguity

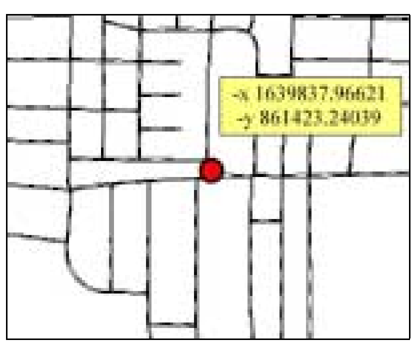
> *Contiguity refers to adjacent areas that are represented by adjacent polygons.*

The following map shows how a GIS includes adjacent polygons representing parcels and buildings. The ability of the GIS to recognize adjacent polygons allows for querying, selection of polygons within others, and visualization of complex land units.

Geometry

> *Geometry refers to the fact that all features in the geographic information system have at least one set of –x and –y coordinates.*

In the example depicted below, the point on the map has a distinct –x and –y coordinate which is listed in the yellow box.



Although these numbers may not make sense at first glance, they are an integral part of the GIS reference system, as every feature in a GIS has at least one –x and –y coordinate. For a point, the –x and –y feature is the center of the point. For a line segment or a polygon, the –x and –y coordinate is at the center of that particular line segment or polygon. Having an –x and –y coordinate for map features, especially points, is important because the location is more precise and there is no need for geocoding (see the explanation of geocoding later in the report).

Visual display/mapping

<u>Thematic approach</u>

> *In a geographic information system, the data are separated by type of feature into what are called "layers" or "themes" as well as by type of data.*

For example, point data of crime and calls for service would not be contained in the same layer or theme because these data come from two different sources. This is a thematic approach to organizing data. This component allows the data to be analyzed and visualized separately or together. Thus, when more than one layer is viewed in the GIS, they are stacked, similar to a stack of pancakes. In the following figure, each layer represents a different type of feature (point, line, polygon, or image) and a different type of data (shopping centers, bus routes, roads, and census tracts).

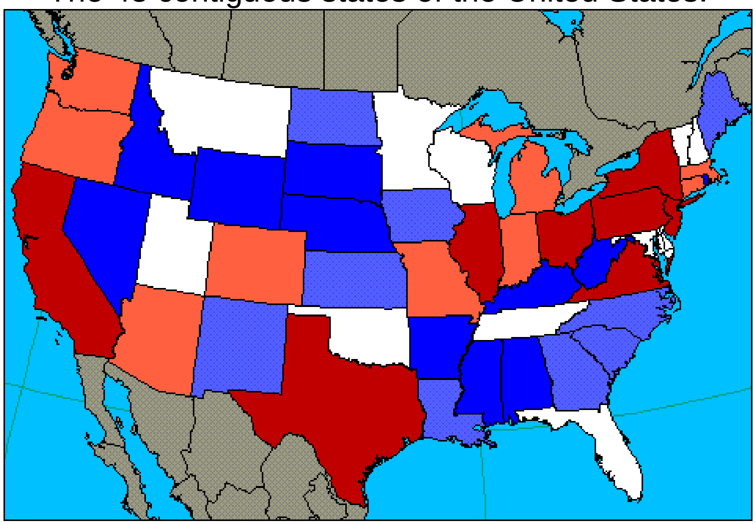
In a GIS, how the layers are stacked is important since some layers are opaque and hide others. For example, orthophotographs are opaque and if placed on top will cover any layers underneath.

Scale

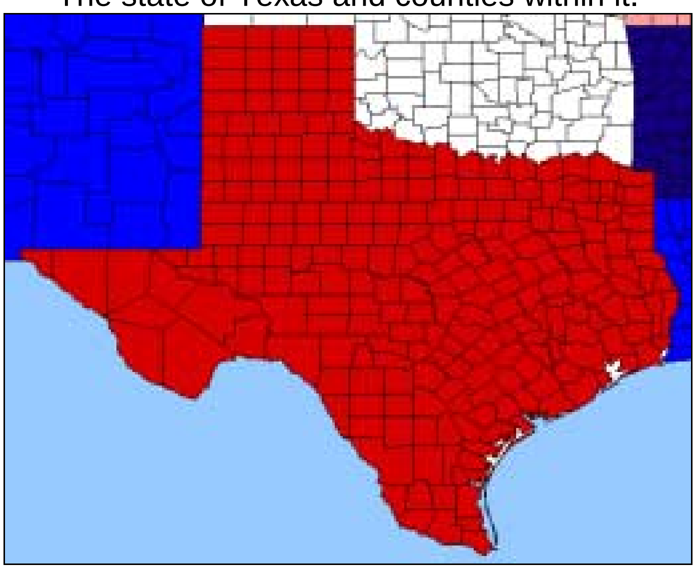
> *Scale is the relationship between the dimensions of the map and the dimensions of the Earth.*

Usually, the scale depends on the purpose of the analysis or map. The following are examples of maps at various scales.

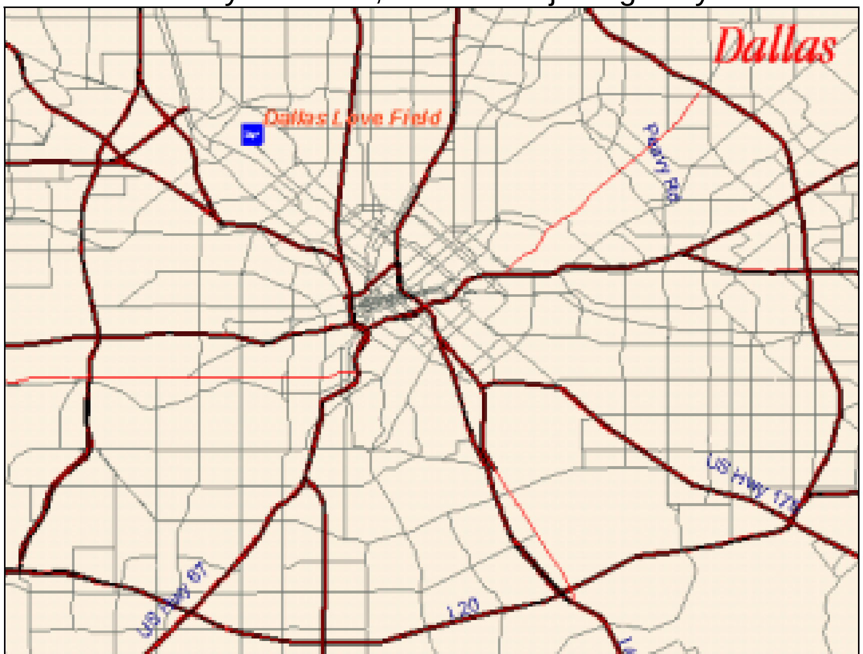
The 48 contiguous states of the United States.



The state of Texas and counties within it.

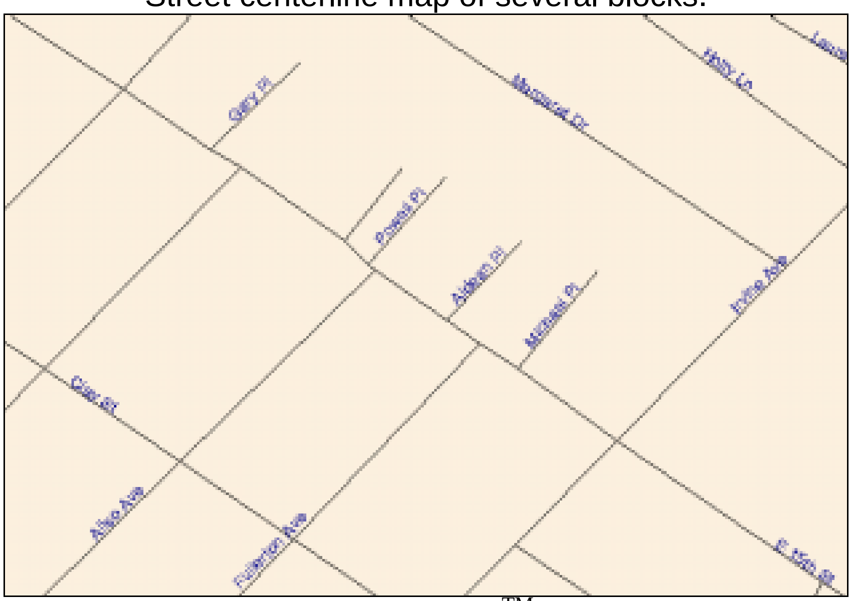


The city of Dallas, TX and major highways.



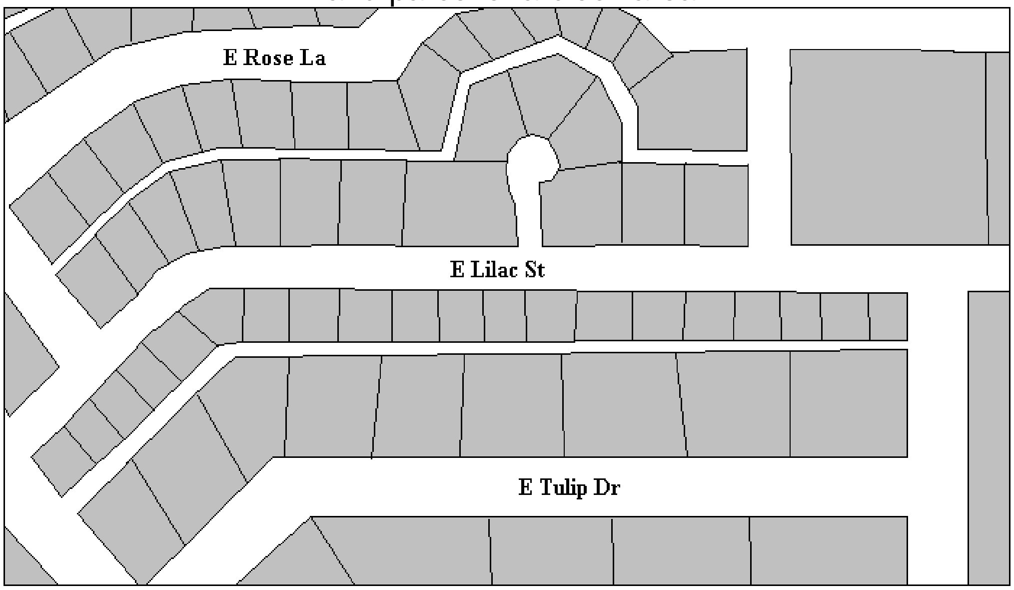
Taken from ArcView® StreetMap™ 1.1 for Windows®.

Street centerline map of several blocks.



Taken from ArcView® StreetMap™ 1.1 for Windows®.

Land parcel of a block area.



Parcel map with buildings.

Orthophotograph of a neighborhood.

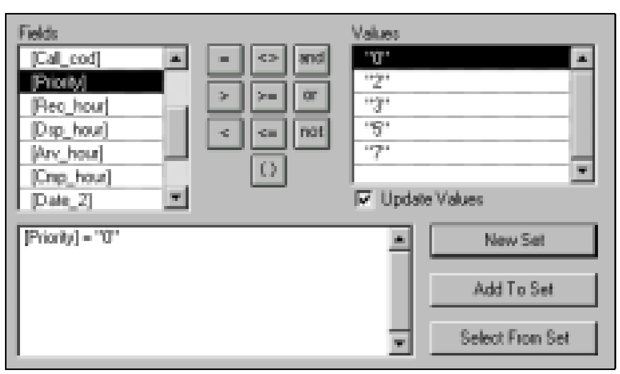
The appropriate scale depends on both the purpose of the map and the type of data that are displayed. For example, it would be impossible to view orthophotographs like the one above for the entire United States at one time. The GIS allows the user to set the scale at which orthophotographs are viewed (e.g., ½ mile or 1 mile). That way, the orthophotographs only become activated when the map is at that scale.

