Mapping the Path to Problem Solving

by Thomas Rich

Computer mapping and geographic information systems (GIS) are used in a variety of criminal justice and public safety settings. Most of the data sets agencies and organizations routinely collect and maintain include location information—police files contain addresses of crimes and arrests, court files contain addresses of offenders, corrections files contain addresses of probationers. Other public agencies manage property databases, street and physical infrastructure files, licensing data, and public health data. The Census Bureau manages block-level demographic information.

Many tools allow these data sets to be viewed and analyzed, but only computer mapping software can create a single map that combines multiple data sets into one display so that public agencies not only can isolate factors contributing to crime

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and other problems, but also reduce operating costs, manage resources more effectively, and assess the efficacy of interventions.

In the last 10 years, advances in computer hardware, software, and networking have made mapping more widely available. Perhaps the most important of these advances has been the development of low-cost yet powerful mapping software. In 1989, the National Institute of Justice (NIJ) had only one active grant involving computer mapping, although a second, more ambitious program—a five-city Drug Market Analysis Program—was under development. By the mid-1990's, mapping played highly visible roles in departmentwide transformations at the New York City and Chicago

police departments. In 1997, NIJ established a crime mapping program to coordinate research, disseminate information on mapping, and provide training to spur development of new spatial analysis methods and software. (See "For More Information," page 9.) Mapping also captured the attention of both the Vice President, who established a Crime Mapping and Data-Driven Management Task Force in 1998, and more recently the President, who highlighted computer mapping of crime data in his 1999 State of the Union Address.

Mapping in Law Enforcement

Mapping in criminal justice agencies started with law enforcement agency crime analysts placing different colored pushpins on paper street maps. Today, automated versions of crime "pin maps" represent the most common mapping application among the estimated 36 percent of law enforcement agencies with 100 or more sworn officers that use computer mapping.[1]

Several agencies around the country are following a process, developed by the New York City Police Department's CompStat (computerized statistics) unit, that adds mapping to the mix of information that flows among the department's leaders, precinct commanders, and patrol officers. Each week, the CompStat unit prepares a report that is the focal point of discussion at weekly briefings attended by department executives and commanders. The CompStat database is used to create maps depicting virtually any combination of crime and arrest locations,

Figure 1: Cambridge (Massachusetts) Police Department Crime Bulletin of Larcenies from Motor Vehicles
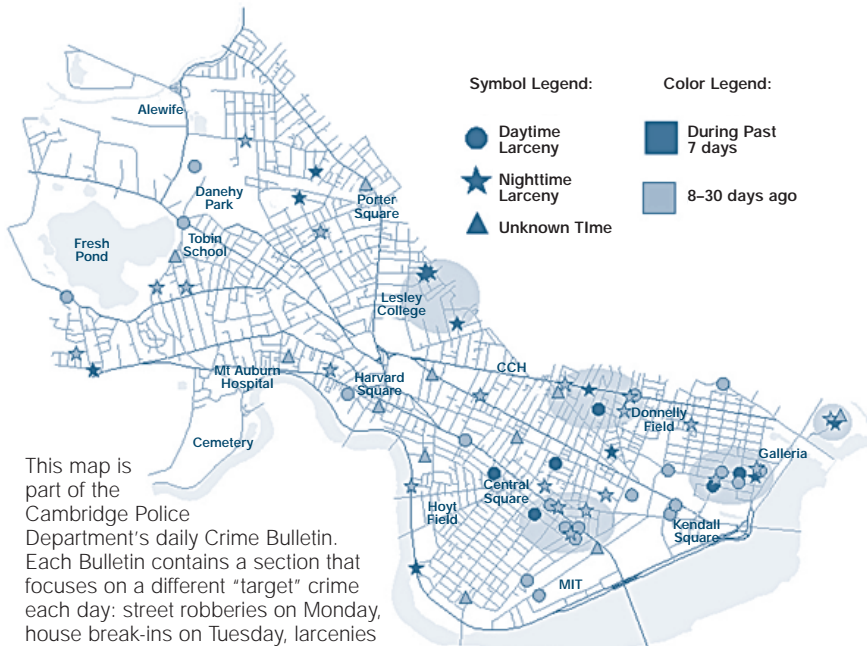
This map is part of the Cambridge Police Department's daily Crime Bulletin. Each Bulletin contains a section that focuses on a different "target" crime each day: street robberies on Monday, house break-ins on Tuesday, larcenies from motor vehicles on Wednesday, auto theft on Thursday, and commercial break-ins on Friday.

