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ORIGINAL PAPER

Exploring the ethical, organisational and technological challenges of crime mapping: a critical approach to urban safety technologies

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Abstract
Technology is pervasive in current police practices, and has been for a long time. From CCTV to crime mapping, databases, biometrics, predictive analytics, open source intelligence, applications and a myriad of other technological solutions take centre stage in urban safety management. But before efficient use of these applications can be made, it is necessary to confront a series of challenges relating to the organizational structures that will be used to manage them, to their technical capacities and expectations, and to weigh up the positive and negative external factors at play at the intersection between technology, society and urban management. The paper contributes to this discussion by looking into the dynamics that drive technological uptake in the field of urban safety, the different theories underpinning the relationship between crime and space, and the history and technological characteristics of Geographic Information Systems to later present specific case studies and practical examples of crime mapping systems. Finally, addressing matters related to organisational constraints, technological possibilities and societal impact from a critical point of view, the paper lays out guidelines to ensure that using technology to manage urban safety does not result in increased victimisation, inequalities or inefficiency. Taking one of the longest established technology used in police practice, crime mapping, and using a multidisciplinary, critical approach to escape technological solutionism and bridge the gap between the academic literature (STS, urban sociology, environmental criminology) and policy needs and recommendations, this paper sends a cautionary tale to those hoping that technology alone can solve complex urban and social problems.

Keywords Ethics of technology · Policing · Policy · Mapping

'Technology won't save us'—David Lyon.

Introduction: the use of technology to manage urban safety

Technology has been at the centre of many of the police-related developments of recent years. However, budget cuts and growing security concerns in a globalised society have increased this trend, pushing towards and increased 'informationalisation' of the police and security forces (Završnik 2013). Technology has always been present in policing—pictures of suspects were used by the police quickly after the invention of photography, and the first CCTV cameras for security purposes were introduced in the 1950s, for instance. Databases have also been used for a long time in police departments, initially in the form of physical files and more recently in digital form. In the 1980s, new technological developments allowed for the crossing of different sources of data using computers, statistics and data to produce crime maps, and geolocating different categories of events on these maps. It was then that police officers began to realise that patterns could emerge, intelligence could be derived and more efficient security services could be provided by maximising the possibilities of new technologies.

Today, technology is pervasive in police practice, both as product, structure and process. An average police force can use statistics and databases (e.g. predictive policing

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systems, criminal records); sensors (CCTV, smart cameras, unusual activity detection, smart city devices, etc.); biometric records (fingerprints, DNA, etc.); mapping and geolocalization, (heatmaps, etc.); Automatic Number Plate Recognition (ANPR) and records: mobile devices (Automotive Navigation Systems, mobile phones); social media tools and open source intelligence (OSINT); e-mail; IM; e-government or the increasing possibilities of the "Internet of Things" (wearables, smart devices and home automation, etc.) (Chan 2001; Byrne and Rebovich 2007).

The use of ICT in policing is aimed at fighting major security threats like terrorism and organized crime, but also petty crime. Regular crime (Pleasance 2014) or online offensive comments (Sawers 2015) might also be addressed with the support of digital resources. Online and offline tools can be combined to enhance investigations' results: fingerprints obtained at a crime scene may lead to an official name and date of birth; this name can be linked to numerous additional records like credit card use, telecommunications, travelling routines, or online social network activities.

There are different reasons that contribute to explain this reliance on technology and computer applictions to tackle urban safety problems. On the one hand, the availability of software tools to manage programmes and organizations. In the case of crime mapping, since the late 1990s products such as MapInfo and ArcGIS were incorporated as consumer products as well as in the management of assets in private companies and in public administration. These products include software applications developed specifically for the analysis of crimes, such as CrimeStat, CrimeWiew, Spatian Analyst, HotSpot Detective, Vertical Mapper or SpaceSat. On the other hand, advances in the possibilities of data digitization (and therefore categorization nd sharing) and the growing trend of 'open data' to promote transparency and accountability.This release of data has consequences not only for the relationship between the Administration and citizens, but also on relationships between different branches of the Administration, as they now have a quick and easy way to access information from other departments.

On the other hand, the existence of a social consensus on the benefits of the technology, which translates in a growing public and private investment in gadgets with very little questioning of the promises and hidden costs of technological solutions. All investment in technology is considered a good investment: "He intuitively believes there is value in it. Reflecting this, unlike most other things, he hasn't asked for its value to be proved." complained one worker in a pharmaceutical company where the Manager had decided to introduce information management software (Currie and Kerrin 2004, p. 18). This belief in the technological fix endures despite a wealth of academic evidence that questions the ability of technological solutions to manage urban spaces, administrative processes or knowledge and information (Nedovic-Budic 1999; Rosner 2004; Morozov 2014). However, analysis attempting to tone down the 'cyberbole' (Woolgar 2002) have seldom gone beyond academic walls, and so the 'technological imperative' is dominant in public discourse and management practices.

In addition, in the collective imagination, technology (and science in general) tends to be seen from two opposed points of view, representing two extremes in the debate on the social impact of ICTs. On the one hand, there is an instrumental view that sees technology as a neutral instrument; on the other hand, there is a substantive vision where technology is morally and culturally loaded and must therefore be suspected upon (Swierstra and Jelsma 2005). Despite the emergence of Science and Technology studies aimed at understanding how values and social practices affect the development of technological tools and their impact on society, politics and culture, these perspectives have not had a significant impact on government practices. Policies therefore continue to be based on an instrumental understanding of the capabilities of technological solutions, relying on their potential and denying or neglecting that the technological drive is also a political commitment and, therefore, is not neutral nor devoid of problems and social consequences.

Related to the last point, the technological drive often responds to the desire to find fast, visible and tangible solutions to social problems. The idea that the Cyber utopia will be able to improve our lives, reduce suffering or make us happier is the clearest example of an end-of-the-pipe dynamic that prevails in the media and in the public discourse, where complex social questions are only addressed at their end-point, without exploring or tackling their causes. This technological determinism, thus, reinforces the tendency to look for shortcuts, and technology seems to provide elected officials with a theatrical and effective resource (Schneier 2003), a physical tool that allows them to communicate an image of dynamism and response-capacity that they usually lack, and that would be difficult to convey on the basis of long-term social policies. The technological solution [technological fix] is rife during late modernity crisis, while other longer-term, non-technological alternative solutions are discarded (Nedovic-Budic 1999; Rosner 2004; Morozov 2014).