Querying GIS data

Geographic information systems contain the ability to query or select data in various ways.

Tabular queries

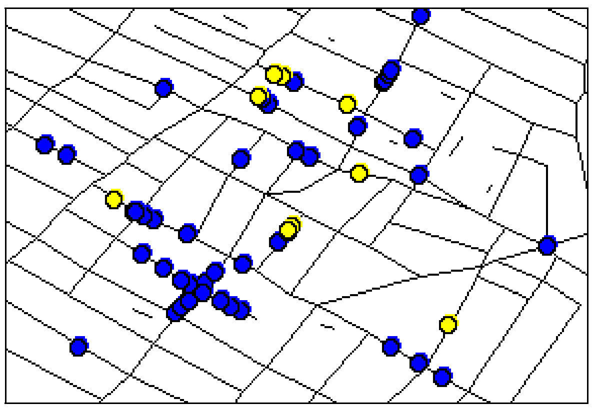
In a GIS software program, query expressions can be created to select features both in the data and on the map. For instance, one can construct a query to select emergency calls for service (priority 0) from tabular calls for service data.



After running this query, the priority 0 calls are selected (highlighted yellow) in the table.

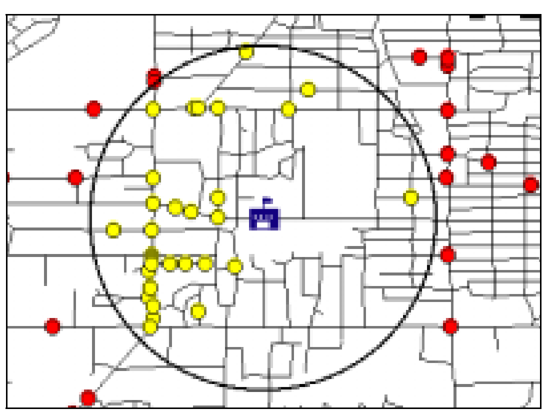
Event_no	Str_name	Str_apt	Date	Distric	Grid	Call_cod	Priority
00203108	9 HECKMAN DR		960628	S	1133	G1300	0
00231068	9 SHERMAN AVE		960720	N	4402	G1300	0
00239616	253 STEGMAN ST		960727	S	1127	G1300	5
00203160	238 CARBON ST		960628	E	3523	G1300	0
00240989	348 WOODWARD ST		960728		3528	G1300	5
00247027	127 RANDOLPH AVE		960802	S	1614	G13	7

Additionally, the priority 0 calls are selected (highlighted yellow) on the map.

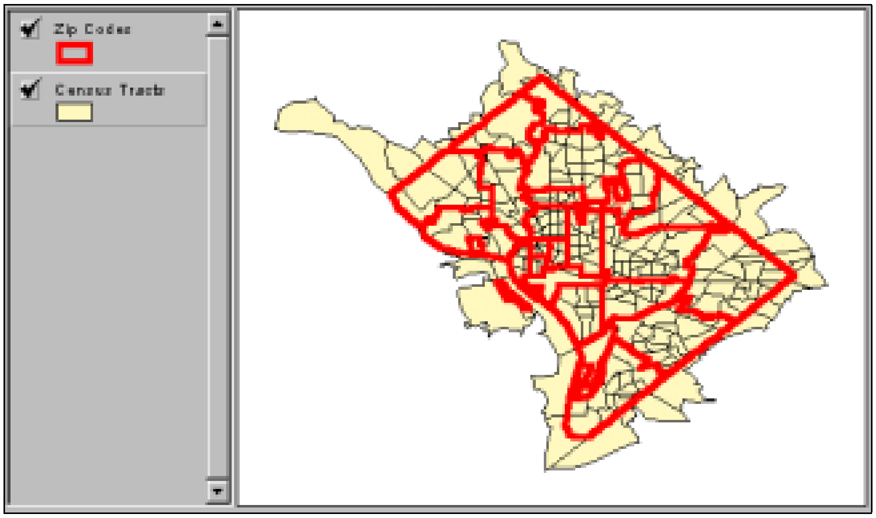


Spatial queries

Spatial queries enable map features to be queried based on their location on the map or their location relative to other features. A very simple example is drawing a one-mile buffer around a school to select the crimes that have occurred within a mile of the school.



In addition, one can select a feature of a map based on its relationship to another feature. The following is an example of selecting zip codes (in yellow) that border any census tract in Washington D.C.



IV. Introduction to Problem Solving

The following is a brief discussion of problem solving. The source of the problem solving and SARA definitions as well as the location of extensive literature on problem solving is the Office of Community Oriented Policing Services (COPS) Web site at www.usdoj.gov/cops/cp_resources/pubs_prod/s5.htm.

Definition of Problem Solving

A methodical process for reducing the impact of crime and disorder problems in a community. The problem solving approach is an integral component of the philosophy of community policing.

SARA Approach to Problem Solving

The SARA approach to problem solving is described as scanning (S), analysis (A), response (R), and assessment (A). That is, once a problem is identified and its characteristics are analyzed, a response is developed and deployed to combat the problem, and after a determined time period, the response is evaluated. The following is a brief discussion of each aspect of the SARA process.

Scanning

Scanning is the first step to problem solving and is the identification of a cluster of similar, related, or recurring incidents through a preliminary review of information, and the selection of this crime/disorder problem among competing priorities for future examination.

One example of using crime analysis information to scan for crime problems is comparison of crime on a monthly basis. Comparison of specific areas over time may indicate a problem area or type of crime. Another example is examining housebreaks over a six-month period to identify small patterns of activity, which could represent a larger housebreak problem.

Analysis

Analysis is the use of several sources of information to determine why a problem is occurring, who is responsible, who is affected, where the problem is located, when it occurs, and what form the problem takes.

Often, individuals think they already know the nature and cause of problems identified in the scanning phase; thus, they do not conduct intensive analysis of the problem. However, analysis of the problem from several perspectives with several types of data often yields information not previously known. For example, while discussing the auto theft problem, detectives in a jurisdiction in the Southwest US insisted that the auto theft problem centered on cars being taken to Mexico. Yet, when the data were analyzed, it was discovered that nearly 85% of the vehicles were being recovered in or near the jurisdiction. The detectives did not have a good sense of the problem because they only saw a select few of the auto theft and recovery reports.

Response

> *Response is the execution of a tailored set of actions that address the most important findings of the analysis phase.*

A recent report by Mike Scott, entitled *Problem-Oriented Policing: Reflections on the First 20 Years*, offers an evaluation of the last twenty years of problem solving and problem oriented policing and found that police departments are getting very good at responding creatively to the types of problems that they identify (Scott, 2000). Police departments are now working with communities and developing partnerships on a regular basis. Some examples of responses that have been used are working with city engineers to redesign a park that had a high number of assaults, vandalism, and drug dealing incidents (Mankato, MN); convening an advisory board composed of law enforcement, residents, business owners, and charities to address traffic and safety concerns at day-laborer gathering points (Glendale, CA); and establishing a juvenile diversion program whereby police bring together adolescent taggers and the owners of the property they deface to agree on terms for restitution and community service (Santa Ana, CA) (Sampson and Scott, 2000).

Assessment

> *Assessment is the measurement of the impact(s) of the responses on the targeted crime/disorder problem using information collected from multiple sources, both before and after the responses have been implemented.*

For law enforcement agencies, assessment is probably the most challenging part of the SARA process, not only because measures of effectiveness are often difficult to determine and capture, but also because assessment takes time and effort to complete at a time when the problem solving process is winding down. For example, measuring a response such as a crime prevention education campaign is difficult because there may be substantial lag time between intervention and measurable effects of the response.

Crime Analysis and Problem Solving

Crime analysis and mapping play a major role in all phases of the problem solving process. It is important to measure the problem accurately during the scanning, analysis and the assessment phases. Analysts can also assist in the response phase of the SARA process by informing the effective allocation of resources by determining the times when, and areas where the offenses are most frequently or disproportionately occurring. The role of crime analysis in problem solving lies in the fact that members of a law enforcement agency have different experiences and understandings of a problem, and it is necessary for the crime analyst to either support or refute these assumptions by providing a comprehensive analysis of a problem and an evaluation of process and response impact.

V. Data and Geocoding

Types of Data

Data collection and dissemination is a cyclical and on-going process. The term "database" can refer to anything from entire records management systems to simple spreadsheets containing a few variables and a handful of cases. Databases are vital for conducting crime analysis and mapping. It is essential to identify the actual and potential data sources within an agency that can be used for analysis. Below is a description of two distinct categories in which law enforcement information falls.

Tabular Data

> *A list of records contained in a table that, along with information about the record, contain addresses or some other type of geographic variable.*

The unit of analysis in tabular data can be anything that is not inherently geographic. Law enforcement examples of tabular data include crime, calls for service, accidents, field information, sex offender information, and arrests.

Geographic Data

> *Data that are inherently geographic; that is, they describe geographic features.*

The unit of analysis in geographic data is a geographic feature. Examples of quantitative geographic data sources include streets, districts, jurisdictions, census tracks, and bus stop/route data. Law enforcement examples of qualitative geographic data include neighborhood boundaries and pathways children take to and from school. Even though all geographic data have associated attributes (tabular data), the tabular data do not make much sense outside of a GIS. The following table contains the attributes of a geographic street file. Variables such as the length of the street in feet, prefix, street name, suffix, and number of lanes describe each street segment on the map.

Length	Pre	Name	Type	Lanes
373.68484	E	THIRTIETH	ST	2
65.24045	E	FOURTH	ST	2
430.24857	E	THIRD	ST	3
134.70268	E	SECOND	ST	2
309.69322	E	FIFTH	ST	3
234.76184	E	FIRST	ST	4
202.07008	E	TWENTY-EIGHTH	ST	4
240.78427	E	TWELFTH	ST	2
376.39829	E	TWENTY-SEVENTH	ST	2

General Data Integrity Issues

There are various data integrity issues associated with tabular and geographic law enforcement data. This section is not meant to serve as a comprehensive description of the data integrity issues in law enforcement but instead gives a general overview of the major issues.

Data Entry

In a law enforcement setting, oftentimes the individuals, officers, dispatchers and records clerks, who are conducting data entry, do not realize that others are using the data they produce. This lack of awareness can lead to carelessness and result in unreliable data. Data entry errors can be improved by technology (address cleaning software), proper training, and making individuals aware of the uses and importance of the data.

Timeliness

A primary concern in crime analysis, especially in tactical crime analysis, is that data obtained are current and available in a timely manner. Unfortunately, because of human error and technological difficulties, this is not always possible. One method to remedy this problem is to stress the need for and the value of current data for crime analysis. This need should be communicated throughout the department in order to come up with solutions for improving data timeliness.

Data Validity

Validity refers to whether data accurately reflect the concept that they are intended to measure. Although true validity is difficult to measure, law enforcement data, like any other data, are prone to validity issues. For example, many police departments use calls for service information as a proxy for crime. This is problematic, because not all calls that are originally dispatched as a crime are in fact crimes. The best example is a robbery call for service, since there is a common confusion about the difference between a robbery and a burglary. A citizen who has been burglarized may call 911 to report, “they’ve been robbed” when in fact they were not. If the dispatcher enters what the citizen reports and the title of the call is not changed when the actual crime is determined (a common problem), the call for service would not accurately represent the crime that occurred. Even if the call title and crime match, using calls as a proxy for crime is problematic as the date and time variable would indicate when the call was received by the police department, not when the crime actually occurred. Analysis of these variables would yield invalid results in that they would indicate when the citizen called the police and not when the crime actually occurred.

Reliability

Reliability refers to the whether data are measured the same in repeated observations. An example of a reliability issue related to law enforcement data is when there is a policy or law change (e.g., mandatory arrest for domestic violence offenses). Frequently, there will be a sharp increase or decrease that indicates that the data no longer represent the same phenomenon and thus, the numbers are not reliable. Obviously, reliability issues can significantly affect crime analysis results.