Mapping Drug Flow into the United States

Research funded by the Office of National Drug Control Policy is examining the use of computer mapping to study how drugs flow from source countries into the United States. One project uses mapping to examine the spatial relationship between drug smuggling patterns and the use of drug-interdiction assets, such as ships, airplanes, radar, Federal agents, and drug-sniffing dogs. Mapping also provides a visual picture of the number of ships, trucks, passenger vehicles, pedestrians, airplanes, and other conveyors entering the country through ports of entry.

crime "hot spots," and other relevant information. The maps are used not only to analyze crime, but also to enforce accountability and evaluate performance.

In Chicago, community police officers use the department's Information Collection for Automated Mapping (ICAM) program to produce maps of crime conditions in their assigned beats and share them with residents at neighborhood beat meetings. Other law enforcement agencies use mapping to support problem-solving and community policing, improve law enforcement operations, and apprehend and convict offenders.[2] Figure 1 (on page 3) shows the Cambridge (Massachusetts) Police Department's "Daily Crime Bulletin," through which the department shares maps and crime analysis so that all officers and staff are more aware and knowledgeable of crime trends in various neighborhoods.

Regional Law Enforcement Systems.
In some areas of the country, law enforcement agencies have established regional systems that merge crime and other police data from several, typically adjacent, law enforcement agencies. Although regional systems often are difficult to establish and maintain, they offer obvious benefits, most notably the ability to detect crime patterns that cross jurisdictional boundaries.

Automobiles, for example, often are stolen in one jurisdiction and recovered in a neighboring one. A regional system that includes sophisticated query and mapping tools enables a crime analyst to spot patterns in these and other crimes that otherwise would likely go undetected.

Collaborative Enforcement and Problem-Solving Efforts

To address the many factors that contribute to crime and disorder, communities are forming partnerships between their law enforcement agency and other city, State, and Federal agencies. Because of its ability to merge mappable data from different agencies and organizations, GIS is an ideal information tool for these collaborations.

Risk-Focused Policing.
In Redlands, California, the police department has adopted "risk-focused policing," which systematically focuses on the underlying causes of disorder and the factors that place its youths and families most at-risk for criminal and other problem behavior.[3] The model is based on the extensive research literature on risk and protective factors.[4]

Although Redlands had accurate data on crime, it did not have

accurate data relating to risk and protective factors and behaviors of adolescents, such as the extent of substance abuse, delinquent and violent behavior, teen pregnancy, truancy, and weapon carrying. To fill the gap, the city conducted a series of citywide surveys of high school students. The police department then entered the findings into a database and used mapping software to display the results by Census block. Figure 2 (opposite) is a map that the Redlands Police Department used to examine levels of risk factors relative to the locations of community resources that provide an opportunity to develop skills and receive recognition.

The effort enabled various city and county agencies and community-based organizations to better target their resources. For example, neighborhoods where a high percentage of students indicated "there's nothing for me to do" received additional youth recreation programming. In the future, the city hopes to make the maps and other survey results available to city agencies, community organizations, and the public through a regional Intranet.