Finally, in the case of urban management, these narratives and the policies deriving from them made it to the agenda a while ago. The intelligent techno-utopia of the city 'the dream of perfect cities in a sea of digital ubiquity where information flows perfectly, where citizens connect to urban information flows that operate in real time, and were the web becomes a new paradise'[1] is not a futuristic picture anymore.

[1] Ateneo Naider: De la ciudad sostenible a la smart city. No perder la perspectiva http://www.ateneonaider.com/blog/manu-fernandez/de-la-ciudad-sostenible-la-smart-city-no-perder-la-perspectiva.

Despite the fact that until recently the attention seemed to be focused on sustainable growth and paying attention to the multiple local actors involved in the construction of the city, in a narrative that did not put technology at the centre of urban improvement, this is changing. Today, the emphasis is on technological gadgets, solutions and processes and the role that large companies can play in developing 'smart solutions'. The focus seems to have shifted from people to artifacts. While the evidence that the investment in technology has a direct impact on the improvement of service provision or the quality of life of the population is sparse (Nedovic-Budic 1999), the technological hyperbole seems to be a good fit for a consumer society where political strategies seek visibility and publicity over efficiency, where the media are seduced by the futuristic imagery provided by technology, and where a large business network of multinationals producing "artifacts" seek to capture public investment (Lyon 2003).

The combination of these variables leads us to believe that it is likely that in the short and medium term public administrations continue to focus on technical and technological solutions to tackle restructuring and organizational challenges.

As mentioned above, this technological drive has been felt in policing and urban management for a while now. In the field of security, georeferencing and Geographic Information Systems (GIS) became common in the late twentieth Century in order to improve the management and visualization of information and to facilitate the exchange between police platforms and increasingly between the police and citizens.

The geography of crime

Before further exploring the relationship between technology, security and crime mapping, it may be useful to address the relation between events (crime) and places (spaces) in the understanding and tackling of public safety problems. Crime has an undeniable geographic component-most crimes happen in specific places and are perpetrated by people that come from somewhere and end up somewhere. Even in case of cybercrime, events and cases can be represented graphically on a map as financial or telecommunication flows. If we accept that most crimes have a specific spatial logic (and that criminal acts are not always the result of chance or random, and that even when they are the conditions that create the opportunity can be incorporated in the analysis of the crime and perhaps have explanatory and predictive value), the value of the ability to generate records of georeferenciated crime data becomes self-evident.

Since the 1970s all disciplines dealing with the study of deviancy (psychology, criminology, sociology) recognize that crime can be better understood and explained by taking into account the geographical component.[2] Since then, therefore, the police have incorporated the identification of crime patterns, links between crime and the socio-economic context and the analysis of the impact of police activity on specific geographic areas. During a good part of the twentieth century, however, the geographical representation of the crime had to be done in big maps using pins. This was useful in terms of helping determine the spatial patterns of the data recorded and to see areas of the city where most crimes occurred and concentrated, but left much to be desired in terms of the size of the maps, the little information that could be recorded and the time evolution of the data. Towards the end of the century, with the proliferation of computers and computer software, computer databases and maps began to be generated, allowing a better systematization and representation of crimes, as well as the automation of manual tasks. Despite this, the functions and operation of these early programs were very limited in terms of data and only generated themed maps.

In recent times, however, the possibilities of the technology have changed the field: the significant reduction of prices of technological components, coupled with the availability of data, both at the level of the representation of spaces and movement (digital cartography, GPS, satellite view, etc.) as well as information about social issues, political, demographic, behavioral and leisure patterns, forms of relationship (physical and virtual), etc. have turned mapping into a discipline in itself and within the reach of all levels of government, as well as private and civil society organizations (Longley et al. 2001; Bhagat and Mogel 2008).

The link between crime and space, however, has not been limited to the stage of diagnosis or the simple georeferencing of crimes. Since the 1980s, the environmental variables play a key role in the study of crime, especially in urban environments. There is a current within the Criminology that has had a strong impact on political discourse and public policies, and that is based on the idea that crime is the result of a rational decision of the offender, who evaluates pros and cons before acting and, even under the influence of narcotics or motivated by material needs, decides on the basis of this assessment what are the costs and opportunities of the act. According to this theory, therefore, altering the physical environment can influence this assessment and the author (Clarke and Felson 1993), in the same way that non-intervention on a degraded physical environment can convey a message of impunity which, according to the Broken

[2] The importance of the geographical and situational component has been caputred, for instance, by Crime Prevention Through Enviromental Design (CPTED), an international and multi-disciplinary collection of design principles for the built environment, both indoors and outdoors to prevent crime and increase security.

Windows theory (Wilson and Kelling 1982), contributes to the rise of antisocial and crime-related behaviour. These theories are based on environmental criminology, crime prevention through urban design and planning (CPTED) and 'defensible space' (Ray Jeffery 1999). Despite the fact that many voices questioned this emphasis on the physical environment to tackle urban insecurities, situational prevention became one of the most successful police and urban management strategies of the 1990s.

Crime and space, therefore, have for decades linked both the possibility to relate crime with specific physical spaces (and hence the possibility to extract knowledge about the dynamics of crime) and the widespread belief that it is possible to build spaces/cities that disincentives criminal activity. This criminological interest in 'places' found a natural echo in the development of systems of digitalization and analysis of data and geographic information systems (GIS). The digital mapping of complex and multifaceted processes and socio-cultural phenomena, however, goes far beyond mapping or visualisation—as Stephen Hall anticipated in Mapping the Next Millenium (1994), the uses and potential of georeferencing tools articulated a before and an after moment in police investigation (and in the social sciences in general), facilitating the analysis of social phenomena through the study of multiple variables.

However, a careful look into the realities of the introduction of these new technologies and methods of investigation in police practice tells us that the implementation of geographic information systems and maps in police management in the twenty-first century presents significant challenges which could end up crushing the potential and promise of these new tools under the uncritical belief in the potential of the technology.

Geographic information systems (GIS)

GIS are an appropriate and long-standing example of both the potential and challenges of using technologies to relate crime and space to generate intelligence. Crime maps based on GIS technology have become an indispensable tool in police analysis and management. Beyond the representation of different types of data, these systems allow the development of analytical methodologies that were unthinkable of before their development. Since in the early 1960s the Department of Agriculture of Canada started to use what is now considered the first GIS, the use of these systems has grown considerably, and GIS is now an essential tool in the fields of natural science and resource management, marketing and logistics (to name just a few).