Data Transfer Process

The data transfer process can affect data quality and integrity in that data can be inadvertently or unavoidably lost or reformatted. An issue associated with the data transfer process is data compatibility. Police departments are notorious for having data in many different formats, and converting and combining these data is often a time-consuming and frustrating process.

Data Confidentiality/Privacy

Crime analysts are managers of law enforcement data; therefore, crime analysts are responsible for protecting the information and individuals represented within the data. Normally, the data used and created in crime analysis adheres to a jurisdiction's policies on privacy and confidentiality. New situations of providing information have surfaced which require additional and more detailed policies such as the invention of the Internet and the use of mapping. Thus, police departments should include specific crime analysis concerns into their data-protection plan.

On a related issue, the crime analysis unit, itself, should have a written data and analysis request policy that addresses common issues surrounding requests for crime analysis information. A policy, supported by the agency's administration, can provide guidelines for requesting information and expectations of what will and will not be provided. A recent document published by the National Institute of Justice provides a discussion and suggestions specifically for mapping and data confidentiality, see www.ojp.usdoj.gov/cmrc/pubs/welcome.html to download or order a copy of the publication entitled, *Privacy and the Information Age* (Wartell and McEwen, 2001).

Data Management

Metadata

Metadata refers to the data that describes the analyst's work.

Metadata are the data that describe data. Every police department has its own set of procedures that outlines how crime analysis is conducted. Frequently, these procedures are kept only in the analysts' memories, and it is important to have them written down for a variety of reasons. They include consistent data handling and cleaning procedures, guidelines for sharing work with others, keeping track of products and files created, and reducing duplication of effort. These written procedures are also invaluable training tools for new analysts. Some examples of categories of metadata include:

- Location of data files (e.g., on network, mainframe, personal computer)
- Source of the data (e.g., Records Management System, Investigation Bureau)
- Data cleaning procedures
- Geocoding procedures
- Report and map formats
- Methodology for regular reports and studies (e.g., monthly crime report, annual staffing analysis)

Geocoding

The following discussion of geocoding is taken directly from another document produced by the Police Foundation's Crime Mapping Laboratory as a part of the work conducted for COPS. The report is entitled, *Geocoding in Law Enforcement* (2000) and can be found on both the Police Foundation (www.policefoundation.org) and COPS (www.cops.usdoj.gov) Web sites.

Introduction

Geocoding is the process of bringing tabular and geographic data together based on a common geographic unit of analysis. A geographic unit of analysis refers to a spatial characteristic within the data that is necessary to locate it on a map such as address, zip code, beat, or grid. Tabular data are contained in a table and are a list of records that, along with information about the record, contain addresses or some other type of geographic variable. Examples of law enforcement tabular data are calls for service, crime, accidents, citations, sex offenders, and arrests. Along with information about nature of the incident (e.g., type of call or crime, date, time), these data contain the location of the incident (e.g., address, grid, and/or beat), which will allow it to be geocoded. Geographic data are data that can be displayed on a map such as streets, census tracts, parcels, and buildings. Examples of geographic data specific to law enforcement are police districts, beats, or grid boundaries.

The purpose of geocoding is to assign tabular data to a location on the earth's surface to visualize the spatial characteristics of the data. It is analogous to placing a pin on a map in the appropriate location. Unlike the paper map, when geocoding in a geographic information system, data associated with the pin, or data point, are available. In order to geocode either electronically or manually, there must be a common geographic unit of analysis. In law enforcement, address is primarily used as the geographic unit of analysis to which tabular data are geocoded. However, other types of geographic units are also used such as parcels, zip codes, census tracts, census blocks, or beats. In the case of geocoding, geographic data used for geocoding are called "reference data" since the geographic data are used to reference the tabular data.

The following is a discussion of the geocoding process, regardless of the geographic information system (GIS) software used, and some common problems faced when geocoding law enforcement data.

The geocoding process

In general, there are five basic steps in the geocoding process. They are:

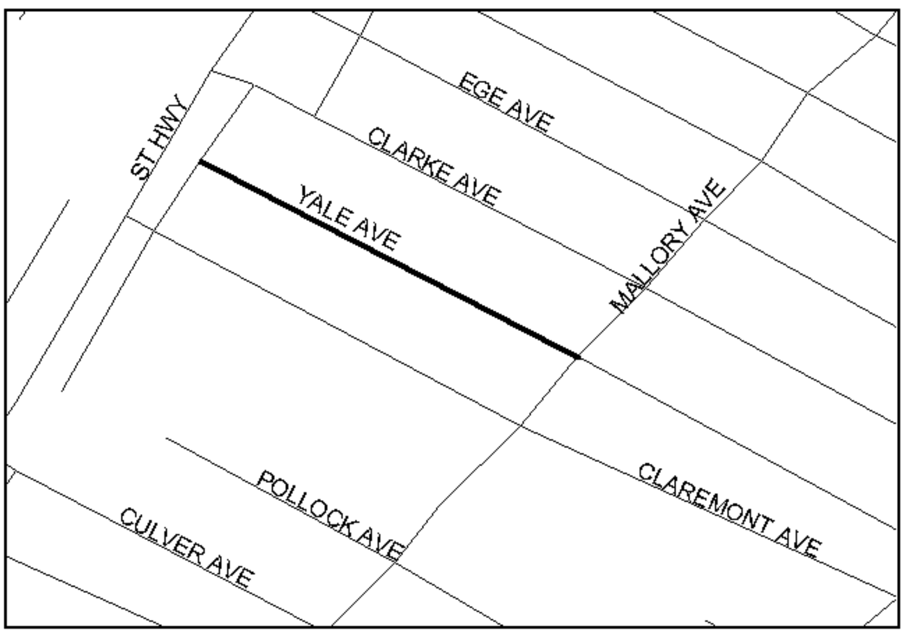
1. Prepare the geographic and tabular files for geocoding.
2. Specify the geocoding parameters.
3. Geocode.
4. Review results.
5. If necessary, respecify parameters and geocode again.

Step 1: Prepare the geographic and tabular files for geocoding

The first step is preparing the tabular and geographic files, which is the most important and can be the most time consuming of the five steps.

Tabular data. Tabular data used in law enforcement primarily consist of calls for service, crime, arrests, and accident data. Other types of tabular law enforcement data can include field information, sex registrant information, or intelligence information. In the past, much of this information was not captured electronically. However, currently, many departments either already have in place or plan to acquire an automated computer aided dispatch (CAD) system and a records management system (RMS) which have the capacity to store digital information as well as standardized tables of addresses and location names. The most important aspects of these systems as they relate to geocoding are that they reduce the need for manual data entry and provide clear and consistent rules in order to ensure that data are reliable and valid. Because individuals are the data entry mechanism, there is still the possibility of human error and inconsistencies, which is why training should coincide with the technology.

Geographic data. A variety of geographic data types may be used as a reference layer, though street files such as the Census Bureau's TIGER/Line ® files are the most commonly used. Street files are often called centerline files in that they depict the center of the streets by line segments. Details of curbs, alleys, or cul de sacs are not depicted in centerline files. In this context, street files are geographic databases containing records that describe interconnected street segments. More specifically, each street is broken down into sections with address ranges associated with them. These sections usually span between cross streets. The following map is an example of a street centerline file and the darkened line is one street segment. The table below is the data describing the streets.



Street	Fromleft	Toleft	Fromright	Toright
YORK ST	473	479	478	480
YALE AVE	83	173	84	174
YALE AVE	1	81	2	82
WRIGHT AVE	1	91	2	96
WOODWARD ST	283	395	304	380

Street centerline databases generally have fields that describe the physical address along each street segment in the layer. Conventionally, addresses are recorded as 'from' and 'to' ranges for both the left and right sides of each street segment. In the above example, the centerline street segment of Yale Ave that is thicker than the others is represented by the address ranges of 83 to 173 on one side of the street and 84 to 174 on the other side, as highlighted in the table.

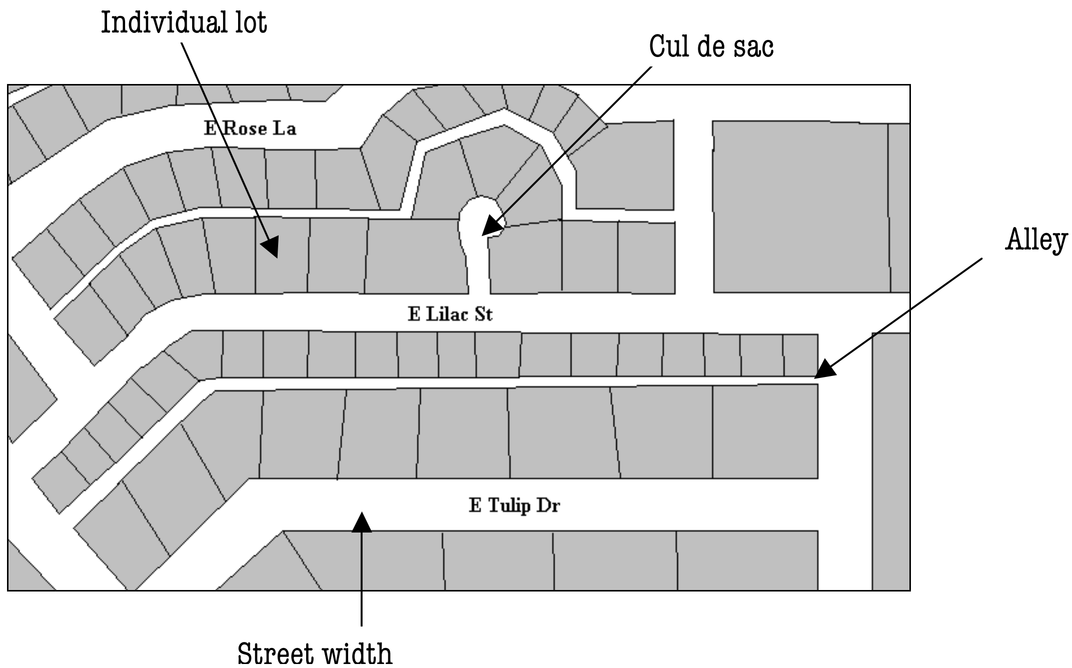
In addition to address ranges, street segments can be depicted by several variables such as street name, type, prefix, and suffix, as noted earlier. Street centerline databases vary in how the addresses are described. In the previous example, address is depicted with a variable called "street" along with the address ranges. The following are tables with highlighted examples of two additional ways in which addresses are found in a geographic database. The prefix and suffix fields are used to store information such as quadrant. The first table highlights a street segment with the prefix W for West Northern Ave. The second table highlights a street segment with the suffix NW for Chesterfield Place Northwest. Type refers to the type of roadway (e.g., street, road, lane, and drive). The highlighted examples in the following tables show Ave for Northern Avenue and Pl for Chesterfield Place.

Shape	L_f_add	L_t_add	R_f_add	R_t_add	Prefix	Name	Type	Suffix
PolyLine	4901	5099	4900	5098	W	Vista	Ave	
PolyLine	5051	5099	5050	5098	W	Kaler	Cir	
PolyLine	5947	5999	6000	6098	W	Northern	Ave	
PolyLine	5401	5499	5400	5498	W	Orangewood	Ave	
PolyLine	5301	5399	5300	5398	W	Orangewood	Ave	
PolyLine	7451	7301	7452	7300	N	51st	Ave	
PolyLine	7499	7453	7498	7454	N	51st	Ave	
PolyLine	7515	7501	7516	7500	N	51st	Ave	
PolyLine	7605	7517	7604	7518	N	51st	Ave	
PolyLine	7647	7607	7648	7606	N	51st	Ave	

Shape	L_f_add	L_t_add	R_f_add	R_t_add	Prefix	Name	Type	Suffix
PolyLine	2799	2701	2798	2700		Albemarle	St	NW
PolyLine	3099	2901	3098	2950		Audubon	Ter	NW
PolyLine	2699	2601	2698	2600		Tilden	Pl	NW
PolyLine	2899	2801	2898	2800		Chesterfield	Pl	NW
PolyLine	2899	2801	2898	2800		Allendale	Pl	NW
PolyLine	4201	4249	4200	4298		Lenore	Ln	NW
PolyLine	4799	4601	4798	4600		Broad Branch	Rd	NW
PolyLine	4499	4423	4498	4400		Broad Branch	Rd	NW
PolyLine	4421	4401	0	0		Broad Branch	Rd	NW
PolyLine	4599	4583	4598	4546		Broad Branch	Rd	NW

Because the Census Bureau's mission to count and profile the nation's people and institutions does not require a high level of positional accuracy in its geographic products, its TIGER/Line ® files and centerline maps are designed to show only the relative position of geographic elements.