Strategic Approaches to Community Safety Initiative.
Over the past decade, the U.S. Department of Justice has funded a number of community revitalization efforts involving multiple local, State, and Federal agencies. Examples include the Comprehensive Communities Program and Operation Weed and Seed. Most recently the Justice Department initiated the Strategic Approaches to Community Safety Initiative, or SACSI, a new strategy that builds from the lessons of these earlier programs. (See "Using Knowledge and Teamwork to Reduce Crime," page 16.) Each SACSI site is gathering data from its criminal justice and social service agencies and merging them into one database that will be

Figure 2: Average Risk, Family Domain, and Community Assets Providing Skills, Opportunities, and Recognition
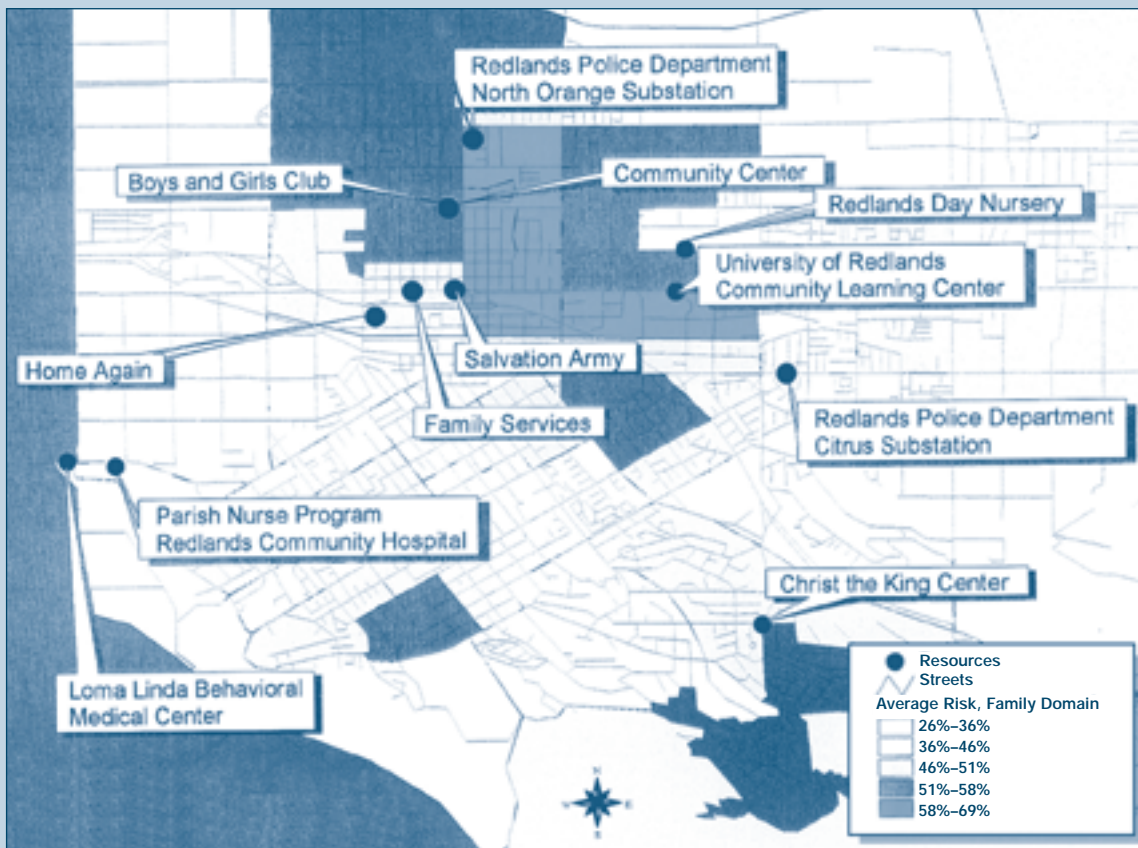
As part of its risk-focused policing strategy, the Redlands (California) Police Department combined crime data with data from citywide surveys on risk factors to determine where resources were needed most.

accessible to each of the contributing agencies to help the site analyze its crime problem, assess the impact of interventions, and make adjustments in its strategy.