A GIS is a system consisting of hardware, software and various computer procedures drawn up in order to facilitate the acquisition, management, manipulation, analysis,

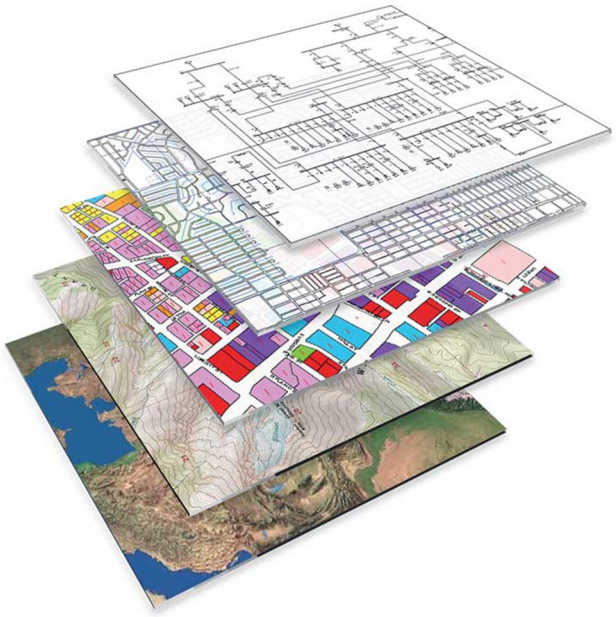


Fig. 1 Data layers in a geographic information system. Source: http://www.etap.com

modelling and representation of geographically referenced data in order to show patterns, correlations or not-so-obvious dynamics and to understand complex realities. Understand the functioning of a GIS is quite simple: it consists of an alphanumeric database with geographical information that is linked to a set of graphic objects from a map. This allows, on the one hand, that when pointing out a certain object on the map, we can access all the information associated with it, and, on the other hand, to access the geographical location of the object in question (Fig. 1).

This layered distribution allows us to analyse the spatial and thematic characteristics of an area in order to get a better understanding of both the object that we looked at and how the entire space is represented. With this system we can find out the number of thefts that have been registered in areas of a particular type (single family homes, for example, if we have the relevant data) or in specific perimeters (a place or space especially conflictive), or identify patterns or routes related to criminal activity.[3] Georeferencing, therefore, is not just a computer application. It is a process in which the computer components are part of a chain that includes the

[3] Bullen (in Chainey and Tompson 2008) describes a case where georeferencing allowed practitioners to identify one day in the week, Wednesday, where crime went up in an area that a priori did not have any of the characteristisc or elements that made it a conflictive enclave. The availability of complex data on the surronding areas revealed that this specific spot was located between an area with serious drug problems and the centre of the city, where methadone was distributed... on Wednesdays. While a simple quantitative analysis had failed to identify the problemshare, linking crime data to Health and socio-economic data allowed for a relevant diagnosis.

hardware, software and data, but also the users and the procedures. It is the relationship and interaction between these five factors that will determine the functionality, the quality and the usefulness of the final system. However, all too often the design of the applications takes precedence over key components such as data and users.

The feature of a GIS that sets it apart from other automatic mapping procedures is its potential to establish relations between the cartographic objects that are in the system. These relationships are stored in the database, where we can use the available data and draw up new information, make measurements, comparisons, ask questions, come up with three-dimensional representations and solve statistical problems. But the development of these operations and their degree of usefulness will depend on the design of the system and the efficiency in its use, as well as on the understanding of this potential by the developers of the technology, the users of the systems (the police) and the intermediaries who carry out the task (public administration). This relationship/interaction is not easy, and often the deficient management of the information and the expectations is the reason why, despite technological advances, in many cases maps are just a computer-generated cartographic representation of figures from databases that can be non-exhaustive and where the information is not properly categorised or hierarchically organised. In such cases, the possibilities of spatial analysis, based on the intelligence it can bring to policing processes, is lost.

The challenge is thus to understand what are the possibilities for the improvement of research and police efficiency that georeferencing and mapping present. The understanding of the technological possibilities, its institutional environments and the societies where they are embedded should guide the development of analytical tools that are capable of carrying out social, economic and political analysis of the data presented in highly visual, multidisciplinary and innovative ways. In the following pages some of the early experiences with the analysis and representation of data and processes are reviewed on order to tackle the challenges of introducing technological tools in police practices.

GIS in action: CompStat

The first crime mapping applications developed from geographic information systems appeared in the late 1960s, thanks to a computer programme called SYMAP, designed by Harvard University (Harries 1999). A few years later, its successor, the SYMVU, was successfully used by the St. Louis Police Department in the US to improve the efficacy of the patrolling routes, drawn from recorded criminal acts and their geographic representation to a very small scale. In the 1980s and 1990s, computer prices began to fall and the commercialisation of GIS solutions increased, and the Mapping and Analysis for Public Safety Department (MAPS) of the National Institute of Justice of the US became a major provider.[4] The impact from MAPS has been crucial in promoting the development of crime mapping and related information Systems both in the US and elsewhere.