As previously mentioned, another common layer used as a reference for geocoding is the parcel file. A parcel file is a polygon layer used to keep track of lots, subdivisions, and ownership information primarily for planning and tax purposes. The following is an example of how a parcel map looks in a GIS. Note that it is more specific than a centerline map in that alleys, cul de sacs, lot size, and street widths are discernable.



Parcel files provide a good base layer to examine relationships between land use, zoning, demographic data, and economic data as all of this information is contained in parcel files. Also, parcel reference layers can be very helpful in mapping law enforcement information because they can help to indicate the exact location of an incident (e.g., corner lot), and provide ownership information, which may prove valuable as in the case of rental property.

While parcel files have the ability to be highly accurate, like street files, accuracy is largely dependent on how often and how well the files are maintained. Because of the nature of real estate and other planning mechanisms, keeping parcel files updated and accurate can be a full-time job for several technicians depending on the area.

Successful geocoding depends not only on the quality of the geographic reference layer, but also the tabular data to be mapped. For any crime mapping application to be effective, basic reporting procedures need to be uniform and consistent. While most high-end geocoding software packages incorporate complicated algorithms making them somewhat forgiving, a well established reporting procedure is often the best way to ensure a high rate of accuracy.

Step 2: Specify geocoding parameters

Step two consists of specifying the parameters of both the reference data and the tabular data to determine how the geographic units from each source will be matched successfully.

Selection of which reference layer would be most effectively used for geocoding must consider the needs of the individual end user. Considerations of accuracy, cost of product, maintenance costs, utility, current reporting procedures, and compatibility with other existing reference layers must be dealt with on a case-by-case basis. In the case of law enforcement, most information is geocoded to the street reference layer. However, sometimes it is necessary to be more specific, in which case a parcel reference layer may be used. For example, one might use the street centerline file to pin map residential burglaries in an entire city since the exact location of the burglary would not be as important as getting a general idea of where the incidents are occurring throughout the city. On the other hand, one might use a parcel file to pin map residential burglaries in a one or two block area to determine exactly which houses were targeted and whether they were along alleys, wooded areas, or on the end of the block.

Parameters set to determine how tabular and geographic data are matched are set within the GIS software and may include spelling sensitivity of the match, address style (e.g., whether to match on address only or address and zip code, or whether to accept partial match scores). A match score denotes the number of address records from the tabular file that were located in the reference layer. Another parameter is offset distance, which is placing a data point a predetermined distance away from the original geocoded location. This may be done to place points on one side of the street segment or another to make the map more readable and/or realistic.

These parameters are choices within the GIS software that will affect the geocode match rate. These preferences should be set and modified only after an examination of the tabular data. One should be completely familiar with the data in order to set these preferences. For example, if the spelling sensitivity parameter is lowered in a city that has two streets named Mill and Miller, inaccurate geocoding may result.

Step 3: Geocode

Once the parameters are set, geocoding is just a push of a button that starts the geocoding process. Often, software packages use a fairly simple method to accomplish the actual placement of the tabular data in relation to the reference layer. The common approach is to place the address point along the street within the range of the street number. For example, this first table highlights one call for service at the address "292 Princeton Ave."

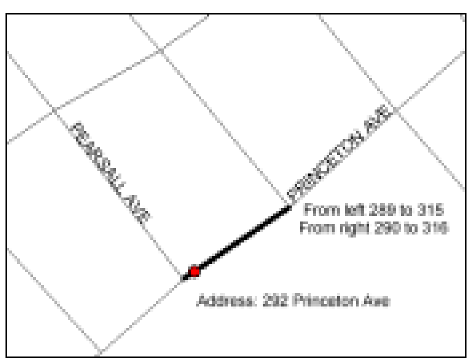
Shape	Bg	Str_name	Str_apt	Date	District	Grid	Call_cod	Priority
Point	37001	292 PRINCETON AVE		960622	S	1112	G1300	5
Point	21002	24 VIRGINIA AVE	F-BSMT	960813	S	1620	G1300	5
Point	09022	133 MARTIN LUTHER KING DR		960801	S	1603	G1300	0
Point	25002	227 MARTIN LUTHER KING DR		960604		1625	G1300	5

The following table depicts the data for the street reference layer, and highlighted is the street segment in which "292 Princeton Ave" falls.

Shape	Street	Fromleft	Toleft	Fromright	Toright
PolyLine	PRINCETON AVE	289	315	290	316
PolyLine	E 53RD ST	33	65	34	66
PolyLine	ADLER ST	1	41	2	42
PolyLine	ALBERT PL	1	29	2	30
PolyLine	ARLINGTON AVE	23	71	24	70
PolyLine	ARLINGTON AVE	73	101	72	100

When an incident is geocoded, the point is placed relative to a proportioned length derived from the ratio of the difference between the maximum and minimum address values and the physical length of the line segment.

For example, a segment may represent a street with an address range of 101 to 151 for the left side. An address of 125 would be placed approximately halfway down the line on the left side. Although this method usually misses exact real world coordinates, it is often sufficient given the detail of the street file and necessary resolution of the final map. In this example, "292 Princeton Ave" is located near the beginning of the street segment.



As noted earlier, geocoding by street centerline may not be adequate to depict the exact location of an incident. In the case of mapping a few blocks of residential burglaries, one may want to geocode by parcel address. In some cases, such as recording traffic citations along routes that may not have readily discernable addresses, intersection address data can be recorded for later geocoding using street files. Intersection geocoding is often more accurate than street geocoding since there is no mathematical algorithm to define the physical location of the point generated; instead, the point is placed at the center of the intersection of the appropriate line segments. However, even using intersection data to geocode is not completely accurate since, in reality, most incidents occurring at an intersection address do not occur exactly in the middle of where the two streets intersect.

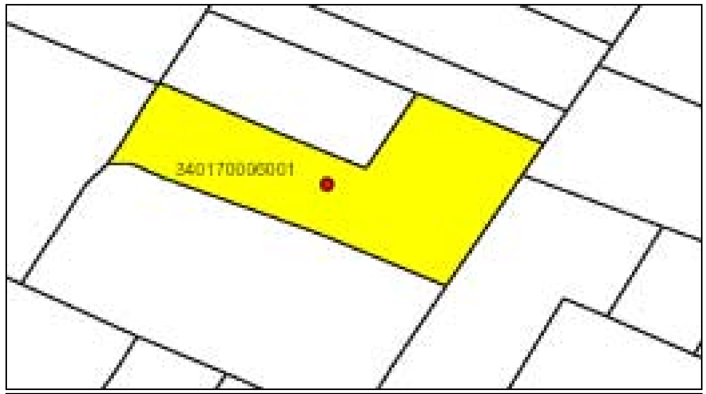
A similar geocoding strategy uses polygons as opposed to previously discussed street centerline files. This method is the same as geocoding specific address data in that a value from the tabular data must match that of a geographic reference layer. For example, calls for service data often have a grid, beat, or district field in addition to an address field. In this case, the incident data has a census block number field.

Shape	Str_name	Str_apt	Call_cod	Priority	Census Block Number
Point	237 MONTICELLO AVE		G13	7	340170006001
Point	95 STEGMAN ST		G1300	5	340170089000
Point	51 MERRITT ST	APT2C&E	G1320	3	340170056002
Point	576 COMMUNIPAW AVE		G1300	5	340170046002
Point	253 STEGMAN ST		G1300	5	340170043005

When geocoding polygons, the grid, beat, or district value is geocoded to the center of the polygon that represents the grid, beat, or district layer. In this example, the census block group layer matches that from the incident data.

Shape	Area	Census Block Group	Pop1990	Pop1999
Polygon	0.12219	34017000600	5227	5521
Polygon	1.38054	34017000901	0	12
Polygon	0.17121	34017000100	5396	5633
Polygon	0.10119	34017000200	4715	4681
Polygon	0.11900	34017000300	4071	4187
Polygon	0.17429	34017000400	3467	3509

Once the incident is geocoded, the point is placed in the exact middle of the polygon, as are all the points geocoded to that polygon.



This type of geocoding is often used to create graduated color thematic maps by aggregating the data by polygon since data geocoded by polygon can no longer be located by address. However, many people geocode by address first and aggregate the data by polygon after the fact to avoid losing address data. Other types of geographic polygon data that can be used as reference layers for geocoding are zip codes, census blocks, census tracts, county, state, and country. Geocoding data at the polygon level is particularly useful when a dataset is very large or when address information is not as reliable as information such as grid or beat information.

Step 4: Review results

Step four, reviewing results, is a matter of determining whether the geocoding process was successful and how successful it was. Most GIS software will have geocoding outcome statistics that indicate how many of the cases were successfully geocoded, how many are a partial match, and how many were not geocoded at all. Obviously, the ideal successful geocoding rate is 100%. Depending on the number of cases and the purpose of the analysis, a rate of 95% can also be acceptable. The important factor in accepting a geocoding rate less than 100% is understanding why some of the incidents are not geocoded. In some cases, missing data or data outside the mappable jurisdiction make up the incidents that are not geocoded. However, many times, there are other reasons that can and should be corrected.

In the case of a street centerline layer, geocoding problems are generally manifested in the form of missing or incorrect address ranges or missing street segments. Street layers often lack address ranges for streets because of recent construction of new roads or errors in the original creation process of the reference layer. The quality of these layers will depend both on those maintaining the layers and the growth rate of the jurisdiction. For example, in a small town that has not added new streets in fifty years, the street reference layer would be easy to maintain, not only because nothing is being added but also because the town has relatively few streets to maintain. On the other hand, in a large city that is growing rapidly, the street layer would be much more difficult to maintain.

Because street files are generally manually updated, they are also prone to data entry errors. The combination of these problems can be difficult to solve. Many agencies produce and maintain their own street centerline files or rely on their city or town's engineering department to maintain them, and others have opted to purchase street centerline files that have been corrected and are bundled with contracts for regular updates. However, for layers particular to the police department, such as police district boundaries or beat boundaries, someone at the police department will most likely be tasked to maintain these. Fortunately, these layers are typically composed of many less geographic components than a street reference file. In any case, interagency cooperation can prove invaluable as a means for resolving geocoding problems.

Even if the geographic reference layers are complete, there may still be problems with the tabular data used by law enforcement agencies, which stem primarily from having incorrect information or inaccurate data entry. Address errors in calls for service, crime, or accident data are often the source of much of the woes of geocoding in law enforcement and can be categorized into five common types: incorrect street numbers, street name errors, direction errors, incorrect intersections (in the case of intersection geocoding), and discrepancy errors.

- Street number errors can be the result of entry mistakes and are frequently identified as range errors; the address identified is either less than or greater than the address range of the corresponding records in the source file.

- Street name errors can occur for a variety of reasons and are a result of the address record not matching the street name in the source database. These errors are among the most common, with reasons including misspellings, abbreviations, inconsistent street types, or lack of compliance with city addressing standards.

- Direction errors occur when the direction code of the address record does not match the direction code in the source database, either because they are incorrect or missing.

