Crime and Traffic Safety Analysis:

Techniques to Support DDACTS

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DDACTS Program

Edition 3.0
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DDACTS

Data-Driven Approaches to Crime and Traffic Safety is an operational model designed and supported by a partnership between the National Highway Traffic Safety Administration (NHTSA) of the U.S. Department of Transportation and the National Institute of Justice (NIJ) and the Bureau of Justice Assistance (BJA) of the U.S. Department of Justice. DDACTS integrates location-based crime and collision data to determine effective long-term approaches to reduce these social harms.

The DDACTS program consists of various national efforts plus a series of regional workshops administered by the International Association of Directors of Law Enforcement Standards and Training (IADLEST).

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Crime and Traffic Safety Analysis: Techniques to Support DDACTS

This workbook, and its accompanying 2-day course, was created by Christopher Bruce, DDACTS Analytical Director, under contract with IADLEST. It is meant to support the analytical tools and skills necessary to implement DDACTS and similar data-driven programs.

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1 Introduction

DDACTS and Crime Analysis

> "**Crime analysis** is a profession and process in which a set of quantitative and qualitative techniques are used to analyze data valuable to police agencies and their communities. It includes the analysis of crime and criminals, crime victims, disorder, quality of life issues, **traffic issues**, and internal police operations, and its results support criminal investigation and prosecution, patrol activities, crime prevention and reduction strategies, problem-solving, and the evaluation of police efforts."
>
> --International Association of Crime Analysts, *Exploring Crime Analysis* (3rd edition), 2016

The profession of **crime analysis** traces its history to the 1950s, when specialized units began to appear at large American police agencies, formalizing the processes of hot spot analysis, pattern identification, and intelligence collection that had been performed informally by police officers, detectives, constables, and other law enforcement officials extending back into ancient times. In 1963, Chicago Police Superintendent O. W. Wilson published his second edition of *Police Administration* and named "crime analysis" as an ideal section to have within a planning division. Wilson's mentor, Berkeley (California) Police chief August Vollmer (1876-1955), planted the seeds for crime analysis in American policing nearly half a century earlier in a series of writings that emphasized the importance of data in policing. In one of his papers, he notes:

> On the assumption of regularity of crime and similar occurrences, it is possible to tabulate these occurrences by areas within a city and thus determine the points which have the greatest danger of such crimes and what points have the least danger[1].

Vollmer was talking about "**hot spots**," although the term did not yet exist in policing. Over the next 80 years, police administrators and then full-time crime analysts would tabulate such hot spots with colored dots and pushpins stuck on paper maps—a process that did not change until the desktop computing revolution brought computer mapping programs to the world's police agencies in the 1990s.

The first true "science" of crime analysis emerged in the 1970s, as the U.S. government's Law Enforcement Assistance Administration (LEAA) offered funding for the development of analysis and published several manuals to help agencies develop crime analysis programs. Since then, the profession has continued to develop, taking advantage of new technologies (databases, GIS, intranets) and aligning itself with progressive policing models (problem-oriented policing, intelligence-led policing). DDACTS is one such model.

[1] Quoted in Reinier, G. H., Greenlee, M. R., Gibbens, M. H., & Marshall, S. P. (1977). *Crime Analysis in Support of Patrol*. Washington, DC: National Institute of Law Enforcement and Criminal Justice, p. 9.

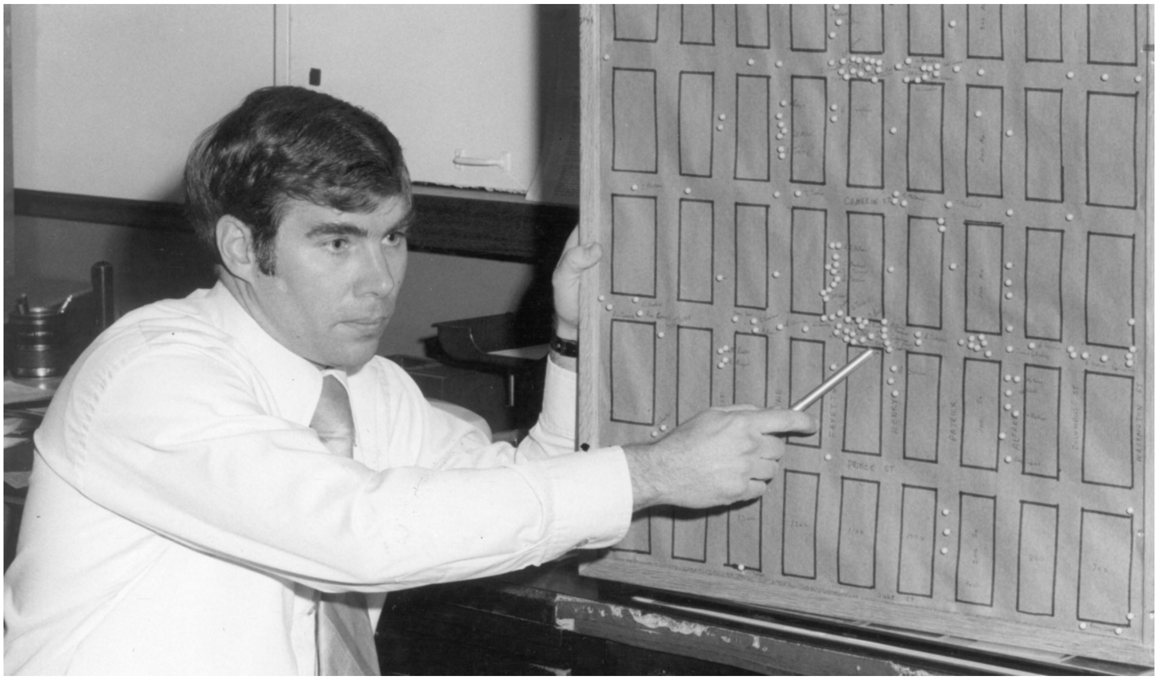


Figure 1: A 1970s crime map in the Alexandria, Virginia Police Department

DDACTS is an operational paradigm that encourages the analysis of data to help police reduce social harms--primarily crime and traffic collisions. These are some of its characteristics:

- DDACTS is **hot spot-focused.** It analyzes streets, intersections, neighborhoods, and other discrete locations where crime, disorder, and collisions gather in numbers greater than in the rest of the community.

- Identifying DDACTS hot spots is not necessarily as simple as mapping crime and collisions and looking for areas of overlap. The key to DDACTS is to **synthesize responses to crime and collisions**. Obviously, this is easy when hot spots for both directly overlap, but there are ways to create this synthesis even when the hot spots occur some distance apart.

- DDACTS works best with **crimes and disorder incidents that can be affected by patrol-based strategies**, such as thefts from vehicles, burglary, street robbery, vandalism, youth disorder, street prostitution, and open-air drug markets.

- A cornerstone of DDACTS is **highly-visible enforcement**, meant to suppress crime and collisions, deter offenses, identify suspects, gather intelligence, and educate the community.

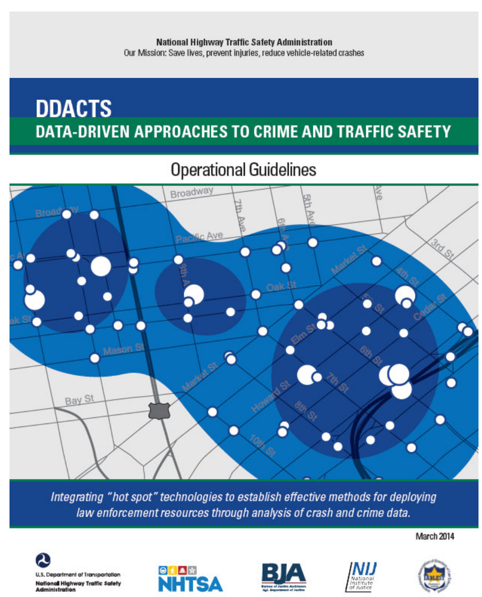
- Beyond highly-visible enforcement, DDACTS supports a **wide variety of tactics and strategies**. The term “approaches” is meant literally. DDACTS encourages problem-oriented approaches, community-based problem-solving, re-engineering, community education, offender-focused tactics, and situational crime prevention strategies if they help abate the hot spots.

- As such, DDACTS is **compatible with most progressive policing models**, including problem-oriented policing, intelligence-led policing, community policing, Crime Prevention through Environmental Design (CPTED), and “broken windows” approaches.

- DDACTS also works well with **CompStat**. CompStat serves as a natural mechanism to review analysis, determine responses, and monitor results.

What DDACTS Is:	What DDACTS Is Not:
• DDACTS is a successful **program** of the U.S. government that teaches police agencies how to better analyze their crime and traffic data and craft effective responses. • DDACTS is a series of **workshops** at which police agencies come to learn better techniques, and to craft their models for data, analysis, response, and evaluation. • DDACTS is a **philosophy** that data-driven techniques, properly implemented, can reduce crime, traffic collisions, and other social harms • DDACTS is a **set of approaches** that emphasize synthesis and synergy in the use of police and community resources to address multiple social harms.	• DDACTS is not a **model**; it is, rather, a process by which an organization creates one or more models. • DDACTS is not a **tactic** or **strategy**; it can incorporate a large number of tactics and strategies. • DDACTS is not just about **police enforcement**. Although enforcement may take a prominent role in a DDACTS model, a good model also includes prevention and problem-solving approaches. • DDACTS is not just about **overlapping hot spots**. Although agencies participating in the program often emphasize enforcement at locations where crime and traffic issues correspond, this is only one of many ways to synthesize analysis and enforcement.

DDACTS Guiding Principles



The DDACTS model is built upon seven guiding principles, with associated key elements.[2]

1. *A focus on* ***outcomes****:* Agencies should set specific crime and collision reduction goals, administrative goals, and community goals, and evaluate observed results against them.

2. ***Partner and stakeholder participation***. Agencies should identify key partners and stakeholders, both internal and external, to both assist in the development of DDACTS strategies and share information.

[2] National Highway Traffic Safety Administration. (2009). *Data-Driven Approaches to Crime and Traffic Safety (DDACTS): Operational Guidelines*. Washington, DC: Author. Retrieved from http://www.nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/811185.pdf

- Identify and make contact with potential partners and stakeholders.
- Develop a plan for partner and stakeholder participation.

3. ***Data collection***. DDACTS depends on quality, timely data on calls for service, crimes, collisions, and enforcement. The agency should have the ability to flexibly query these data sets.

- Review current data collection and analysis systems
- Identify data sources and create a data collection plan
- Select mapping and analysis software

4. ***Data analysis***. DDACTS responses are built on quality, thorough analysis of who, what, when, where, and how factors. Mapping is a key component of DDACTS data analysis, but it does not end with the identification of hot spots; hot spots are dissected for temporal, offender, victim, property, and causation factors to help direct the best enforcement.

- Develop a clear process for data analysis
- Develop reporting procedures

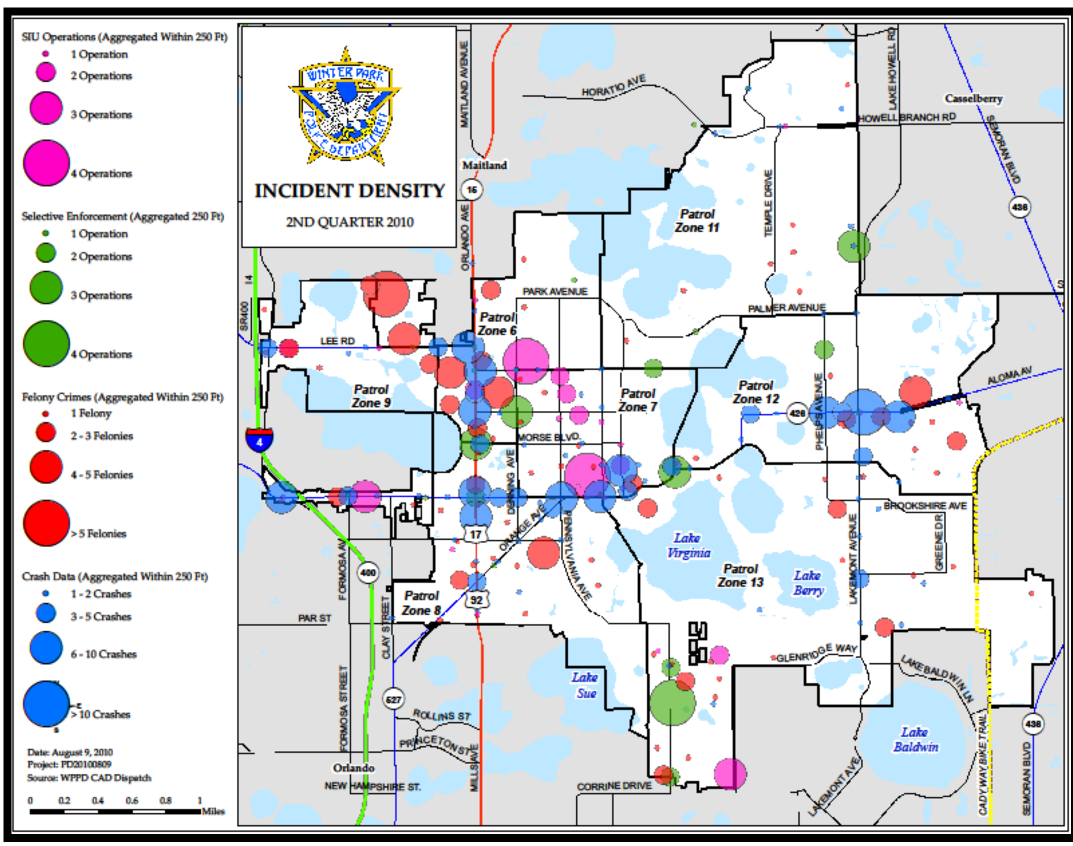


Figure 1-2: The ability to map crime, collisions, and other social harms, as well as enforcement data, is a key element of DDACTS.

5. ***Strategic operations***. The agency uses the analysis to develop the right responses for the hot spot. In addition to highly-visible enforcement, this might include traffic engineering and environmental engineering strategies, warning signs and other

community information, automated enforcement, surveillance (direct or camera-based), apprehension tactics, intelligence collection, and community-based problem solving.

- Identify strategies and tactics
- Develop short-term and long-term operational plans
- Implement plans

6. ***Information sharing and outreach***. The agency shares information on crime, collisions, and enforcement with its partners and stakeholders, and receives feedback on its approaches.

- Review partner and stakeholder plan to identify strategies for information sharing and outreach
- Develop a plan for communicating through media outlets

7. ***Monitoring, evaluation, and adjustments***. The agency continually monitors the effectiveness of its strategies, applies an evaluation model to determine the level of success towards its goals, and adjusts its responses as indicated by the evaluation.

- Develop a robust evaluation model
- Use analysis to make adjustments to field operations
- Document and report changes

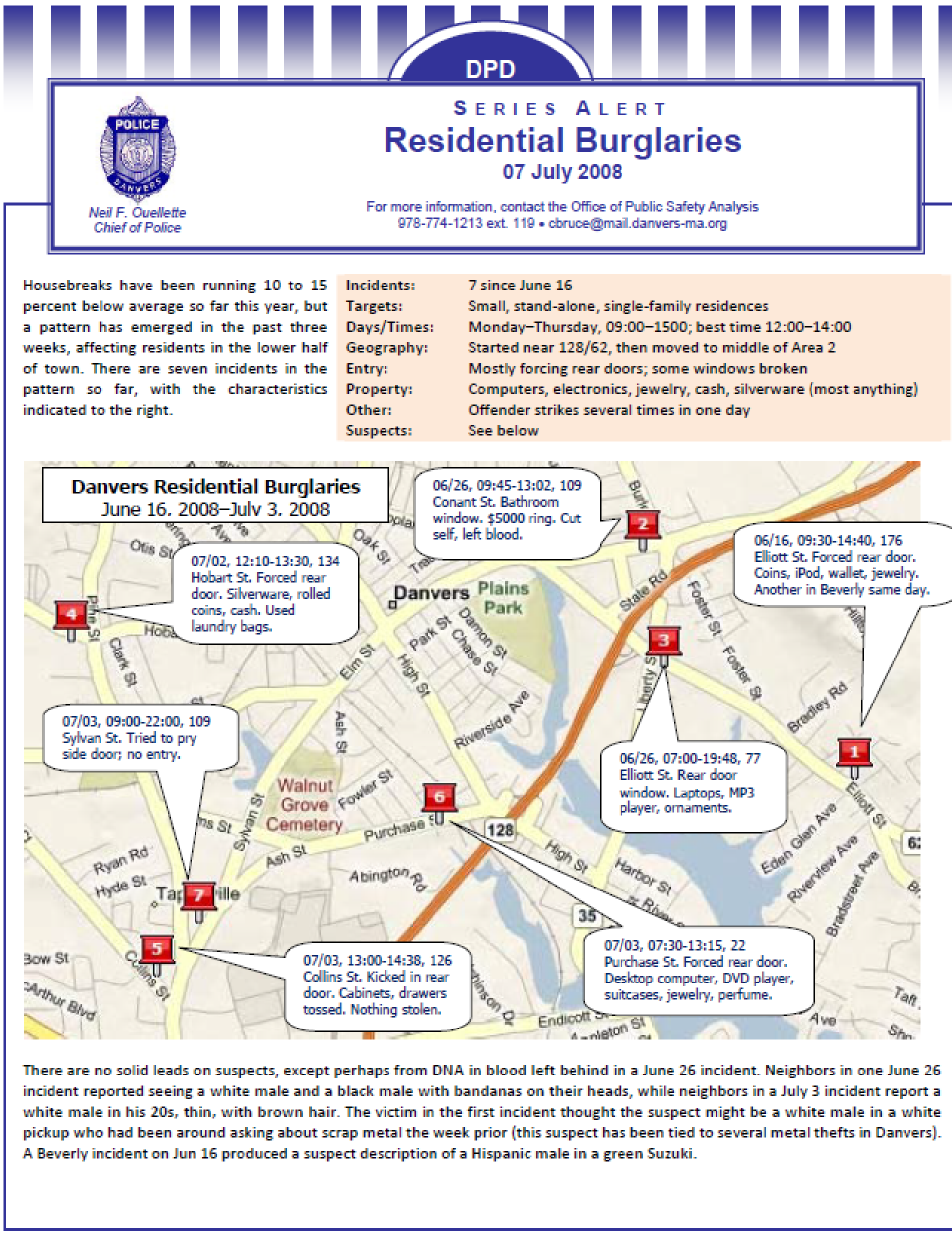
Categories and Functions of Crime Analysis

Despite its name, crime analysis supports almost all substantive aspects of police agency operations, including the analysis of non-crime social harms, including noise, disorder, traffic, and enforcement data. The profession generally recognizes several distinct "categories" of crime analysis, distinguished by the topic of study and the purpose of analysis.[3] Some crime analysts—especially sole analysts in smaller agencies—are generalists, dabbling in all from time to time. Others are specialists, focused on only one or. Analysts' focuses also vary depending on the nature of the agencies that employ them: national and international agencies tend to require little to no tactical analysis; agencies with special purposes might need only intelligence analysis, whereas small municipal agencies might rarely require these categories.

- **Tactical analysis** describes the identification and analysis of crime patterns and series for the purpose of tactical intervention by patrol or investigations. Tactical analysis is a daily process that results in bulletins and alerts that operational units can use immediately.
- **Strategic analysis** is the identification and analysis of trends, hot spots, and problems for the purposes of long-term planning and strategy development. Strategic analysis usually takes the form of longer reports that fully document the underlying factor associated with long-term issues.

[3] For more on these types of crime analysis, see International Association of Crime Analysts. (2014). *Definition and types of crime analysis* [White Paper 2014-02]. Overland Park, KS: Author. http://www.iaca.net/Publications/Whitepapers/iacawp_2014_02_definition_types_crime_analysis.pdf

- **Administrative** crime analysis is analysis directed towards the administrative needs of the police agency, its government, and its community. As a broad category, it includes a variety of techniques and products, performed both regularly and on request, including statistics, data printouts, maps, and charts. Examples include workload calculations by area and shift, officer activity reports, responses to media requests, statistics provided for grant applications, reports to community groups, and cost-benefit analysis of police programs.
- **Intelligence analysis** focuses on repeat offenders and criminal organizations, using special information, often covertly obtained, to support investigative and prosecutorial tactics.


DPD

SERIES ALERT

Residential Burglaries

07 July 2008

Neil F. Ouellette
Chief of Police

For more information, contact the Office of Public Safety Analysis
978-774-1213 ext. 119 • cbruce@mail.danvers-ma.org

Housebreaks have been running 10 to 15 percent below average so far this year, but a pattern has emerged in the past three weeks, affecting residents in the lower half of town. There are seven incidents in the pattern so far, with the characteristics indicated to the right.

Incidents:	7 since June 16
Targets:	Small, stand-alone, single-family residences
Days/Times:	Monday–Thursday, 09:00–1500; best time 12:00–14:00
Geography:	Started near 128/62, then moved to middle of Area 2
Entry:	Mostly forcing rear doors; some windows broken
Property:	Computers, electronics, jewelry, cash, silverware (most anything)
Other:	Offender strikes several times in one day
Suspects:	See below

There are no solid leads on suspects, except perhaps from DNA in blood left behind in a June 26 incident. Neighbors in one June 26 incident reported seeing a white male and a black male with bandanas on their heads, while neighbors in a July 3 incident report a white male in his 20s, thin, with brown hair. The victim in the first incident thought the suspect might be a white male in a white pickup who had been around asking about scrap metal the week prior (this suspect has been tied to several metal thefts in Danvers). A Beverly incident on Jun 16 produced a suspect description of a Hispanic male in a green Suzuki.

Figure 1-3: Tactical analysis products focus on immediate patterns and series.

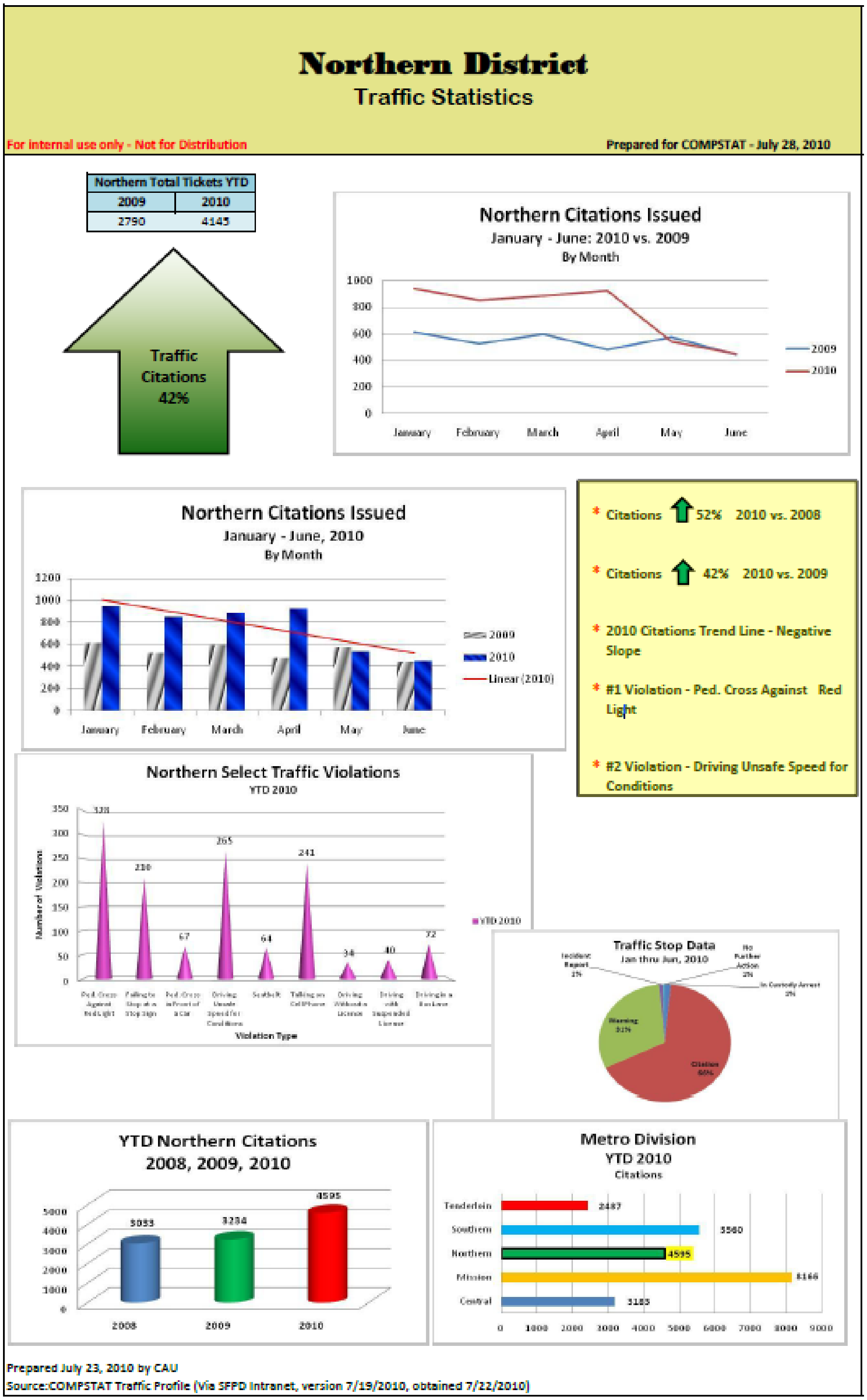
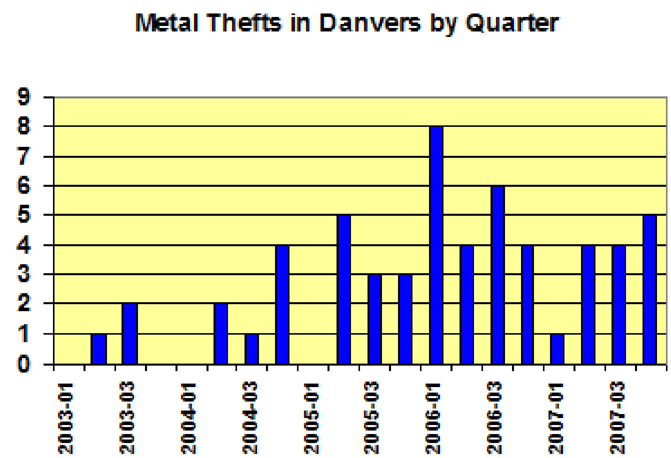


Figure 1-4: Strategic crime analysis looks at long-term trends and changes in social harms.

20 **Danvers Police Department**

Thefts of Wire, Piping, and Scrap Metal

In May 2006, copper futures reached a record high of $4.04 per pound, driving up the prices commanded for used copper at salvage yards. It had been climbing steadily since 2002, driven by new construction in Asia. Not coincidentally, reported thefts of copper wiring, piping, and scrap copper began increasing in 2002 as well and peaked in the spring of 2006. Thieves first stole it from construction sites, hauled it away from utility yards, and shoplifted it from Home Depot and Lowe's. Then, as these sources became more difficult to tap, thieves asked, why steal only *inactive* copper? From Honolulu, Hawaii to Amesbury, Massachusetts, they began tearing down live wires, disrupting power to thousands (many thieves have been electrocuted and killed in these attempts). We've even seen reports of burglars entering businesses, tearing down the drywall, and stealing the copper pipes directly out of the walls. Prices fell towards the end of 2006 and beginning of 2007, but have started to climb again since the fall. The problem certainly isn't over.



In Danvers, this problem manifested itself in several ways:

- **Shoplifting at Home Depot**. For some reason, the phenomenon has not affected Lowe's (or they're not reporting it to us). The Home Depot on Route 1 reported eight incidents of shoplifting in the last two years, and the one by the Liberty Tree mall reported three. These aren't sophisticated thefts; the thieves just wheel or carry it right out the front door. Almost all of the incidents have resulted in arrests.

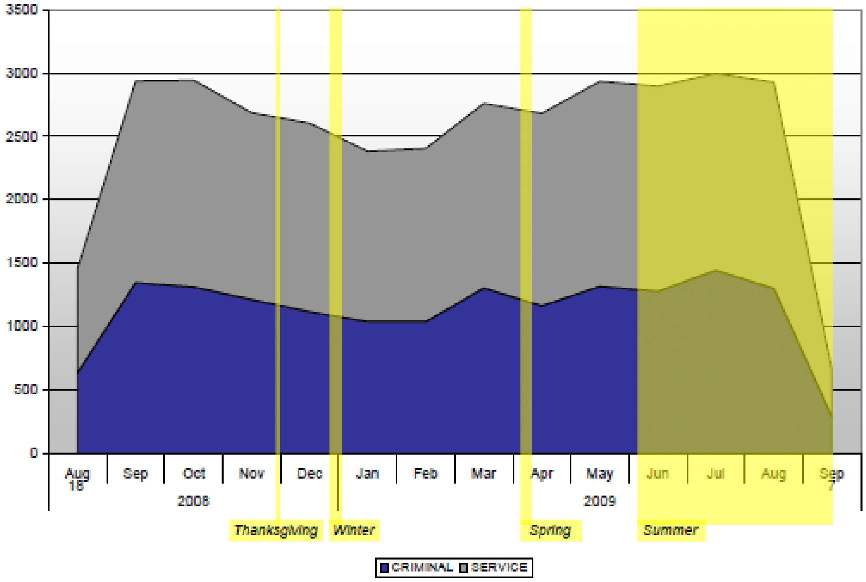
- **Burglaries and thefts at construction sites**. There have been seven such incidents in the past two years, with some sites suffering multiple thefts. Poorly secured and unguarded at night, construction sites often make attractive targets for thieves.