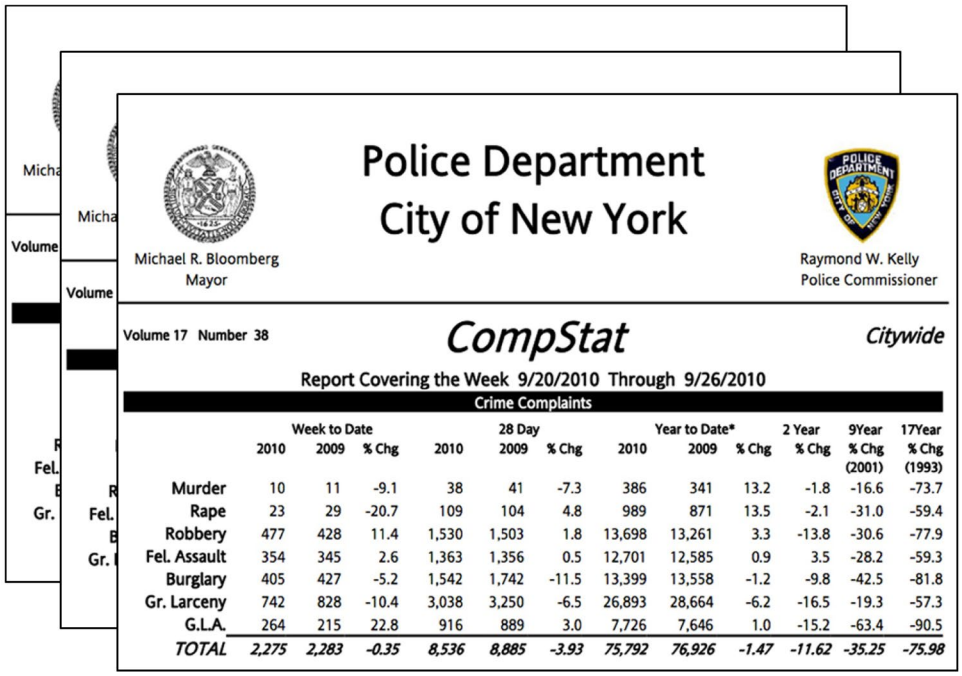
From a set of projects performed by MAPS in the 1980s, the platform for the development of a comprehensive management system for crime emerged, which ended popularizing the use of GIS as an efficient tool in the police field. In 1994, Rudolph Giuliani became the Mayor of New York with an ambitious and controversial police reform program that gave the final accolade to the incorporation of information systems in the police field, popularizing the CompStat program—a strategic control system developed by the New York Police Department to systematize information on city crime and monitor the response given by the authorities. The main goal of CompStat was to provide detailed information to design strategies on effective police actions including the treatment of large amounts of statistical information related to crime and other factors (demographic, urban, socioeconomic, etc.) and an institutional reorganization to improve the communication and coordination of the various departments, territories, and police units, creating weekly meeting spaces to analyse the date and identify trends. Is in these meetings, the data represented in maps, the comparative graphs and indicators, and the reports written by the analysis unit using GIS tools were used to determine which operations and actions should be implemented.Even though the information systems used by CompStat were just one part of a broader strategy, statistical analysis and maps were the core of the program and the basis on which police strategies were developed (Walsh 2001) (Fig. 2).

While, over the years, CompStat has proven to have strengths and weaknesses,[5] its parallel development to the term of Rudolph Giuliani, to whom the decreasing of the crime rates in New York during the 1990s is credited,[6]

[4] To consult other organizations, universities, and companies that develop innovations in the geo-reference field of crime, see Vann and Garson (2001).

[5] John Eterno and Eli Silverman, former criminologists of the New York Police Department, have been reporting the statistics of manipulation in the NYPD. They have collected documents, analysisis and case studies to prove that this practice exists and published it in *The Crime Numbers Game: Management by Manipulation* (2012: CRC Press). A truthful representation of this complex institutional reorgatization involved in the adoption of CompStat can also be found in Season 3 of the TV series "The Wire" broadcasted by the North American channel HBO between 2002 and 2008.

[6] This extreme has also generated an intense academic debate, which highlights that the cities that did not implement Giuliani-like strategies during this period also experimented significant reductions in their crime rates, pointing to the need to look at other related phenomena such as the lowering rates of drug use (and therefore, the success of prevention programs and strategies developed during the 1980s) or demographic changes (see Harcourt 2001).



Police Department
City of New York

Michael R. Bloomberg
Mayor

Raymond W. Kelly
Police Commissioner

Volume 17 Number 38

CompStat

Citywide

Report Covering the Week 9/20/2010 Through 9/26/2010

Crime Complaints

	Week to Date			28 Day			Year to Date*			2 Year	9Year	17Year
	2010	2009	% Chg	2010	2009	% Chg	2010	2009	% Chg	% Chg	% Chg (2001)	% Chg (1993)
Murder	10	11	-9.1	38	41	-7.3	386	341	13.2	-1.8	-16.6	-73.7
Rape	23	29	-20.7	109	104	4.8	989	871	13.5	-2.1	-31.0	-59.4
Robbery	477	428	11.4	1,530	1,503	1.8	13,698	13,261	3.3	-13.8	-30.6	-77.9
Fel. Assault	354	345	2.6	1,363	1,356	0.5	12,701	12,585	0.9	3.5	-28.2	-59.3
Burglary	405	427	-5.2	1,542	1,742	-11.5	13,399	13,558	-1.2	-9.8	-42.5	-81.8
Gr. Larceny	742	828	-10.4	3,038	3,250	-6.5	26,893	28,664	-6.2	-16.5	-19.3	-57.3
G.L.A.	264	215	22.8	916	889	3.0	7,726	7,646	1.0	-15.2	-63.4	-90.5
TOTAL	*2,275*	*2,283*	*-0.35*	*8,536*	*8,885*	*-3.93*	*75,792*	*76,926*	*-1.47*	*-11.62*	*-35.25*	*-75.98*

Fig. 2 Statistical reports on crime from the New York Police Department generated by CompStat. Source: http://www.nyc.gov