- Unmatched intersections can result from inaccurate intersection addresses or incorrect format. For instance, the intersection of Main Street and Center Avenue is referred to as “Main St & Center Av” and will not be recognized by many GIS software packages if entered as “Main St/Center Av” or “Center Av & Main St.”

- Other errors can occur because there is a discrepancy between the common name of a location and the official address. For example, a police agency may have in its computer aided dispatch system a street called “Route 123,” but the official name in the street centerline file may be “US HWY 123;” thus, they will not match.

Step 5: If necessary, respecify parameters and geocode again.

Step five is only necessary when there is not a 100% geocoding rate, which seems to happen most of the time with law enforcement data. Once the data have been geocoded and problems have been determined by the geocoding process, there are a few solutions. Some may choose to take care of the problems by changing the preferences (e.g., lowering the spelling sensitivity). However, as noted earlier, this should be done cautiously and with full knowledge of the tabular and geographic datasets, as changing preferences such as spelling sensitivity can lead to incorrect address geocoding.

Another solution is developing alias tables, which allow for multiple names for a single entity. For example, a location such as a park or a mall may be referred to in a computer aided dispatch system as “Central Park” or “Centertown Mall” instead of by address to make them easy for dispatchers to enter. An alias table would replace the common name with the appropriate address in the GIS system so it can be located on the map. However, even though alias tables are helpful, it is still recommended that data be cleaned in the original database to reduce confusion and facilitate consistency in data. Data are not only used for mapping purposes, so cleaning the data only in the GIS would not solve data integrity issues when the data are used elsewhere.

The best way to correct data is to fix it at the source; in other words, bring the errors to the attention of those administering the computer aided dispatch system, to those maintaining the street centerline file, to the officers writing the reports, or to the clerks entering the data. However, this may not always be a realistic or a fast enough solution. In small projects or where a large number of cases share the same few mistakes, manual correction may be possible. Large datasets can often be corrected more efficiently when imported into a database or spreadsheet program which has a “search and replace” utility. In addition, specialized software programs, referred to as "scrubbers" can be useful for large projects and in instances where data are regularly imported.

Conclusion

These five steps outline the general process of geocoding law enforcement data. Because the types of data, problems, and solutions are common among law enforcement agencies, there is much to learn and share with one another. This overview has not detailed the specific methodology of geocoding in a particular GIS software program since the software used varies from agency to agency. For a specific outline of how to geocode in particular GIS software applications, see the text manual or electronic help files accompanying the software.

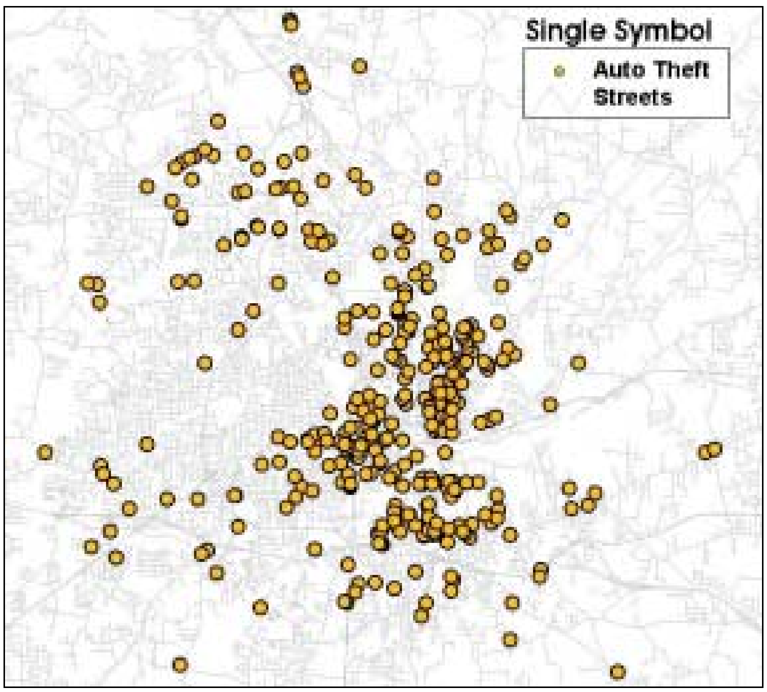
VI. Spatial Analysis Techniques

This section describes and illustrates basic types of mapping that are most commonly used and data classifications that are available in a GIS. This section is meant to serve as a guide and reference for these types of mapping rather than as a "how to" guide for creating crime analysis maps (please note that all of the data used here are fictional, and the maps do not have labels, scales, and North arrows that would be included in a map for presentation, as they are meant to illustrate a point and not represent a map for distribution. For elements of a map and final formatting, see section VII). For assistance in developing thoughtful, appropriate crime analysis maps, see the *Manual of Map Production* (2000) at www.policefoundation.org or www.cops.usdoj.gov produced by the Police Foundation's Crime Mapping Laboratory as a part of the work conducted for COPS.

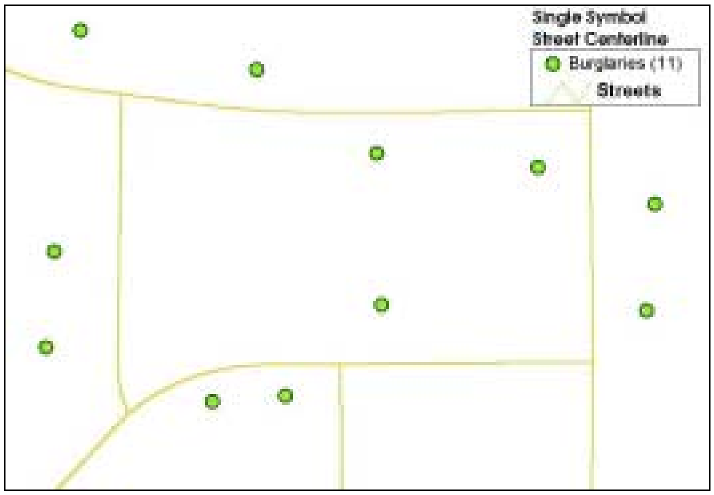
Single Symbol Mapping

Single symbol mapping refers to the use of individual symbols to represent point, line, and polygon features.

The utility of single symbol maps is that they allow for a detailed analysis of small amounts of data. This following is an example of an inadequate single symbol map. This map has too much data for this scale, which is why this method is primarily used for small amounts of data.



A drawback of single symbol mapping is that if two incidents have the same address, they are placed exactly on top of one another and cannot be differentiated by looking at the map.   The following map is a better example of single symbol mapping that uses an appropriate scale. However, to avoid confusion since the points may still be placed on top of one another, one should list the number of incidents in the legend, as is done here or place a number (2) next to a location with more than one incident.



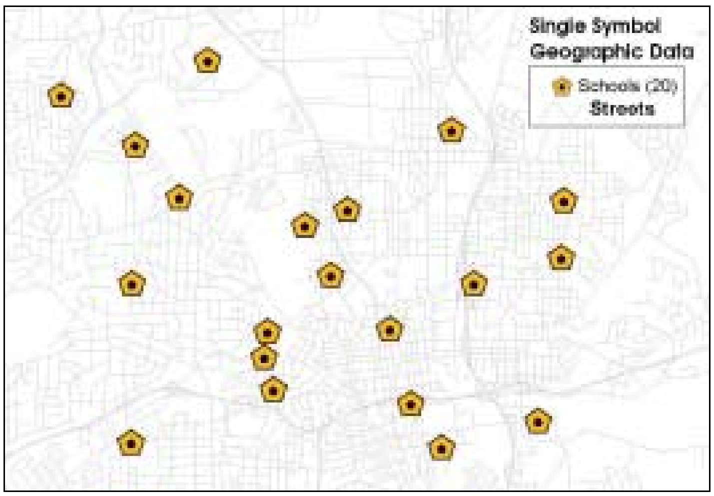
Because single symbol maps are more useful for small amounts of data, they are particularly useful for tactical crime analysis and mapping crime patterns. In addition, they allow a more detailed look at the geography surrounding the incidents. For example, the following map illustrates the same burglary incidents as above with the land parcels drawn that show the number of houses on each block and which were burglarized.

The next map depicts the same data as well as centerline streets with the digitized orthophotograph of the neighborhood that shows the actual houses and surroundings of the burglary locations.

Finally, this map depicts the parcels, orthophotographs, street centerlines, and burglary incident data together. This map could assist in determining additional characteristics of the burglary pattern by examining neighborhood characteristics such as proximity to alleyways or shrubbery, and in responding to the problem by determining potential surveillance locations.

These maps could be used for a neighborhood analysis of accidents or burglary and provide a good example of the use of descriptive geographic data. The key to using a single symbol map effectively is for the analyst to be aware of the number of incidents on the map and be sure they are all represented and their scale is appropriate.

Single symbol mapping is also helpful in representing geographic data such as schools or churches in that it is known that they are discrete addresses and the risk of two points on top of one another is low. The following is an example of schools in a single symbol map. The user should be aware of the readability of the map in order to determine what is "too much" data.



Graduated Mapping

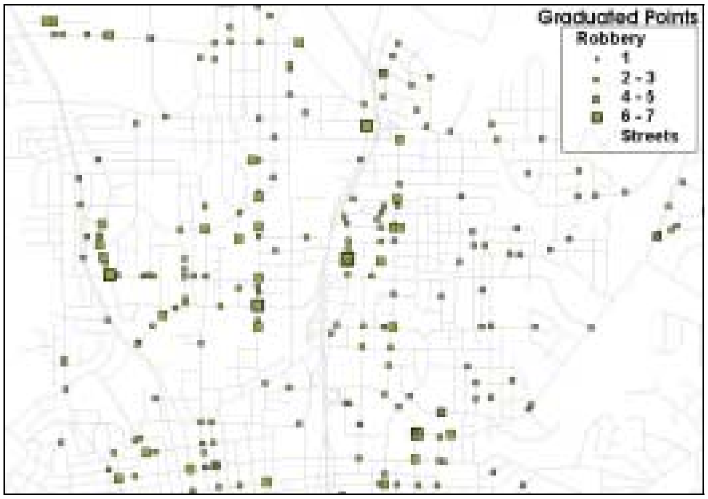
> *Graduated mapping consists of aggregating data into groupings that are displayed on the map.*

These groupings can be graduated by size or by color and can be classified statistically in various ways. This next section describes the size and color graduations as well as the classifications that are available in most GIS software packages.

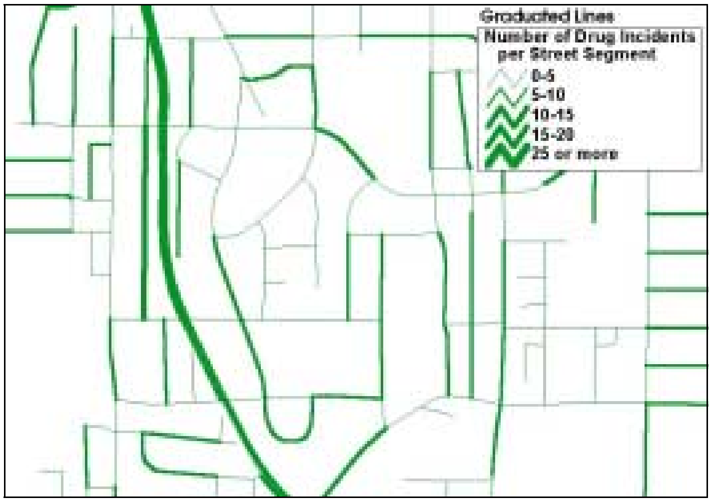
Graduation By Size

> *Graduated size mapping is the process by which data are summarized so that symbols (point or line features) are altered in size to reflect the frequencies in the data.*

In other words, in this type of map, more than one incident at a given point or line is represented with a larger symbol or a thicker line. One drawback is that oftentimes, the size of the symbol or line is difficult to distinguish and the actual value associated with that symbol is not clearly displayed. In addition, similar to single symbol mapping, this type of map is most helpful with smaller amounts of data, since too many incidents make the map unclear and difficult to read. The following map is an example where size is difficult to determine and points are overlapping.