Mapping Local Drug Markets and Treatment Needs. Officials in the 35 metropolitan areas participating in NIJ's Arrestee Drug Abuse Monitoring (ADAM) program, which tracks drug use trends among adult and juvenile arrestees, soon will have more information about the location and characteristics of their drug markets and the potential demand for treatment and other health services in different neighborhoods. In early 2000, the ADAM sites will begin collecting geographic information, including arrestees'

ZIP codes and arrest locations. When these new data are combined and mapped with other ADAM data—such as the type and quantity of drugs purchased, the purchase price, and the arrestee's level of dependence on drugs and need for treatment—analysts will be able to better pinpoint where resources are most needed.

Schools. Some communities, including many receiving funding from the Justice Department's Office of Community Oriented Policing Services' School-Based Partnership program, have begun to use mapping in conjunction with school-based problem solving. In these efforts, law enforcement agencies and schools form partner-

ships to develop and use the SARA (scanning, analysis, response, and assessment) model to address specific school-related crime problems. In Akron, Ohio, for example, the School-Based Partnership project is focusing on crimes occurring within a two-block area of a targeted school, and mapping software will plot the precise locations of juvenile crime occurring in the area.

Mapping crime and disorder inside schools or on the school grounds requires a large-scale or "high-definition" mapping system that includes digitized floor plans, building blueprints, and detailed maps of school grounds and surrounding areas. Crime, victimization, and other data are then linked to specific

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locations (for example, a particular classroom or section of a parking lot). Temple University researchers recently conducted a pilot test of a high-definition mapping system at the university. Working with the campus police, Temple researchers constructed digitized maps of all campus buildings, including floor plans of multistory buildings. The campus police department modified its records management system to link crimes to one of several hundred specific campus locations. The study included a victimization survey in which students rated the safety of different geographic regions on campus.[5]

Community Organizations.
Community involvement in crime control and prevention efforts is a central tenet of community policing. One effective way of getting the community more involved in community policing is for city agencies—particularly the police department—to share information with the community. Recognizing this, many law enforcement agencies routinely make crime information available to the public, often through the department's Web site.

A project in Hartford, Connecticut, is providing local crime prevention organizations with basic mapping and analytical tools to create their own maps and analyze incident-level calls for service, crime, and arrest data.[6] The mapping system enables community groups to quantify suspected problems, thus confirming—or disproving—the perceptions of neighborhood residents. In turn, this enables community groups to make a stronger case to residents, the police, and other city agencies to focus on particular problems. One community leader noted, "We were somewhat skittish about going after a problem if the only evidence was citizen perception." Other community leaders say the system improved communication between the police and residents by ensuring that they shared a common platform on which to judge the nature and extent of neighborhood problems.

Mapping in Corrections

Probation and parole departments also use mapping, often in conjunction with community corrections initiatives. Delaware recently undertook a systematic examination of the proximity of probationers' and parolees' homes to drug treatment, employment, and other social service centers and used the results to guide future placement of these centers.[7] Other uses include electronic monitoring and police-corrections partnerships.

Electronic Monitoring. Electronic monitoring devices have been used for many years to help probation and parole officials enforce home detention, curfew, and restraining orders. A typical arrangement involves a device connected to a phone line and a special ankle bracelet worn by the offender; each time the device is polled, it reports whether the offender is at home or at some other location where he is supposed to be (or not supposed to be).

An alternative approach, one with which some corrections agencies are beginning to experiment, involves continuously monitoring the location of offenders using global positioning system (GPS) technology. Computer mapping software is used in conjunction with GPS to display the location of the tracked offender on a digitized street map and, most importantly, to monitor his location relative to other areas. Thus, a corrections official could be alerted if an offender left a specific area (for example, the 1-mile radius of his house) or if he came within a certain distance of forbidden areas (such as a school, playground, or other location).