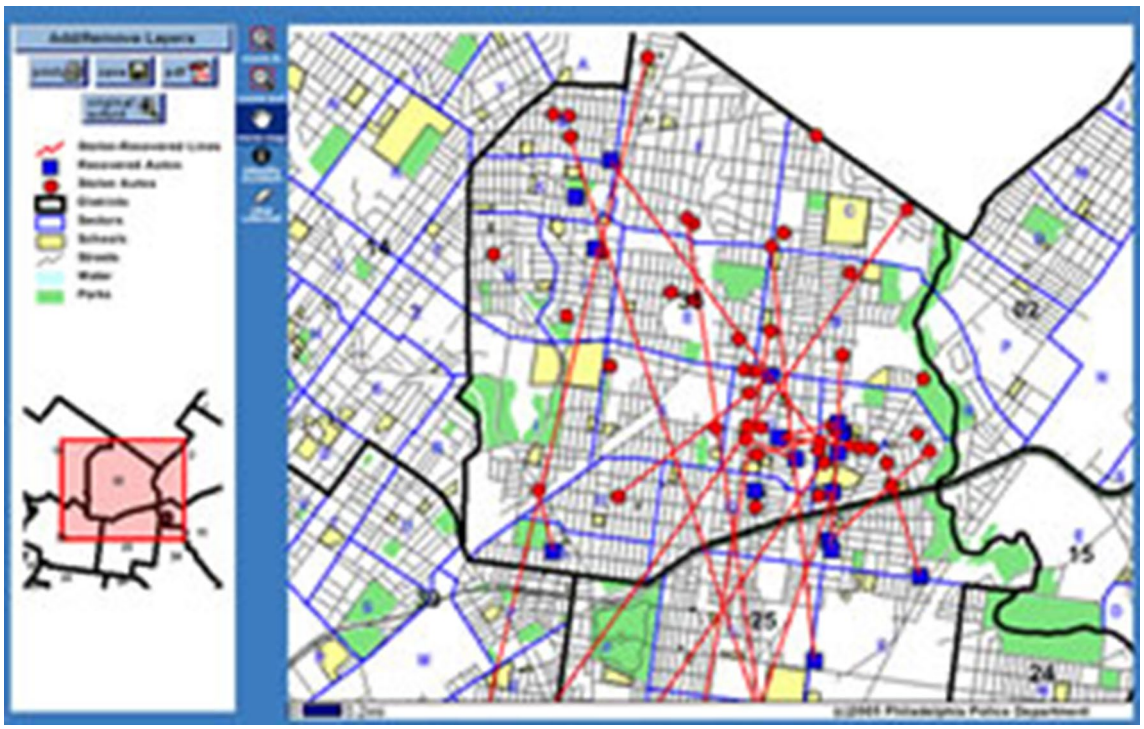


Fig. 3 Tracking route of stolen and recuperated vehicles in district 35, Philadelphia, US. Source: http://www.esri.com

Fig. 4 Applications that can be developed through CrimeView Software, according to data characteristics and type of representations. Source: http://www.theomegagroup.com/

popularized this tool and facilitated its general incorporation to the police departments of many cities in the US and throughout the world (Fig. 3).

GIS in action: promises, expectations and facts

According to MAPS, crime maps can be differentiated in three categories, according to their functionalities:

descriptive (with similar functions to traditional mapping, as they represent static information),

analytical (those that can reproduce relationships between objects through spatial analysis),

innovative (interactive maps which allow for dynamic and immediate analysis of information by incorporating different parameters) (Harries 1999).

In a synthesis exercise, Chainey and Ratcliffe (2005) enumerate the main utilities that GIS can develop in the crime field when their full potential is explored: registering unit activity, calls and incidents, the prediction of repeated probabilities in specific crime categories on the basis of registered facts, hotspot identification, and the proper deployment of forces; the understanding of the distribution of crime activity, mechanisms, dynamics and generators of crime activity for pattern identification and cross-referring data; the evaluation of the impact of prevention initiatives, and improved communication of Police results to the population. Even though this is not an exhaustive list, it rises the multiple and complex uses of georeferencing and states clearly that mapping goes beyond the digitalization of traditional tack maps (Fig. 4).

Since crime maps are common today, we can infer that the variety of tools is as vast as the number of examples. Some of the systems have been developed in urban areas by their police departments, while others deal with police information of entire regions. It's interesting then, to ponder different examples to know what are the best practices and to adapt them to the needs of a specific geographical and institutional environment. This general overview can also give an idea of what are he issues that arise during GIS implementation.

ClearMap in Chicago

ClearMap (Citizen Law Enforcement Analysis and Reporting Map) from the Chicago Police Department in the US[7] is a good example of the evolution that these tools have experienced in recent years. On a first stage, the program used by the department only allowed the registry of criminal incidents and relating them with a database of the owners of the city's buildings. The system also presented a set of operational and maintenance limitations which didn't allow its regular use in all precincts. Registry and data update also

[7] For more information, see http://www.gis.chicagopolice.org.

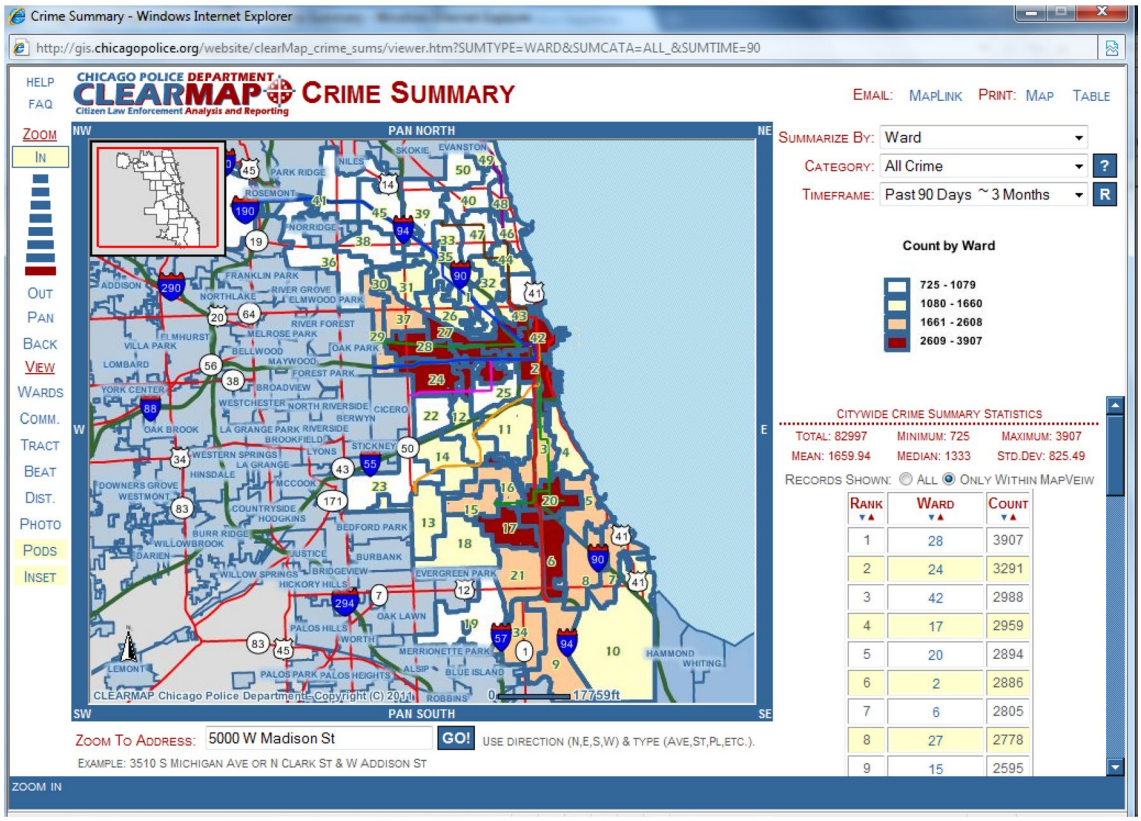


Fig. 5 ClearMap data search with crime acts data register, according to data census in Chicago. Source: http://www.gis.chicagopolice.org

presented some deficiencies regarding geo-coding, and many of the crime incidents were not registered due to a faulty platform design which rendered the whole system useless. When the system was updated, this included new software, a through redesign of the platform and organisational changes. An intranet was created, with access to the whole system to allow for a functional and operational data gathering. Data registry could be done from the mobile units through GPS, which was very innovative back then and provided a remarkable improvement in data gathering processes. The final step included making the data of all criminal incidents recorded in the previous year publicly available through an open website. The web space allows users to search through different offences and spaces: from the last year's summary of criminal incidents to the exact location of all criminal activity in the last 90 days. In some cases, one can even access the exact coordinates where a criminal act took place (Fig. 5).[8]