- **Thefts from utility yards**. Danvers Electric Light suffered two thefts in 2006, but the problem went away on the adoption of better security (and, possibly, the arrests of the offenders in Lynn).

The media has made out these copper thieves to be some special breed of criminal. But, in reality, they seem to be the same disorganized, substance-abusing thieves that we find involved in other crimes. The majority in Danvers are heroin addicts in their late 20s and early 30s. Many of the shopliftings are committed by boyfriend/girlfriend or husband/wife teams: one wheeling the goods out in a shopping cart, the other driving the getaway car. The utility yard thefts seem to be committed more by pairs of male offenders with their own pickup trucks.

Figure 1-5: Problem analysis focuses in depth on discrete problems (including certain hot spots), identifies their causes, and recommends preventative solutions.

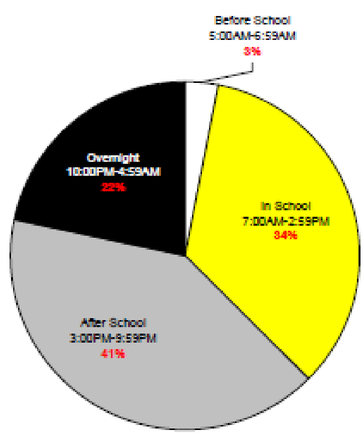
Calls for Service to Patrol Areas* Serving Selected School Attendance Areas**
August 18, 2008 (1st Day of 2008-2009 School Year)
through
September 7, 2009 (day before 1st Day of 2009-2010 School Year)

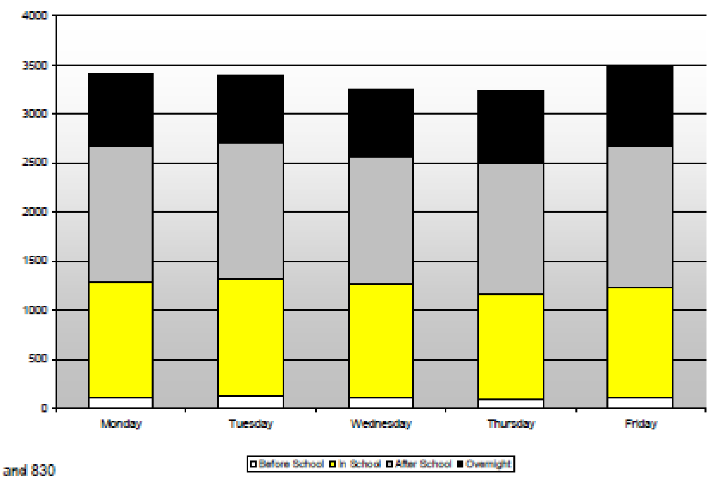


The chart at left illustrates the pattern of calls for service by month to patrol ares serving the selected school attendance areas. The yellow overlay highlights periods of extended break when school is not in session (based on the 'modified' secondary school calendar).

As is typical, calls for service are lowest during the colder, winter months and peak during the warmer, summer months.

The pie chart at the bottom left illustrates calls for service volume to patrol areas serving the selected school attendance areas by time of day. *This chart includes only weekdays when school was in session.* The largest proportion of calls for service were received during the after school hours. As evidenced in the chart at the bottom right, this pattern is consistent across all weekdays.





*Patrol Areas 331, 341, 342, 400 through 441 and 830
**Luther Jackson MS, Glasgow MS, Falls Church HS & Jeb Stuart HS
Source: FCPD Altaris calls for service closed as a 'service' or 'criminal' event type. Includes 98'd and 99'd calls only.
FCPD/CAU/MAS/JBL
11/16/09

Figure 1-6: Administrative analysis products tend to answer specific administrative questions.

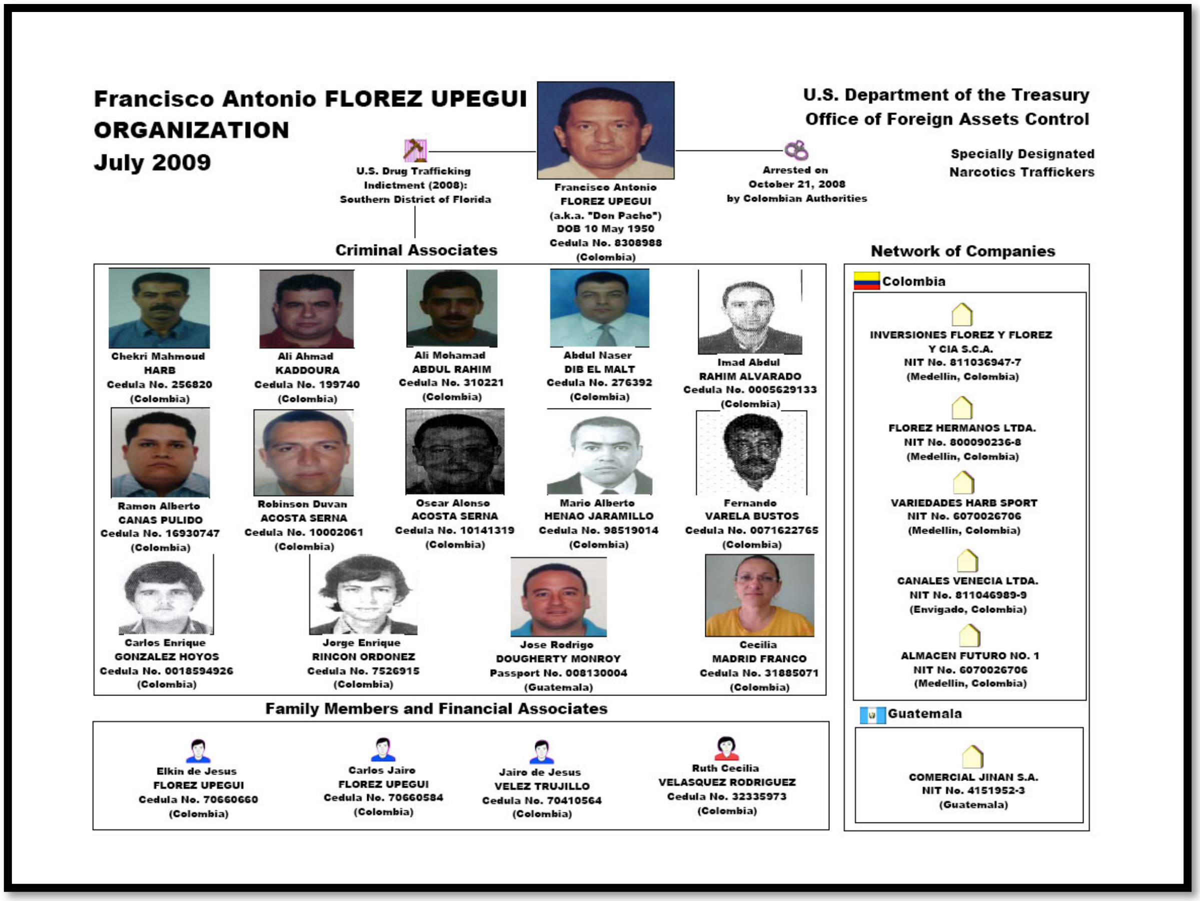


Figure 1-7: Intelligence analysis focuses on criminal organizations for purposes of investigation and prosecution.

The key to understanding the relationship between DDACTS and these types of crime analysis is the third word: "approaches." DDACTS does not consist of a single model but rather a variety of approaches, each of which calls upon various analytical techniques. Most DDACTS implementations feature strategic analysis and operations analysis, but there are potential applications of problem analysis, tactical analysis, and intelligence analysis to the DDACTS process as well.

Table 1-1 provides a list of the different analysis types, with thoughts about their use in various DDACTS approaches.

Type of Analysis	Subject of Focus	Responses Supported	Uses in DDACTS
Tactical	Current patterns and series, including emerging hot spots	Tactical intervention by patrol and investigations	**Moderate**. Depends on the agency's specific DDACTS operational model. If model is flexible on a day-to-day or week-to-week basis, can move DDACTS enforcement areas to align with various suppression and apprehension tactics related to recent crime series.
Strategic	Trends, including long-term hot spots	Long-term strategy and policy Prevention strategies, often involving external partners and stakeholders	**Significant**. Strategic analysis would apply to hot spots and problems in both crime and traffic analysis. It is through strategic analysis that plans and policies are made related to both DDACTS and other enforcement strategies. Problem analysis offers the best opportunity for long-term abatement of both crime and traffic collision hot spots.
Administrative	Allocation of resources and personnel	Changes in shift, beat, and division allocation	**Significant**. A DDACTS implementation offers a good excuse to revisit key operations and deployment questions, including shift, beat, and unit staffing and unit resources. Analysis to evaluate a DDACTS implementation would also fall into this category.
Intelligence	Repeat offenders and criminal organizations	Investigation and prosecution	**Moderate**. Traffic stops can be a tool for the collection of intelligence if agency thoroughly documents each stop.

Table 1-1: Types of crime analysis and uses in DDACTS.

DDACTS Templates

The different types of crime analysis combine to support four major "templates" to implementing DDACTS in a police agency. These are not necessarily exclusive of each other, and it is possible to construct a model that combines elements of all four, but it is useful to consider them individually first.

1. Strategic DDACTS. This approach is favored by most of the agencies that have implemented DDACTS so far. It attempts to predict hot spots for crime, collisions, and other social harms (usually based on past data). The agency selects a number of target areas and times, assigns traffic and patrol units to conduct highly-visible enforcement in the area, and evaluates the effects on crime and collisions at the end of the implementation period (usually several months). The advantage to this model is its simplicity. It requires nothing more analytically intensive than a map of hot spots at different times of day; it keeps the implementation fully within control of the police agency; and the responses using existing resources.

2. Tactical DDACTS. This more tactical approach is not as concerned with "hot spots" in the long-term, but rather those locations that have emerged as hot spots, or potential target locations, very recently. The technique depends on techniques like series analysis and threshold analysis to identify locations with recent above-average activity or locations that might be targeted in a current crime pattern. The agency conducts highly-visible enforcement, directed patrols, and field interviews at the target locations, hoping to suppress activity or apprehend offenders. It is more complex than the strategic focus because it relies on daily or weekly analyses of emerging patterns and hot spots. It is also more difficult to evaluate because the target areas are constantly shifting.

3. Problem-Oriented DDACTS. Based on the principles of problem-oriented policing, the problem-oriented method starts with hot spot identification similar to the strategic method. But rather than simply implement highly-visible enforcement at the target locations, the agency disaggregates the data to identify discrete crime, disorder, and collision problems within the target areas. The analyst then engages in a thorough analysis of these discrete problems, using field research and qualitative methods to supplement what is collected in the agency's data systems. Response involves long-term prevention methods, enlisting key partners and stakeholders in the community. Evaluation is complicated, involving both qualitative and quantitative methods and a consideration of displacement and diffusion of benefits. This is the most analysis-intensive of the approaches.

4. Offender-Oriented DDACTS. The emphasis in this model is on the idea that criminal offenders are likely to drive vehicles through your jurisdiction. The intelligence-led focus leverages information about known offenders, organizations, and routes of travel to inform "total stops" and field interviews along key routes, with the goals of collecting field intelligence, suppressing offender activity, boosting warrant arrests, and generating arrests for offenses such as drug violations, weapon violations, and stolen property. In the short-term, evaluation for this approach generally focuses on outputs such as stops, field interview reports, arrests, and other criminal charges; in the long-term, it should have a jurisdiction-wide effect on crime.

Note that the role of traffic enforcement differs among these four approaches. In the strategic approach and the problem-oriented approach, collisions may be among the social harms identified and targeted in the hot spots. Strategies and tactics, including highly-visible enforcement, are meant to directly impact these hot spots, and reductions in collisions at these locations are among the outcomes evaluated.

In the tactical and offender-oriented approaches, on the other hand, traffic enforcement is used as a *tool to achieve other goals* related to crimes and offenders. Such enforcement will likely have a generalized deterrent effect among those stopped, and among those who pass through the enforcement area, but not in a way that is directly assessable.

Again, keep in mind that an agency can mix models. For instance, a police department might start with the strategic approach, to get an operation going quickly, but gradually transition to a more problem-oriented approach as it enlists key partners and stakeholders and has more time for analysis. The offender-oriented approach, in the right places, could be combined with the other approaches to add benefits to the DDACTS implementation.

Table 1-2 summarizes the various approaches to DDACTS.

Table 1-2: Approaches to DDACTS

Approach	Goals	Target Areas	Analysis Involvement	Types of Responses	Monitoring, Evaluation, and Adjustment
Strategic	Abate crime, disorder, and collision hot spots and times	Locations with historically-high volumes of activity	Basic. Needed to identify hot spots and times, perform evaluation. Basic mapping required.	Highly-visible enforcement Directed patrol	3-6 months, looking for statistically significant decreases in target crimes, collisions, and other social harms. Some consideration of displacement.
Tactical	Quickly respond to emerging patterns and hot spots.	Locations with recent higher-than average activity; locations that may be targeted in a crime pattern.	Heavy. Needed to regularly monitor current activity compared to baseline thresholds, create reports.	Highly-visible enforcement Directed patrols Field interviews	Daily or weekly. Evaluation is difficult; generally looking at individual cases rather than total volume.
Problem-Oriented	Solve long-term or chronic crime, collision, and safety problems.	Chronic crime, collision, and disorder hot spots.	Heavy. Must engage in thorough quantitative analysis of police data and qualitative analysis of hot spots.	Preventative measures involving key partners and stakeholders	Long-term; yearly or more. And, just like the analysis, both qualitative and quantitative.
Offender-Oriented	Increase arrests, suppress activity, collect intelligence	Locations through which offenders may travel.	Moderate. Needed to identify best locations and types of offenders, vehicles, and activities to watch for.	Highly-visible enforcement “Total stops” Field interviews	In the short-term, based on outputs (activity, arrests); in the long-term, based on total crime volume.

Summary

- DDACTS is an operational paradigm that uses crime analysis to focus on hot spots of crime, collisions, and other social harms.
- DDACTS encourages synthesized responses to crime and collision hot spots, involving all operational units and resources.
- Highly-visible enforcement is a cornerstone of the DDACTS philosophy and is used in almost all DDACTS implementations, but it does not need to be used exclusively.
- The seven guiding principles of DDACTS are a focus on outcomes, partner and stakeholder participation, data collection, data analysis, effective strategic operations, information sharing and outreach, and monitoring, evaluation, and adjustments.
- DDACTS is very compatible with existing policing models, including community-oriented policing, problem-oriented policing, intelligence-led policing, and CompStat.
- There are five major categories of crime analysis: tactical analysis, strategic analysis, problem analysis, administrative analysis, and intelligence analysis. Each has something to contribute to DDACTS, though some more than others.
- These categories of crime analysis help inform four major approaches to DDACTS: the strategic approach, the tactical approach, the problem-oriented approach, and the offender-oriented approach. These approaches are not mutually exclusive and can be combined in various ways in a DDACTS model.
- Some approaches to DDACTS attempt to directly reduce collisions at target locations; others use traffic enforcement as a tool to achieve other goals.

For Further Reading

Boba, R. (2009). *Crime analysis with crime mapping* (2nd ed.). Thousand Oaks, CA: Sage.

International Association of Crime Analysts. (2008). *Exploring crime analysis* (2nd ed.). Overland Park, KS: Author.

National Highway Traffic Safety Administration. (2009). *Data-Driven Approaches to Crime and Traffic Safety (DDACTS): Operational guidelines*. Washington, DC: Author. Available at http://www.nhtsa.gov/DOT/NHTSA/Traffic%20Injury%20Control/Articles/Associated%20Files/811185.pdf

2 Data Sources and Management

Strategies for accessing, querying, and cleaning

As the name of the model makes clear, *data* is the key driving component of a DDACTS implementation. Decisions about where, when, and how to enforce should be based on a thorough analysis of collision, crime, call-for-service, and enforcement data. This section of the book covers the strategies and technologies necessary to access, manage, clean, and analyze data.

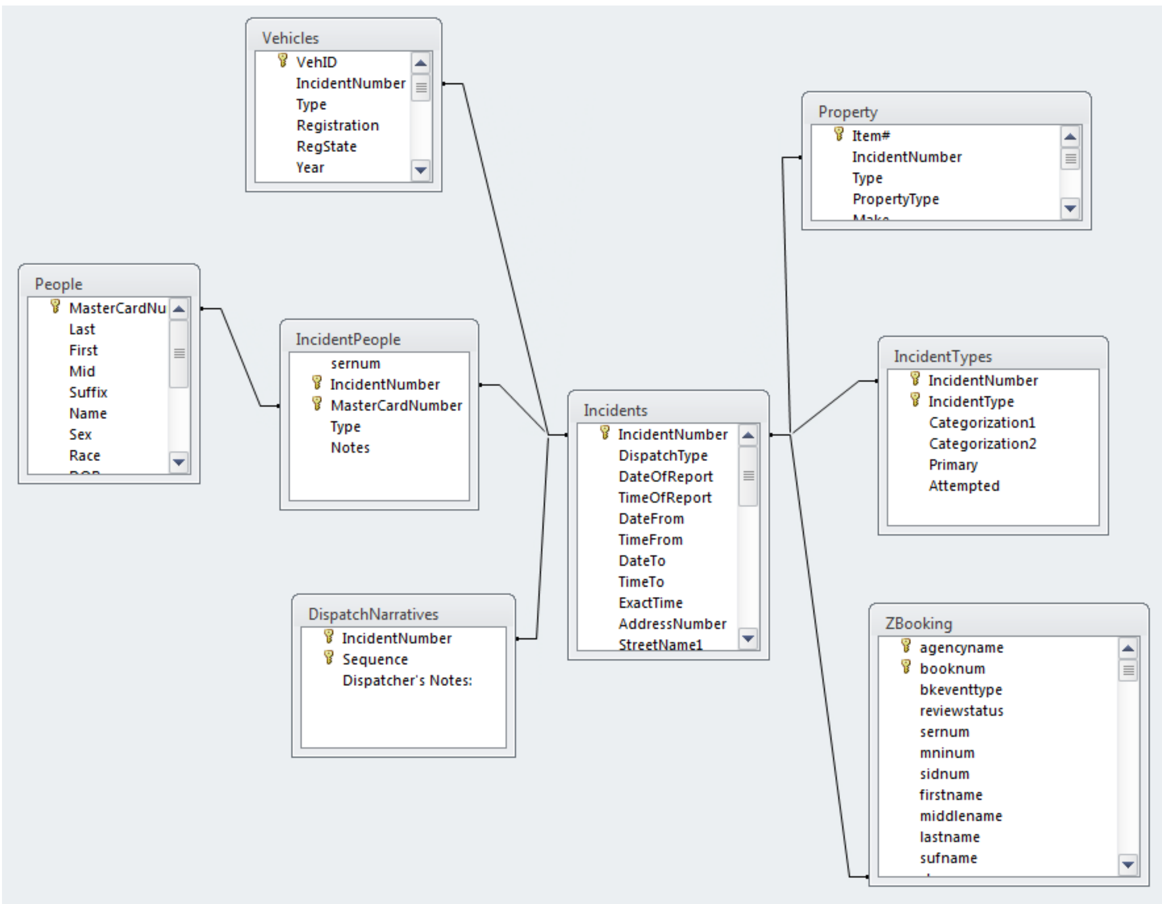


Figure 2-1: Crime analysis, and DDACTS analysis, require the ability to access and query many data sources in a flexible manner.

Data Sources Useful to DDACTS Analysis

Crime analysis can draw on dozens of different datasets to both identify and analyze crime and safety phenomena. Figure 2-3 shows a list from the IACA's *Exploring Crime Analysis*. Specifically for DDACTS, however, there are five key categories of *quantitative* data (data stored in records and fields) that you must access:

1. Incident data, representing both criminal and non-criminal calls for service and police reports. These include:

- Crime and case report records stored in records management systems (RMS)
- Call-for-service records stored in computer-aided dispatch (CAD) systems

The specific records from these systems that agencies use in their DDACTS implementations will depend on the types of social harms that they experience regularly. They will also depend on the types of strategies the agency wishes to enact; certain incident types are more responsive to highly-visible enforcement, for instance, than others.

IncidentNumber	DispatchType	DateOfReport	TimeOfReport	DateFrom	TimeFrom	DateTo	TimeTo	ExactTime	Addre	StreetName1
10000116	MVA NO PI	01/03/2010	06:29	01/03/2010	06:29	01/03/2010	06:29	06:29	32	Centre St
10000117	DISABLED M/V	01/03/2010	06:33	01/03/2010	06:33	01/03/2010	06:33	06:33		Briarwood Dr
10000118	ALARM BUSINESS	01/03/2010	06:34	01/03/2010	06:34	01/03/2010	06:34	06:34	139	Endicott St
10000119	CHECK OTHER	01/03/2010	06:40	01/03/2010	06:40	01/03/2010	06:40	06:40		Collins St
10000120	MOTOR VEHICLE S	01/03/2010	06:42	01/03/2010	06:42	01/03/2010	06:42	06:42	102	Newbury St
10000121	DISABLED M/V	01/03/2010	07:23	01/03/2010	07:23	01/03/2010	07:23	07:23		Maple St
10000122	PUBLIC SERVICE	01/03/2010	07:41	01/03/2010	07:41	01/03/2010	07:41	07:41		Endicott St
10000123	ROAD CONDITIONS	01/03/2010	07:42	01/03/2010	07:42	01/03/2010	07:42	07:42	151	Andover St
10000124	NOTIFICATION	01/03/2010	08:27	01/03/2010	08:27	01/03/2010	08:27	08:27	34	Conant St
10000125	ALARM BUSINESS	01/03/2010	08:32	01/03/2010	08:32	01/03/2010	08:32	08:32	144	Pine St
10000126	ALARM BUSINESS	01/03/2010	08:56	01/03/2010	08:56	01/03/2010	08:56	08:56	382	Newbury St
10000127	MVA NO PI	01/03/2010	09:17	01/03/2010	09:17	01/03/2010	09:17	09:17		Conant St
10000128	M/V VIOLATION	01/03/2010	10:25	01/03/2010	10:25	01/03/2010	10:25	10:25		Armory Rd
10000129	CHECK OTHER	01/03/2010	11:17	01/03/2010	11:17	01/03/2010	11:17	11:17		Sylvan St
10000130	MEDICAL AID	01/03/2010	11:55	01/03/2010	11:55	01/03/2010	11:55	11:55	180	Newbury St
10000132	MVA NO PI	01/03/2010	12:22	01/03/2010	12:22	01/03/2010	12:22	12:22	50	Independence Way

Figure 2-2: A typical CAD data table with associated fields.

2. Collision data. The best, most timely data for collisions will come out of a local collision reporting system, with fields that consider the type of collision, injury severity, and contributing factors. In the absence of a full collision reporting system, the agency can use CAD data for certain collision analysis purposes or try to get data from state reporting agencies.

3. Offender data. Offender-oriented DDACTS implementations require the ability to identify repeat offenders and associations between offenders. Offender data, depending on the nature of the RMS, may include:

- Arrest records
- Suspect records (as attached to incidents, generally)
- Field interview reports
- Known offender files
- Intelligence files
- Association tables linking offenders to each other

4. Crime enforcement data, representing measures the agency has taken specifically to intercede in criminal incidents, namely:

- Arrests
- Field interviews
- Directed patrols
- Other types of pro-active enforcement tactics

Data Sources Checklist

Listed below are many sources of data that a crime analyst might want to obtain.

INCIDENT DATA

- ❑ **Crime Reports** from a records management system (RMS) or from paper copies.
- ❑ **Arrest Reports**, which may be the same as crime reports.
- ❑ **Call for Service Records**, which include both criminal and non-criminal policing issues. Again, in some departments, these are kept in the same system as crime reports.
- ❑ **Accident reports.**

OTHER AGENCY DATA

- ❑ **Teletypes**, received from the antiquated but venerable NLETS system. Most departments have at least one terminal and printer in the dispatch center.
- ❑ **Bulletins and Reports**, issued by crime analysts in surrounding cities and towns.
- ❑ **Regional Newspapers** that cover the analyst's area. Many newspapers now offer their articles on the Internet.
- ❑ **Meetings** of analysts, detectives or other groups in which intelligence is shared.
- ❑ **Online Bulletin Boards & Discussion Groups**
- ❑ **E-Mail Discussion Lists**

OTHER AGENCY DATA (cont.)

- ❑ **Regional Crime Analysis Network** (available in select locations)
- ❑ **Police Magazines, Newsletters, and Journals** sometimes carry pattern and trend information.
- ❑ **Web Sites** maintained by other police departments.

JURISDICTIONAL DATA

- ❑ **Demographic Data**, published by the U.S. Census Bureau (see Chapter 12).
- ❑ **Local Newspaper Articles** on demographic, social, economic, and physical changes in your area
- ❑ **Business Listings** to identify the different types of commercial establishments
- ❑ **Tax Assessment Information** provides economic information and ownership for properties.
- ❑ **Government Web Sites** for news, political information, statistics, other information about the jurisdiction.

PERSONS & BUSINESSES

- ❑ **Field Interview Reports** (certain agencies only)
- ❑ **Intelligence Reports** from informants and other sources.

PERSONS & BUSINESSES (cont.)

- ❑ **Parole Release Notices** from your local corrections agency.
- ❑ **Criminal Histories**
- ❑ **Known Offender Files**
- ❑ **Motor Vehicle Registration and Licensing Data**
- ❑ **Deeds and Tax Assessment Data**
- ❑ **Telephone Directories** (including online "reverse" directories)
- ❑ **City and Town Registers** (in certain jurisdictions)
- ❑ **Pawn Data** (if required by local laws)
- ❑ **Sex Offender Registries**

POLICE ACTIVITY DATA

- ❑ **Call for Service Records**
- ❑ **Arrest Records**
- ❑ **Patrol Rosters** showing which units and areas were staffed on each shift.
- ❑ **Case Histories**
- ❑ **Citation Records**
- ❑ **Directed Patrol Logs**
- ❑ **Budgets**

Figure 2-3: A full list of crime analysis data sources. Source: International Association of Crime Analysts. (2008). Exploring crime analysis *(2nd ed.). Overland Park, KS: Author, p. 21.*

5. Traffic enforcement data, representing measures the agency has taken to intercede in collisions and traffic problems, including:

- Stops
- Citations and warnings
- Selective enforcement assignments
- Assignments spent on specialized traffic programs

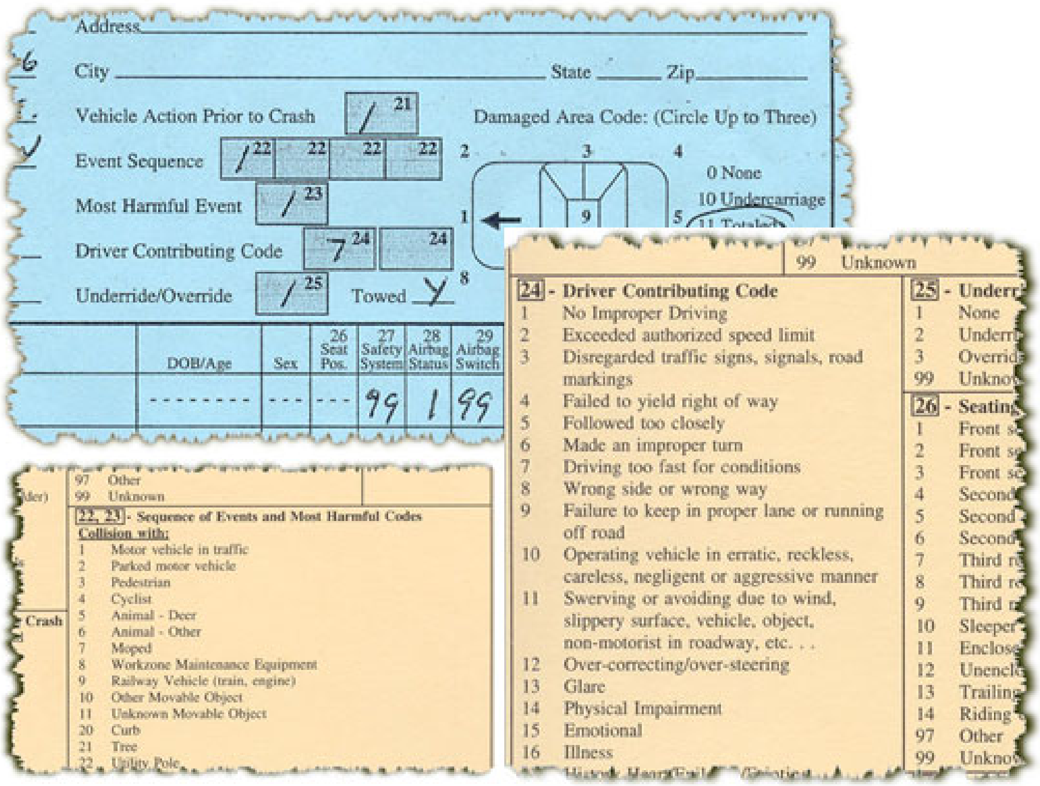


Figure 2-4: A collision report section with associated code tables.