Police-Corrections Partnerships. Many cities have implemented law enforcement-corrections partnerships as a way to provide enhanced supervision of probationers, apprehend persons who abscond from supervision, and implement joint problem-solving efforts.[8] Information sharing between law enforcement and corrections officials is a key component of these partnerships. In Phoenix, Arizona, for example, local law enforcement and probation officials are implementing a mapping system that links to a database containing both police crime data and information on probationers, including residential

and work addresses, conditions of probation, and probation history. Teams of police and probation officials working in targeted areas will then use this system to plan and implement strategies for reducing burglary. For example, a map showing the addresses of current probationers convicted of or with a history of burglary might show that there are clusters of these probationers near clusters of recent reported burglaries. As a result, area probation officers might increase the frequency of visits to probationers residing near the burglary clusters.[9]

Analytic Mapping

Computer mapping can be a highly effective technique for presenting data and communicating ideas. However, maps are sometimes difficult to interpret and may appear simply as a jumble of dots. Comparing two maps that depict, say, crime locations in two different time periods can be even more difficult. The development of spatial statistic methods and software tools will expand the ability to interpret spatial data.

Figure 3: Arson "Hot Spots" in Detroit 1994 & 1997

Hot Spots: Change Over Time
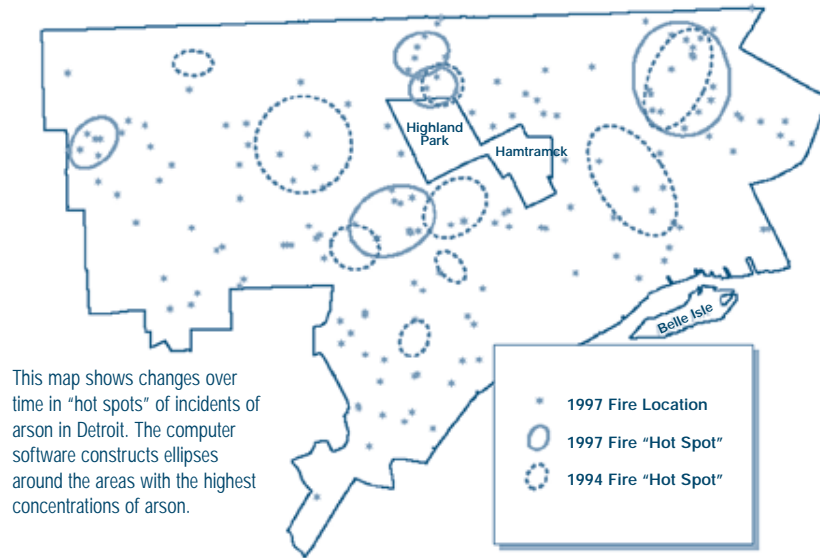
This map shows changes over time in "hot spots" of incidents of arson in Detroit. The computer software constructs ellipses around the areas with the highest concentrations of arson.

• 1997 Fire Location

○ 1997 Fire "Hot Spot"

◌ 1994 Fire "Hot Spot"

Highland Park
Hamtramck
Belle Isle

Source: D. Martin, E. Barnes, and D. Britt, "Multiple Impacts of Mapping It Out," in N. LaVigne and J. Wartell, eds., *Crime Mapping Case Studies: Successes in the Field,* Washington, D.C.: Police Executive Research Forum, pp. 3–14.

Various techniques have been developed to identify clusters of spatial data, the most common example being the crime "hot spot." Researchers at the Illinois Criminal Justice Information Authority developed one of the first of such techniques, a computer program called STAC (Spatial and Temporal Analysis of Crime) that constructs ellipses around the densest concentrations of crime or other spatial point data. (See figure 3.) STAC has been distributed to more than 200 law enforcement agencies.

Another technique used to show areas of high crime density was developed through a research partnership between the City University of New York and the

Recent Trends in Analytic Mapping

Aerial Photography. Overlaying criminal justice data on digital aerial photographs makes maps appear more "real," and, hence, easier to interpret. This also provides additional environmental context within which to interpret criminal justice data.

When users of the Baltimore County Police Department's mapping system were asked what additional information would be most useful, digital aerial photographs were one of the top three choices, along with the last known address of offenders and the addresses to which incarcerated offenders are released.

While only a few criminal justice agencies currently use aerial photographs, it is conceivable that in the future, as more cities commission aerial surveys of their jurisdictions and as data storage costs continue to decrease, map displays routinely will show aerial photographs instead of "stick" representations of streets.