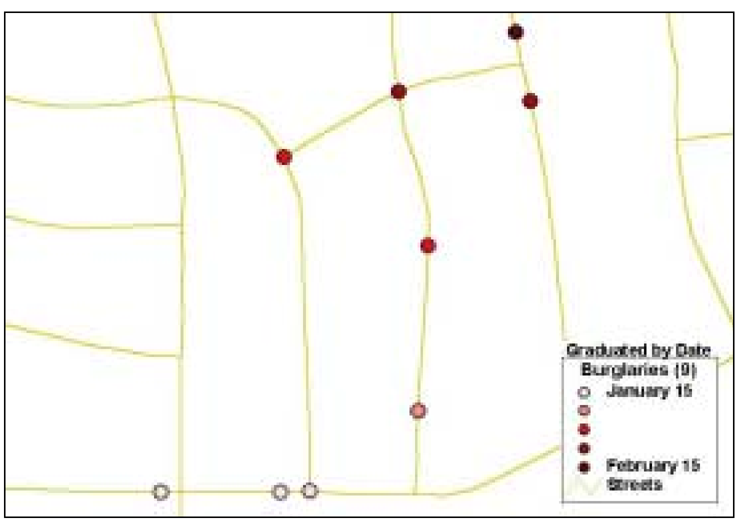
This type of map is more useful when mapping law enforcement tabular data when the scale is smaller, see below and at the top of the next page.



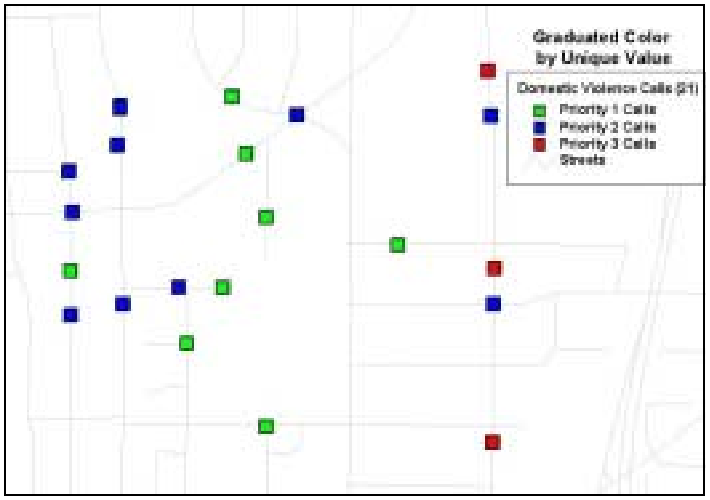
Graduation By Color

> *In graduated color mapping, symbols (point, line, or polygon features) are altered in color to reflect a particular value of the feature.*

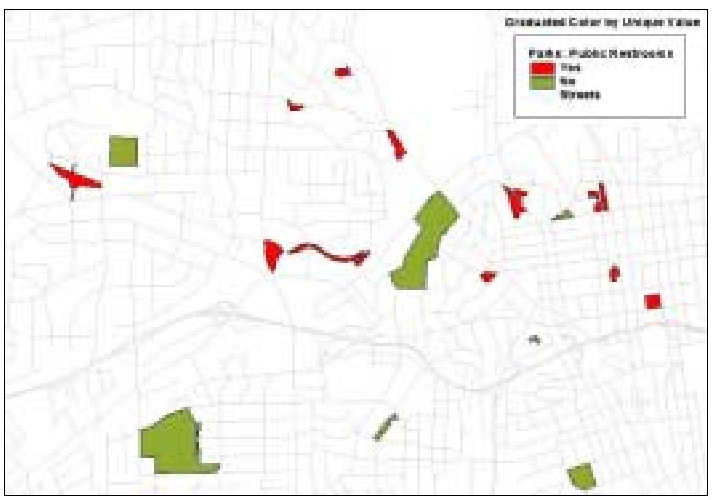
Features can be graduated by any variable. Law enforcement variables include shading by date/time, by priority, by crime type, by number of crimes at a location or in an area, or by crime rate of an area. The next map contains points that are shaded by their date of occurrence and shows the progression from older to the most recent incidents, which are in dark red However, each location must only represent one incident since it would be impossible to shade one point with data from two incidents. As with single symbol mapping, this map is most helpful when examining a small number of cases within crime patterns.



Points can also be shaded by a categorical variable. Each category or unique value is a different color. In the example, the priority of each domestic violence call is a different color.



This method can also be used for line and polygon features. The next map is an example of parks shaded by whether or not they contain public bathroom facilities, which could impact the type of criminal activity in that park.



Classification Methods

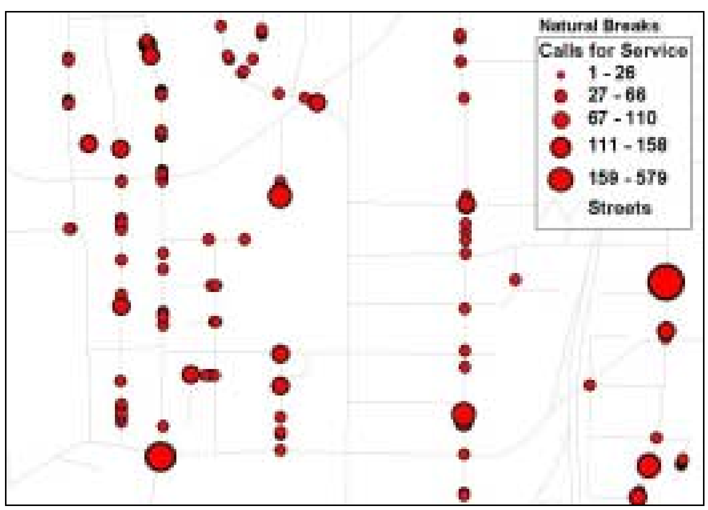
There are several different statistical methods for classifying numeric data in a GIS when creating both graduated size and graduated color maps. The same data are used in the respective point and polygon illustrations to show how different classification methods result in very different maps. Note that in each of the classifications, the user can also change the number of categories, which can also result in different maps of the same data.

Natural breaks

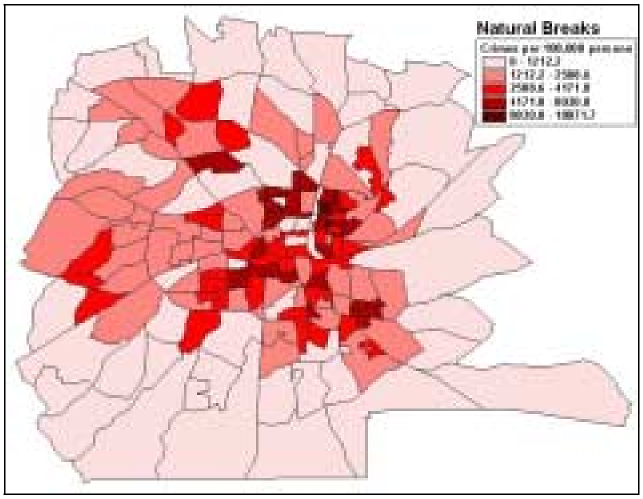
> *This is the default classification in most GIS programs and identifies the natural break points within the data using a statistical formula.*

The software program examines the selected data and their distribution, identifies natural break points, and creates the categories based on the best fit to the data. With each data set, the natural breaks classification would result in different ranges of categories; thus, the classification is "data dependent."

The following is an example of points graduated by size. Note in the legend that the categories do not make much sense, in that they are not evenly distributed or have equal number of values in each. This is because the ranges are determined by the GIS and the nature of the data distribution.



The following is an example of polygons graduated by color.

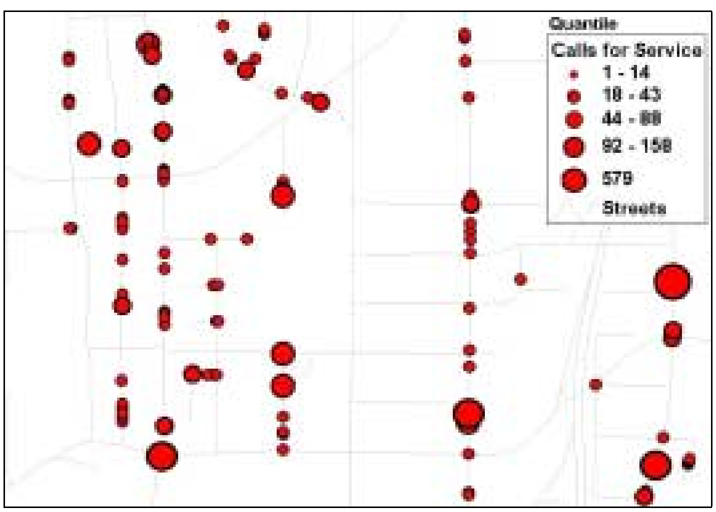


Quantile

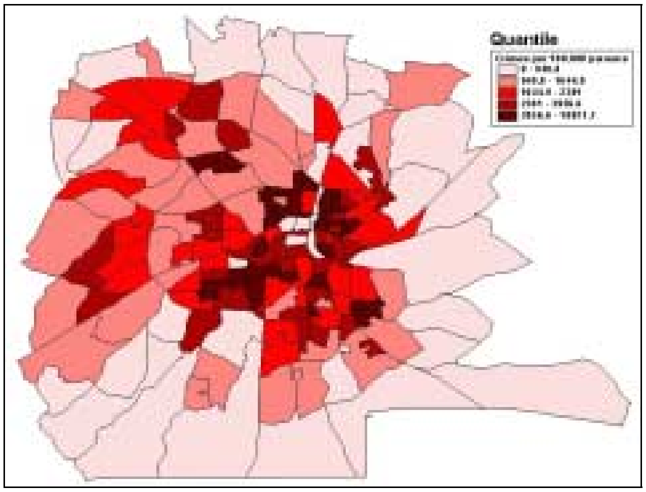
Each class contains the same number of data points.

That is, if there are 100 cases in the data, the GIS sorts them by their values and with five categories, includes the value range for the first 20 cases, the second 20, and so on. Similar to the natural breaks classification, the quantile classification is data dependent.

The following is an example of points graduated by size. Again, the categories do not make much sense, but if we were to look at the data we would see that there are the same number of cases in each category.



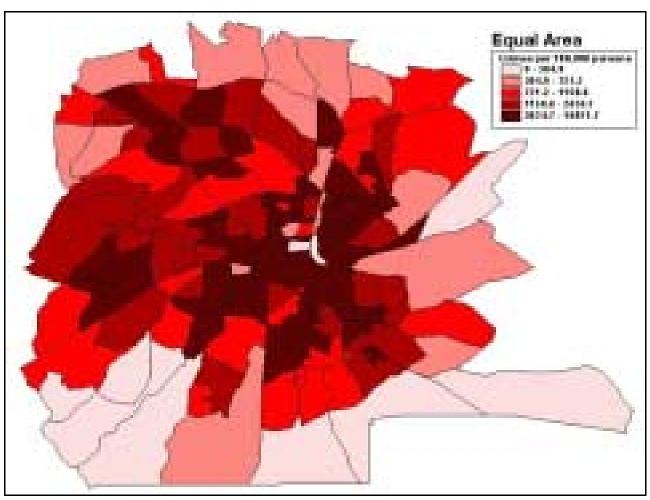
The following is an example of polygons graduated by color.



Equal area

> *This classification applies to polygon features only and determines categories so that the total area of the polygons in each class is approximately the same.*

This method is similar to the quantile classification; however, it looks to the square mileage or other appropriate units of the geographic areas in each class versus the number of data points. Thus, in a legend with five classifications, each category will contain polygons that make up 20% of the total area of the polygons in the analysis. The following is an example of polygons graduated by color.