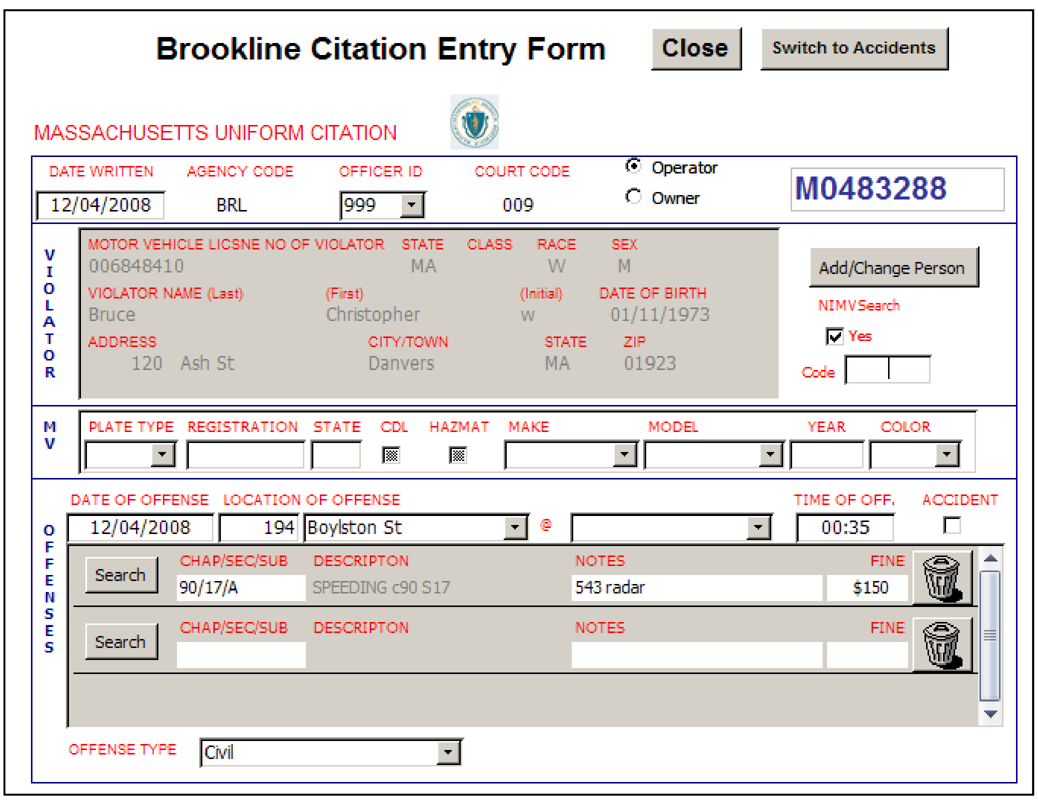


Figure 2-5: An agency-created citation database.

Agencies without existing systems to track these key fields should explore the possibility of creating and maintaining specialized databases to track what their CAD, RMS, and other commercial systems do not. Some agencies will naturally have too much volume to make this feasible, and there are associated costs with personnel and time, but the advantages to having readily-available data often outweigh these obstacles.

Data Management Goals

Data management—a process in which all police departments engage, in some form or another—is one of the most crucial steps in the analysis process, because everything that follows relies upon it. Bad data systems pollute the entire analysis process, from hot spot identification to strategy evaluation. Good ones make an analysts' jobs much easier, allowing them to spend more time conducting crime analysis and less time tracking their information. (In many cases, the most effective and valued analysts are "data masters"—experts at querying, manipulating, and displaying data.)

The means by which various police agencies approach this critical process are as varied as anything in police science. In many agencies, data management remains in its infancy, characterized by the collection of very little data in flat files or even paper-based systems; in others, it is extremely advanced, characterized by expensive computerized records management systems, with aggressive quality control and strong data querying capabilities. But whether an analyst finds the department's data management processes in fine order or in mind-breaking chaos, his or her goal is the same:

> To have **easy access** to a **complete set** of **timely, accurate data** on which he or she can conduct **flexible queries** and **extract** data into common formats for further analysis.

The extent to which the department's data management systems allow or do not allow for each of these five crucial factors determines how much time the analyst must spend entering and managing his own data. In departments with utterly intolerable systems, the analyst may find that he needs to spend half of his day simply entering and tracking reports in a database or matrix of his own design. In departments with superior systems, the analyst will be able to jump right into the process of analysis with little or no preamble.

- **Easy access** means that the analyst has the data at his or her fingertips. The analyst does not need to call someone to get the data. The analyst is not required to use a complicated program. The system does not always hang or crash whenever the analyst tries to conduct a query.
- **Complete set** generally means all the data that is collected in computerized format that the analyst can tap into. In an ideal scenario, the analyst has access to all the tables and fields that he or she might potentially wish to query or display, not just a small subset or a single table at a time.
- **Timely data** refers to the speed at which the data appears in the system. For tactical analysis (and tactical DDACTS) in particular, it is important that the records appear within a day or two.
- **Accurate data** refers to the quality of the dataset. Incidents are coded correctly, locations and times match reality, and in general all important fields are entered without error.

Implications of, and solutions to, common data quality and access problems

Problem	Implications for analysis	Implications for evaluation	Recommended solutions
Inconsistency of reporting or recording data in databases (e.g., shopliftings reported as such sometimes or "larcenies" other times)	Analysis will not be based on a full dataset and may end up inaccurate in places	Cannot properly evaluate changes in categories that are not consistently reported	Extract categories that are consistently reported (e.g., personal injury collisions from "all collisions") and use these for evaluation. Strive for greater consistency in the future.
Limited historical data in database (less than three years)	Cannot develop truly predictive models; can still perform basic hot spot analysis	Cannot evaluate post-DDACTS period against an average, rending evaluation of questionable validity	Do the best you can with what you have, build larger dataset for use in the future.
RMS, CAD, collision, or other systems only allow querying or export on limited selection of data fields or records	Can only perform very basic analysis. Can perhaps only use the strategic model.	Often renders evaluation impossible	Work with RMS vendor to establish open access to raw data for querying, analysis, and reporting
Collision, crime, or call-for-service categories improperly coded	Limited ability to perform detailed analysis of patterns and problems within hot spots, rendering tactical and problem-oriented models difficult	Depending on extent of mis-coding, may render evaluation impossible in those categories	If dataset is small enough, invest time and personnel in re-coding effort for past data. If not possible, evaluate with broader categories. Institute better quality control measures for the future.
Time of occurrence fields (from, to) often left blank or entered inconsistently	Cannot properly analyze and forecast times for property crimes; collisions and person crimes usually unaffected	Cannot evaluate changes in crimes within specific time-of-day periods	If dataset is small enough, invest time and personnel in fixing past data. Institute training and better processes for the future.
Large number or percentage of invalid addresses (low "hit rate" when geocoding)	Some hot spots might be under-reported or missed entirely	May not be able to properly evaluate changes at specific hot spots	Use geocoders with greater tolerance for spelling errors; embark on effort to manually geocode invalid addresses; work with vendors to improve entry of addresses in future.
Large number or percentage of incorrect addresses (e.g., police station, hospital instead of incident address)	May not get full picture at certain hot spots.	May not be able to properly evaluate changes at specific hot spots	If dataset is small enough, invest time and personnel in fixing past data. Institute training and better processes for the future.

Problem	Implications for analysis	Implications for evaluation	Recommended solutions
Missing or incorrect data in other key fields (e.g., type of location, stolen property type, type of collision, characteristics of victims, offenders, drivers)	Makes thorough analysis difficult; may affect ability to implement tactical and problem-oriented models	Generally unaffected, except for inability to evaluate for these specific factors	Institute training and polices to improve data collection in the future.
Causation factors not entered for collision data	Cannot analyze and tailor responses to specific collision causes	Cannot evaluate whether efforts have impacted specific causation factors	Institute better training and quality control efforts on these fields.
Data often takes days or longer to be entered in the database.	Cannot use tactical model. Other models generally unaffected.	Generally unaffected	Institute better reporting processes and policies
Duplicate entries in master name index	May create problems generating "top offenders" for offender-oriented model	Generally unaffected	Work with RMS vendor to develop data querying and merging strategies. Institute training for avoiding problem in the future.

ODBC

ODBC ("Open Database Connectivity") is a technology developed by Microsoft. It uses Microsoft's SQL ("Structured Query Language") to translate data from almost any Database Management System (DBMS).

What this basically means is that almost any application that uses a database (like ArcGIS, SPSS, or Access) can connect to almost any kind of database format. ODBC allows you to open information from an Informix database in a Microsoft Excel file. It allows you to connect to a SQL Server database from a GIS program like ArcGIS. And—best of all—it allows you to bypass your old, clumsy, inadequate records management system and link directly to the data with Microsoft Access.

Unfortunately, setting up an ODBC connection is a difficult, multi-stage process, and it often begins with convincing your records management system (RMS) RMS vendor to allow you access to the data in the first place. Some vendors have taken the stance that their database structures are "proprietary," and they consequently refuse to allow open access to the data. This is an obnoxious, harmful stance for vendors to take, and those that refuse open access should be weeded out in the RMS selection process.

Assuming the RMS vendor allows ODBC access, the next step is to install on your computer the appropriate drivers for the DBMS that the RMS uses. Some of the most common are SQL Server, Oracle, and Informix. Windows comes with a number of drivers already installed, and certain applications (such as GIS systems) will install additional drivers. If you do not already have the driver for the DBMS that your vendor uses, they should be able to help you obtain it.

With the drivers installed, the next step is to set up the connection to the DBMS in the ODBC control panel. In Windows 2000 and above, this is found by clicking on the "Start" menu, then choosing "Control Panel," "Administrative Tools," and finally "Data Sources (ODBC)." You will need a number of parameters, such as the location and name of the database, and a user name and password to log in. These parameters should, again, be provided by your RMS vendor.

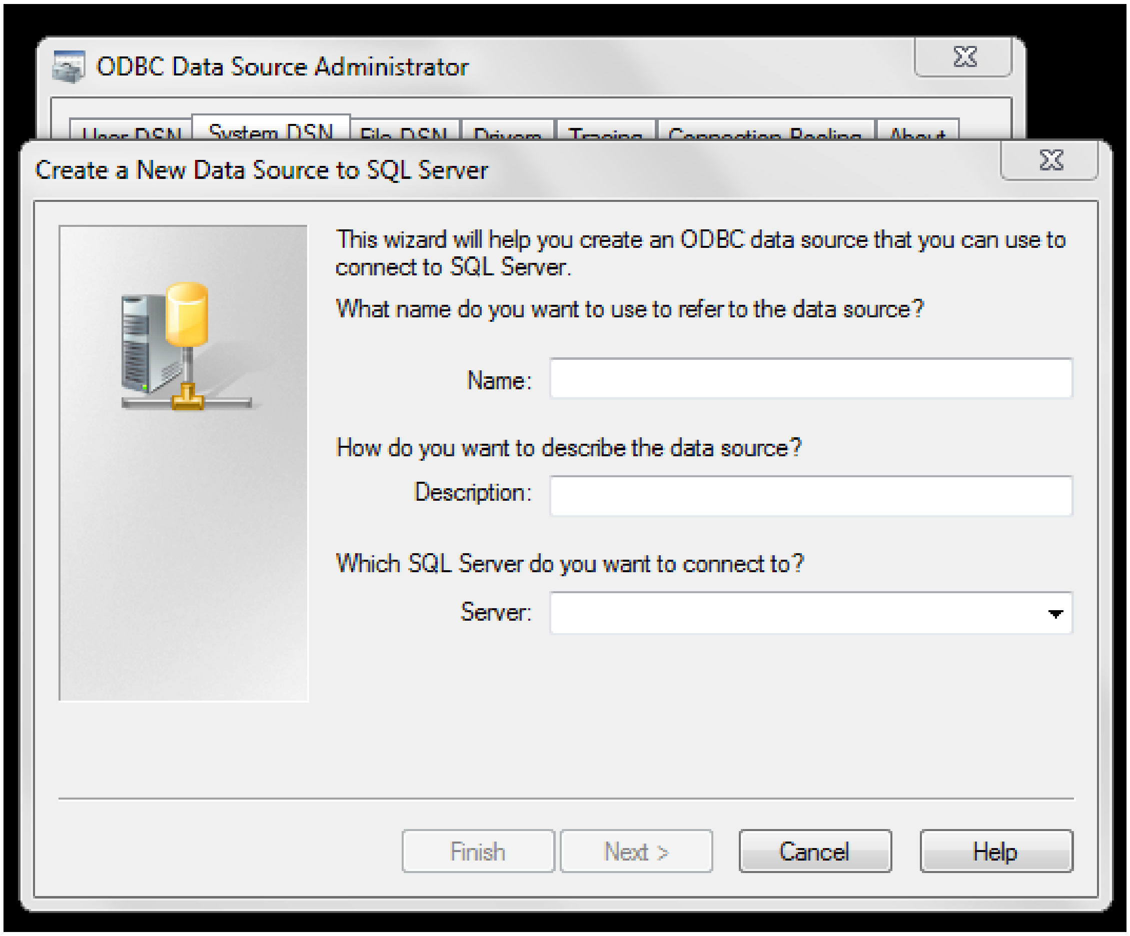


Figure 2-6: Setting up an ODBC connection in Access

Once you've set up the data source, you can link to it from almost any application, including Access.

Even after you successfully link to the RMS database, however, you many still need to choose from a vast list of tables with confusing names, and within each table you may have to puzzle through dozens of fields before you find the ones you want. Depending on the DBMS, you may also have to tell Access how each table is related to the others. It is at this point that a detailed data dictionary from your RMS vendor becomes invaluable. But some RMS vendors are unwilling to provide such documentation, and others simply haven't taken the time to create it. The availability of a data dictionary is another question that should be asked during the RMS vendor selection process.

Approaches to Data Management

The availability of technologies like ODBC offer a variety of options to the analyst when it comes to managing data for DDACTS (or crime analysis in general) on a regular basis. From one extreme to the other, the options are:

1. *Simply use the RMS*[*]. If the records management system is truly complete and accurate enough, and the RMS vendor has given you enough tools to query data as flexibly as you want, and the ability to export or link the data to programs like ArcGIS, you might need to seek no other solution.

2. *Link to the RMS data and use external applications for querying*. If the data is complete, timely, and accurate, but only querying flexibility is a problem, establishing an ODBC link will allow you to use external applications like Access without having to do any querying at all.

3. *Link to the RMS data but supplement with locally-stored tables*. This is a good solution when the data tracked in the RMS isn't *bad*, but rather incomplete. The analyst links to the good data (avoiding unnecessarily replicating it) but supplements it with data he or she tracks manually, such as *modus operandi* factors, collision causes, pattern information, or narrative summaries.

4. *Export data from the RMS, manage in external applications*. This approach makes a copy of the data in the RMS, usually via a series of "append" queries that replicate the crime and collision data in permanent tables. This is a good solution if the data quality is poor and the analyst must do a lot of data cleaning. It is not idea because it takes some effort to ensure that changes in the original database are reflected in the analyst's copy.

5. *A "shadow RMS."* In this drastic solution, the analyst maintains a completely separate database, with all (or almost all) data hand-entered. It is only recommended when no access to the RMS data is possible, or when the data quality and completeness is so poor it would actually be more work to clean it than to type it from scratch.

Summary

- DDACTS requires the collection of analysis of several types of data. At a minimum, these datasets include incident data (from a CAD and RMS system), collision data, and enforcement data. Offender data may be necessary for an offender-oriented model.
- For all datasets, analysts should strive for easy access to a complete set of timely, accurate data on which they can perform flexible queries and extract data into common formats.

[*] For the purposes of DDACTS, "RMS" indicates all important datasets, including CAD data, incident data, collision data, and enforcement data. It may be that one of these approaches works for one type of data, but another must be used for a different type of data.

- ODBC is a technology that allows direct connections to police records management systems and similar datasets. Leveraging it is a key to data access and management.
- Every analyst needs to determine a data management strategy. Options range from simply using the RMS to maintaining a separate database, with various options for linked and local tables in between.

Indicators for different approaches to data management

Timeliness	Quality	Completeness	Querying Flexibility	Solution
Good	Good	Good	Good	Use the RMS
Good	Good	Good	Bad	Link to the RMS through ODBC Use querying tools like Access
Good	Good	Bad	Good	Link to RMS through ODBC Join linked tables to tables you maintain
Good	Bad	Good	Good	Use the RMS Pressure agency to develop better processes *Or* establish two-way ODBC link to clean data
Bad	Good	Good	Good	Pressure agency to develop better processes *Or* use your own "shadow RMS"
Good	Good	Bad	Bad	Link to RMS through ODBC Join linked tables to tables you maintain Use querying tools like Access
Good	Bad	Good	Bad	Import from RMS through ODBC Clean data with tools like Access Use querying tools like Access
Good	Bad	Bad	Good	Import from RMS through ODBC Clean data with tools like Access Join imported tables to tables you maintain Use querying tools like Access
Bad	Good	Good	Bad	Use your own "Shadow RMS"
Bad	Good	Bad	Good	Use your own "Shadow RMS"
Bad	Bad	Good	Good	Use your own "Shadow RMS"
Good	Bad	Bad	Bad	Import from RMS through ODBC Clean data with tools like Access Join imported tables to tables you maintain Use querying tools like Access
Bad	Bad	Bad	Good	Use your own "Shadow RMS"
Bad	Bad	Good	Bad	Use your own "Shadow RMS"
Bad	Good	Bad	Bad	Use your own "Shadow RMS"
Bad	Bad	Bad	Bad	Use your own "Shadow RMS"

3 DDACTS and GIS Data

Getting dots on the map

DDACTS is a location-based paradigm, so spatial analysis of police data with geographic information systems, popularly called “crime mapping,” is a major part of any DDACTS approach. While some small agencies may get by with simple pin maps in cheap desktop mapping tools, online tools, or even paper, any serious approach to DDACTS requires the use of a proper GIS with querying and hot spot identification techniques.

Software

While spatial analysis for DDACTS can be performed with any GIS application, there is currently no serious competitor, with law enforcement agencies, to ArcGIS.

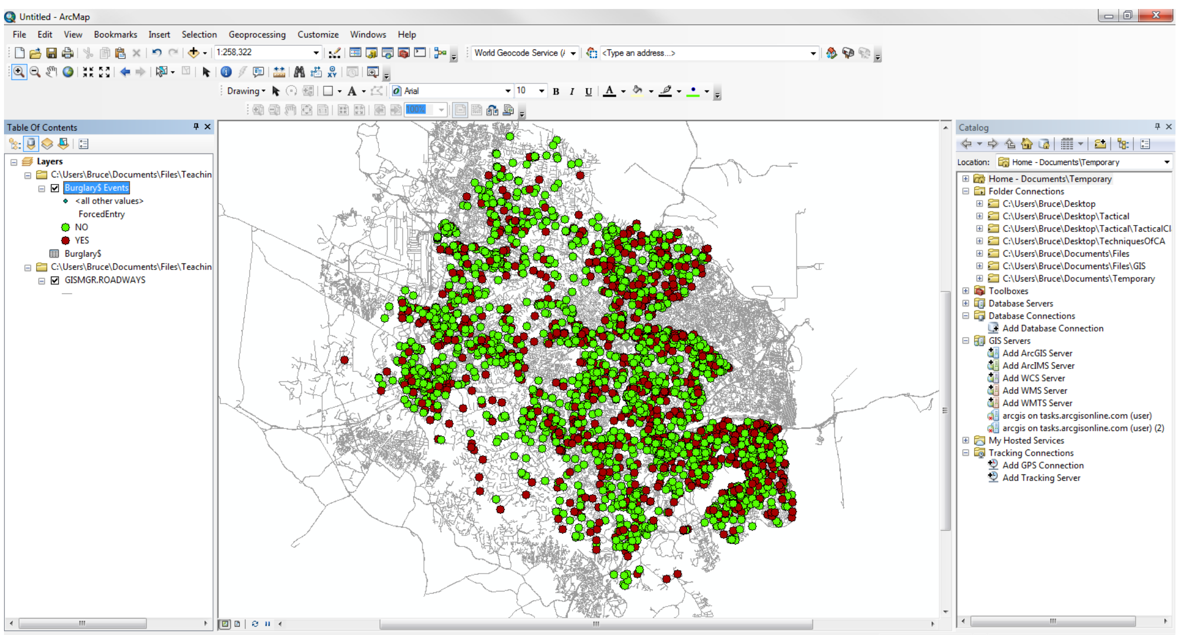


Figure 3-1: The ArcMap application is where most GIS users do their primary work.

ArcGIS is an umbrella term to describe a suite of software and services from **Esri** (this capitalization is the company’s current preference). The software includes:

- **ArcGIS for Desktop Basic**: the software we are using in this class, formerly known as ArcView. ArcGIS for Desktop Basic is the most widely-used GIS software in American law enforcement.
- **ArcGIS for Desktop Standard**, formerly known as ArcEditor. This software provides additional editing capabilities.
- **ArcGIS for Desktop Advanced**, formerly known as ArcInfo, which provides even more editing and analysis capabilities.

These three applications are essentially the same, with more features unlocked as the user produces higher license levels.

- **ArcReader**, **ArcGIS Explorer**, and **ArcExplorer**, all free applications that, with various capabilities and restrictions, allow users to view maps created with the Desktop applications.
- **ArcGIS for Mobile**, a suite of smart phone and tablet solutions.
- **ArcGIS for Server**, an enterprise application that allows organizations to deliver GIS as a service to desktops and mobile applications.
- **ArcGIS Online**, a suite of services with applications hosted, and data stored, on the Internet.

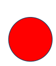
Within the ArcGIS for Desktop installations, there are a number of individual applications:

- **ArcMap**, the main mapping application in which users will spend most time.
- **ArcCatalog**, where users organize and manage their GIS layers and data connections.
- **ArcGlobe**, a 3D visualization application that requires the 3D Analyst extension.
- **ArcScene**, a 3D visualization application that uses the Spatial Analyst extension.

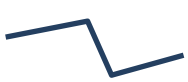
Data

Broadly speaking, there are two types of data in a GIS: **vector data**, stored as geographic coordinates, and **raster data**, stored as pixels. Of the two, vector data is the most common and most useful. Raster data is used for special purposes, such as displaying an aerial photograph of the jurisdiction.

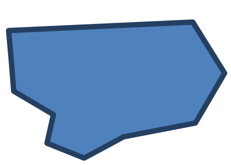
Vector data can exist in three categories: **points, lines, and polygons**, and in ArcGIS, only one type can exist per layer.



Points are stored as only two coordinates: X and Y. Although you can change the size of the symbol, they have no actual dimensions. They are used for collisions, crimes, offender residences, trees, fire hydrants, and other fixed objects and locations.



Lines are stored as two or more pairs of coordinates representing the beginning, ending, and each **node** where the line turns. They are commonly used to depict street (centerlines), rivers, railroads, and other linear features.



Polygons are stored as three or more pairs of coordinates and represent areas, such as parks, lakes, buildings, police beats, city and county boundaries, and DDACTS target areas.

In reality, all features and events on the surface of the Earth are three-dimensional and would be best represented by polygons. However, we use points and lines as acceptable *abstractions* of data

A primary advantage of vector data is that it does not simply exist as a map object. Rather, there is an underlying **database** underneath it, in which each object is a record. It is this database that makes the application a geographic information system, and not simply a map that happens to exist on the computer. The database makes it possible for us to query and represent data in various ways.

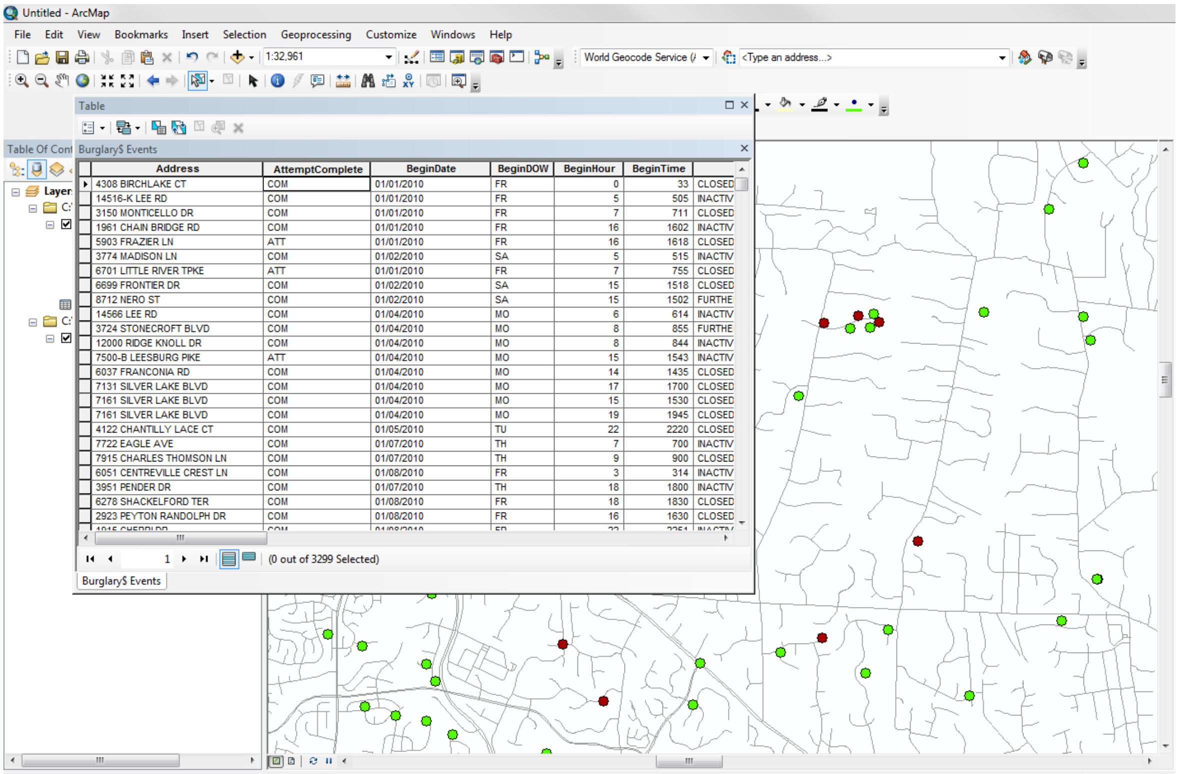


Figure 3-2: Each object on the map has an entry in the database attached to the map layer.

In the GIS map, multiple **layers** appear at once, in the order that the user specifies, much like transparent sheets laid on top of each other. The order matters; polygon features on top of point features will block the user from seeing the points. It generally makes sense to put points above lines, lines above small polygons, and small polygons above large polygons.

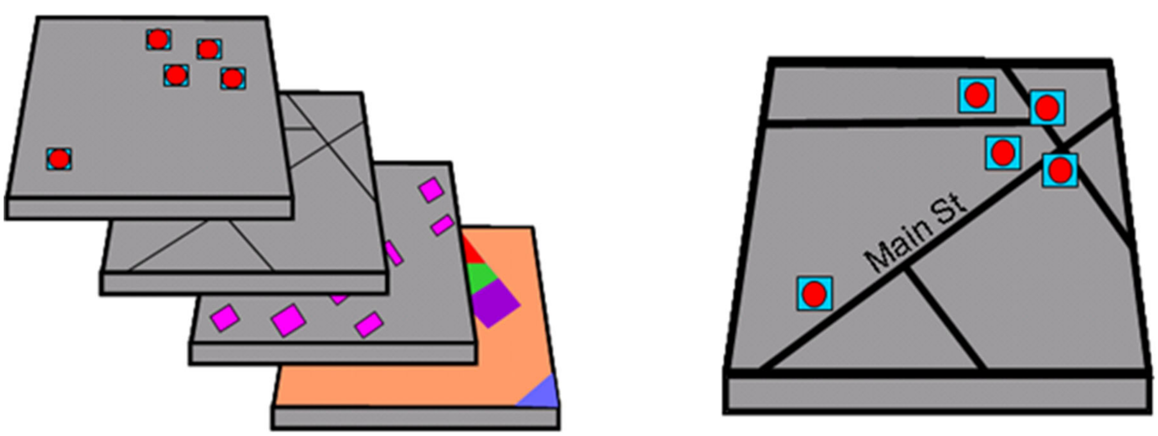


Figure 3-3: Multiple vector layers, overlaid, make the final map.

A **basemap** is a collection of commonly-used layers, establishing the basic geography of the jurisdiction, with the features an analyst or user would most often want to see, with appropriate colors and symbology. Most analysts have a basemap that they use as a starting point for other maps.