MAPS in New Zealand

Besides becoming a tool for analysing crime in big cities, mapping can also improve the operations and communications of state departments or even within different police departments of the same country. GIS can improve communication and coordination by creating shared management and analysis systems from the same database. When the National Police in New Zealand decided to renew their management system in the 1990s, they incorporated GIS technology as a tool to analyse their databases. The Map-Based Analytical Policing System (MAPS) was launched in the year 2000 with the aim of integrating different agencies and units state-wide. MAPS became a channel of access and communication between the two large databases in the country: the Police Communication and Resource Deployment Information Center (CARD) which collects all emergency calls and public services and integrates them into MAPS in less than 15 min, and the National Intelligence Application (NIA), where all generated information from different nationwide police agencies is registered. The process of adapting the system to a not too flexible organizational structure required much time and effort at the beginning. Initially, in order to adapt the system to the needs of the police department, the performance requirements and the

[8] This "public" use of crime maps (open data) is rising and shows its own complexities (linked to fundamental rights, such as privacy, the presumption of innocence, rehabilitation, etc.) which fall beyond the scope of this text.

operational potential had to be designed. The whole procedure of how data was collected and processes had to be redesigned, and the police had to change its way of operating. Data registry and the exact location of each crime incident became the key to the subsequent operation of the entire system. Currently, the level of data accuracy is 80%.[9]

The implementation of MAPS required political support and a long-term vision that was key to its success. The system has been updated three times already and different applications have been developed for different users. Today, the system has become a basic tool within the department and a platform to share information among agencies and departments, overcoming the usual resistance from units used to work against each other and often in competition. In the future, MAPS is expected to integrate the rest of the units and agencies of the national police, including the maritime police, a factor that will require a comprehensive rethinking of the organizational structure and the standardization of new procedures in the police department.

The vulnerable localities index

The use of GIS as an internal tool when registering crime incidents not only serves to generate better dynamics or set new communication channels between police units, but also allows for the development of new analytical tools and to design more efficient intervention strategies, specially when social, economic and demographic data is incorporated into the analysis. This is technically challenging, but there are good examples pointing to the possibility of using GIS to capture complex realities, such as the Vulnerable Localities Index (VLI). This methodology was first proposed by England's Central Police Training and Development Authority (CENTREX) in 2003. Its goal was to automatically detect areas of high social vulnerability. It emerged only months after the social unrest that took place in northern England during the Summer of 2001.[10] The project's goal was to create tools to identify future conflict, define high risk areas, follow up on them, and, if necessary, define possible actions (Chainey 2004). The original intention was to develop a national indicator for different variables linked to crime, demographics, and socio-economic factors,[11]

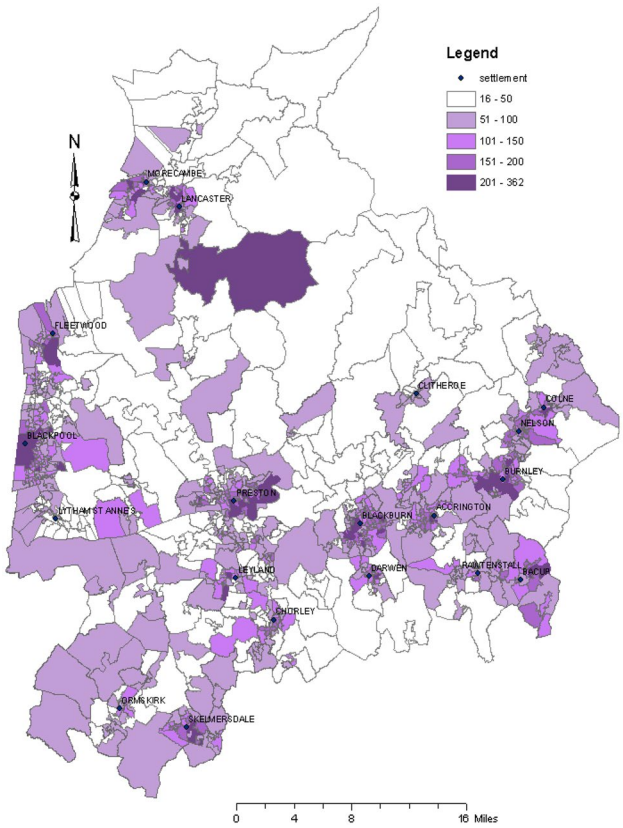


Fig. 6 VLI mapping in Lancashire, England, 2003 (an indicator higher than 200 is considered a vey vulnerable social situation). Source: http://www.lancashire.gov.uk

and eight cities were initially chosen as part of a pilot program. In order for this index to be used by all departments in England and Wales, the data needed to be standardized nationwide, accessible, and updated periodically. But system implementation was troublesome due to the lack of standardization of procedures in the police departments of the cities chosen. In the design stage, there where no specific mechanisms to improve the degree of adaptation of the new procedures to the existing reality and prevailing dynamics, and no one thought of incorporating specific local traits and characteristics (Chainey 2008). In the city of Wigan, for instance, they ended up elaborating an alternative index that was more truthful to their specific situation, with indicators from the city itself and its police service, the fire department and emergency services (Bullen 2008). Despite these initial obstacles and the need to redesign, modify and allow for some flexibility in the indicators, the VLI nowadays is a basic tool to measure the level of social cohesion in some England cities and its methods have led to the development of other detection tools, such as the Neighborhood Policy initiated by the British government in 2005 (Fig. 6).

[9] A figure above many systems that do not usually exceed 60% of correct data. For more information about this case, see Gilmour and Barclay (2008).

[10] During the Summer of 2001, various populations in northern England like Oldham, Burnley, Bradford, and Wrexham witnessed generalised unrest led by youngsters of different ethnic groups and where right-wing parties were also involved.