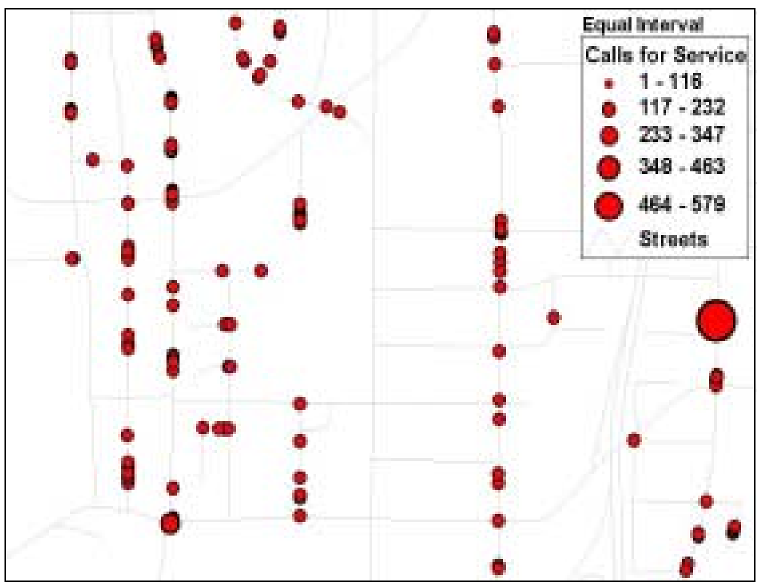


Equal interval

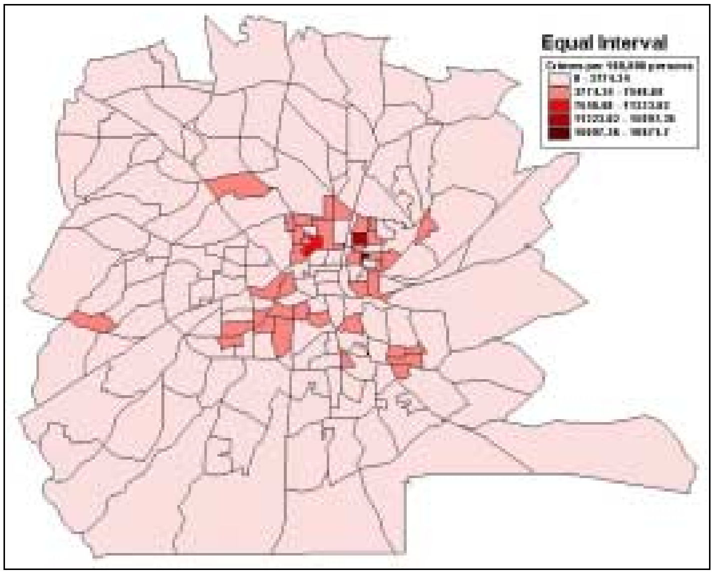
Divides the range of attribute values into equal size sub-ranges.

The GIS determines the range of the values of the distribution and divides by the number of categories to determine the range. For example, if the number of assaults in all the beats of a city ranged from 1 assault to 100 assaults, the categories would be 1-20, 20-40, 40-80, etc. Note that even though the categories seem to overlap, they in fact do not. In this case, all beats with 1 to 20 assaults would be in the first category, but beats with 20.00001 to 40 assaults would be in the second. Even if this is not realistically possible, it is mathematically possible, and it is very important to explain the breakdown system to those individuals using the maps.

The following is an example of points graduated by size. In this case, the categories are even. This classification is still dependent on the data distribution, since as the range of the distribution changes so does the categories. For example, in a data distribution ranging from 1 to 200, the categories would be 1-40, 40-80 and so on, which is different than the categories in the example above.



The following is an example of polygons graduated by color.



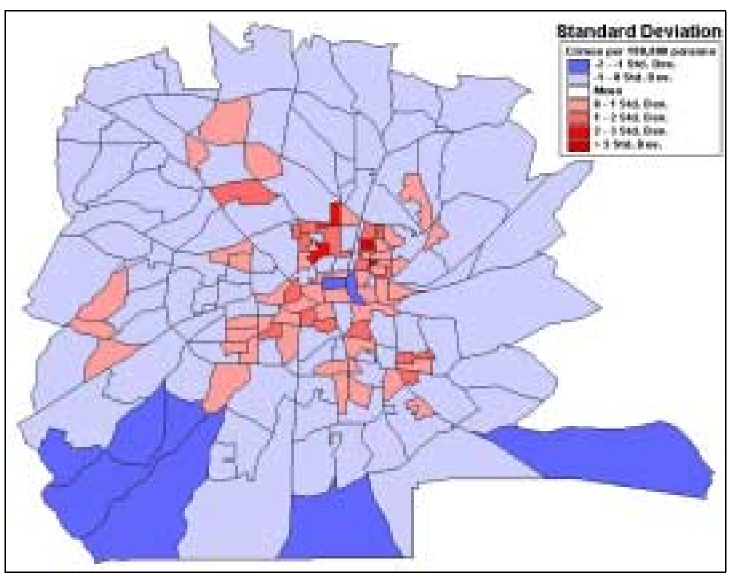
Standard deviation

> *The mean value and standard deviations of the geographic features are computed, and the features are shaded according to which category they fall within.*

This classification does not display the actual values of the feature but shows categories of one, two, or three standard deviations above or below the mean. The values behind the classification can be viewed through another function, depending on the GIS software. This classification allows identification of outliers in a distribution and comparison of data with different distributions (would be displayed in two different maps), since the measures of a normal distribution give a common denominator of relative difference.

The following is an example of points graduated by size. Once again, this classification is dependent on the data distribution. Notice that the mean value is not displayed on either one of these maps. Also, in this map there is only one standard deviation below the mean and two above. This indicates that most of the points fall closely around the mean.

The following is an example of polygons graduated by color.



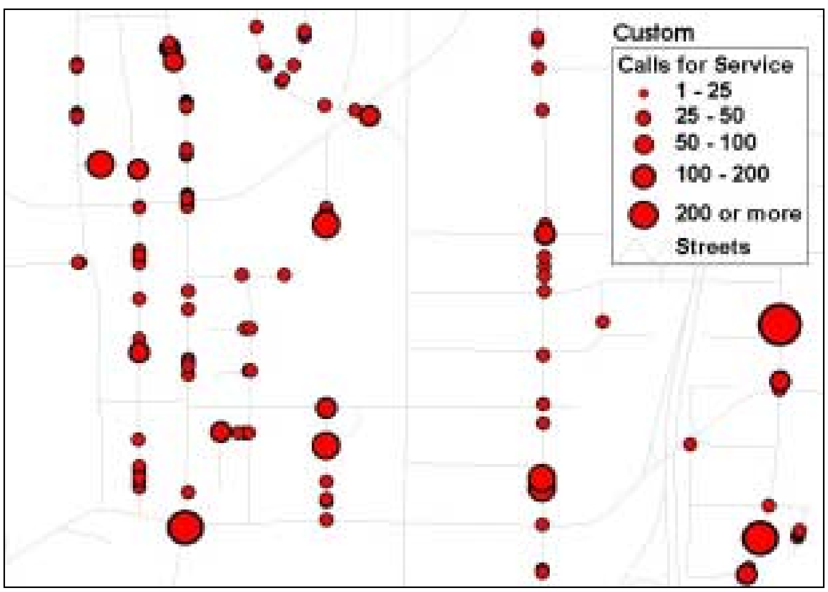
Custom

User determined ranges.

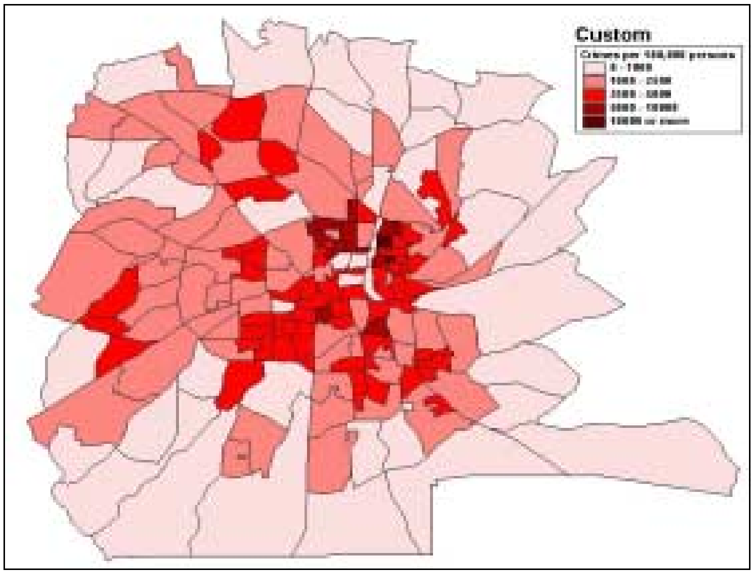
This is the only classification that is not determined by the software and by the characteristics of the data but by the analyst. This method is best for comparing crime or other law enforcement information over time. For instance, calls for service totals and the nature of the distributions tend to be different from month to month. If a classification that is data dependent is used, the colors or size of the symbols will vary in value from map to map. A custom range can be created in which the values for each color or size are the same every month and on every map, which allows comparison.

In order to create custom categories, one might use any of the previous classifications discussed here to get a sense of the data distributions. In addition, it is recommended that when doing a monthly or yearly comparison using custom ranges, that several months or years of data be examined to determine the most appropriate ranges. For this reason, it is best to make the upper limit of the highest range unlimited and use the phrase "or more" as a label (see below) to account for differences. Subjective considerations may also dictate the ranges. For example, in a department that fines properties with more than five false alarm calls for service, the graduation may distinguish between locations with more and less than five calls for service.

The following is an example of points graduated by size.



The following is an example of polygons graduated by color.



VII. Crime Analysis Product Format and Dissemination

The effectiveness of any crime analysis or mapping endeavor has as much to do with the presentation of the results as it does the analysis. If the resulting document of analysis is not legible and understandable to its audience, it is worthless. The following is a discussion of factors to consider when developing a final product, such as methods of dissemination, components of a crime analysis product, and types of crime analysis products. Included also are recommendations for elements of a crime analysis product and elements of a map. These are distinguished from one another since maps include additional elements such as a legend, North arrow, and scale.

Factors to Consider

When developing a crime analysis product, one must consider both the purpose and audience of the product. Crime analysis products can serve many purposes, from informing citizens about recent activity, to assisting the agency in planning, to apprehending a suspected criminal. For example, monthly maps of a town that depict reported crime are useful for providing general information to the public about changes in hotspots of reported crime; however, a detailed map of each hotspot location may be necessary for patrol officers and investigators who need specific information in order to focus their problem solving efforts. In either case, it is important to prepare maps that are appropriate to the purpose.

In addition, there are also many audiences for crime analysis products. They can include police department personnel, the general public, community groups, business groups, school officials, or city council members. By gauging the needs, expectations, and skill level of these individuals, products that are appropriate for each group can be developed. For example, a map of the residences of all known gang members that includes names and case numbers may be useful to gang enforcement officers compiling intelligence information. However, a map with this level of detail would not be disseminated to the public as it may violate an individual's privacy rights or compromise an investigation. It may be appropriate to include a brief notation on the map, such as "law enforcement use only" or "external use" to indicate the intended audience. In general, when producing a crime analysis product, the needs of users of the information need to be balanced with political, legal, and ethical concerns.

Methods of Dissemination

Methods of dissemination of a product inherently rely on the intended purpose and audience. They also rely on the means available, such as the Internet and Intranet capabilities, reverse 911 technology, or the newspaper. For example, a crime analyst may want to let officers know that there is a sexual assault pattern happening in a certain part of the city and provide them with detailed information about the pattern. The analyst, of course, would not provide this information on the Internet for the public to see, but instead may include selected information on fliers to hand out at a briefing, send a department-wide (internal) e-mail, or attend the briefings of the officers in the affected areas. Thus, the purpose, informing the patrol officers in an area, dictates how that information should be disseminated.