Projection and Coordinates

Any space on the surface of the Earth can be identified by its **coordinates**, usually given as the horizontal coordinate, or **x coordinate**, followed by the vertical coordinate, or **y coordinate**. Some advanced GIS applications, particularly in institutions like universities and hospitals, will also include a vertical coordinate, or **z coordinate**, to indicate the specific floor on which an incident occurred.

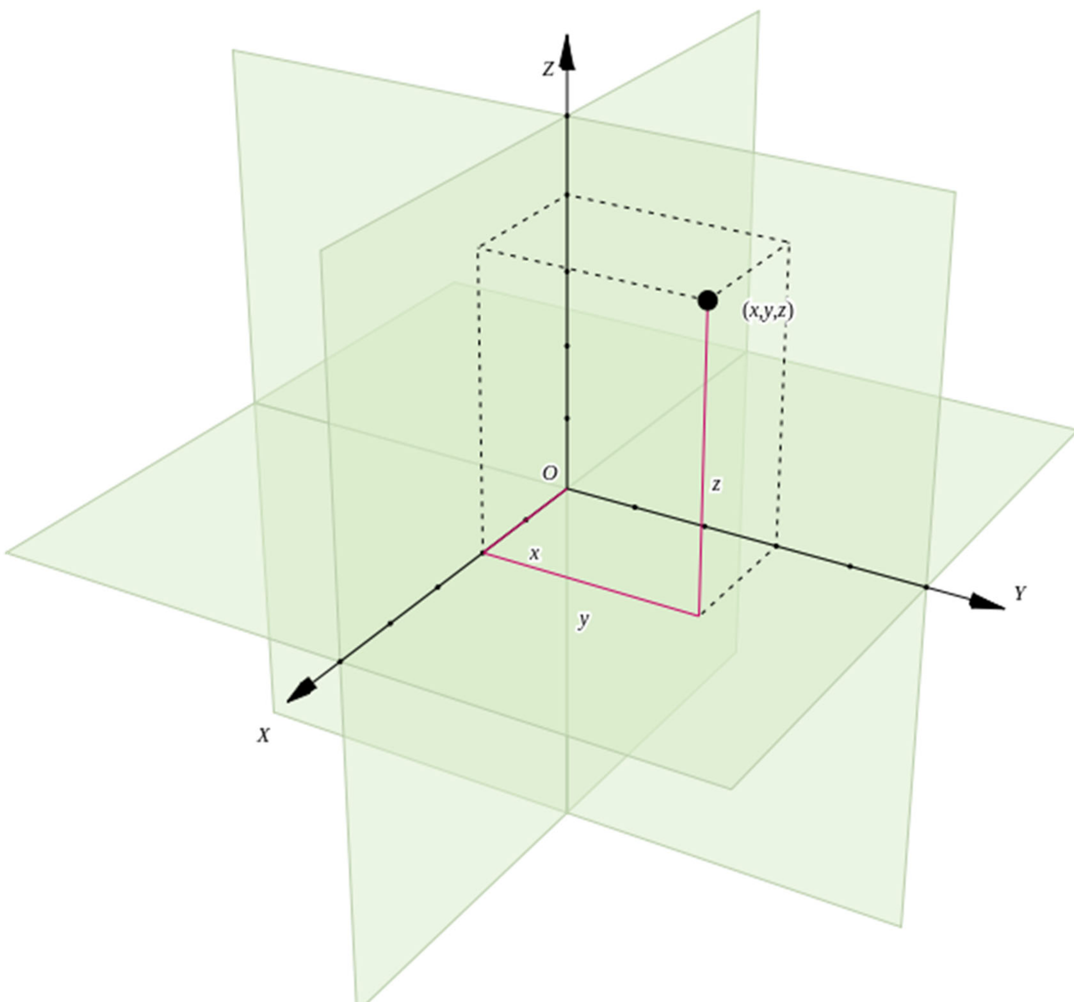


Figure 3-4: A location on the Earth's surface can be represented by two coordinates: X and Y. If we want to also take elevation into account, we need a Z coordinate as well.

There are various systems for representing coordinates depending on a) the origin point; and b) the method used to translate the curved surface of the earth to a flat map. There are two types of coordinate systems commonly encountered in crime analysis:

1. **Geographic coordinate systems**, which do not project the result. These are based on the spherical surface of the Earth. Of these, the most common is simple **longitude** (X) and **latitude** (Y), which use Prime Meridian (running north/south through Greenwich, England) and the equator as their respective origin points. Locations in the western hemisphere, including the United States, have negative X coordinates. Locations in the southern hemisphere have negative X coordinates.

2. **Projected coordinate systems**, which use a *projection* to render the curved surface of the Earth on a flat map. All projections distort some element of shape or distance, but these effects are minimal at the county or city level. In any event, projected coordinate systems use an origin point at an arbitrary location to the south and west of the area of study. In the U.S., the most common projections are transverse Mercator and Lambert conformal conic, both used in the *U.S. State Plane Coordinate System*.

Crime mappers rarely have to worry about choosing the appropriate coordinate system or projection. Moreover, ArcGIS does a fine job synthesizing data from multiple coordinate systems on the same map. However, crime mappers often have to troubleshoot problems with data showing up at the wrong location, and this is often the result of an incorrectly-applied projection.

The key point to understand about ArcGIS and coordinates is this: **If ArcGIS does not know the coordinate system of the data source, it will assume that it uses the same coordinate system as the active data frame**. The coordinate system of the active data frame, in turn, is determined by the first file opened unless the user deliberately changes it.

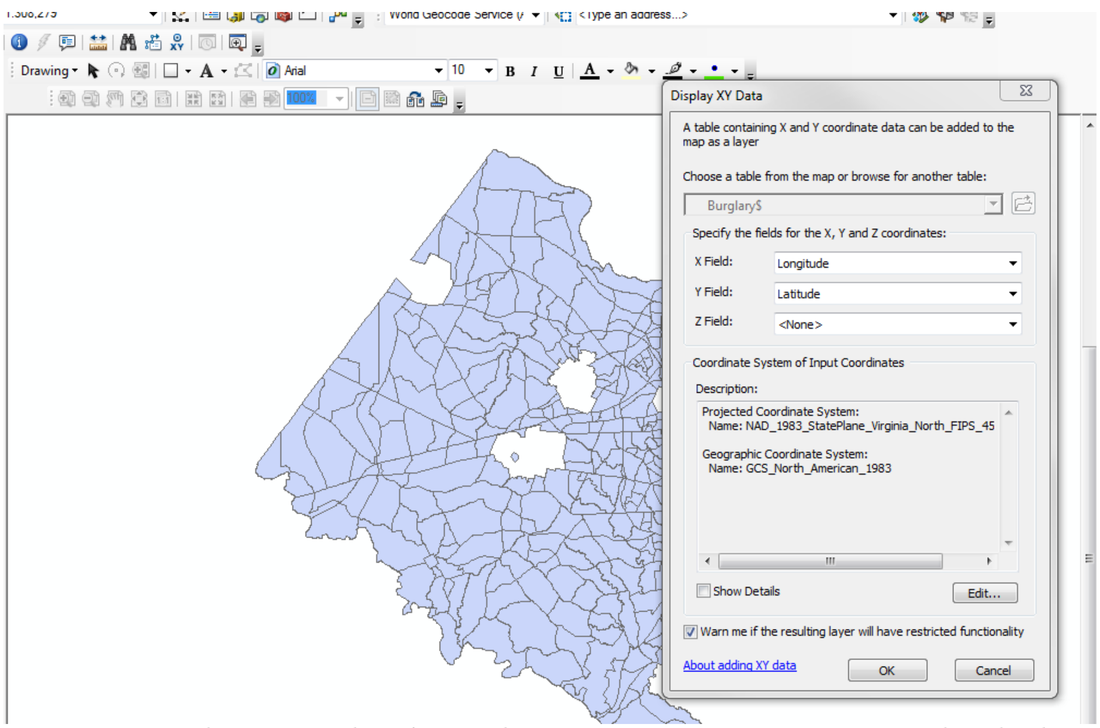


Figure 3-5: Displaying X/Y data from a dataset, ArcGIS prepares to assume that the dataset uses the same coordinates as the data frame (U.S. State Plane). If it is wrong, the data will not display in the right location.

ArcGIS data and files

In the ArcMap application, multiple **datasets** and **layers** are arranged in a **data frame**. One or more data frames make up the **map document**.

Datasets are files to which geography has not yet been assigned, like a crime file linked or imported from a records management system.

Layers are point, line, or polygon files with both spatial coordinates and **attribute data** (the underlying database). Layers can come from a variety of sources, including:

- **Shapefiles**: Esri's native geographic data file format
- **Layer (.lyr) files:** Shapefiles saved with symbology and other information related to how the file displays
- **Coverages**, containing groups of files with a common theme
- **Geodatabases**, which store the attribute and spatial data as part of a relational database
- **Servers** (ArcGIS or SDE), which can provide any of the file formats above over a network

Although Esri strongly pushed for a switch to geodatabases from shapefiles starting in version 8.x, many crime analysts still work primarily with shapefiles. Although there are some limitations with the shapefile format, it is easier to transfer data from one location to another as a shapefile and easier to work with temporary datasets with shapefiles.

In general, at one's own agency, it's best to use whatever data source is provided by the city, town, or county GIS department, establishing a live link whenever possible.

Police data

Police data that you may want to map includes:

- Crimes
- Calls for service
- Traffic collisions
- Recovery locations of stolen property and vehicles
- Offender addresses
- Addresses of individuals with active warrants
- Special locations (e.g., pawn shops, homeless shelters) not found in your existing spatial data

In the case of incident data (crimes, calls for service, traffic collisions), the way that you get it into ArcGIS will depend on its original format. ArcGIS 10.1 will read a large number of different data sources, including:

- dBASE (.dbf) files
- Text files (.txt, .csv)
- Microsoft Excel files
- Microsoft Access databases (via an OLE database connection)
- ODBC databases

Some of these options are accessible under the “add data” button, but for others, you will need to establish database connections in ArcCatalog first.

Most users will not want to link directly to their RMS via ArcGIS but rather though an intermediate database like Microsoft Access, in which they can query the data, clean the data, add additional fields, and perform other manipulation before passing it on to ArcGIS.

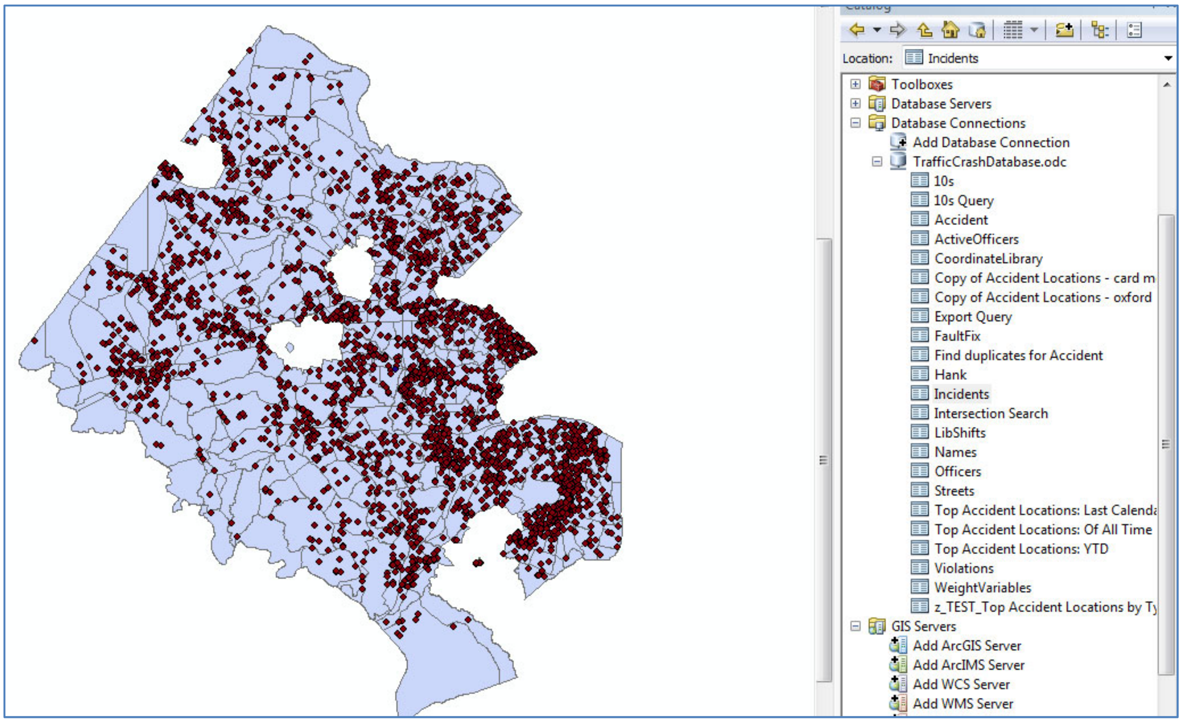


Figure 3-6: This user has established a OLE database connection to an Access database and is viewing the queries within it.

ArcGIS is not a relational database system, so you will have to use your relational database querying applications to ask the questions of the data that you want to map. Pass the data to ArcGIS with as many fields as you feel you need to symbolize it and conduct attribute queries in ArcGIS. At minimum, the data you send to ArcGIS will need proper address fields for geocoding, the subject of the next section.

Geocoding

Geocoding is the process by which we take crimes, calls for service, offender addresses, and other data that interest us and represent it spatially, both for visual interpretation and for calculating spatial statistics. It is one of the most fundamental processes of crime mapping, and fraught with numerous traps and pitfalls. Mastery of an effective, consistent geocoding process should be top priority for any crime analyst.

Geocoding is essentially a process of *assigning coordinates* to a set of records, through one of several means.

Types of geocoding

There are three basic methods for assigning coordinates to database records.

Figure 3-7: Police can achieve perfect precision by standing at incident locations and capturing the coordinates with a GPS.

1. *Acquiring coordinates on-scene through GPS*. This is by far the most accurate method. If done properly, it can result in geocoding precision that allows micro-analysis of hot spots and even plotting crime scenes. (To achieve this precision, we must use hand-held GPS devices; devices installed in police cruisers only show us where the cruiser was parked, not the specific incident location.) It is, unfortunately, very time-consuming, and few agencies have systems in place to do this for anything but the most serious crimes. Even when GPS coordinates are collected on-scene, there is often no mechanism for interfacing the GPS with the original data to populate the coordinate fields. In general, this is a rarely-used but growing technology in policing and crime analysis.

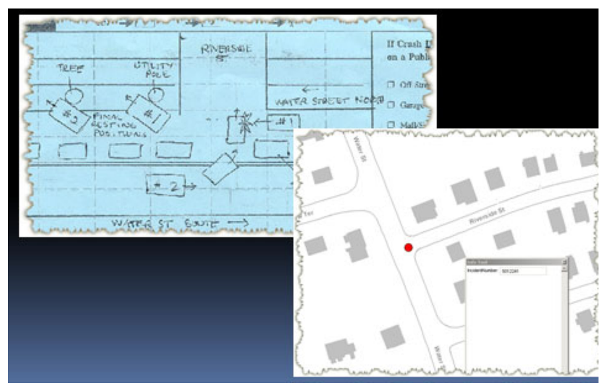


Figure 3-7: Drawing a point on a map based on a collision diagram.

2. *Digitizing*, a fancy term for simply drawing the points on an existing basemap. GIS professionals often use automated digitizing to create basemaps; they interpret features like street centerlines and building outlines from aerial photography and create the vector data based on that interpretation.

When digitizing crime and other incident data, we don't generally have the luxury of automated methods, meaning someone must study the map or diagram of an area and carefully draw the point on the map, thus assigning the coordinates to the incident. When done in policing, this is most often done for traffic collisions. Limited digitizing can also be used to create an address point file (see below).

3. *Address matching*. Address matching is by far the most common method of geocoding in policing, in which coordinates are assigned to each incident based on the incident address when compared against a *reference layer* containing the addresses in the jurisdiction. This process has some inherent inaccuracy, as covered below.

Displaying X and Y coordinates

Data with X and Y coordinates (longitude and latitude) already assigned in the attribute file does not need any special handling in ArcGIS; you simply right click on the file and choose "Display X/Y" to get the points on the map. However, if the coordinate system used in those fields in the incident data does not match the coordinate system used in the data frame, the points will not appear in the right location. You may have to tell ArcGIS what coordinate system the data uses so it can do the right underlying mathematics.

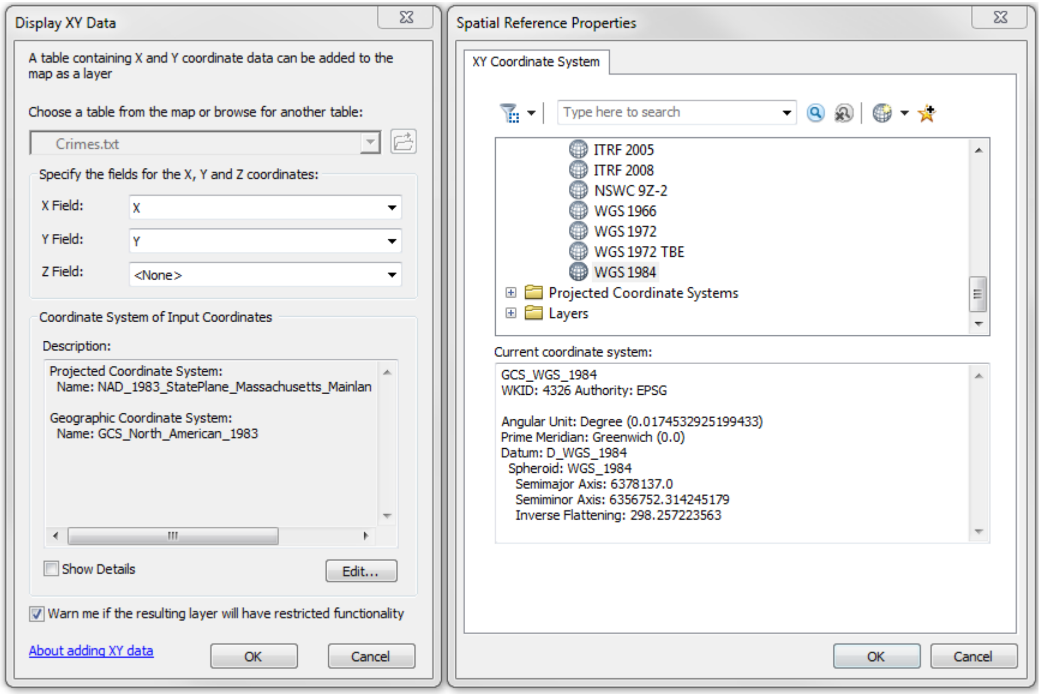


Figure 3-8: Displaying data with X and Y coordinates already assigned, and choosing the correct coordinate system.

The resulting layer in ArcGIS will have "limited functionality" because ArcGIS hasn't assigned an ObjectID. To be able to select by the attributes in that layer and use it in some of the spatial statistics routines, you will need to export the layer as a shapefile or geodatabase feature class.

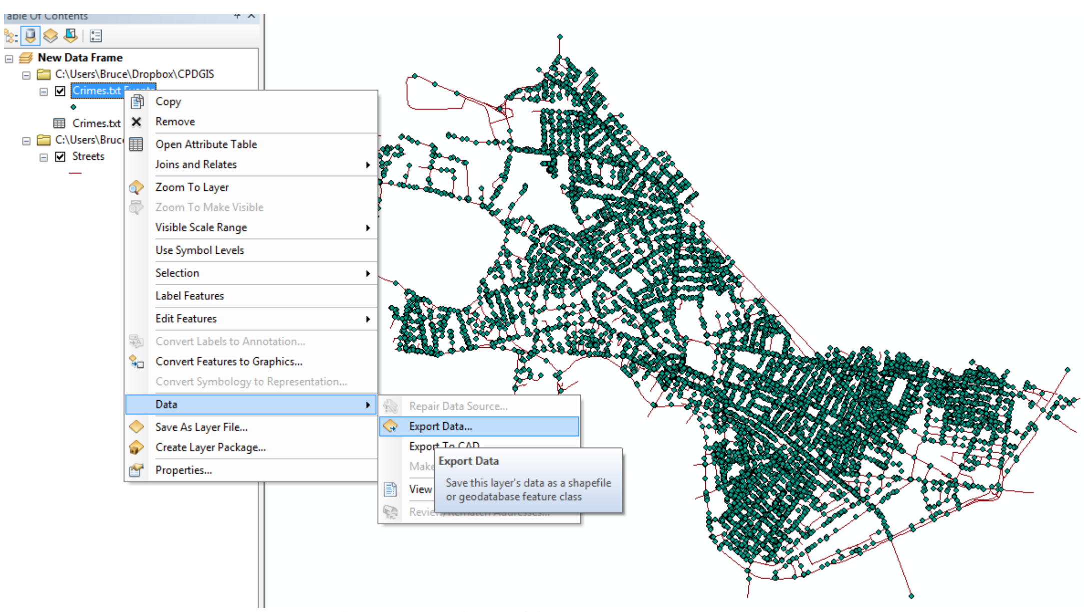


Figure 3-9: Exporting X/Y data as a shapefile.

Address matching

Address matching is a process of comparing a dataset without coordinates to a dataset *with* coordinates to assign the coordinates from the latter to the former. There are multiple methods of address matching and multiple types of files against which the user can match. The most common methods of address matching in policing, in order of precision, are:

- Matching to an "address points" layer that has all valid addresses in the jurisdiction
- Matching to a parcel layer with each parcel's unique address
- Matching to a street centerline file with address ranges for both sides of the street

Whatever the reference layer, the analyst will have to create an **address locator** against which to match incident data. There are many styles of address locators in ArcGIS, but probably the most common are:

- **Single field:** Used when all the address data in the reference layer is in one field, such as in a parcel, building, or address point layer.
- **U.S. Address – Dual Ranges**: Used for street reference layers that have fields for the street name and the address ranges (lowest and highest) on both sides of the street.

The second option is probably the most commonly used by law enforcement agencies. With this style, the only fields *required* in the reference layer to create an address locator are:

- Street name ("Street Name")
- Lowest address number on the left side ("From Left")
- Highest address number on the left side ("To Left")
- Lowest address number on the right side ("From Right")
- Highest address number on the right side ("To Right")

However, the locator also supports additional fields, such as the city or zip code on either side of the street. If this exists within the reference data, it's fine to include it in the locator **as long as it will also exist in your incident data**. If your incident data will not have city names or zip codes, do not include them when creating the locator even if they are in your reference layer (the street centerline file).

Address locators created from a street file will *interpolate* (estimate) the locations of specific addresses based on their proportion along the range. For instance, in the figure below, the address range goes from 101 to 119, but the actual highest house on the segment is 113. When the user geocodes incident data, it will place 113 slightly more than halfway down the street segment, since 113 is slightly more than halfway between 101 and 119. Thus, there is always some inherent inaccuracy in street-based geocoding. It is, however, the only method (short of an address point layer that includes every intersection) to geocode incidents that occur at street intersections.

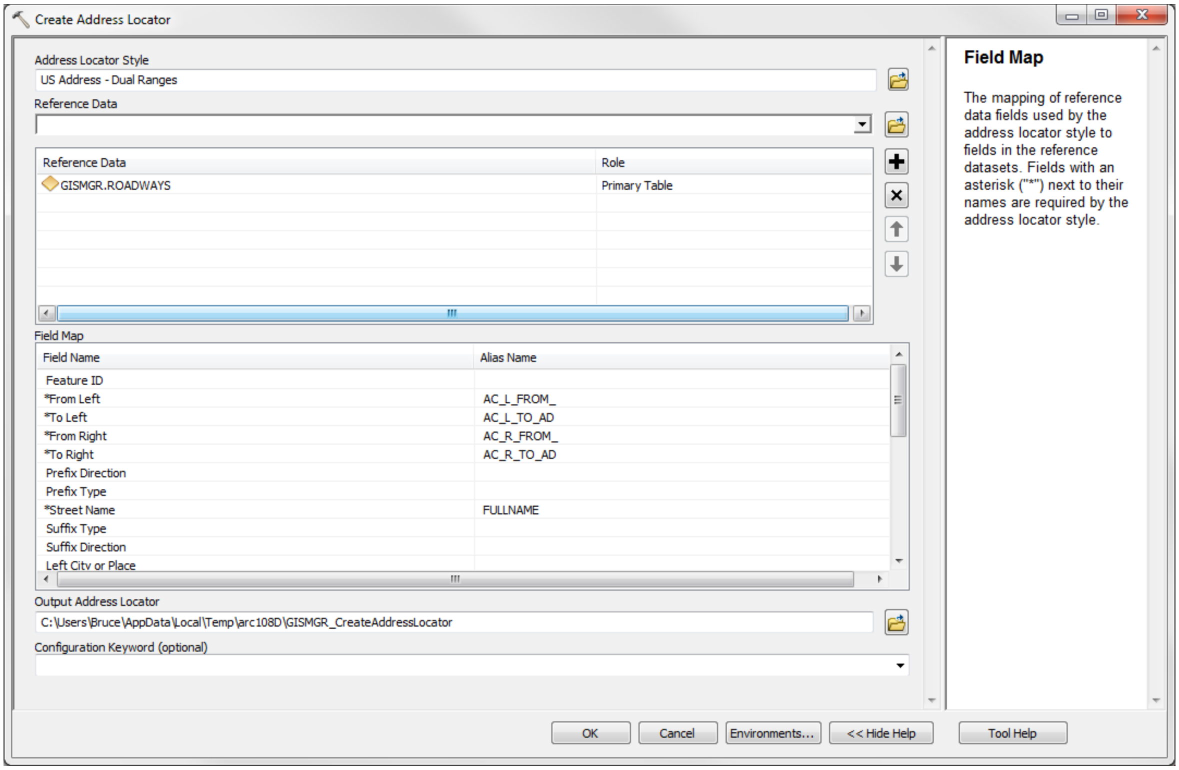


Figure 3-10: Setting up an address locater for a street file.

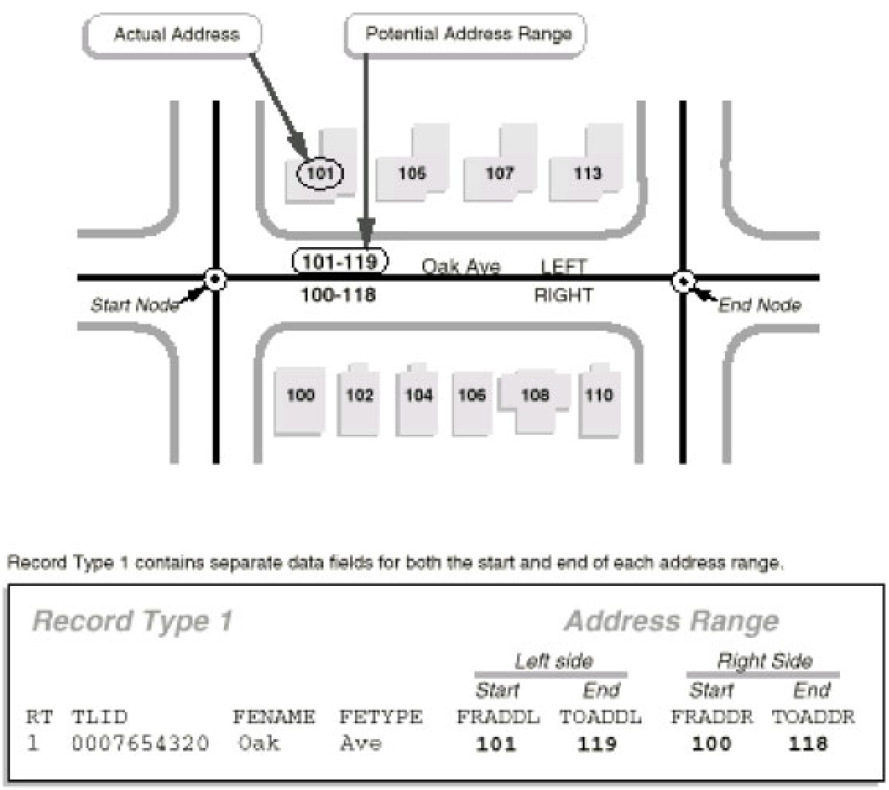


Figure 3-11: The logic of address matching through interpolated street locators.

When geocoding against a street-based locator, the analyst has a few additional options. One involves the **side offset**. This determines how far to the side of the street centerline the point appears. If geocoding house burglaries, for instance, you might logically assume that most houses are offset about 50 feet from the street, and thus offset the geocoding by 50 feet. When geocoding crashes, on the other hand, you probably want to set the offset to 0 since most will occur right on the street.

The **end offset** is an additional setting. By default it is set to 3%, which means that even if an incident location has the same address as the lowest "from" address on the street, the point will not literally appear at the end of the street. Instead, it will appear 3% down the length of the street segment. This is to prevent, for instance, incidents that occurred in buildings from being geocoded to the street intersection. There are few reasons to adjust this setting downward. You may want to adjust it up.

The locator may not **output** the X and Y coordinates by default, meaning they will not show up in the attribute data. It is extremely valuable for later use in spatial statistics to check this box and include the coordinates in the output.

It is possible to create a **composite address locator** by joining two or more address locators together. You may, for instance, first want to geocode against a parcel layer and then, for those incidents that could not be matched, against a street centerline locator.