Geographic Profiling. A criminal investigative technique called geographic profiling produces a map that shows the probable home or work address of a particular serial offender. Figure 4 shows the locations of robberies thought to have been committed by a single person. The robber's likely residence is indicated with a house icon. Based on this map, investigators were able to focus their search for the offender, who was eventually arrested. Kim Rossino, a detective in the Vancouver Police Department, developed this technique in 1990, incorporating findings from the field of environmental criminology, such as the distances offenders travel to commit crimes.* While only three police agencies, all Canadian, currently have full-time geographic profilers, the use of geographic profiling should increase substantially in the future as DNA databases, ballistics identification systems, and other techniques improve investigators' ability to link crimes.
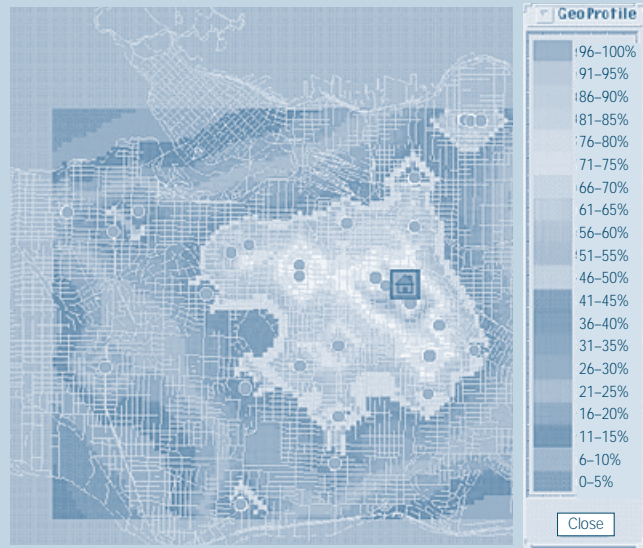
Figure 4: This map of Vancouver is an example of geographic profiling. The house represents the probable location of the offender's residence and the dark circles represent the robberies committed by the offender in nearby neighborhoods.
Source: Vancouver Police Department.

* *Note:* For more information, see Rossmo, D. Kim, "Place, Space, and Police Investigations: Hunting Serial Violent Criminals," in John E. Eck and David Weisburd, eds., *Crime and Place, Crime Prevention Studies,* Vol. 4, Monsey, NY: Criminal Justice Press, 1985, 217–35.

New York City Police Department. It involves a statistical technique that blends, or "smooths out," the pinpoints that represent specific incidents to create an image that represents the overall density of crime rather than the specific locations of those crimes.[10]

Research on hot-spot identification and other spatial statistics methods has applications beyond simply identifying areas where criminal justice resources should be focused. For example, measures of spatial correlation provide a means to judge the relationship between crime and bars, liquor stores, or other geographic features. Spatial statistics also can be used to quantify the extent to which

spatial distributions have changed over time. Indeed, law enforcement and problem-solving efforts that focus on a particular geographic area must address two critical questions: (1) Did the interventions change the geographic distribution of crime, for example, by displacing the problem to other areas, and (2) to what extent can the detected changes be attributed to the intervention.

A logical next question to ask is whether it is possible to forecast changes in hot spots or the emergence of new hot spots. Basic research in the area of predictive modeling is investigating whether spatial forecasting tools can be developed for use by law

enforcement agencies to improve the targeting of enforcement and prevention efforts.[11] One approach involves testing the "broken windows" theory—that signs of physical disorder, such as abandoned cars, graffiti, and litter, will eventually lead to more serious crime—by studying the temporal and spatial relationships between public order and other "leading indicator" crime hot spots and serious violent and property crime hot spots. Another approach incorporates a "rational criminal" model and assumes that criminals search for geographic locations that offer a low risk and high return, such as a particular type of house or locations with easy access to getaway routes.

These and other research efforts on spatial methods are all attempting to move computer mapping beyond simple pin maps and into analytic mapping. In the near future, it is likely that these tools will be standard features in computer mapping software and will be widely used by law enforcement and other criminal justice agencies.