The analyst must also consider what is the most efficient and effective method of dissemination, because frequently, the easiest method is not the most effective. For example, it may be simple to publish a crime pattern bulletin and e-mail it to the department or place fliers on a table in the briefing room for officers to read. But if the officers do not regularly check their e-mail or the table is full of other similar fliers, these methods of dissemination may be ineffective and a more time-consuming method, such as attending briefings, may be warranted. The most effective way to disseminate information depends on the current specific circumstances of the department, and the analyst should continually pay attention to what is appropriate and effective.

Components of Crime Analysis Products

A crime analysis product can include one or more of several types of analytical output, which can include tables, charts, graphs, maps, images, and narratives. In a law enforcement setting, a balance of one or more of these components should be used in any one product, and including all or just one component should be avoided. For example, a two-page essay on the recent burglary activity in Beat 33 will not be as effective as a simple description of the pattern, a table of the relevant information, a chart depicting the time of day and day of week of the activity, and a map that indicates where the activity is occurring. Conversely, a crime analysis product should not contain only a map or a chart. Even though a map or chart should be produced to stand on its own, the crime analyst should also include additional information such as interesting findings, interpretation of the results, and recommendations for future analysis.

Types of Crime Analysis Products

The following are some general types of crime analysis products.

> ***Crime bulletins.*** Short one to two-page documents that describe a tactical short-term trend or pattern.

Memos. A document in letter form that summarizes a request, explains the analysis, highlights the interesting findings, and, in some cases, makes recommendations for response or further analysis. These should be included as cover letters for research and special reports.

Weekly/monthly/quarterly reports and maps. Documents and maps that convey the same information in regular intervals to inform about activity and allow for identifying problems. These products should be consistently formatted to ensure recognizability by customers and allow comparison.

Annual reports. Reports that provide information aggregated by year and are published on a yearly basis. They would include breakdowns by geography, months, and types of activity (e.g., types of crime, types of calls, and accidents) and comparisons among years. They might also include comparisons to other similar jurisdictions as well as to state and national figures.

Research reports. Reports that provide a description of the data, methodology, and analysis of a research project (i.e., problem solving project or evaluation of a program) as well as the results of the analysis, interpretations of the findings, and recommendations for response or future research.

Special reports. These are reports that are requested on an ad hoc basis and address a particular issue such as traffic accidents around schools or efficient allocation of a new squad of officers. The analysis that makes up these reports is less rigorous than the research reports and subsequently takes less time. These special reports make up much of the daily work of the crime analyst.

These general categories can include information about crime, calls for service, arrests, and accidents. They also can be specific to a particular area such as street segment, neighborhood, beat, district, and the entire city. Other more specific types may include lists of incidents, “attempt to locate” bulletins, gang information bulletins, missing persons fliers, and FI card summaries. For template of such reports, see the Police Foundation’s product, *Crime Analysis and Mapping Templates* (2001) that are documents that provide guidelines and actual templates (computer files in which the analyst insert his/her own agency and analysis information) for producing these types of reports and maps.

General Crime Analysis Product Elements

The following are the general elements of a crime analysis product.

Title. Includes the nature of the data and geography included as well as the time span included. For example, "Citizen Generated Calls for Service in Precinct 9: January 1, 2001 through June 30, 2001."

File path. This is where the document is located. This is important, so that future requests for the report, an update, or similar report can be easily filled. This assists the analyst in finding the product versus redoing it. An example: F:\Part I Crime 2001\Auto Theft\JanuaryReport.doc.

Credits/date. This includes the name or divisions of the individual(s) who created the report and the date it was created. This allows for the analysts to get credit, for others to direct questions about the product to the appropriate people, and for everyone to know when the product was disseminated. For example, "Prepared by Crime Analysis Unit, December, 2001" or "Prepared by Jane Doe, 01/06/02."

Text, tables, graphics, and/or maps. This is the substantive content of the product and what is included varies from product to product.

Analysis summary. This is an interpretation of the data and interesting findings and is important to ensure appropriate interpretations of the data and results by others. This section is often omitted from crime analysis products.

Disclaimers. This information details what the data and analysis results do not say. For example, conclusions drawn from any report containing crime information can only be made about crimes known to the police, not all crime. Another example is the use of calls for service in lieu of crime data. The difference between the two data sources should be noted as should the limitations of using calls for service (e.g., time and date of call may not be time and date of the criminal incident).

Recommendations. This section would contain suggestions for future analysis or actions based on the results. It is considered optional and may not always be included in a crime analysis product.

Because these elements can be included and combined in an infinite number of ways, a specific example of a crime analysis product is not included here. See below for an example of the map design elements.

Map Design Elements

Maps differ substantively from other components of a crime analysis product, and they contain specific features unique to maps. The following are guidelines for map design elements.

Title. Similar to the title of a general crime analysis product, the title of a map should contain the nature of the data and geography included as well as the time span included.

Legend. This element lists the tabular and geographic data sources displayed in the map and indicates the symbols that are used to represent each data source. In addition, in the case of a map that includes graduation by color or size, the classification used should also be listed. This will allow the reader to understand the divisions of the categories and the analysis that has been conducted. For example, “Classification = Natural Breaks” or “Quantile Classification.”

Geocoding rate. As with statistics and tables that are presented in social science, data that are missing from the map should be noted. In the case of a map, this would be displayed as a percentage of the data that have been successfully geocoded. For example, “Geocoding Rate = 99%.”

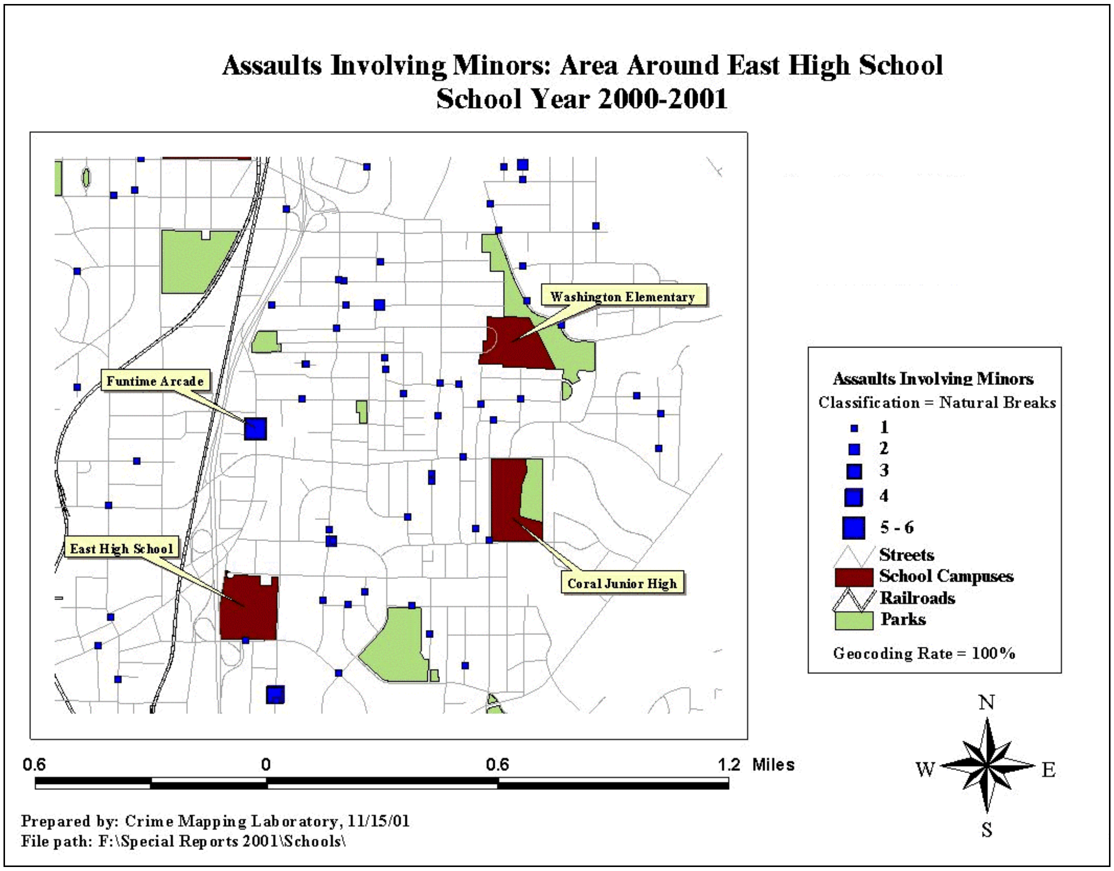
Labels. Should be used in moderation and where appropriate within the map. Labels should orient users to the map as well as highlight analytical results.

Scale Bar. Describes the distance units used in the map.

North Directional. Indicates the geographic orientation of the map.

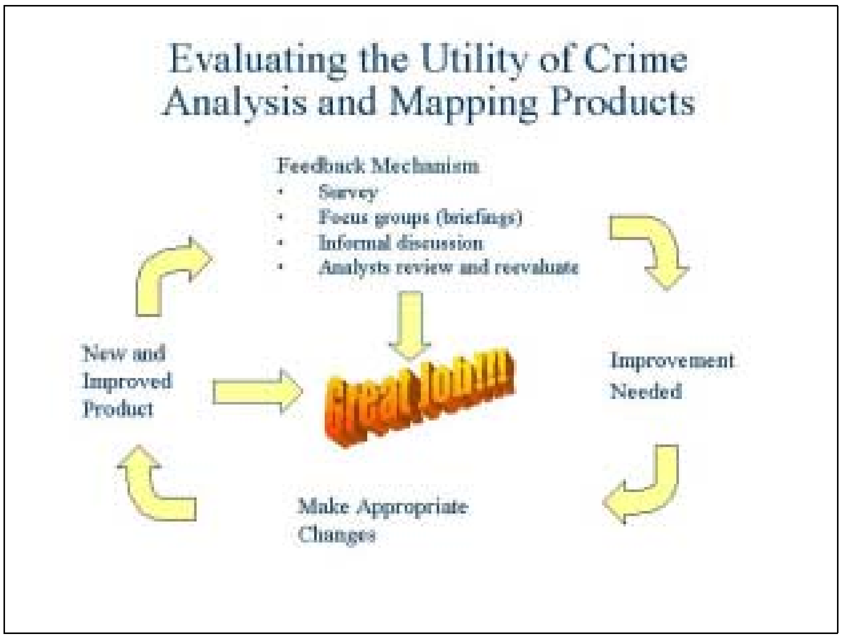
Credits/date. As in the general crime analysis product, this contains the name or division of the individual who produced the map as well as the date it was created.

Remember, these elements are specific to maps and even though maps should basically stand on their own, supplemental description and interpretation of the analysis should be included. The next page shows an example of a map with all of these elements.


Assaults Involving Minors: Area Around East High School
School Year 2000-2001
Washington Elementary
Funtime Arcade
East High School
Coral Junior High
Assaults Involving Minors
Classification = Natural Breaks
1
2
3
4
5 - 6
Streets
School Campuses
Railroads
Parks
Geocoding Rate = 100%
N
W
E
S
0.6
0
0.6
1.2 Miles
Prepared by: Crime Mapping Laboratory, 11/15/01
File path: F:\Special Reports 2001\Schools\

Evaluating the Utility of Crime Analysis and Mapping Products

Finally, a feedback mechanism for crime analysis products is important to determine both their relevance and effectiveness. Customer surveys, informal discussions, and/or focus groups can be used to learn whether a product is serving its intended purpose and is useful to its audience. In addition, it is necessary for the analysts themselves to review and reevaluate current crime analysis products. As noted in the following figure, this process is ongoing. Changes in focus of the department, capabilities of customers, the nature of criminal activity, and information technology are only a few of the factors that could influence needs and purposes of crime analysis products.



VIII. References

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