Finally, ArcGIS has several online services that allow you to use their national and world locators, updated periodically, instead of bothering to create your own. Their locators tend to be sophisticated composite locators that take into account alternate spellings and other common data errors. The downside is speed; it can take hours to geocode thousands of incidents over the Internet, and the process might fail in the middle, forcing you to start over. Also, Esri keeps changing the availability of these locators. Esri's locators are a good idea when geocoding data outside your jurisdiction for which you do not have a reference layer.

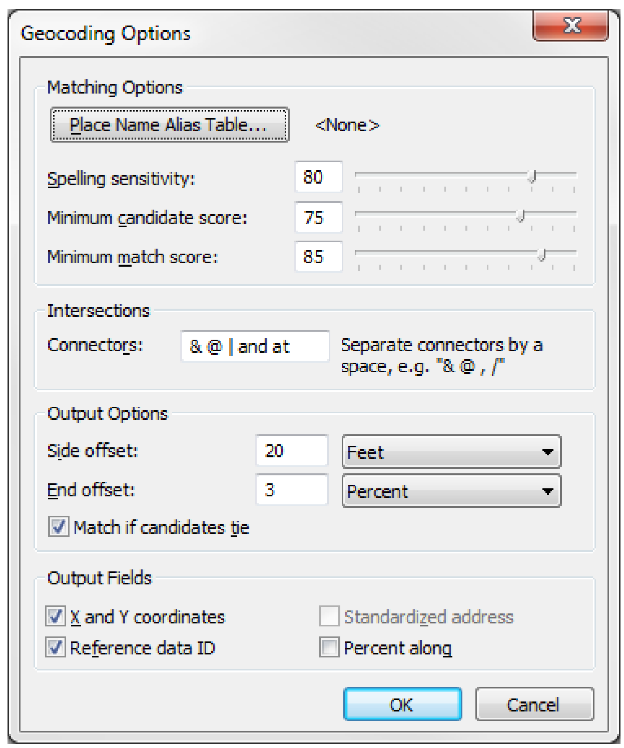


Figure 3-12: Geocoding options using a street locator.

Hit rates and data cleaning

Whatever you use as the reference layer, when ArcGIS finishes geocoding, it will display the number of matches, ties, and records that it could not match. The percentage that it could match (and perhaps the percentage that tied, depending on your settings) is known as the "geocode rate" or "**hit rate**."

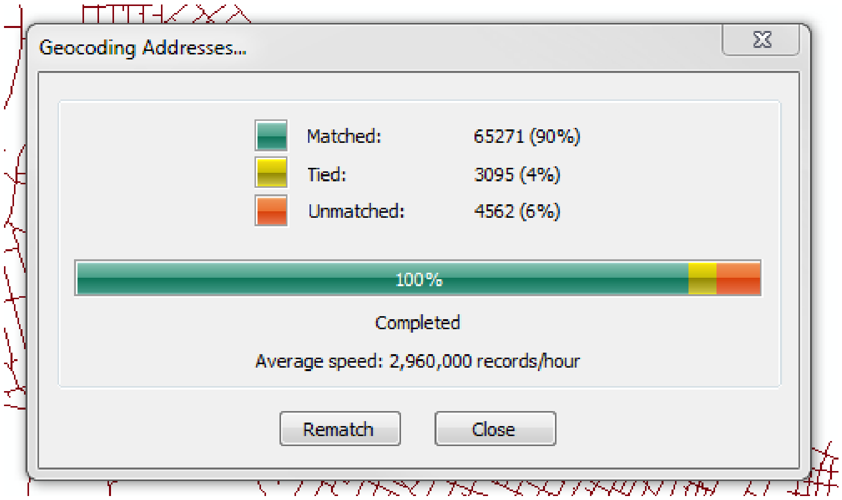


Figure 3-13: Geocoding produces a "hit rate" at the end. This rate is either 90% or 94% depending on whether the analyst selected the "match on tie" option.

The hit rate depends on how well the addresses in the incident table matched the addresses in the reference layers. There is no universal standard for what is an "acceptable" hit rate, since the nature of data and data quality varies tremendously across agencies. Generally speaking, we should always strive for 100%--after all, if we get a hit rate of 99%, the other 1% may all be at the same location, and we'll miss a major hot spot. Practically, however, police incident data often has addresses that can *never* be geocoded—not without a significant investment of time tracking down the original officer or reporting person—so analysts often live with hit rates in the 80s or 90s. It is obviously less forgivable to have low hit rates with smaller datasets (for tactical crime analysis, there's rarely any excuse for not getting 100%, no matter how much effort it takes) than larger ones.

Addresses can fail to geocode for any number of reasons, generally falling into four categories:

1. The location of the incident is unknown, and there is no associated address data. This is fairly rare, but it can happen if, say, a victim parked his car at several locations throughout the day and some property was stolen at one of them. It also happens with intoxicated victims or victims unfamiliar with the jurisdiction who report the crime later. When dealing with personal addresses, this occurs if the individual is homeless.

2. The location given in the police data is incorrect, but the reference data does not have it. This happens with old reference data that does not update new streets, houses, or businesses.

3. The location given in the police data is incorrect. This can take many forms, including:

- The street is misspelled
- The location refers to an intersection of two streets that do not intersect
- Unrecognized symbols to indicate an intersection junction

- The street is correct but the address number does not exist
- A common place name or abbreviation is used instead of the actual street address
- A key address field (street number, street, intersecting street) is not entered

StNo	Street	Street2
	Creek Crossing Rd	
190		
2070	Chian Brig Rd	
	Old Courthouse Rd	International Dr
	Westwood Country Club	
2070	CBR	
2000700	Chain Bridge Rd	

Figure 3-14: All of these addresses will fail to geocode, but for different reasons.

In the short-term, the analyst has the option to conduct a manual re-match of addresses, considering each one and making adjustments to the address in ArcGIS. It is unfeasible for very large datasets.

In the long-term, analysts should try to achieve better geocoding precision through a number of mechanisms.

- If the problem is with the reference data, the analyst should refresh the data from the source or (if the source is the problem) manually edit the layer to add the new features.
- If the problem is with the source data, the general rule is to clean it as close to the point of error as possible. In order, this is:
    - Validation rules on the database where the original record is entered, prohibiting incorrect data entry without at least making the user "force" the bad address
    - Automated routines to clean the data at the source
    - Routines to clean data within an analysis database copied from the source
    - Routines that clean the data while passing it to ArcGIS for geocoding
    - Use of an alias table in ArcGIS to convert the most common errors
    - Manual address matching in ArcGIS

Most analysts will have to perform some combination of the above to maximize geocoding accuracy, although the best solution, covered below, is to assign X and Y coordinates at the data source and abandon regular geocoding in general.

Assigning coordinates from a database

The best way to "address match" in the long term is to do it outside the GIS. This is done via a database table called a **coordinate library** that has all of the addresses in the jurisdiction and the associated X and Y coordinates. The primary advantage to this process is that you can link to queries that use the coordinate library from ArcGIS and immediately display the data, with no geocoding required. You can also fine-tune where various points appear.

In some police agencies, this process is handled automatically by the CAD system or RMS. You have to be very careful about this process. The accuracy of the geocoding will depend on the accuracy of the original address-matching process that created the coordinate library. Moreover, the coordinates assigned by the CAD system or RMS may not automatically update if someone changes the address. They may reflect the original call location rather than where the incident actually occurred. It is possible that you have a fantastic system that takes all these variables into account, but I have rarely encountered a situation in which I didn't recommend that the analysts maintain their own coordinate library.

Generating the library is relatively simple, though extremely time-consuming. It is nonetheless worth doing at least once:

1. Pool together multiple data sources to create an exhaustive list of addresses used in your jurisdiction. If you don't have a master address file anywhere, you can pool records of calls for service, crimes, victim addresses, and offender addresses over a multi-year period, which should cover all but the most obscure addresses in your city.

2. Delete from the list addresses that will never be geocodable, such as streets with no address number or intersection.

3. Geocode the master list using one or more of the address matching methods above.

4. Take the time to manually geocode those addresses that do not geocode during the automatic process. Discard those that simply don't exist, of course, but otherwise try to assign the best coordinates to each real address, including aliases and abbreviations if these will continue to show up in your records.

5. Convert the resulting ArcGIS .dbf file (with the address fields and coordinates) to whatever format you prefer. For instance, you might import it into Access to link with your incident records.

Address	X	Y
410 Norfolk St	765551.087474	2961891.02374
23 RESERVOIR ST	754392.92643746	2963323.25193786
Erie St & Sidney St	762960.919956	2955869.08005
125 Brookline St	763062.013122	2956722.82319
29 Hutchinson St	754740.242131	2964739.65376
138 Antrim St	763893.010486	2961440.5466
1039 Massachusetts Ave	760848.963935	2960035.96179
12 Waterhouse St	758275.20780137	2962802.80980908
Flagg St & Memorial Dr	759841.510038	2959281.69007
249 Walden St	755869.847996	2965967.76377
413 Washington Ave	764071.150938	2958648.88034
210 River St	761304.496924	2957592.69999
Cambridge Common	758582	2962269
Bow St & Plympton St	759679.810155	2960674.01001

Figure 3-14: An example of a coordinate library in Access. Some jurisdictions might need additional fields beyond the "Address."

6. Manually adjust the coordinates as assigned by this process to your preferred location. For instance, you might want to adjust the coordinates of your top "hot spots" to preferred locations in their parcels or building foot prints.

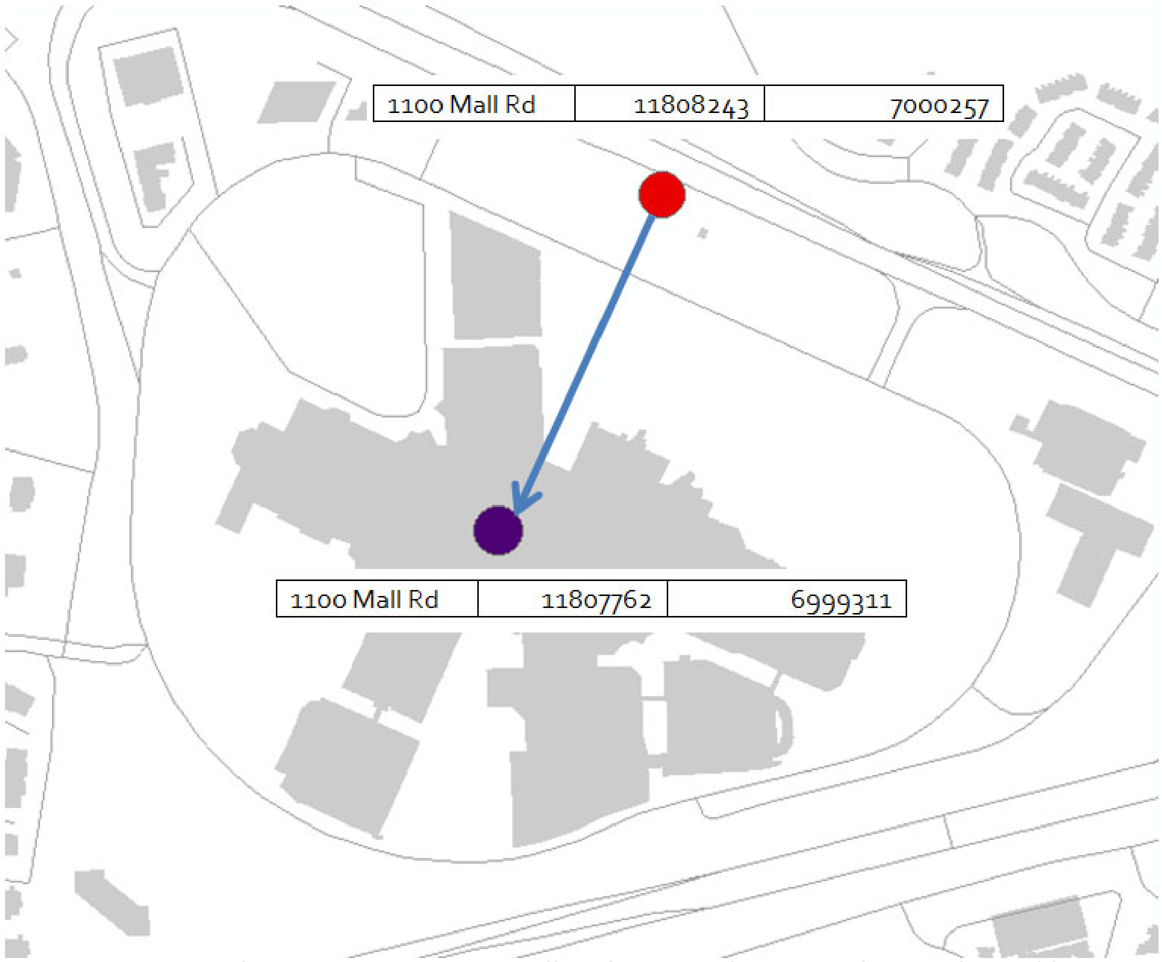


Figure 3-15: An analyst may want to manually adjust coordinates in the coordinate library, so that (for instance) coordinates originally geocoded to the street centerline appear on top of major facilities.

7. Link this file to your incident (or other address) data whenever you want to display the results on a map.

8. Regularly analyze addresses in your incident records that do not have matches in the coordinate library, and make additions as required.

The beauty of a coordinate library is that you can add additional fields from your incident dataset to the library to fine-tune the coordinate locations. For instance, if your incident dataset has a "location type" field, with entries for things like "Parking Lot," "Street," and "Restaurant," you can have a separate set of coordinates for each of these variables to ensure that the dots appear in the right place. Unit numbers and names of businesses can also help fine-tune the coordinate library.

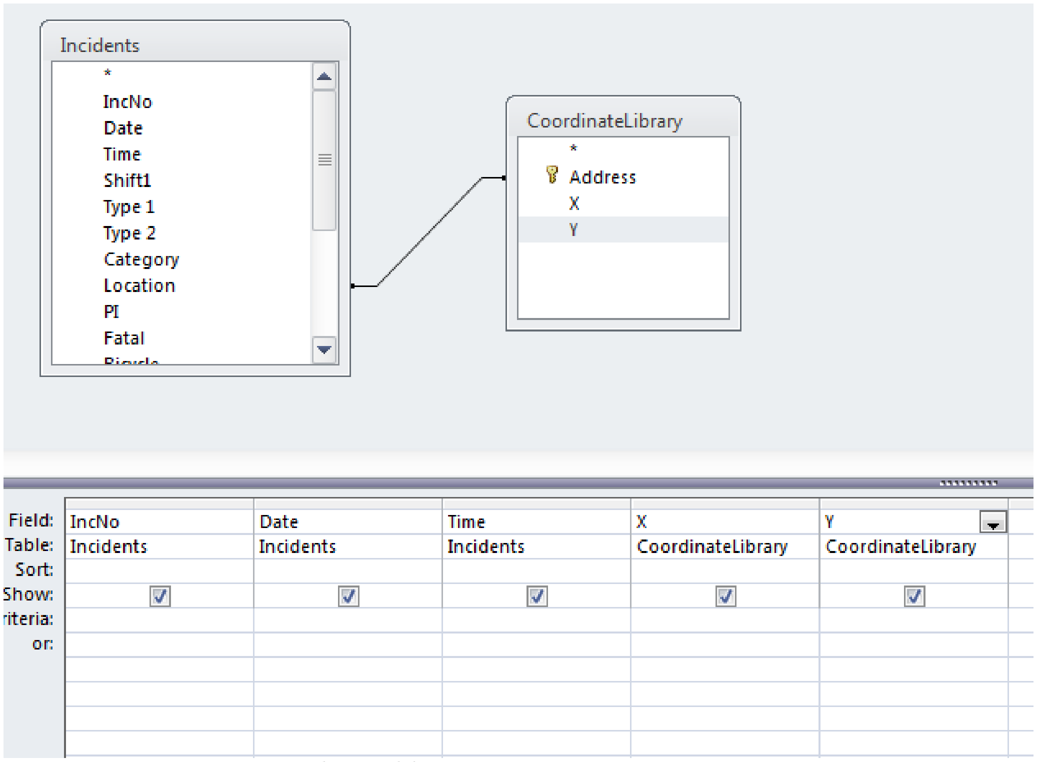


Figure 3-16: Using a coordinate library in an Access query.

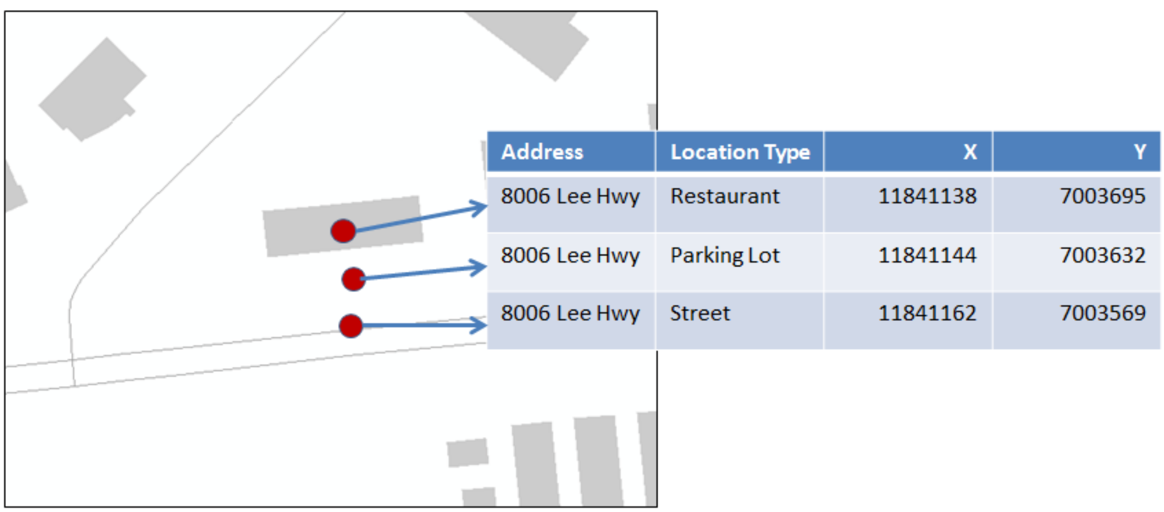


Figure 3-17: A coordinate library can help you fine-tune where points appear based on other fields.

In striving for completeness, accuracy, and precision in our geocoding, we must of course balance with the amount of effort and time that it takes. But a strong investment of time and effort during a limited period can pay off for years to come.

However we get the points on the map, the result—a pin map—is usually the basis for all the other types of maps we want to create and the spatial statistics that we want to calculate. The lessons continue with thematic mapping.

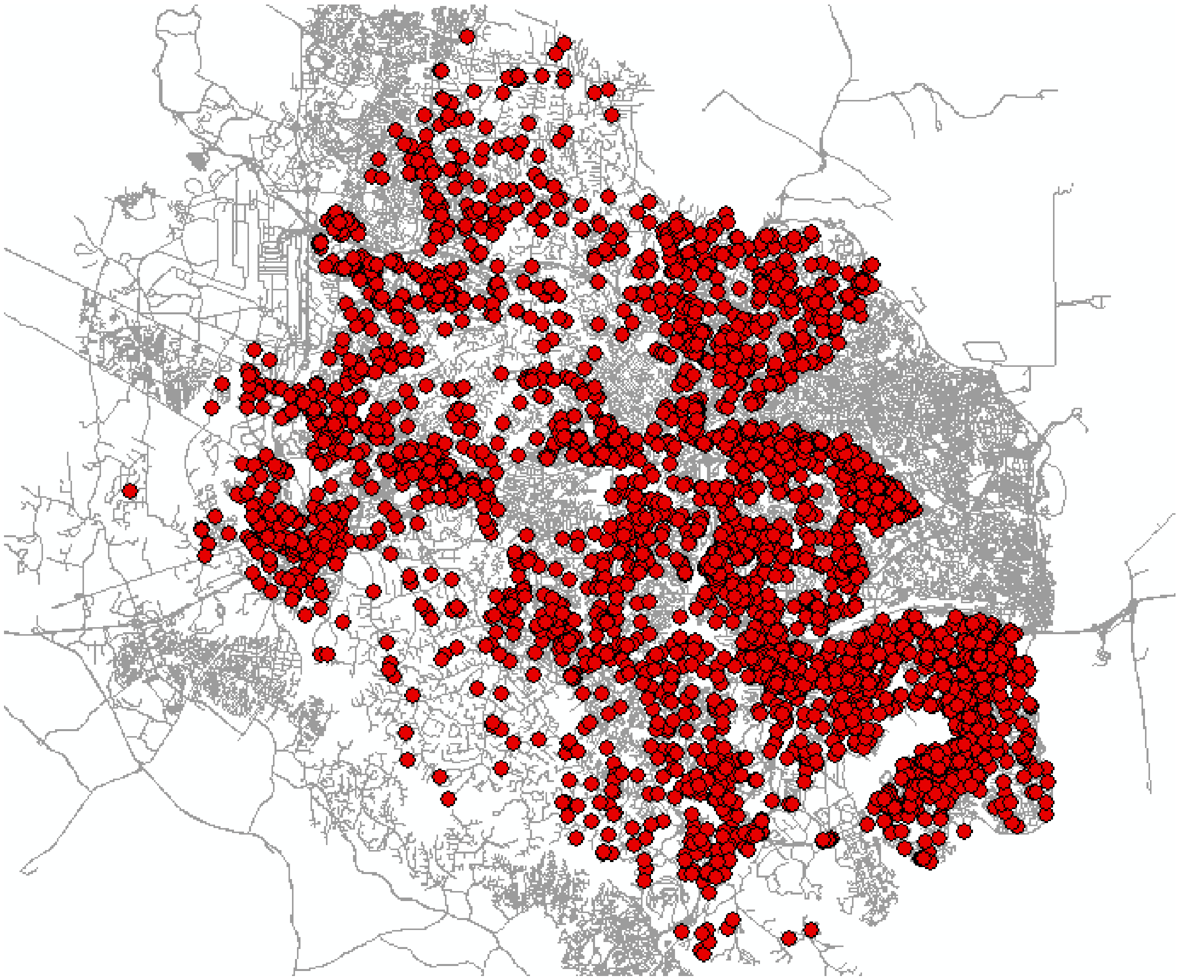


Figure 3-18: A pin map, or the initial result of geocoding.

4 DDACTS and Thematic Mapping

Identifying hot spots and other key areas

Thematic maps are so-named because they tell "themes" or "stories." They don't really represent actual geography of the Earth's surface but rather depict some social, political, cultural, economic, or other aspects of the area.

Types and Uses of Thematic maps

The following section lists the most common types of thematic maps, how to create them, and when to use them. They are presented roughly in order of complexity.

Point symbol maps

Point symbol maps simply vary the basic pin map by using a different color, symbol style, or both to represent characteristics of the data.

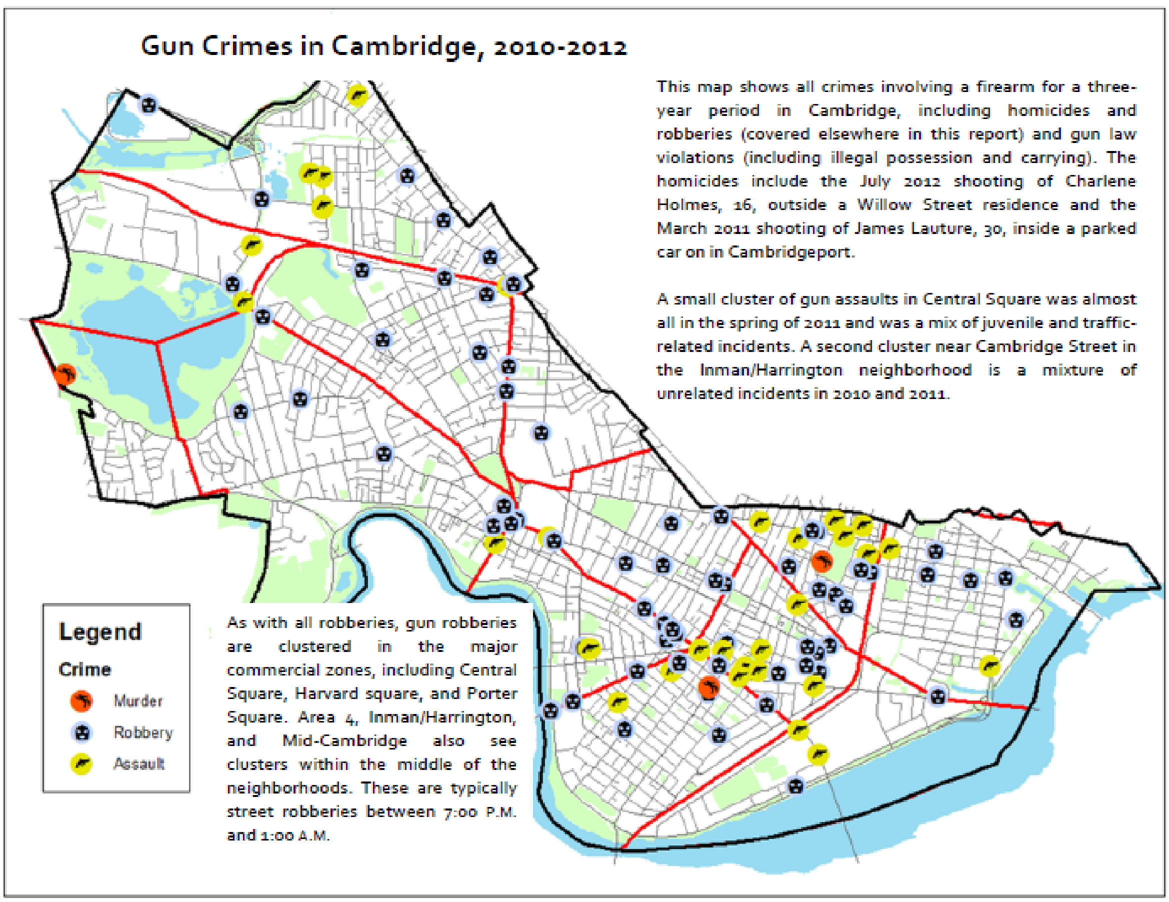


Figure 4-1: A point symbol map from the Cambridge Police 2012 Annual Crime Report

Point symbol maps help display patterns within certain datasets. For instance, in the map above, although the common dataset is "gun crimes," we see that almost all gun assaults occur in three clusters, while robberies have a greater rate of dispersion across the city. Unfortunately, point symbol maps are not feasible with very large datasets. Even in this dataset, we see many overlapping points that obscure visual interpretation.

Point symbol maps are also a poor choice with too many categories. Five to seven is probably the maximum number that readers can visually interpret, especially when the symbol is based on color.

To create a point symbol map in ArcGIS, start with a pinmap. In the “Layer Properties,” change the symbology from “Single Symbol” to “Categories,” and put the desired category into the “Value Field” box. “Add All Values” to load them, and set the symbology accordingly.

You do not have to display all values on the map. You can remove selected values, in which case they appear under “all other values,” a category that you can choose whether to show or not.

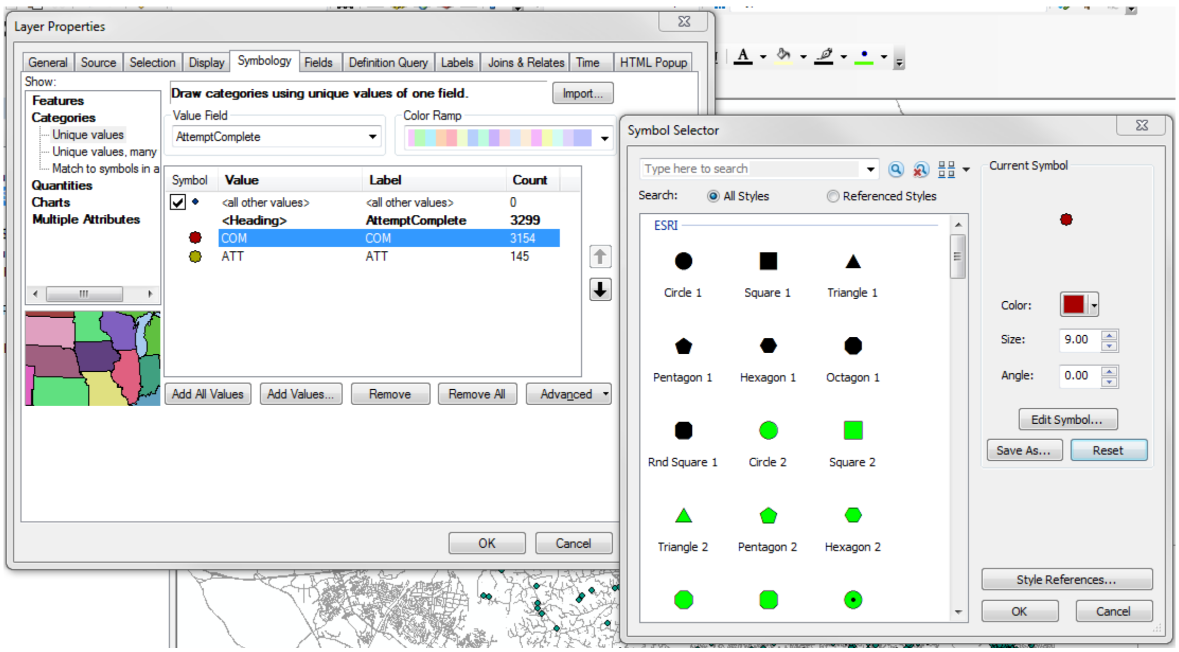


Figure 4-2: Creating a point symbol map in ArcGIS

Graduated symbol and proportional symbol maps

Graduated symbol maps and proportional symbol maps are helpful when you have multiple events at the same pair of coordinates. They display larger dots at locations with more incidents.