Notes

1. Mamalian, Cynthia, and Nancy La Vigne, *The Use of Computerized Mapping by Law Enforcement: Survey Results,* Research Preview, Washington, DC: U.S. Department of Justice, National Institute of Justice, 1999 (FS000237).

2. La Vigne, Nancy and Julie Wartell, eds., *Crime Mapping Case Studies: Successes in the Field,* Washington, DC: Police Executive Research Forum, 1998.

3. Redlands Police Department, *Transforming Community Policing for the 21st Century: Risk-Focused Policing,* 1999.

4. This research is discussed in the report, *Comprehensive Strategy for Serious, Violent, and Chronic Juvenile Offenders,* by John J. Wilson and James C. Howell, Washington, DC: U.S. Department of Justice, Office of Juvenile Justice and Delinquency Prevention, 1993 (NCJ 143453).

5. This project is supported by the NIJ grant Using a High-Definition Geographic Information System To Enhance Community Policing on College Campuses, grant number 98–IJ–CX–0001.

6. This project is supported by the NIJ grant Development of a Neighborhood Problem-Solving System, grant number 97–IJ–CX–K017.

7. Harris, Richard, Charles Huenke, and John O'Connell, "Using

Mapping To Increase Released Offenders' Access to Services," in *Crime Mapping Case Studies: Successes in the Field,* Nancy La Vigne and Julie Wartell, eds., Washington, DC: Police Executive Research Forum, 1998, 61–67.

8. Parent, Dale, and Brad Snyder, *Police-Corrections Partnerships,* Issues and Practices, Washington, DC: U.S. Department of Justice, National Institute of Justice, 1999 (NCJ 175047).

9. With NIJ funding, researchers at Arizona State University are assessing the impact of this approach to reduce the incidence of burglary. The project is supported under the NIJ grant Combining Police and Probation

Research To Reduce Burglary, grant number 98–IJ–CX–0059.

10. The statistical method used in this technique is called "kernel smoothing." The project to develop kernel smoothing is being supported by the NIJ grant Innovative Crime Mapping Techniques and Spatial Analysis, grant number 97–LB–VX–K013.

11. See, for example, Liu, Hua, and Donald E. Brown, "Spatial-Temporal Event Prediction: A New Model," proceedings of the Institute of Electrical and Electronics Engineers International Conference on Systems, Man, and Cybernectics, October 1998, San Diego, CA.

For More Information

NIJ has funded several of the efforts discussed in this article and is helping State and local law enforcement and corrections practitioners learn more about geographic information systems through grants, fellowships, workshops, annual conferences, Web sites, and a listserv.

The Crime Mapping Research Center supports the development of new analytic software and training curricula, evaluation of best practices, and assessment of the practical applications of mapping as well as its use as a research tool. For more information about the Center, visit its Web site at http://www.ojp.usdoj.gov/cmrc/.

The Crime Mapping and Analysis Program, housed at the NIJ-funded National Law Enforcement and Corrections Technology Center at Denver University, provides hands-on crime mapping workshops and technical assistance in the areas of crime and intelligence analysis and geographic information systems to State and local law enforcement and corrections practitioners. For more information about the Program, visit its Web site at http://www.nlectc.org/nlectcrm/cmap.html.

Additional information on computer mapping applications discussed in this article is available at the following Web sites:

Geographic Profiling: http://www.city.vancouver.bc.ca/police/structure/op-support/geo/geo.html

ADAM Program: http://www.adam-nij.net/

Mapping by Community Organizations: http://www.civic.com/pubs/1999/march/civ-communities-3-1-99.html

Chicago Police Department ICAM Program: http://www.ci.chi.il.us/CommunityPolicing/AboutCAPS/NewTech/ICAM.html

New York City Police Department CompStat Process: http://www.ci.nyc.ny.us/html/nypd/html/chfdept/process.html

Illinois Criminal Justice Information Authority's STAC: http://www.icjia.state.il.us/public/index.cfm?metaSection=data&metaPage=stacfacts