[11] The six indicators were: rate of robberies in houses; rate of violent robberies in houses; index of poverty; unemployment rate; population with lower education; and percentage of population between ages of 15 and 24.

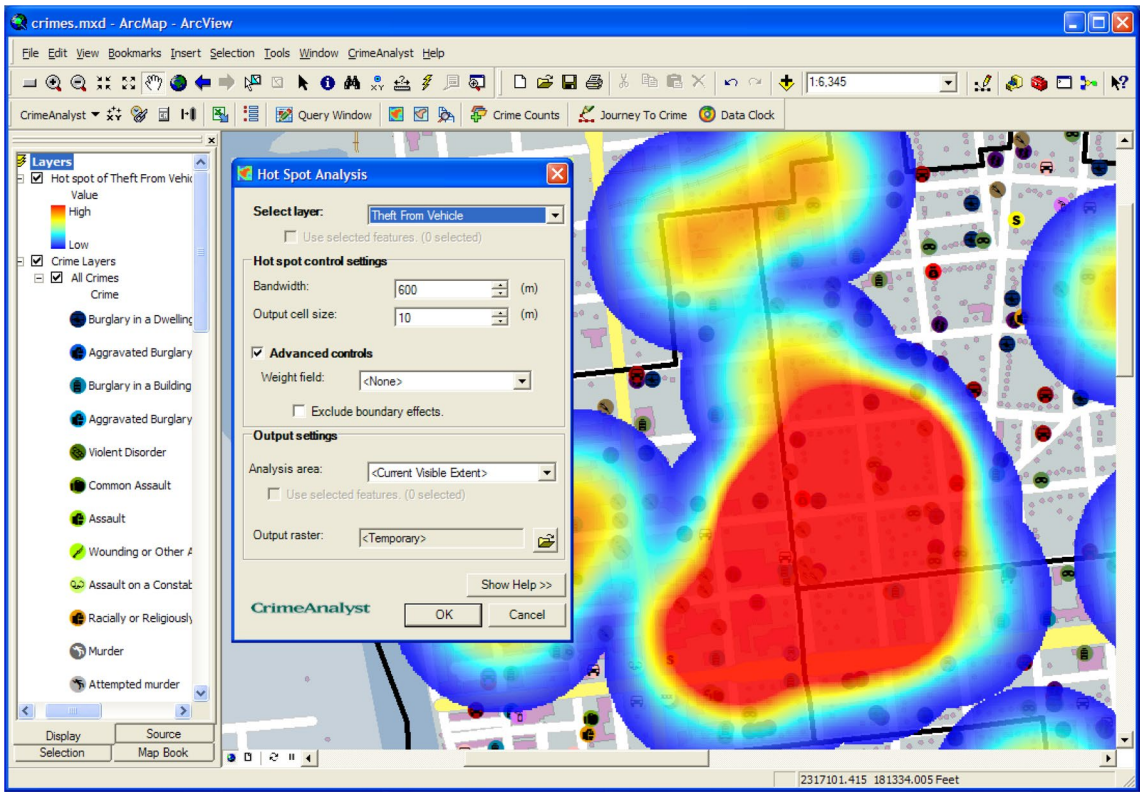


Fig. 7 Application of ArcGis to identify "*hot spots*" on a map. Source: http://www.esri.com

The lessons of crime mapping

Ethical: the dark side of 'hot spot policing'

Even though the possibilities of georeferencing go far beyond the digitization of maps, one of the basic functions of mapping solutions is the detection of sensitive areas or areas where crime is a serious problem—what is known as 'hot spots'. There are very different techniques when it comes to identify these areas, and practically the majority of software applications on the market have developed spatial analysis tools designed for this purpose. As many authors emphasise, one of the best ways to predict future crime is through the study of the patterns and dynamics of past crimes. But beyond the technical aspects and visualization techniques, the implications that arise in the process of identifying and mapping such sensitive areas is a good example of the complexity and challenges surrounding the use and representation of data as sensitive as that generated by criminal activity.

Without denying the usefulness of being able to identify hot spots, it is important not to forget that the identification of a space as a 'hot spot' on the basis of processing data that synthetises social processes and specific events can paint a stigmatising picture that fails to capture the complexities of the situation. That is why many authors agree that it is important to consider different aspects when chosing this approach (Ratcliffe 2005; Ratcliffe and McCullagh 1999). On the one hand, to take into account the issue of scale: different scales can be chosen when looking for hot spots, and for each of those scales the characteristics of the information and the analysis will vary. The impact of identifying a street, a block or a neighbourhood as a hot spot will be different in each case, both for those living there and for the authorities or other citizens. On the other hand, the kind of crime activity being recorded will also need different treatment depending on its location or characteristics (while drugs can be sold in a specific street or building, the analysis will need to take into account other factors such as the dynamics of organisation of those involved, or the drug trade circuits). Depending on the type of crime, the specific geographical identification of one of the moments of the crime will be more or less useful to understand its dynamics.

Likewise, in a scenario of generalization of the public's use of these maps (what is known as 'open data'), these stigmatising risks are joint by others, like the need to protect the privacy of the personal data used (also those of offenders) and the impact of certain information on the perception of a particular area. The identification of a space as a 'hot spot' can, for example, have negative effects on the value of the

land and the local economic activity, impact on insurance fees for those living there and their chances of getting credit from financial institutions, thus subjecting the residents of a hot spot to a double victimisation (Wartell and McEwen 2001). A recent survey, for instance, showed that 11% of respondents chose not to report an incident out of fear of the impact of a high delinquency rate on the value of their properties (Hand 2012) (Fig. 7).

In the background of this debate on the negative externalities of hot spots, there lays a much more structural debate on the possibilities of the mapping technology to capture complex social processes and provide solutions and the need to broaden the data inputs needed to achieve that goal. To a great extent, technology can only provide useful answers to questions that are posed properly, taking into account multiple variables and building them into the analysis. In order for georeferencing tools to go beyond the digitalisation of tack map and become a tool of police intelligence capable of representing reality through the processing of data along diverse analytical perspectives is one of the most important challenges cureently facing the development of GIS (Harries 1999; Chainey and Ratcliffe 2005).