Graduated symbol maps organize the size of the symbols into categories, using the different classification schemes listed above. *Proportional symbol maps* vary the size of *every* symbol according to its value (volume of incidents, in most cases), with only a few reference symbols in the legend.

These types of maps can be useful to depict hot spots. However, they are only possible because of inherent imprecision in geocoding. In reality, two incidents rarely occupy the *same* coordinates; they are only assigned the same coordinates because most coordinates are assigned via address matching. There are other vagaries in the data that might cause some individual locations to stand out as hot spots while other locations have a lot of incidents near each other, but not right on top of each other.

It is possible to overcome these problems by creating graduated symbol maps based on aggregation by small polygon; see “Choropleth maps” below.

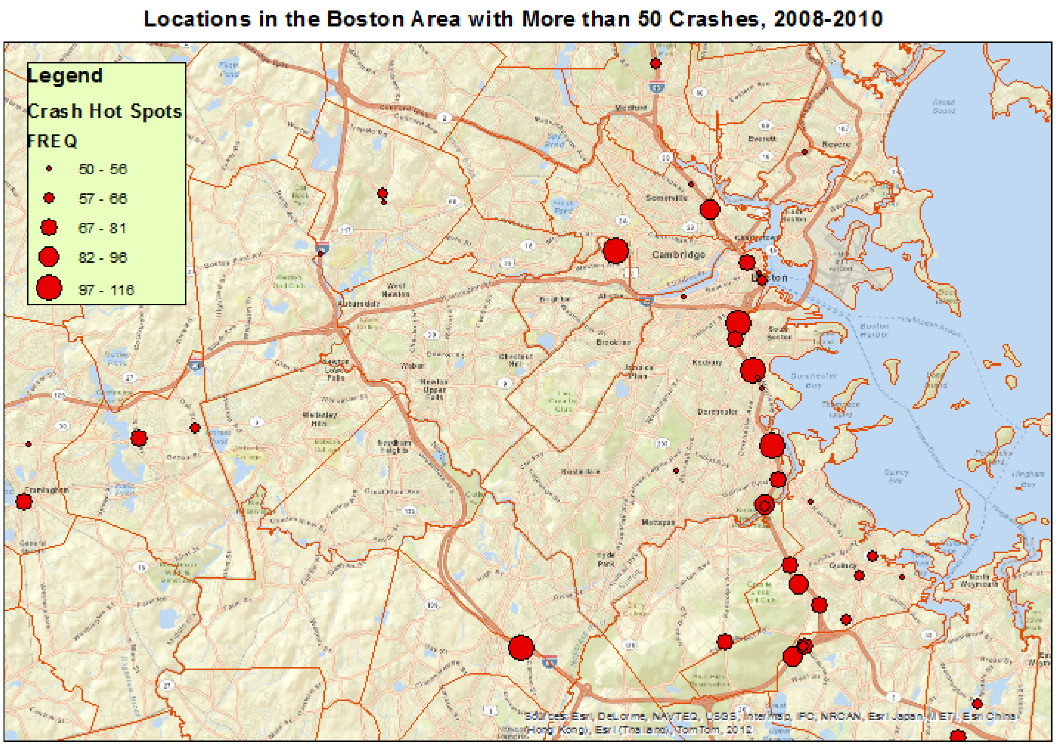


Figure 4-3: A graduated symbol map showing collision hot spots near Boston.

To create a graduated or proportional symbol map in ArcGIS, we must first start with a file that gives a count of the number of incidents at each location. This can be generated from the crime database or calculated using the "Mode" routine in CrimeStat.

The more common method, if we start with a typical geocoded layer, is to use the "Collect Events" tool in ArcGIS. This is located in the toolbox, under "Spatial Statistics Tools," then "Utilities," then "Collect Events." You simply specify an input layer (the original dataset) and an output layer, and the routine generates an file with each location and the number of events that have occurred there.

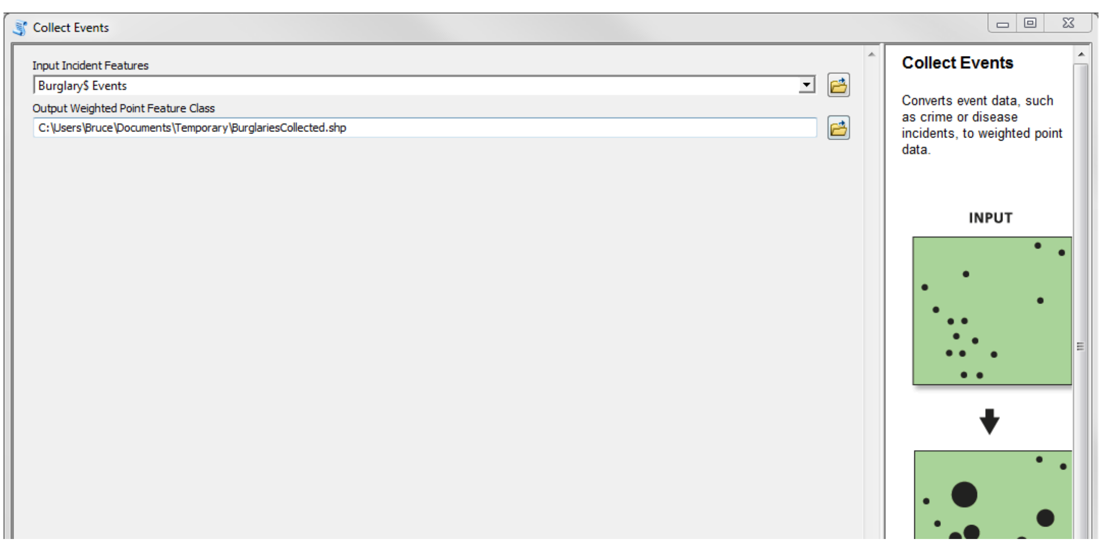


Figure 4-4: Running the "collect events" tool in ArcGIS.

No matter how we obtain the data, if we have a dataset containing the number of events at each location, creating a graduated symbol map is a simple matter of going to “Layer Properties,” choosing “Symbology,” and choosing “Quantities” for the method. Put the field that has the count or sum in the “Value” field and set the method of classification.

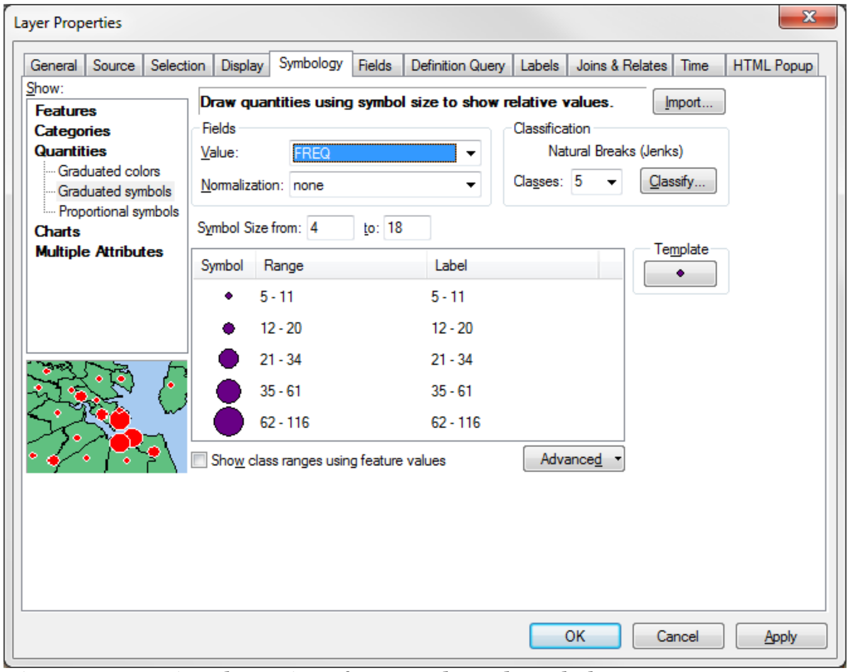


Figure 4-5: Setting the options for a graduated symbol map.

Graduated symbol maps are not limited to points. They are equally effective with lines, especially for collision analysis, in which case this type of map often highlights hot “routes.” Aggregation by line is usually done via spatial join (see below), at which point the lines can be adjusted for color or thickness.

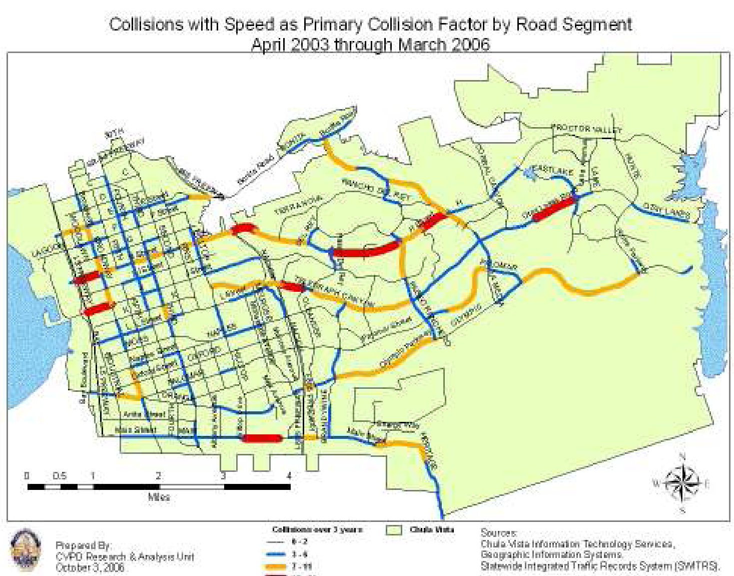


Figure 4-6: A graduated symbol map based on line segments rather than points. This is an effective way to map collision hot spots.

Choropleth maps

Choropleth maps (from the Greek "multiple area") are maps in which polygons are colored, shaded, patterned, or otherwise symbolized to represent some statistical variable associated with them, such as the volume of crime. The primary advantage of choropleths is to represent data in terms of geographic regions that have some other meaning to the audience.

Choropleth maps are easy to symbolize, but first we need to have a field associated with the polygon file that contains the data we want to symbolize. In ArcGIS, this is often accomplished through the use of a **spatial join**, by which ArcGIS counts or sums the value of points falling within each polygon.

To display the results, we use the "Quantities" option under "Symbology" in "Layer Properties." The most common option here is "Graduated colors."

When displaying results in terms of polygons of varying size, it is common to normalize the data using the size of the polygon, although this often produces extremely small numbers, so it is sometimes easier for your audience if you perform the calculation in the attribute table using the "Field Calculator" and represent the results in terms of a multiplier.

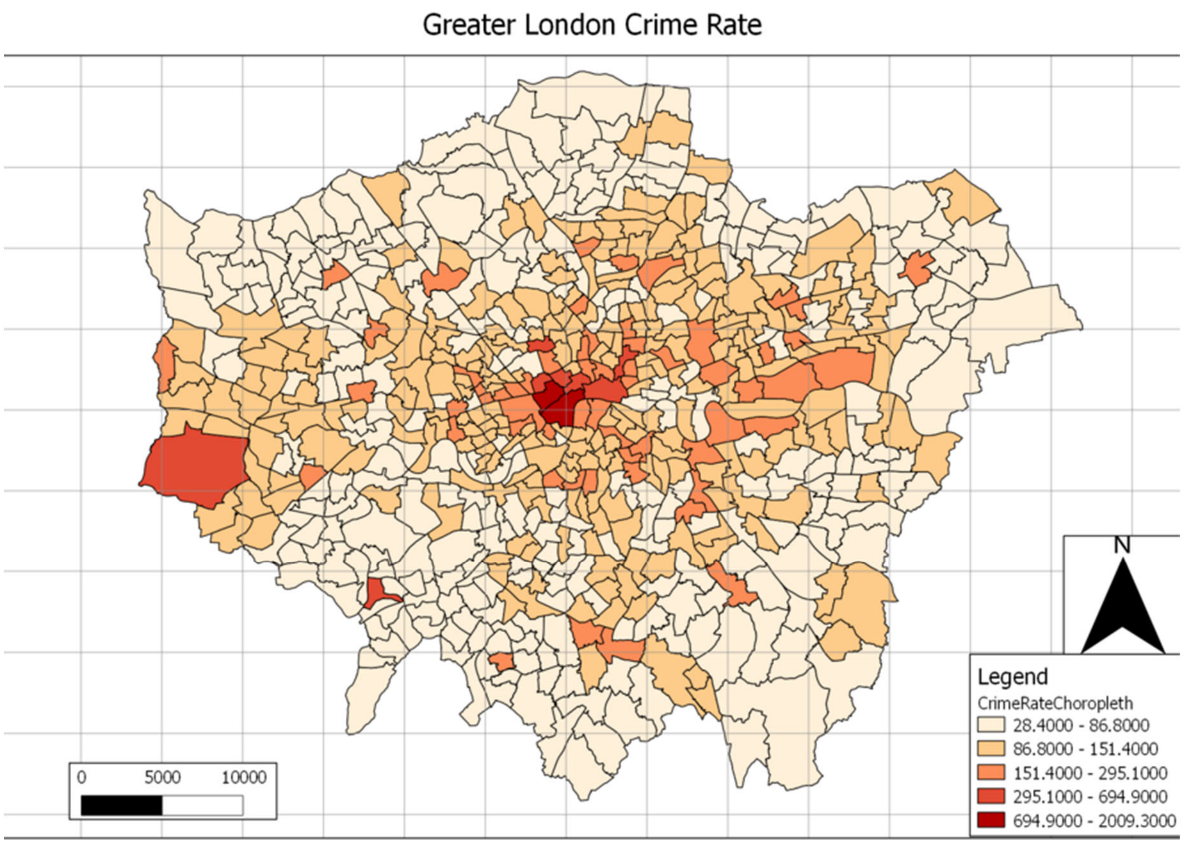


Figure 4-7: A choropleth map indicating the crime rate in various boroughs of greater London.

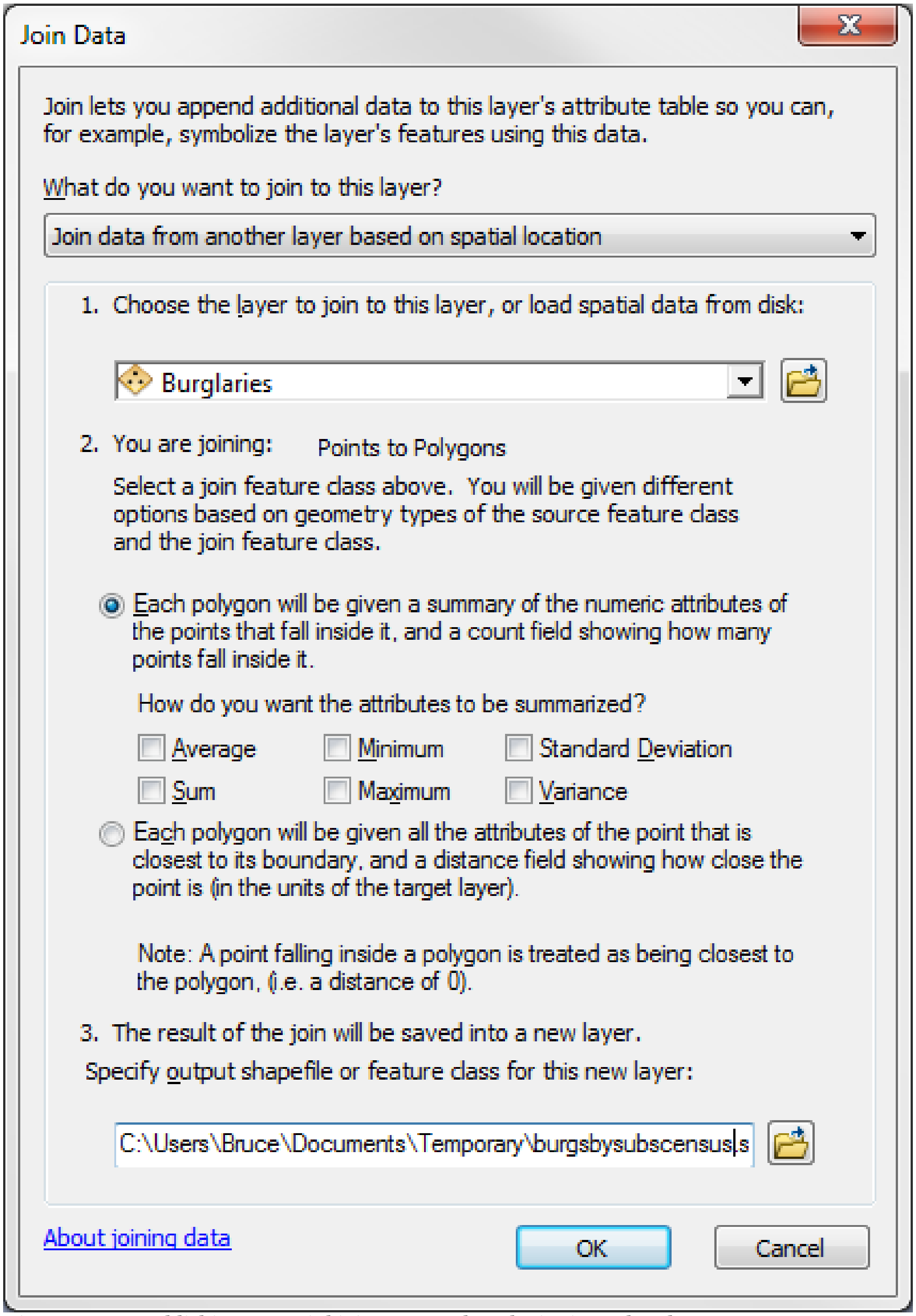


Figure 4-8: Establishing a spatial join to count burglaries in each polygon.

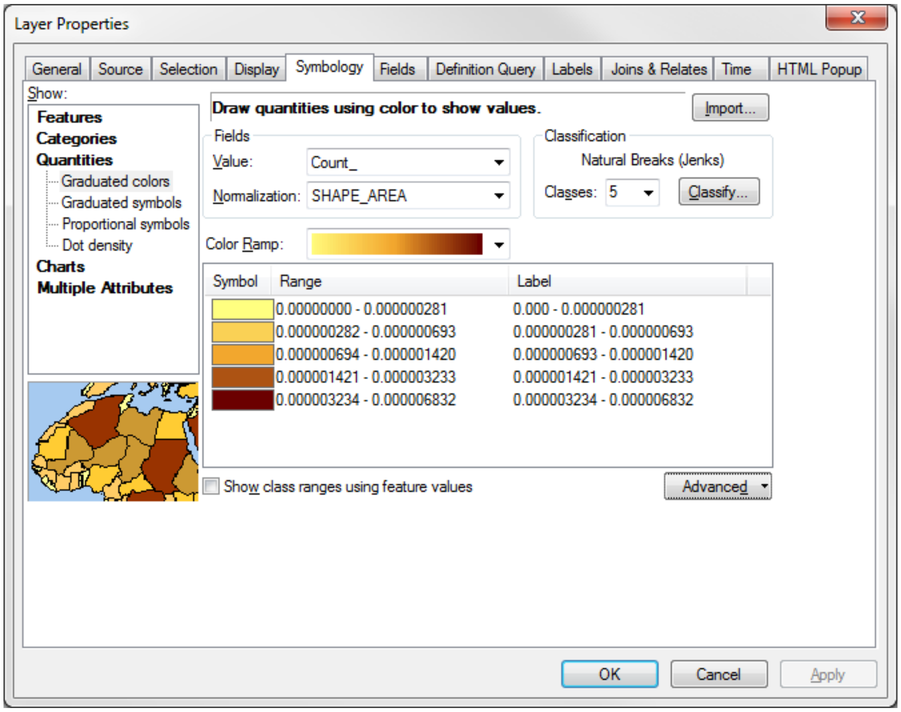


Figure 4-9: Creating a choropleth map to represent burglaries per square mile after performing a spatial join.

As discussed above, it is perfectly acceptable to use graduated symbols or dot densities to represent choropleths as well, as long as the audience members understand that the dots do not literally represent locations of crimes.

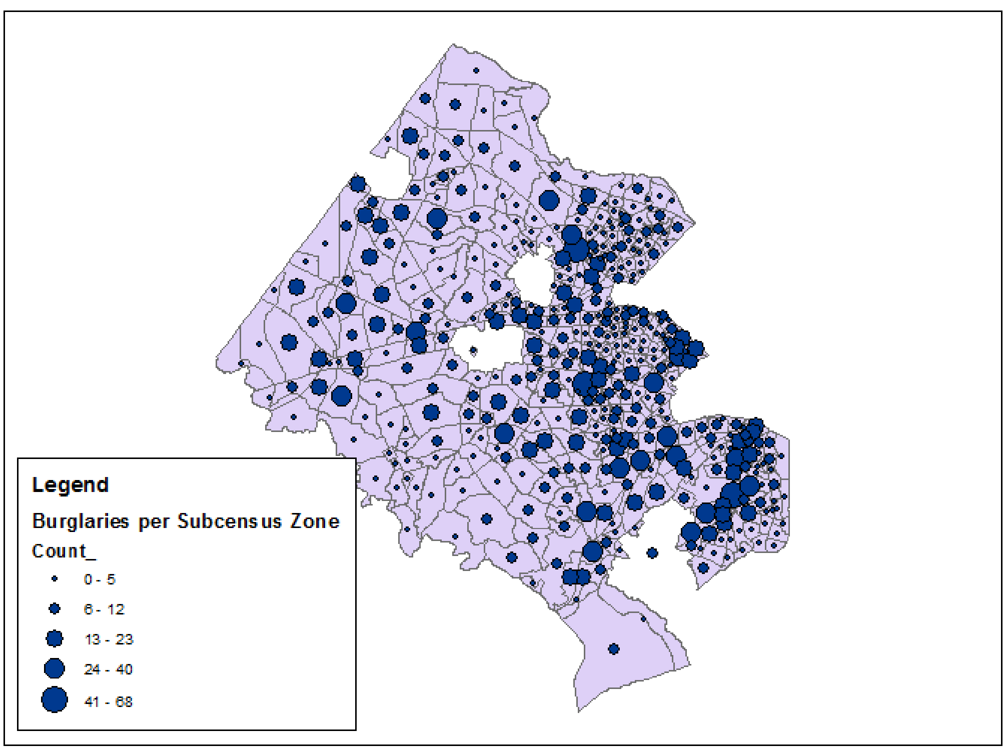


Figure 4-10: A choropleth represented with graduated symbols at the centerpoints of each polygon.

Density maps

Density maps are often seen in crime analysis because they look cool and draw the eye to "hot spots." They are essentially choropleth maps created with very small grid cells as the polygon layer. The tiny size of the cell means that the color regions look smooth when observed from a large scale. Some applications that create density maps draw isolines between the centerpoints of the grid cells to complete the illusion.

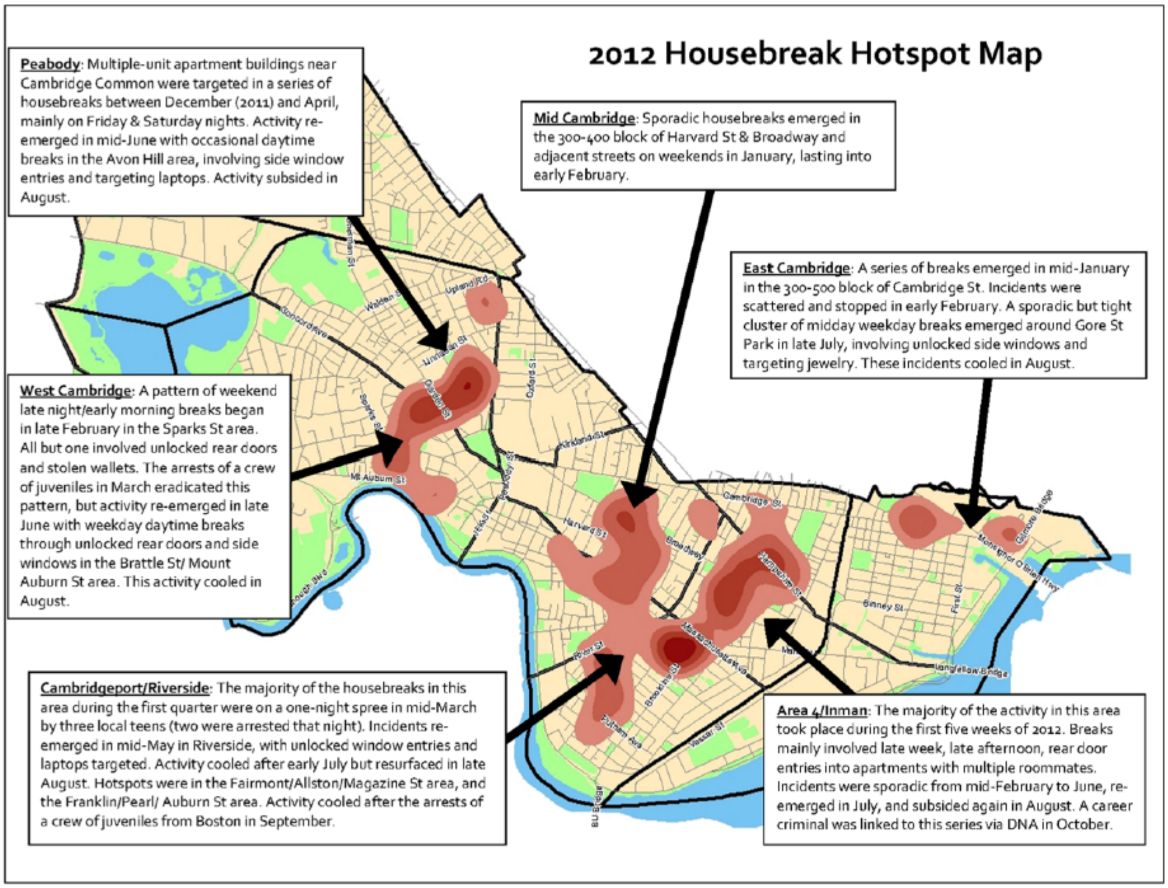


Figure 4-11: A density map of house burglaries in Cambridge, Massachusetts.

Although the method of symbolizing the values is similar to a choropleth map, the method of calculating them generally is not. With density maps, the value for each grid cell is generally *interpolated* from the number of points in surrounding areas. The analyst controls the size of the search radius and the type of weight given to the points found within the radius. The general result is that density maps partly represent where crimes have occurred and partly represent *risk* of crime for the surrounding area.

Density maps cannot be created in ArcGIS alone; they must be created in the Spatial Analyst extension or through the use of the Kernel Density Estimation routines in CrimeStat.

Because their basic function is to spread risk around a two-dimensional area, density maps are usually not suitable for collision analysis, where risk spreads only in a single dimension (along a linear route).

Route maps

Route maps indicate the travel routes (or likely travel routes) between two or more events. They are created through spatial statistics applications. Common uses of route maps are to display the relationship between stolen locations and recovered locations for vehicles; drunk driving crashes and the last bar at which the driver had a drink; and abduction sites, murder sites, and body dump sites. Route maps have uses in strategic, tactical, and investigative analysis, and they are particularly useful in an offender-oriented DDACTS model.

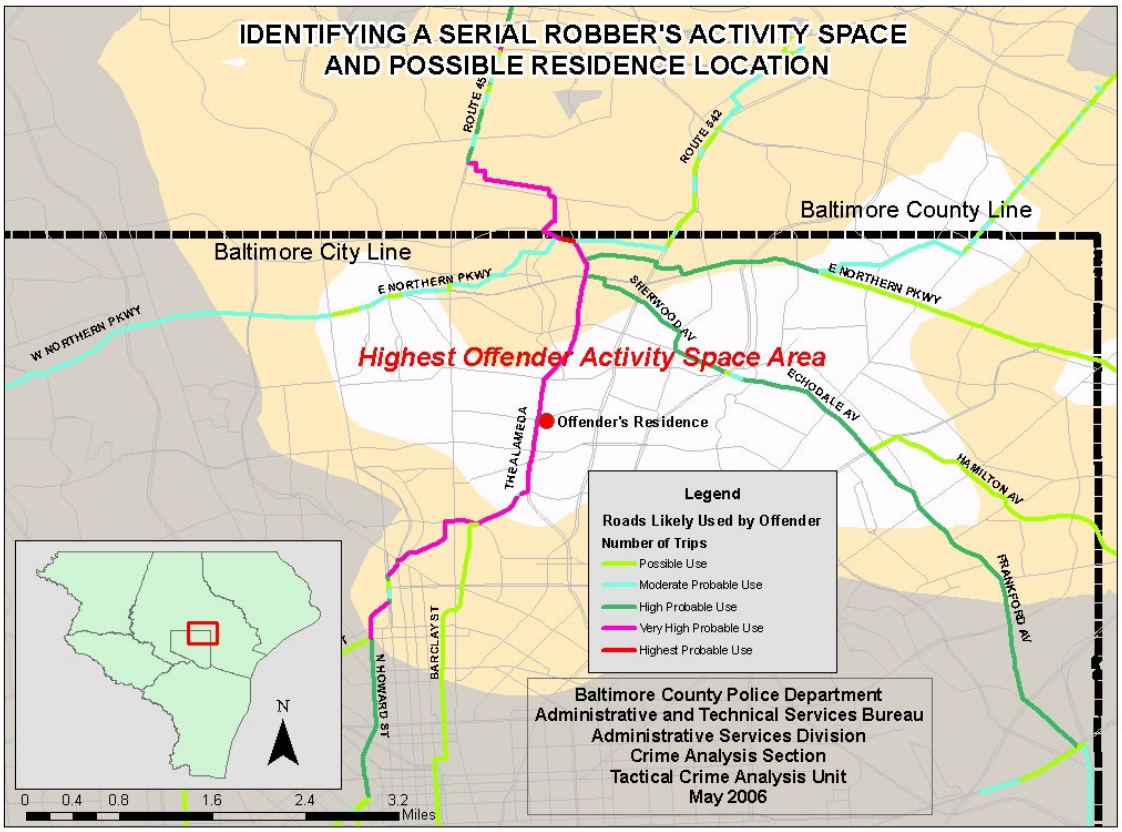


Figure 4-12: Identifying the routes most likely used by a serial robber in Baltimore County, Maryland.

There is, of course, nor requirement that you can only show one thematic layer at a time. The award-winning map below from the St. John Police Force in New Brunswick, Canada, has a point symbol map on top of a density map, all well-annotated with callout boxes. This is an effective way to conduct mapping for DDACTS, with one type of thematic map showing crime (or multiple thematic maps showing various types of crime), and another showing traffic collisions.

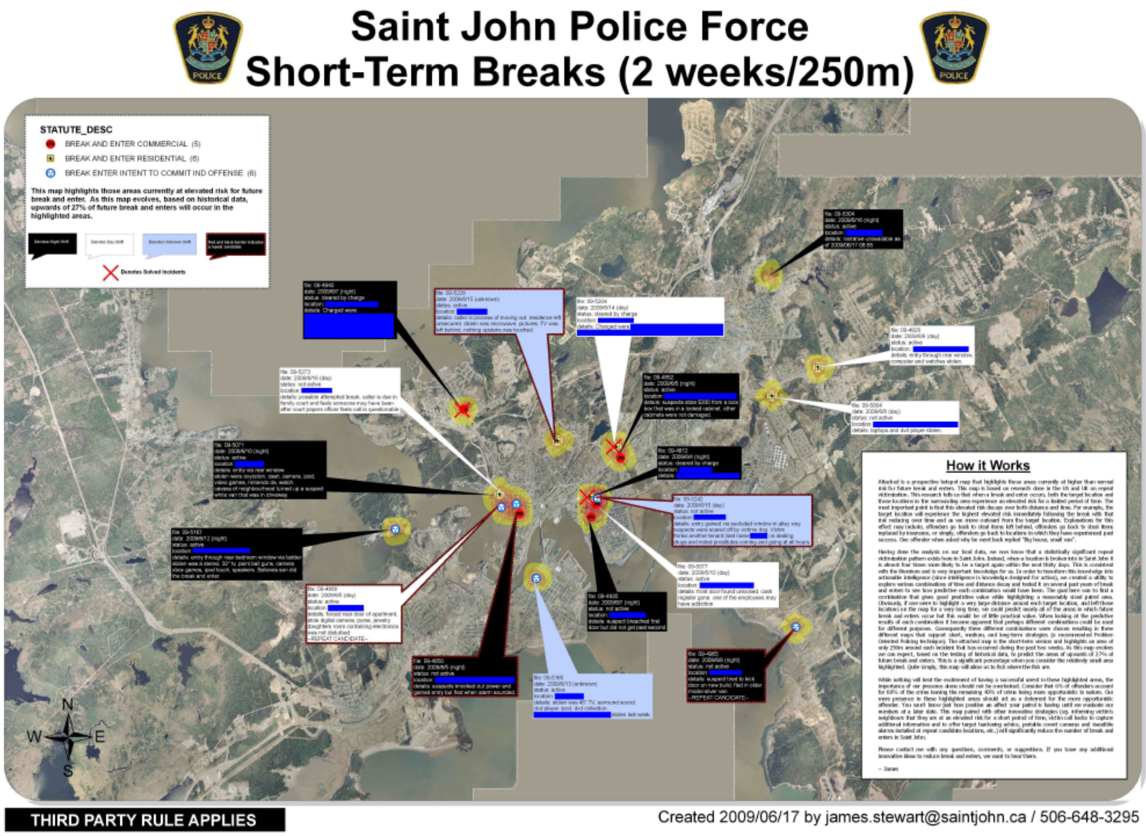


Figure 4-13: Two thematic maps combined in a single map layout.

Classification methods

In creating multiple types of thematic maps—particularly graduated symbol maps and choropleth maps—analysts will have to choose the appropriate *method of classification* in ArcGIS. This is the method used to divide the data into logical groups. For instance, if you were mapping thefts from vehicles by zone, and there was a range from 0 to 110 thefts, you certainly wouldn't want a different color or symbol for every potential number (0, 1, 2, 3, etc.). Instead, you would group them into logical *bins* for categorization. But how do you make the grouping? You could do it by equal intervals:

0
1–10
11–20
21–30

But you might find that almost all of the zones were in the 0 or 1–10 categories, and each of the others only had a few, or none.

You could do it by equal count instead, ensuring that each of the groupings had the same (or roughly the same number of incidents.

Grouping	Total
0	20
1–5	20
6–16	20
17–40	20
41–110	20

This method keeps an equal number, but there's such a large range in the top category that it'll be hard to pick out the top hot spot.

Because of these considerations, a solid understanding of classification methods helps the analyst make the right choice. There are times in which you may want to highlight only one or two "hot spots" and keep the highest volume in the lower categories, and there are times that you may want to equally distribute the different ranges.

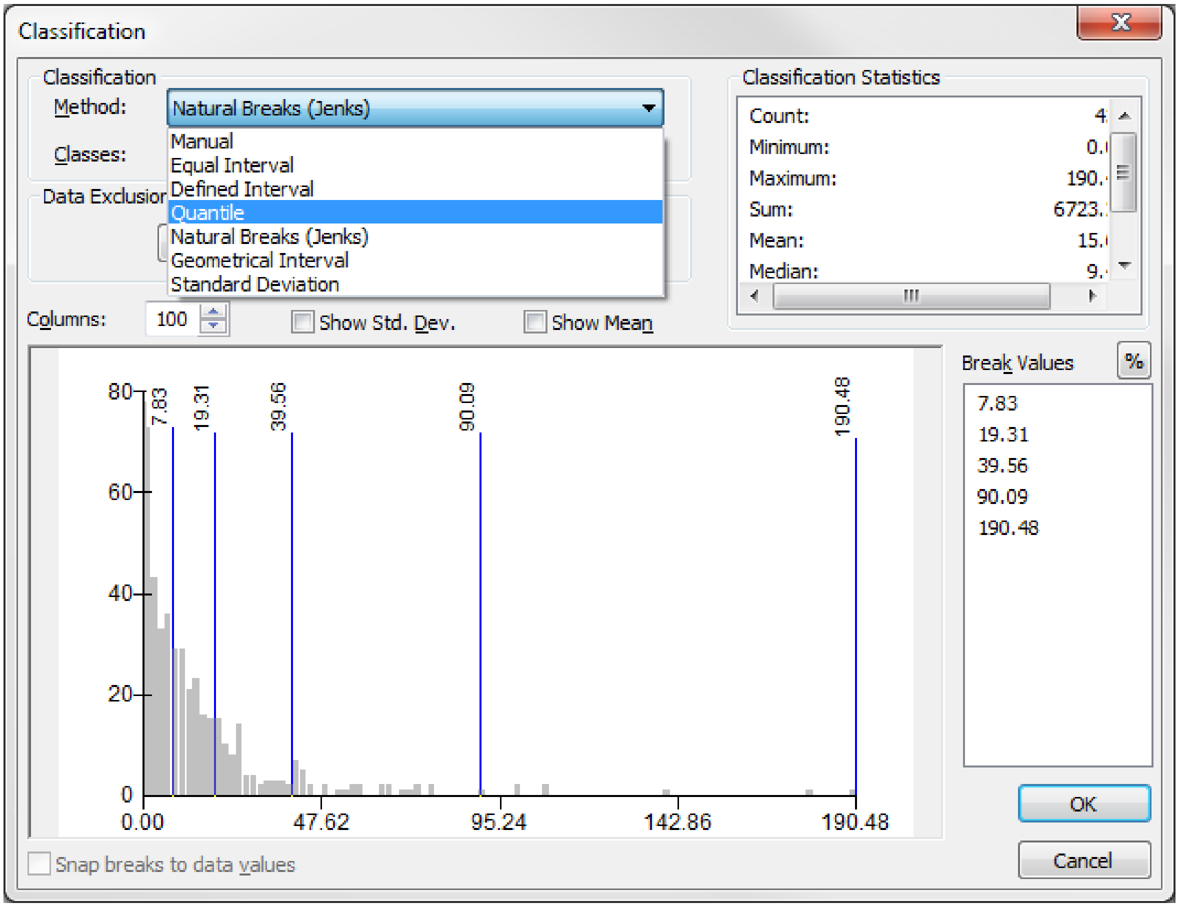


Figure 4-14: Different methods of classifying ranges in ArcGIS.

These are the methods of classification that ArcGIS supports:

- **Natural breaks**. This method uses something called the Jenks Optimization Algorithm to look for "natural breaks" in the dataset. For instance, if you had a lot of zones with between 20 and 38 crimes and a lot of zones between 45 and 60 crimes, but not many between 39 and 44, the algorithm might create a "natural break" in that range. The default method in ArcGIS, it works for most purposes but because it lacks consistency, you can't use it to compare multiple areas or time periods.
- **Equal interval**. This method creates equal intervals for the data regardless of how many values fall in those intervals. If you had a range of 1 to 100 and specified 5 intervals, they would be 1–20, 21–40, 41–60, 61–80, and 81–100.
- **Quantile**. This method tries to put an equal number of values in each category, regardless of how it has to adjust the categories. In extreme situations, you could end up with 0–1, 2–4, 5–6, 7–10, and 11–1000.

- **Standard deviation** applies a bell curve to the data and classifies the categories in terms of standard deviations from the average (-2 to -1, -1 to 0, 0-1, 1-2). If the data follows roughly a normal distribution, this is a good way to highlight locations that are unusually high or unusually low.
- **Defined interval** is an odd method of classification by which the user specifies the interval size, and ArcGIS figures out the number of classes.
- **Geometrical interval** uses an algorithm meant to work with very skewed data—such as if 70% of your zones had no incidents. It tends to put most of the values in the middle and low values at either extreme of the dataset.
- Finally, there is a **manual** method by which you can specify the values in each range. This method is often useful if you want to compare one area or time period to another and ensure they are using consistent ranges.

The table below shows the differences in the result for classification methods using 5 categories (except for defined interval and standard deviation). The dataset has between 0 and 68 burglaries per zone, and there are 431 zones.

Natural Breaks	Equal Interval	Quantile
0–5 (222)	0–14 (367)	0–1 (88)
6–12 (129)	15–27 (58)	2–4 (107)
13–23 (58)	28–41 (13)	5–8 (93)
24–40 (19)	42–54 (1)	9–14 (82)
41–68 (3)	55–68 (2)	15–68 (61)
Standard Deviation	**Defined Interval (15)**	**Geometrical Interval**
0–3 (171)	0–15 (378)	0–1 (46)
4–12 (177)	16–30 (44)	2–3 (125)
13–20 (52)	31–45 (6)	4–9 (117)
21–68 (31)	46–60 (2)	10–25 (124)
	61–75 (1)	26–68 (19)

Figure 4-15: Six methods of classification for the same dataset.

Natural breaks works best in this case if our goal is to highlight the top areas; it has the fewest values in the top categories. Geometrical interval works well if the goal ist o highlight hot *and* cold spots and have everything else in the middle. The other methods create weird distributions for this dataset, particularly the standard deviation method, as the distribution in this case is not normal.

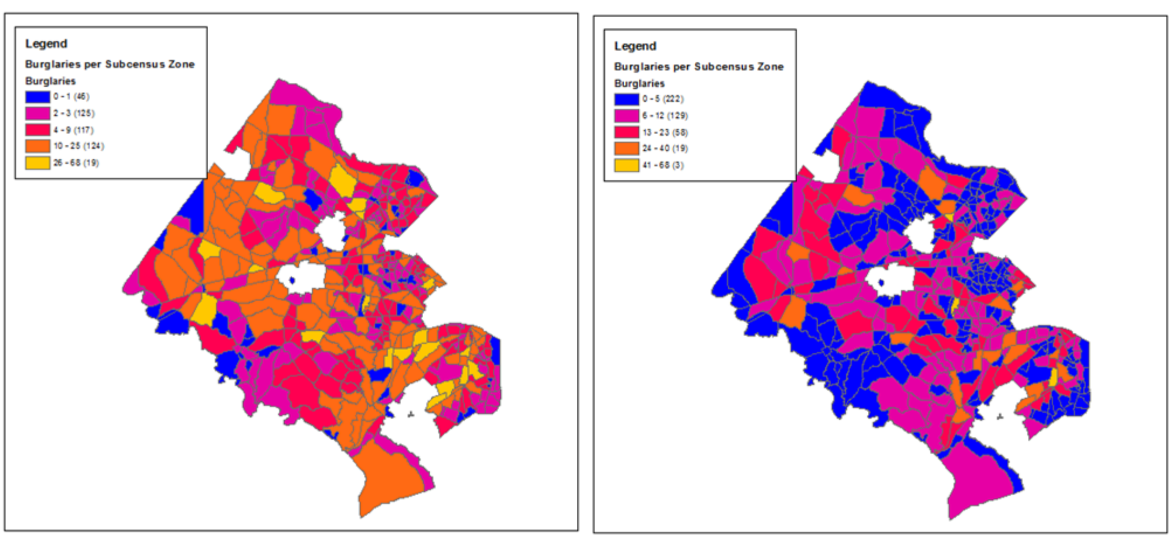


Figure 4-16: Burglaries by zone using the geometrical method (left) and the natural breaks method (right).

A few extra things worth noting on classification:

1. Five is a good number of classes to have. It's easy to interpret visually and creates enough variance to highlight differences. But ArcGIS will support any number from 1 to 32.

2. You can use the **exclusion** button to remove values from showing up at all. For instance, in the map of crash hot spots in Massachusetts below, showing all locations with 1 crash would have overwhelmed the map. By excluding anything less than 25 crashes, it becomes easier (though still not easy) to visually interpret.

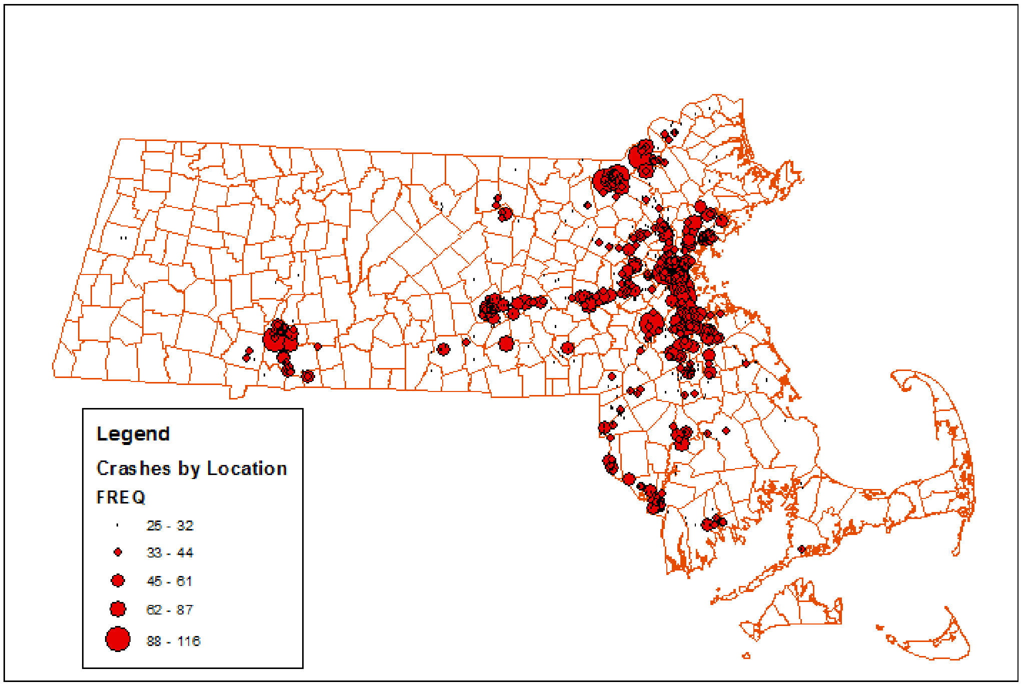


Figure 4-17: A map of crashes in Massachusetts, with locations with less than 25 crashes excluded.

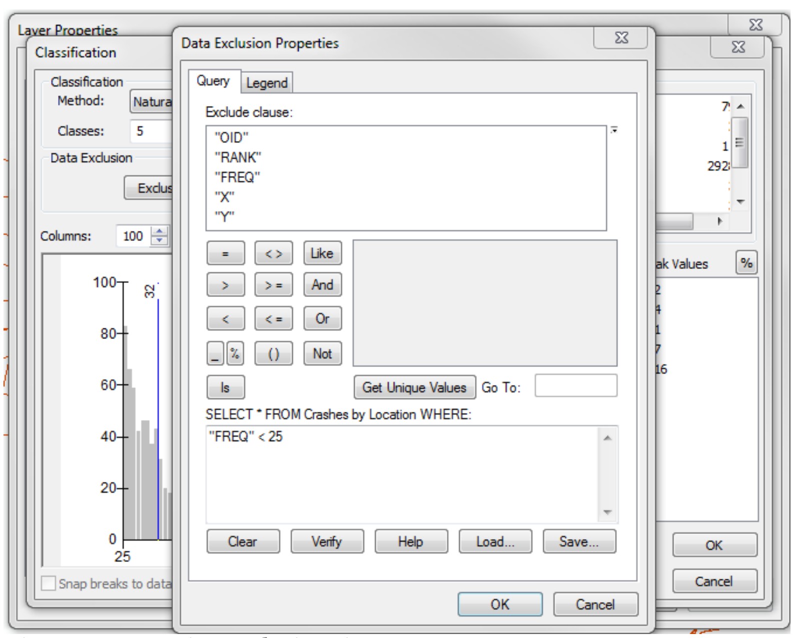


Figure 4-18: Setting exclusions in ArcGIS.

3. In determining what values to use in each class, no matter what method of classification you use, ArcGIS by default only samples the first 10,000 records. If your dataset has more than that, you will need to increase the number sampled by clicking the "Sample" button. There is no way that I know to set this to a higher value by default.

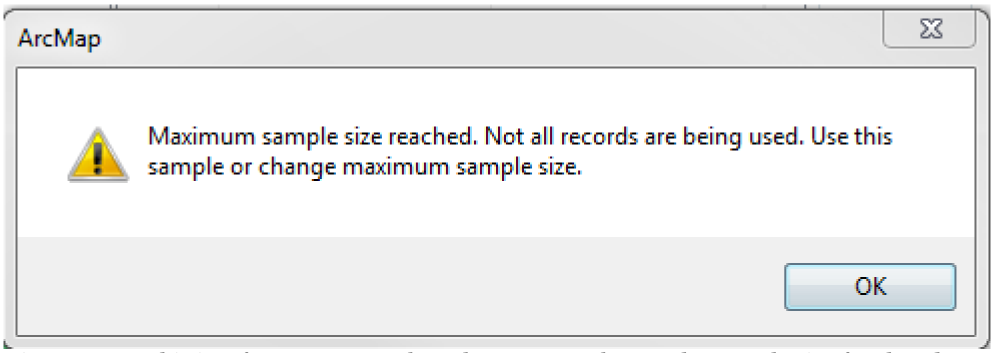


Figure 4-19: This is a frequent error that alerts you to change the sample size for that dataset.

Even with complex thematic mapping, there are limitations to what can be accomplished through visual interpretation. In the next section, we look at spatial statistics, which can help us when visual interpretation fails.

Identifying hot spots

In both GIS and spatial statistics programs, hot spots are identified and displayed through one of four primary means:

- **Aggregation**. Points can be aggregated (generally just counted, but sometimes also weighted) by specific address, street segment, grid cell, beat, census block, or some other unit of geography. CrimeStat's mode and fuzzy mode routines are methods of aggregation, as are choropleth maps and graduated symbol maps.
- **Buffering**. We use buffering when we want to represent hot spots in relation to a radius around existing geographic features, such as intersections or schools.
- **Adaptive scan**. Scanning methods do not attempt to summarize or aggregate points in reference to another object. Rather, they leave the points where they are and create polygons of varying sizes to encompass points with dense concentrations. CrimeStat's Nearest Neighbor Hierarchical Spatial Clustering, STAC, and K-means Clustering routines are examples of scans.
- **Density mapping**, which as we discussed above deals more with *risk* that with literal locations of criminal events.

A second consideration with all of these methods is what, specifically, we count. The most common approach is to count each incident once, so that a choropleth map, for instance, shows a total count of all incidents that occurred within each geographic area. But there are other ways to do it using *weights*. Perhaps, for instance, we want to count certain crimes more than others. Perhaps we want to count fatal collisions more than injury collisions, and injury collisions more than regular collisions. If we've assigned a weight to each record within the original data, we can sum by that weight for any of these methods rather than representing the data as a raw count.

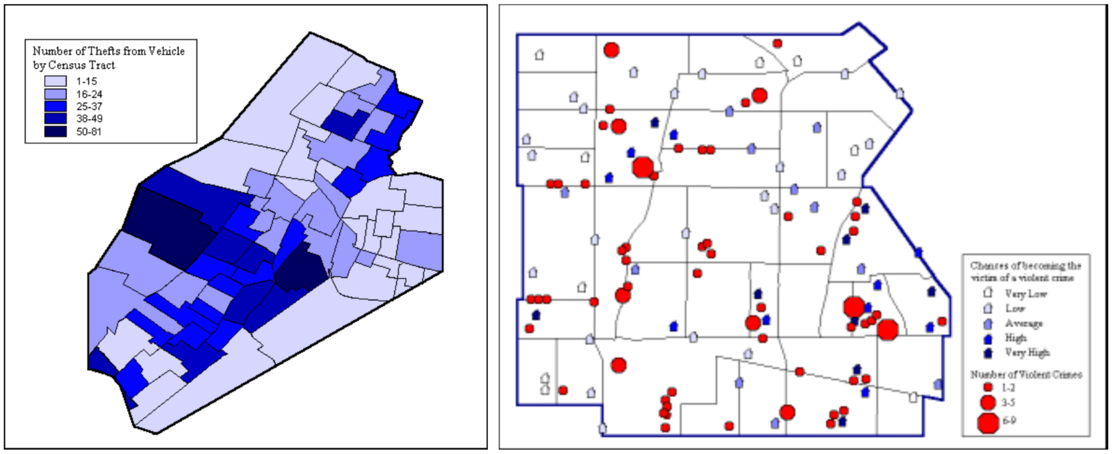


Figure 4-20: Choropleth maps (left) and graduated symbol maps (right) aggregate points into hot spots

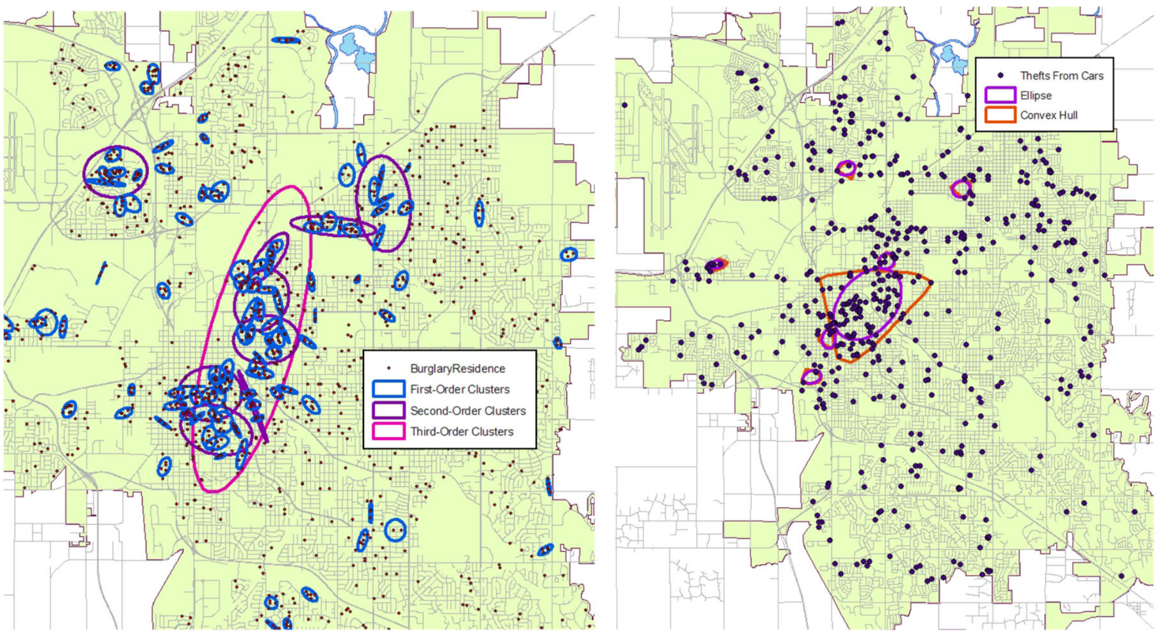
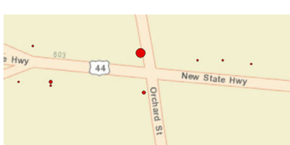
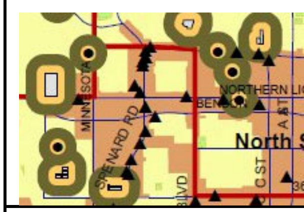
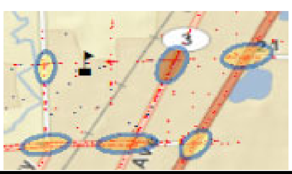


Figure 4-21: Adaptive scanning methods expand and contract the size of the hot spots to fit the specific points that make them up.

Hot spot method	Uses and Pitfalls	How to do it
Aggregation by point 	To identify specific locations that have a lot of activity. This method depends on inherent imprecision in geocoding (two incidents rarely share the same exact coordinates).	Three options: 1. Export data from incident databases with count at each location already queried 2. Use CrimeStat "mode" routine 3. Use "collect events" in ArcGIS Whichever method above, display as a graduated or proportional symbol map.

Hot spot method	Uses and Pitfalls	How to do it
Aggregation by line 	An odd method, but occasionally useful for depicting incidents that happen on the street, such as crashes or thefts from vehicles.	Spatial join to count points along each street segment, then graduated symbol map to depict results.
Aggregation by polygon 	Useful for depicting volume (and other values) in relation to existing geographic areas.	Spatial join to polygon layer, then graduated color map.
Buffering 	Useful to show hot spots in relation to a central point that has some meaning, such as drug incidents within 1000 feet of a school.	Use buffer tool in ArcGIS to create buffers, then spatial join to count points within the buffers. Dissolve (combine overlapping) buffers if desired.
Adaptive scanning 	Identify hot spots irrespective of underlying geography. Apply tests of statistical significance to hot spots.	CrimeStat nearest neighbor hierarchical spatial clustering or STAC routines.
Density mapping 	Spread the effects of each incident in a radius around where it actually occurred to create a "risk surface" for crime or other events.	Spatial Analyst "Density" tools or CrimeStat Kernel Density Estimation routines.

5 Strategic DDACTS

Analysis considerations for the strategic model

The strategic DDACTS approach is the "classic" approach, offering a relatively simple model for new agencies to get started. The basic process is simple:

- Using a large dataset, identify long-term hotspots for crime and collisions (3 months-a year)
- Based on these hot spots, identify target areas and enforcement points
- Conduct highly-visible enforcement in the target areas at indicated times
- Optional: Supplement highly-visible enforcement with other strategies, such as community outreach and prevention strategies
- On a quarterly-to-annual basis, evaluate changes on collisions and crime in the target areas

Data

The strategic model is the least data-intensive of the four approaches, making it suitable for agencies just getting started with access to data and analysis.