This is no easy task, however. It requires the configuration of much more complex analytical tools to capture the diversity of crime causes, processes and consequences. Accessing databases not directly related to criminal activity or the police field, therefore, becomes essential[12] to be able to develop this capacity for a multi-sectorial, multi-disciplinary analysis and visualization of processes. But improved acess to data and new methodologies of data analysis are only part of the challenge. The departments providing the data need also to collaborate in order to design over-arching solutions and strategies, and these should be able to travel from the head of the policy initiator to the daily processes of the front-office service provider so as to follow through the whole process of implementation (Pressman and Wildavsky 1984). Addressing the need for transversal policies, technologies and ways of woking is essential to ensure that the investment in geographic information systems and mapping technologies translated into more effective and efficient public interventions in the field of public safety.

[12] This point should not be understood as a call for more data sharing, but for better, more responsable and anonymised data sharing to improve public outcomes. Data sharing between public agencies, and between public and private agencies, has its own ethical and legal challenges, and while getting into these would be outside of the scope of this paper, the author would like to stress the need for consent, accountability, purpose limitation and compliance with the EU General Data Protection Regulation. Any attempt to use personal data in the ways described above would most probably require a Data Protection Impact Assessment to address these ethical and legal aspects.

Organisational: the challenges of implementation

As we have seen, the possibilitie of crime mapping are almost endless. The attention to the practical elements of the implementation of new policies in institutional environments, however, brings forward challenges that are not obvious at first glance, related to the complexities of introducing technological innovations in rigid institutional environments. As shown in the cases described above, if Geographic Information Systems are to be integrated into the police practice, there are a number of factors that need to be taken into account and on which the success of the introduction of tools to improve the effectiveness of the police and their approach to public safety depends.

Any new technoogical initiative should start with a design and implementation plan. This should allow for policy entrepreneurs to explore the possibilities and limits of a given strategy, moving away from a technological fix or theatrical approach. The first step should be a complex diagnosis of the problem(s) at hand and the definition of specific indicators. These should allow the monitoring of the results and expectations, and provide those involved with clear indicators of what to assess in the short, medium and long term. In this phase, it is advisable for plans and strategies to be adapted to the local context where they want to be implemented, avoiding policy 'imitation' and instead opting for a disembedding of successful initiatives elsewhere to then re-embed them in the relevant context.

In this sense, the adaptation of expectations to the reality of the possibilities of the technology, the ability to design a realistic and thorough implementation plan and to set up a space for dialogue and exchange between experts, operators and software developers are key elements for the good design of public policy tools. A good implementation plan should take into account the costs of entry and maintenance of the systems, the consistency and quality of the data and systems available, the design of specific and complex quantitative tools that take systems from a mere counting and georeferencing of events to the possibility of generating new knowledge about the social processes relevant to criminal activity.

Finally, special attention should be paid to the phase defining the specific implementation of the changes and new processes at the point of service provision.The introduction of new tools in existing processes generates new dynamics of organization and decision making, and changes the functioning of the day to day activities. These changes and new dynamics need to be identified and addressed. Here is where matters related to the exchange of information, training and coordination of operators, communication and clarification of roles, and the ability of leadership to overcome resistance and inertia (that can paralyze the process of introduction of new practices) and to generate intelligence is crucial. This

is a key moment, which will determine the chances of success of the innovations in the management of public policies. It requires leadership not only to generate support in the adoption of the new tools, but also to create reaction mechanisms in the face of the inevitable mismatches and unforeseen events that will emerge in the process of turning a good idea into a good public policy.

Technological: towards responsible innovation

It can't be denied that the use of ICT solutions and Bid Data processes for security purposes can contribute new and unexpected informational inputs that enhance the quality and efficiency of police investigation and intelligence, that transnational investigations can be enhanced by the use of data-sharing mechanisms, that the real-time analysis of risks can improve rescue missions and that data analysis can lead to better prevention strategies. However, it is also true that data is only as neutral as those designing the data collection mechanisms and algorithms. Therefore, data can also be used for unjustified or illegal profiling based on ethnic, religious or socio-economic traits. Moreover, increasing the interconnection of devices may weaken security and privacy: cloud services, mobile devices and online sharing practices demand additional security measures and attitudes which are still not fully developed. There is also the related risk of "datacentrism", which can derive in a sort of data despotism or minimization of the consequences of the digital divide (thus privileging those digitally included, or substituting actual citizens for their data doubles in policy-making). Delegating data processing to private actors may also lead to risk practices, as these may have perverse incentives and the regulation of private entities isa still underdeveloped. The factual provenance of data is another related and often overlooked risk.

In order to address these challenges, current legislation provides useful cues as to what needs to be taken into account. Data minimisation is a principle of data protection and privacy by design which states that only the data that has a clear and useful purpose should be gathered and used. In a context where the tendency is for data mining processes to attempt to capture all available information, regardless of consent or specific use, this basic legal principle is often overlooked, Once that data has been collected, anonymization techniques should be designed to protect the data subjects and avoid re-identification. This is specially sensitive in georeferencing, as people's addresses or moving patterns can reveal details of their personal lives even when their names are obfuscated. Advances in privacy-enhancing mechanisms such as differential privacy or attribute-based encryption provide promising avenues for a more respectful and responsible technological future, but these techniques are still being developed and are often not known by those buying the technology for public use.

Conclusion

As shown by the examples of the first mapping solutions, the lessons of crime mapping point to the need to not take or use technoogy as face value, to throughly plan implementation processes and ensure the appropriate training and organisational capacity, and to be aware of the negative externalities of any new project or initiative. In the introduction of technology in policing practice, privacy-enhancing mechanisms can contribute to a greater awareness and respect of privacy and security risks, concerns and the rights of the data subjects. Good policy-making, on the other hand, provides the tools to design and implement new policies while taking into account the needs of all involved stakeholders. Finally, an engaged audience is key to provide the feedback that is needed to fine-tune new programs and policies.

While this may seem self-evident, a great deal of the discourse around the possibilities of mapping tools has fallen victim to the technological imperative, and the popularity of GIS has been growing often in an uncritical, simplistic way, without pondering a full understanding of the relationship between technology and the institutional contexts, nor alerting about the limits of mapping in fulfilling the expectations generated by the media and part of the expert field. The reality is that in most cases current GIS Applications in Police departments continue to rely only on crime or traffic data and are aimed at improving the performance of specific routine procedures in police departments (vehicle Deployment, for instance), without developing GIS to their full potential.

Understanding and activating ethical, social, organisational and technological concerns, therefore, is not a way to limit the potential of technology, but to ensure that it can reach its full potential. The point is not wether technology should or should not be used, but how to do it while bearing in mind and taking into account the social and cultural complexity of the institutional environment where the technology will be deployed.

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