For collisions:

- Date of collision
- Time of collision
- Type of collision
- Location (address, and if available, X and Y coordinates)
- Type of location (primarily public road, private way, or parking lot)

For crime:

- Date of crime
- Time of crime
- Type of crime
- Location (address, and if available, X and Y coordinates)

IncNum	Offense	DTReported	DTFrom	DTTo	StNo	Street	PremisesType
10017516	Larceny from MV	08/21/2010 10:09:00	08/20/2010 21:00:00	08/21/2010 09:00:00	30	Mohawk St	House
10017549	Housebreak	08/21/2010 22:36:00	08/21/2010 17:30:00	08/21/2010 20:00:00	12	Charles St	House
10017574	Commercial Break	08/22/2010 10:41:00	08/22/2010 01:00:00	08/22/2010 10:30:00	120	Water St	Restaurant
10017580	Housebreak	08/22/2010 12:37:00	08/22/2010 10:30:00	08/22/2010 12:00:00	12	Charles St	House
10017594	Larceny from MV	08/22/2010 16:51:00	08/22/2010 14:00:00	08/22/2010 16:51:00	100	Independence Way	Shopping Mall
10017605	Robbery	08/22/2010 23:44:00	08/22/2010 23:00:00	08/22/2010 23:00:00	10	Water St	Street
10017612	Housebreak	08/23/2010 06:50:00	08/21/2010 12:00:00	08/23/2010 06:30:00	13	Ash St	Apartment
10017803	Commercial Break	08/26/2010 02:41:00	08/26/2010 02:41:00	08/26/2010 02:41:00	562	Maple St	School
10017850	Housebreak	08/26/2010 14:40:00	08/26/2010 11:30:00	08/26/2010 14:30:00	5	Amanda Dr	House
10017869	Auto Theft	08/26/2010 18:01:00	08/26/2010 16:45:00	08/26/2010 17:30:00	100	Independence Way	Shopping Mall
10017922	Larceny from MV	08/27/2010 10:39:00	08/27/2010 10:10:00	08/27/2010 10:30:00	100	Independence Way	Shopping Mall
10018107	Housebreak	08/29/2010 19:56:00	08/27/2010	08/27/2010 15:00:00	11	Stafford Rd	House
10018380	Larceny from MV	09/02/2010 11:07:00	09/01/2010 20:00:00	09/02/2010 11:07:00	90	Andover St	Auto Sales
10018457	Housebreak	09/03/2010 09:09:00	09/03/2010	09/03/2010 07:30:00	4	Stone St	House
10018526	Larceny from MV	09/04/2010 07:37:00	09/03/2010 19:30:00	09/04/2010 08:00:00	20	Newbury St	Auto Service
10018588	Commercial Break	09/05/2010 01:02:00	09/03/2010 17:00:00	09/04/2010 08:00:00	20	Newbury St	Jewelry Store

Figure 4-1: A typical selection of crime records and fields for a strategic DDACTS analysis

Dates and times ought to reflect the occurrence of the incident, and not the date and time of report. For collisions, these are usually the same, but for many crimes—particularly property crimes—times of occurrence are often far afield from times of report. For incidents that occur over a range of time, analysts should estimate the most likely time of occurrence through midpoint or, ideally, time-weighted methods such as aoristic analysis.

Additional data elements, such as would be required for the problem-oriented model (see below) are of course welcome, but basic identification of hot spots and quantitative evaluation can be performed with only these fields.

In terms of which records to select, the key filters are by date and type of incident. The date ranges needed for the hot spot identification and analysis phase differ from those needed for evaluation. Identification can be done with a single previous year's data, although three is ideal. Proper evaluation requires at least three, but ideally five years of previous data.

Filter records so that only incident types (both crime and collisions) that you have a chance to affect with your chosen enforcement strategies appear on your final list. This generally means excluding collisions that occur on private property and crimes that do not involve an outdoor element.

Analysis

The major component of analysis in the strategic model is the simple identification of hot spots.

There are many ways to conceptualize and identify "hot spots"; the term does not have a specific definition. Depending on the nature of the geography and the phenomenon studied, a hot spot can be:

- A street or street segment
- A single intersection
- A single business or parcel
- One or more blocks
- A neighborhood

Moreover, there are multiple means to identify hot spots, including:

- Aggregating points by point, line, or polygon (e.g., choropleth maps, graduated symbol maps)
- Scanning for clusters (e.g., nearest-neighbor hierarchical spatial clustering)
- Interpolating a risk surface based on past data (e.g., kernel density estimation)
- Interpolating a risk surface based on environmental and demographic variables (e.g., risk terrain modeling)

Hot spot identification should make use of the past two or three years' worth of data for the same time period in which the agency intends to employ operations. For instance, if the agency intends to deploy highly-visible enforcement for July–September 2012, the hot spots should be identified with data from July–September of 2009, 2010, and 2011, *not* April–June of 2012. This ensures that the agency's interventions take place in the areas that are most likely to experience problems within the appropriate time frame. Agencies with trained analysts (or with researchers assisting in the DDACTS process) might explore advanced methods that combine historical data with recent data, or with demographic and geographic data, to produce the best model to predict activity during the DDACTS period.

Agencies will want to identify multiple hot spot layers—at the very least, one for crashes and one for crime. This allows the agency to better analyze and plan target areas.

Consideration of time and day

Whether to consider time during the identification phase or the analytical phase depends on the agency's approach to strategic enforcement. If the agency plans to designate one or more permanent target areas and instruct officers to spend more time in those areas on all shifts and days, then considerations of time are best reserved for the analytical phase. On the other hand, if the agency plans to designate separate hot spots for each shift (or other time period), the analyst will need to create separate hot spot maps during the identification phase. If choosing the latter method, the agency should go through the process outlined in the section above, but make sure that the selection of data occurs *only* in the designated shift. For property crimes, this means determining the most likely time of occurrence (through midpoint or aoristic methods) before creating the initial maps.

Identifying and analyzing target areas and enforcement areas

The *target area* is the area in which the agency hopes its efforts will have a reduction effect. It may comprise a single hot spot or several hot spots depending on their proximity. It is best to designate the target area using common boundaries such as street blocks or police reporting areas so as to facilitate evaluation.

Enforcement areas are where the agency intends to deploy personnel to affect the target area. Depending on the nature of the geography and the incidents themselves, the enforcement areas might be larger or smaller than the target areas, and they may be located inside or outside. When crash and crime hot spots directly overlap, identification of enforcement areas is often easier than when they are nearby but not directly on top of each other. Figure 3 and Table 3 give examples of how hot spots, target areas, and enforcement areas might differ.

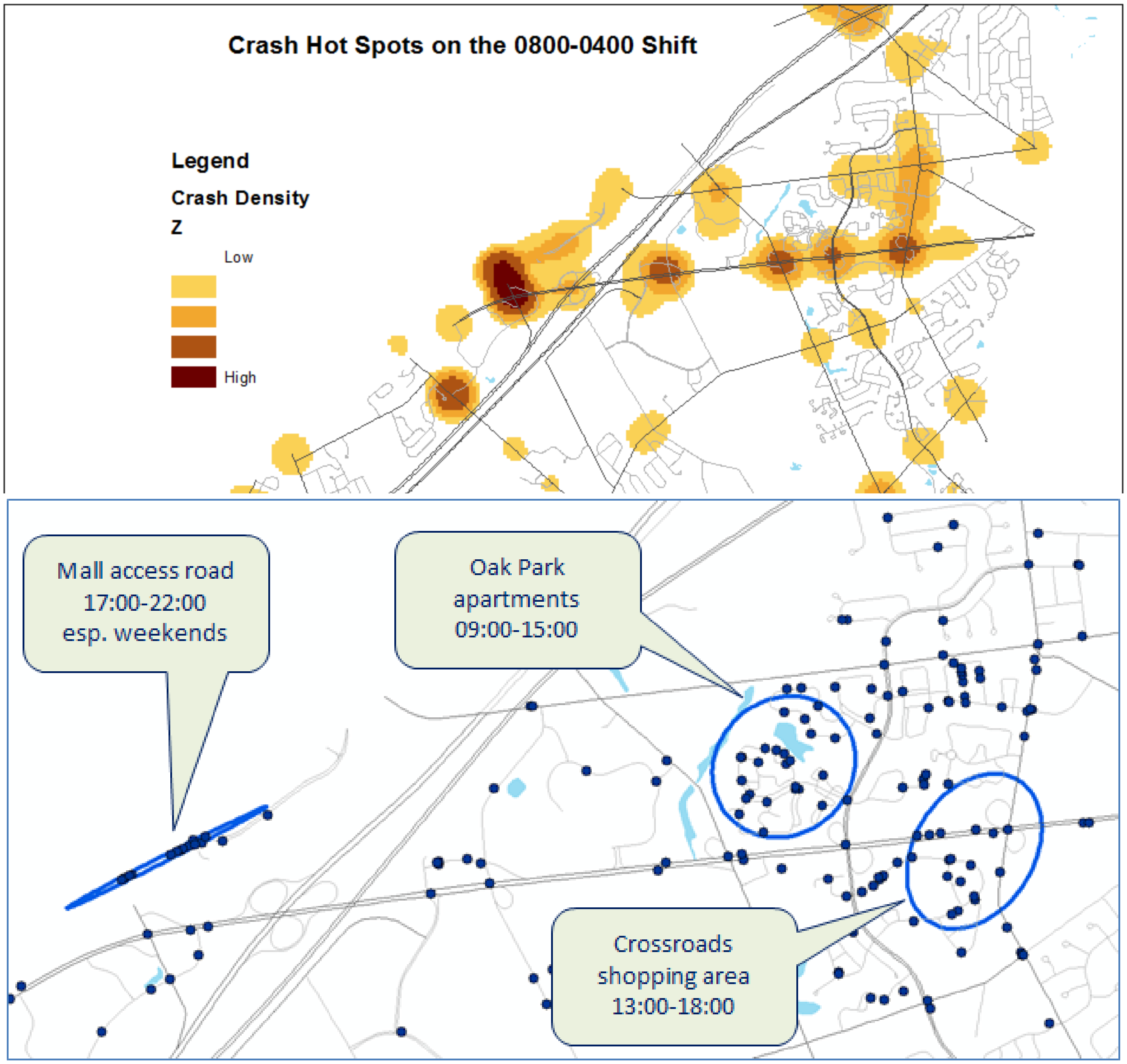


Figure 4-2: Two approaches to considering time in the strategic model. The top highlights only crash hot spots for a particular shift; the second shows all crash hot spots but recommends best enforcement times.

Hot spots, target areas, and enforcement area examples

Hot spots	Target area	Enforcement area
A busy intersection with a high rate of crashes and street crimes	A 1000-foot radius of the intersection	Directly within the intersection
A shopping mall parking lot with many property crimes and an adjacent (but not overlapping) crash hot spot on the busy street out front	The police reporting area including both the shopping mall and the street	Entrances to the shopping mall along the busy street

Hot spots	Target area	Enforcement area
A high-traffic downtown business area	A six-city block area encompassing the business area	A saturation patrol zone of 10 city blocks, encompassing both the business area and streets leading in and out
A residential subdivision with high property crimes and limited access located a quarter mile from a crash hot spot on a major state route	A customized polygon encompassing both the subdivision and the state route	The state route, focusing on secondary roads leading into the subdivision

Designation of target and enforcement areas is part of an analytical process that also includes several other factors, even in the strategic model. The depth of this analysis will depend on the available data, technology, and analytical experience in the agency. Highly-visible enforcement can be initiated immediately upon designation of target and enforcement areas, but consideration of these other factors will help the agency refine the nature, duration, and type of enforcement.

- *Time and day:* A consideration of time of day and days of the week for various crashes and crimes can direct enforcement to those times in which it is most likely to have a preventative effect.
- *Victim characteristics:* For crimes, identification of common victim or target characteristics can help officers give attention to those most likely in danger.
- *Offender characteristics*: Similarly, a consideration of common offender and offender vehicle characteristics can help officers identify those most likely to be engaged in criminal activity (with appropriate consideration for due process and civil liberties).
- *Crash types and causes*: Knowledge of crash types and causation factors can help target specific enforcement efforts rather than just general highly-visible enforcement.
- *Modus operandi factors for crime*: If there are common M.O.s at work within the target area, officers can be alert for that type of behavior.
- *Type of location:* Understanding the types of locations within the target area at which incidents occur (e.g., parking lots, convenience stores, crosswalks) can help direct enforcement efforts.

Generally speaking, the analysis phase in the strategic model is not as intensive as in the other models, but any analysis that can help tailor enforcement is encouraged.

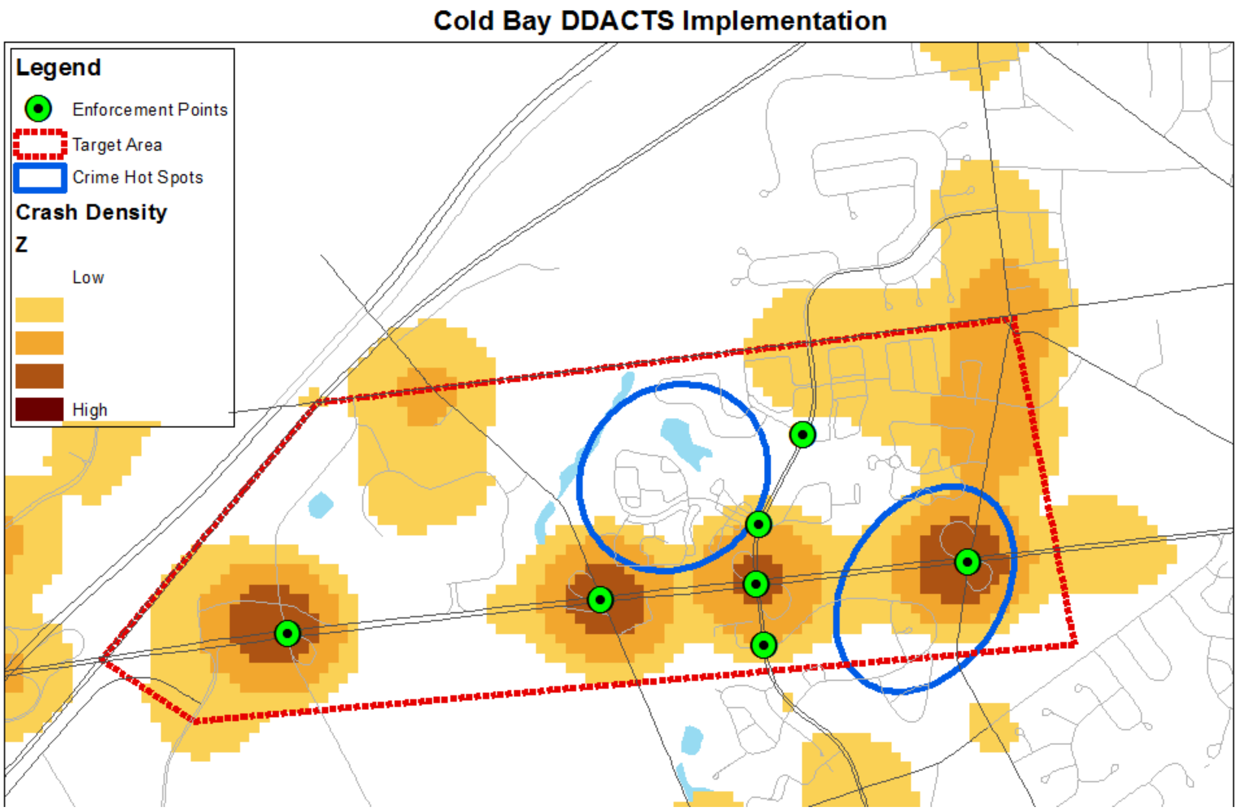


Figure 4-3: The difference between hot spots, target areas, and enforcement areas. In this case, because some of the crash and crime hot spots do not directly overlap, the agency has identified enforcement points that "feed" into the two hot spots.

Reporting

Reporting the results of the analysis in the strategic model is simpler than in the other models. Often, the map of hot spots, target areas, and enforcement areas serves as its own "report," especially if properly annotated. The report should describe any of the characteristics of the target areas, as per the analysis above, that are important for strategic operations. We recommend that the report include a description of the source data and analysis method (perhaps as an attachment), as this may be of interest to external evaluators.

Figure 4-4 shows an example of a strategic DDACTS analysis report.

CBPD

D D A C T S

Target Area Analysis

Summer 2012

Trina Cook
Chief of Police

For more information, contact the Office of Public Safety Analysis
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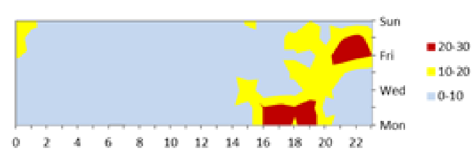
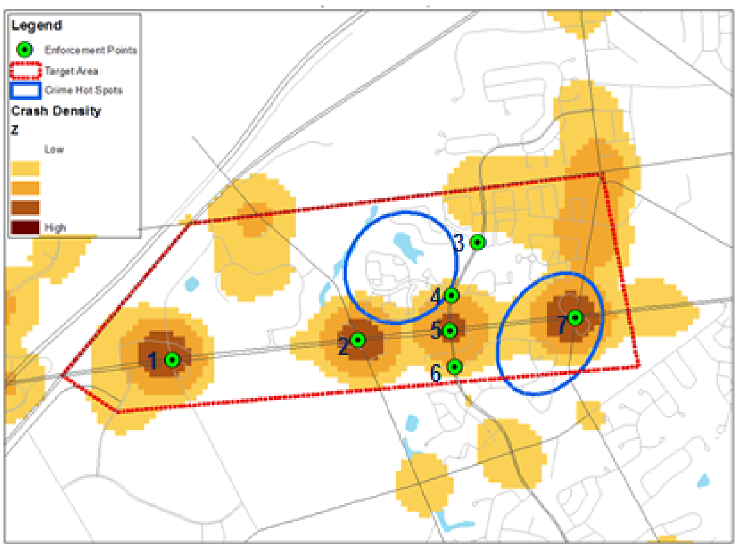
An analysis of the data for the past three summers (2009–2011) supports the identification of the WA53 corridor between Rainier Street and Interstate 5, including residential areas north to Seattle Parkway, as the best target area. Within this area, we have identified seven deployment points for various hours of the day and activities.

The problems contributing to a high number of crashes and crimes within this hot spot include:

Crimes by Hour and Day



- Speeding along WA53, including efforts to "beat the light" at the four major intersections, most common during the evening commute (16:00-19:00) on weekdays
- "No left turn" violations at WA53 and Tacoma Avenue
- Drunk driving along Rainier Street between midnight and 04:00 on weekends
- Residential burglaries in the Oak Park neighborhood on weekend days. Because of the large items typically stolen, the burglars are presumed to have a vehicle.
- Thefts from vehicles in residential driveways in the Oak Park neighborhood in the early morning hours, usually from unlocked cars.
- Thefts from vehicles in commercial parking lots in the Crossroads Plaza area, mostly 15:00-22:00.
- Thefts of car parts from the two auto dealerships at WA53 and Rainier Street, late nights.



The analysis supports the following deployment points by shift, with the primary type of enforcement noted:

1. WA53 & Puyallup Pkwy. 08:00-20:00, speeders coming off highway.
2. WA53 & Tacoma Ave, 07:00-11:00, 15:00-18:00, left turn violations.
3 & 4. Bellingham Blvd, entrances to Oak Park #1, 08:00-15:00, 00:00-03:00, general visibility
5. WA53 & Bellingham Blvd, 08:00-20:00, speeding enforcement
6. Bellingham Blvd, entrance to Crossroads Plaza, 15:00-22:00, general visibility
7. WA53 & Rainier St, 08:00-20:00, speeding enforcement, 23:00-03:00, DWI enforcement

Figure 4-4: Sample first page from a strategic analysis report.

Evaluation

Strategic DDACTS evaluation is the simplest of the four models. An agency must simply determine if there was a statistically significant decrease in crashes and crimes (including particular types of crashes and crimes) within the target zone. Although the process is *relatively* simple, it involves data analysis and statistics that might be cumbersome to inexperienced agencies, so we encourage the use of external partners to assist with the evaluation process.

We use the term *statistical significance* loosely. The purpose behind statistical significance is to give the agency and its stakeholders some confidence that observed reductions were the result of the DDACTS implementation, and not random fluctuations that the agency would expect to see year to year anyway, and not based on some external factor having nothing to do with the DDACTS implementation. It does not mean that the evaluation needs to pass muster for a peer-reviewed scientific journal, although we use many of the same techniques.

A thorough evaluation answers four key questions:

1) How does the volume of activity during the DDACTS period compare to what is normal?
2) How do changes within the DDACTS area compare to changes in control areas?
3) Does the intensity of the enforcement within the DDACTS area correlate to the observed changes?
4) Is there any evidence that we displaced activity, or any evidence that our efforts caused reductions in areas outside the target areas (i.e., displacement or diffusion of benefits)?

To answer question 1, the agency should calculate the average number of incidents for each crash and crime category, within the target area, for the past *n* years, during the same time period as the DDACTS implementation. The number of years is ideally 5—certainly no more than 7 and no less than 3.

The agency should then compare the changes from this average. Ideally, this is done in units of standard deviation, known as the *z-score*. Using the z-score is helpful because it allows analysts and researchers to immediately assess statistical significance. However, agencies without training in these statistics should simply use percentage change.

Question 2 is answered by making the same calculations for control areas—that is, areas that did not receive any additional enforcement due to DDACTS. Ideally, an agency would designate as many control areas as target areas, although "the rest of the jurisdiction" is acceptable as a control area if the agency lacks the time and resources to carve out individual control polygons. If the target areas show significantly different changes than the control areas, it is a good sign that the DDACTS implementation "caused" the changes in the target areas.

Question 3 is tougher to answer. It involves correlating enforcement metrics (number of hours spent, number of citations written, number of arrests made, number of vehicle stops, and so on) with the observed reductions to determine if greater enforcement led to more significant reductions. This process is only possible when the agency has designated more than one target area or when the enforcement takes place over a long time period (i.e., a year or more) so that the agency can calculate reductions for multiple quarters. Whether the agency has the ability to complete this step, it should at least report on the enforcement metrics so that readers can judge whether the observed reductions could reasonably have been caused by the level of enforcement the target areas received.

Category	5-Year Average	Standard Dev.	DDACTS Year	% Change	Z-Score	Significance
Collisions with Injury	31.6	10.2	20	-37%	-1.14	0.13
Collisions without Injury	181.6	17.8	148	-19%	-1.89	0.03
Total Collisions	213.2	23.3	168	-21%	-1.94	0.03
Auto Burglary	81.6	27.9	66	-19%	-0.56	0.29
Residential Burglary	64.8	14.7	52	-20%	-0.87	0.19
Auto Theft	82.4	14.4	32	-61%	-3.50	0.00
Theft	134.0	22.8	112	-16%	-0.97	0.17
Vandalism	78.4	14.4	66	-16%	-0.86	0.19
Persons Crimes	52.4	11.0	48	-8%	-0.40	0.34
Property Crimes	461.2	38.4	348	-25%	-2.95	0.00
All Target Crimes	513.6	48.6	396	-23%	-2.42	0.01

Figure 4-5: Sample strategic evaluation in an agency with a single target zone

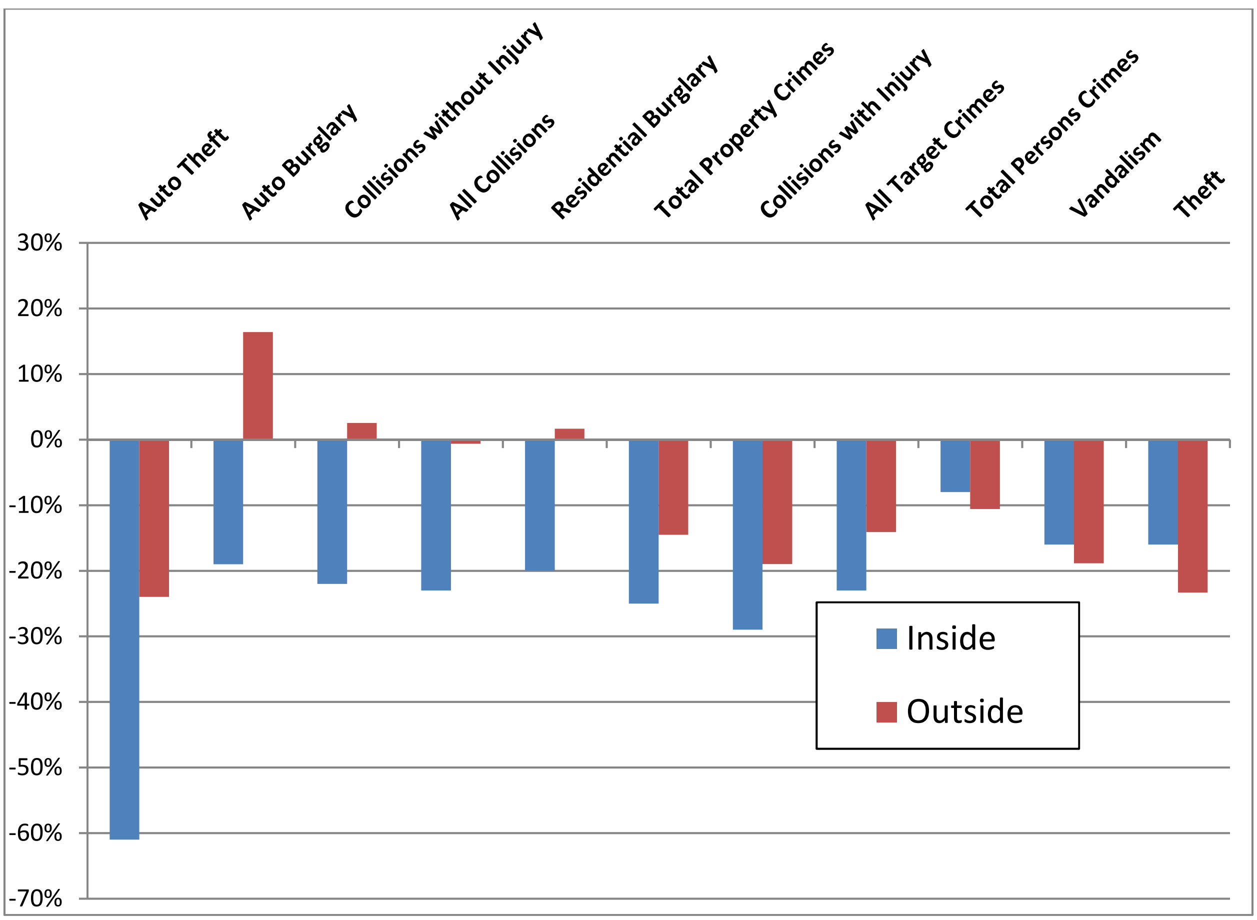


Figure 4-6: Comparison of changes in target zone to control area in a strategic evaluation

Question 4 is also very difficult to answer for sure. There are five types of displacement—geographic, temporal, target, tactical, and crime type—and some of them are essentially undetectable. Since DDACTS is hot spot-focused, we generally think primarily in terms of geographic displacement and diffusion. Constructing a full model to measure these phenomena is very difficult, and best done with support of literature (e.g., Guerette, 2009) or a local research partner. Nonetheless, the police agency can take an initial scan of the data to find at least any obvious evidence of geographic displacement and diffusion. Geographic displacement can take two forms:

- Displacement to the immediate surrounding area: enforcement at 1st Avenue and A Street moves much of the activity to 2nd Avenue and B Street.
- Displacement to other areas of a similar type: enforcement around a Wal-Mart moves activity to a Target on the other side of town.

Analysts should conduct database queries to look for evidence of both types of displacement, and the agency should adjust its response strategies accordingly.

Finally, when reporting the results of the evaluation, be sure to include the actual figures (average, current totals) along with the percentage or z-score changes. Including the raw numbers will remove concerns that large changes are simply the result of small numbers (e.g., a 50% decrease when a category goes from 4 incidents to 2).

About the Author

Christopher W. Bruce started his crime analysis career at the Cambridge (MA) Police Department Crime Analysis Unit in 1994, and moved to the Danvers (MA) Police Department in 2001. He became has served on the board of the International Association of Crime Analysts as Vice President of Administration (2000–2006), President (2007–2012), and Vice President of Membership (2016–Present). He was also President of the Massachusetts Association of Crime Analysts (MACA) between 2000 and 2004. He served as the senior editor for the IACA's 2004 publication, *Exploring Crime Analysis*. His other publications include *Better Policing with Microsoft Office 2007* (2009, with Mark Stallo) and *Crime Analysis with CrimeStat* (2008, with Susan Smith).

Christopher has served as a contracted analytical specialist and analytical director for the Data-Driven Approaches to Crime and Traffic Safety (DDACTS) program since 2011.

Christopher frequently teaches spatial statistics and crime mapping, as well as other crime analysis topics, at various venues in the U.S. and other countries. He has lectured at 18 IACA conferences, 17 MACA conferences, and many other regional crime analysis conferences. He has taught crime mapping and analysis for the Crime Mapping and Analysis Program (CMAP) at the National Law Enforcement and Corrections Technology Center (NLECTC), and he is a lecturer for Suffolk University, Tiffin University, the University of Massachusetts at Lowell, and Westfield State College. He lives in New Hampshire.